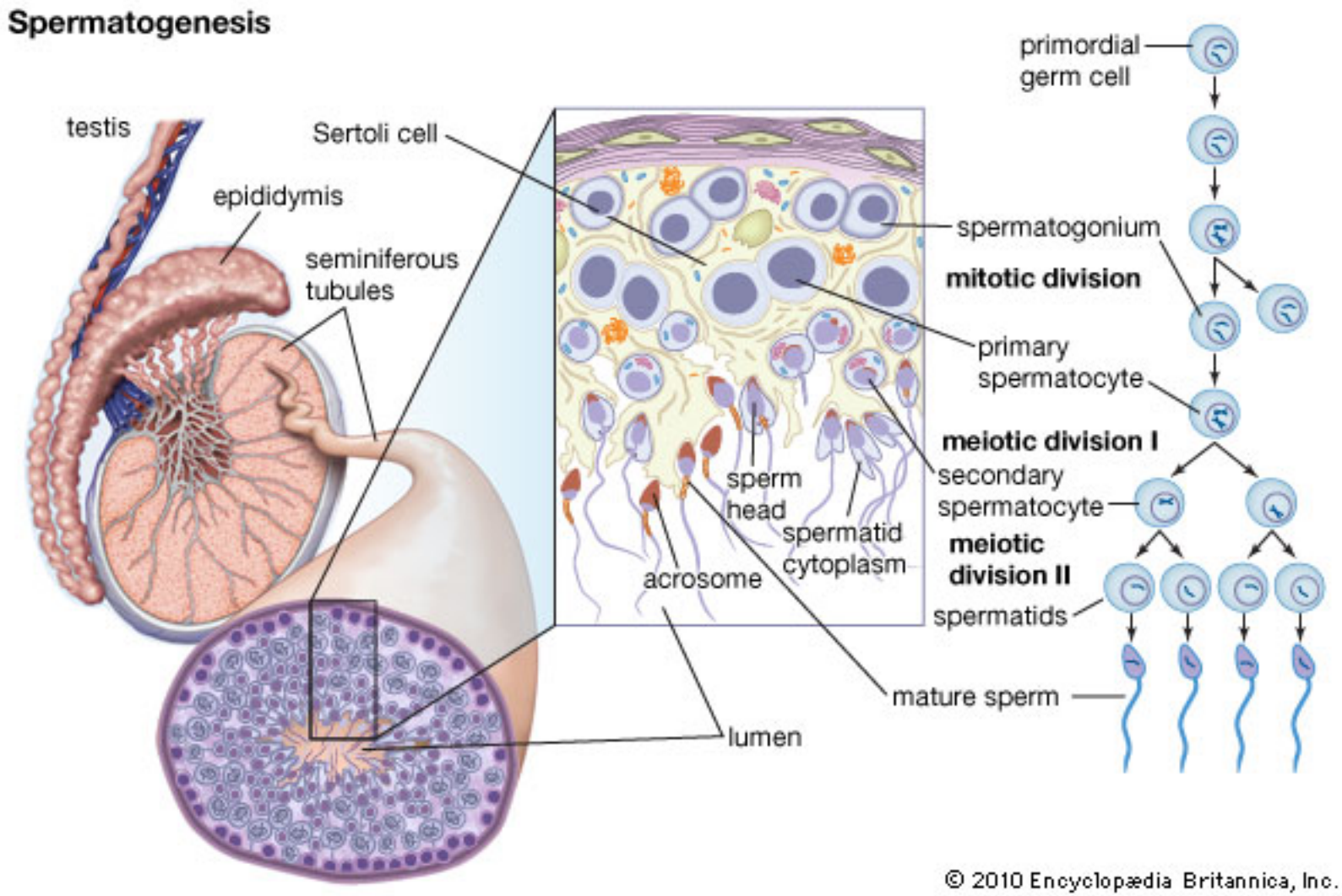
Human Health & Physiology

11.4 – Reproduction

Spermatogenesis

- Production of sperm cells takes place in the seminiferous tubules of the testes
- Developing sperm are nourished by **Sertoli cells**
- Testosterone is produced by **interstitial cells**
- Mitosis produces 1° spermatocytes (2n)


Spermatogenesis
testis
epididymis
seminiferous tubules
Sertoli cell
spermatogonium
mitotic division
primary spermatocyte
meiotic division I
secondary spermatocyte
meiotic division II
spermatids
mature sperm
sperm head
spermatid cytoplasm
acrosome
lumen
primordial germ cell
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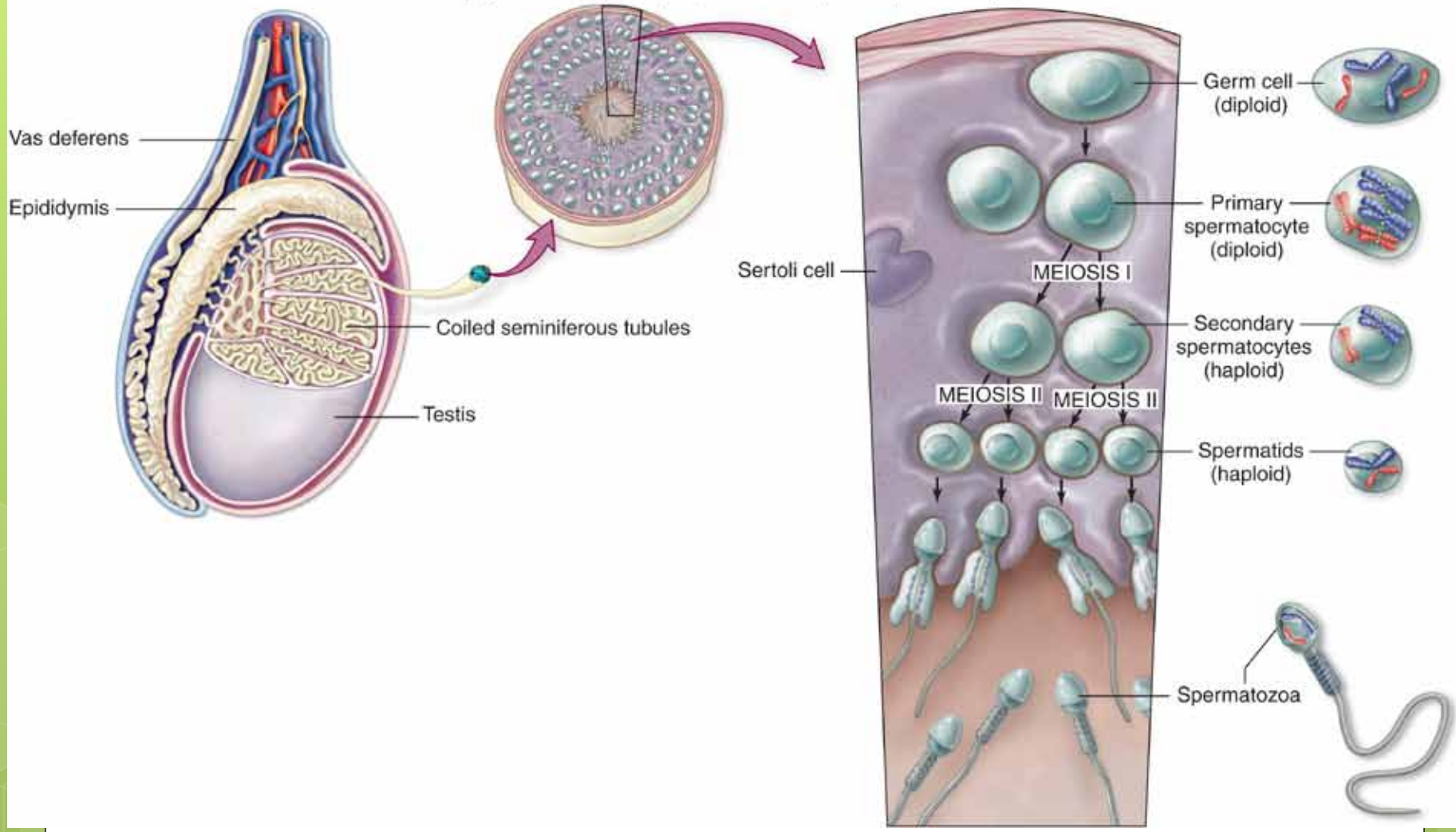
Spermatogenesis

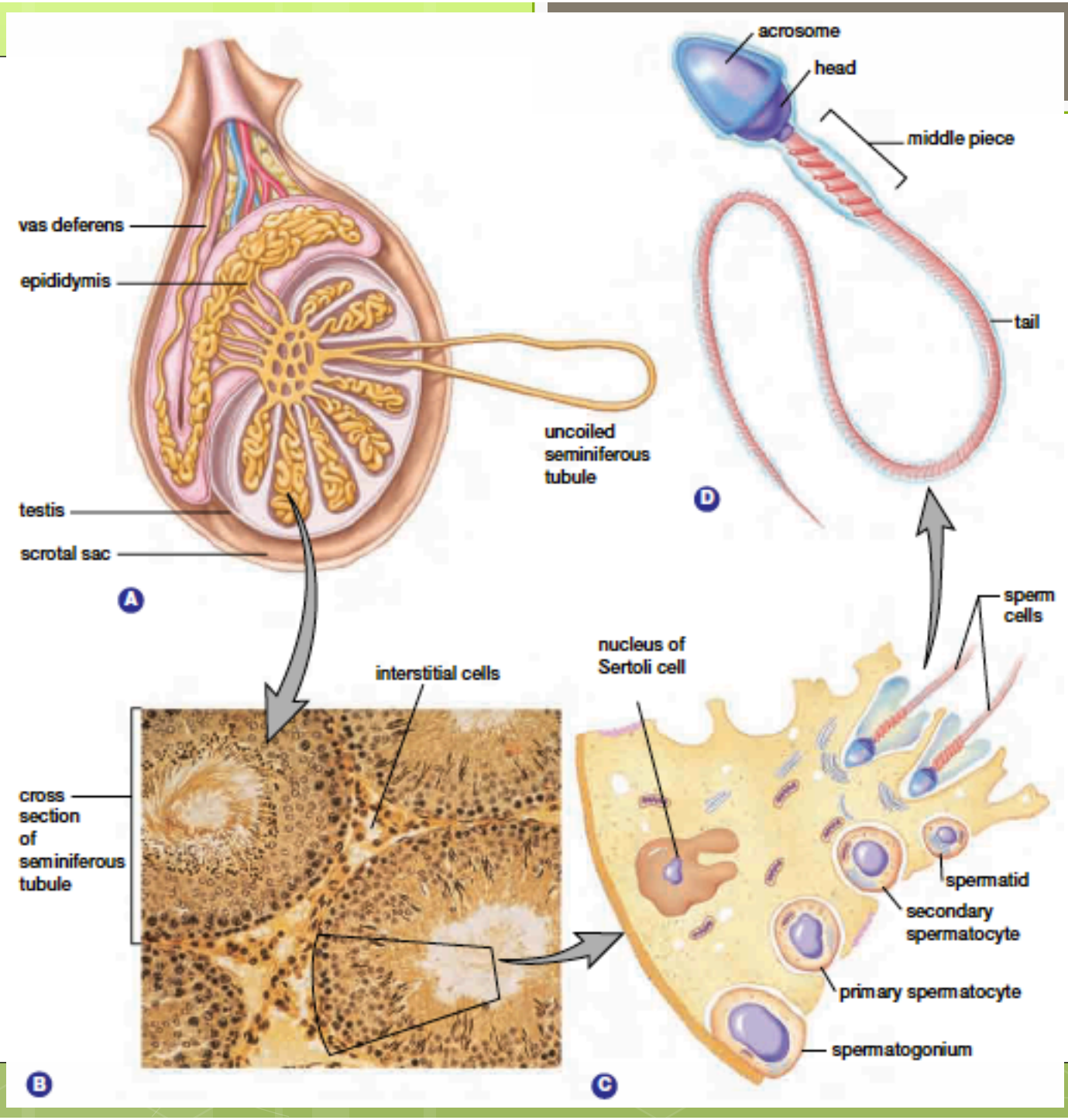
- Meiosis I produces 2° spermatocytes (n)
- Meiosis II produces sermatids (n) which differentiate into mature spermatozoa
- RESULT = 4 haploid sperm cells
- Produced ongoing from puberty until death



Spermatogenesis

Roles of hormones

- FSH – stimulate 1° spermatocytes to mature into 2° spermatocytes
- LH – stimulate interstitial cells to produce testosterone
- Testosterone – stimulate maturation of 2° spermatocytes into spermatozoa

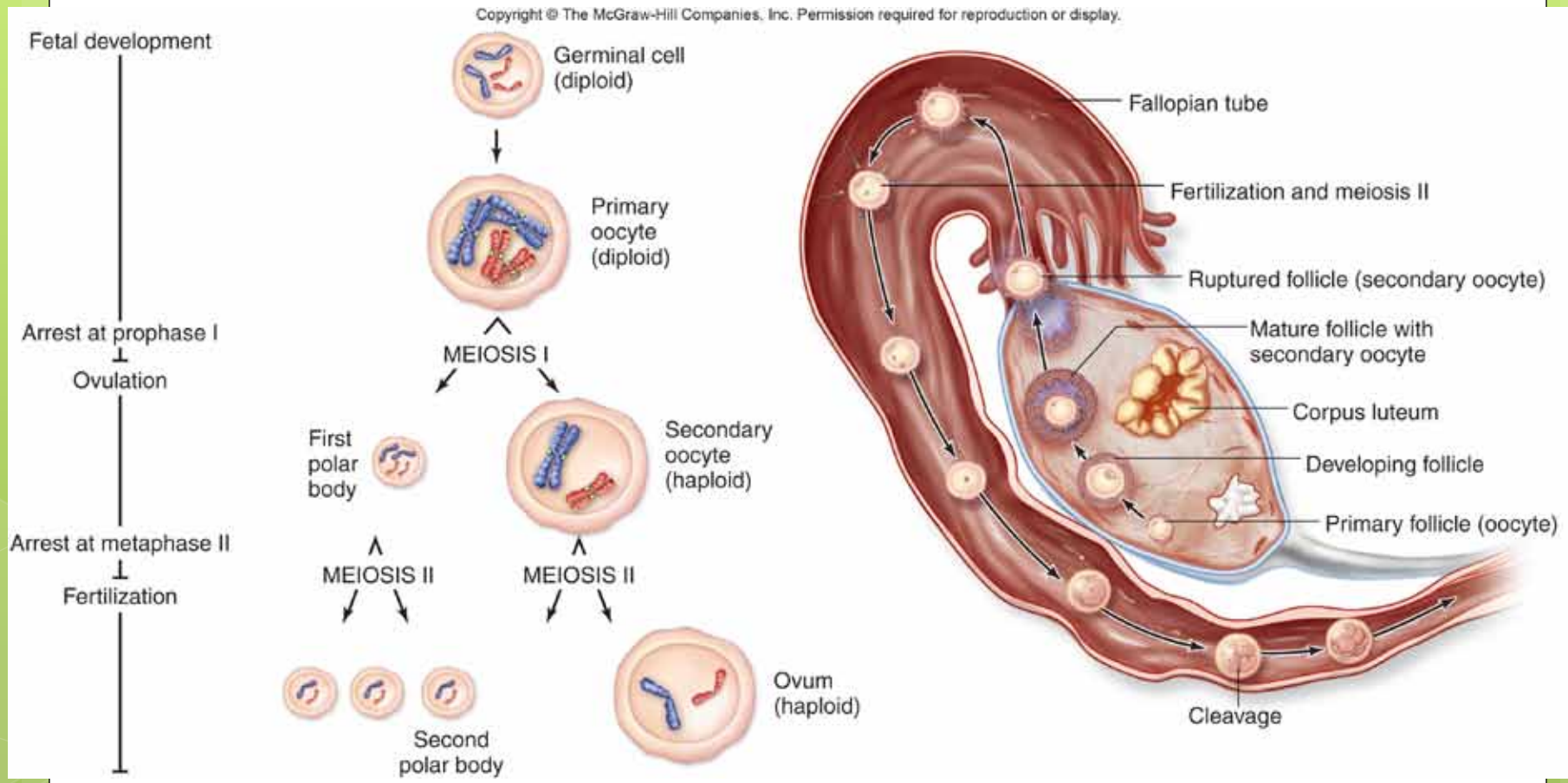

vas deferens
epididymis
uncoiled seminiferous tubule
testis
scrotal sac
A
acrosome
head
middle piece
tail
D
sperm cells
nucleus of Sertoli cell
interstitial cells
cross section of seminiferous tubule
spermatid
secondary spermatocyte
primary spermatocyte
spermatogonium
B
C

Oogenesis

- Production of ova (eggs) occurs in the ovaries
- Mitosis produces 1° oocytes (2n) before birth
- Meiosis I stops at prophase I until puberty
- Meiosis I results in a 2° oocyte (n) and a polar body

Oogenesis

- Meiosis II produces an ovum and possibly 2 polar bodies
- The ovum will only progress to the end of meiosis if fertilized
- Polar bodies do not go beyond metaphase II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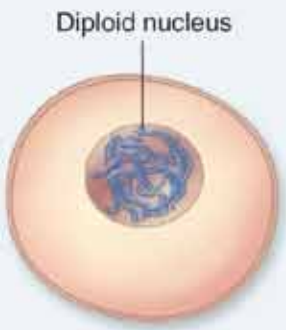
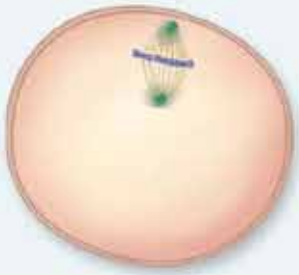
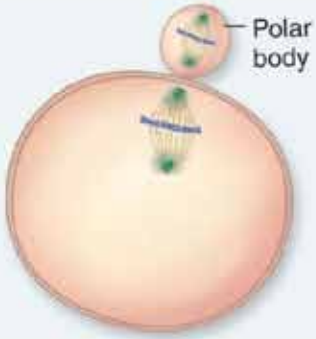
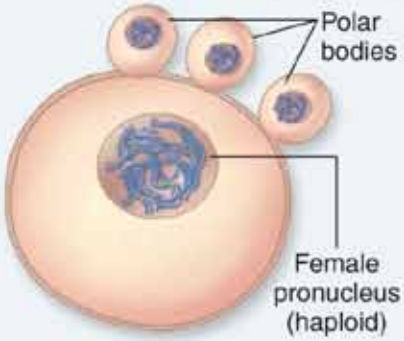
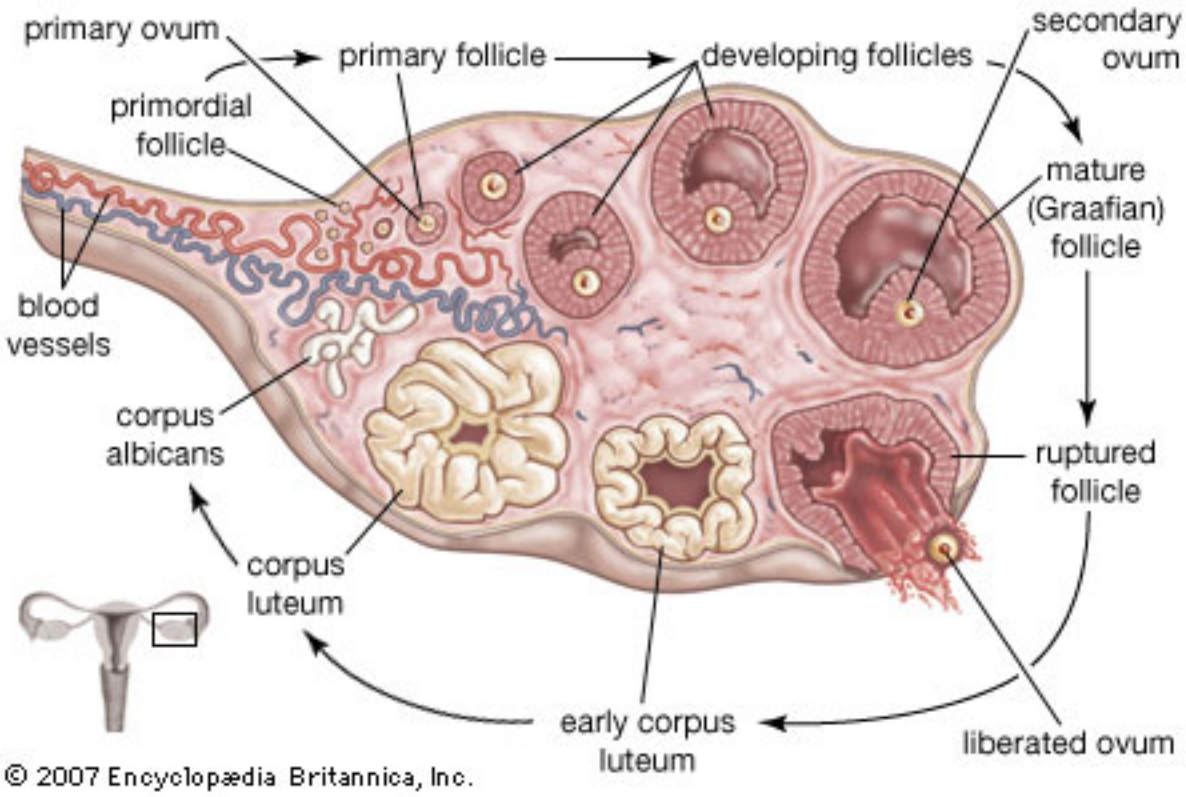
Fetal development
Germinal cell (diploid)
Primary oocyte (diploid)
Arrest at prophase I
Ovulation
MEIOSIS I
First polar body
Secondary oocyte (haploid)
Arrest at metaphase II
Fertilization
MEIOSIS II
MEIOSIS II
Ovum (haploid)
Second polar body
Fallopian tube
Fertilization and meiosis II
Ruptured follicle (secondary oocyte)
Mature follicle with secondary oocyte
Corpus luteum
Developing follicle
Primary follicle (oocyte)
Cleavage

Oogenesis

- RESULT = 1 mature egg cell(+3 polar bodies)
- 400 000 primary follicles at birth
- Mature at puberty
- Released once a month until menopause

Primary Oocyte	First Metaphase of Meiosis	Second Metaphase of Meiosis	Meiosis Complete
			
• Roundworms (*Ascaris*) • Polychaete worms (*Myzostoma*) • Clam worms (*Nereis*) • Clams (*Spisula*)	• Nemertean worms (*Cerebratulus*) • Polychaete worms (*Chaetopterus*) • Mollusks (*Dentalium*) • Many insects • Sea stars	• Lancelets (*Branchiostoma*) • Amphibians • Mammals • Fish	• Cnidarians • Sea urchins


primary ovum
primary follicle
developing follicles
secondary ovum
primordial follicle
mature (Graafian) follicle
blood vessels
corpus albicans
ruptured follicle
corpus luteum
early corpus luteum
liberated ovum
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Comparison of spermatogenesis & oogenesis

Spermatogenesis	Oogenesis
Millions of sperm cells are produced every day	Typically, one secondary oocyte is ovulated per menstrual cycle
Four gametes are produced for each germinal cell which begins meiosis	One gamete is produced for each germinal cell which begins meiosis (plus polar bodies)
The resulting gametes are very small	The resulting gametes are very large
Occurs within testis (gonad tissue)	Occurs within ovaries (gonad tissue)

Damon, A., McGonegal, R., Tosto, P., & Ward, W. (2007). *Higher Level Biology*. England: Pearson Education, Inc.

Comparison of spermatogenesis & oogenesis

Spermatogenesis	Oogenesis
Spermatozoa are released during ejaculation	Secondary oocyte is released during ovulation
Haploid nucleus results from meiosis	Haploid nucleus results from meiosis
Spermatogenesis continues all through life (starting at puberty)	Ovulation starts at puberty, occurs with each menstrual cycle, then stops during menopause
Begins with mitosis	Begins with mitosis

Damon, A., McGonegal, R., Tosto, P., & Ward, W. (2007). *Higher Level Biology*. England: Pearson Education, Inc.

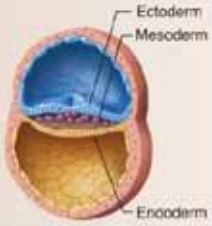
Semen production

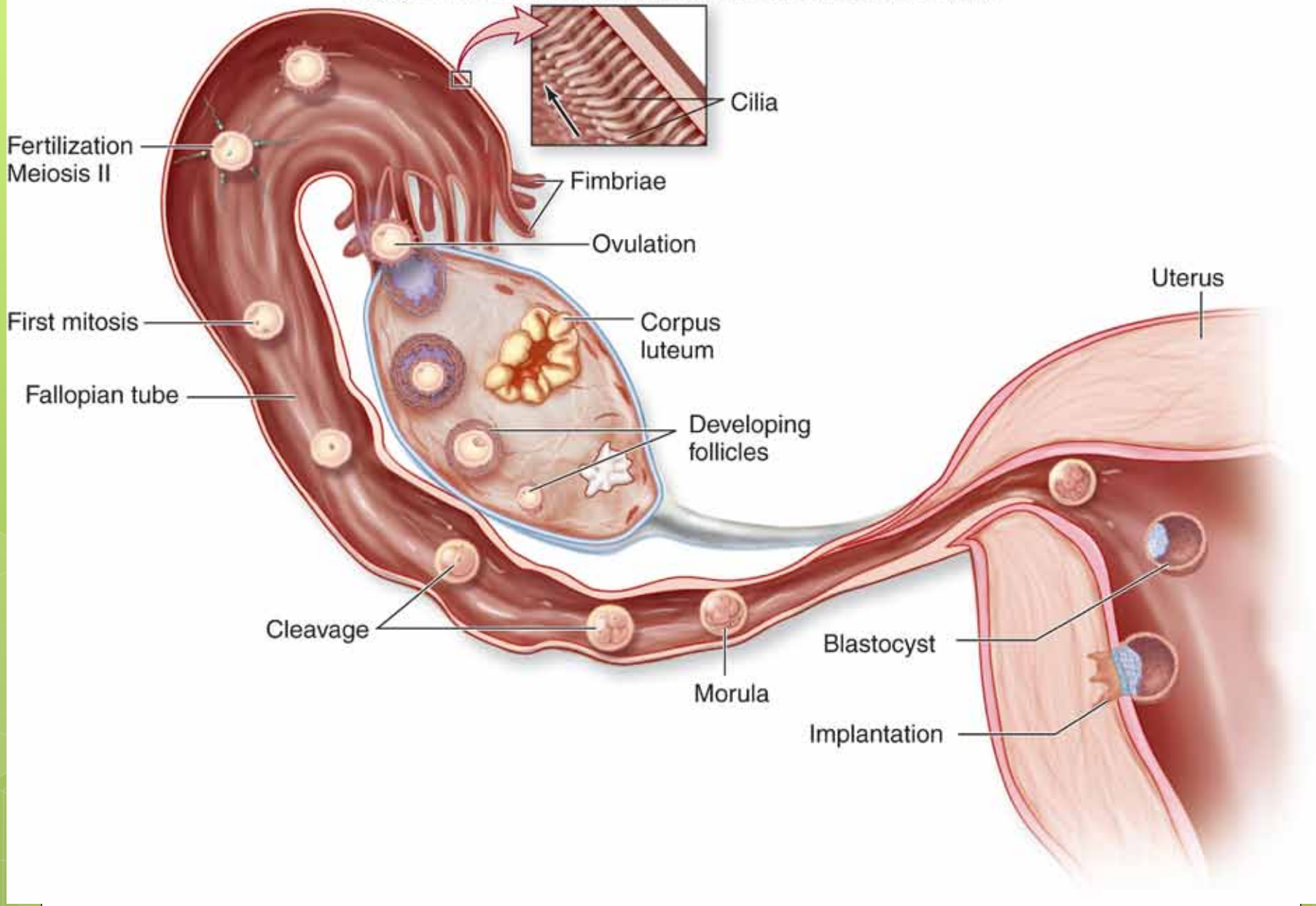
- Sperm move to the **epididymis** where they continue to mature and develop the ability to swim
- During ejaculation, they combine with fluid from the seminal vesicle and prostrate gland
- **Prostate gland:** adds alkaline fluid to neutralize the pH of the acidic vagina

Semen production

- **Seminal vesicle:** fluid contains fructose to provide energy, prostaglandins to stimulate female contraction, and mucous for protection
- All this = **SEMEN** (10% is sperm cells; 90% is fluid)

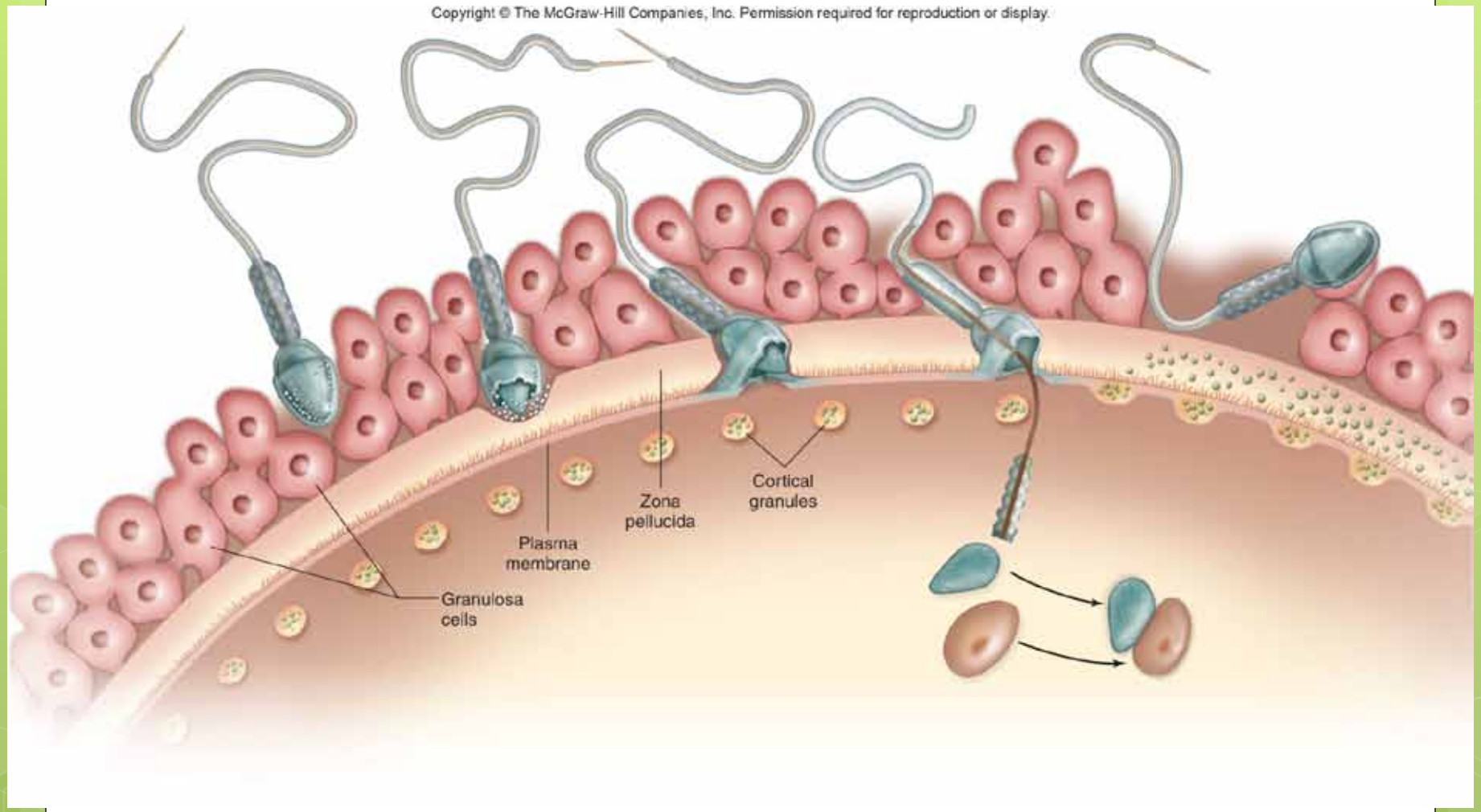
TABLE 54.1 Stages of Animal Development (Using a Mammal as an Example)

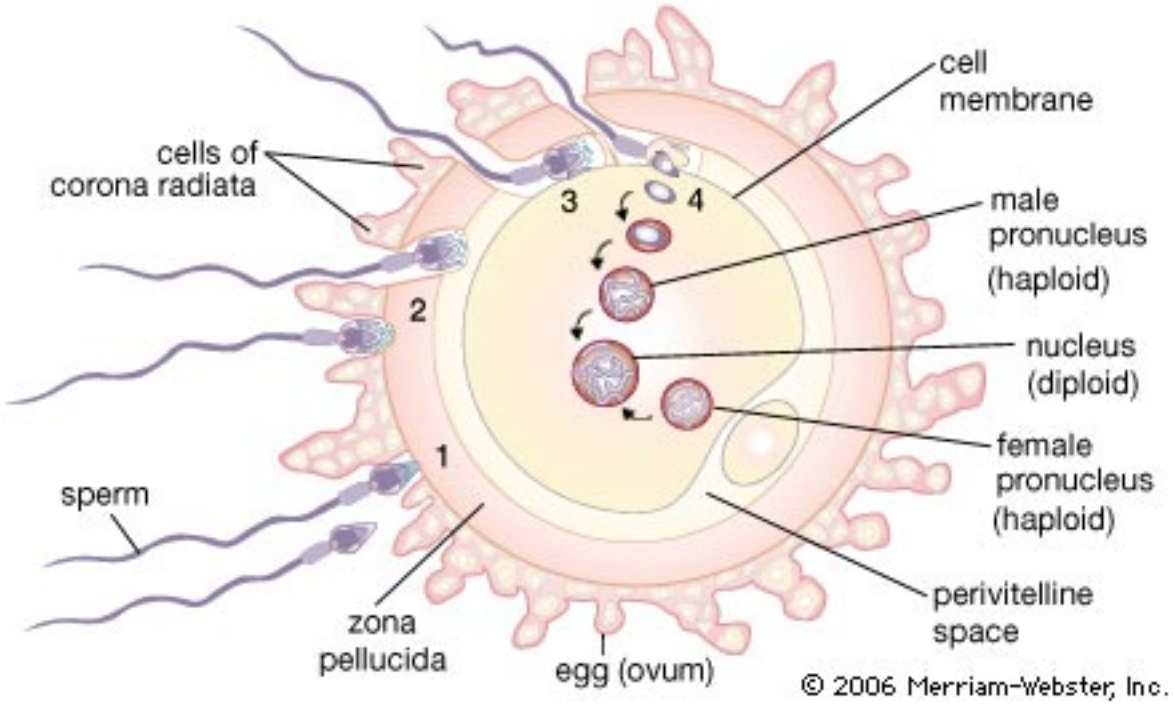
Fertilization	The haploid male and female gametes fuse to form a diploid zygote.	
Cleavage	The zygote rapidly divides into many cells, with no overall increase in size. In many animals, these divisions affect future development because different cells receive different portions of the egg cytoplasm and, hence, different cytoplasmic determinants. Cleavage ends with formation of a blastula (called a blastocyst in mammals), which varies in structure among animal embryos.	  Blastocyst
Gastrulation	The cells of the embryo move, forming the three primary germ layers: ectoderm, mesoderm, and endoderm.	
Organogenesis	Cells from the three primary germ layers interact in various ways to produce the organs of the body. In chordates, organogenesis begins with formation of the notochord and the hollow dorsal nerve cord in the process of neurulation.	



Acrosome reaction

- Fertilization is the union of egg and sperm to produce a zygote
- Fertilization occurs in the fallopian tubes
- One sperm will penetrate the egg
- The sperm initially bind to receptors on the outside of the egg
- Enzymes in the acrosome will degrade the zone pellucida




cell membrane
cells of corona radiata
male pronucleus (haploid)
nucleus (diploid)
female pronucleus (haploid)
perivitelline space
sperm
zona pellucida
egg (ovum)
1
2
3
4
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Acrosome reaction

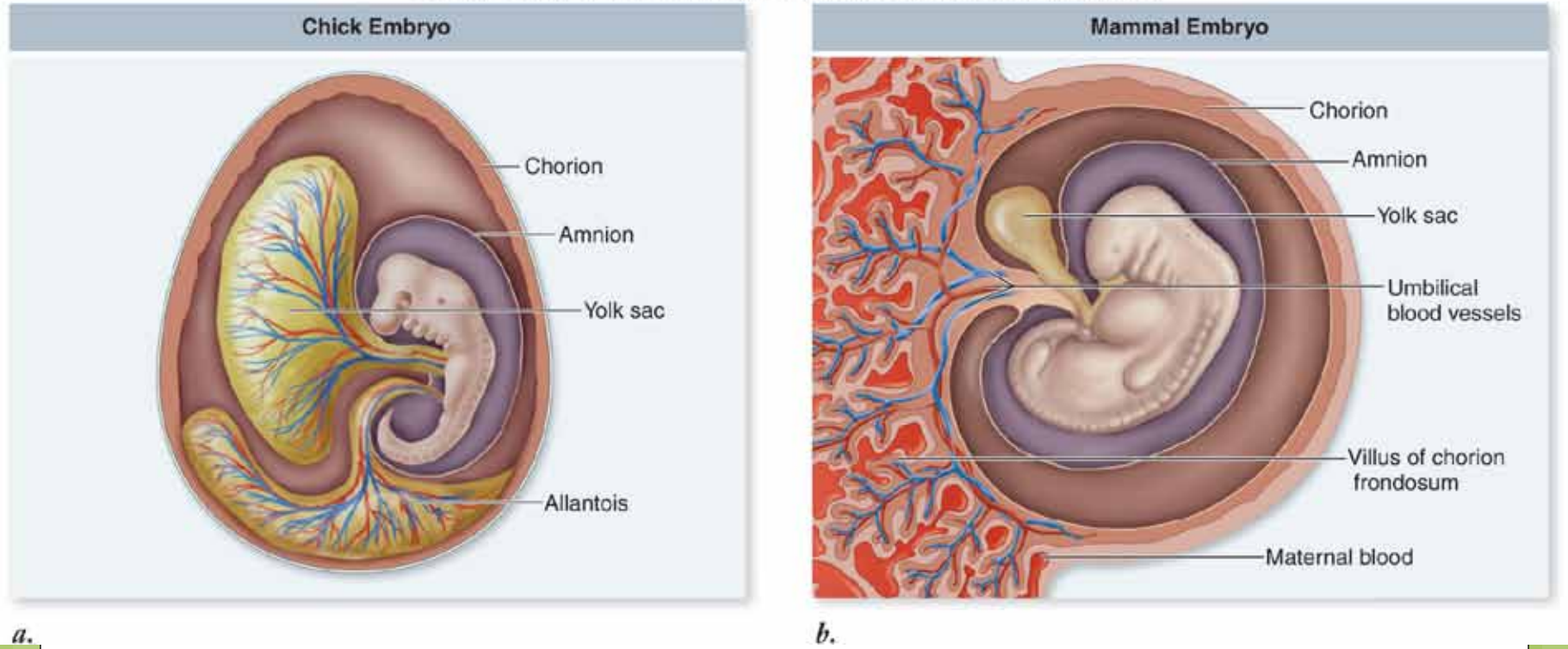
- Plasma membranes from the sperm and egg fuse
- Cortical granules release enzymes that harden the zona pellucida preventing any other sperm from entering
- The sperm nucleus enters the egg and combines with the egg nucleus

Early embryo development

- After the first mitotic division occurs there is a cleavage division in which no cell growth occurs
- A hollow ball of cells called a **morula** forms
- This travels to the uterus (~4 days)
- Unequal divisions occur and form a fluid filled ball of cells called the **blastocyst**

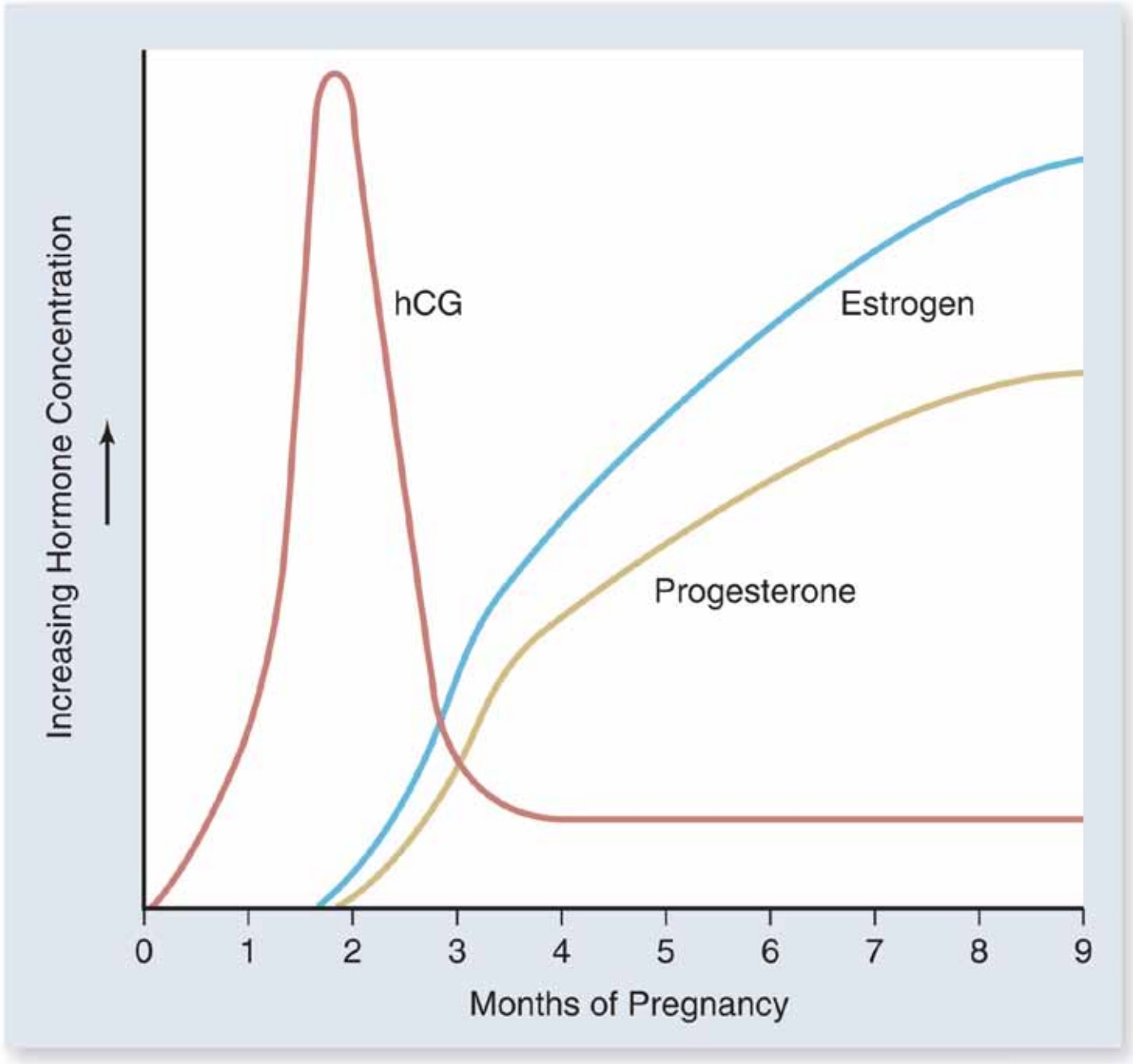
Early embryo development

- The inner cell mass will form into the embryo
- The fluid filled space will form the amnion
- Around 7 days after fertilization, the blastocyst will implant into the uterine wall
- The developing fetus is surrounded by an **amniotic sac** filled with **amniotic fluid**
- This offers protection and support for the fetus



Role of HCG in early pregnancy

- HCG = Human Chorionic Gonadotropin
- Hormone secreted by the blastocyst
- Stimulates the corpus luteum to continue to produce progesterone and estrogen which maintains the uterine lining (endometrium) and inhibits FSH and LH
- HCG levels will increase during the first 8-10 weeks of pregnancy
- HCG is excreted into the urine = pregnancy test

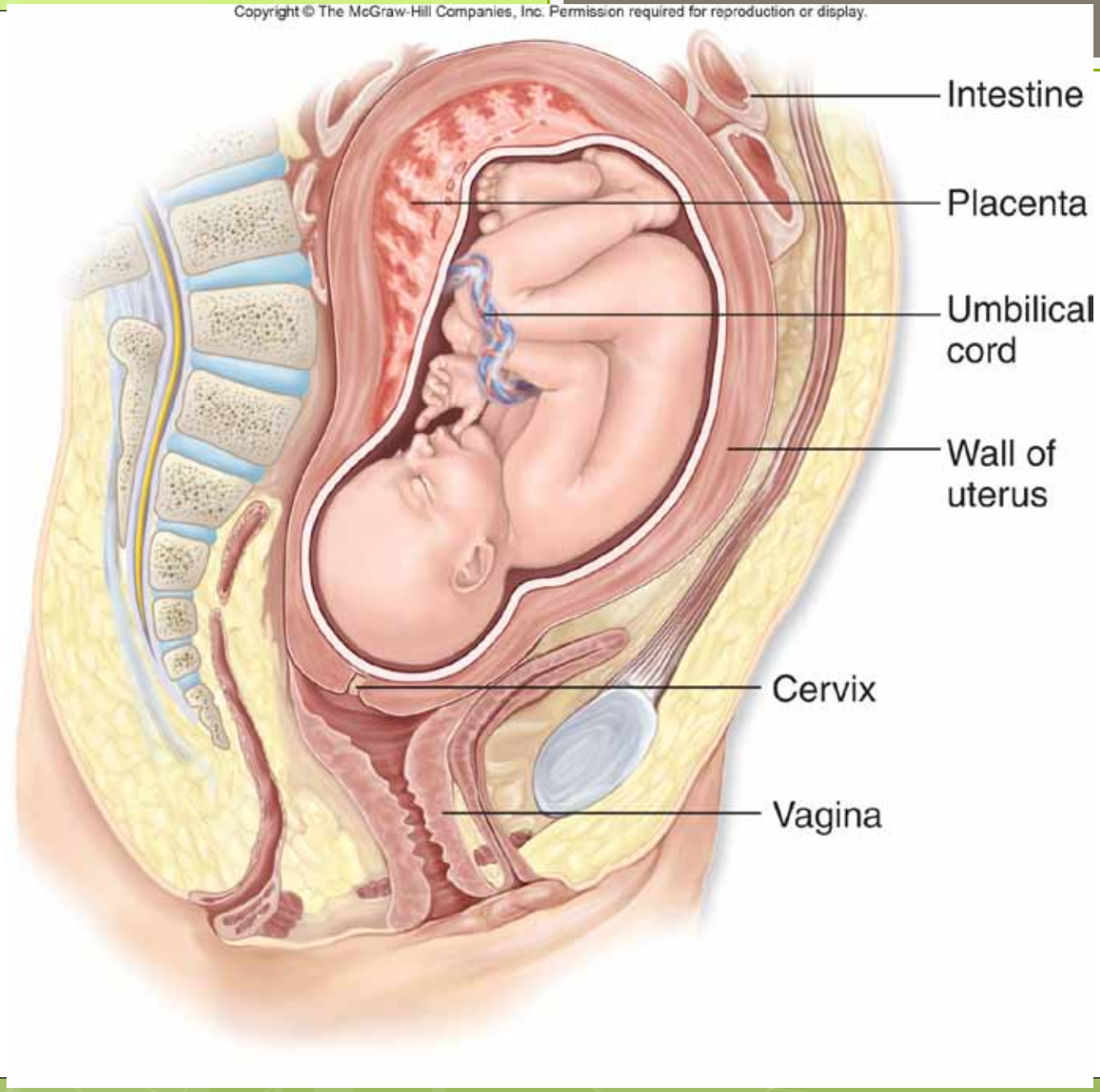


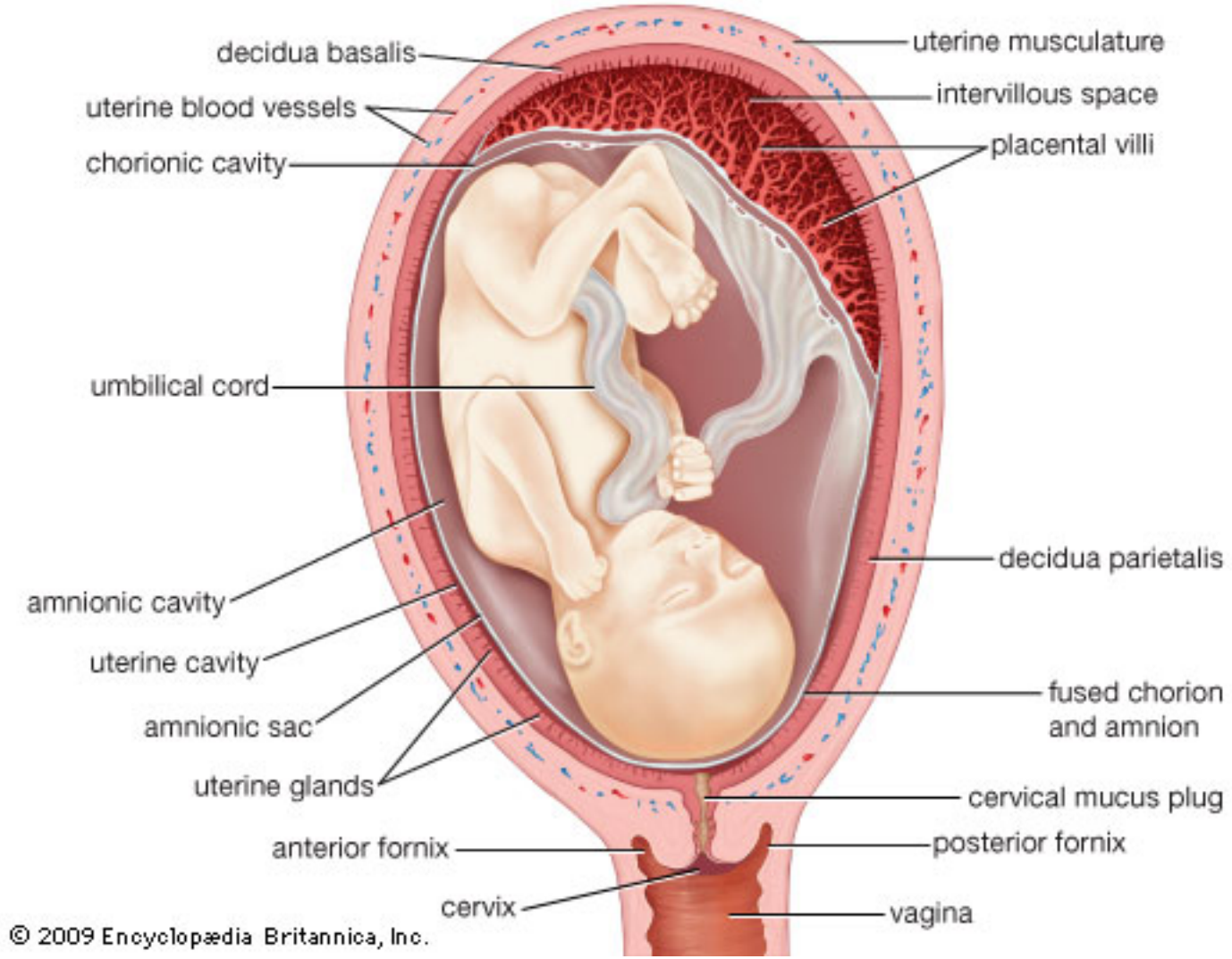
Structure & role of placenta

- The placenta connects the mother to the fetus through the umbilical cord
- The placenta runs through a cavity of maternal blood
- Two umbilical arteries carry deoxygenated blood to the placenta
- One umbilical vein carries oxygenated blood to the fetus

Structure & role of placenta

- Site for exchange of nutrients and waste between the mother and fetus
- Will take over the role of producing progesterone and estrogen throughout pregnancy
- Levels will rise throughout gestation
- A drop in the production of progesterone is the signal for labour to begin




decidua basalis
uterine blood vessels
chorionic cavity
umbilical cord
amnionic cavity
uterine cavity
amnionic sac
uterine glands
anterior fornix
cervix
uterine musculature
intervillous space
placental villi
decidua parietalis
fused chorion and amnion
cervical mucus plug
posterior fornix
vagina
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Birth process

- Progesterone levels drop
- Prostaglandins are secreted from the fetus (placenta) to initiate contractions and stimulate the pituitary gland
- Oxytocin is produced when the baby's head pushes against the cervix
- Oxytocin blocks progesterone and causes uterine contractions

Birth process

- Contractions of the uterus push the fetus against the cervix which in turn causes more oxytocin production = positive feedback
- Strength of uterine contractions increase as more oxytocin is produced
- Contractions continue until the placenta is delivered after birth


4 months
5 months
6 months
7 months
8 months
9 months
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References

1. Damon, A., McGonegal, R., Tosto, P., & Ward, W. (2007). *Higher Level Biology*. England: Pearson Education, Inc.
2. Raven, P.H., Johnson, G.B., Losos, J.B., Mason, K.A., & Singer, S.R. (2008). *Biology*. (8th ed.). New York: McGraw-Hill Companies, Inc.
3. Blake, L., Craven, M., Dobell, D., Flood, N., Jasper, G., Little, C., Mason, A., Price, G., Banerd, K., Bocknek, J., Letcher, M., & Little, D. (2003). *Biology 12*. Canada: McGraw-Hill Companies, Inc.
4. Encyclopedia Britannica Online. <www.britannica.com>