Chapter 27

Reproduction and Embryonic Development

PowerPoint Lectures for

Biology: Concepts & Connections, Sixth Edition

Campbell, Reece, Taylor, Simon, and Dickey

Lecture by Edward J. Zalisko

Introduction: *Baby Bonanza*

- Fertility drugs
  - Increase the number of eggs that are ovulated
  - 10% of women taking fertility drugs become pregnant with more than one embryo

Introduction: *Baby Bonanza*

- Multiple births carry increased risk
  - Premature birth
  - Lower birth weight
  - Increased risk of mortality
    - Five times higher in twins
    - Twelve times higher in supertwins

ASEXUAL AND SEXUAL REPRODUCTION

27.1 Asexual reproduction results in the generation of genetically identical offspring

- **Asexual reproduction**
  - One parent produces genetically identical offspring
  - Very rapid reproduction
  - Can proceed via
    - **Budding**
    - **Fission**
    - **Fragmentation/regeneration**

PLAY Video: Hydra Budding

27.2 Sexual reproduction results in the generation of genetically unique offspring

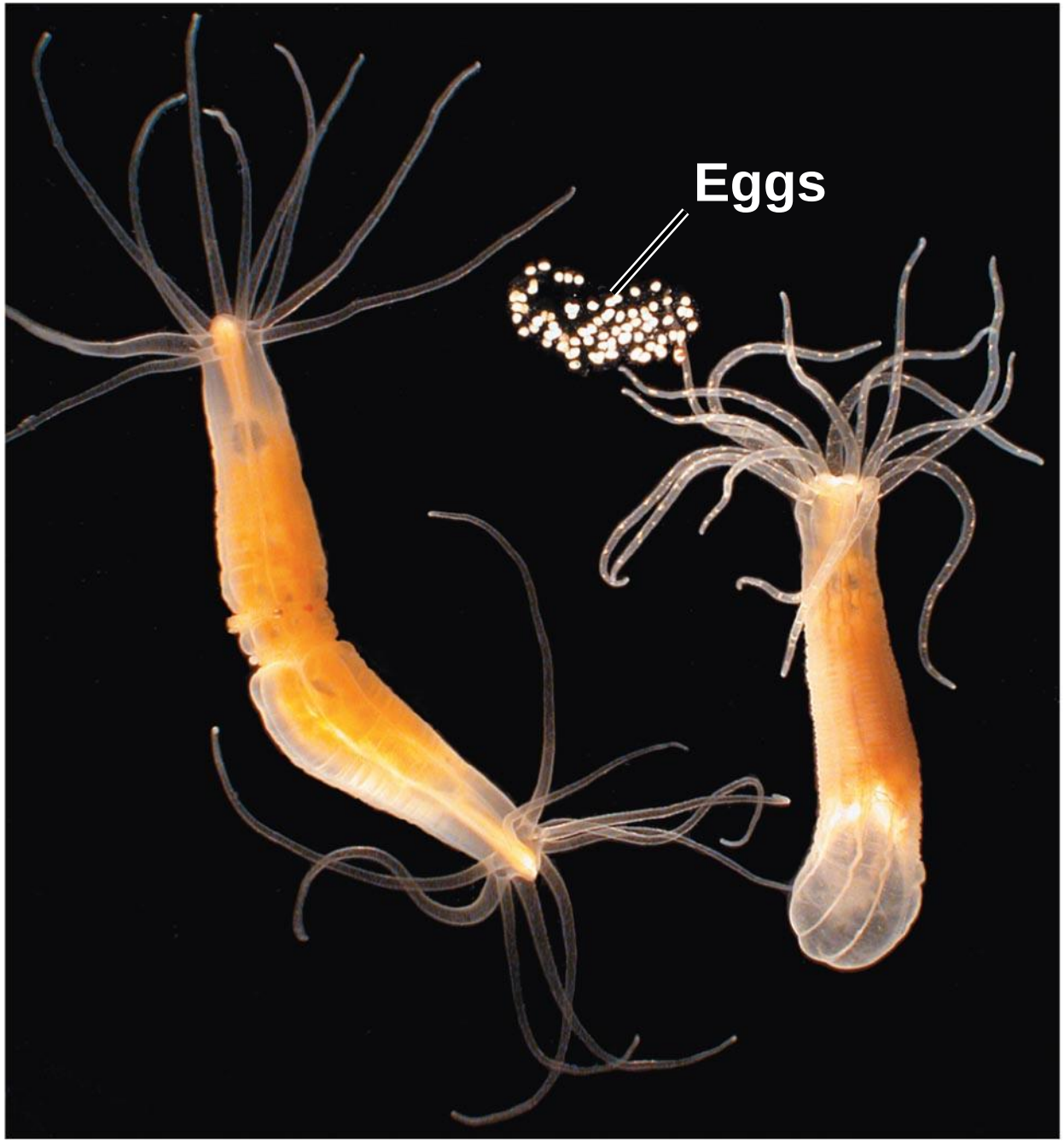
- **Sexual reproduction** involves the fusion of **gametes** from two parents
  - Resulting in genetic variation among offspring
  - Increased reproductive success in changing environments

27.2 Sexual reproduction results in the generation of genetically unique offspring

- Some organisms can reproduce
  - Asexually or
  - Sexually

PLAY

Video: Hydra Releasing Sperm



27.2 Sexual reproduction results in the generation of genetically unique offspring

- Some animals exhibit **hermaphroditism**
  - One individual with male and female reproductive systems
  - Easier to find a mate for animals less mobile or solitary

27.2 Sexual reproduction results in the generation of genetically unique offspring

- Sperm may be transferred to the female by
  - **External fertilization**
    - Many fish and amphibian species
    - Eggs and sperm are discharged near each other
  - **Internal fertilization**
    - Some fish and amphibian species
    - Nearly all terrestrial animals
    - Sperm is deposited in or near the female reproductive tract

HUMAN REPRODUCTION

27.3 Reproductive anatomy of the human female

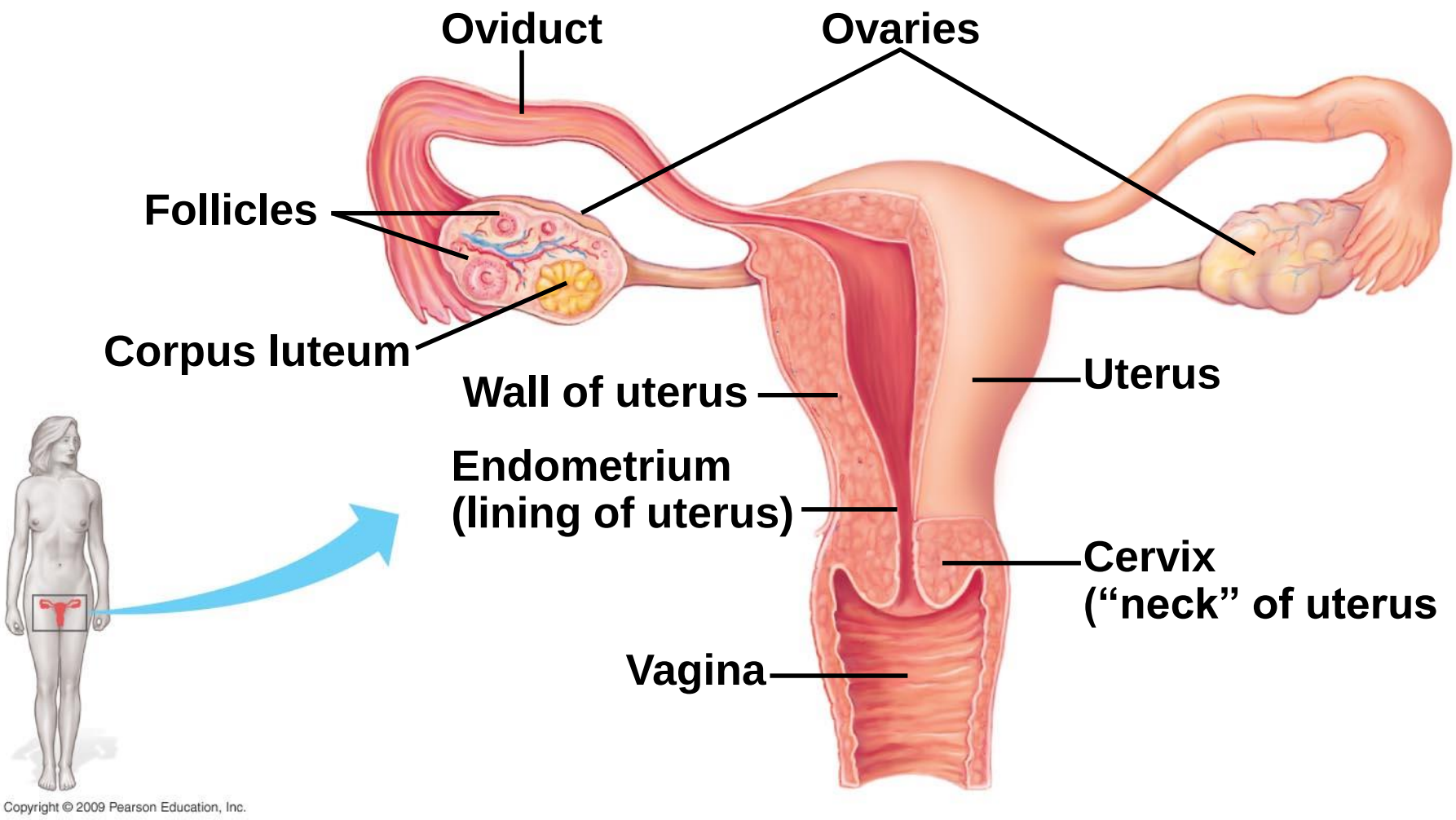
- Both sexes in humans have
  - A set of gonads where gametes are produced
  - Ducts for gamete transport
  - Structures for copulation

27.3 Reproductive anatomy of the human female

- **Ovaries** contain **follicles** that
  - Nurture eggs
  - Produce sex hormones

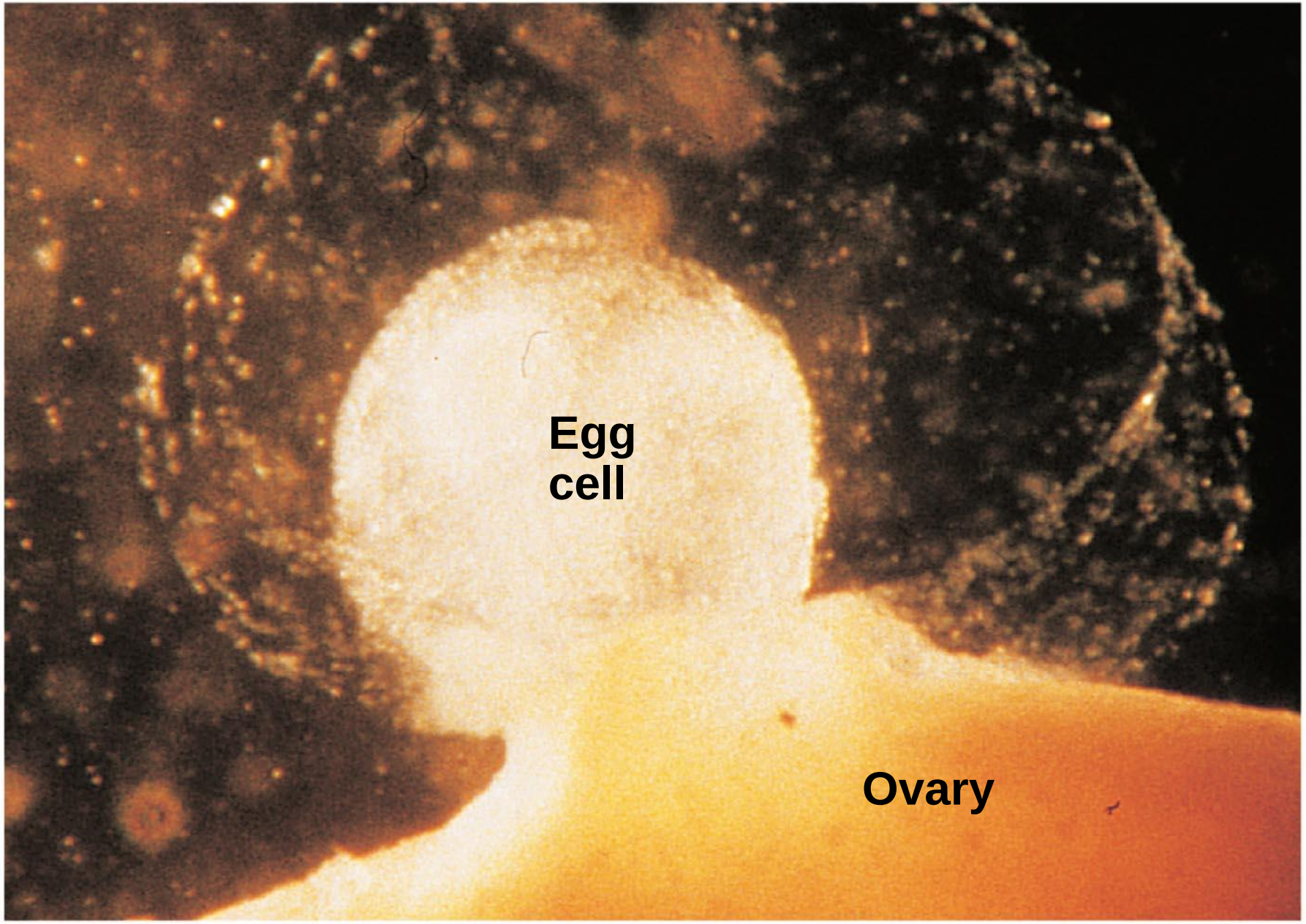
PLAY

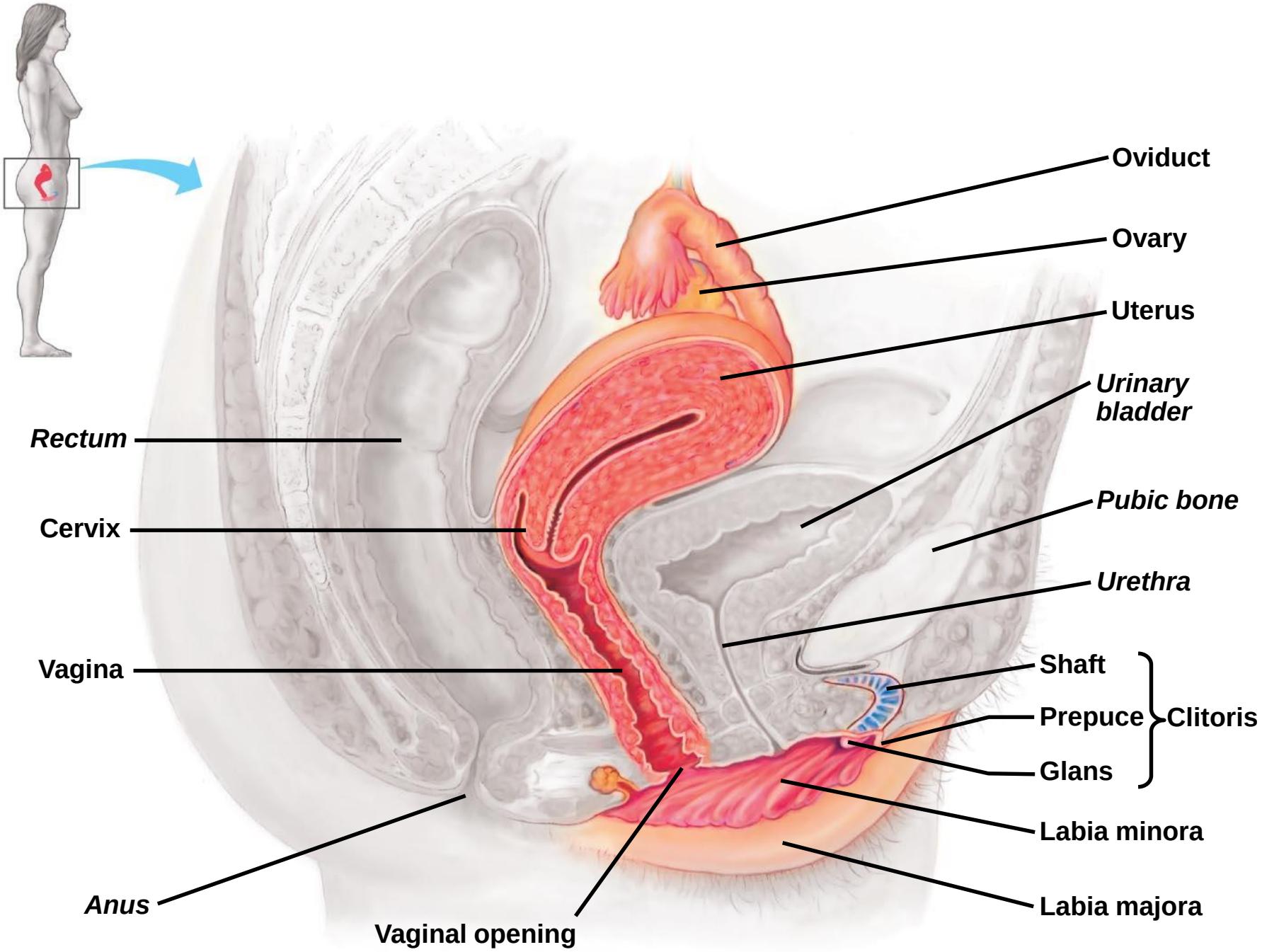
Animation: Female Reproductive Anatomy



27.3 Reproductive anatomy of the human female

- **Oviducts** convey eggs to the **uterus** where **embryos** develop
- The uterus opens into the **vagina** through the **cervix**
- The vagina
  - Receives the penis during sexual intercourse
  - Forms the birth canal



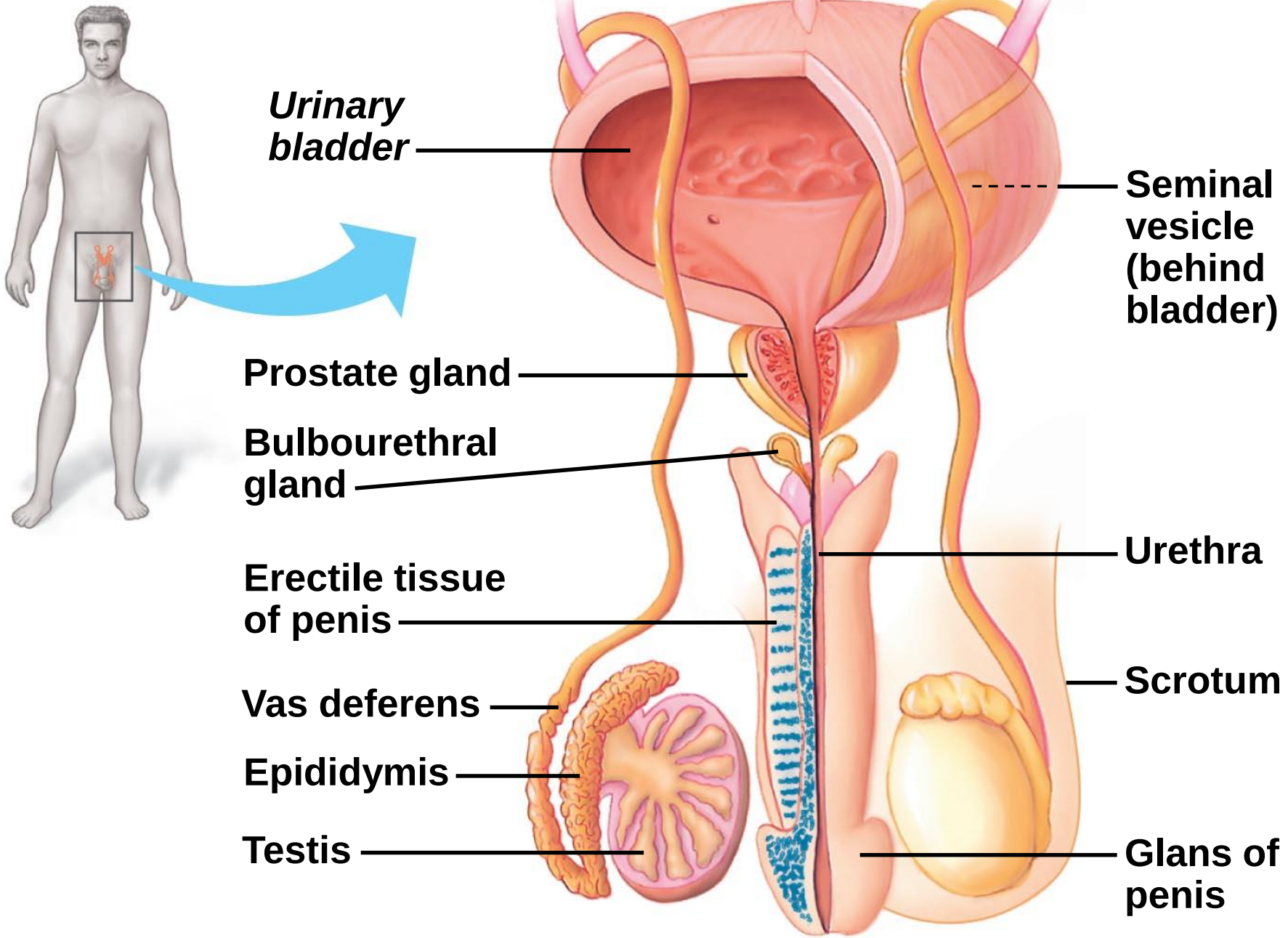


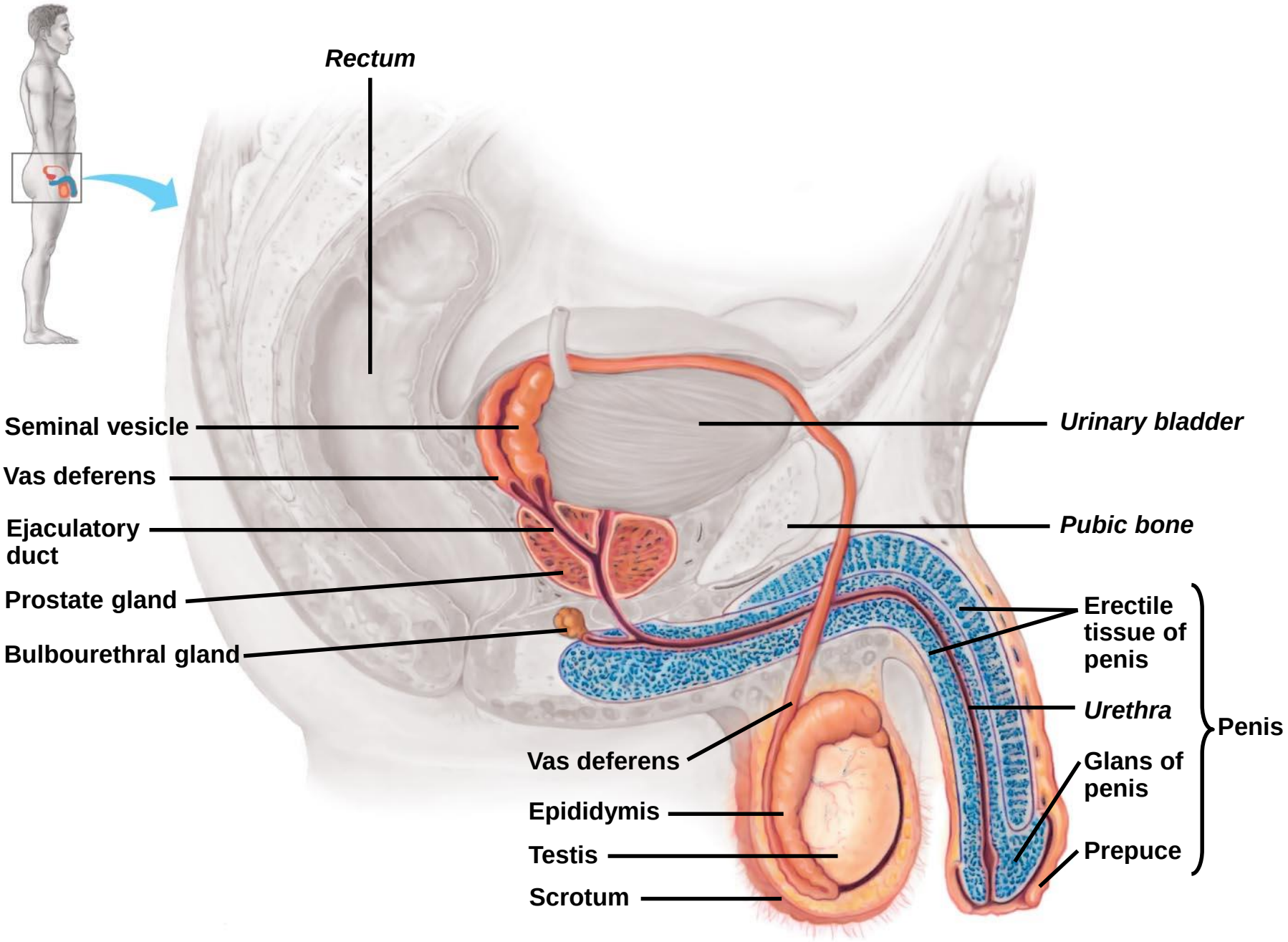
27.4 Reproductive anatomy of the human male

- **Testes** (singular *testis*) produce
  - Sperm
  - Male hormones
- **Epididymis** stores sperm as they develop further
- Several glands contribute to semen
  - **Seminal vesicles**
  - **Prostate**
  - **Bulbourethral**

PLAY

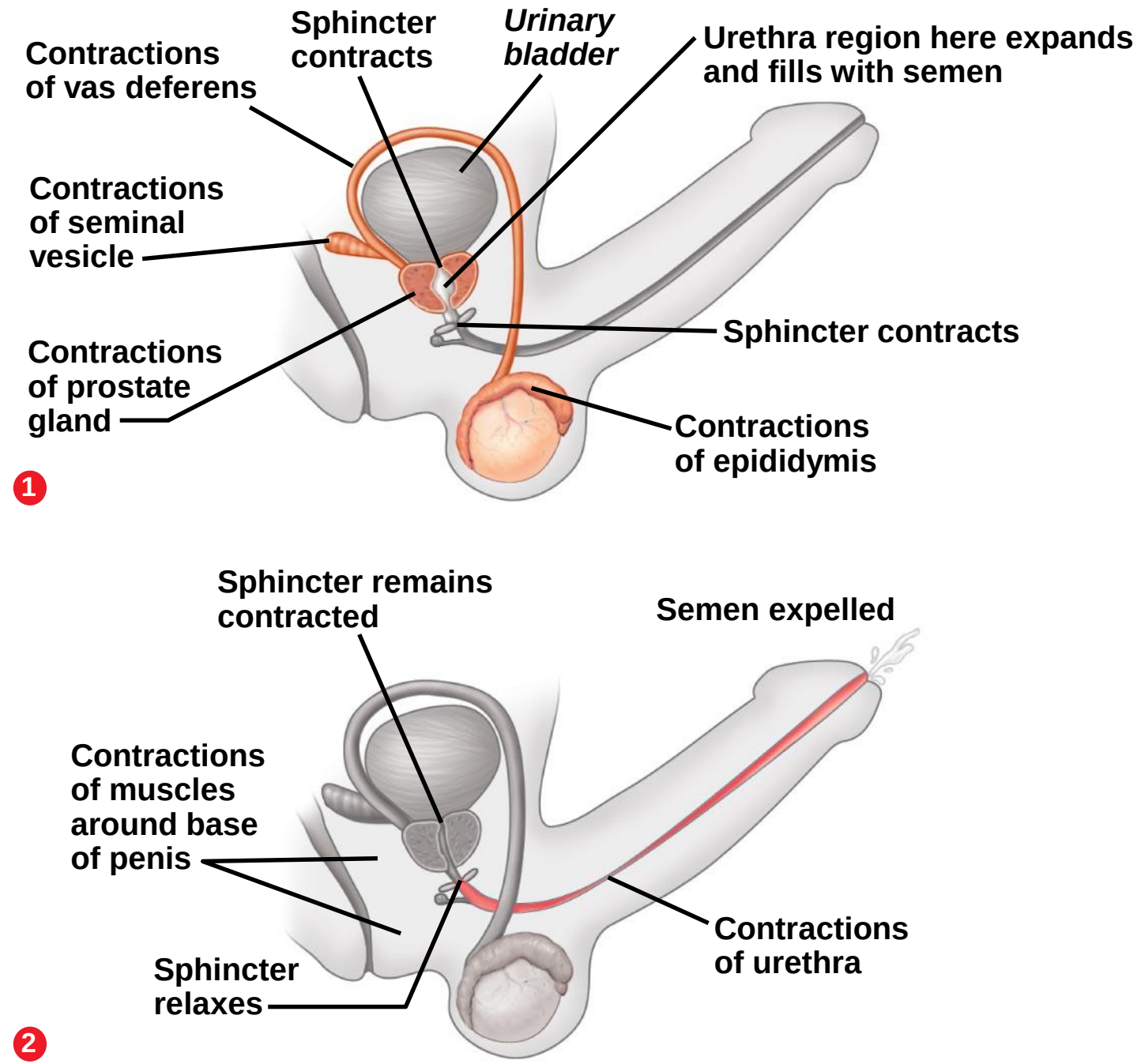
Animation: Male Reproductive Anatomy





27.4 Reproductive anatomy of the human male

- During **ejaculation**
  - Sperm is expelled from the epididymis
  - The seminal vesicles, prostate, and bulbourethral glands secrete into the urethra
  - **Semen** is formed and expelled from the penis

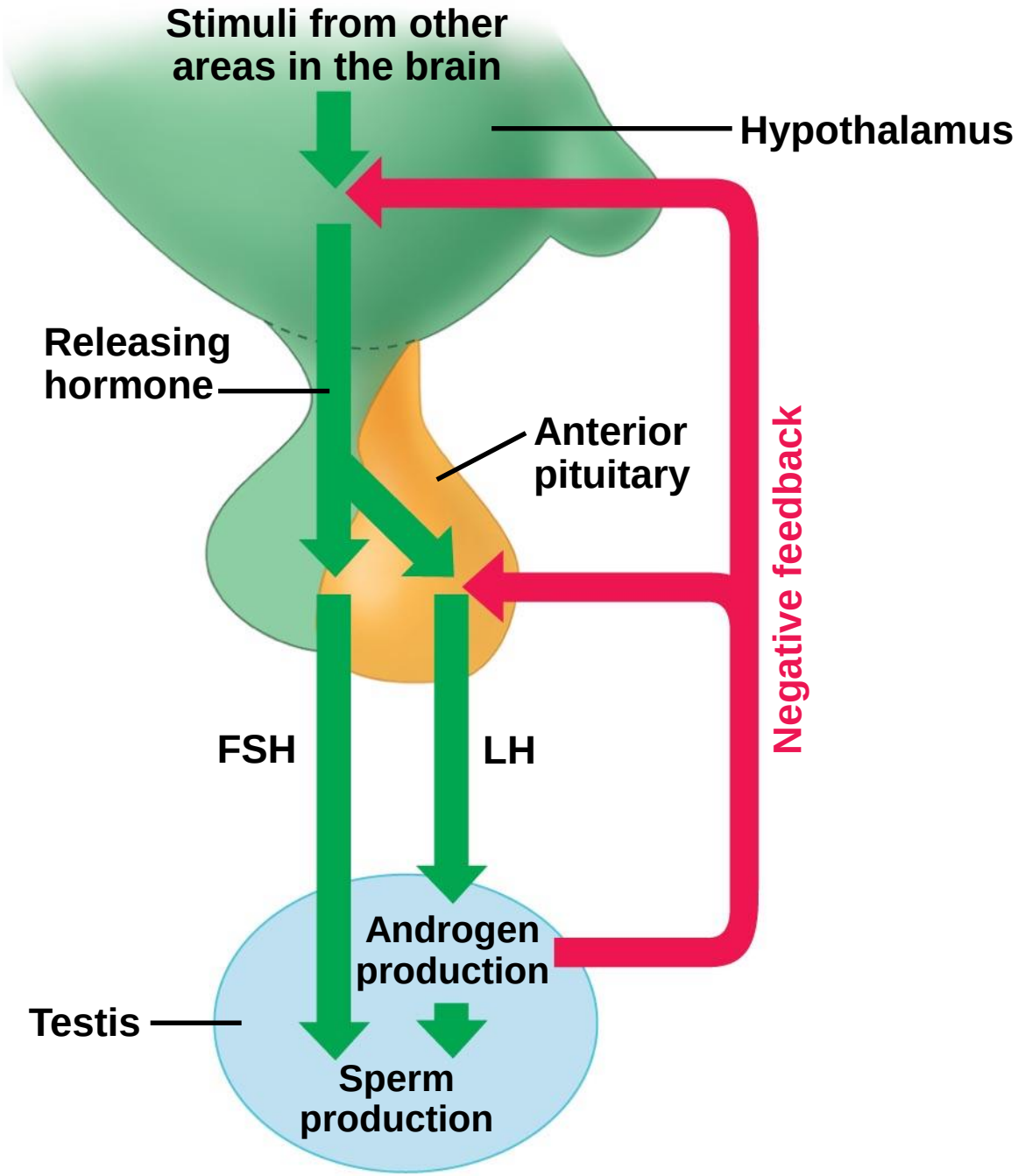


27.4 Reproductive anatomy of the human male

- Sperm production
  - Regulated by a negative feedback system of hormones
  - Involves the hypothalamus, pituitary, and testes

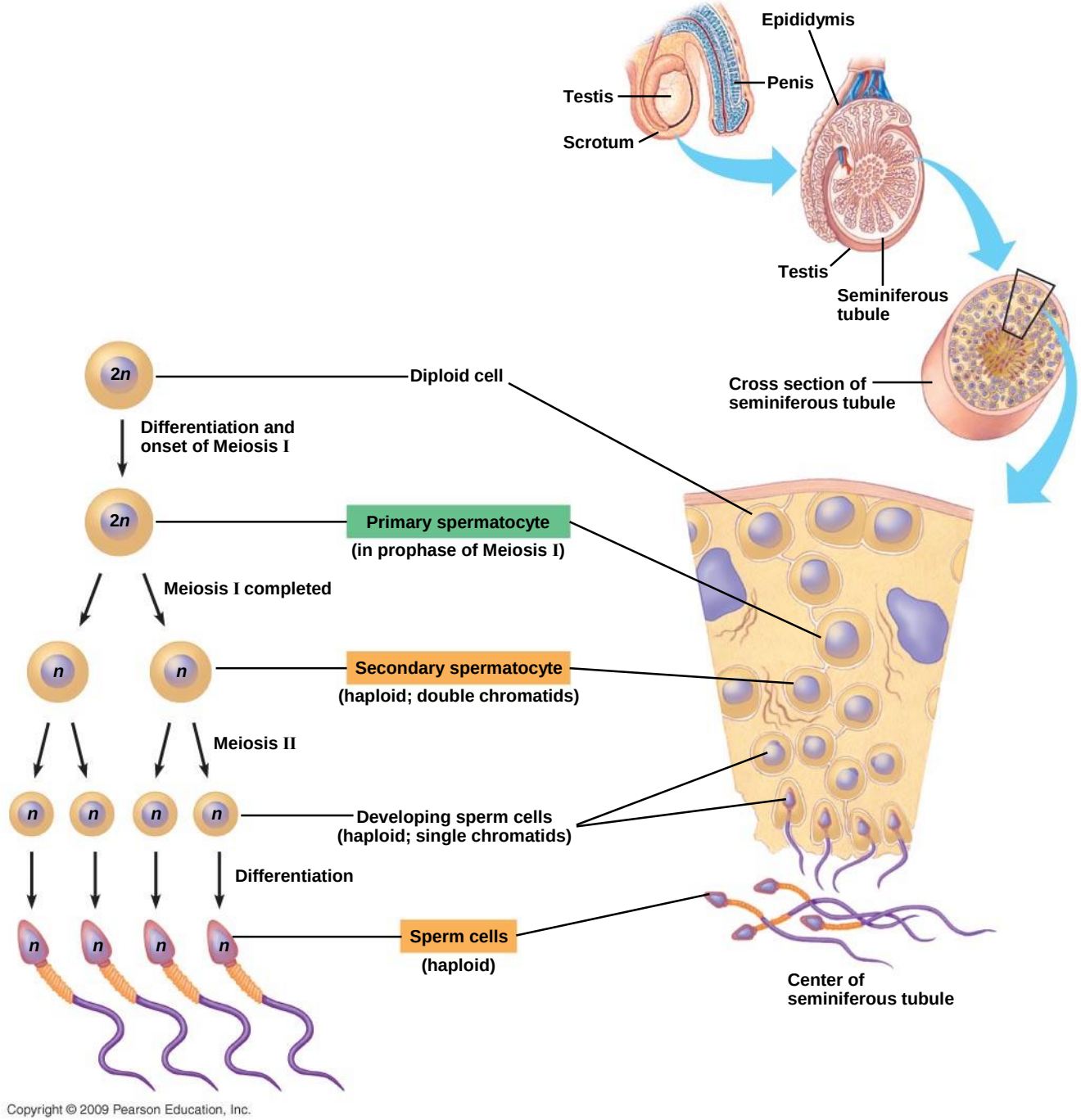
PLAY

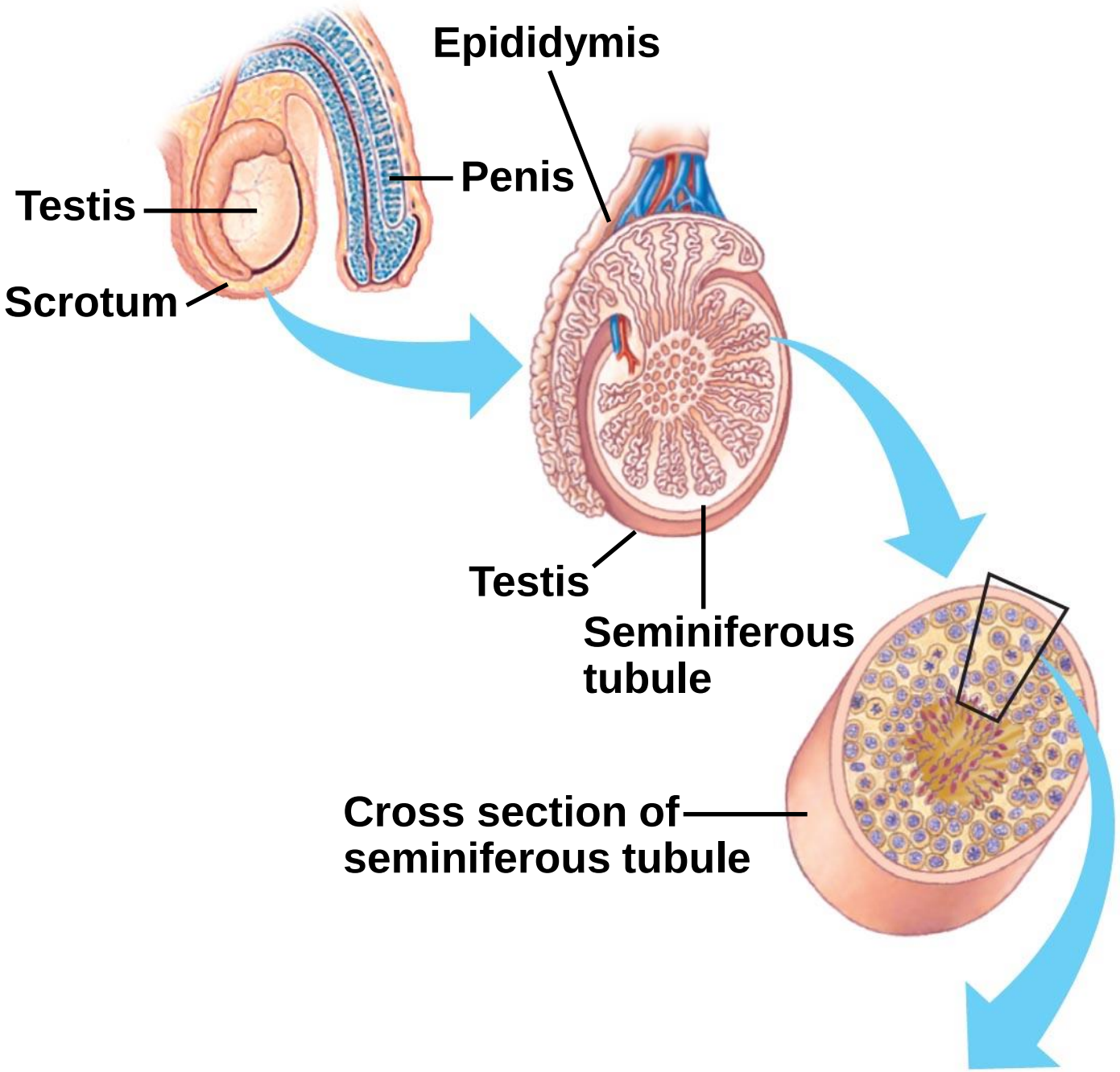
Animation: Male Hormones

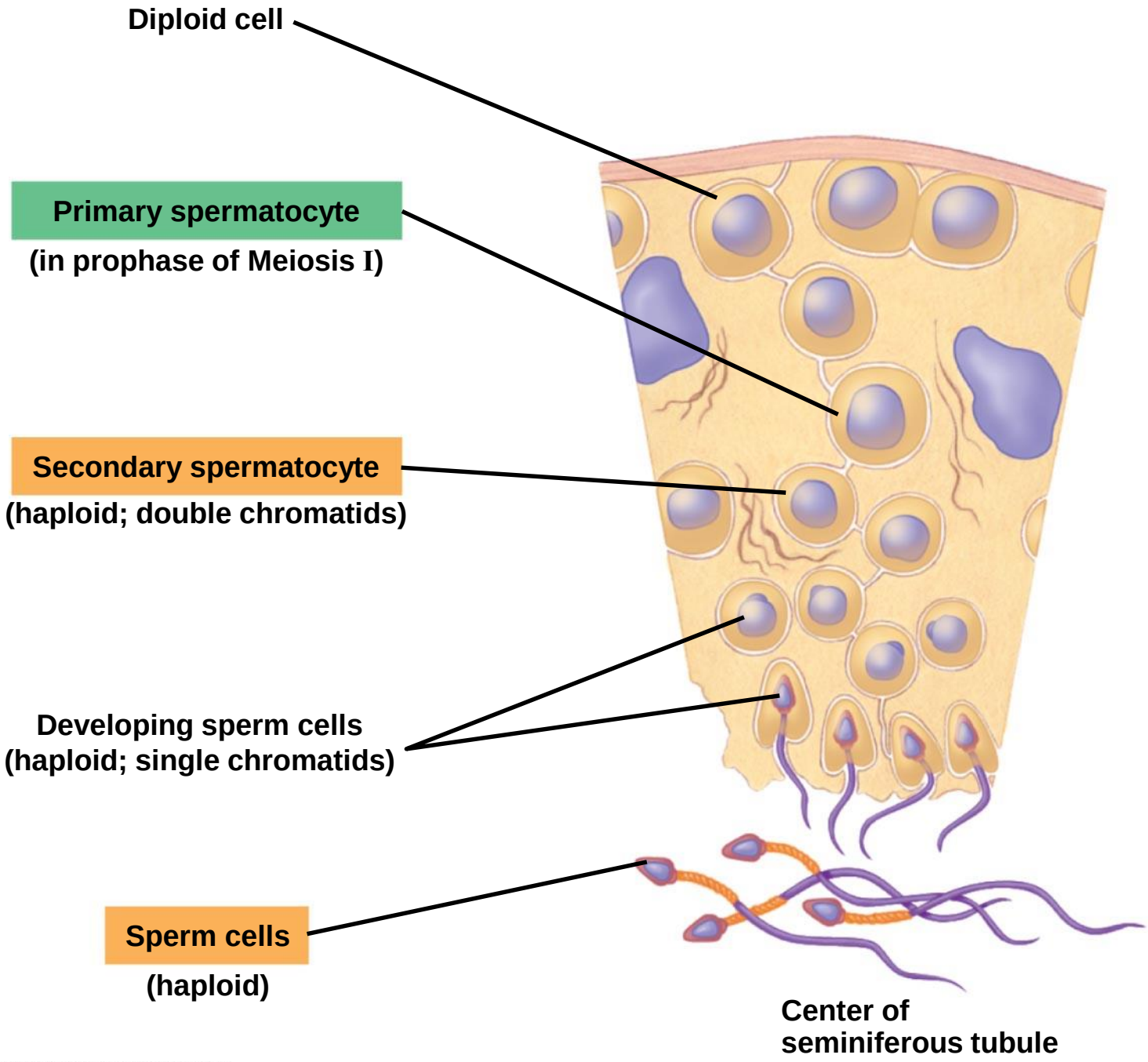


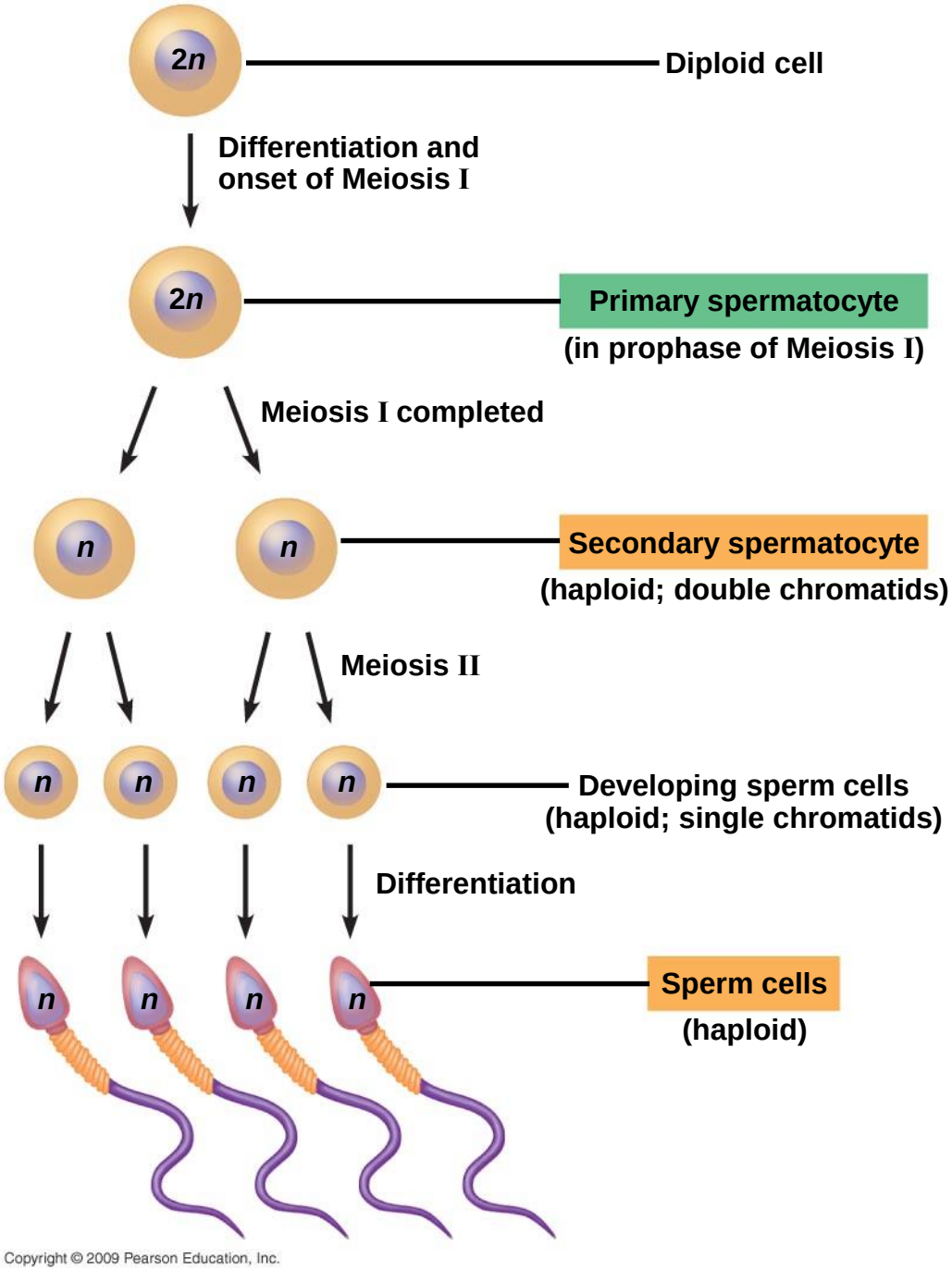
27.5 The formation of sperm and egg requires meiosis

- **Spermatogenesis**
  - Occurs in **seminiferous tubules**
  - **Primary spermatocytes**
    - Formed by mitosis
    - Divide by meiosis I to produce secondary spermatocytes
  - **Secondary spermatocytes** divide by meiosis II to produce spermatids
  - Round spermatids differentiate into elongate sperm
  - Mature sperm released into seminiferous tubule



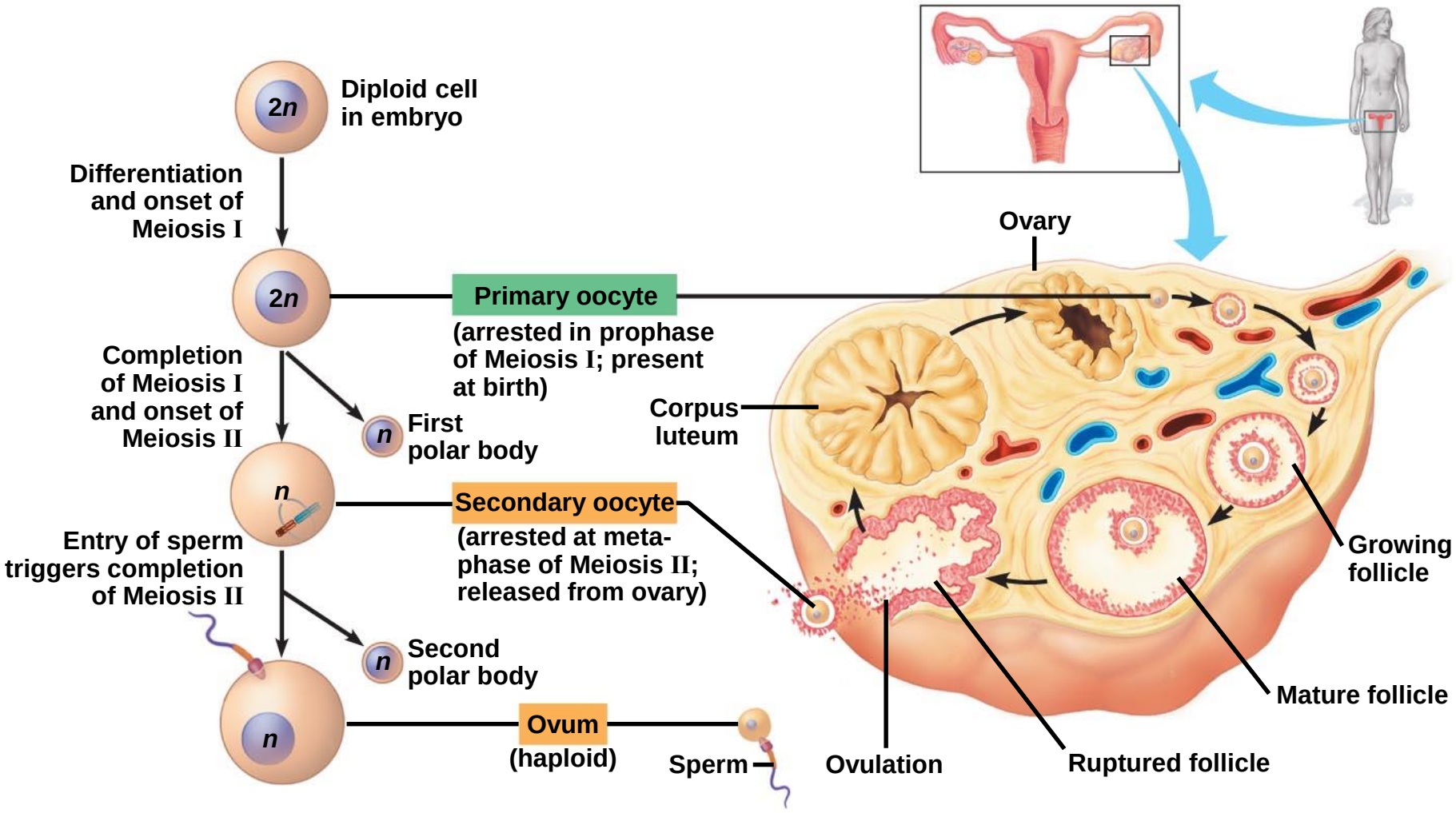


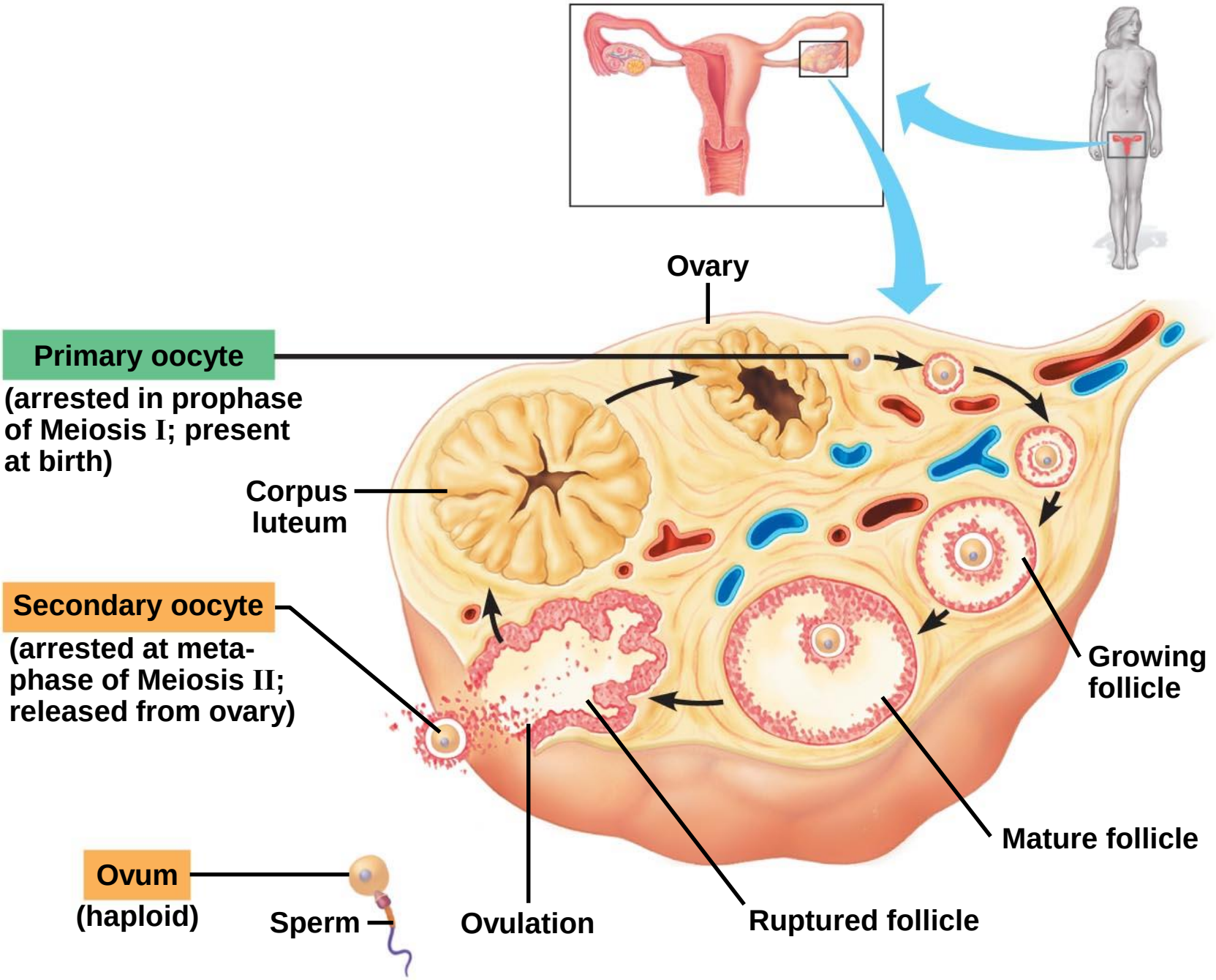


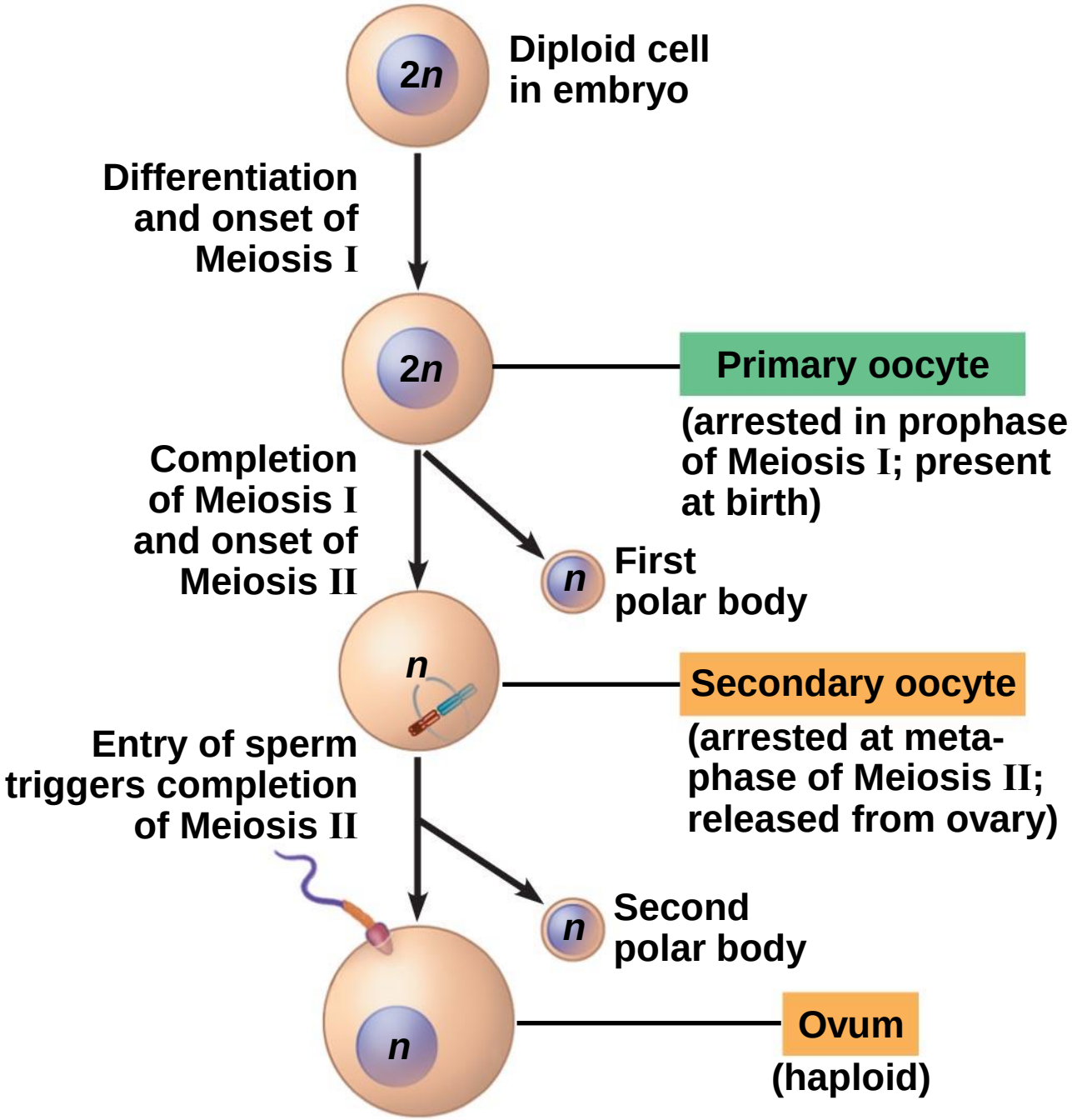


27.5 The formation of sperm and egg requires meiosis

- **Oogenesis**
  - Begins before birth—diploid cells start meiosis and stop
  - Each month about one **primary oocyte** resumes meiosis
  - A **secondary oocyte** arrested at metaphase of meiosis II is ovulated
  - Meiosis of the ovum is completed after fertilization







27.6 Hormones synchronize cyclic changes in the ovary and uterus

- **Ovarian** and **menstrual cycles**
  - Occur about every 28 days
  - Hypothalamus signals the anterior pituitary to secrete follicle-stimulating hormone (FSH) and leuteinizing hormone (LH), which trigger
    - Growth of a follicle
    - Ovulation

TABLE 27.6 HORMONES OF THE OVARIAN AND MENSTRUAL CYCLES

Hormone	Secreted by	Major Roles
Releasing hormone	Hypothalamus	Regulates secretion of LH and FSH by pituitary
Follicle-stimulating hormone (FSH)	Pituitary	Stimulates growth of ovarian follicle
Leuteinizing hormone (LH)	Pituitary	Stimulates growth of ovarian follicle and production of secondary oocyte; promotes ovulation; promotes development of corpus luteum and secretion of hormones
Estrogen	Ovarian follicle	Low levels inhibit pituitary; high levels stimulate hypothalamus; promotes endometrium
Estrogen and progesterone	Corpus luteum	Maintain endometrium; high levels inhibit hypothalamus and pituitary; sharp drops promote menstruation

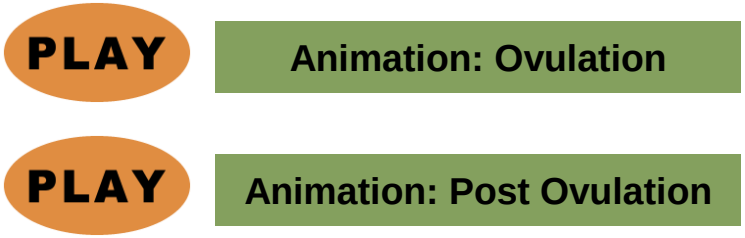
27.6 Hormones synchronize cyclic changes in the ovary and uterus

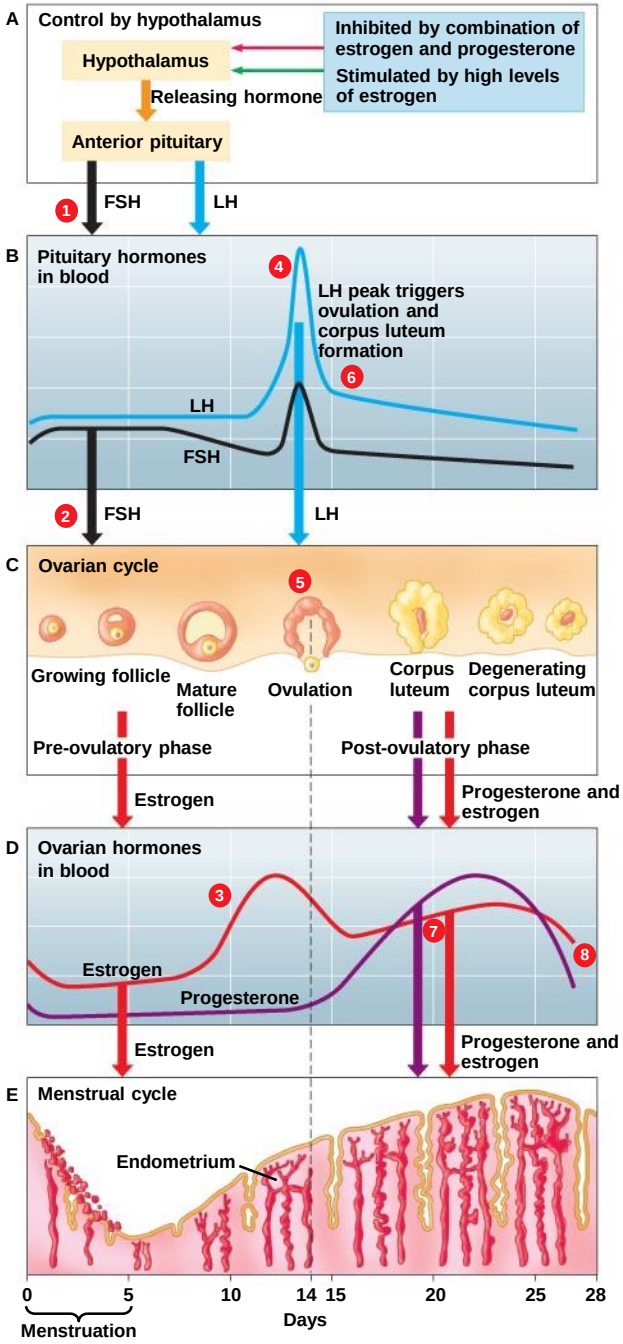
- After ovulation, ovarian follicle becomes corpus luteum
- Corpus luteum secretes estrogen and progesterone, which
  - Stimulate the endometrium to thicken
  - Prepare the uterus for implantation of the embryo
  - Inhibit hypothalamus, reducing FSH and LH secretion

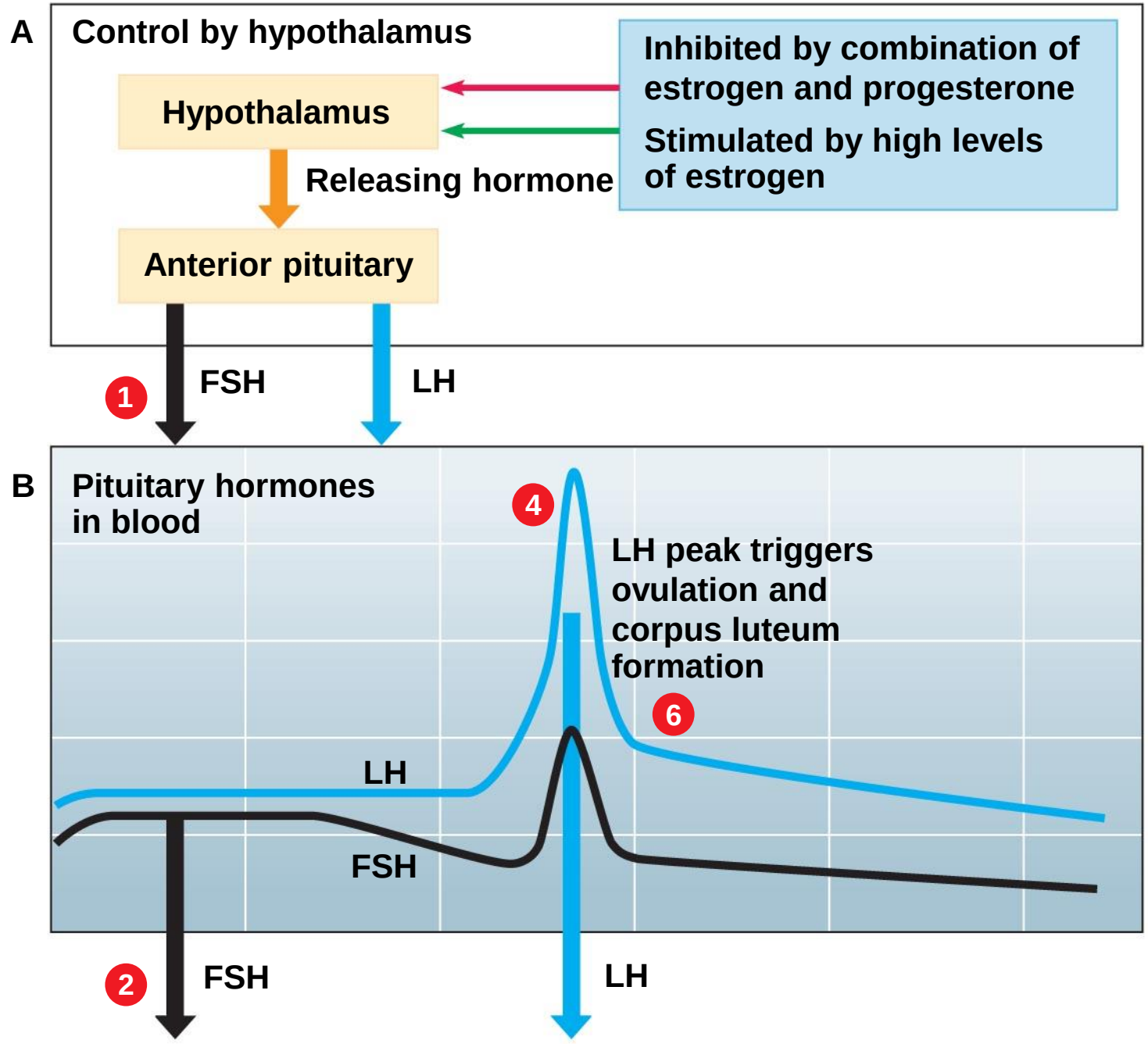
27.6 Hormones synchronize cyclic changes in the ovary and uterus

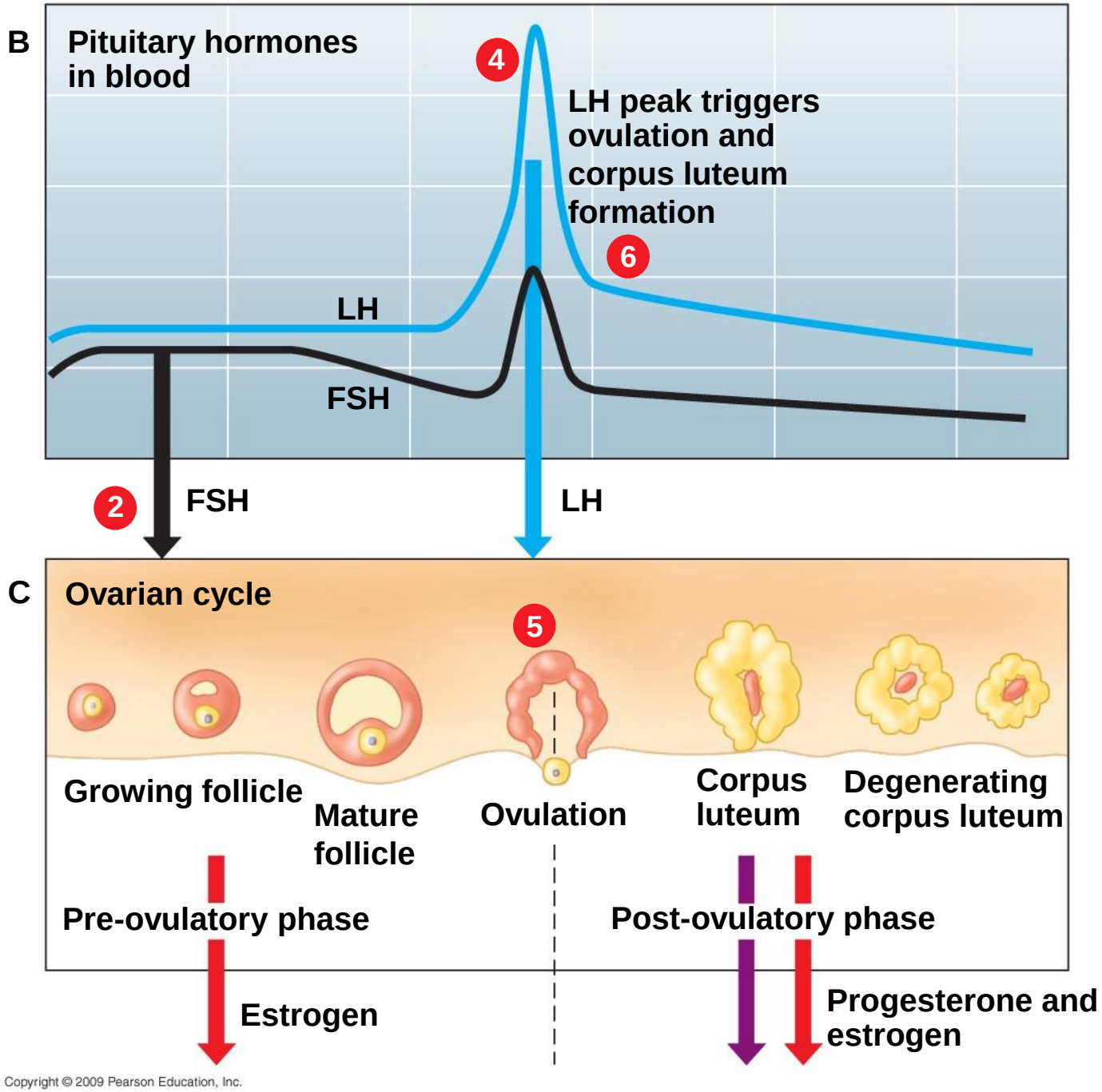
- If egg is fertilized
  - Embryo releases hormones that maintain the uterine lining
  - Menstruation does not occur
- If egg is not fertilized
  - Drop in LH shuts down corpus luteum and its hormones
  - Menstruation is triggered
  - Hypothalamus and pituitary stimulate development of a new follicle

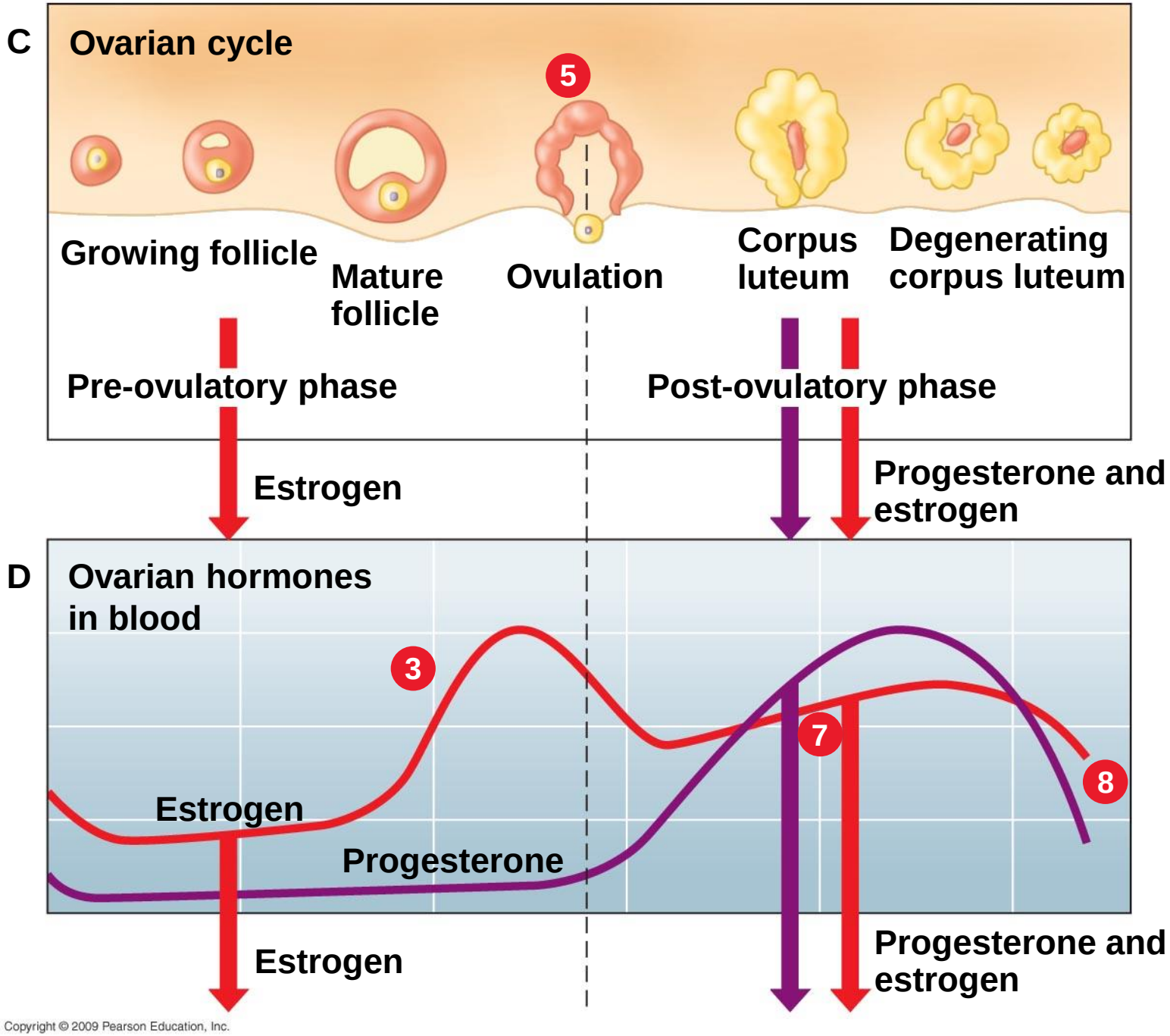
27.6 Hormones synchronize cyclic changes in the ovary and uterus

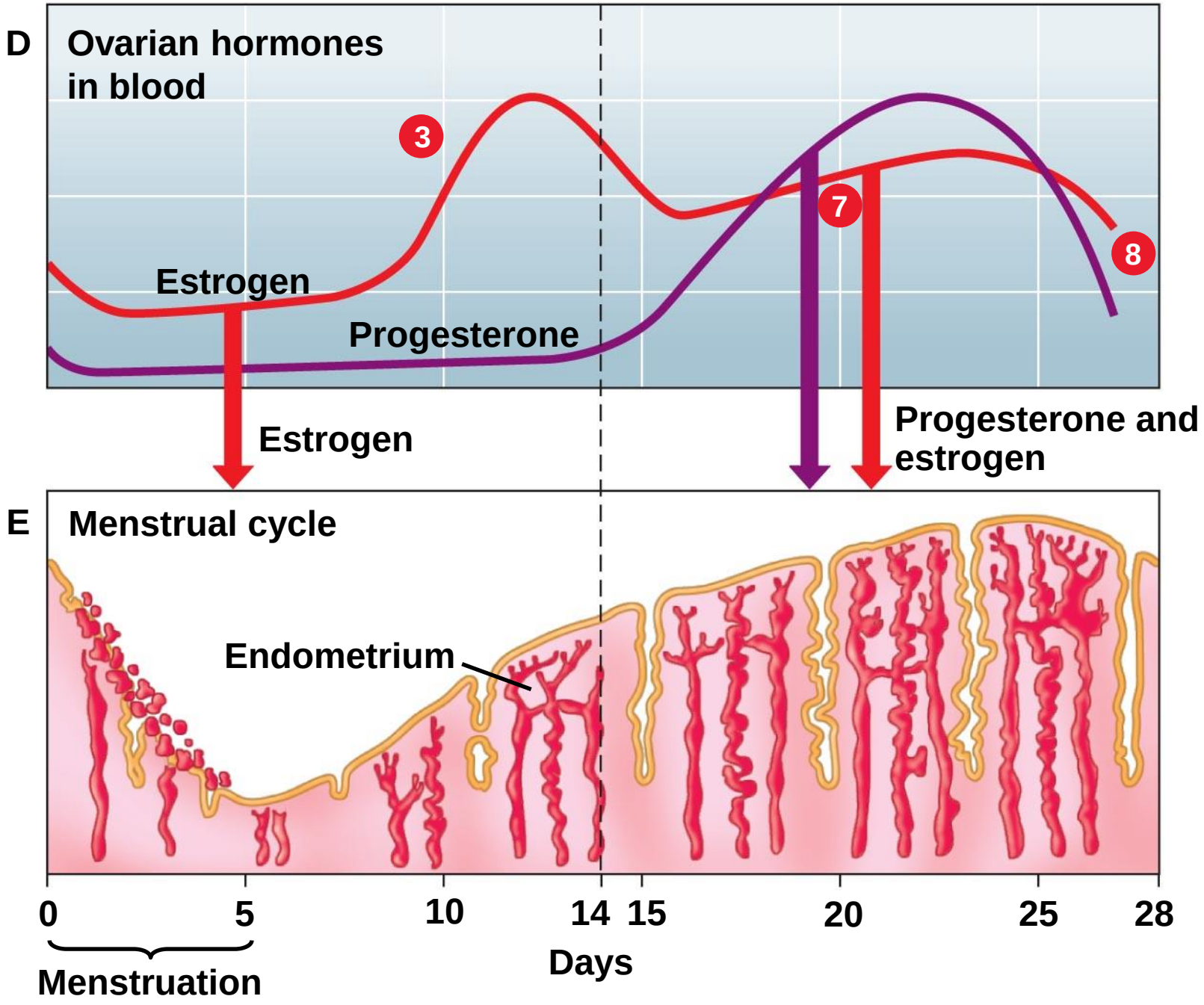












27.7 CONNECTION: Sexual activity can transmit disease

- Bacterial diseases can often be cured
  - **Chlamydia**
    - Most common bacterial STD
    - Often produces no symptoms
    - Can lead to pelvic inflammatory disease and infertility
- Viral diseases can only be controlled
- Latex condoms provide the best protection against disease transmission

TABLE 27.7 STDS COMMON IN THE UNITED STATES

Disease	Microbial Agent	Major Symptom and Effects	Treatment
Bacterial			
Chlamydia	*Chlamydia trachomatis*	Genital discharge, itching, and/or painful urination; often no symptoms in women; pelvic inflammatory disease (PID)	Antibiotics
Gonorrhea	*Neisseria gonorrhoeae*	Genital discharge; painful urination; sometimes no symptoms in women; PID	Antibiotics
Syphilis	*Treponema pallidum*	Ulcer (chancre) on genitalia in early stages; spreads throughout body and can be fatal if not treated	Antibiotics can cure in early stages
Viral			
Genital herpes	Herpes simplex virus type 2, occasionally type 1	Recurring symptoms: small blisters on genitalia, painful urination, skin inflammation; linked to cervical cancer, miscarriage, birth defects	Valacyclovir can prevent recurrences
Genital warts	Papilloma-viruses	Painless growths on genitalia; some of the viruses linked to cancer	Removal by freezing
AIDS and HIV infection	HIV	See Module 24.13	Combination of drugs
Protozoan			
Trichomoniasis	*Trichomonas vaginalis*	Vaginal irritation, itching, and discharge; usually no symptoms in men	Antiprotozoal drugs
Fungal			
Candidiasis (yeast infections)	*Candida albicans*	Similar to symptoms of trichomoniasis; frequently acquired nonsexually	Antifungal drugs

TABLE 27.7 STDS COMMON IN THE UNITED STATES

Disease	Microbial Agent	Major Symptom and Effects	Treatment
Bacterial			
Chlamydia	*Chlamydia trachomatis*	Genital discharge, itching, and/or painful urination; often no symptoms in women; pelvic inflammatory disease (PID)	Antibiotics
Gonorrhea	*Neisseria gonorrhoeae*	Genital discharge; painful urination; sometimes no symptoms in women; PID	Antibiotics
Syphilis	*Treponema pallidum*	Ulcer (chancre) on genitalia in early stages; spreads throughout body and can be fatal if not treated	Antibiotics can cure in early stages

TABLE 27.7 STDS COMMON IN THE UNITED STATES

Disease	Microbial Agent	Major Symptom and Effects	Treatment
Viral			
Genital herpes	Herpes simplex virus type 2, occasionally type 1	Recurring symptoms: small blisters on genitalia, painful urination, skin inflammation; linked to cervical cancer, miscarriage, birth defects	Valacyclovir can prevent recurrences
Genital warts	Papilloma-viruses	Painless growths on genitalia; some of the viruses linked to cancer	Removal by freezing
AIDS and HIV infection	HIV	See Module 24.13	Combination of drugs
Protozoan			
Trichomoniasis	*Trichomonas vaginalis*	Vaginal irritation, itching, and discharge; usually no symptoms in men	Antiprotozoal drugs
Fungal			
Candidiasis (yeast infections)	*Candida albicans*	Similar to symptoms of trichomoniasis; frequently acquired nonsexually	Antifungal drugs

27.8 CONNECTION: Contraception can prevent unwanted pregnancy

- **Contraception** is the deliberate prevention of pregnancy
- Methods are effective to varying degrees

TABLE 27.8 CONTRACEPTIVE METHODS

Method	Pregnancies/ 100 Women/Year*	
	Used Perfectly	Typically
Birth control pill (combination)	0.1	5
Vasectomy	0.1	0.15
Tubal ligation	0.2	0.5
Rhythm method	1–9	20
Withdrawal	4	19
Condom (male)	3	14
Diaphragm and spermicide	6	20
Spermicide alone	6	26

*Without contraception, about 85 pregnancies would occur.

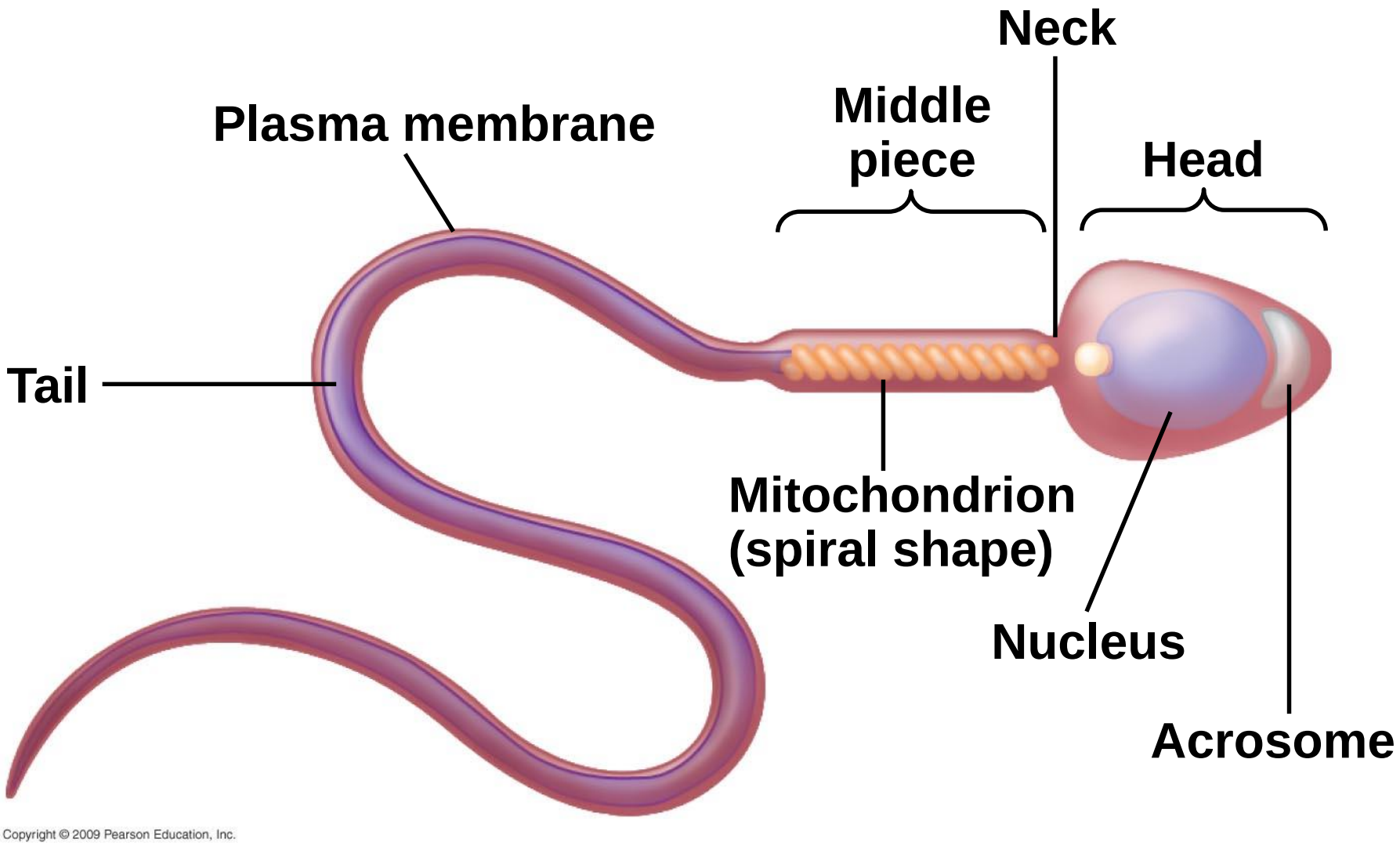
PRINCIPLES OF EMBRYONIC DEVELOPMENT

27.9 Fertilization results in a zygote and triggers embryonic development

- Embryonic development begins with fertilization
  - The union of sperm and egg
  - To form a diploid zygote

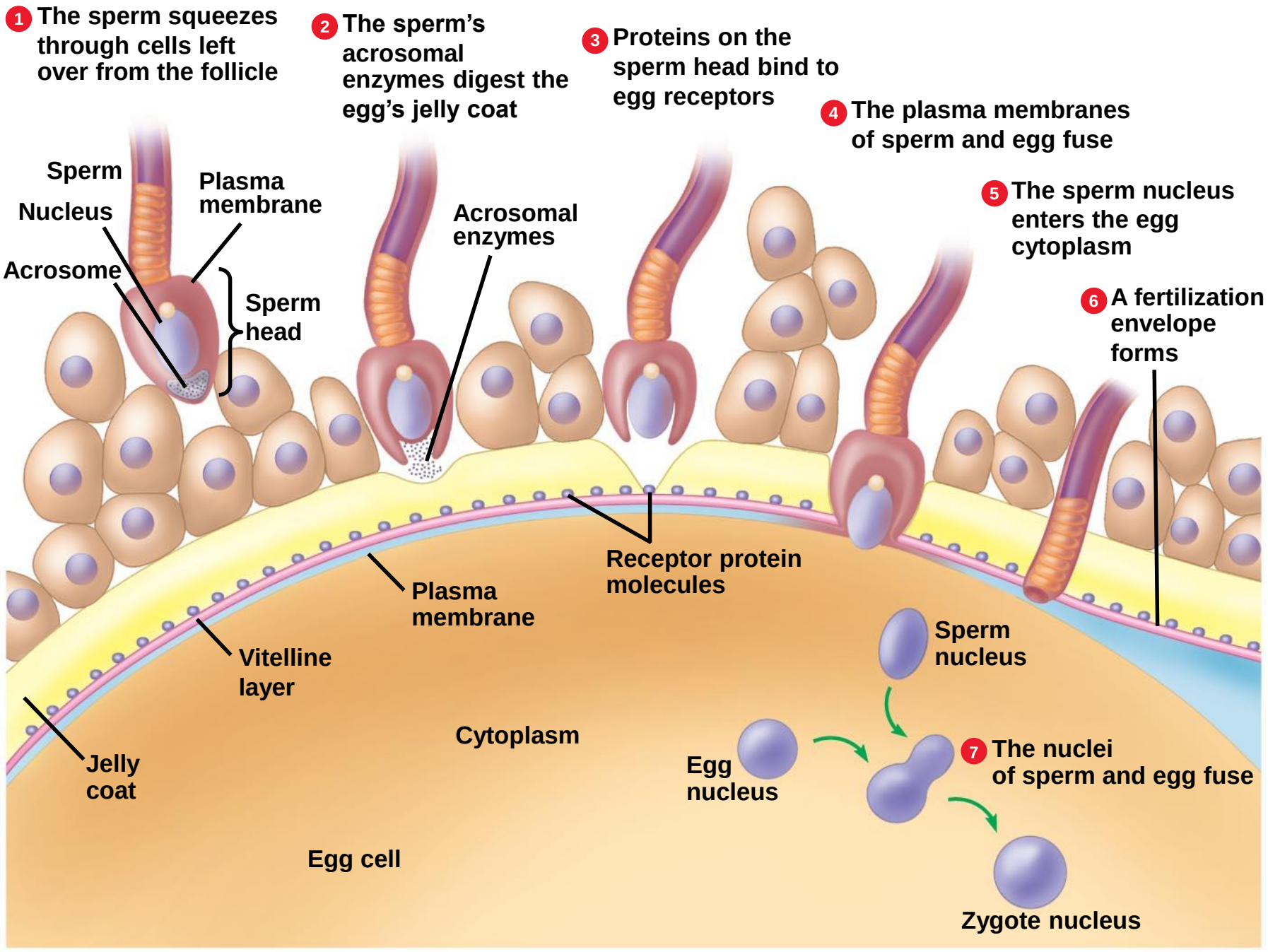
27.9 Fertilization results in a zygote and triggers embryonic development

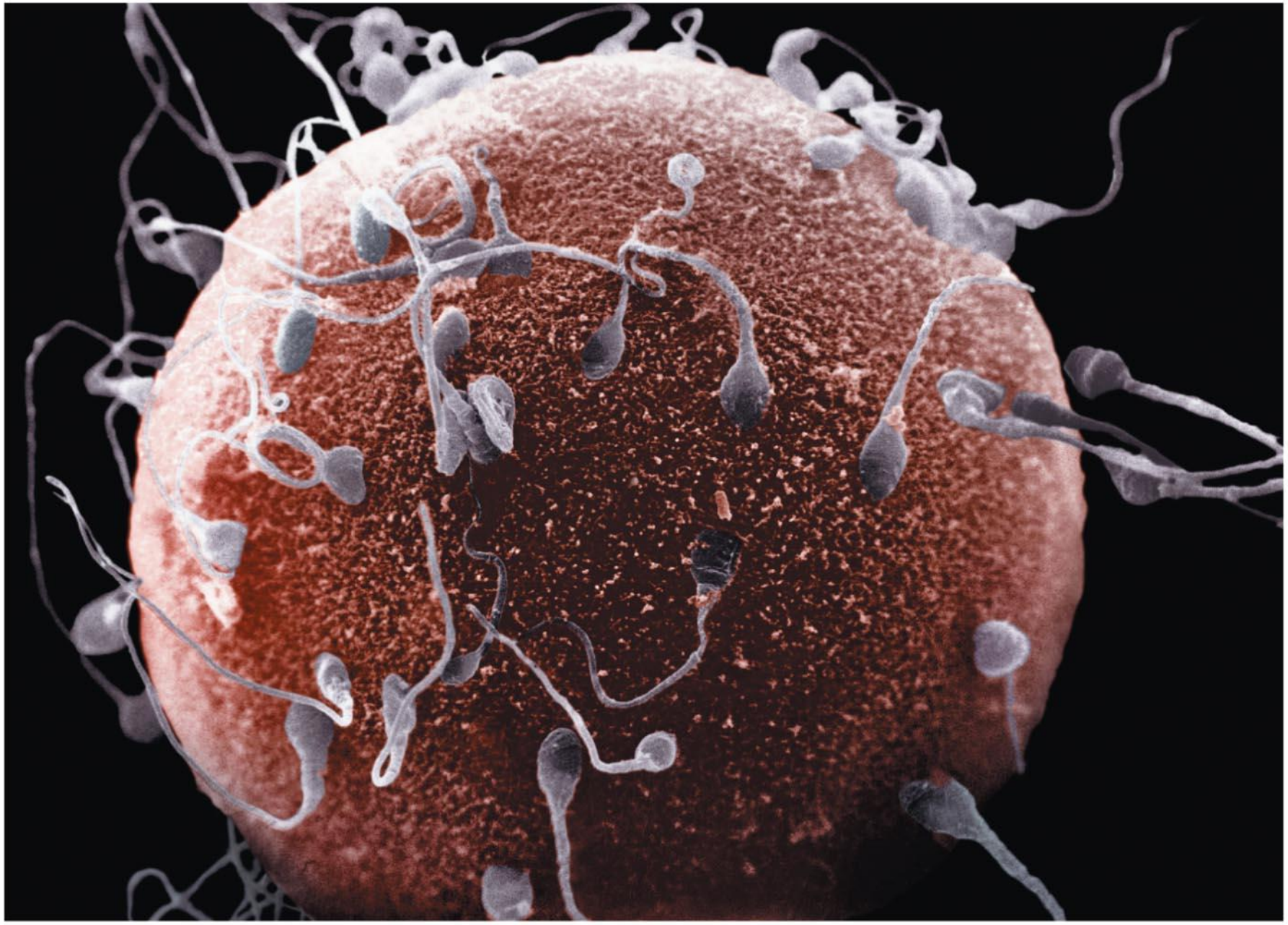
- Sperm are adapted to reach and fertilize an egg
  - Streamlined shape moves more easily through fluids
  - Many mitochondria provide ATP for tail movements
  - Head contains
    - A haploid nucleus
    - Tipped with an acrosome containing penetrating enzymes



27.9 Fertilization results in a zygote and triggers embryonic development

- Fertilization events
  - Sperm squeeze past follicle cells
  - Acrosomal enzymes pierce egg's coat
  - Sperm binds to vitelline layer
  - Sperm and egg plasma membranes fuse
  - Egg is stimulated to develop further
  - Egg and sperm nuclei fuse



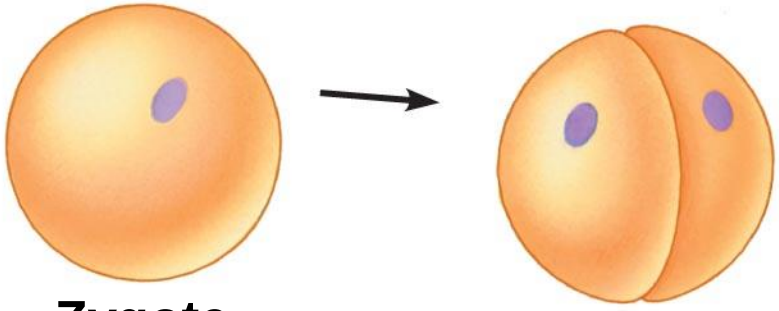


27.10 Cleavage produces a ball of cells from the zygote

- Cleavage is a rapid series of cell divisions
  - More cells
  - Embryo does not get larger
  - Thus new cells are smaller in size

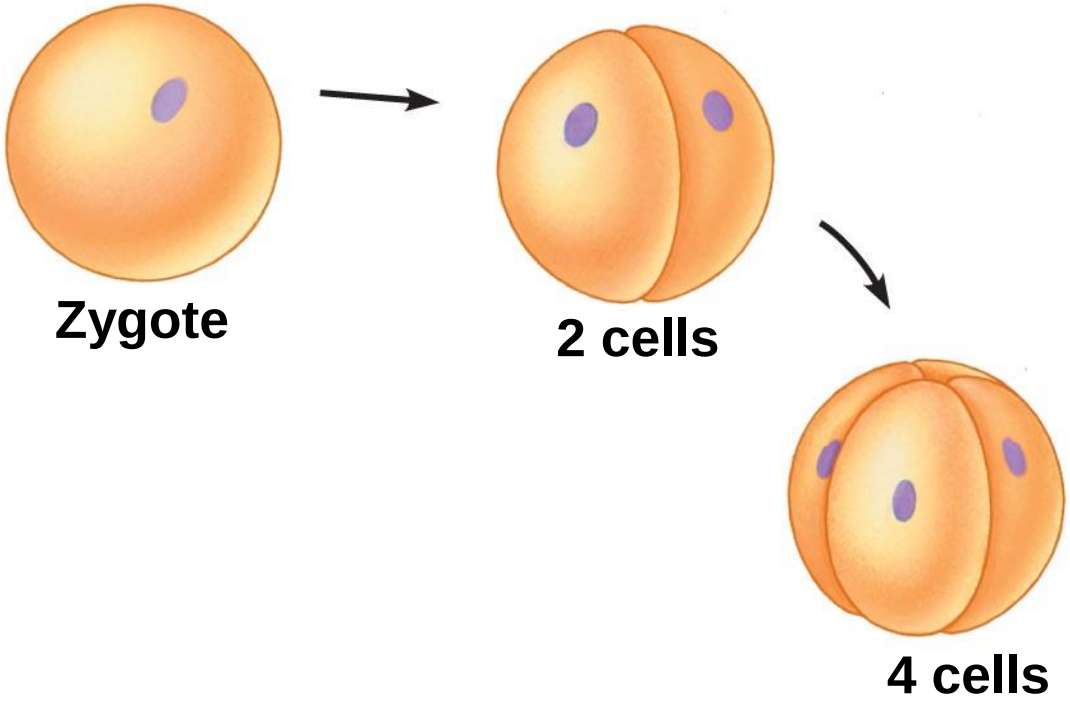
PLAY

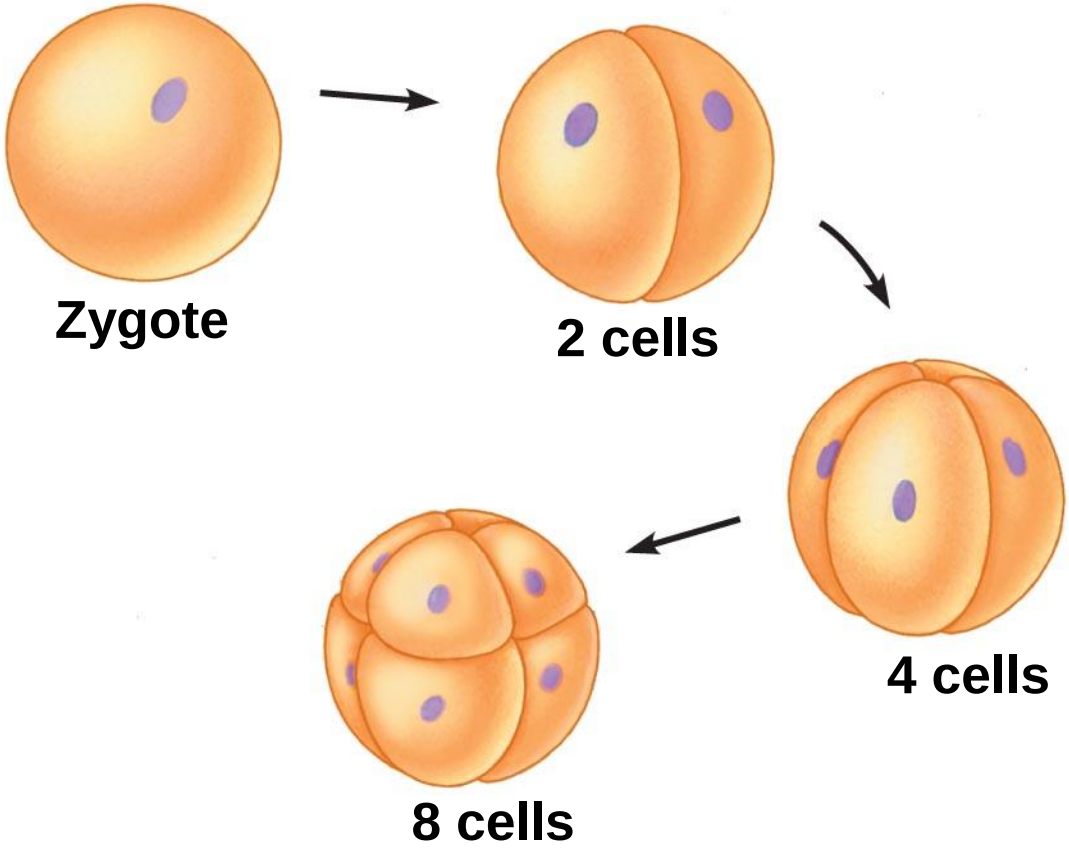
Video: Sea Urchin Embryonic Development

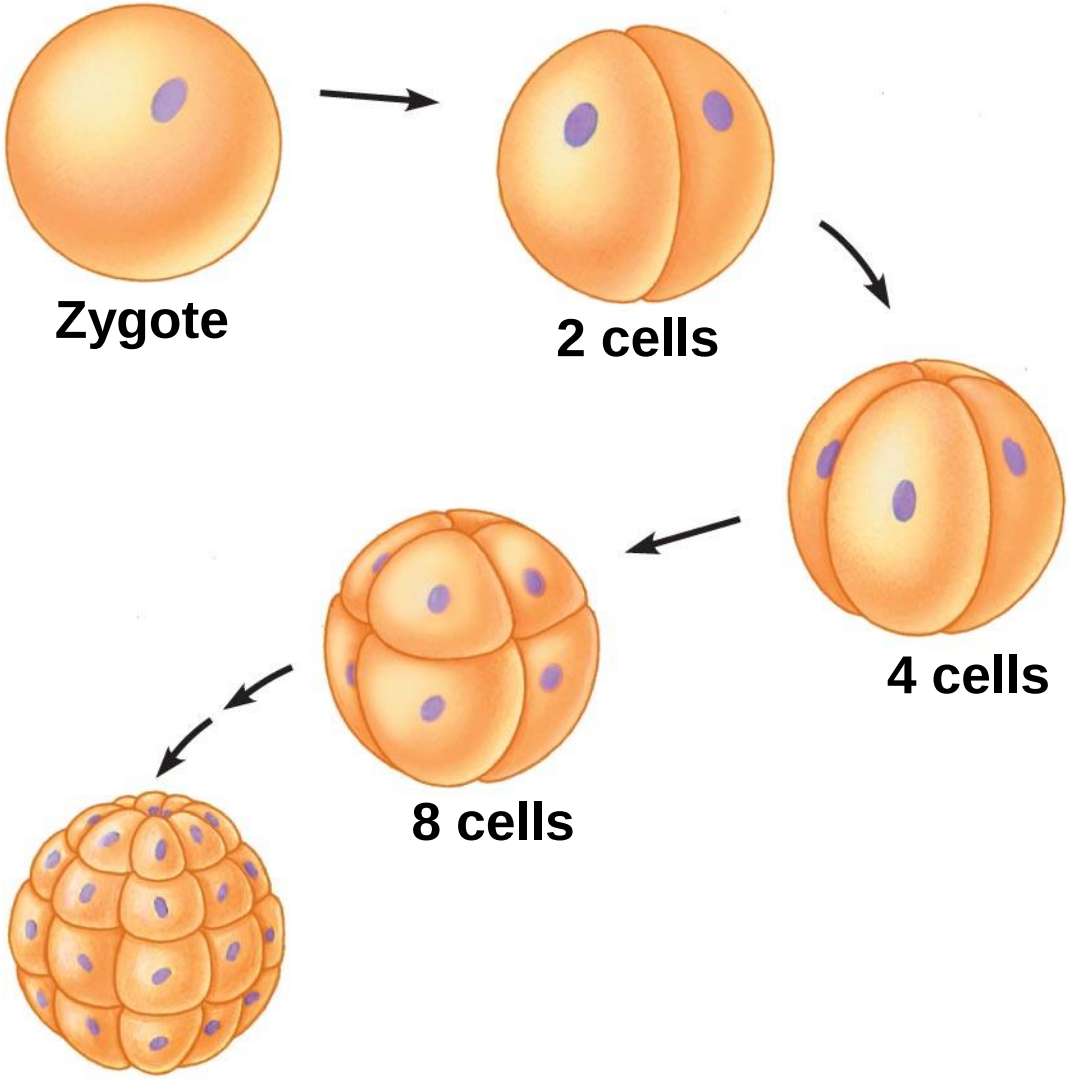


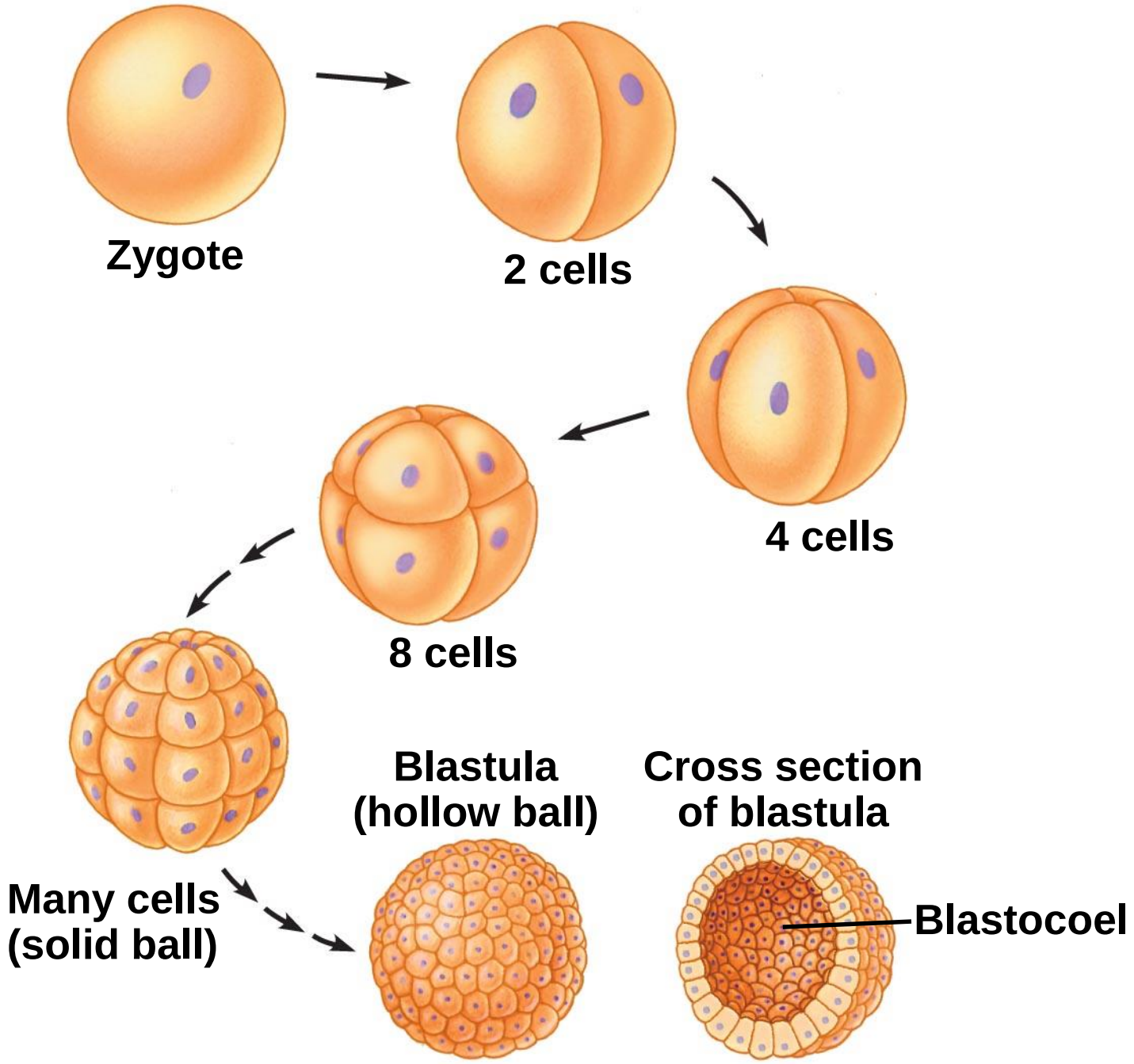
Zygote

2 cells



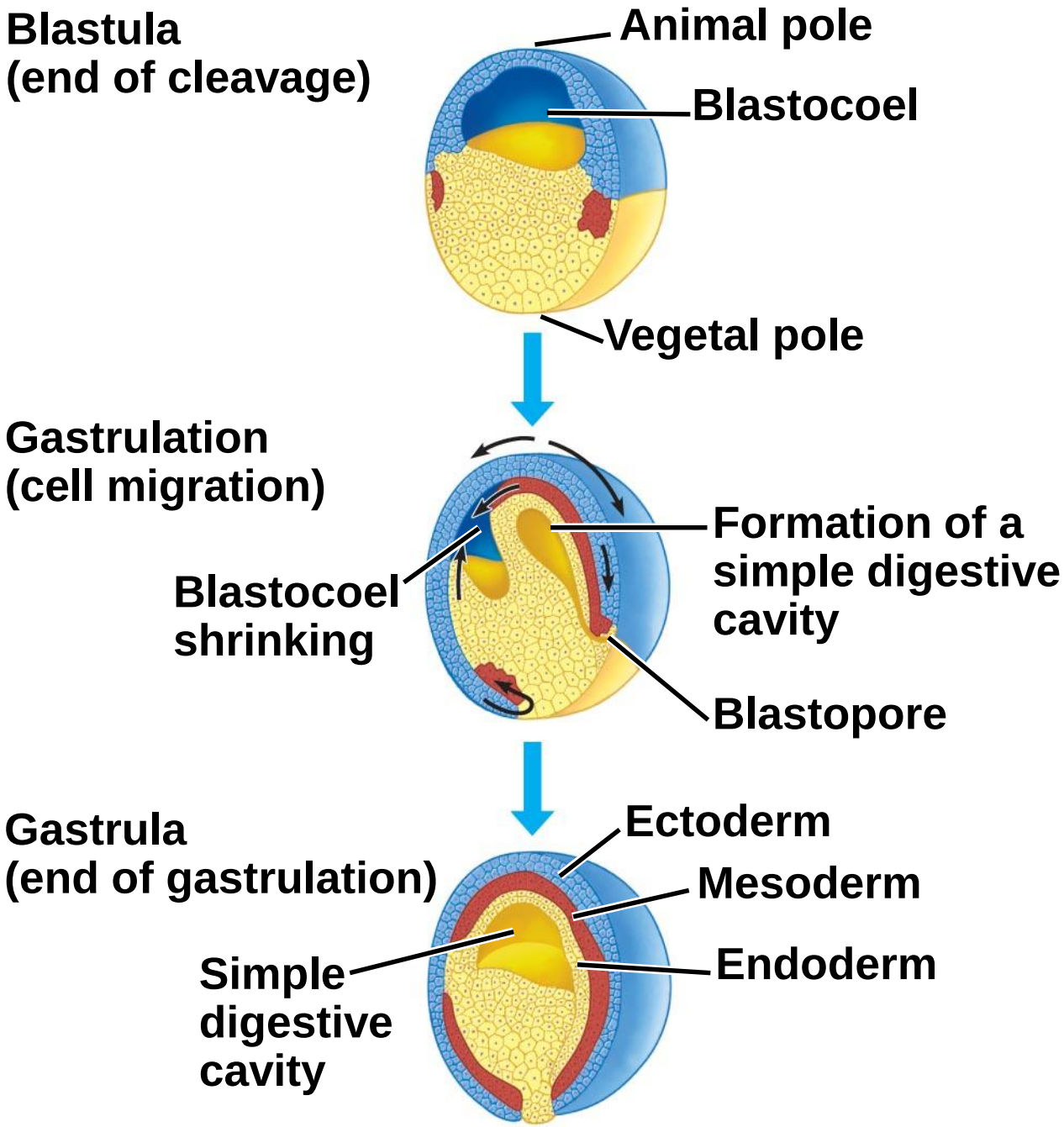




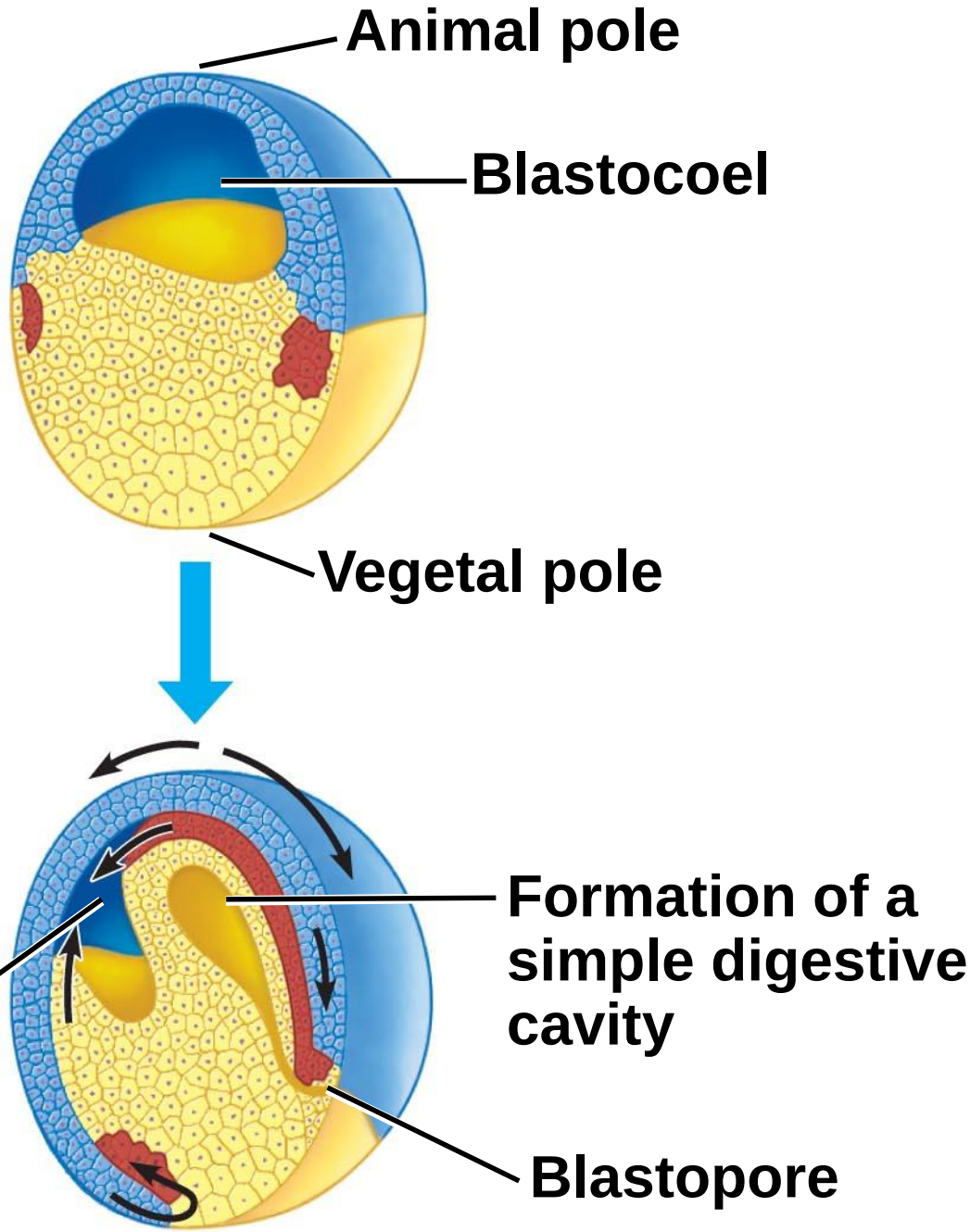


27.11 Gastrulation produces a three-layered embryo

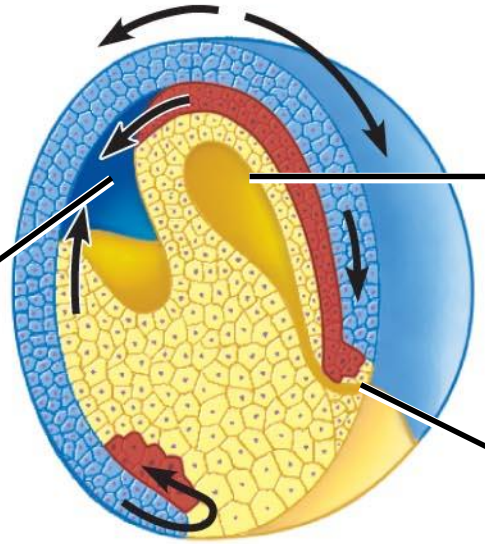
- **Gastrulation**
  - Cells migrate
  - The basic body plan of three layers is established
    - **Ectoderm** outside—becomes skin and nervous systems
    - **Endoderm** inside—becomes digestive tract
    - **Mesoderm** in middle—muscle and bone
  - A rudimentary digestive cavity forms



Blastula
(end of cleavage)



Gastrulation
(cell migration)



Formation of a simple digestive cavity

Blastocoel shrinking

Blastopore

Gastrula
(end of gastrulation)

Ectoderm

Mesoderm

Endoderm

Simple digestive cavity

TABLE 27.11 DERIVATIVES OF THE THREE EMBRYONIC TISSUE LAYERS

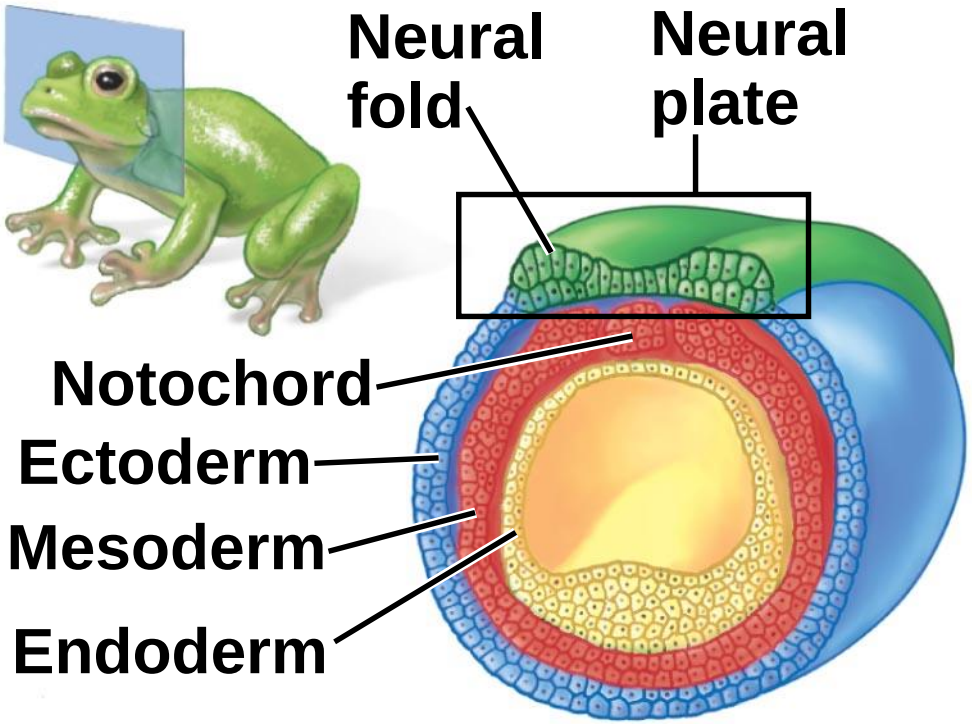
Embryonic Layer	Organs and Tissues in the Adult
Ectoderm	Epidermis of skin; epithelial lining of mouth and rectum; sense receptors in epidermis; cornea and lens of eye; nervous system
Endoderm	Epithelial lining of digestive tract (except mouth and rectum); epithelial lining of respiratory system; liver; pancreas; thyroid; parathyroids; thymus; lining of urethra, urinary bladder, and reproductive system
Mesoderm	Skeletal system; muscular system; circulatory system; excretory system; reproductive system (except gamete-forming cells); dermis of skin; lining of body cavity

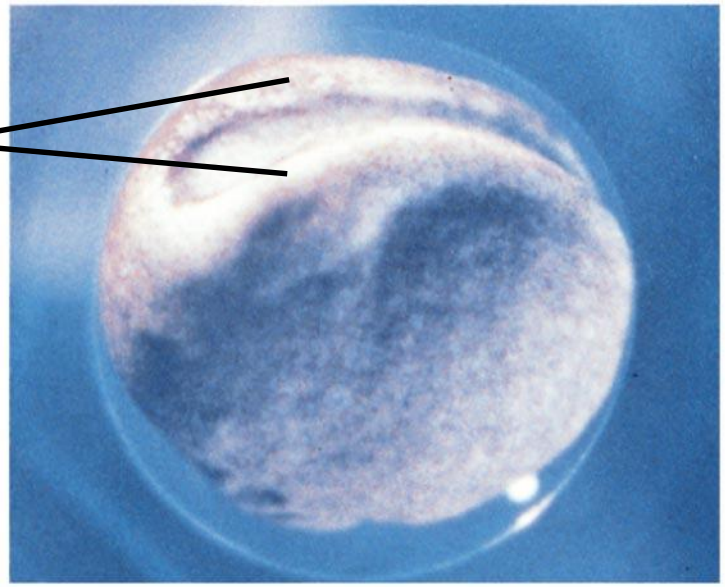
27.12 Organs start to form after gastrulation

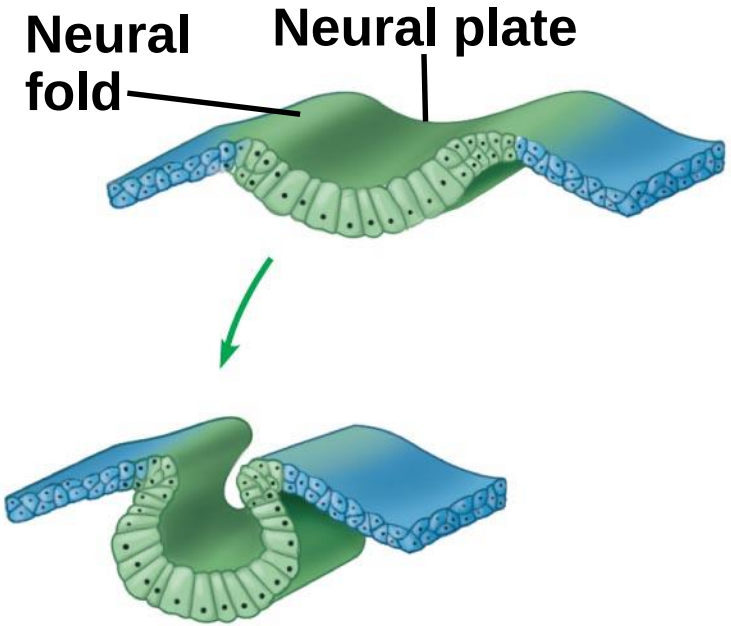
- Organs develop from the three embryonic layers
  - Stiff **notochord** forms the main axis of the body
    - Later replaced by the vertebral column
  - **Neural tube** develops above the notochord and will become the
    - Brain
    - Spinal cord

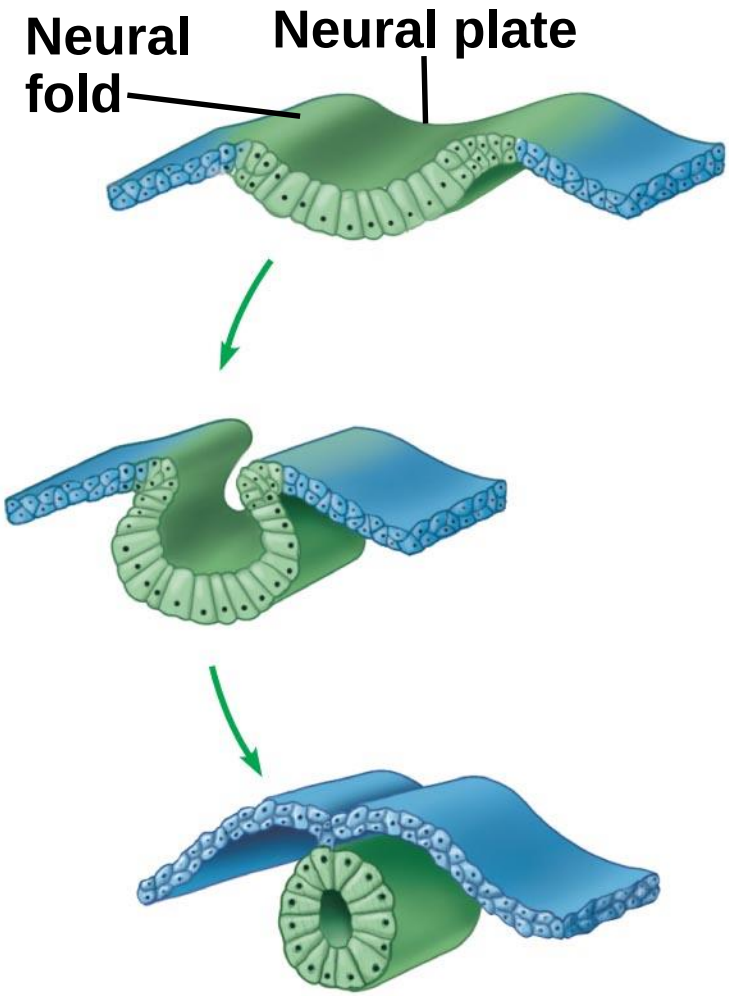
PLAY

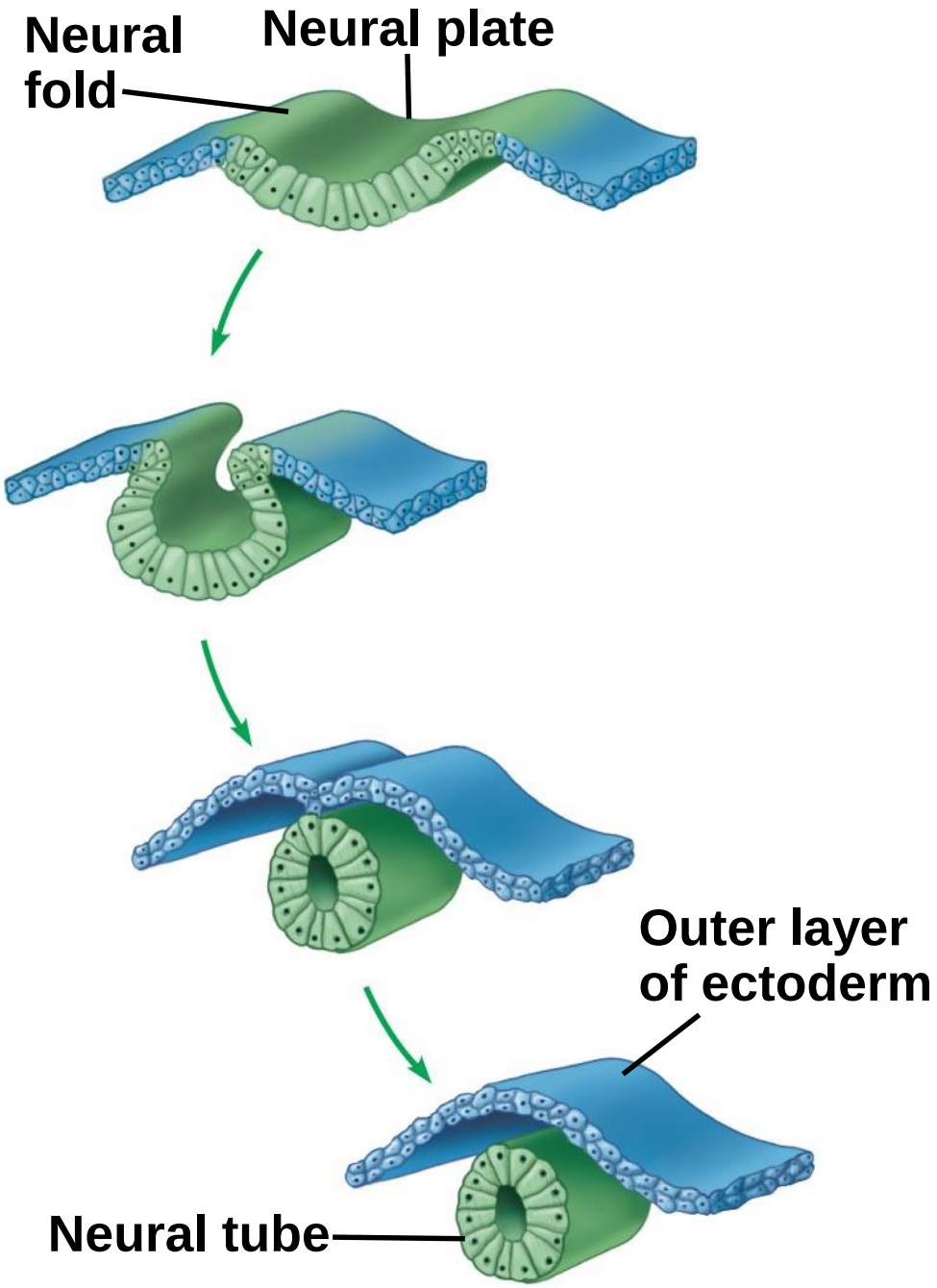
Video: Frog Embryo Development





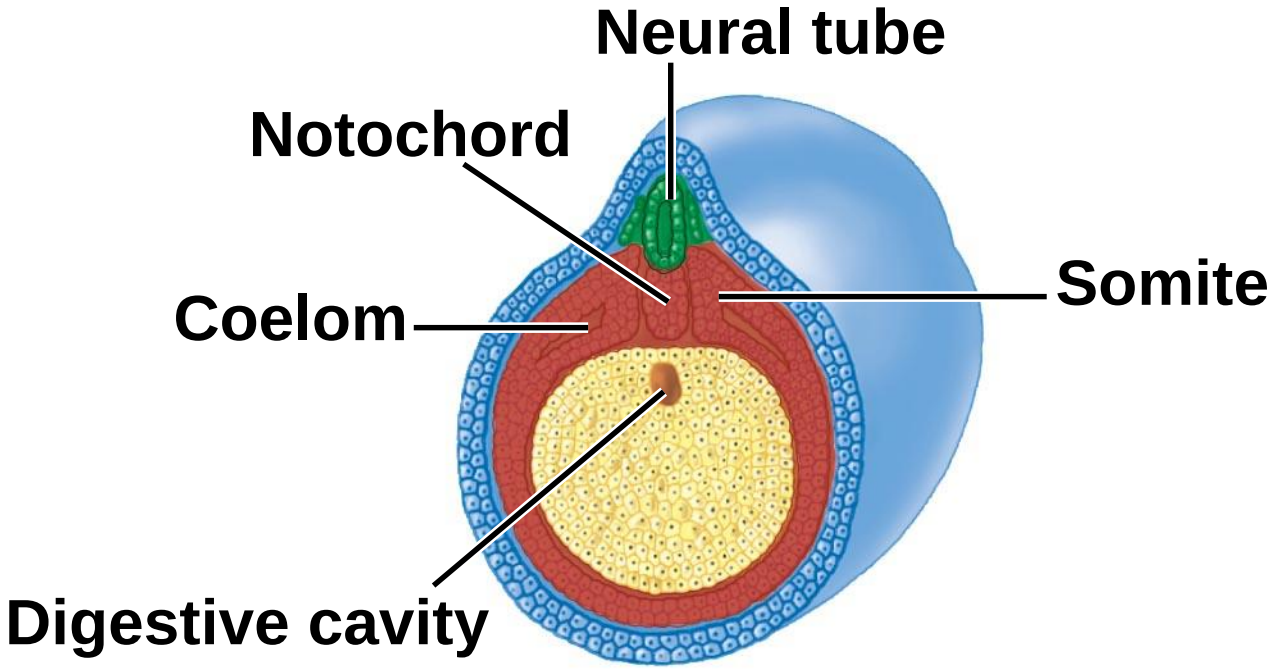


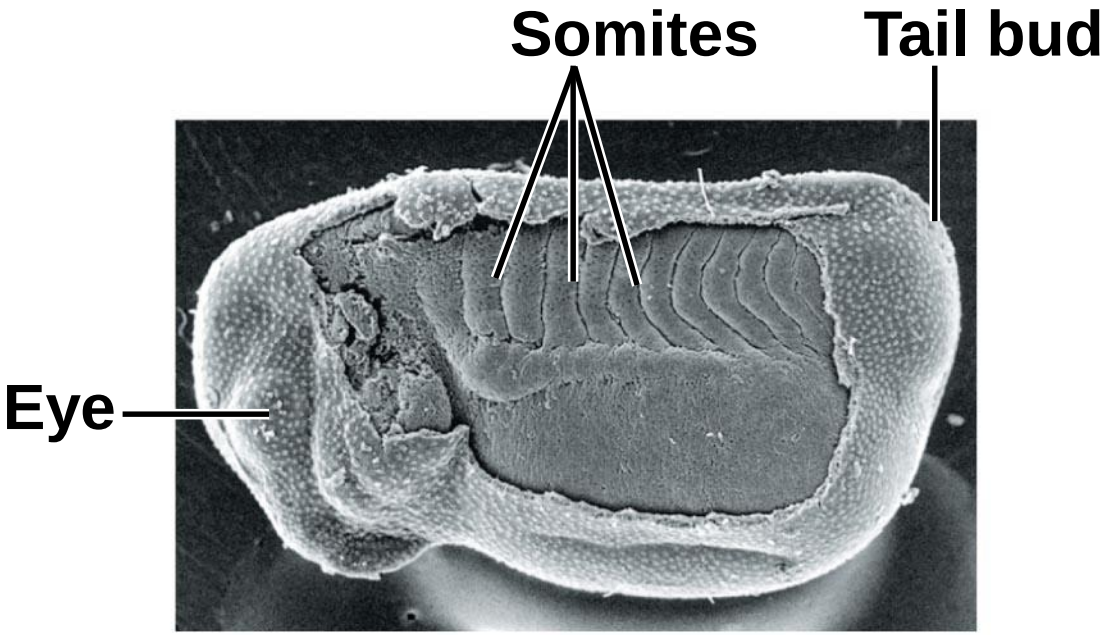




27.12 Organs start to form after gastrulation

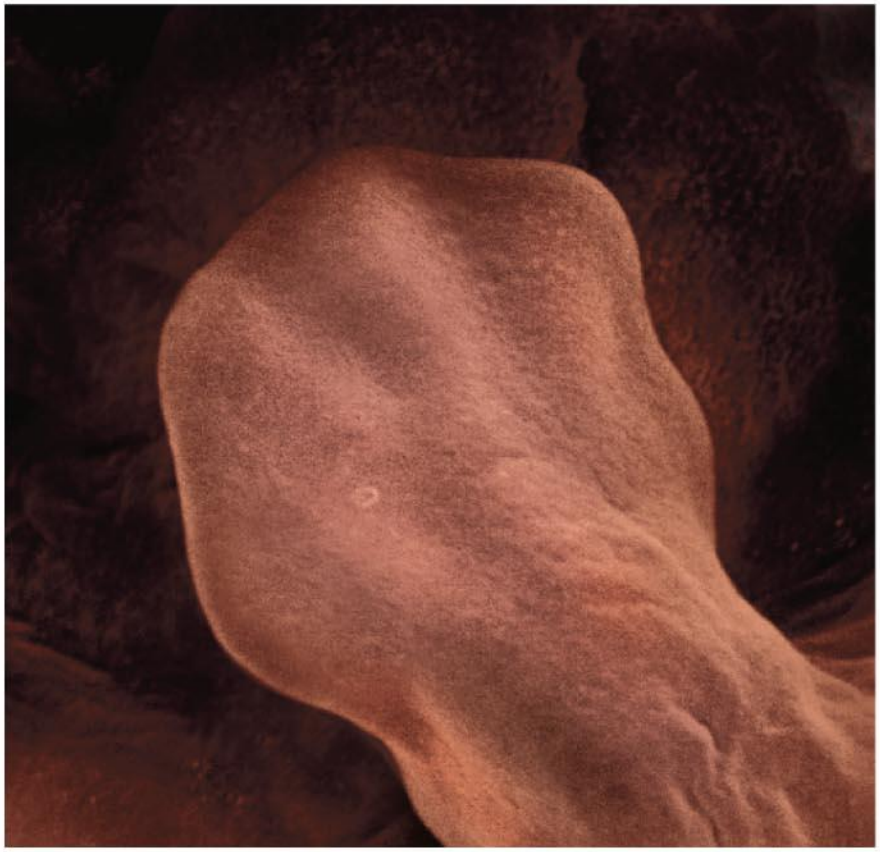
- As the embryo elongates
  - Paired somites form along the sides of the notochord
    - Future muscle
    - Future bone and other connective tissues
  - Later, somites hollow out to form a coelom
  - Other systems also develop

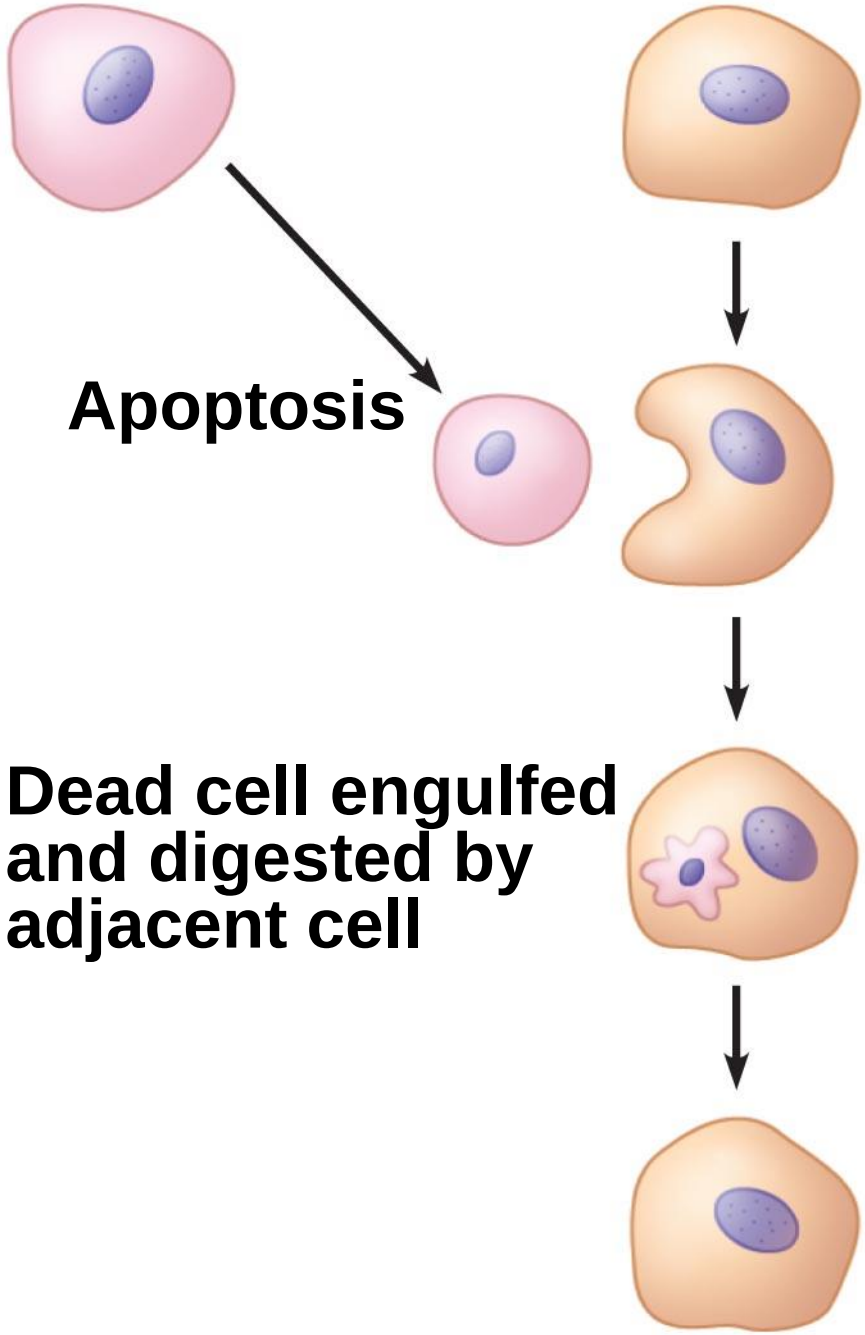




27.13 Multiple processes give form to the developing animal

- Tissues and organs develop by
  - Changes in cell shape
  - Cell migration
  - Programmed cell death



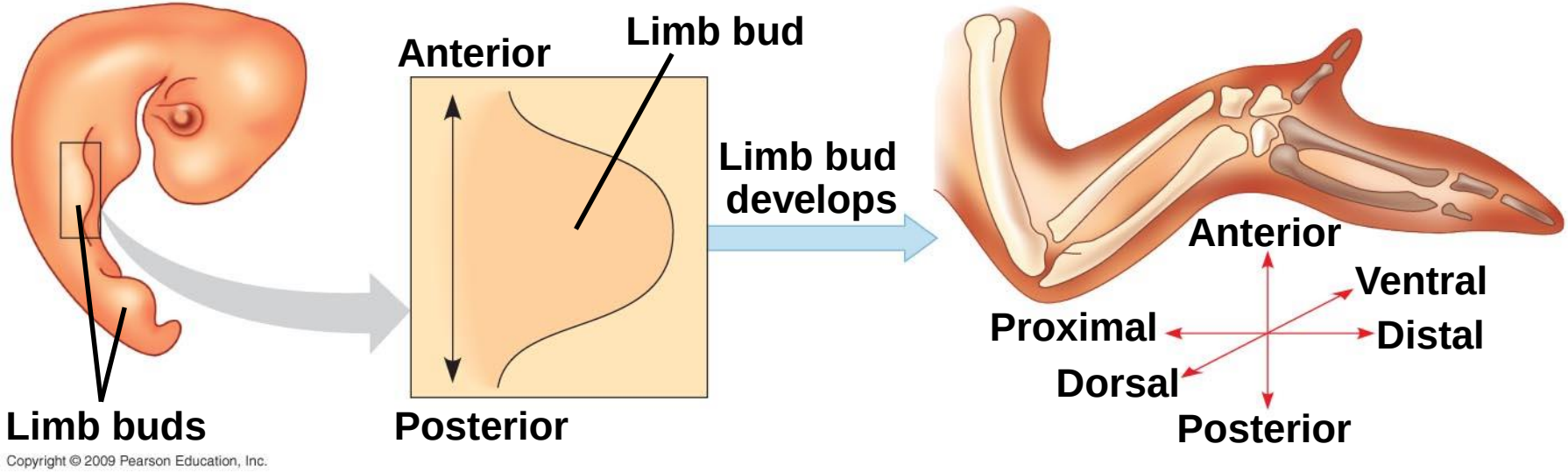


27.13 Multiple processes give form to the developing animal

- **Induction**
  - Adjacent cells and cell layers
  - Influence each other's differentiation via chemical signals

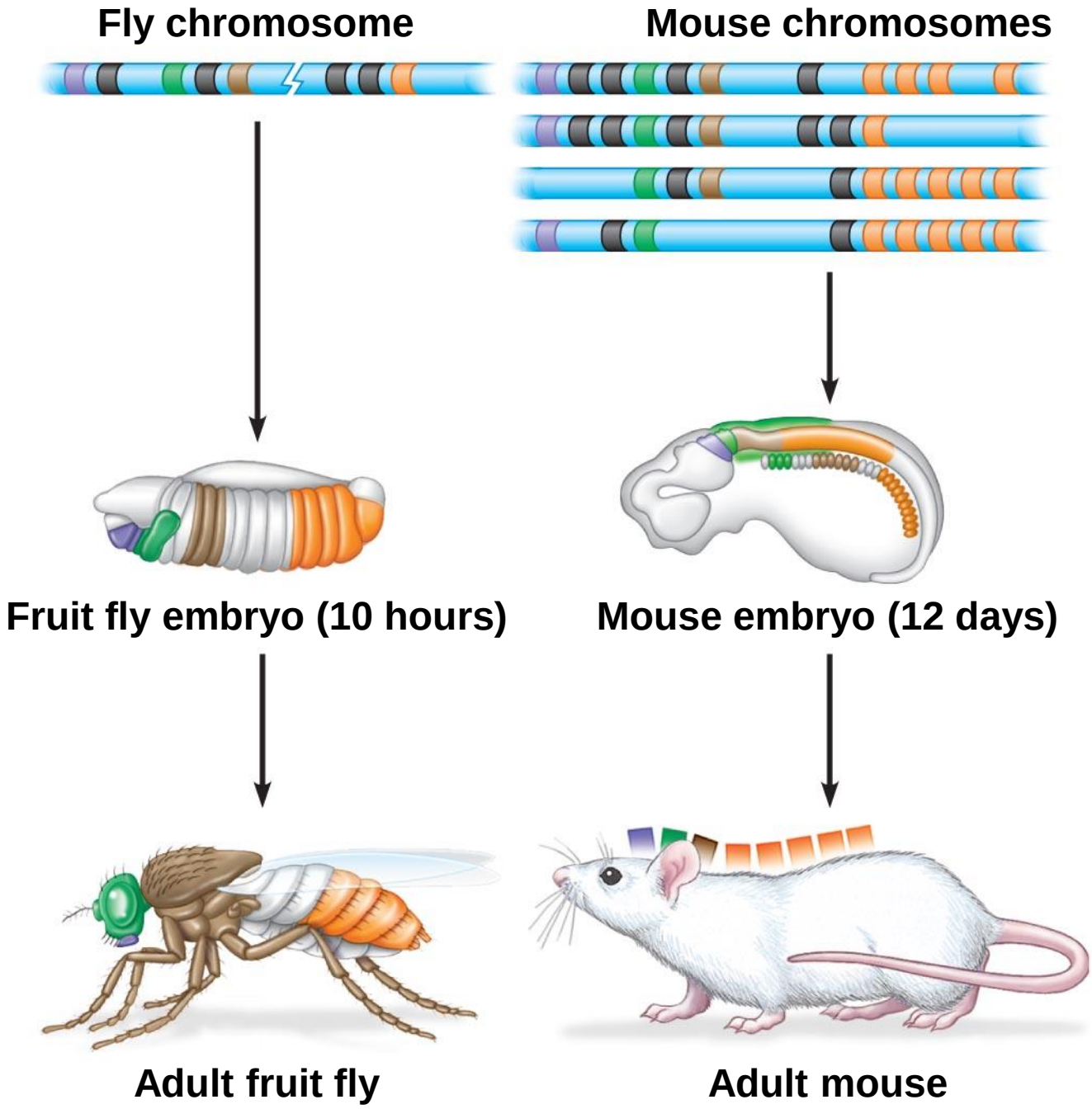
27.14 EVOLUTION CONNECTION: Pattern formation during embryonic development is controlled by ancient genes

- **Pattern formation** organizes the animal body
- Tissues and organs develop
  - In their proper positions
  - At the correct times



27.14 EVOLUTION CONNECTION: Pattern formation during embryonic development is controlled by ancient genes

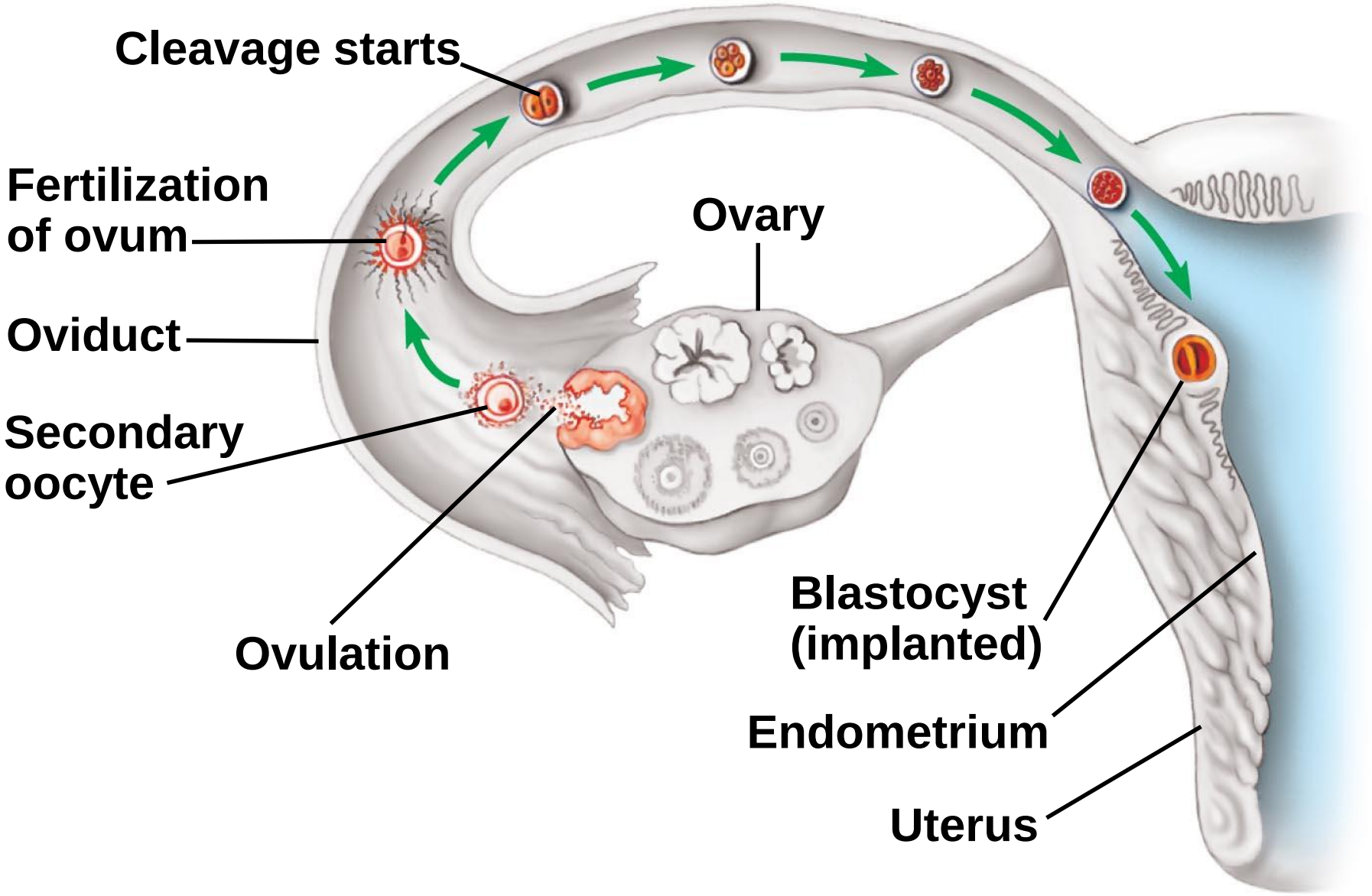
- Spatial variations of chemicals guide this organization
- **Homeotic genes** contain
  - Nucleotide sequences (homeoboxes)
  - Homeotic genes guide pattern formation in embryos
  - Very similar homeotic genes occur in diverse groups
    - Yeast, plants, animals
    - Reveal the shared evolutionary history of life

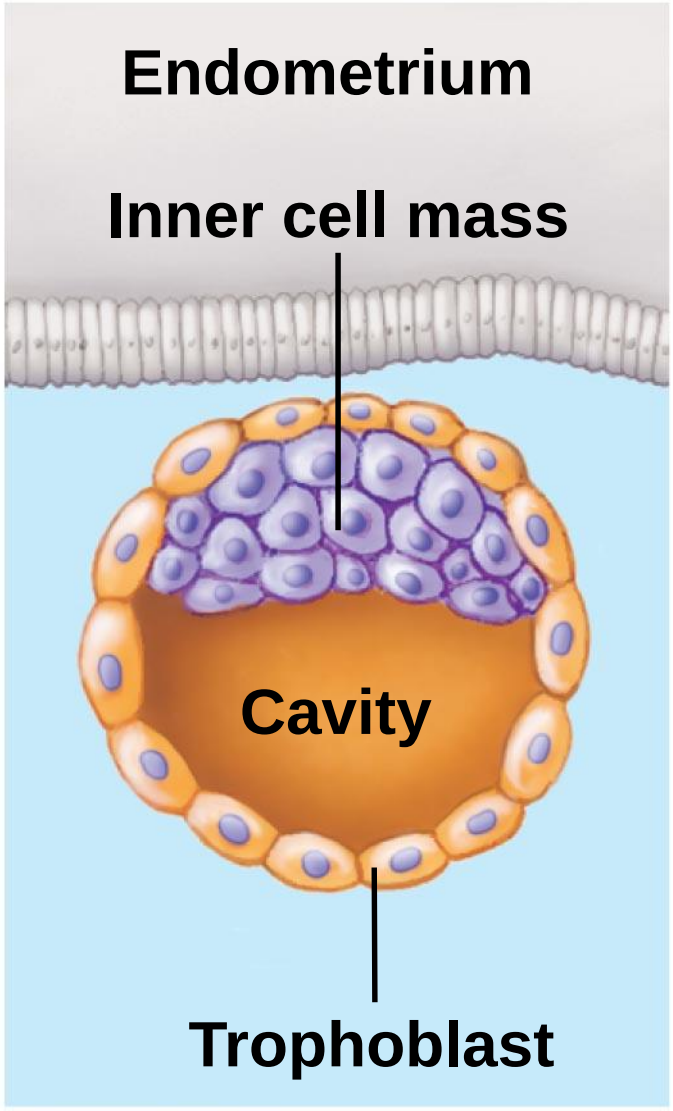


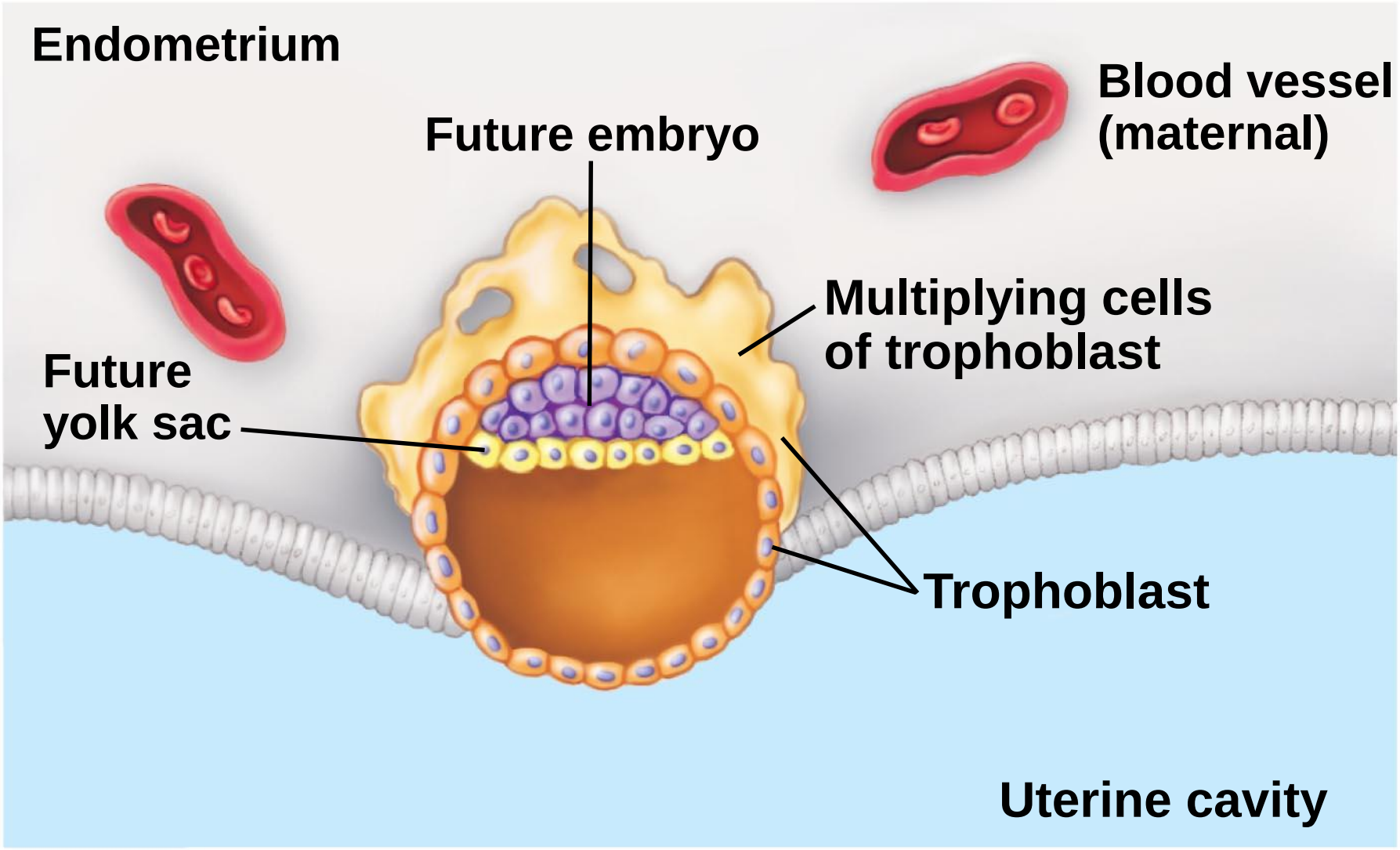
HUMAN DEVELOPMENT

27.15 The embryo and placenta take shape during the first month of pregnancy

- Human fertilization occurs in the oviduct
- Cleavage produces a **blastocyst**
  - Inner cell mass becomes the embryo
  - **Trophoblast**
    - Outer cell layer
    - Attaches to the uterine wall
    - Forms part of the **placenta**





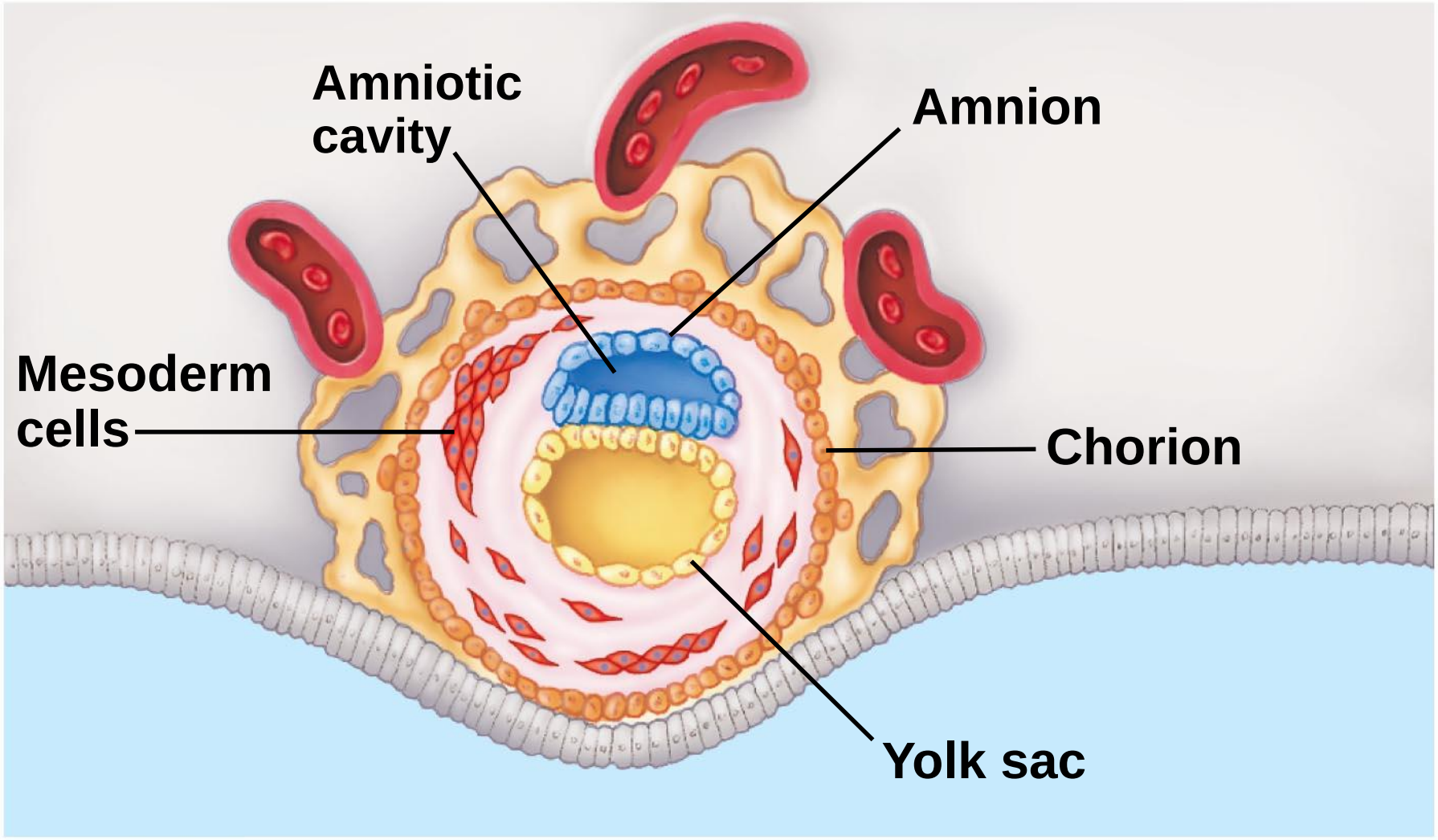


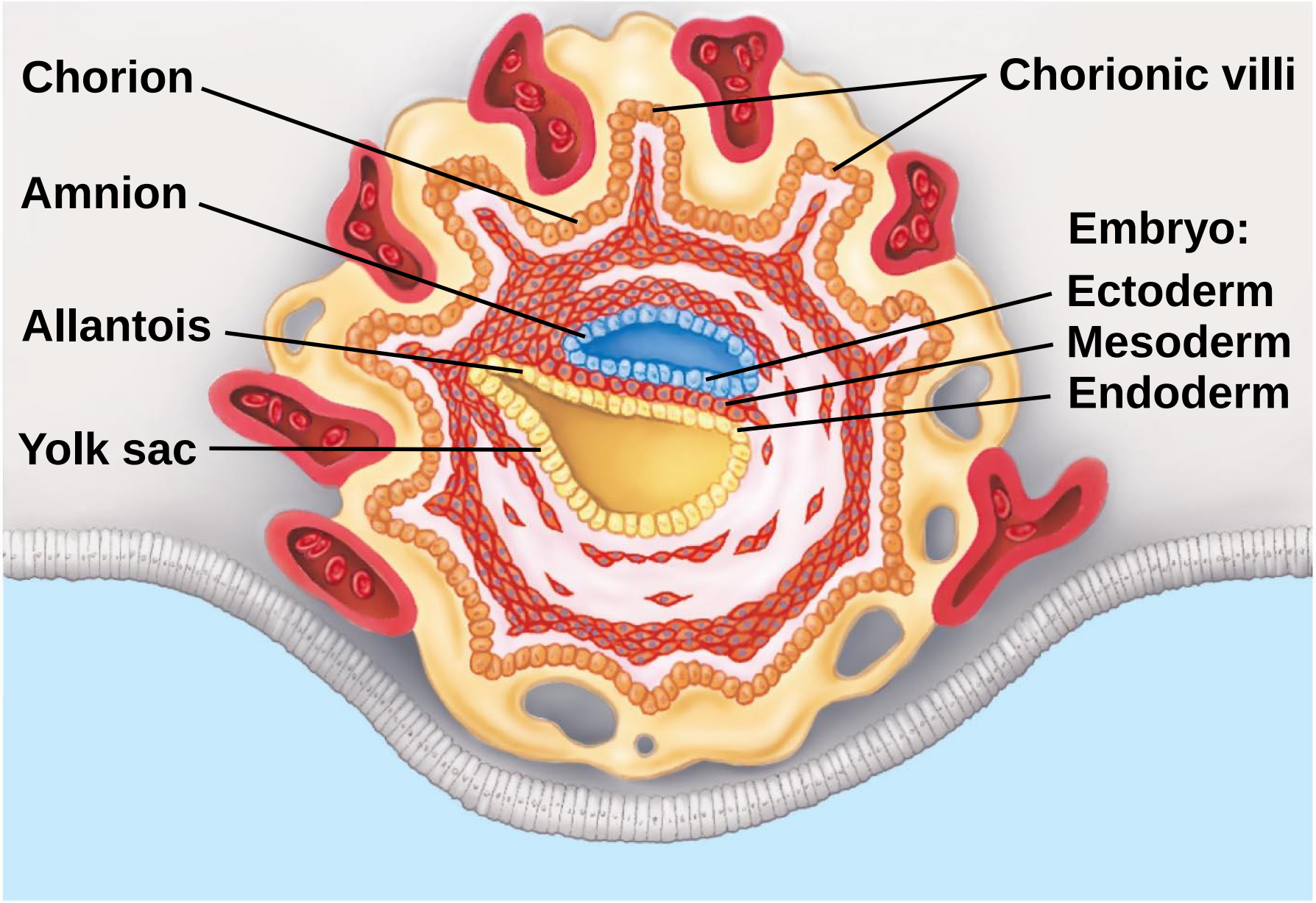
27.15 The embryo and placenta take shape during the first month of pregnancy

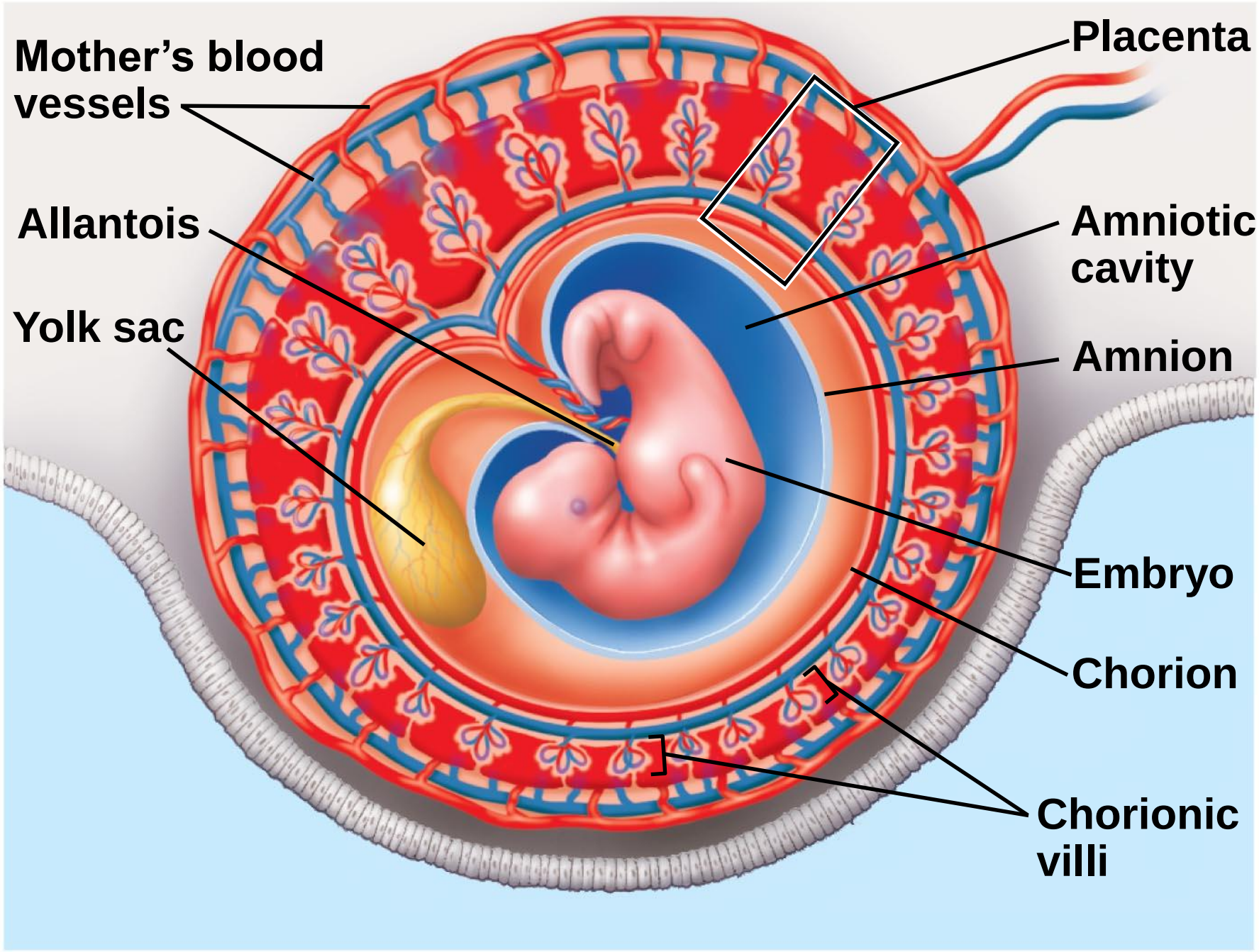
- Four **extraembryonic membranes** develop
  - **Amnion**
    - Surrounds the embryo
    - Forms a fluid-filled amniotic cavity that protects the embryo
  - **Yolk sac**
    - In reptiles, it stores yolk
    - No yolk in humans
    - Yolk sac is source of important cells
      - First germ cells
      - First blood cells

27.15 The embryo and placenta take shape during the first month of pregnancy

- **Allantois**
  - Contributes to the umbilical cord
  - Forms part of urinary bladder
  - In reptiles it stores embryonic waste
- **Chorion**
  - Contributes to the placenta
  - Secretes human chorionic gonadotropin (HCG), which prevents menstruation in mammals







27.15 The embryo and placenta take shape during the first month of pregnancy

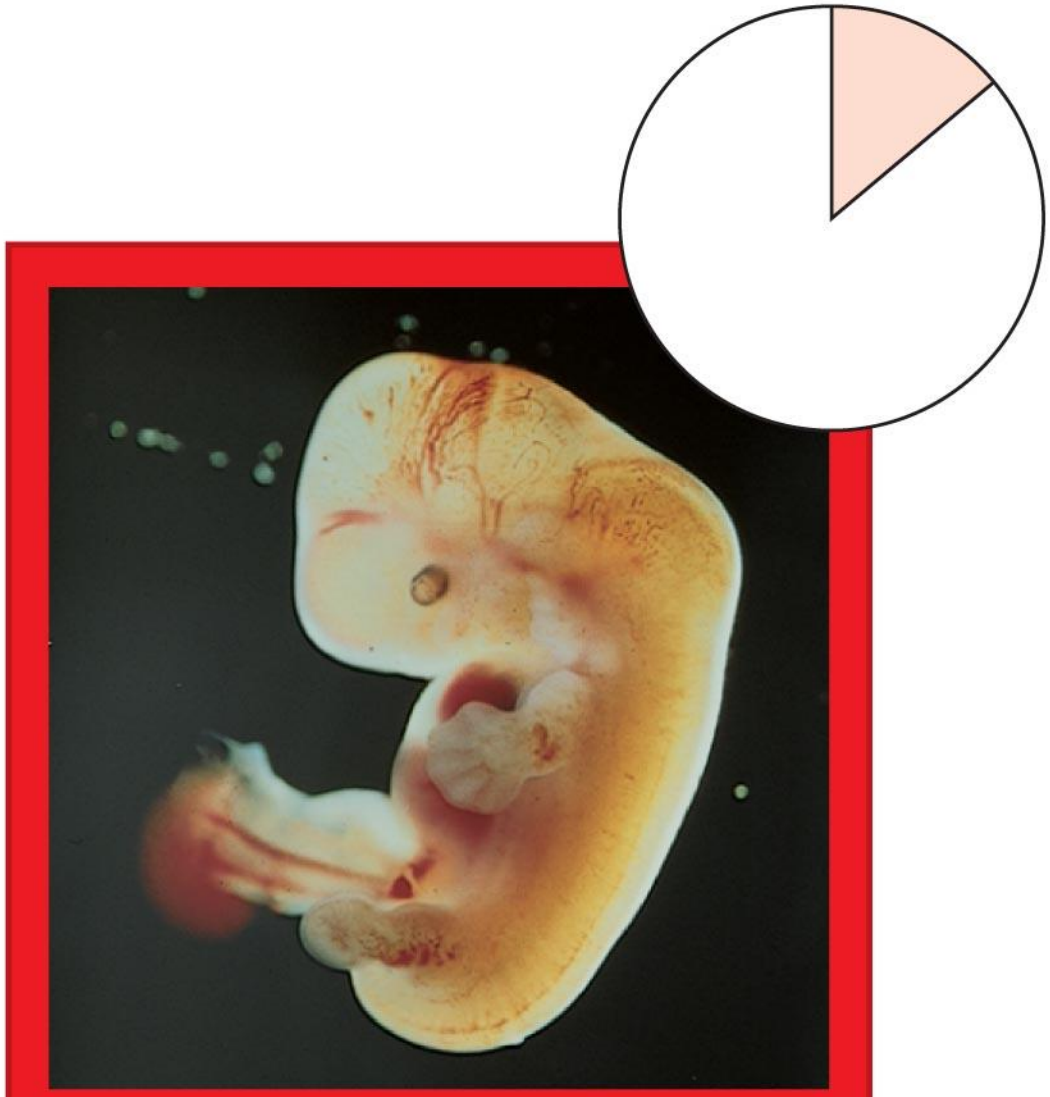
- Placenta
  - Close association of
    - Embryonic chorion
    - Mother's blood vessels
  - Site of
    - Gas exchange—from mother to embryo
    - Nutrient exchange—from mother to embryo
    - Waste exchange—from embryo to mother

27.16 Human development from conception to birth is divided into three trimesters

- First trimester
  - Time of most radical change for mother and embryo
  - Embryo forms—looks like other vertebrate embryos
  - Extraembryonic membranes form
  - All major organ systems are established
  - At 9 weeks after fertilization, now called a fetus
    - Can move its arms and legs
    - Starts to look distinctly human

PLAY Video: Ultrasound of Human Fetus 1

PLAY Video: Ultrasound of Human Fetus 2



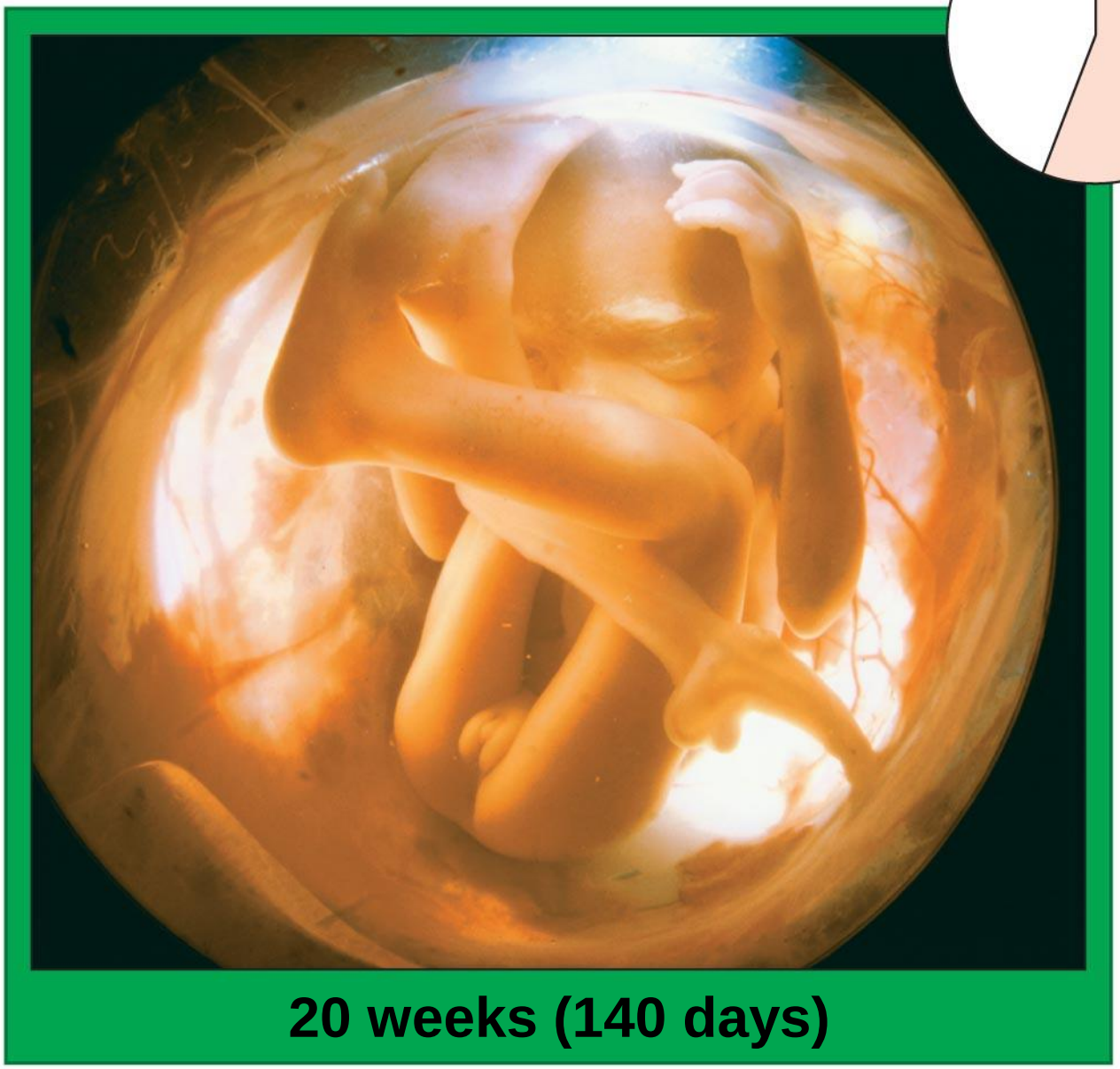
5 weeks (35 days)

9 weeks (63 days)

27.16 Human development from conception to birth is divided into three trimesters

- Second trimester
  - Increase in size
  - Refinement of human features
  - At 20 weeks
    - About 19 cm long (7.6 in.)
    - Weighs about 0.5 kg (1 lb.)

14 weeks (98 days)



20 weeks (140 days)

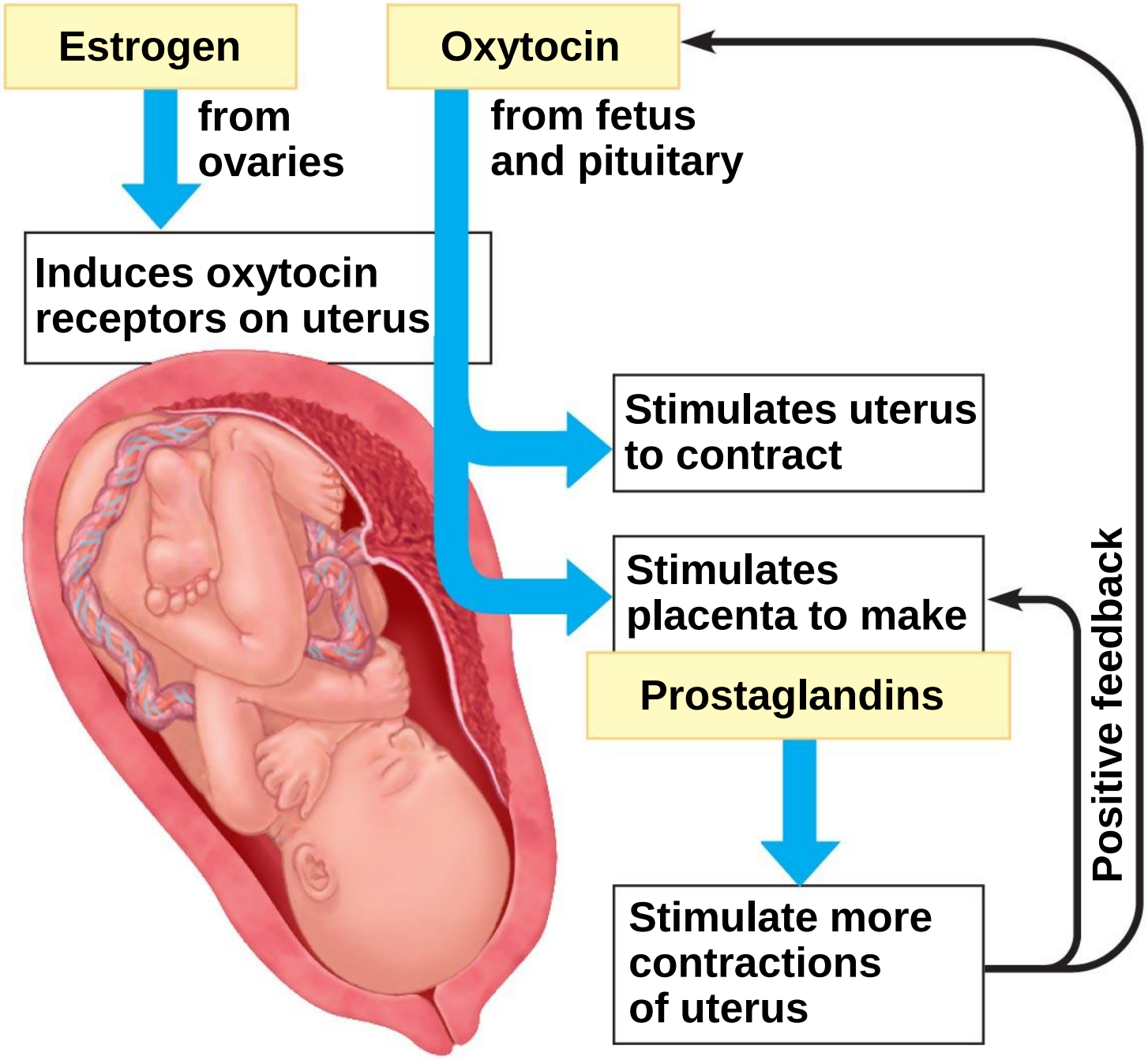
27.16 Human development from conception to birth is divided into three trimesters

- Third trimester
  - Time of rapid growth
  - Circulatory and respiratory systems mature
  - Muscles thicken and skeleton hardens
  - Ends with birth
  - Babies born at start of third trimester (28 weeks) may survive with extensive medical care

At birth (280 days)

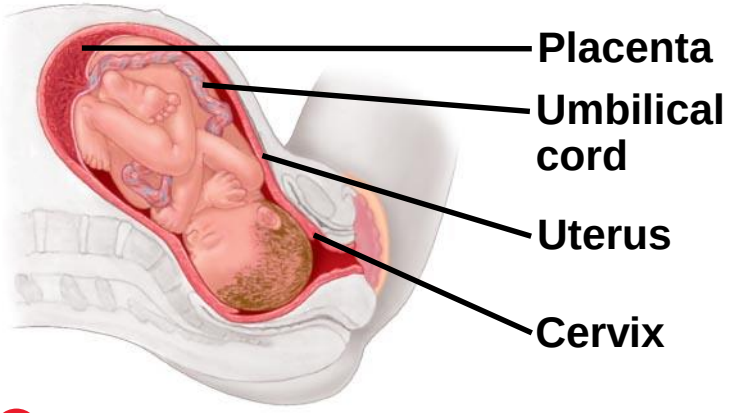
27.17 Childbirth is hormonally induced and occurs in three stages

- Hormonal changes induce birth
  - Estrogen makes the uterus more sensitive to oxytocin
  - Oxytocin acts with prostaglandins to initiate **labor**
  - Cervix dilates
  - Baby is expelled by strong contractions of the uterus
  - Placenta dislodges and is expelled after the baby



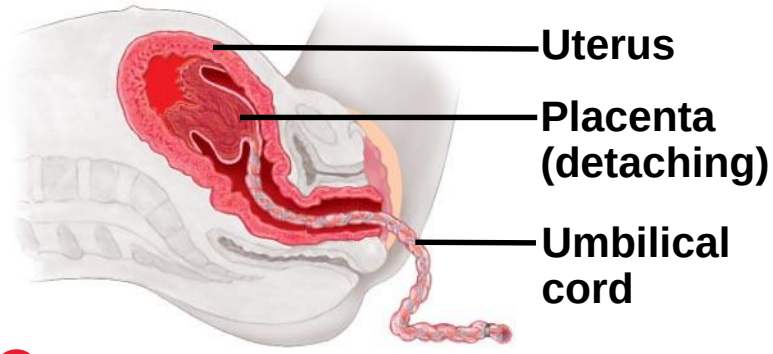
27.17 Childbirth is hormonally induced and occurs in three stages

- Labor occurs in three stages
  - Dilation of the cervix
  - Expulsion: delivery of the infant
  - Delivery of the placenta

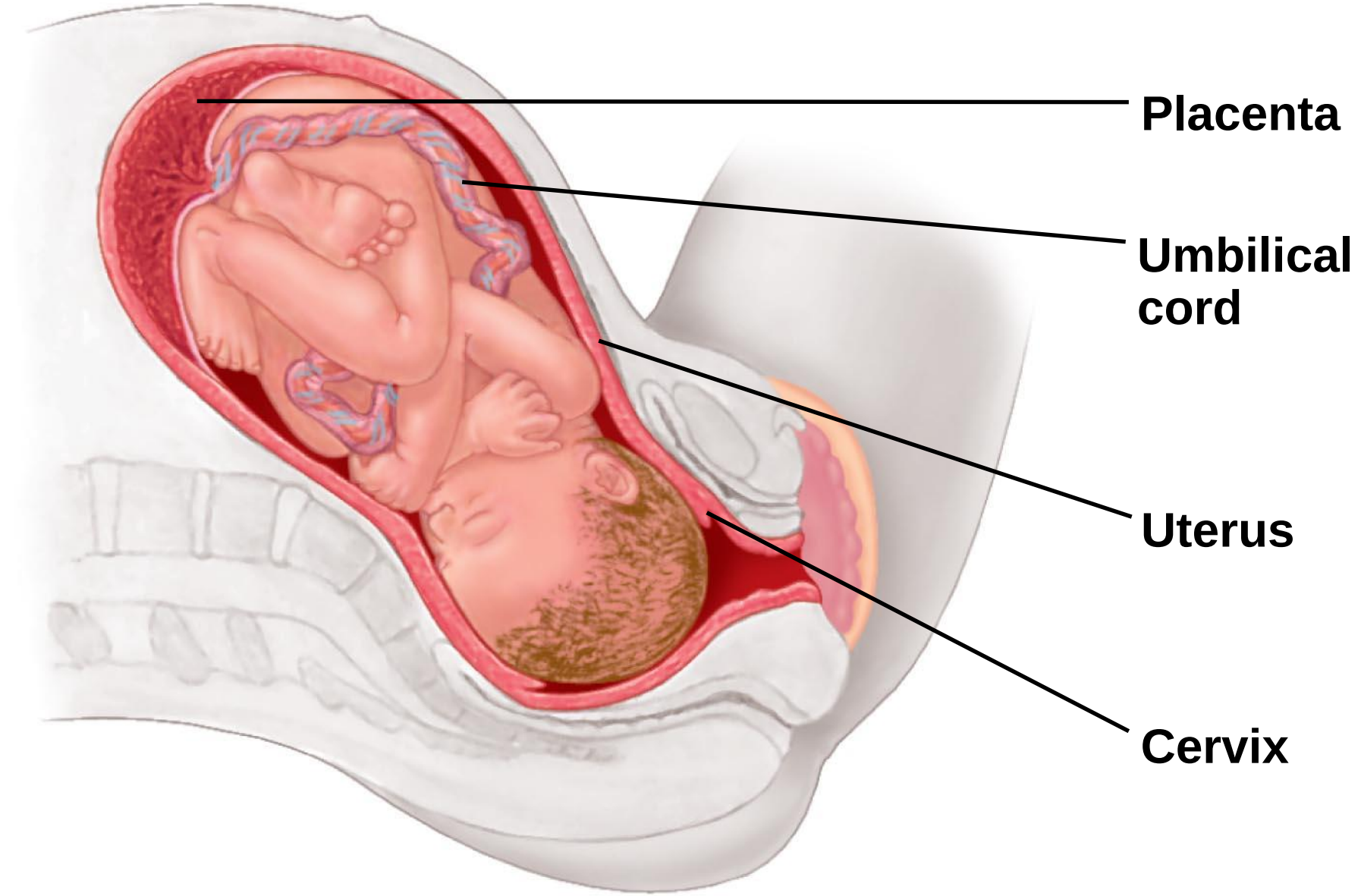


1 Dilation of the cervix

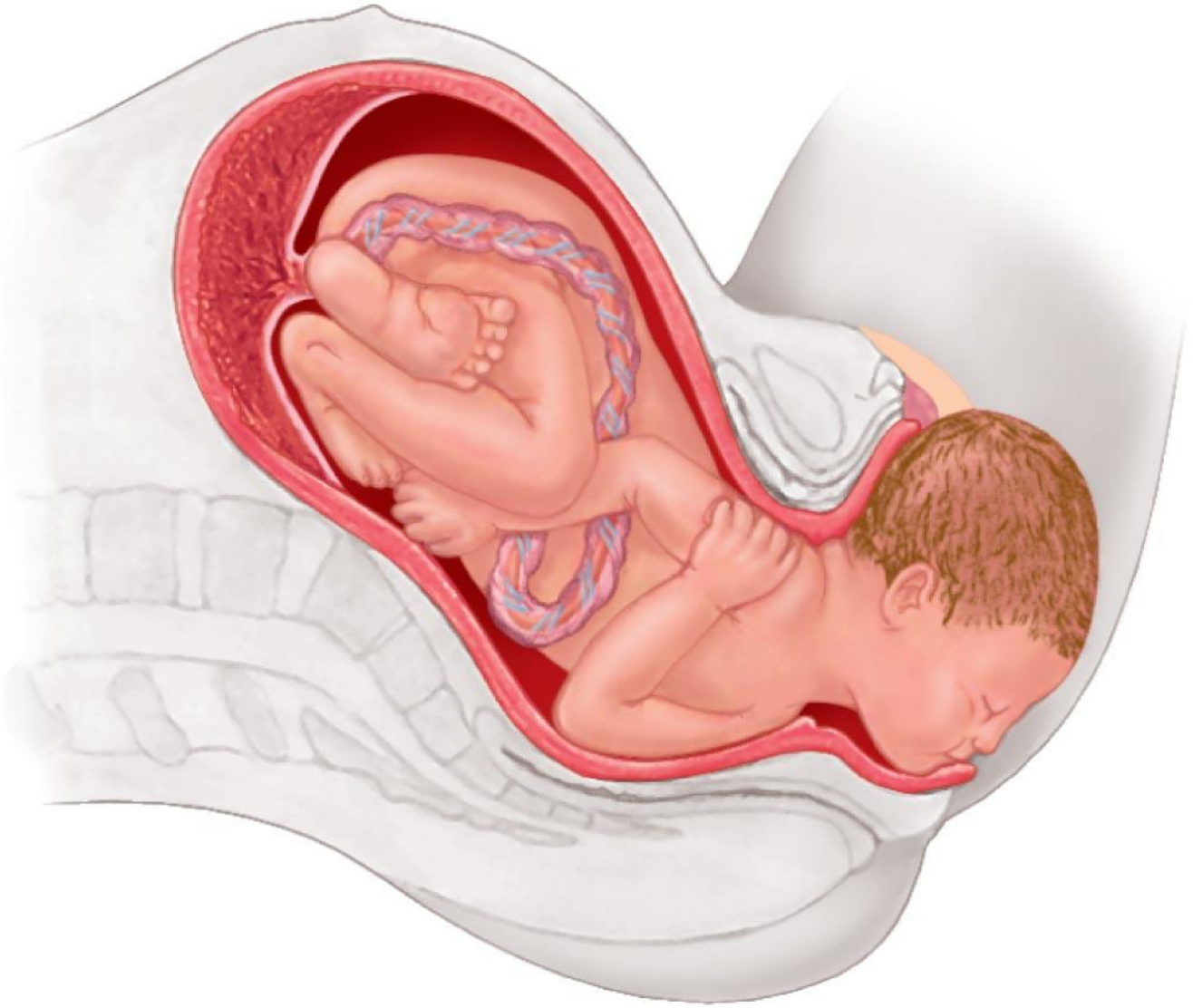
2 Expulsion: delivery of the infant



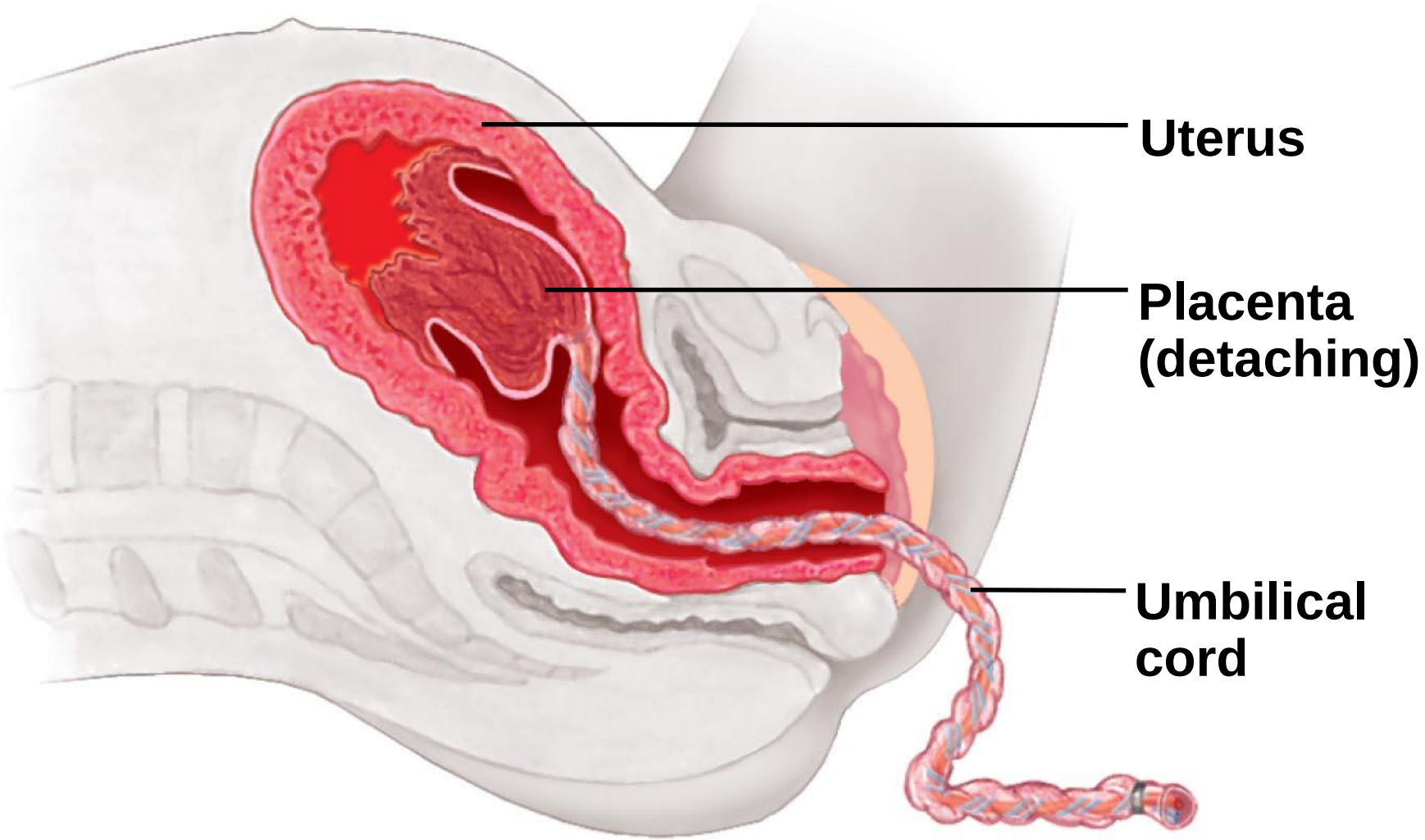
3 Delivery of the placenta



1 Dilation of the cervix



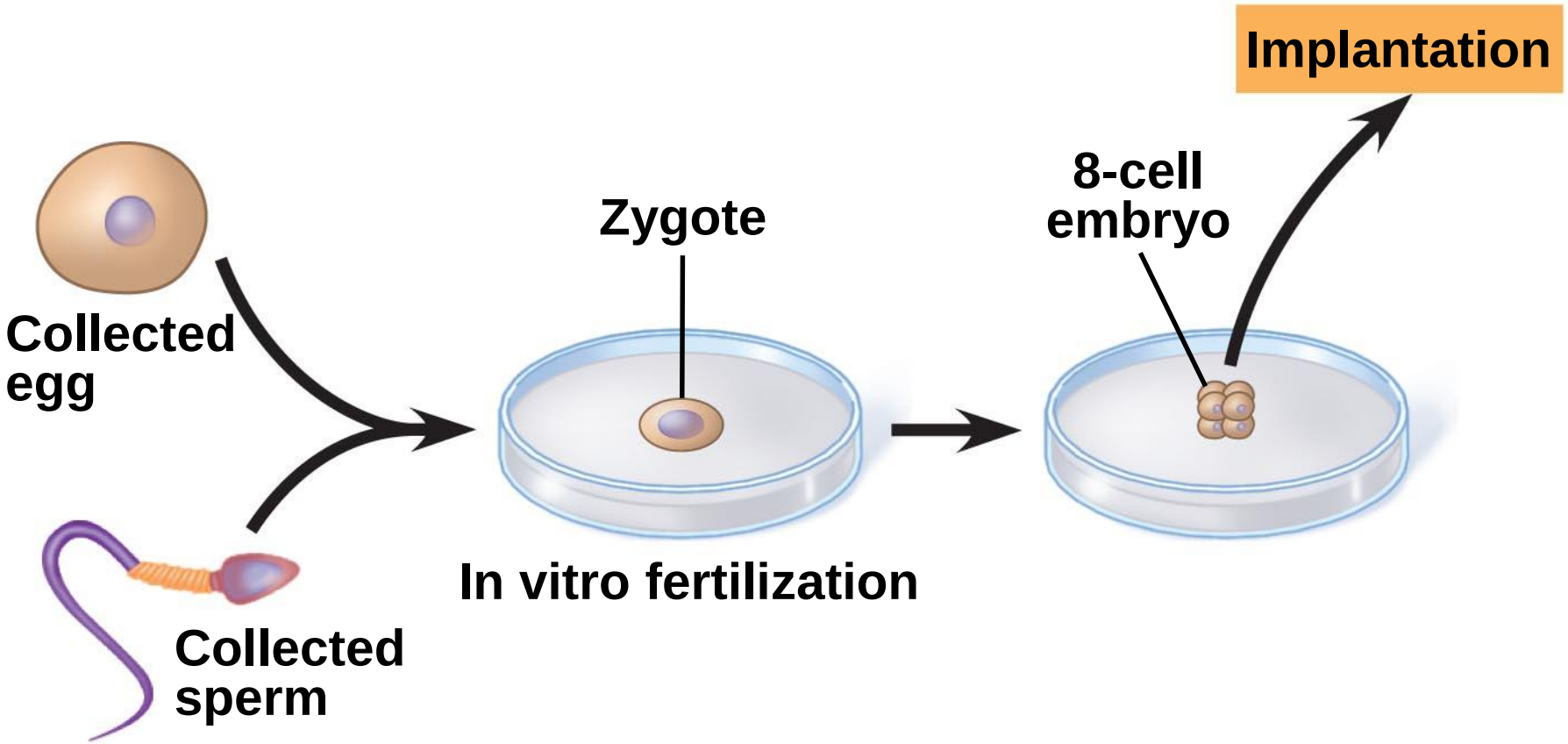
2 Expulsion: delivery of the infant

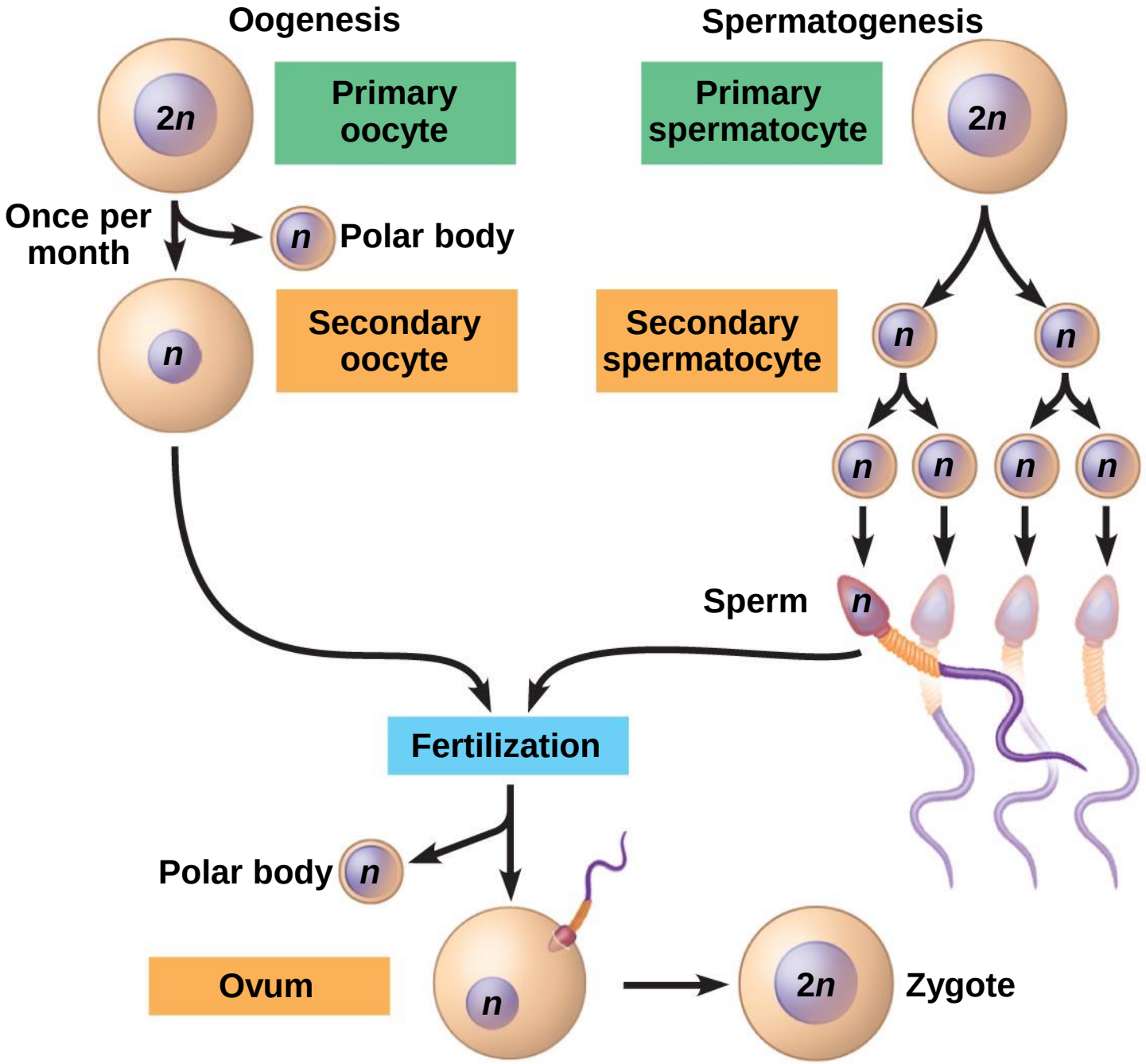


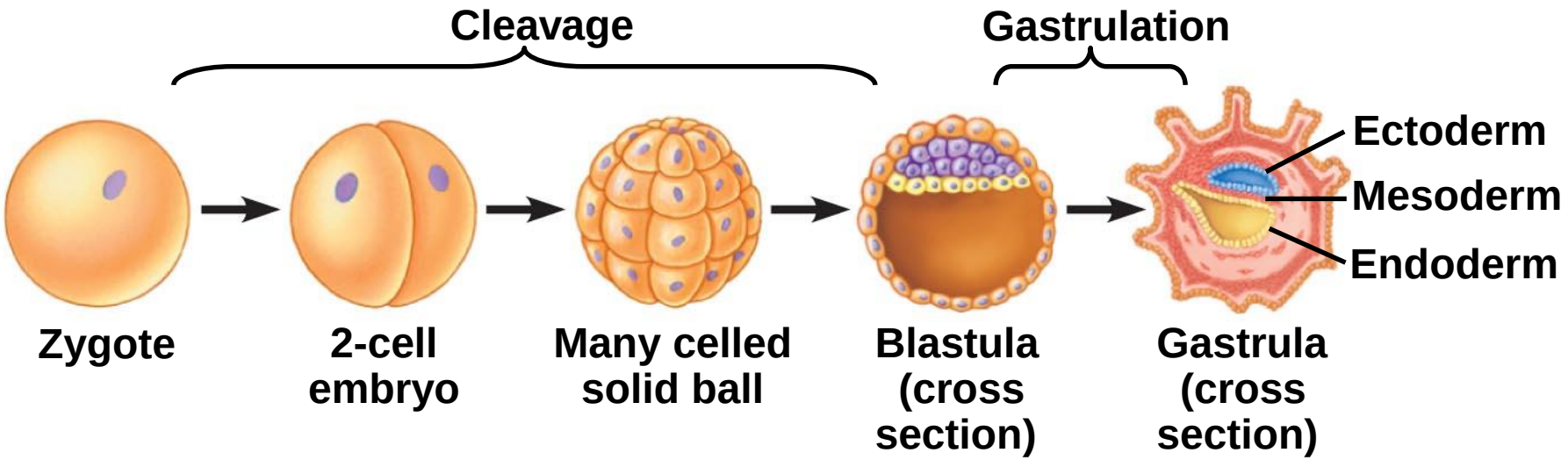
3 Delivery of the placenta

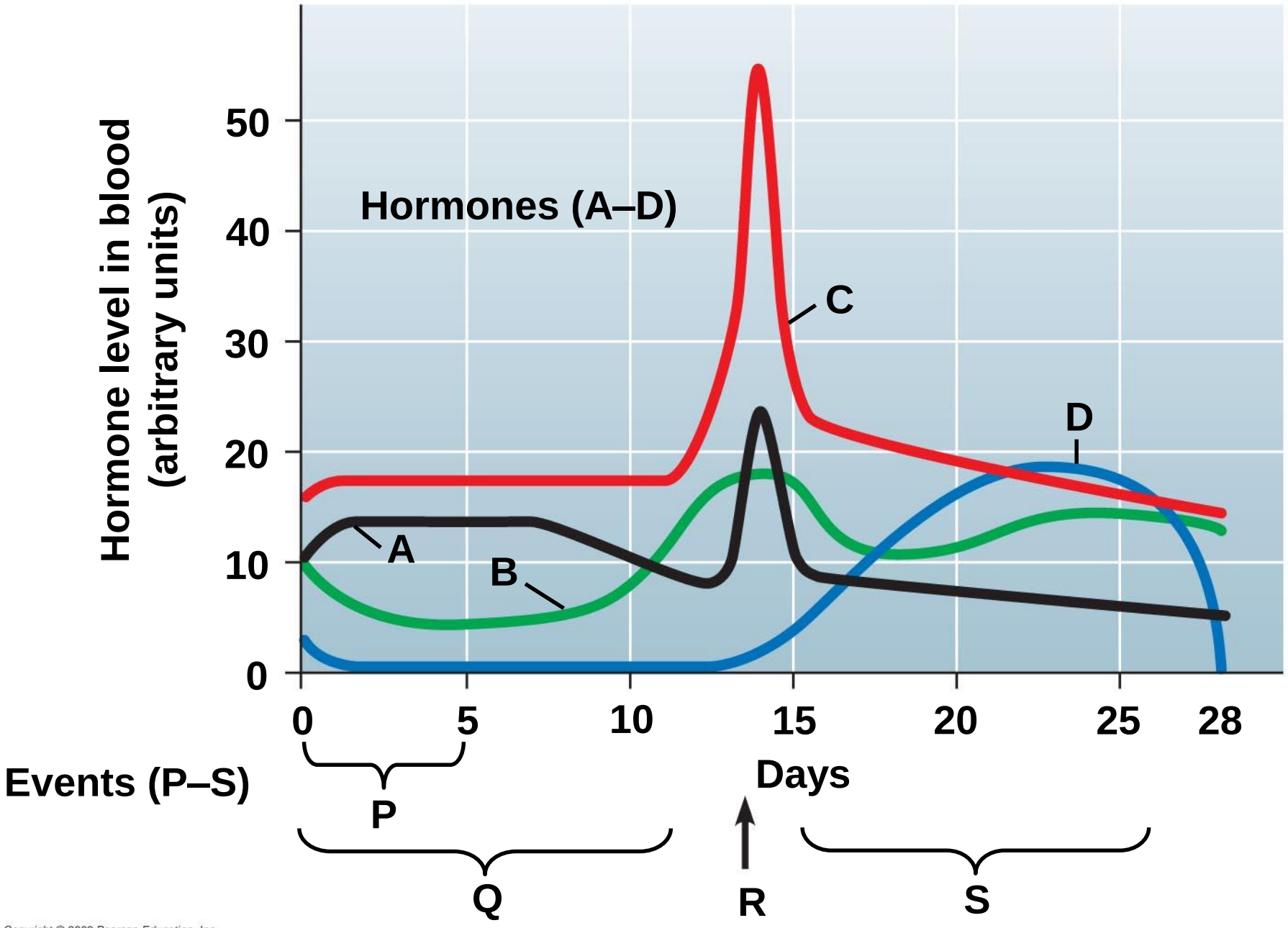
27.18 CONNECTION: Reproductive technology increases our reproductive options

- New techniques can help many infertile couples
  - About 15% of couples wanting children are infertile
  - Drug therapies
    - **Impotence**—erectile dysfunction
    - To induce ovulation
  - **Assisted reproductive technologies** (**ART**)
  - ***In vitro*** **fertilization** (**IVF**)









You should now be able to

1. Explain how fertility drugs have affected multiple births in the United States
2. Compare the types of asexual and sexual reproduction
3. Describe the structures and functions of the male and female human reproductive tracts
4. Describe and compare spermatogenesis and oogenesis
5. Describe the events of the menstrual cycle

You should now be able to

6. Describe the nature of the most common STDs
7. Describe the most common forms of birth control
8. Relate the structure of sperm to its roles in fertilization
9. Describe the processes of cleavage and gastrulation
10. Describe the functions of the four extraembryonic membranes

You should now be able to

11. Describe the main changes that occur during each trimester of human development

12. Describe the most common reproductive technologies