BIOLOGY Life on Earth
WITH PHYSIOLOGY Tenth Edition

Audesirk Audesirk Byers

42
Animal Development

Lecture Presentations by
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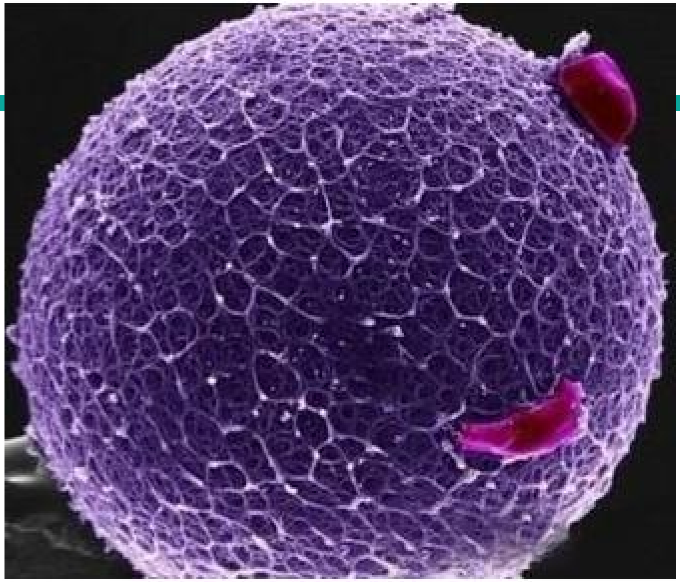
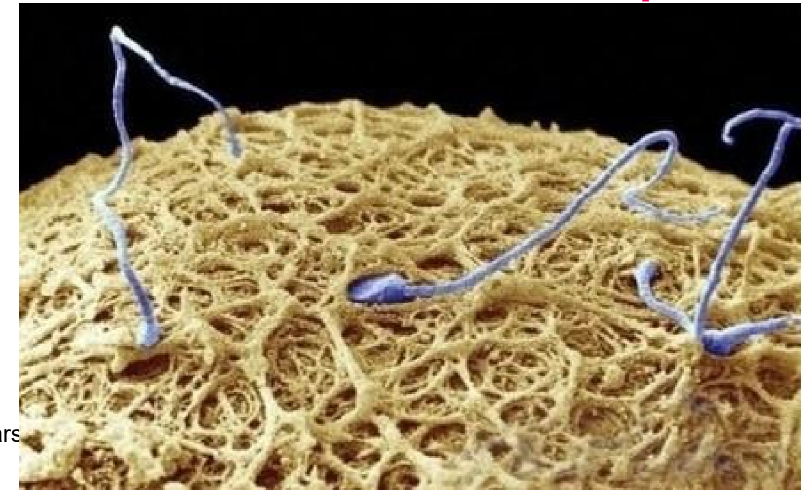
显微镜下，“她”(卵）仿若一个神秘的星球，美不胜收



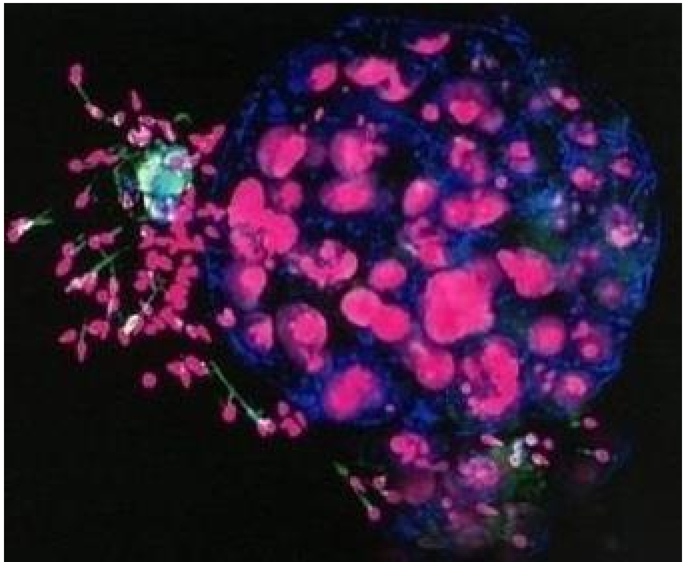
hundreds of sperm reach the egg

在一次受精过程中，无数赛跑的精子只为争取一个卵细胞，比例很夸张

100 million to 400 million sperms



一个成功受精的卵细胞，它宣告着一个鲜活生命的开始



Chapter 42 At a Glance

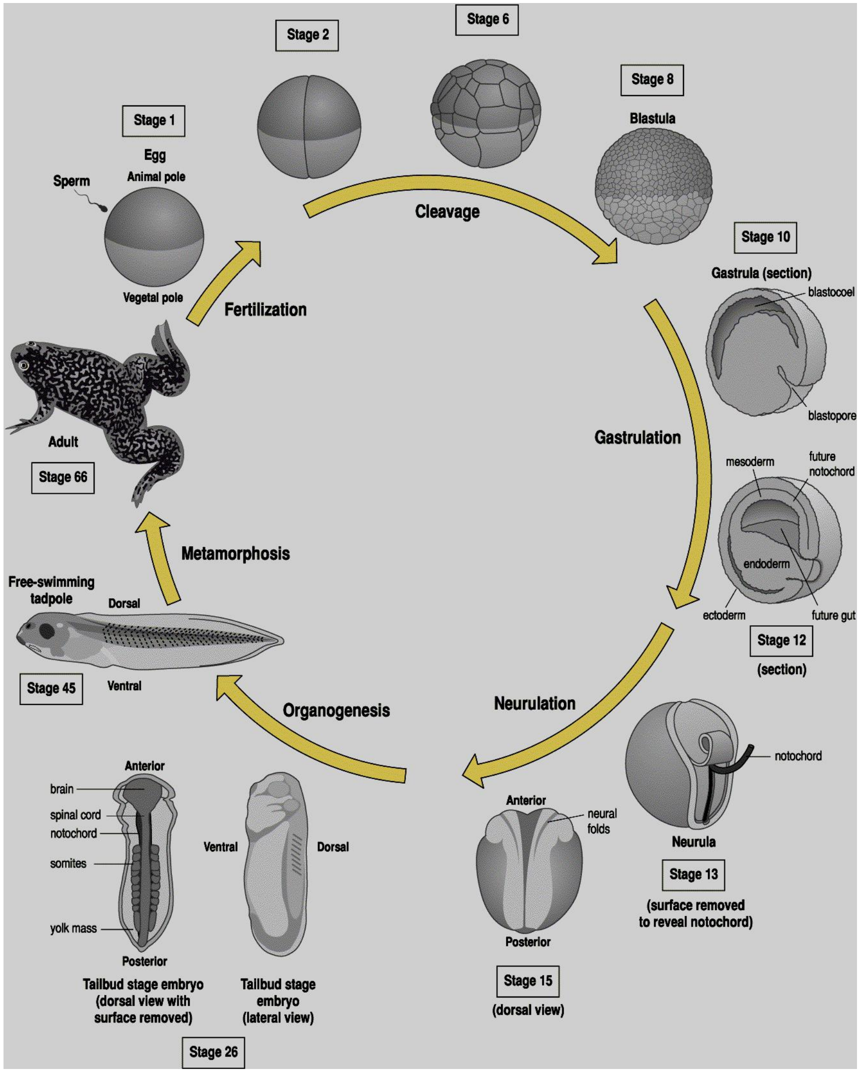
- 42.1 What Are the Principles of Animal Development?
- 42.2 How Do Indirect and Direct Development Differ?
- 42.3 How Does Animal Development Proceed?
- 42.4 How Is Development Controlled?
- 42.5 How Do Humans Develop?
- 42.6 Is Aging the Final Stage of Human Development?

- Cellular level: control cell proliferation and differentiation
- Molecular level: control gene expression

42.1 What Are the Principles of Animal Development?

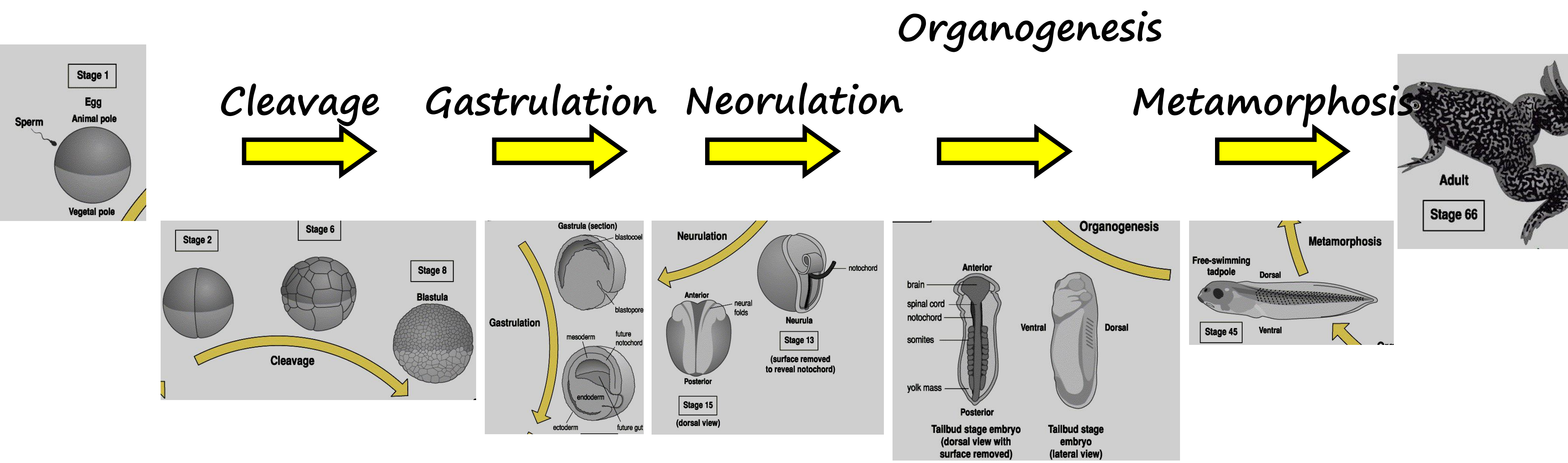
- **Development** is the process by which multicellular organisms grow and increase in organization and complexity
  - Development is usually considered to begin with a fertilized egg and end with a sexually mature adult

Life cycle of Xenopus



42.1 What Are the Principles of Animal Development?

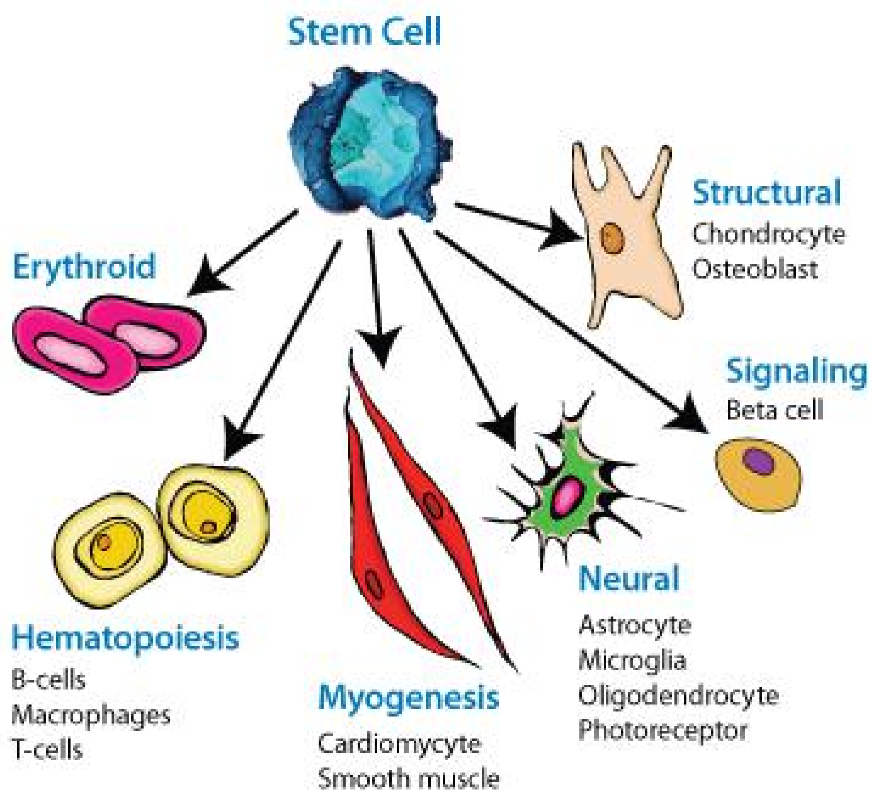
- Three principle mechanisms contribute to development
  - First, individual cells multiply **(proliferation)**
  - Second, some of their daughter cells **differentiate**, or specialize in both structure and function; for example, as nerve cells or muscle cells **(differentiation)**
  - Third, as they differentiate, groups of cells move about and become organized into multicellular structures, such as a brain or a biceps muscle **(morphogenesis)**

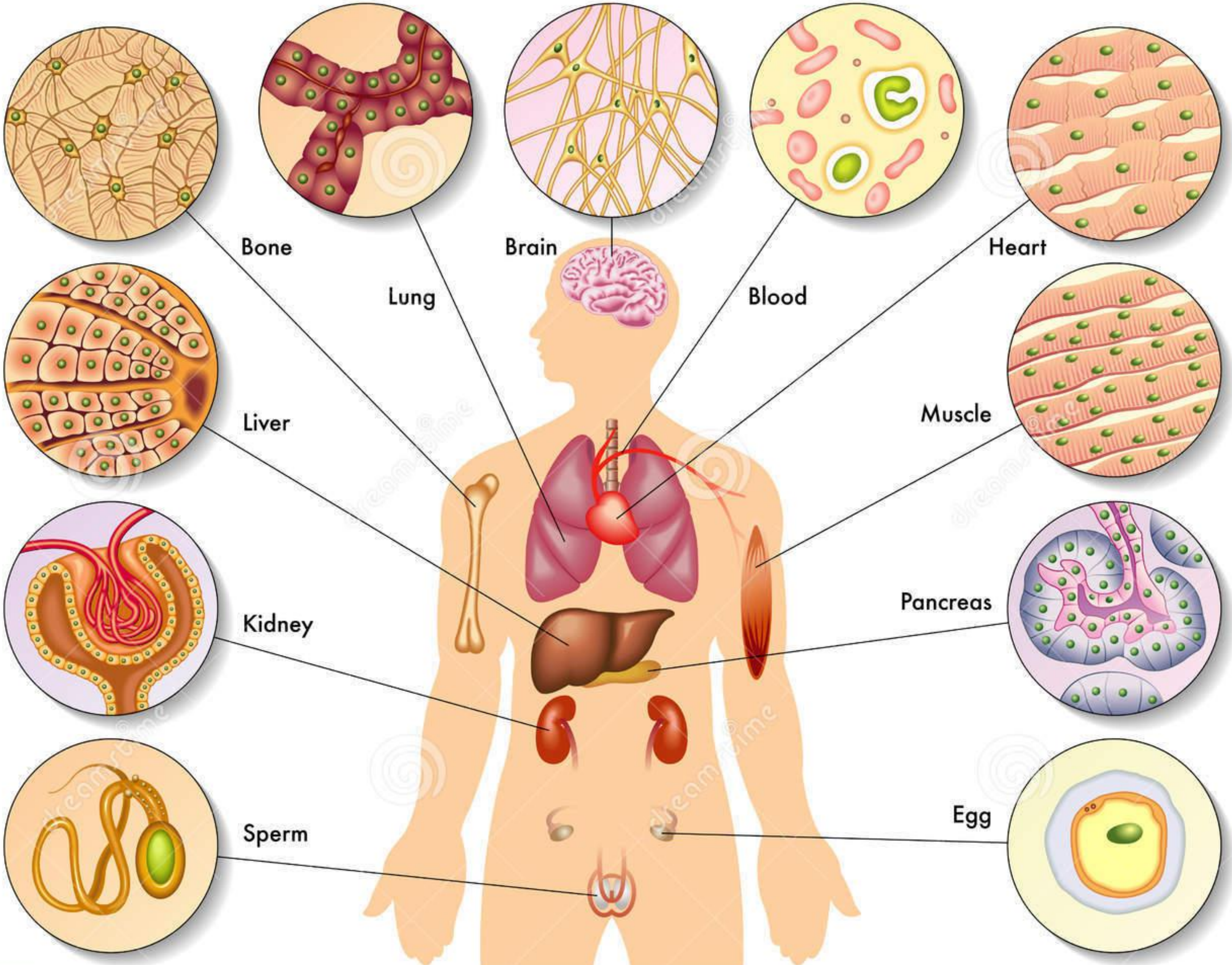

Organogenesis
Cleavage
Gastrulation
Neorulation
Metamorphosis
Stage 1
Egg
Sperm
Animal pole
Vegetal pole
Stage 2
Stage 6
Stage 8
Blastula
Cleavage
Gastrula (section)
blastocoel
blastopore
Gastrulation
mesoderm
future notochord
endoderm
ectoderm
future gut
Neurulation
notochord
Anterior
neural folds
Neurula
Stage 13
(surface removed to reveal notochord)
Posterior
Stage 15
(dorsal view)
Organogenesis
Anterior
brain
spinal cord
notochord
somites
yolk mass
Posterior
Ventral
Dorsal
Tailbud stage embryo (dorsal view with surface removed)
Tailbud stage embryo (lateral view)
Metamorphosis
Free-swimming tadpole
Dorsal
Stage 45
Ventral
Adult
Stage 66

42.1 What Are the Principles of Animal Development?

- All of the cells of an individual animal's body are genetically identical to one another and to the fertilized egg from which they came
- Genetically identical cells differentiate and become remarkably different structures through the use of different genes in different places in an animal's body and at different times during an animal's life (differential expression)

Mechanisms of cellular differentiation




Bone
Lung
Brain
Blood
Heart
Liver
Muscle
Kidney
Pancreas
Sperm
Egg

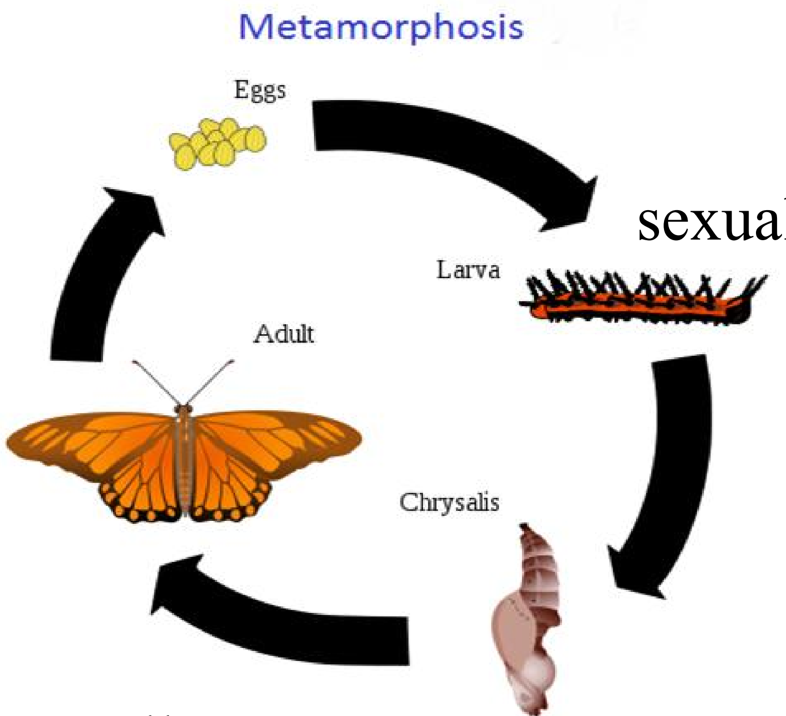
42.2 How Do Indirect and Direct Development Differ?

- Baby mammals and reptiles (including birds) are miniature versions of the adults of their species, undergoing a process called **direct development**

No **Metamorphosis**

- Many animal species, however, undergo **indirect development**, in which the newborn has a very different body structure than the adult

indirect development



sexually immature

sexually mature

1. occurs in amphibians and in most invertebrates.
2. typically produces huge numbers of eggs.
3. The yolk nourishes the developing embryo until **larva** stage.
4. **larva** feeds by itself for a period of time
5. Metamorphosis

Figure 42-1 Indirect development

(a) Caterpillar (larva)

(b) Butterfly (adult)

42.2 Direct Development

- **Newborn** resemble **miniature** adults
  - the newborn animal closely resembles the adult.

    including some **snails** and **fish**, **all mammals** and **reptile**s (including birds)

  - W/o undergoing metamorphosis

    grow bigger, but does not fundamentally change its body form

Figure 42-2 Direct development

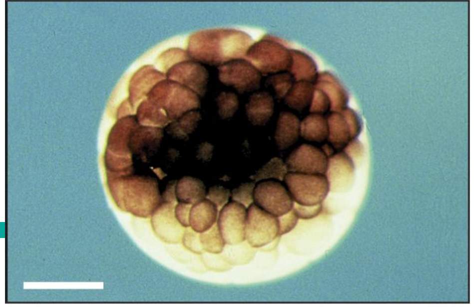
(a) Seahorses

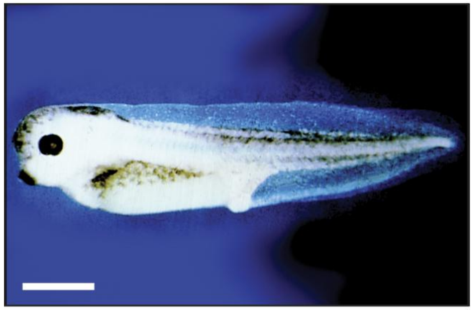
(b) Snails

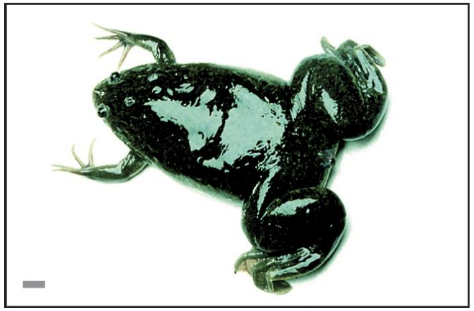
(c) Polar bears

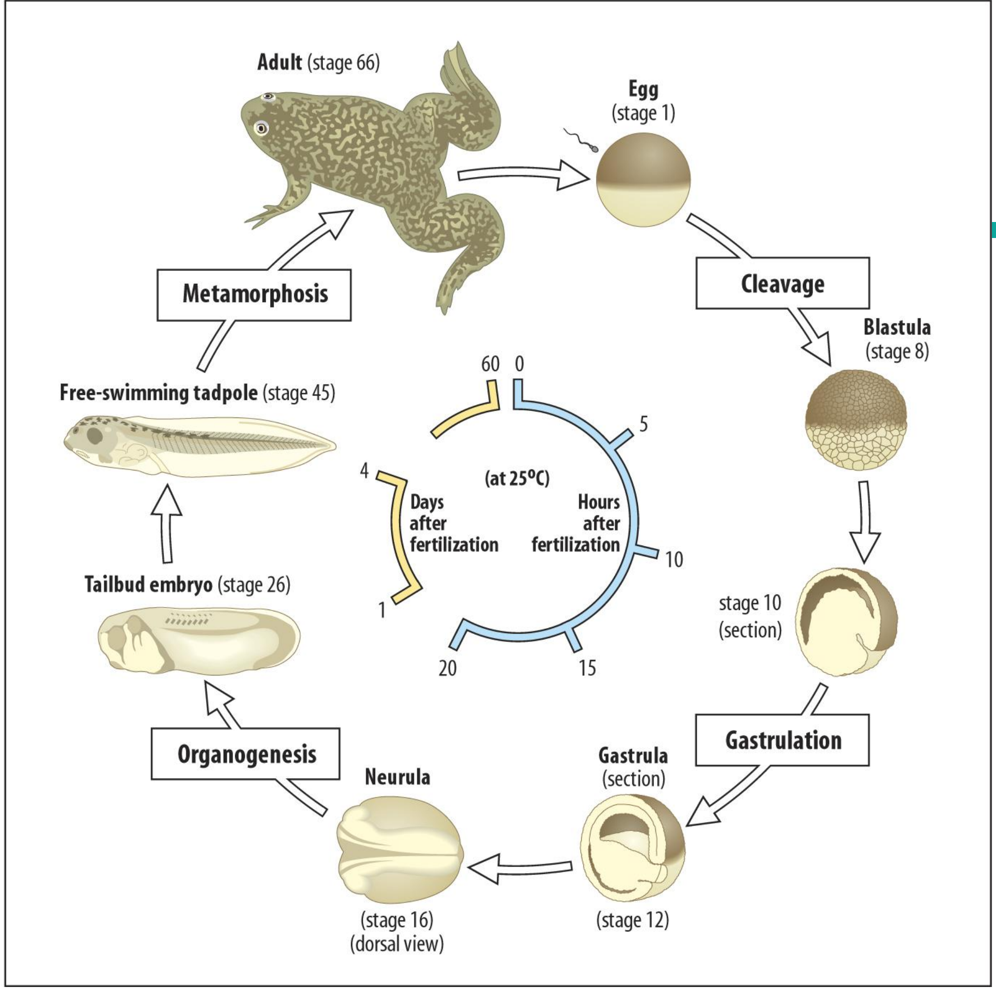
42.3 How Does Animal Development Proceed?

- Most of the mechanisms of development are similar in all animals
- Amphibians have long been favored subjects for the study of development because:

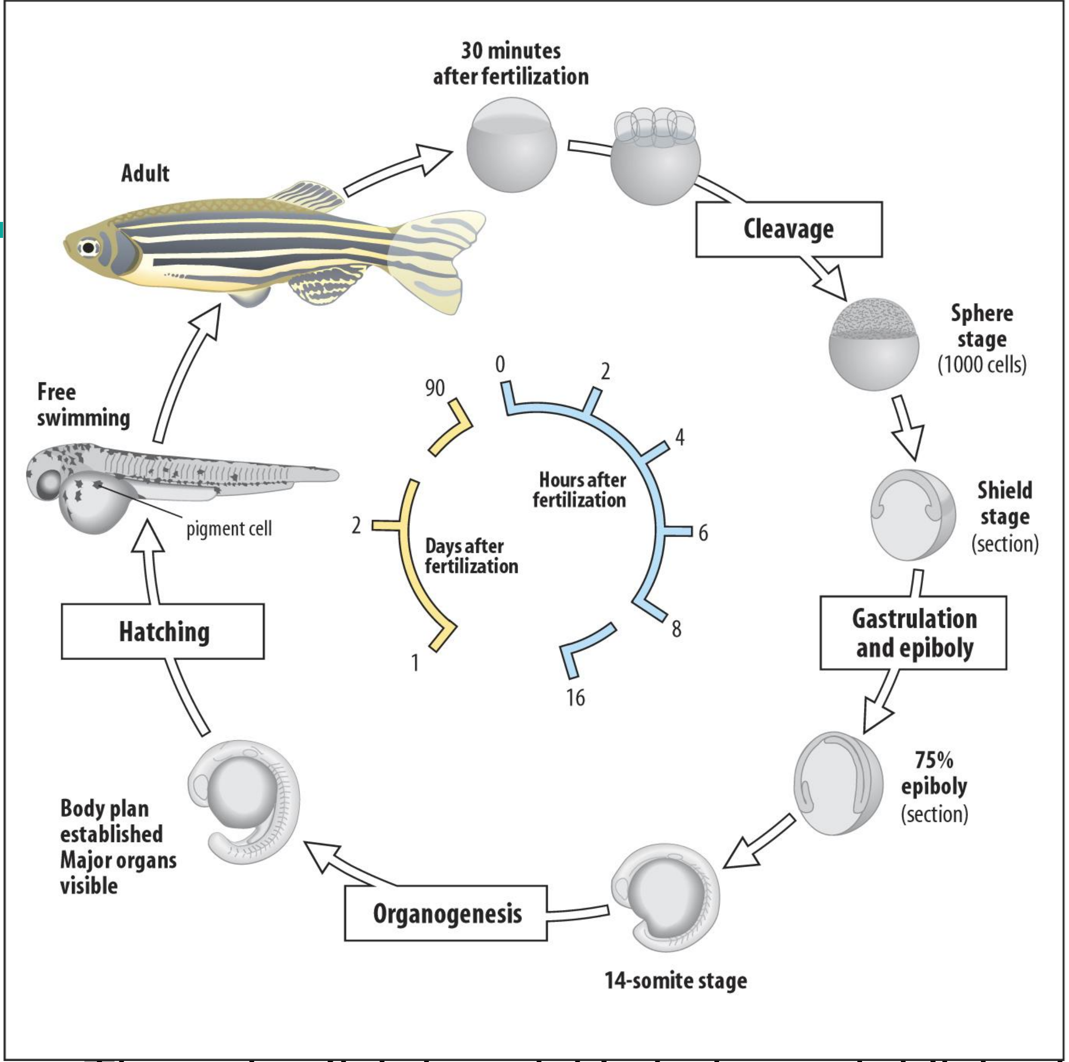


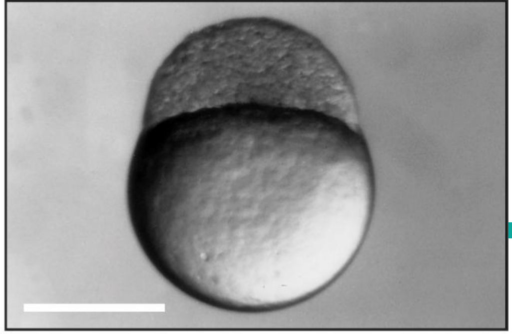


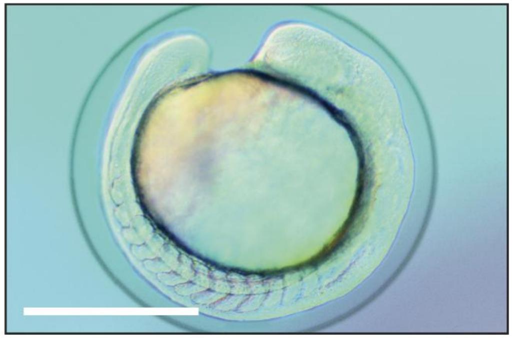




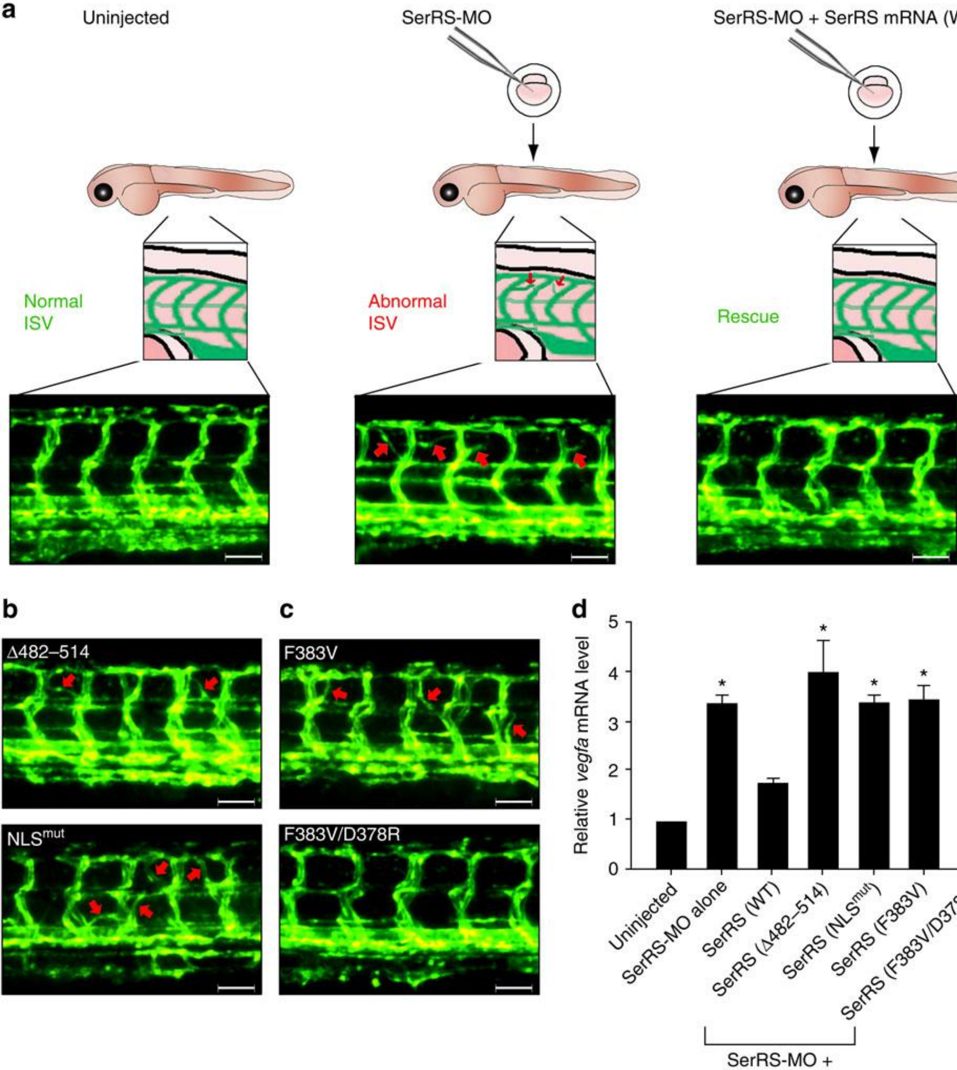
- breed at any time of year
- produce numerous large eggs and embryos
- develop in water and can be easily observed
- Most aspects of amphibian development are comparable to the development of other vertebrates

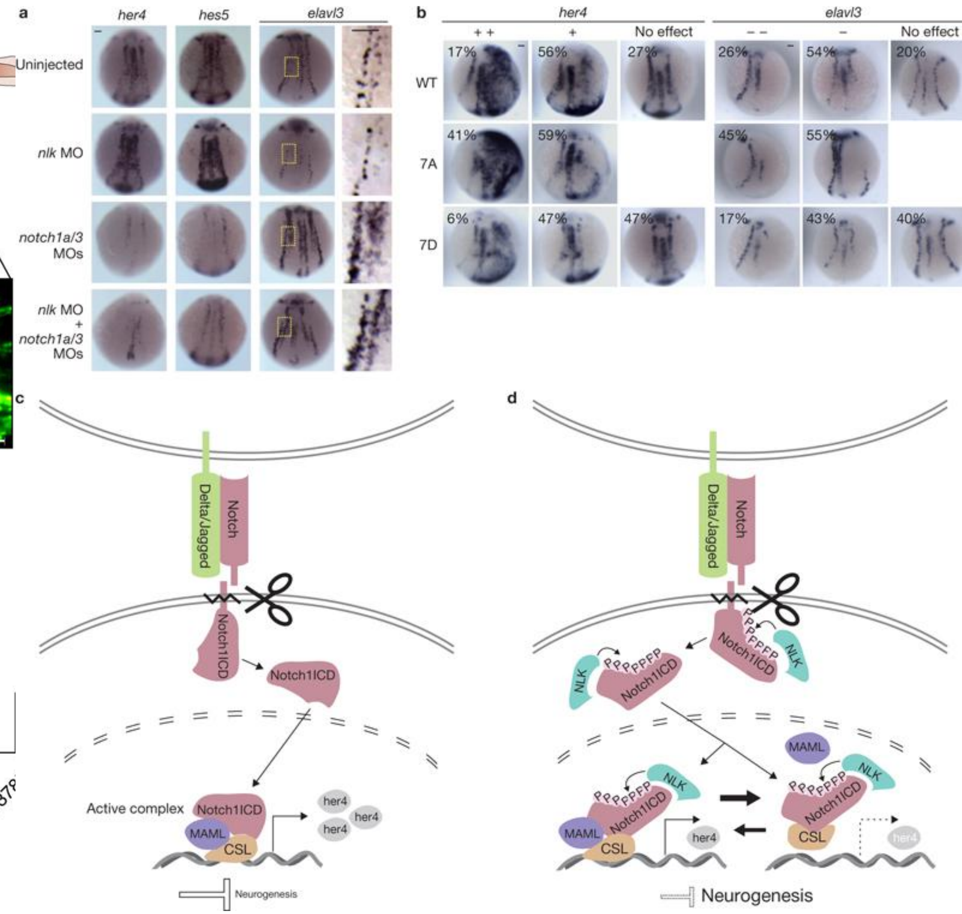






- The zebrafish is quickly being established as the model for fish development.
  The short life cycle of ~12 weeks and the transparent 0.7 mm embryo are great advantages.
  Similar to the chick, cleavage does not involve the yolk and results in a zygote forming on top of the yolk


a
Uninjected
SerRS-MO
SerRS-MO + SerRS mRNA (WT)
Normal ISV
Abnormal ISV
Rescue
b
Δ482–514
NLS^mut
c
F383V
F383V/D378R
d
Relative vegfa mRNA level
Uninjected
SerRS-MO alone
SerRS (WT)
SerRS (Δ482–514)
SerRS (NLS^mut)
SerRS (F383V)
SerRS-MO +


a
her4
hes5
elavl3
Uninjected
nlk MO
notch1a/3 MOs
nlk MO + notch1a/3 MOs
b
her4
elavl3
No effect
WT
7A
7D
17%
56%
27%
26%
54%
20%
41%
59%
45%
55%
6%
47%
47%
17%
43%
40%
c
Delta/Jagged
Notch
Notch1ICD
Active complex
MAML
CSL
her4
Neurogenesis
d
NLK
MAML
CSL
Notch1ICD
her4
Neurogenesis

42.3 How Does Animal Development Proceed?

- **Cleavage**

Cleavage of the zygote begins development

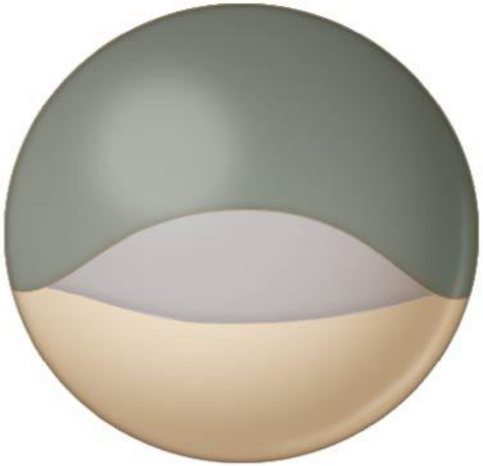
- **Zygote:** a fertilized egg
- **Cleavage:** a series of mitotic cell divisions collectively called Cleavage

The **zygote is a very large cell**

- A frog zygote, for example, may be a million times larger than an average cell in an adult frog

During cleavage, there is **little or no cell growth** between cell divisions

Figure 42-3a Zygote

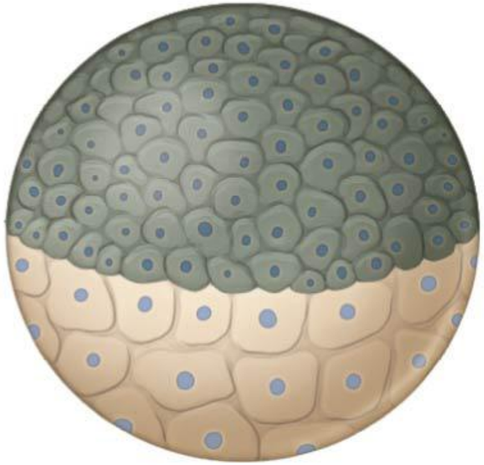


(a) Zygote

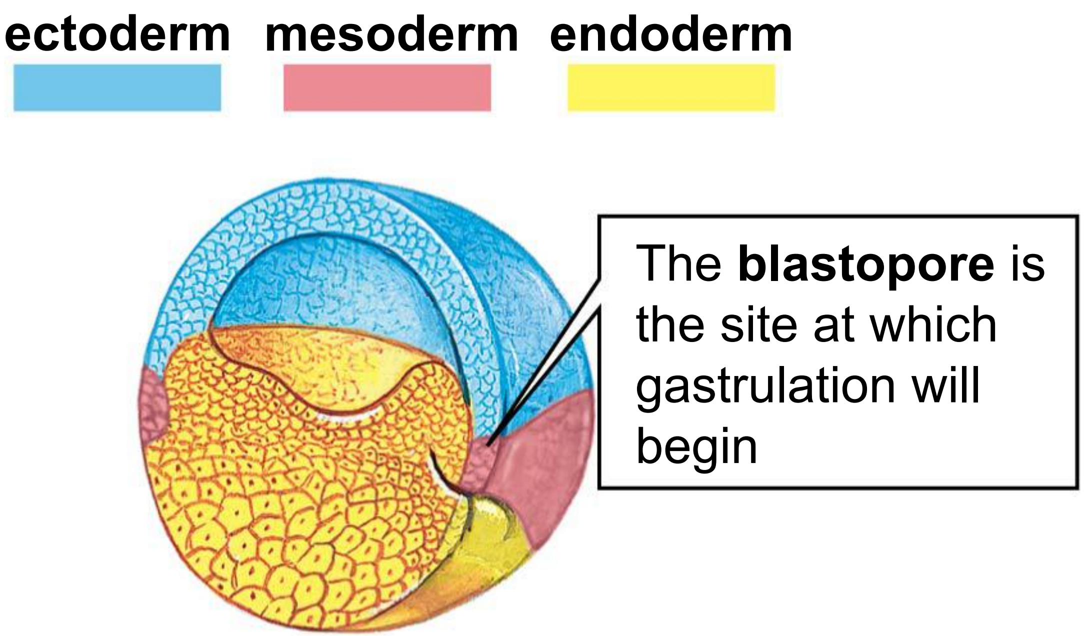
42.3 How Does Animal Development Proceed?

- Cleavage of the zygote begins development *(continued)*
  - After a few cell divisions, a solid ball of cells, the **morula**, is formed
  - As cleavage continues, a cavity opens within the morula, and the cells become the outer covering of a hollow structure called the **blastula**

Figure 42-3b Cleavage of the zygote forms a morula

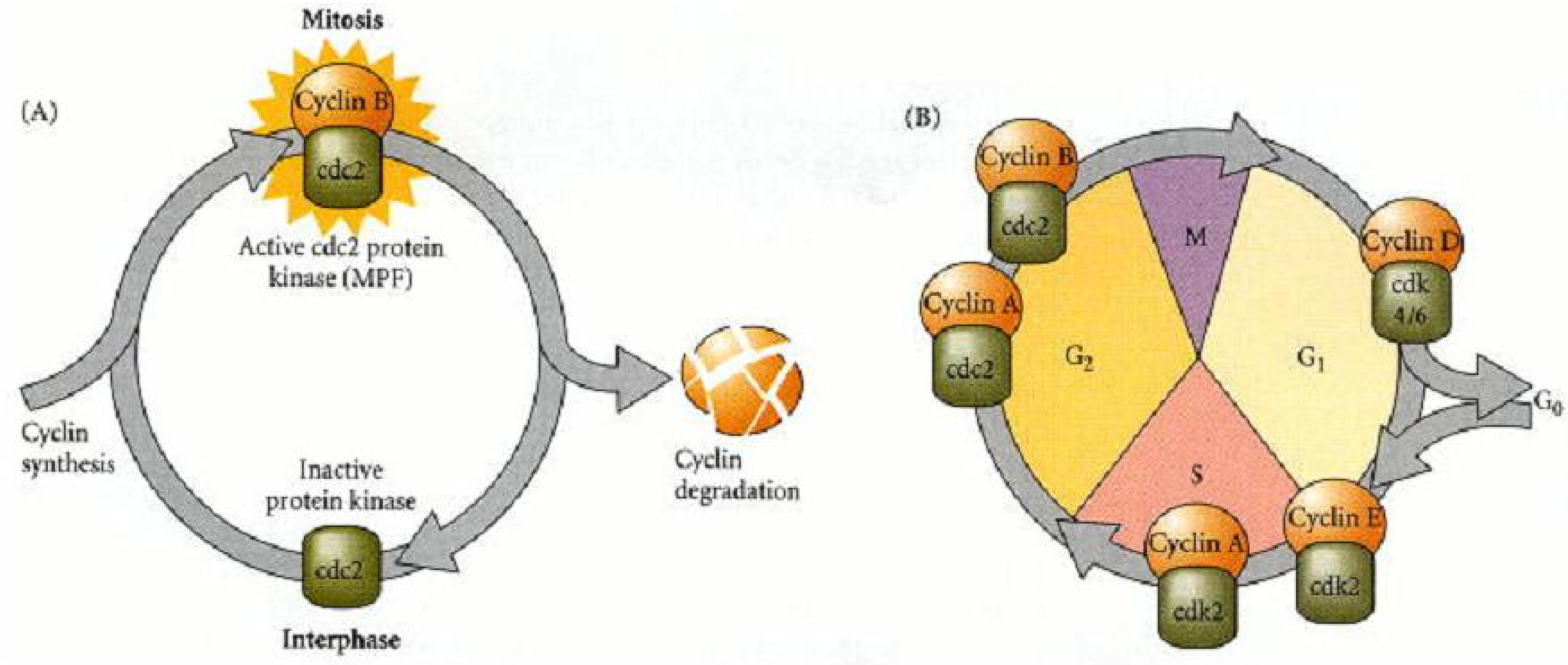


(b) Cleavage of the zygote forms a morula



(c) The **blastula** just before gastrulation

Comparison of Cell cycle in somatic and blastomere cells



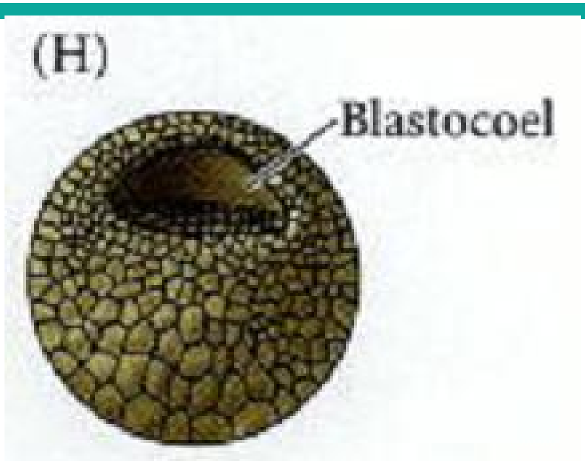
biphasic cell cycleof early blastomeres

The early divisions of most species tend to be rapid and synchronous.

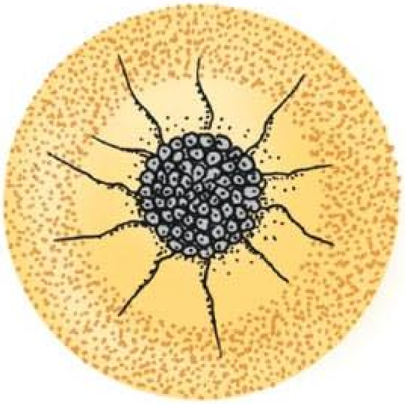
42.3 How Does Animal Development Proceed?

- Cleavage of the zygote begins development *(continued)*
  - The details of cleavage differ by species

    partly determined by the amount of yolk



hollow blastula



blastula
in birds and other reptiles

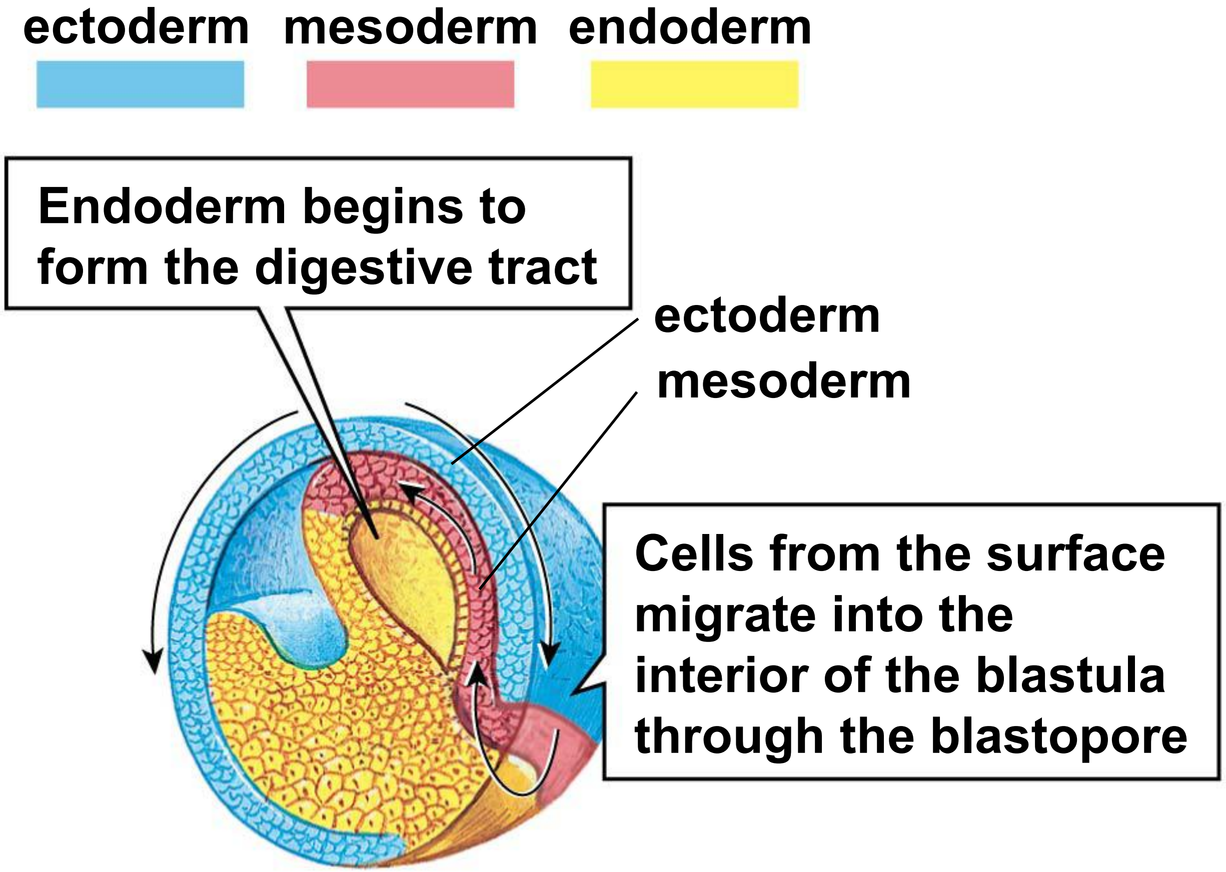
42.3 How Does Animal Development Proceed?

- Gastrulation forms three tissue layers

  Gastrulation : literally, "producing the stomach"

Gastrulation is a phase early in the embryonic development of most animals, during which the single-layered blastula is reorganized into a trilaminar ("three-layered") structure known as the **gastrula**. These three *germ layers* are known as the ectoderm, mesoderm, and endoderm

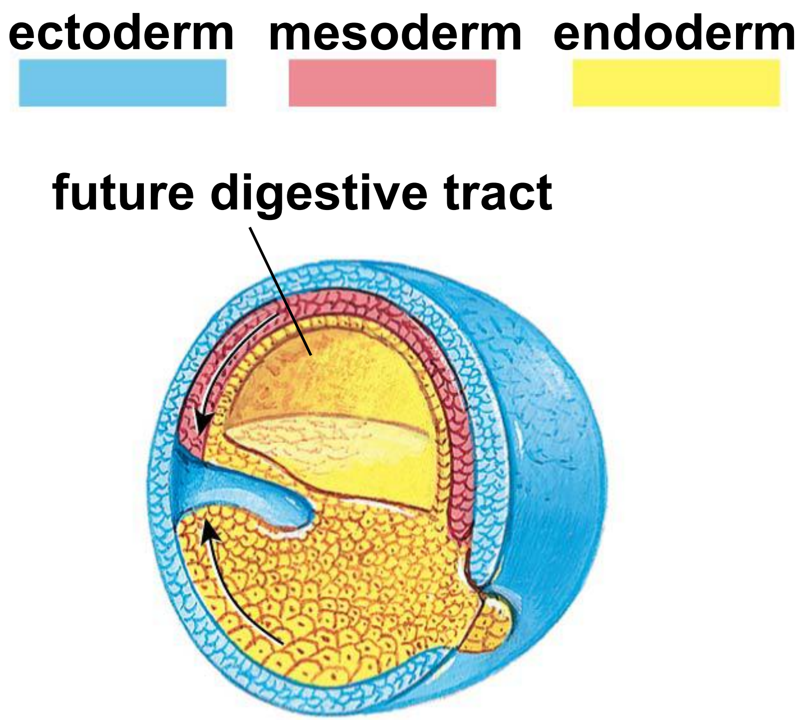
Figure 42-3d Cells migrate at the start of gastrulation



(d) Cells migrate at the start of gastrulation

Gastrulation begins when a dimple called the **blastopore** forms on one side of the blastula

- The dimple enlarges, going deeper and deeper into the blastula and forming a cavity that will eventually become the digestive tract.
- The migrating cells form the three tissue layers in the embryo, which is now called the **gastrula**



(e) A three-layered gastrula has formed

– The cells that move through the blastopore to line the future digestive tract are called **endoderm**

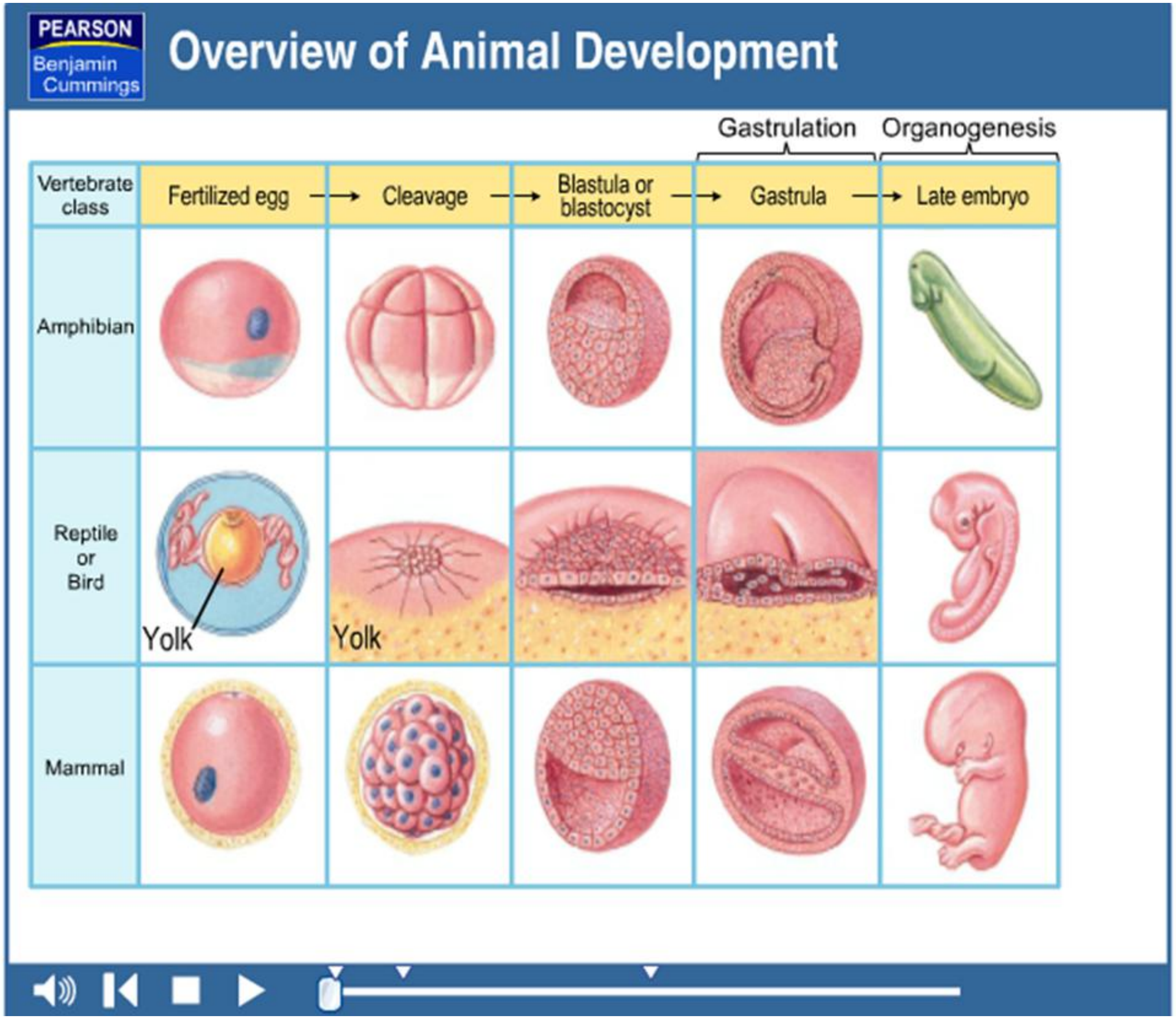
– The cells remaining on the outside of the developing gastrula are called **ectoderm**

– Cells that migrate between the endoderm and ectoderm form the third layer, called the **mesoderm**

Table 42-1 Derivation of Adult Tissues from Embryonic Cell Layers

TABLE 42-1 Derivation of Adult Tissues from Embryonic Cell Layers

Embryonic Layer	Adult Tissue
Ectoderm	Epidermis of the skin; hair; lining of the mouth and nose; glands of the skin; nervous system
Mesoderm	Dermis of the skin; muscle, skeleton; circulatory system; gonads; kidneys; outer layers of the digestive and respiratory tracts
Endoderm	Lining of the digestive and respiratory tracts; liver; pancreas



Animation: Overview of Animal Development

42.3 How Does Animal Development Proceed?

- The major body parts develop during organogenesis
  - **Organogenesis** is the development of the body's organs from the three embryonic layers
  - Two major processes influence organogenesis
    1. A series of "master switch" genes turn on and off in specific cells
    2. In development, the sculpting of body parts often requires the death of excess cells

42.3 How Does Animal Development Proceed?

- **extraembryonic membranes**

1. reptiles and mammals
2. many amphibians
3. Fish
   - By being immersed in water, the embryo does not dehydrate
     - The water surrounding the embryo supplies it with oxygen and carries away its waste, including CO_2

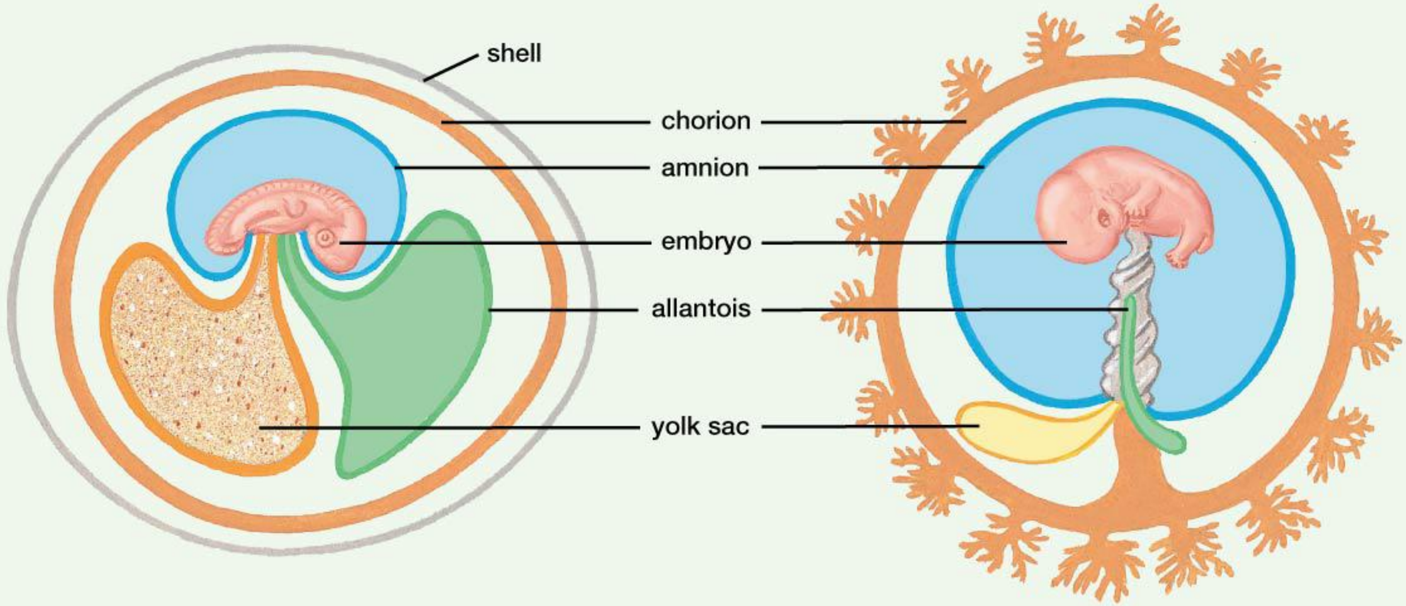
42.3 How Does Animal Development Proceed?

Fully terrestrial vertebrate -----**amniotic egg**

- reptiles, birds, mammals
- It allows members of these groups to complete their development into the adult form in their own "private pond"

Table 42-2 Vertebrate Embryonic Membranes

TABLE 42-2 Vertebrate Embryonic Membranes



Membrane	Structure (Reptile)	Function (Reptile)	Structure (Mammal)	Function (Mammal)
Chorion	Membrane lining the inside of the shell	Acts as a respiratory surface; regulates the exchange of gases and water between the embryo and the air	Fetal contribution to the placenta	Provides for the exchange of gases, nutrients, and wastes between the embryo and the mother
Amnion	Sac surrounding the embryo	Encloses the embryo in fluid	Sac surrounding the embryo	Encloses the embryo in fluid
Allantois	Sac connected to the embryonic urinary tract; a capillary-rich membrane lining the inside of the chorion	Stores wastes (especially urine); acts as a respiratory surface	Membranous sac arising from the gut; varies in size	May store metabolic wastes; contributes to the umbilical cord blood vessels
Yolk sac	Membrane surrounding the yolk	Contains yolk as food; digests yolk and transfers its nutrients to the embryo	Small, membranous, fluid-filled sac	Helps absorb nutrients from the mother; forms blood cells; contributes to the umbilical cord

42.3 How Does Animal Development Proceed?

- Development in reptiles and mammals depends on extraembryonic membranes *(continued)*
  - In mammals (except for platypuses(鸭嘴兽) and echidnas(针鼹), which lay eggs), the embryo develops within the mother's body until birth
    - Nevertheless, all four extraembryonic membranes still persist, and in fact are essential for development

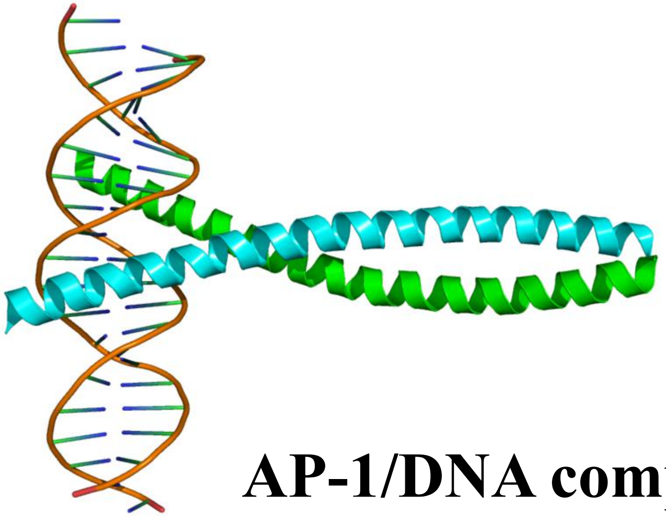
42.4 How Is Development Controlled?

- A zygote contains all of the genes needed to produce an entire animal
  - Nearly every cell of the body also contains all of these genes
  - In any given cell, however, some genes are used, or expressed, while others are not
    - The differentiation of cells during development arises because of these differences in gene expression

42.4 How Is Development Controlled?

- There are several methods of **controlling gene expression**
  - *Transcription*----- mRNA,

    Every cell contains proteins, called *transcription factors*, that bind to specific genes and turn their transcription on or off



AP-1/DNA complex.

42.4 How Is Development Controlled?

- Embryonic development is driven by one or both of two processes

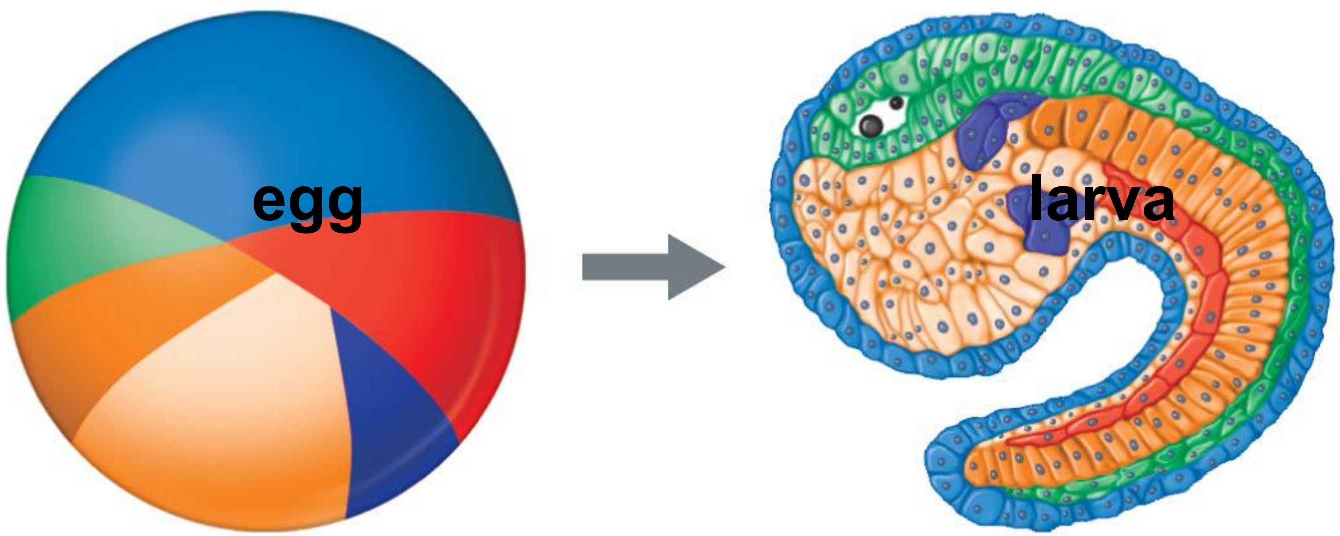
   1. The actions of **transcription factors** and other gene-regulating substances inherited from the mother's egg (Maternal transcripts)

   The sperm contributes little more than a nucleus

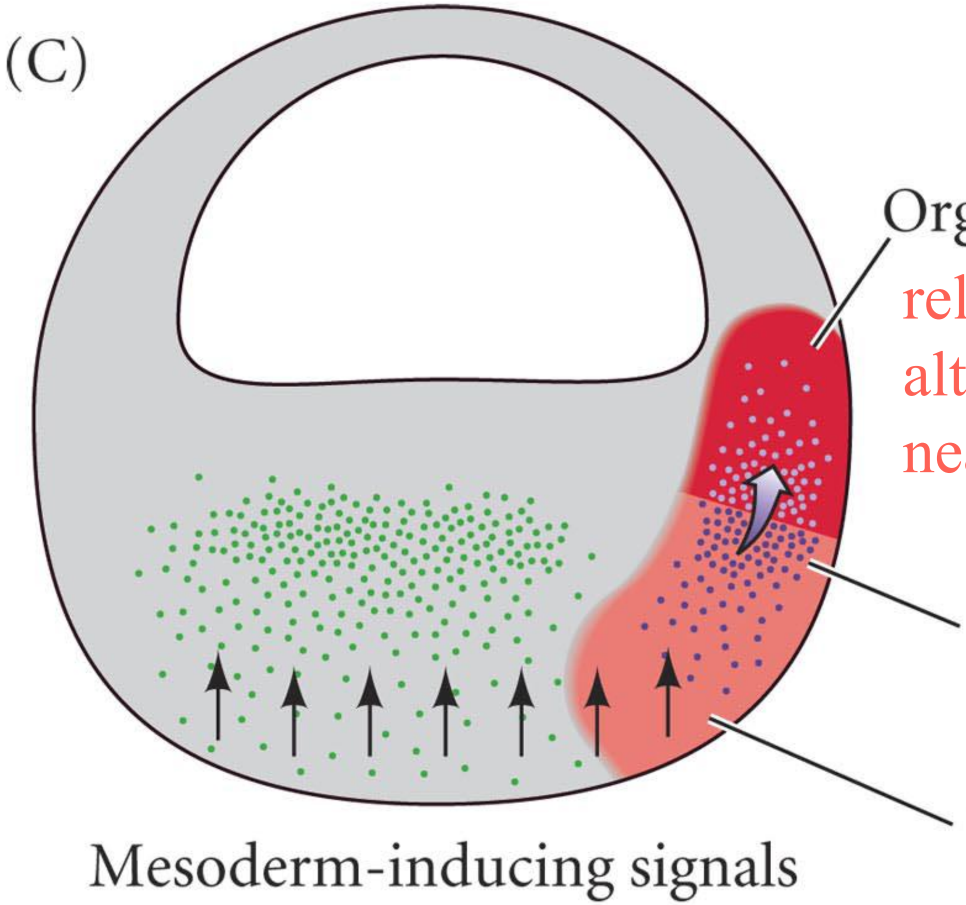
   2. Cell-embryo chemical communication (Signaling transduction)

Figure 42-4 A "fate map" of the sea squirt egg

– In the sea squirt egg, cells that receive certain parts of the cytoplasm will form the skin, cells that receive other cytoplasmic portions will form the nervous system



During later development, the fate of each cell is determined by chemical interactions between cells in a process called **induction**



release chemical messengers that alter the development of other nearby cells (**induction**)

DEVELOPMENTAL BIOLOGY, Seventh Edition, Figure 10.22 (Part 2) Sinauer Associates, Inc.

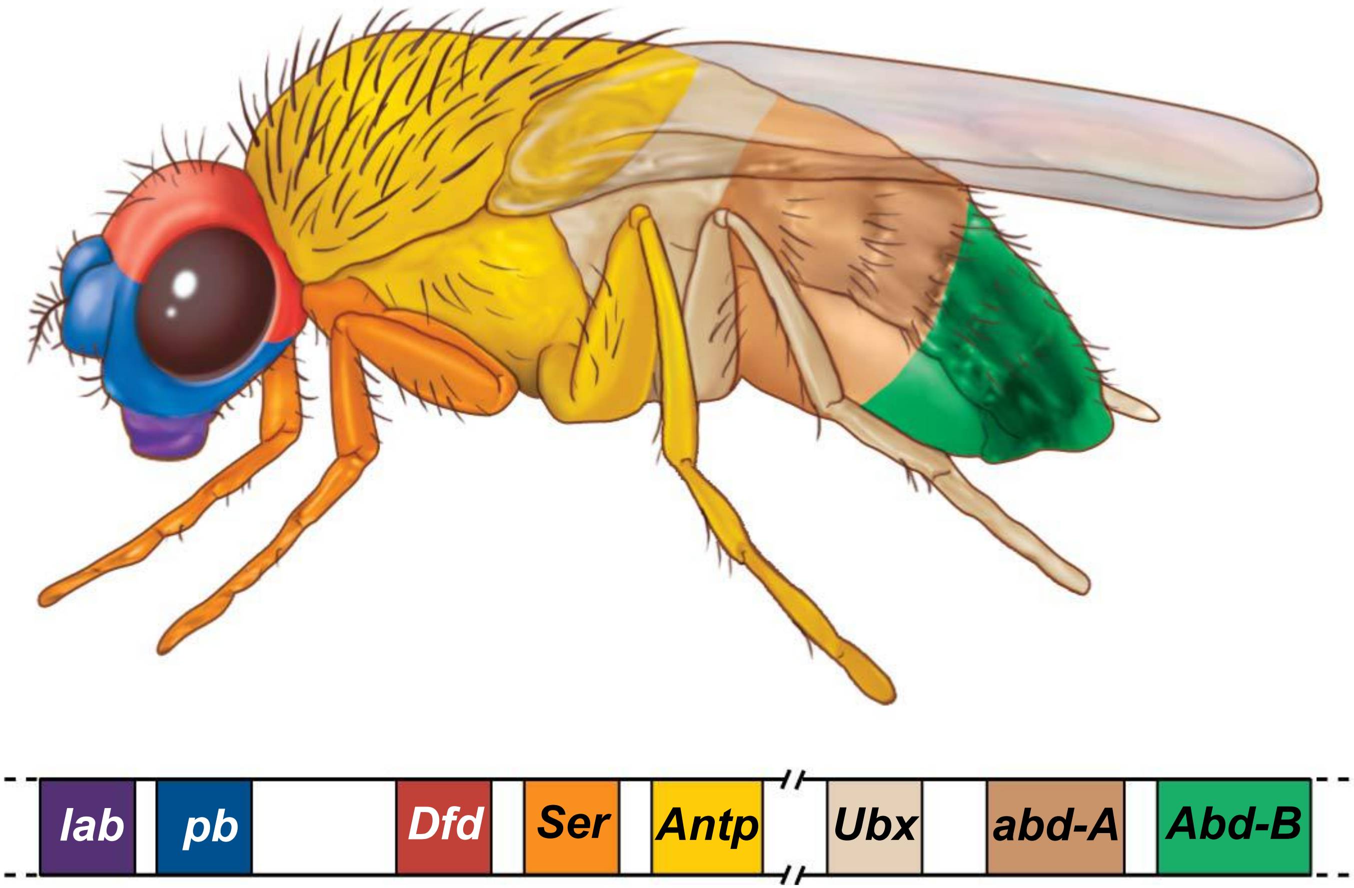
42.4 How Is Development Controlled?

- Homeobox genes regulate development of entire segments of the body

  Homeobox genes are found in animals as diverse as fruit flies, frogs, and humans (evolutionarily conserved)

  - master genes coding for transcription factors
  - Each homeobox gene has major responsibility for the development of a particular region in the body

Figure 42-5 Homeobox genes regulate development of body segments



A Four-winged Fruit Fly Constructed by Putting Together Three Mutations in cis Regulators of the

Homeotic mutants

Ultrabithorax gene is deleted
T3 to T2 transformation

42.5 How Do Humans Develop?

42.5 How Do Humans Develop?

- Human development is **controlled by the same mechanisms** that control the development of other animals
- In fact, our development strongly reflects our evolutionary heritage

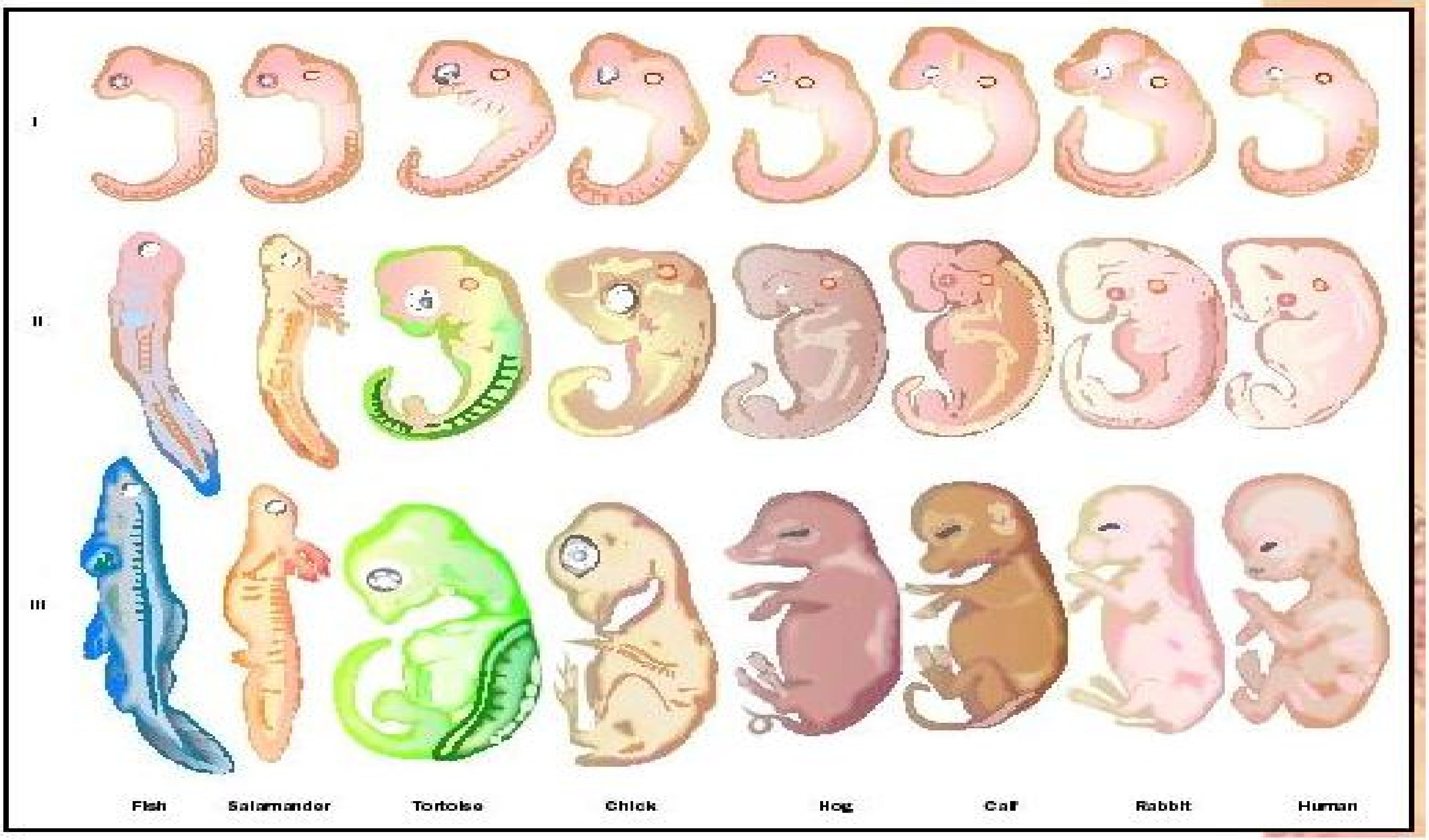


Illustration of von Baer's law

42.5 How Do Humans Develop?

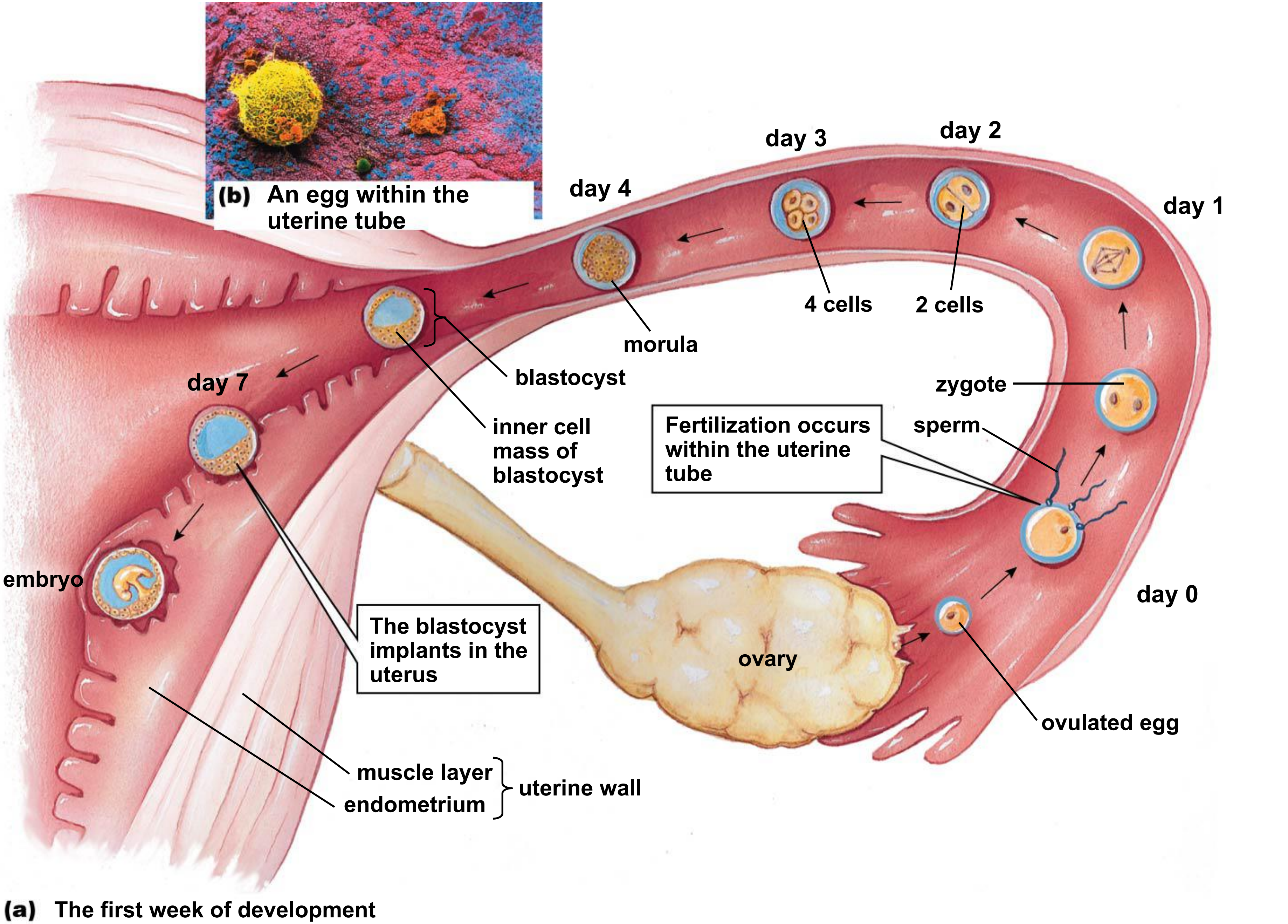
- Differentiation and embryonic growth are rapid during the first two months
  - Fertilization of a human egg usually takes place in the uterine tube

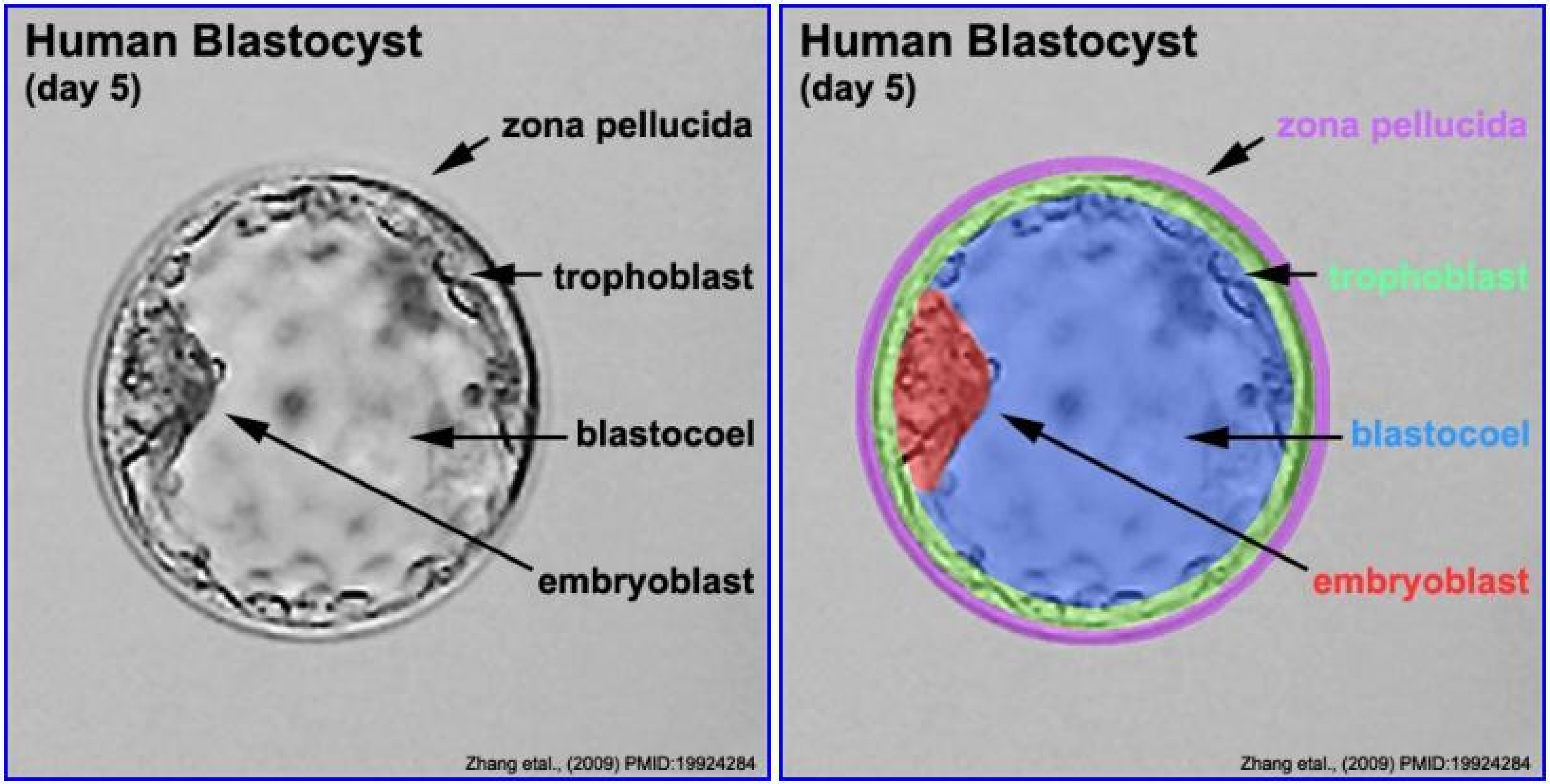
zygote → **morula** → **blastocyst** → **Implantation (**chorion**)**

(blastula)

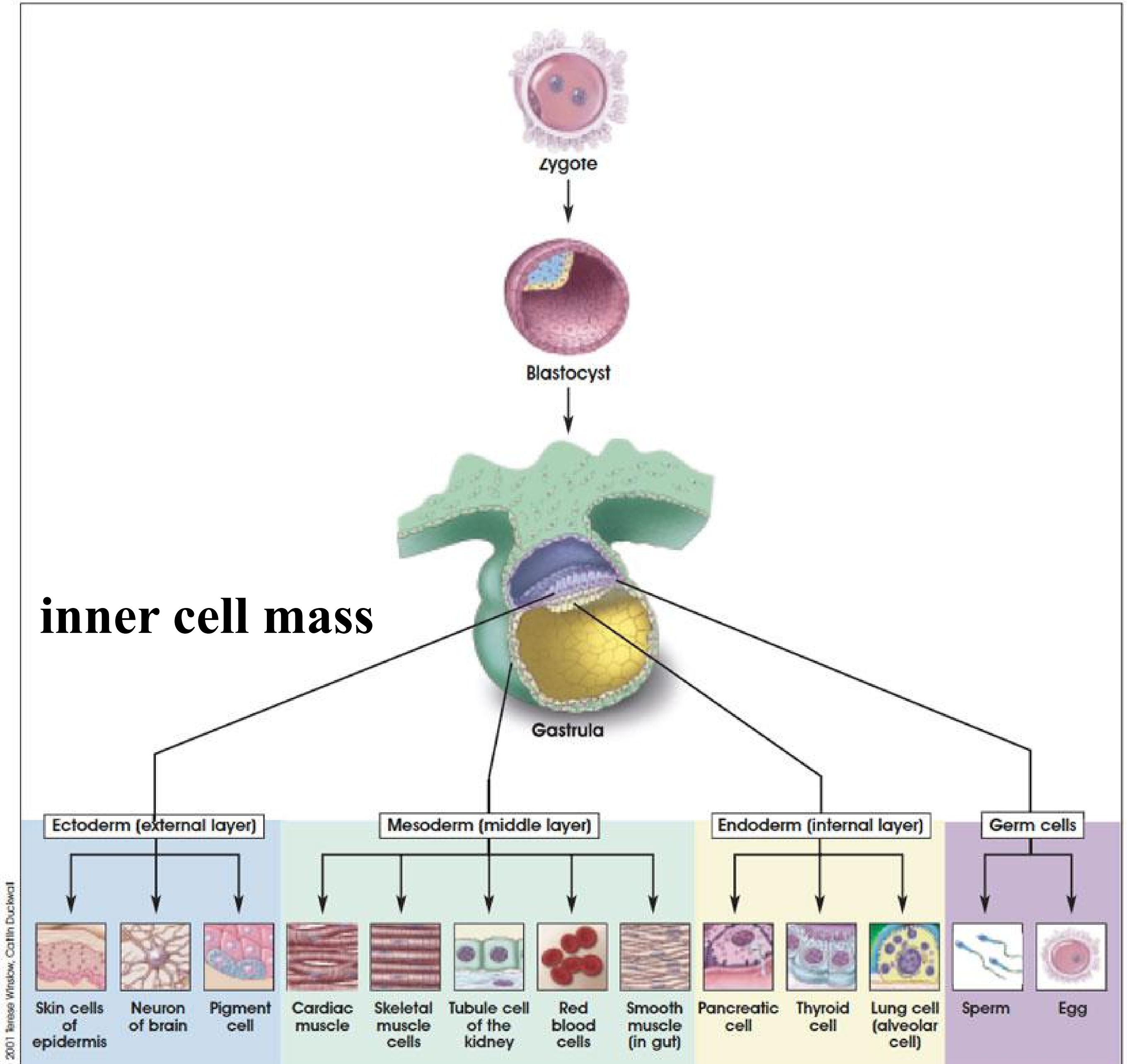
chorion + endometrium -----placenta

Figure 42-6 The journey of the egg





inner cell mass: source of embryonic stem cells



produces the embryo and the three remaining extraembryonic membranes.

42.5 How Do Humans Develop?

zygote $\xrightarrow{d4}$ **morula** $\xrightarrow{d5}$ **blastocyst** $\xrightarrow{d7}$ **late blastocyst**

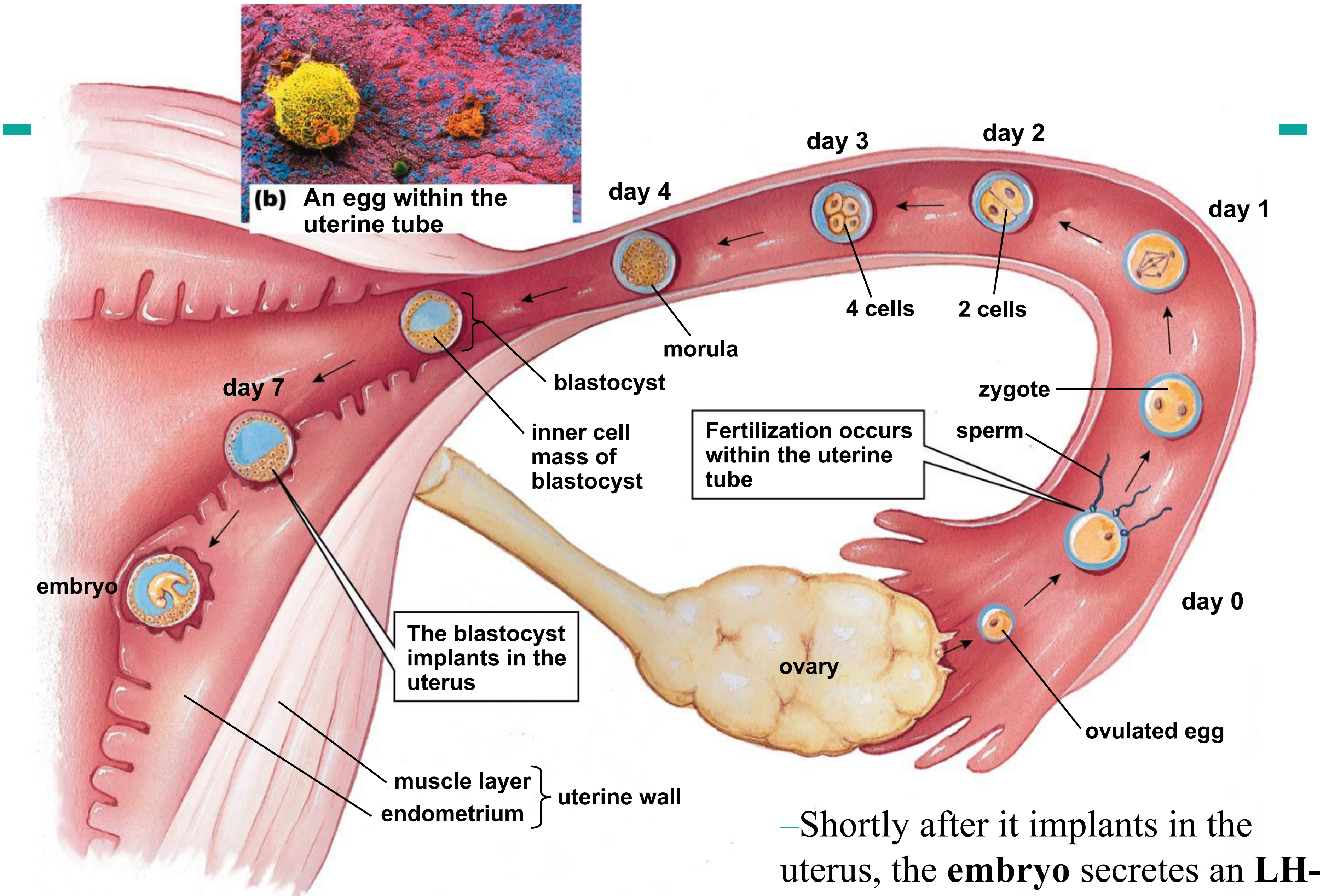
Implantation

(end of second week)

gastrulation

Gastrulation is a phase early in the embryonic development of most animals, during which the single-layered blastula is reorganized into a trilaminar ("three-layered") structure known as the **gastrula**. These three *germ layers* are known as the ectoderm, mesoderm, and endoderm

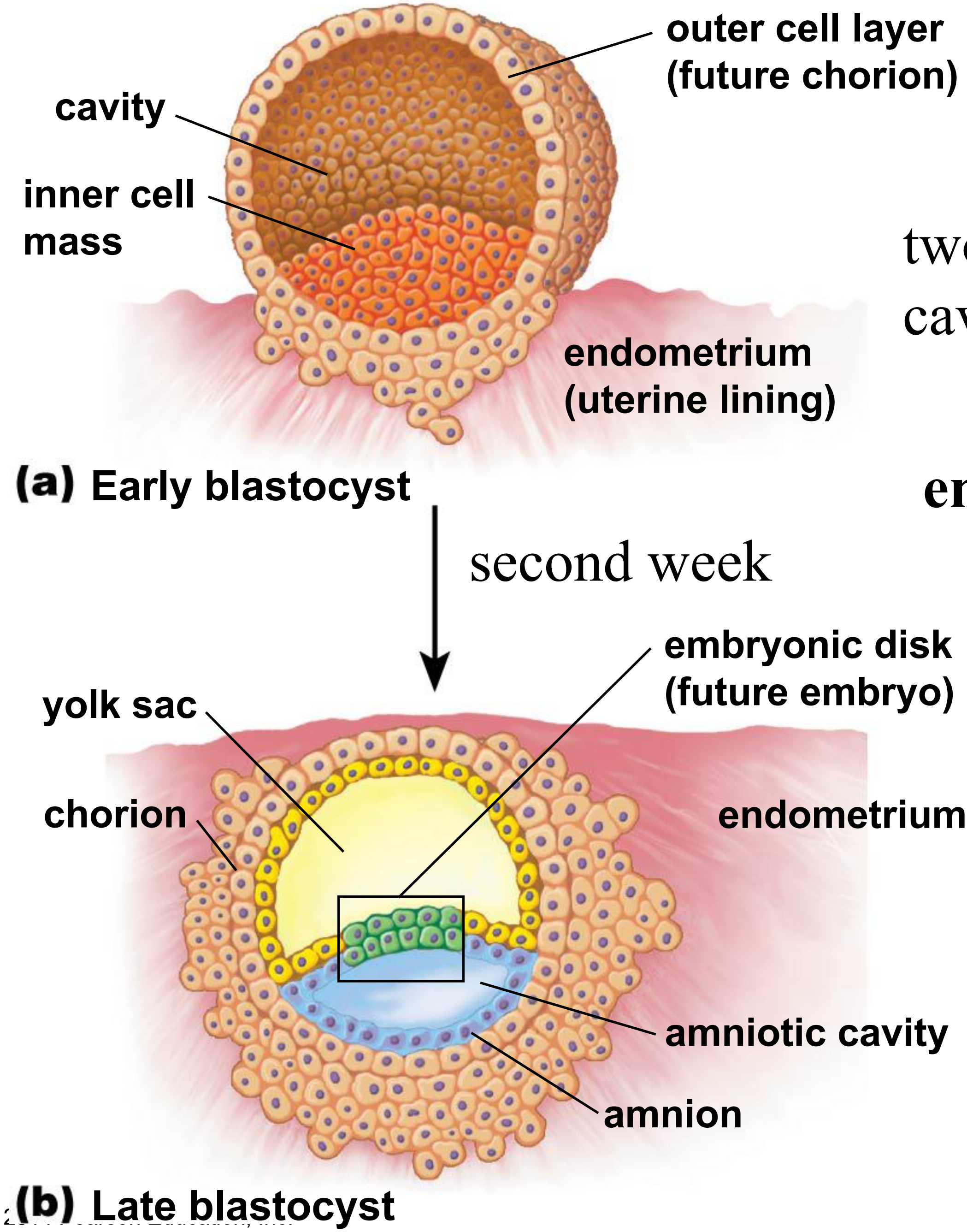
Figure 42-6 **The journey of the egg**



(a) The first week of development

– Shortly after it implants in the uterus, the **embryo** secretes an **LH-like hormone** called **chorionic gonadotropin (CG)**

Figure 42-7 A blastocyst implants



two cavities: yolk sac and amniotic cavity

embryonic disk: two layer cells

42.5 How Do Humans Develop?

After implantation, **two cavities form** and **gastrulation** occurs *(continued)*

- Gastrulation begins near the **end of the second week**
  - Cells migrate through a slit in the amnion side of the embryonic disk (primitive streak)
    - This slit is the disk's equivalent of the amphibian blastopore
    - Once inside the disk, the migrating cells form mesoderm, endoderm, and the fourth extraembryonic membrane, the allantois
  - The cells remaining on the surface become the ectoderm

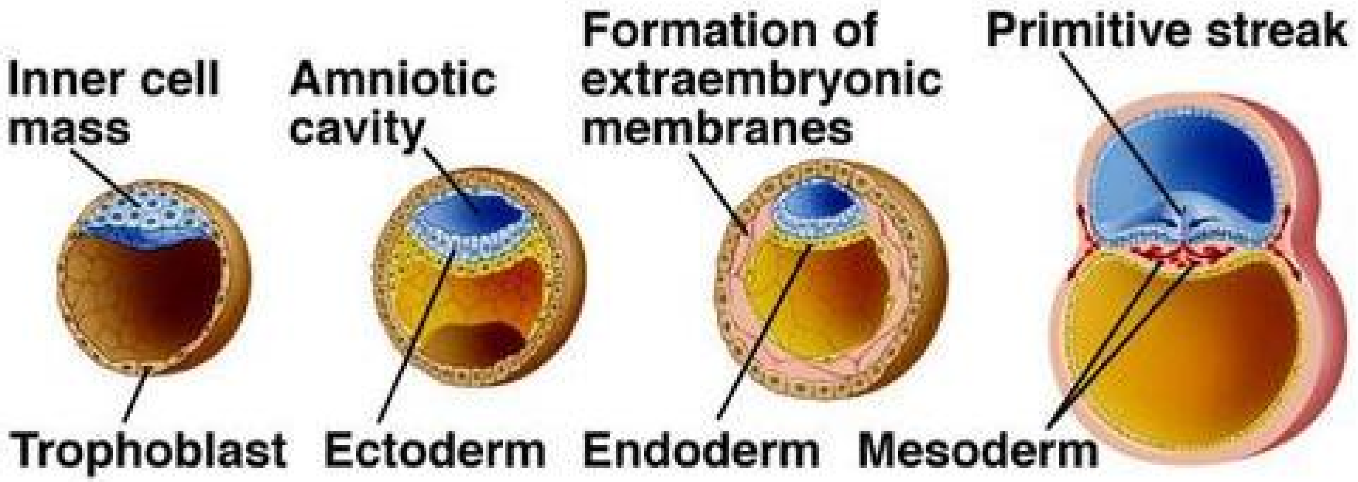
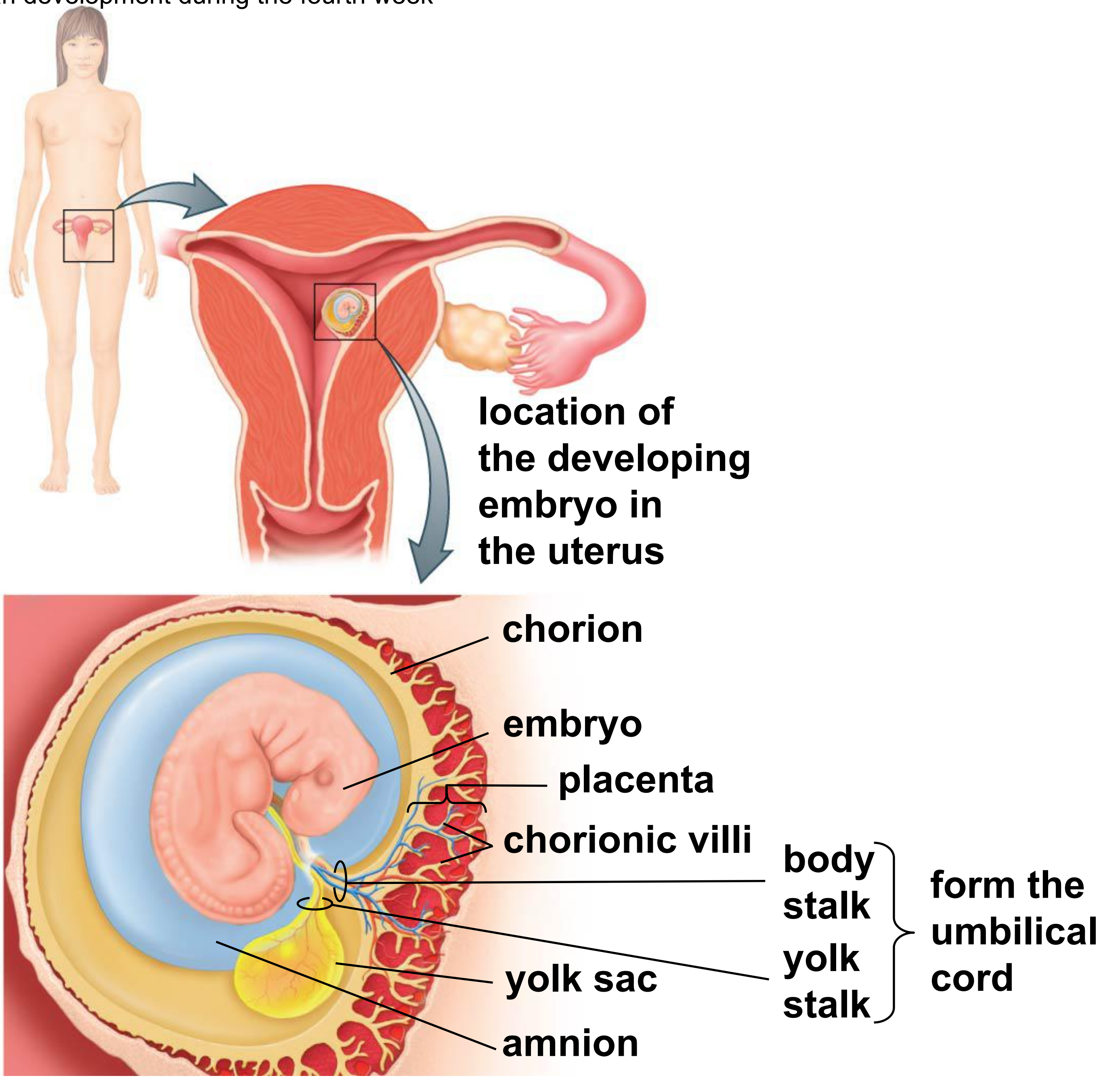
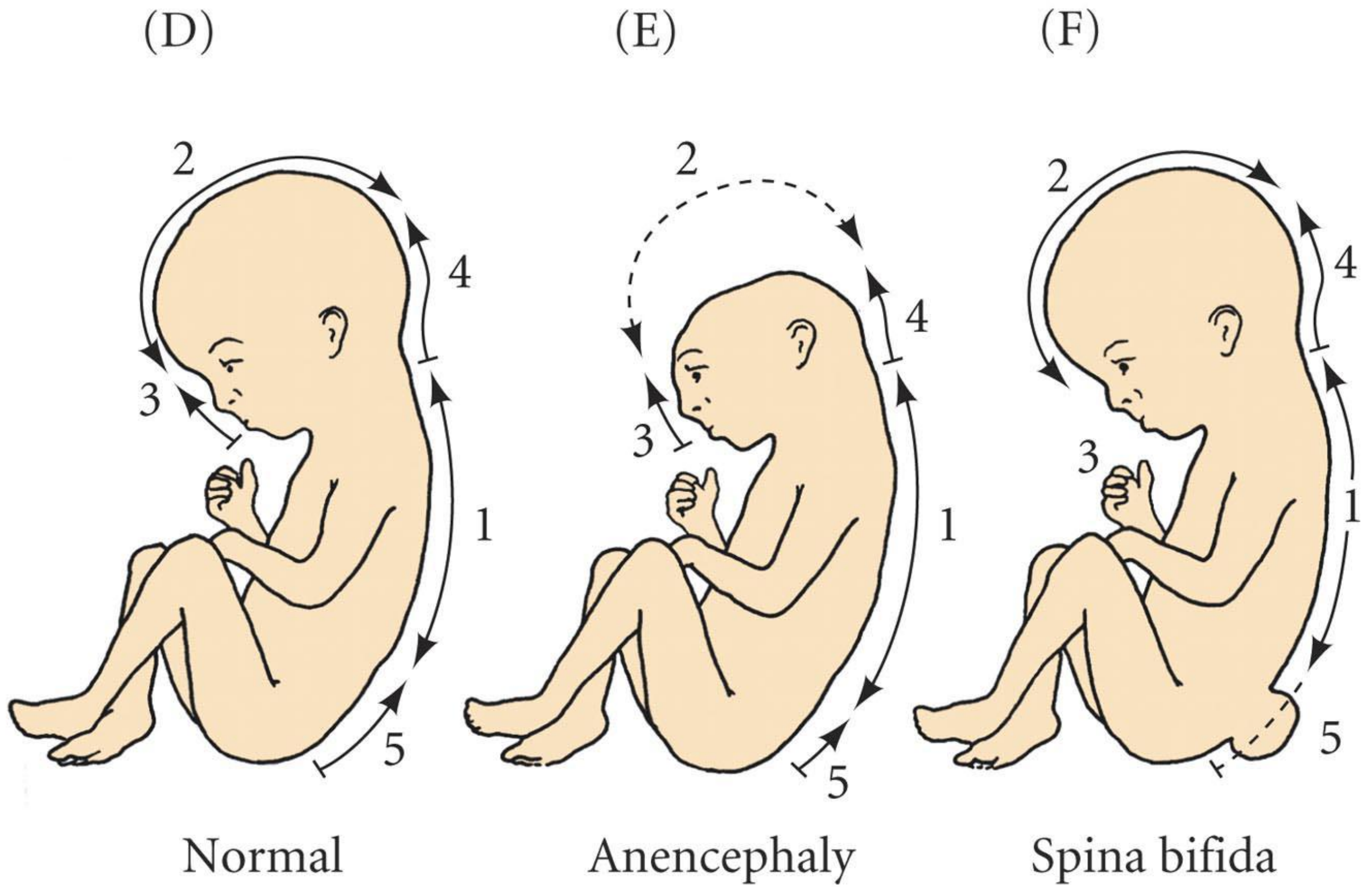

Inner cell mass
Amniotic cavity
Formation of extraembryonic membranes
Primitive streak
Trophoblast
Ectoderm
Endoderm
Mesoderm

Figure 42-8 Human development during the fourth week



42.5 How Do Humans Develop?

- Organogenesis begins during weeks **three to eight**
  - During the **third week** of development, the embryo begins to form the **spinal cord and brain**
  - The **heart** starts beating about the beginning of the **fourth week**
    - The embryo bulges into the uterine cavity, bathed in fluid contained within the amnion



(D)
(E)
(F)
2
4
3
1
5
2
4
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2
4
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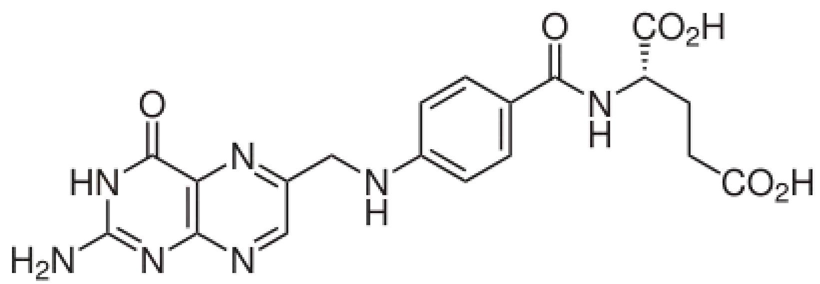
1
5
Normal
Anencephaly
Spina bifida

From Wikipedia, the free encyclopedia

- Folic acid



Folic acid (also known as vitamin M, vitamin B9,vitamin Bc (or folacin), pteroyl-L-glutamic acid, and pteroyl-L-glutamate)[*dubious* – *discuss*] is a form of the water-soluble vitamin B9. Folate is a naturally occurring form of the vitamin, found in food, while folic acid is synthetically produced, and used in fortified foods and supplements. Folic acid is itself not biologically active, but its biological importance is due to tetrahydrofolate and other derivatives after its conversion to dihydrofolic acid in the liver.

叶酸在人体的许多功能中起着极重要的作用：细胞分离、DNA的合成、头脑化学物质和神经传递素的生产。没有一定水平的叶酸，细胞不能完全分离。叶酸在胎儿的神经系统的发展中是至关重要的。在怀孕期间缺乏叶酸会造成胎儿先天缺陷，例如神经管缺陷和脊骨分裂。因此，每天服用至少400微克的叶酸对育龄期女性是极为重要。另外，叶酸对心脏的健康也扮演着重要角色

42.5 How Do Humans Develop?

- Meanwhile, the umbilical cord forms from the fusion of the yolk stalk and body stalk
  - The yolk stalk connects the yolk sac to the embryonic digestive tract

42.5 How Do Humans Develop?

- Differentiation and growth are rapid during the first two months *(continued)*
  - Organogenesis begins during weeks three to eight *(continued)*
    - The **body stalk** contains the **allantois**, which contributes the **blood vessels** that will become the umbilical arteries and vein
    - The umbilical cord now connects the embryo to the placenta, which has formed from the merger of the chorion of the embryo and the lining of the uterus

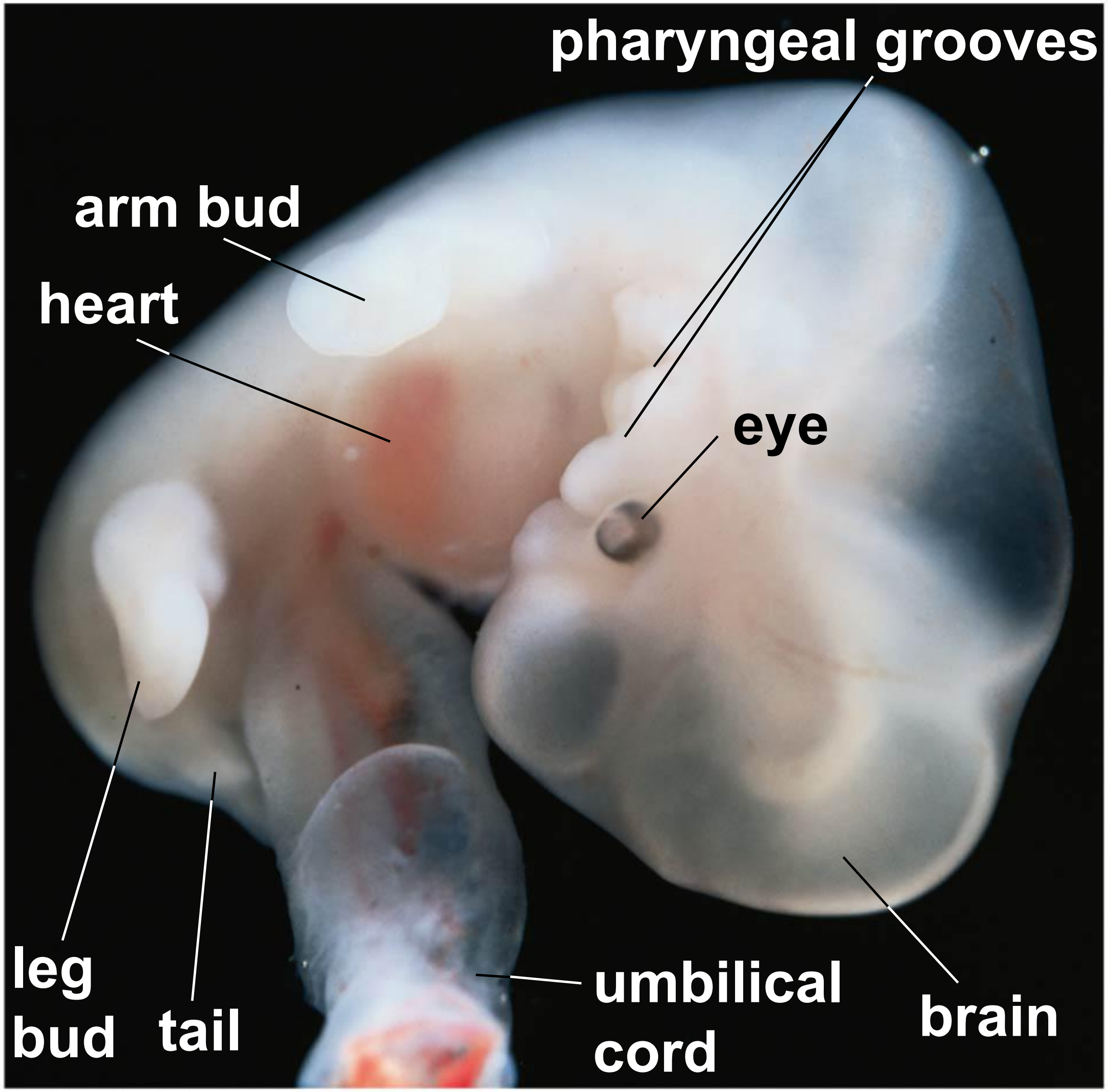
42.5 How Do Humans Develop?

- Differentiation and growth are rapid during the first two months *(continued)*
  - Organogenesis begins during weeks three to eight *(continued)*
    - During the **fourth and fifth weeks**, the embryo develops a prominent **tail** and **pharyngeal** (gill) **grooves**—indentations behind the head that are homologous to the fish embryo's developing gills
      - These structures are reminders that we share ancestry with other vertebrates that retain their gills in adulthood
    - In humans, however, they **disappear** as development continues

42.5 How Do Humans Develop?

- Differentiation and growth are rapid during the first two months *(continued)*
  - Organogenesis begins during weeks three to eight *(continued)*
    - In humans, however, they disappear as development continues
  - By the **seventh week**, the embryo has **rudimentary eyes** and a rapidly developing brain, and the **webbing between its fingers and toes is disappearing**

Figure 42-9 A 5-week-old human embryo



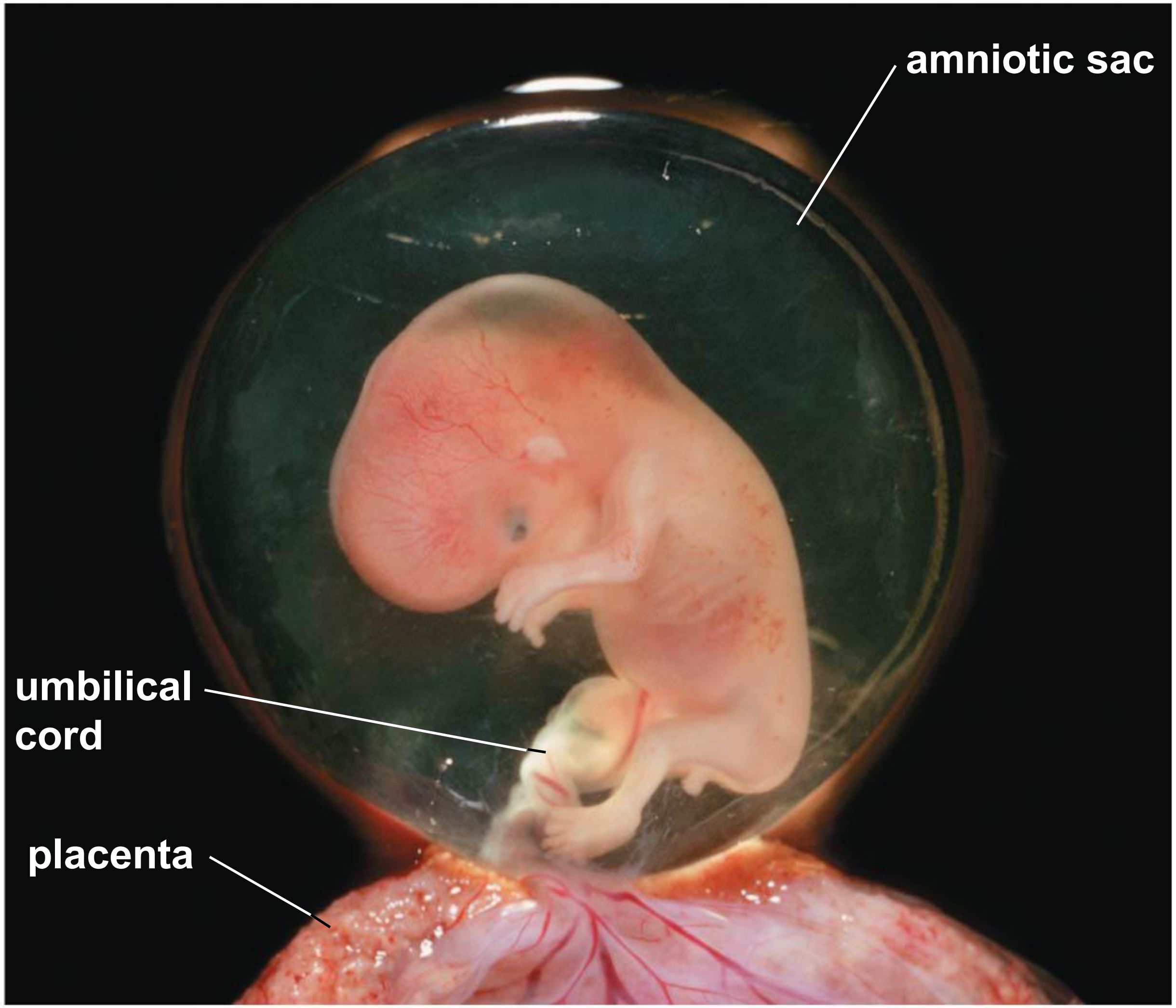
42.5 How Do Humans Develop?

- Differentiation and growth are rapid during the first two months *(continued)*
  - After two months, the embryo is recognizably human
    - As the second month draws to an end, nearly all of the major organs have at least begun to develop
      - The gonads appear and develop into testes or ovaries
      - Sex hormones are secreted—either testosterone from the testes or estrogen from the ovaries
        - These hormones will affect the development of many structures, including the reproductive organs and brain

42.5 How Do Humans Develop?

- Differentiation and growth are rapid during the first two months *(continued)*
  - After two months, the embryo is recognizably human *(continued)*
    - At the end of the second month, the embryo has taken on a generally human appearance and is now called a **fetus**
    - The first two months of pregnancy are a time of extremely rapid differentiation and growth for the embryo, and a time of considerable danger

Figure 42-10 An 8-week-old human embryo



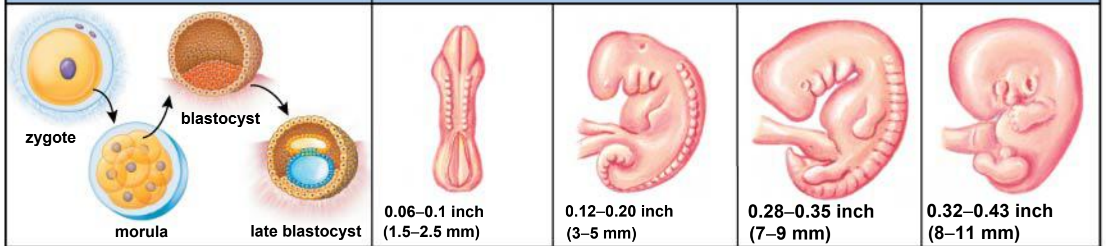
42.5 How Do Humans Develop?

- Growth and development continue during the last seven months
  - The fetus grows and develops for another seven months
    - As the brain and spinal cord grow, they begin to generate behaviors
    - As early as the third month of pregnancy, the fetus can move, respond to stimuli, and even suck its thumb
    - The lungs, stomach, intestine, and kidneys enlarge and become functional

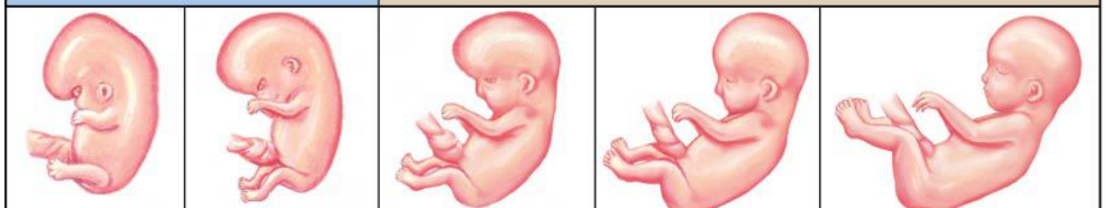
42.5 How Do Humans Develop?

- Growth and development continue during the last seven months *(continued)*
  - Fetal urine, in fact, makes up most of the amniotic fluid during the last 6 months of pregnancy
  - Although a full-term pregnancy lasts about 38 weeks, nearly all fetuses 32 weeks or older can survive outside the womb with medical assistance
  - Most infants born as early as 26 weeks survive if they are given intensive care

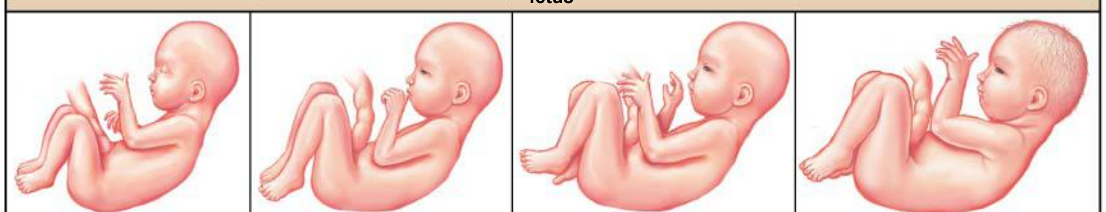
Figure 42-11 A calendar of development from zygote to birth



week 1	week 2	week 3	week 4	week 5	week 6
zygote to late blastocyst		embryo			
		0.06–0.1 inch (1.5–2.5 mm)	0.12–0.20 inch (3–5 mm)	0.28–0.35 inch (7–9 mm)	0.32–0.43 inch (8–11 mm)
Cleavage of zygote forms the morula and then the blastocyst, which implants in the uterus.	The blastocyst burrows into the endometrium; forms the yolk sac, amnion, and embryonic disk.	Gastrulation occurs; the notochord and beginning of the neural tube form.	The neural tube closes; arm buds, tail, and pharyngeal (gill) grooves form; the heart beats.	The eyes begin to form; leg buds form; the brain enlarges.	External ears and webbed fingers form; the pharyngeal (gill) grooves and tail disappear.



week 7	week 8	week 10	week 12	week 16
embryo		fetus		
0.67–0.79 inch (1.7–2.0 cm)	0.90–1.10 inches (2.3–2.8 cm)	1.25–1.75 inches (3.2–4.4 cm)	2–3 inches (5–7.6 cm)	4–5 inches (10.2–12.7 cm)
Webbed toes form; bones begin to stiffen; the back straightens; the eyelids begin to form.	All the major organs begin to form; the arms can bend; fingers and toes are distinct. Facial features and outer ears take shape.	After 8 weeks, the embryo is called a fetus. Red blood cells form; toes separate; eyelids have developed; major brain parts are present; the hands can form fists.	The neck is well defined; all organs are present; distinctly male or female external genitals are present; arms and legs move; teeth begin to form; a heartbeat can be detected.	Sucking and swallowing movements occur; the liver and pancreas begin functioning. The body has grown relative to the head; major organs continue developing. The mother may feel movement; weight is about 5 oz.



week 20	week 24	week 30	week 36
fetus			
6–7 inches (15.2–17.8 cm)	8–9 inches (20.3–22.9 cm)	15–16 inches (38.1–40.6 cm)	16–19 inches (40.6–48.3 cm)
The fetus may suck its thumb; arms and legs can punch and kick; the body can change position. Fingernails are formed; fat is deposited under the skin; eyebrows and eyelashes appear.	Brain development continues, hearing develops, and the eyes can move. The fetus can hiccup, squint, smile, and frown. The fetus may have hair on its head. Unique foot- and fingerprints appear. Weight is about 1–1.5 lbs.	Brain development continues; the eyes open and close and see light; the fetus kicks and stretches. Breathing movements occur but the lungs are not mature. Bones are present but flexible. The baby may survive if born.	Eyes open and close corresponding to wake and sleep cycles; body fat increases; lungs and other organs are functional. The fetus can grasp and orient toward light. Weight is about 5–6 lbs, and the child is no longer considered premature if born. Full term is 38 weeks.

42.5 How Do Humans Develop?

- The placenta exchanges materials between mother and embryo
  - During the first few days after implantation, the embryo obtains nutrients directly from the endometrium of the uterus
  - During the following week or so, the **placenta** begins to develop from the interlocking structures produced by the embryo and the endometrium

42.5 How Do Humans Develop?

- The placenta exchanges materials between mother and embryo *(continued)*
  - The outer layer of the blastocyst forms the chorion, which grows fingerlike **chorionic villi** that extend into the endometrium
  - Blood vessels of the umbilical cord connect the embryo's circulatory system with a dense network of capillaries in the villi

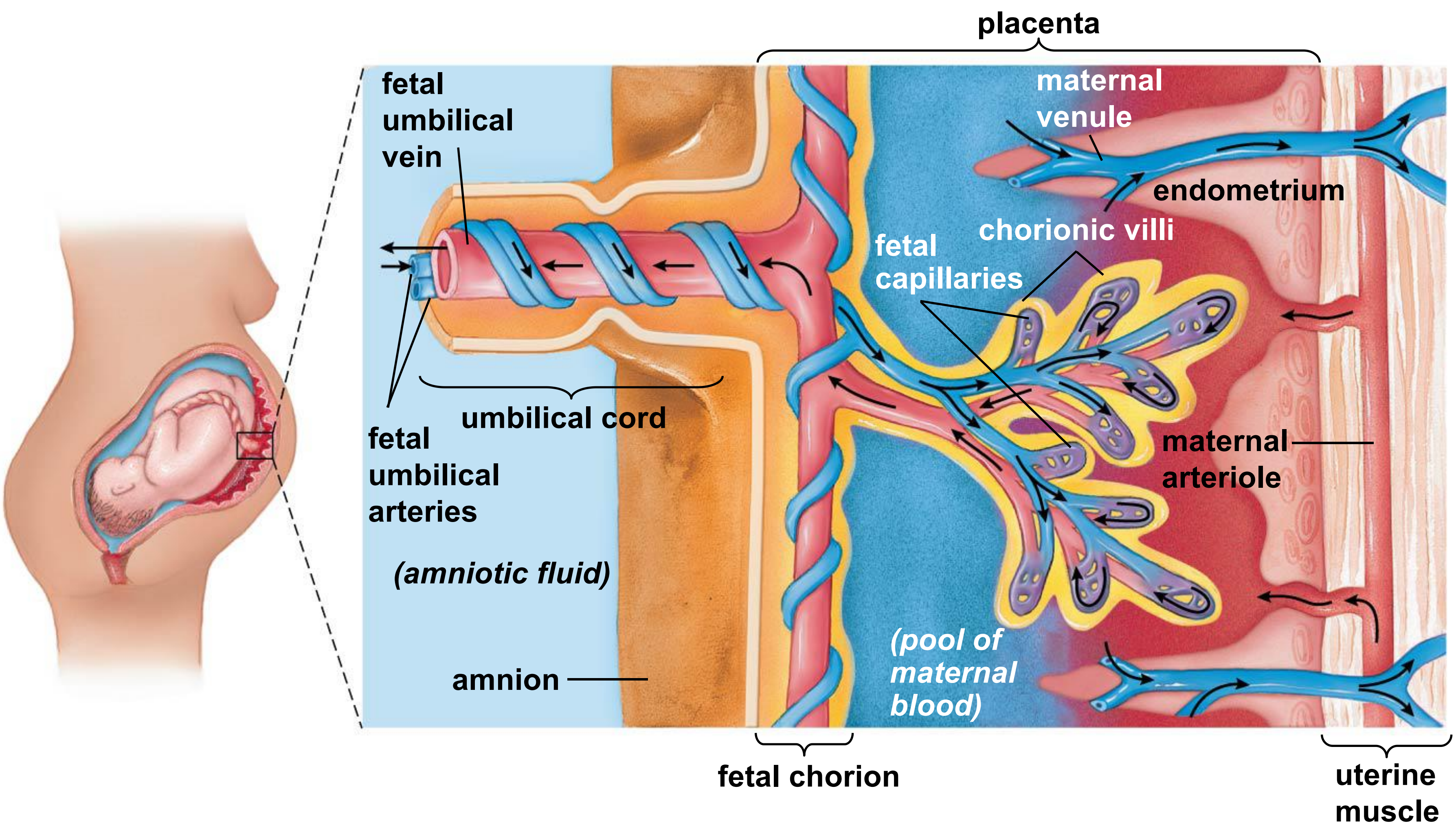
42.5 How Do Humans Develop?

- The placenta exchanges materials between mother and embryo *(continued)*
  - Meanwhile, some of the blood vessels of the endometrium erode away, producing pools of maternal blood that bathe the chorionic villi
  - The embryo's and mother's blood remain separated by the walls of the villi and their capillaries, so the two blood supplies do not actually mix
    - Many small molecules move across their villi and capillary walls

42.5 How Do Humans Develop?

- The placenta exchanges materials between mother and embryo *(continued)*
  - Walls of the capillaries and chorionic villi act as barriers to some substances, including large proteins and most cells
    - Some disease-causing organisms and many harmful chemicals can penetrate the placenta

Figure 42-12 The placenta



42.5 How Do Humans Develop?

- Pregnancy culminates in labor and delivery
  - During the last months of pregnancy, the fetus usually becomes positioned head downward in the uterus, with the crown of the skull resting against and held up by the cervix
  - Childbirth generally begins around the end of the ninth month
    - Birth results from a complex interplay between uterine stretching caused by the growing fetus and maternal and fetal hormones that finally cause **labor**

42.5 How Do Humans Develop?

- Pregnancy culminates in labor and delivery *(continued)*
  - Unlike skeletal muscles, the smooth muscles of the uterus can contract spontaneously, and stretching enhances their tendency to contract
    - As the baby grows, it stretches the uterine muscles, which occasionally contract weeks before delivery
  - No one knows what triggers labor in humans, but chemical signals from both the placenta and maturing fetus may be involved

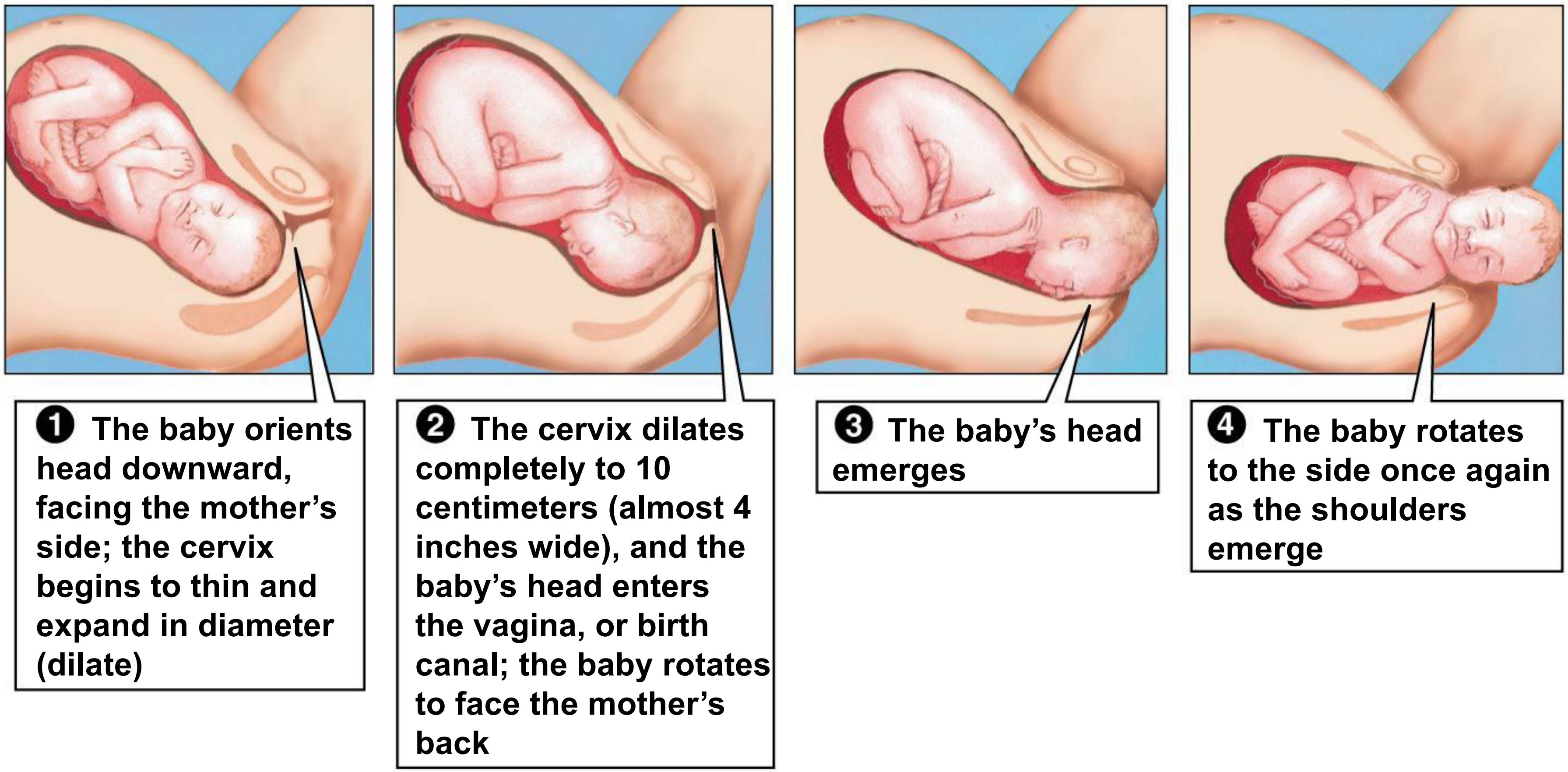
42.5 How Do Humans Develop?

- Pregnancy culminates in labor and delivery *(continued)*
  - Whatever the initial stimulus, the placenta releases prostaglandins, which make the uterine muscles more likely to contract
    - As the uterus contracts, it pushes the fetus' head against the cervix, stretching it
      - Stretching the cervix sends nervous signals to the mother's brain, causing the release of the hormone oxytocin

42.5 How Do Humans Develop?

- Pregnancy culminates in labor and delivery *(continued)*
  - Oxytocin stimulates contractions of the uterine muscles, pushing the baby harder against the cervix, which stretches further, causing still more oxytocin to be released
  - This positive feedback cycle continues until the cervix expands far enough for the baby to emerge
  - After a brief rest following childbirth, the uterus resumes its contractions and shrinks remarkably

Figure 42-13 Human childbirth



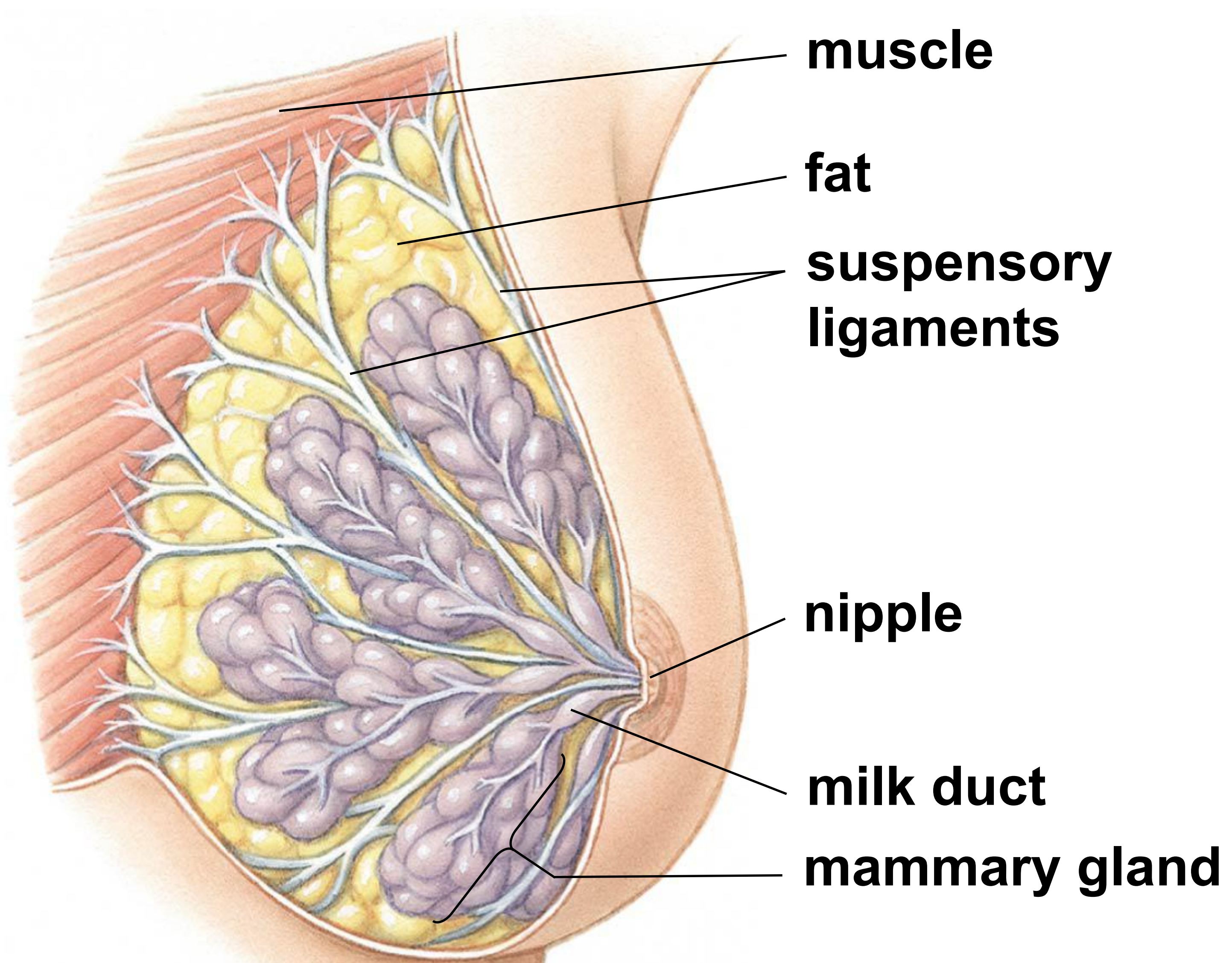
42.5 How Do Humans Develop?

- Pregnancy culminates in labor and delivery *(continued)*
  - During these contractions, the placenta is sheared from the uterine wall and expelled through the vagina
  - The umbilical cord now releases prostaglandins that cause the muscles surrounding fetal blood vessels in the umbilical cord to contract and shut off blood flow
    - Although tying off the umbilical cord is standard practice, it is not usually necessary; if it were, other mammals would not survive birth

42.5 How Do Humans Develop?

- Milk secretion is stimulated by the hormones of pregnancy
  - During pregnancy, large quantities of estrogen and progesterone are secreted by the placenta
    - Estrogen and progesterone, acting together with several other hormones, stimulate the milk-producing **mammary glands** in the breasts to swell and develop the capacity to secrete milk
    - The mammary glands are arranged in a circle around the nipple, each with a milk duct leading to the nipple

Figure 42-14 The structure of the mammary glands



arranged in a circle around the nipple, each with a milk duct leading to the nipple

42.5 How Do Humans Develop?

- Milk secretion is stimulated by the hormones of pregnancy *(continued)*
  - Prolactin, a hormone secreted by the anterior pituitary gland, promotes both mammary gland development and the actual secretion of milk, a process called **lactation**
  - Prolactin release is stimulated by the high levels of estrogen produced by the placenta, so you might think that milk secretion would begin even before the child is born

42.5 How Do Humans Develop?

- Milk secretion is stimulated by the hormones of pregnancy *(continued)*
  - However, lactation is inhibited by progesterone
    - When the placenta is ejected from the uterus right after childbirth, progesterone level plummets, allowing prolactin to cause lactation

42.5 How Do Humans Develop?

- Milk secretion is stimulated by the hormones of pregnancy *(continued)*
  - Milk is released when the infant's suckling stimulates nerve endings in the nipples, which signal the hypothalamus to cause the pituitary gland to release an extra surge of prolactin and oxytocin

42.5 How Do Humans Develop?

- Milk secretion is stimulated by the hormones of pregnancy *(continued)*
  - Oxytocin causes muscles surrounding the mammary glands to contract, ejecting the milk into the ducts that lead to the nipples
  - The prolactin surge stimulates rapid milk production for the next feeding

42.5 How Do Humans Develop?

- Milk secretion is stimulated by the hormones of pregnancy *(continued)*
  - During the first few days after birth, the mammary glands secrete a yellowish fluid called **colostrum**
    - Colostrum is high in protein and contains antibodies from the mother that help protect the infant against some diseases as its immune system is developing
    - Colostrum is gradually replaced by mature milk, which is higher in fat and milk sugar (lactose) and lower in protein

42.6 Is Aging the Final Stage of Human Development?

- **Aging** is the gradual accumulation of damage to essential biological molecules, particularly DNA, resulting in defects in cell functioning, declining health, and ultimately death
  - This damage results from natural errors in DNA replication, radiation from the sun or the rocks beneath our feet, and chemicals in food, cigarettes, and industrial products

42.6 Is Aging the Final Stage of Human Development?

- As an individual ages, however, its repair abilities diminish; eventually, the body's tolerance for damage is exceeded
  - Muscle and bone mass are lost
  - Skin elasticity decreases
  - Reaction time slows
  - Senses such as vision and hearing become less acute
- A less-robust immune response renders the aging individual more vulnerable to disease
  - The animal eventually dies

Figure 42-15 Youth meets age

42.6 Is Aging the Final Stage of Human Development?

- For thousands of years, people have attempted to delay aging and extend the human life span
  - Modern care can prevent or cure many diseases, and can fix or replace some damaged organs
  - Some dietary changes, particularly not eating very much food, can prolong life, at least in animal experiments
- However, what seems to be the maximum human life span, about 130 years, has not changed

42.6 Is Aging the Final Stage of Human Development?

- Several evolutionary hypotheses suggest that aging is unavoidable
  - For example, natural selection favors organisms that leave the largest number of healthy, successful offspring
  - Even a hypothetically immortal animal that wouldn't die from "inside" so to speak, will eventually succumb to predation, accident, or disease

42.6 Is Aging the Final Stage of Human Development?

- Therefore, perhaps natural selection favors devoting more of the body's resources to reproduction than to the continuous bodily repair required for immortality
- The fact that humans can live so long after they stop reproducing is probably evidence of the selective advantage conferred by the care and teaching given to young by their elders