

Coverage Of Biology



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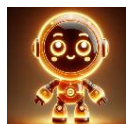
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المزيد من مادة
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التواصل الاجتماعي بحسب الصف التاسع المتقدم



صفحة المناهج
الإماراتية على
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الرياضيات

اللغة الانجليزية

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المواد على تلغرام

المزيد من الملفات بحسب الصف التاسع المتقدم والمادة أحياء في الفصل الثالث

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Coverage Of Biology

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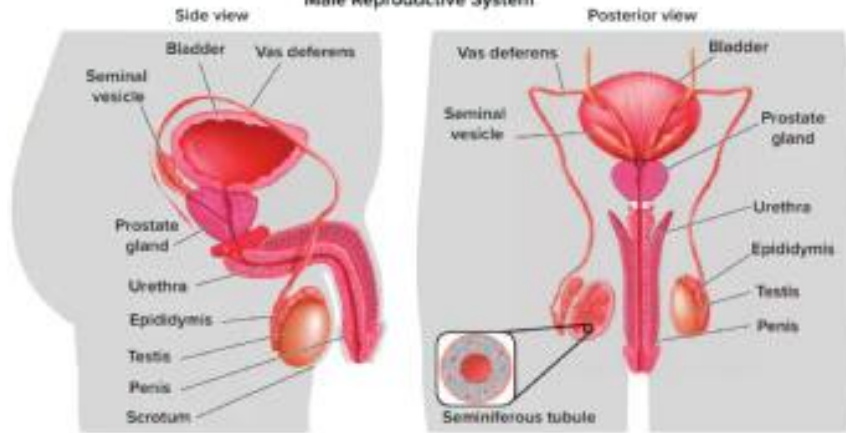
Mr. Ahmed Elhddad

"the first Bio – Sci teacher" 2025 – 2026



BIO.3.1.01.118 Identify the main functions of the human reproductive system: to reproduce and continue the existence of humans, to produce the next generations, and to produce egg and sperm cells

Male Reproductive System



The main function of the human reproductive system is to produce offspring and ensure the survival of the species.

Core Functions

- 1- Gamete production:** Creating sperm in males and eggs (ova) in females.
- 2- Hormone secretion:** Releasing testosterone, estrogen, and progesterone to regulate development.
- 3- Fertilization:** Enabling the fusion of male and female gametes.
- 4- Nurturing development:** Sustaining a fetus during pregnancy (female-specific function).

Male-Specific Functions

- **Sperm production:** Generating male gametes within the testes.
- **Sperm transport:** Delivering sperm into the female reproductive tract.

Q1: Which of the following describes the primary overarching functions of the human reproductive system?

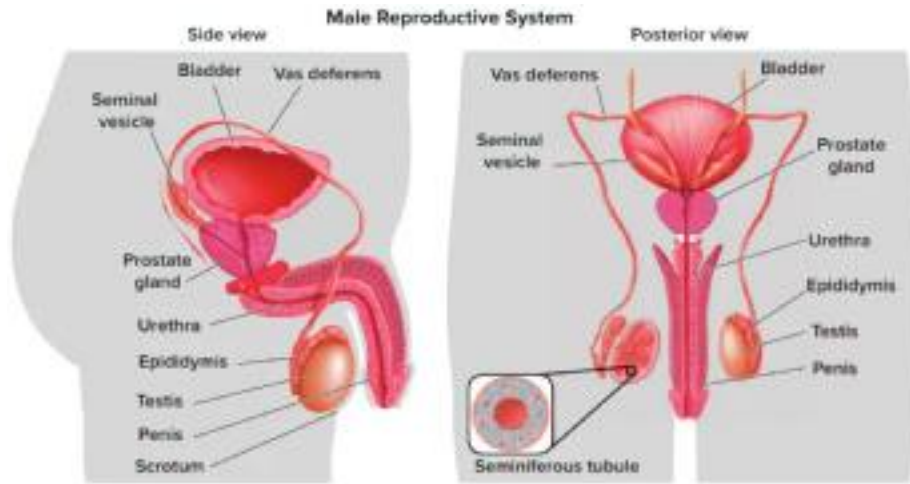
- A) To ensure the continuation of the human species, produce the next generations, and generate egg and sperm cells.
- B) To regulate the body's internal fluid balance, filter toxins, and maintain core blood pressure.
- C) To produce mechanical energy for movement and maintain physical bone density.
- D) To secrete digestive enzymes that facilitate nutrient breakdown and absorption.

Q2: According to Figure, and the accompanying description, what is the biological significance of the scrotum being positioned outside the main body cavity?

- A) It keeps the testes several degrees cooler than the average body temperature of 37°C.
- B) It allows the testes to maintain a temperature much higher than 37°C.
- C) It directly connects the seminiferous tubules to the urinary bladder.
- D) It prevents the vas deferens from looping over the bladder.

Q3: Looking at the detailed inset labeled "Seminiferous tubule" at the bottom of the diagram, what crucial biological process takes place within these microscopic structures?

- A) The actual production and development of sperm cells.
- B) The filtration of metabolic waste from the semen.
- C) The synthesis of fluids that form the majority of semen volume.
- D) The storage of fully mature, motile sperm before ejaculation.



Q4: Trace the pathway of sperm delivery using the provided diagrams. After sperm cells leave the epididymis, through which long duct must they travel to eventually reach the urethra?

- A) Vas deferens
- B) Seminal vesicle
- C) Scrotum
- D) Prostate gland

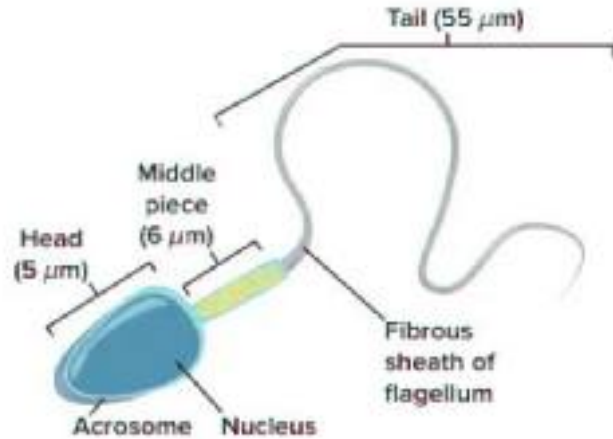
Q5: Based on the provided anatomical diagram of the Male Reproductive System, which structure is responsible for storing sperm cells as they mature?

- A) Epididymis
- B) Bladder
- C) Prostate gland
- D) Seminal vesicle

Q6: A medical researcher is studying factors that affect fertility. During an assessment, a patient is found to have a condition where the testes fail to descend into the scrotum and instead remain inside the abdominal body cavity.

Based on the provided textbook text, what is the most likely consequence of this condition regarding sperm development?

- A) Sperm development will be severely impaired because the temperature inside the body cavity is too high.
- B) Sperm production will increase significantly due to the protective warmth of the internal organs.
- C) Sperm will develop normally, but they will be unable to travel through the vas deferens.
- D) The prostate gland will completely stop secreting fluids because of the abdominal location.



Part	Size	Components / Features
Head	5 μm	Contains the Acrosome (front tip) and the Nucleus .
Middle piece	6 μm	The central connecting segment.
Tail	55 μm	Consists of a Fibrous sheath of flagellum used for movement (swimming).

- Sperm cells are the male reproductive cells.
- The testes produce about 100–200 million sperm cells every single day.
- They need a nourishing fluid known as **semen** to survive long enough to fertilize an egg.

• **A sperm cell develops and travels through the body in the following order:**

1.Seminiferous Tubules: Located inside the testes, this is where sperm cells are initially produced and developed.

2.Epididymis: A structure sitting on top of each testis where sperm cells mature and are stored.

3.Vas Deferens: A duct leading away from each testis. There are two vas deferens that eventually join together.

4.Urethra: The final tube through which sperm (as part of semen) and urine leave the body through the penis.

Q1: Based on the sperm cell structure, which of the following correctly pairs a specific region of the cell with its biological measurement or component?

- A) Head containing the nucleus and acrosome.
- B) Middle piece containing the fibrous sheath.
- C) Tail responsible for genetic storage.
- D) Acrosome containing the flagellum.

Q2: A fertility clinic analyzes a semen sample and discovers that the sperm cells are completely immobile (cannot swim), although they have normal heads and normal genetic material.

Based on the structure of the sperm cell, a defect or malformation in which specific part is most likely causing this lack of motility?

- A) The acrosome
- B) The tail (flagellum)
- C) The nucleus
- D) The seminiferous tubules

Q3: what is the correct sequential pathway that sperm cells follow as they develop and make their way out of the male body?

- A) Epididymis - Urethra - Seminiferous tubules - Vas deferens
- B) Seminiferous tubules - Epididymis - Vas deferens - Urethra
- C) Vas deferens - Seminiferous tubules - Urethra - Epididymis
- D) Urethra - Vas deferens - Epididymis - Seminiferous tubules

Q4: A lab report shows that a patient's semen has an extremely low concentration of sugar (fructose), causing the sperm cells to rapidly run out of energy. which specific glands contribute over half of the semen volume and secrete this necessary sugar?

- A) Prostate glands
- B) Bulbourethral glands
- C) Seminal vesicles
- D) Seminiferous tubules

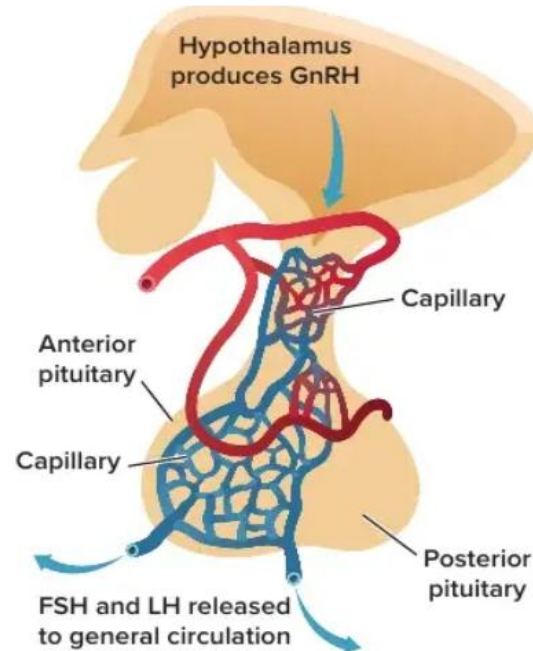
Q5: The sperm encounter acidic environments both inside the male urethra and within the female reproductive tract.

Which structures contribute an alkaline solution to neutralize these hazardous acidic conditions?

- A) The seminal vesicles and the epididymis
- B) The prostate gland and the bulbourethral glands
- C) The seminiferous tubules and the vas deferens
- D) The nucleus and the acrosome

A6: What is the specific biological function of the epididymis?

- A) It is the site where sperm cells are initially produced at a rate of millions per day.
- B) It is the tube that directly carries both semen and urine outside the penis.
- C) It is a structure located on top of each testis where sperm mature and are stored.
- D) It secretes an alkaline solution to protect sperm from acidic pathways.



Male hormones

Testosterone (tes TAHS tuh rohn), a hormone which is made in the testes, is necessary for the production of sperm. It also influences the development of male secondary sex characteristics that begin to appear at **puberty**, the period of growth when sexual maturity is reached. These characteristics include hair on the face and chest, broader shoulders, increased muscle development, and a deeper voice. Three hormones influence testosterone production. **Figure 3** indicates that the hypothalamus produces gonadotropin-releasing hormone (GnRH), which acts on the anterior pituitary gland. GnRH stimulates the production of follicle-stimulating hormone (FSH) and luteinizing (LEW tee uh ni zing) hormone (LH). Both FSH and LH travel from the anterior pituitary gland through the bloodstream and to the testes. In the testes, FSH promotes the production of sperm and LH stimulates the production and secretion of testosterone.

Figure 3 The hypothalamus produces GnRH, which travels to the pituitary gland and influences the rate of LH and FSH production. LH and FSH are regulated by negative feedback.

Levels of the male hormones are regulated by a negative feedback system that starts with the hypothalamus. Increased levels of testosterone in the blood are detected by cells in the hypothalamus and anterior pituitary, and the production of LH and FSH is decreased. When testosterone levels in the blood drop, the body responds by making more LH and FSH.

Q1: Which hormone is produced by the hypothalamus and directly stimulates the anterior pituitary gland to release FSH and LH?

- A) Testosterone
- B) Estrogen
- C) Gonadotropin-releasing hormone (GnRH)
- D) Progesterone

Q2: Which hormone is synthesized in the testes and is primarily responsible for the development of male secondary sex characteristics such as broader shoulders and a deeper voice?

- A) Luteinizing hormone (LH)
- B) Follicle-stimulating hormone (FSH)
- C) Gonadotropin-releasing hormone (GnRH)
- D) Testosterone

Q3: From which specific area are FSH and LH released into the general circulation?

- A) Hypothalamus
- B) Posterior pituitary
- C) Anterior pituitary
- D) Testes capillary bed

Q4: A patient clinical assessment reveals an abnormally high concentration of testosterone circulating in the blood.

How will the negative feedback system respond to normalize these levels?

- A) The hypothalamus and anterior pituitary will decrease the production of LH and FSH.
- B) The hypothalamus will increase the production of GnRH to stimulate more testosterone.
- C) The anterior pituitary will increase the production of LH and decrease FSH.
- D) The testes will automatically signal the posterior pituitary to release more hormones.

Q5: What are the specific operational targets of Follicle-stimulating hormone (FSH) and Luteinizing hormone (LH) once they travel through the bloodstream to the testes?

- A) FSH stimulates testosterone production, and LH promotes sperm development.
- B) FSH promotes sperm production, and LH stimulates testosterone secretion.
- C) FSH activates the hypothalamus, and LH activates the anterior pituitary.
- D) FSH induces broader shoulders, and LH deepens the voice.

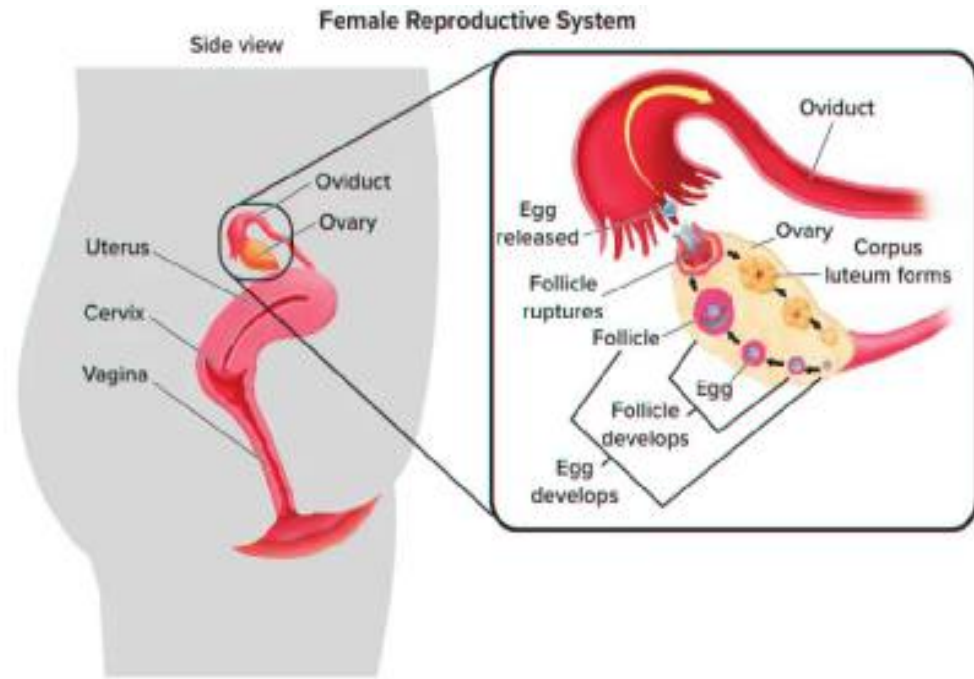
Q6: What happens immediately within the regulatory loop when testosterone levels in the human blood drop significantly below normal?

- A) The body shuts down the anterior pituitary gland entirely.
- B) The production of GnRH is permanently halted by the hypothalamus.
- C) The body responds by making more LH and FSH to stimulate production.
- D) The testes immediately convert existing muscle proteins into secondary sex traits.

Q7: Which of the following physical changes is classified as a male secondary sex characteristic influenced by testosterone at puberty?

- A) Decreased muscle development
- B) Increased hair growth on the face and chest
- C) Narrowing of the shoulders
- D) Transition to a higher pitch voice

:BIO.3.1.01.118 Identify the structures and their functions of the female reproductive systems to include ovaries, uterus, vagina, and oviduct



The female reproductive system is responsible for producing eggs (ova) and receiving sperm. It also provides a suitable environment for fertilization of the egg and the development of the embryo.

Gonads (ovaries): Each is about the size of an almond. They contain egg cells (immature ova). Every 28 days, one mature egg is released, and they also produce female hormones (progesterone and estrogen).

Ovaries

A tube connected to the uterus through which eggs are transported and where fertilization takes place.

Fallopian tubes (oviducts)

A muscular organ about the size of a fist where the fetus develops until birth.

Uterus

The lower part of the uterus is a narrow opening that connects to the vagina, which leads to the outside of the female body.

Cervix

Q1: Which female reproductive structure is directly responsible for producing egg cells and secreting the hormones estrogen and progesterone?

- A) Uterus
- B) Oviduct
- C) Ovary
- D) Vagina

Q2: A patient is diagnosed with an anatomical blockage in both of her fallopian tubes (oviducts), but her ovaries and uterus are confirmed to be completely healthy and functional.

Which of the following biological processes will be directly prevented by this specific condition?

- A) The production of female sex hormones like progesterone.
- B) The physical development of immature ova inside the follicles.
- C) The fertilization of the egg cell by a sperm cell.
- D) The final birth process through the narrow cervical opening.

Q3: Based on the detailed inset diagram of the ovary, what structure is formed immediately after the follicle ruptures and releases the mature egg?

- A) Oviduct
- B) Corpus luteum
- C) Vagina
- D) Cervix

Q4: Which structure undergoes structural expansion to provide a suitable muscular environment where the human fetus develops until birth?

- A) Uterus
- B) Oviduct
- C) Ovary
- D) Cervix

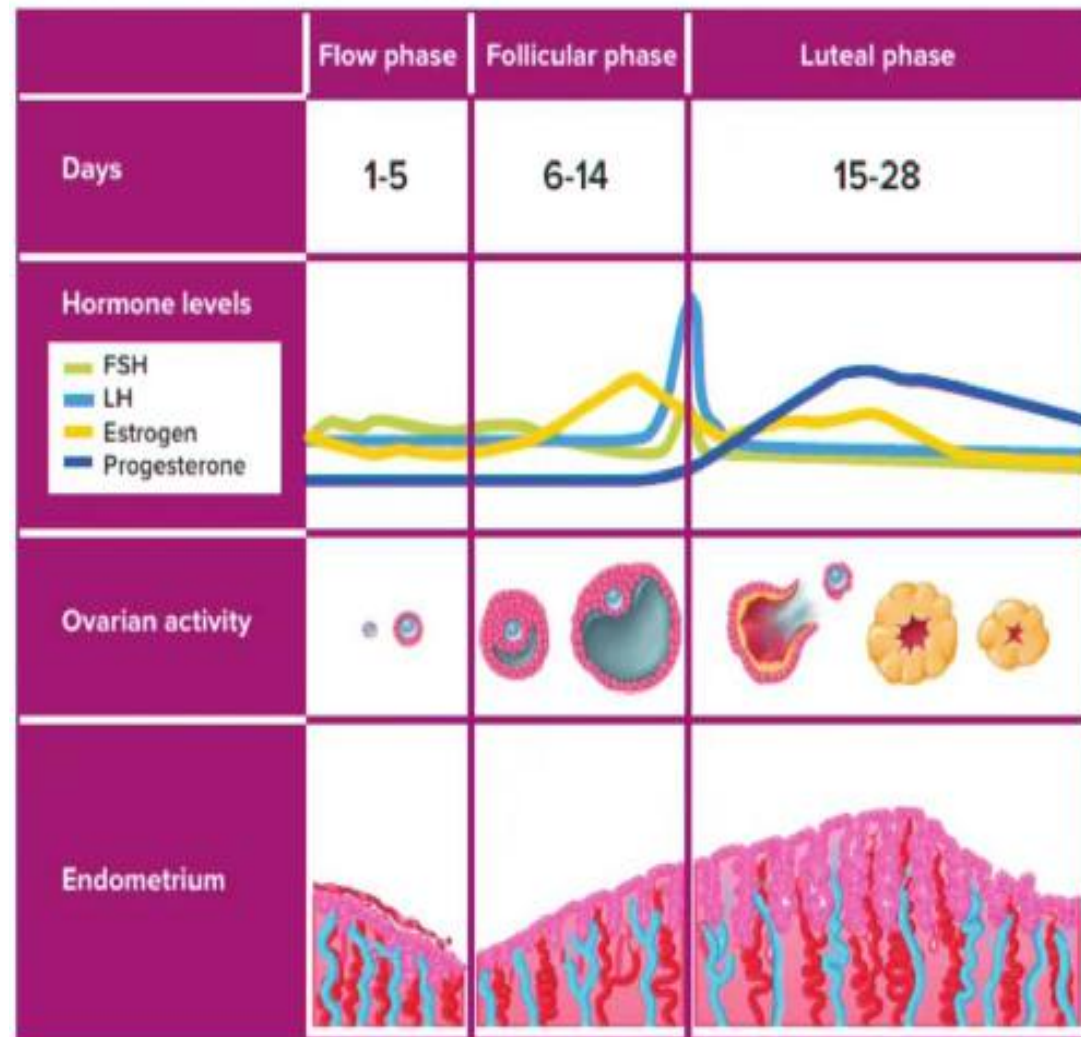
Q5: What is the precise anatomical layout and function of the cervix within the female reproductive system?

- A) It is a tube connected to the ovaries where fertilization takes place.
- B) It is the upper region of the oviduct that catches the released egg.
- C) It is a narrow opening at the lower part of the uterus that connects to the vagina.
- D) It is the main hormone-producing gland that regulates the 28-day cycle.

Q6: What is the correct biological term used to describe the immature egg cells contained within the almond-sized ovaries from birth?

- A) Corpus luteum
- B) Ova
- C) Sperm
- D) Zygotes

Table 1 Menstrual Phases



It is a set of processes that occur every month and help prepare the female body for pregnancy.

The menstrual cycle passes through 4 phases:

1. Menstrual Phase

♀ Occurs in the uterus

🔬 A sharp decrease in estrogen and progesterone levels occurs.

➡ This leads to the shedding of the uterine lining due to rupture of blood vessels.

🔬 Components of menstrual blood: blood, mucus, tissue fluids, and cells from the uterine lining.

🕒 Duration: Day 1 to Day 5 of the cycle.

2. Follicular Phase

♀ Occurs in the ovary

🔬 Under the effect of FSH, follicles grow and develop, and only one follicle matures.

⚙️ Low estrogen and progesterone at the beginning lead to increased secretion of FSH and LH.

🕒 Duration: Day 6 to Day 14.

3. Ovulation Phase

♀ The egg is released from the follicle, surrounded by cells called the corona radiata.

⚙️ Triggered by a rise in estrogen and LH levels.

🕒 Timing: Day 14.

4. Luteal Phase

♀ The follicle transforms into the corpus luteum

⚙️ which secretes a high amount of progesterone and a small amount of estrogen.

🔬 It maintains the uterine lining by inhibiting the secretion of both FSH and LH.

Q1: Based on the cyclical changes, what is the primary structural reason for the rapid degradation and shedding of the endometrium observed during the Flow phase (Days 1–5)?

- A) A sudden surge in Luteinizing Hormone (LH) causing localized tissue toxicity.
- B) A sharp decline in both estrogen and progesterone levels leading to the rupture of blood vessels.
- C) The physical detachment of the mature follicle pushing against the uterine wall.
- D) An overproduction of Follicle-Stimulating Hormone (FSH) that targets and degrades uterine cells.

Q2: A clinical researcher is evaluating a patient who is experiencing difficulties becoming pregnant. Blood tests reveal that the patient's anterior pituitary gland is functioning normally and releasing FSH, but her ovaries fail to produce sufficient levels of estrogen during the first half of her cycle (Days 6–14).

what would be the direct downstream consequence of this hormonal deficiency?

- A) Progesterone levels will prematurely spike, causing immediate shedding of the endometrium.
- B) The corpus luteum will over-develop and cause early ovulation on Day 10.
- C) There will be no triggering rise in LH, preventing the release of the egg from the mature follicle.
- D) The follicle will transform directly into a corpus luteum without growing.

Q3: The Luteal phase is characterized by the transformation of the ruptured follicle into the corpus luteum.

What critical feedback mechanism does the corpus luteum exert to maintain the uterine environment?

- A) It secretes high levels of FSH to encourage a secondary follicle to grow simultaneously.
- B) It secretes low levels of progesterone to stimulate the shedding of the uterine lining.
- C) It secretes high amounts of progesterone and some estrogen to inhibit the secretion of FSH and LH, preventing another ovulation.
- D) It triggers an immediate spike in LH to cause the endometrium to thin down.

Q4: During the Follicular Phase (Days 6–14), changes occur concurrently in both the ovaries and the uterus. What is happening to the Endometrium while follicles are growing and developing under the influence of FSH in the Ovary?

- A) The endometrium is shedding completely due to rising progesterone.
- B) The thickness of the endometrium is gradually rebuilding and recovering.
- C) The endometrium stops all cellular activity and enters a resting stage.
- D) The endometrium becomes thinner and loses its blood vessels.

Q5: A student is reviewing the components of menstrual blood shed during the Menstrual Phase (Days 1–5). Which of the following is NOT a typical component of menstrual fluid?

- A) Mucus and tissue fluids
- B) Cells from the uterine lining
- C) Blood from ruptured vessels
- D) Intact cells from the corpus luteum

Q6: If a spike in Estrogen and LH occurs successfully, at which precise day of the cycle is the egg typically released from the follicle, and what is this specific structure surrounded by?

- A) Day 5; surrounded by mucus fluid.
- B) Day 14; surrounded by cells called the corona radiata.
- C) Day 15; surrounded by cells called the corpus luteum.
- D) Day 28; surrounded by endometrial tissue.

Fertilization

Figure 7 shows fertilization, the process of a sperm joining with an egg. Fertilization usually occurs in the upper portion of an oviduct near the ovary. In humans, both sperm and eggs are haploid, and each normally has 23 chromosomes. Fertilization brings these chromosomes together, restoring the diploid number of 46 chromosomes.

Sperm enter the vagina when strong muscular contractions ejaculate semen from the male's penis during intercourse. Sperm can survive for 48 hours in the female reproductive tract, but an unfertilized egg can survive for only 24 hours. Fertilization can happen if intercourse occurs anytime from a few days before ovulation to a day after ovulation. Overall, there is a relatively short time when fertilization can occur successfully. However, it is important to remember that the length of the menstrual cycle can vary and ovulation can occur at any time.

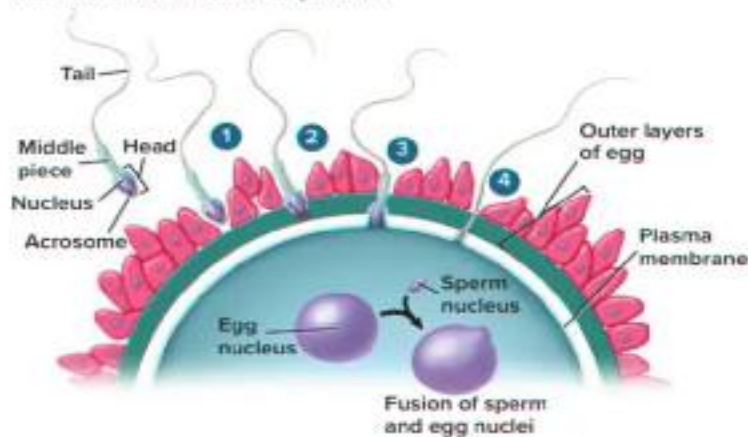


Figure 7 Although many sperm are needed to weaken the barrier that surrounds the egg, only one sperm fertilizes an egg (steps 1-4). Fertilization is complete when the sperm nucleus fuses with the egg nucleus.

About 300 million sperm are released into the vagina during intercourse. Only several hundred of them will successfully reach the egg. Many never make it out of the vagina, some are attacked by white blood cells, and many simply die along the way. Only one sperm can fertilize an egg, but it takes several hundred to participate in the process.

CHEMISTRY Connection A single sperm cannot penetrate the plasma membrane of a human egg. Notice in **Figure 7**, on the previous page, that the tip of each sperm is a specialized lysosome called an acrosome. As several hundred sperm bombard the egg, the enzymes inside of the acrosomes weaken the plasma membrane of the egg. Eventually the plasma membrane becomes weak enough that one sperm can penetrate the egg. Immediately, the egg forms a barrier to prevent other sperm from entering the now-fertilized egg.

Q1: Look at the progressive steps 1 through 4 labeled in image.

What specific structural change must occur at the head of the sperm cell between step 1 and step 3 to allow successful penetration?

- A) The tail detaches and dissolves to provide extra metabolic energy for the nucleus.
- B) The acrosome releases digestive enzymes to weaken and break down the outer layers of the egg.
- C) The plasma membrane thickens to prevent other sperm from entering the egg simultaneously.
- D) The nucleus undergoes rapid mitotic division before passing through the egg's plasma membrane.

Q2: A clinical fertility study evaluates a group of men who produce active, highly motile sperm with perfectly functional tails and normal haploid chromosome counts. However, laboratory testing reveals that their sperm cells carry a genetic mutation causing severely underdeveloped acrosomes. Which of the following is the most likely outcome when these sperm encounter an egg?

- A) The sperm will be unable to survive the 48-hour window inside the female reproductive tract.
- B) The sperm will navigate to the upper portion of the oviduct but will fail to penetrate the outer protective barriers of the egg.
- C) The sperm will successfully fuse with the egg nucleus but will restore a triploid instead of a diploid number of chromosomes.
- D) The sperm will prematurely stimulate the egg to divide without actual fusion of genetic material.

Q3: Human sperm and eggs are specialized reproductive cells that carry a haploid number of chromosomes.

What occurs at the exact moment fertilization is completed in the upper portion of the oviduct?

- A) The single sperm nucleus divides into two separate components to double the maternal genes.
- B) The egg sheds its outer layers to reduce its chromosome number down to zero.
- C) The haploid sperm nucleus fuses with the haploid egg nucleus, successfully restoring the diploid count of 46 chromosomes.
- D) Multiple sperm nuclei combine their genetic material together to maximize genetic variation.

Q4: A couples' counselor is reviewing the biological timelines of human gametes within the female reproductive tract. If a mature egg is ovulated into the oviduct, what is the maximum survival window available for this unfertilized egg compared to the survival window of traveling sperm cells?

- A) The unfertilized egg can survive for up to 48 hours, while sperm can only survive for 24 hours.
- B) Both the unfertilized egg and the sperm cells can survive for exactly 24 hours.
- C) The unfertilized egg can survive for only 24 hours, whereas sperm cells can survive for up to 48 hours.
- D) The unfertilized egg survives indefinitely until a sperm cell releases its acrosomal enzymes.

Q5: Anatomy of a human sperm cell includes three primary regions: the tail, the middle piece, and the head.

Which of the following correctly pairs a specific structural component located within the sperm head to its precise biological function during reproduction?

- A) Middle piece; contains the 23 chromosomes needed to restore diploidy.
- B) Acrosome; contains the enzymes necessary to penetrate the egg's outer layers.
- C) Tail; contains the nucleus that fuses directly with the egg plasma membrane.
- D) Nucleus; contains the mitochondria that drive muscular contractions in the uterus.

Q6: While thousands of sperm cells may travel up the female reproductive tract, only a single sperm cell ultimately fertilizes the egg. What is the evolutionary significance of having a massive number of sperm cells surround the outer layers of the egg simultaneously?

- A) Many sperm are required to collectively release enough acrosomal enzymes to weaken the tough protective barrier surrounding the egg.
- B) Each sperm must donate its tail to build a bridge across the egg's plasma membrane.
- C) The egg requires multiple sperm nuclei to fuse at the same time to activate its metabolic pathways.
- D) A large crowd of sperm is needed to physically push the egg from the ovary down into the lower uterus.

Early Development

Figure 8 illustrates the first week of human development. The fertilized egg, which is called a **zygote** (ZI goht), moves through the oviduct propelled by involuntary smooth muscle contractions and by the cilia lining the oviduct. Around 30 hours after fertilization, the zygote undergoes its first mitosis and cell division. Cell division continues, and by the third day, the embryo leaves the oviduct and enters the uterus. At this point, the embryo is described as a **morula**, a solid ball of cells. By the fifth day, the morula has developed into a **blastocyst**, a hollow ball of cells. The blastocyst attaches to the endometrium around the sixth day and is fully implanted by day 10. **Figure 8** shows that the blastocyst is not completely hollow. Inside the blastocyst is a group of cells called the **inner cell mass**. The inner cell mass eventually will become the embryo.

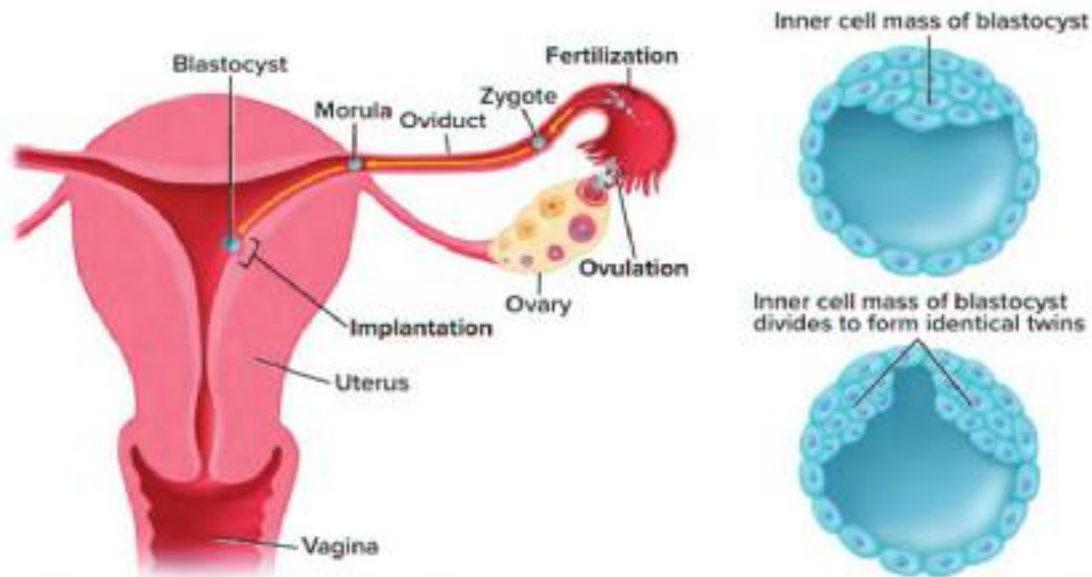


Figure 8 Left: During the first week of development, many changes occur as the zygote travels through the oviduct.

1- The fertilized egg moves through the fallopian tube due to smooth muscle contractions and the movement of cilia lining the tube.

2- About **30 hours** after fertilization, it undergoes mitotic cell division, and cell divisions continue.

3- On the **third day**, the embryo enters the uterus and is known as the **morula** (a solid ball of cells).

4- On the **fifth day**, the morula develops into a **blastocyst** (a hollow ball of cells).

5- On the **sixth day**, it attaches to the uterine lining.

6- By the **tenth day**, implantation in the uterus is complete.

The blastocyst contains a group of cells called the **inner cell mass**, which develops into the embryo.

Q1: At which specific structural point does the developing human organism transition from being a solid ball of cells into a hollow ball of cells, and where is this structural change physically located?

- A) It transitions into a zygote while still inside the ovary.
- B) It transitions into a morula at the moment it implants into the vagina.
- C) It transitions into a blastocyst as it enters and moves within the uterus.
- D) It transitions into an unfertilized egg near the cilia of the outer oviduct.

Q2: A patient experiencing an ectopic pregnancy is found to have an embryo that successfully implanted into the inner wall of the oviduct rather than the uterus. Pathological analysis shows that the tiny hair-like structures lining her oviduct, alongside its smooth muscles, are non-functional due to a past inflammatory condition.

Which mechanical process failed, directly leading to this medical emergency?

- A) The inability of the ovaries to perform ovulation at Day 14.
- B) The failure of mechanical propulsion required to move the zygote through the oviduct toward the uterus.
- C) The premature conversion of a blastocyst back into a single-celled zygote.
- D) The complete lack of mitotic cell division during the first 30 hours.

Q3: What is the specific embryological significance of the inner cell mass found inside the blastocyst, and what unique event is illustrated in the bottom sphere?

- A) It produces the fluid that fills the empty spaces of the morula; the bottom sphere shows it shrinking.
- B) It eventually becomes the fetus itself; the bottom sphere shows the inner cell mass dividing to form identical twins.
- C) It transforms into the muscular wall of the maternal vagina; the bottom sphere shows it self-destructing.
- D) It functions to reject secondary sperm cells; the bottom sphere shows it forming fraternal triplets.

Q4: Imagine tracking a single human zygote under a hypothetical timeline. At approximately 30 hours post-fertilization, what primary cellular process initiates the transformation of this single-celled zygote into a multicellular embryo?

- A) The cell undergoes meiosis to cut its genetic material in half.
- B) The cell undergoes its first mitosis and cell division.
- C) The cell stops growing and immediately sheds its plasma membrane.
- D) The cell fuses with neighboring unfertilized eggs to increase in volume.

Q5: An embryo has successfully travelled through the oviduct and reached the uterine cavity as a hollow ball of cells containing an inner cell mass. What must occur around the sixth day for development to continue successfully, and when is this specific process fully completed?

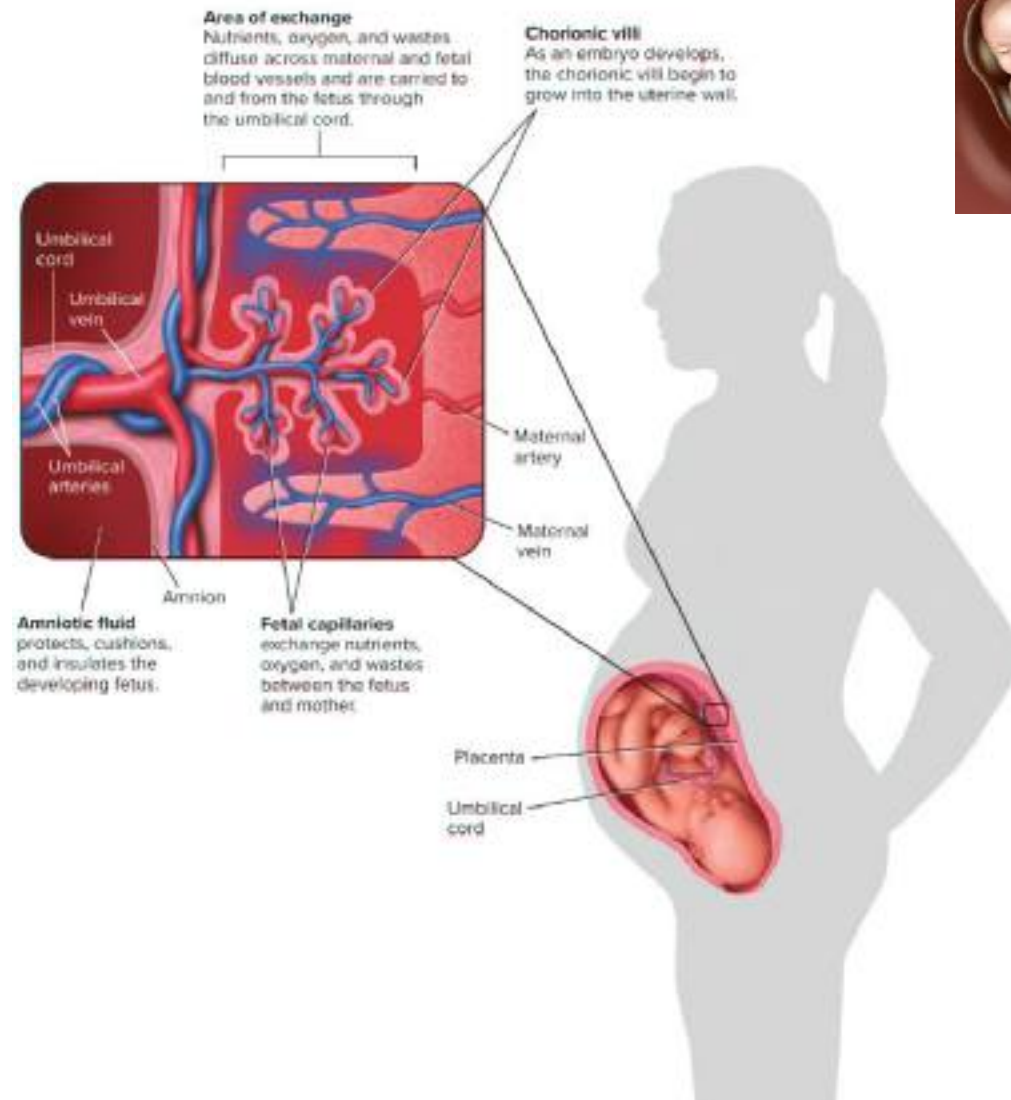
- A) The morula must attach to the vagina around the sixth day and complete its journey by day 14.
- B) The blastocyst must attach to the endometrium around the sixth day and become fully implanted by day 10.
- C) The zygote must detach from the ovary around the sixth day and complete its journey by day 30.
- D) The inner cell mass must dissolve into tissue fluid on the sixth day and complete its journey by day 8.

Which of the following outlines the correct chronological sequence of developmental stages and milestone days that an embryo goes through during its first week of life?

- A) Blastocyst (Day 1) → Morula (Day 3) → Zygote (Day 5) → Ovulation (Day 10)
- B) Zygote (First 30 hours) → Morula (Day 3) → Blastocyst (Day 5) → Attachment to endometrium (Day 6)
- C) Implantation (Day 1) → Mitosis (Day 5) → Morula (Day 6) → Zygote (Day 10)
- D) Morula (First 30 hours) → Blastocyst (Day 3) → Zygote (Day 6) → Ovulation (Day 7)

Figure 10 Visualizing a Placenta

A growing fetus exchanges nutrients, oxygen, and wastes with the mother through the placenta. The placenta contains tissue from both mother and fetus.



- About two weeks after fertilization, chorionic villi begin to grow into the uterine wall, along with which the placenta is formed.
- **The placenta** supplies the embryo with nutrients and oxygen and removes its waste products.
- It consists of two layers: a fetal layer derived from the chorion that faces the embryo, and a maternal layer formed from uterine tissues.
- Its diameter is 15–20 cm, its thickness is about 2.5 cm, and its mass is about 0.45 kg.
- It regulates the transfer of substances between the fetus and the mother through the umbilical cord.

The placenta allows the exchange of:

- Nutrients
- Oxygen
- Waste products
- Carbon dioxide

between the mother and the fetus.

It also allows the passage of:

- Drugs
- Medications
- Antibodies
- HIV (if the mother is infected)

Do blood cells pass through the placenta?

✗ No, blood cells do not normally pass through the placenta.

1. Which embryonic structure begins growing into the uterine wall approximately two weeks after fertilization to form the placenta?

- A) Amnion
- B) Chorionic villi
- C) Umbilical vein
- D) Umbilical arteries

2. The placenta is a unique organ composed of tissues derived from two different sources. What constitutes the maternal layer of the placenta?

- A) Tissues derived from the chorion
- B) Tissues derived from the amnion
- C) Tissues derived from the uterine wall
- D) Tissues derived from the umbilical cord

3. During normal embryonic development, which of the following substances passes from the fetus to the mother through the placenta?

- A) Oxygen
- B) Nutrients
- C) Antibodies
- D) Carbon dioxide

4. A pregnant woman is exposed to a viral pathogen. Which of the following can actively or passively pass from the mother's blood to the fetus across the placenta?

- A) Red blood cells
- B) White blood cells
- C) Antibodies and HIV
- D) Maternal platelets

5. What are the average dimensions and mass of a fully formed human placenta?

- A) Diameter: 5–10 cm, Thickness: 1 cm, Mass: 0.15 kg
- B) Diameter: 15–20 cm, Thickness: 2.5 cm, Mass: 0.45 kg
- C) Diameter: 30–35 cm, Thickness: 5 cm, Mass: 1.20 kg
- D) Diameter: 40–45 cm, Thickness: 0.5 cm, Mass: 2.00 kg

6. Which statement accurately describes the movement of blood cells across the placental barrier?

- A) Fetal red blood cells constantly mix with maternal blood cells.
- B) Blood cells do not normally pass through the placenta.
- C) Only maternal red blood cells can cross into the fetal capillaries.
- D) Waste products are carried by transferring whole red blood cells.

A clinical study analyzes the blood samples taken from an umbilical artery and an umbilical vein right at the area of exchange in the placenta. The lab technicians notice a significant difference in the concentration of metabolic waste and gases between the two vessels.

Which of the following correctly identifies the physiological state of the blood inside these vessels as it interfaces with the placenta?

- A) The umbilical vein carries oxygen-depleted blood containing carbon dioxide and wastes toward the placenta.
- B) The umbilical arteries carry oxygen-rich blood and nutrients away from the placenta to the fetus.
- C) The umbilical arteries carry oxygen-depleted blood and metabolic wastes from the fetus toward the area of exchange.
- D) Both the umbilical vein and umbilical arteries carry identical concentrations of oxygen because mixing occurs inside the chorionic villi.



Figure 11 The embryo develops into a fetus during the first trimester of pregnancy. By the end of the third month, the fetus can make small movements.

First trimester (months 1, 2, and 3):

- ❖ Formation of all tissues, organs, and body systems begins.
- ❖ The embryo is most vulnerable to the effects of alcohol and drugs.
- ❖ Birth defects may occur due to deficiencies in some nutrients.
- ❖ By the end of the 8th week, it is referred to as a fetus.
- ❖ Body systems are formed by the end of the first trimester.
- ❖ It can move its arms, fingers, and toes.
- ❖ It shows some facial expressions.
- ❖ Fingerprints begin to form.

Growth stage (second trimester):

- ❖ The fetal heartbeat can be heard between weeks 18–20.
- ❖ The fetus is able to suck its thumb.
- ❖ It may experience hiccups.
- ❖ The mother feels its movements and kicks.
- ❖ Hair forms and the eyes open.
- ❖ By the end of this stage, it may be able to survive outside the uterus with medical intervention, but the chance is low because it cannot maintain a stable body temperature, its lungs are not fully developed so it cannot breathe properly, and its immune system is not yet complete.

Third trimester:

- ❖ The fetus continues to grow rapidly.
- ❖ Fat accumulates under the skin to provide an insulating layer at birth.
- ❖ Brain nerve cells form at a rate of about 250,000 cells per minute.
- ❖ It responds to sounds such as its mother's voice and music.

Q1: At what developmental milestone is the developing human embryo first officially referred to as a fetus?

- A) 4 weeks
- B) 8 weeks
- C) 12 weeks
- D) 20 weeks

Q2: Which developmental event occurs exclusively during the third trimester of pregnancy?

- A) Fingerprints begin to form.
- B) Hair forms and the eyes open.
- C) Accumulation of insulating fat under the skin.
- D) Formation of all tissues, organs, and body systems.

Q3: What is the specific rate of brain nerve cell formation during the third trimester?

- A) 50,000 cells per minute
- B) 150,000 cells per minute
- C) 250,000 cells per minute
- D) 500,000 cells per minute

Q4: During which period of development is the embryo most highly vulnerable to the damaging effects of alcohol and drugs?

- A) First trimester
- B) Second trimester
- C) Third trimester
- D) Postnatal stage

Q5: Which physiological milestone can typically be detected by a doctor between weeks 18 and 20 of gestation?

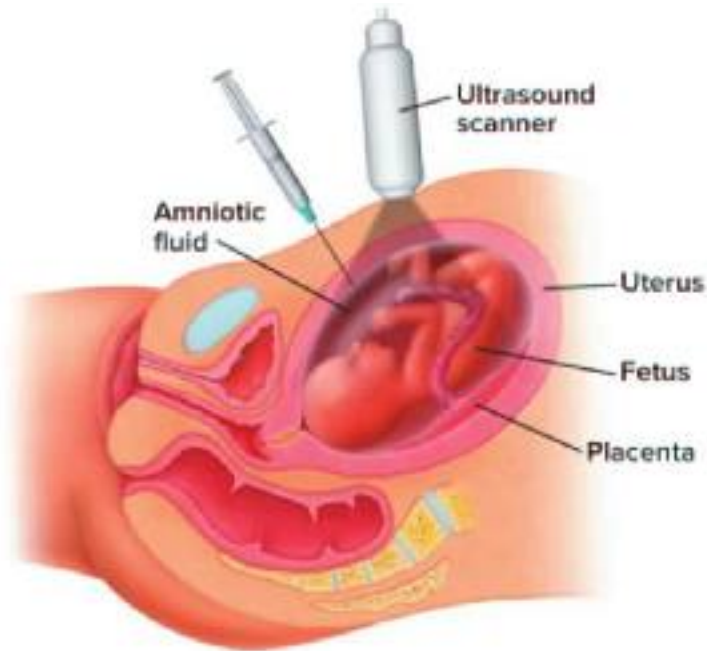
- A) Formation of fingerprints
- B) Rapid accumulation of subcutaneous fat
- C) A fetal heartbeat that can be heard
- D) Complete maturation of the lungs

Q6: What is a major physiological reason why a premature infant born at the very end of the second trimester has a low chance of survival even with medical intervention?

- A) Brain nerve cells have not yet begun to form.
- B) The embryo has not yet transformed into a fetus.
- C) All major body organs and tissues completely fail to start their formation.
- D) The lungs are not fully developed to allow proper breathing.

Q7: A pregnant woman experiences severe nutritional deficiencies during the first two months of her pregnancy. Later in her pregnancy, during the third trimester, she maintains an excellent, nutrient-rich diet. What is the most likely biological outcome of this situation?

- A) The fetus will easily recover because the third trimester is when all body systems and organs first begin their formation.
- B) Birth defects may still occur because major tissue, organ, and body system formation began during the period of nutritional deficiency.
- C) The fetus will not experience any risks because structural defects only occur due to deficiencies in the final month of pregnancy.
- D) Brain nerve cells will fail to form completely because they rely entirely on nutrients stored during the first week of fertilization.



Amniocentesis

Figure 12 In amniocentesis, fluid and cells lost from the fetus are removed from the amniotic fluid and analyzed.



First: Ultrasound (sonography):

- Ultrasound is a method used to examine the fetus during pregnancy.
- It works by sending sound waves that reflect off the fetus to produce images on a screen.
- It helps in checking fetal growth, position in the uterus, and determining its sex.

Second: Amniocentesis :

- Amniocentesis is performed during the second trimester of pregnancy.
- It involves examining fetal cells through karyotyping or DNA analysis.
- It is used to detect abnormal chromosome numbers, determine the sex of the fetus, and measure enzyme levels associated with certain medical conditions.

Third: Chorionic villus sampling (CVS) :

- CVS is performed during the first trimester of pregnancy.
- It involves analyzing fetal cells using karyotyping.
- It is used to detect fetal abnormalities, but it carries a risk of miscarriage.

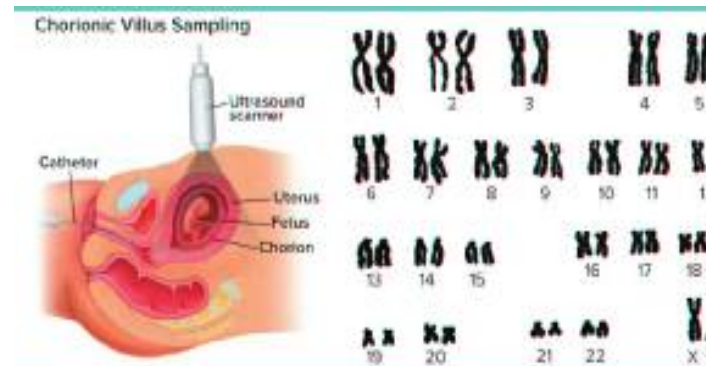


Figure 13 Left: Chorionic villus sampling involves removing cells from the chorion and analyzing them.

Q1: Which diagnostic technique relies entirely on high-frequency sound waves reflecting off fetal tissues to generate real-time structural images without extracting physical samples?

- A) Ultrasound
- B) Amniocentesis
- C) Chorionic villus sampling
- D) Karyotyping

Q2: During which specific period of pregnancy is Amniocentesis typically performed to safely analyze fetal cells?

- A) First trimester
- B) Second trimester
- C) Third trimester
- D) Pre-implantation stage

Q3: Which diagnostic procedure is carried out during the first trimester but is explicitly noted for carrying an inherent risk of miscarriage?

- A) Amniocentesis
- B) Sonography
- C) Chorionic villus sampling
- D) Enzyme level tracking

Q4: What primary cellular analysis technique is used during both Amniocentesis and Chorionic Villus Sampling to detect abnormal chromosome numbers?

- A) Echocardiography
- B) Karyotyping
- C) Enzyme activity assay
- D) Volumetric sonography

Q5: Which clinical observation can be accomplished using ultrasound imaging but cannot be achieved by analyzing fetal cells alone?

- A) Measuring fetal enzyme levels
- B) Detecting abnormal chromosome numbers
- C) Determining exact structural position in the uterus
- D) Performing deep DNA sequencing

Q6: What unique diagnostic capability does Amniocentesis possess that is not shared by Chorionic Villus Sampling?

- A) Measuring enzyme levels associated with medical conditions
- B) Determining the biological sex of the fetus
- C) Utilizing karyotyping for genetic checking
- D) Providing non-invasive screening results

Q7: A medical team evaluates a high-risk pregnancy where a metabolic enzyme disorder is strongly suspected, requiring a precise biochemical test of fluid components. Concurrently, the patient requires reassurance regarding the physical placement of the fetus. Which combination of procedures satisfies all diagnostic needs?

- A) Chorionic Villus Sampling followed by immediate DNA sequencing
- B) Ultrasound for positioning alongside Amniocentesis for enzyme analysis
- C) Amniocentesis alone during the first trimester of pregnancy
- D) Ultrasound coupled with immediate Chorionic Villus Sampling to evaluate fluid enzymes

1. By the end of which week is the developing baby referred to as a fetus?

- A) End of the 6th week
- B) End of the 8th week
- C) End of the 12th week
- D) End of the 20th week

2. During which trimester does the formation of all tissues, organs, and body systems begin?

- A) First trimester
- B) Second trimester
- C) Third trimester
- D) After birth

3. Why is the embryo most vulnerable to the effects of alcohol and drugs?

- A) Because its immune system is complete
- B) Because it is growing rapidly in the third trimester
- C) Because tissues and organs are forming during this time
- D) Because it can already breathe on its own

4. Which of the following can occur by the end of the first trimester?

- A) The fetus can survive outside the uterus
- B) The heartbeat can be heard clearly
- C) The fetus can move its arms, fingers, and toes
- D) Fat accumulates under the skin

5. Between which weeks can the fetal heartbeat typically be heard?

- A) Weeks 8–10
- B) Weeks 12–14
- C) Weeks 18–20
- D) Weeks 25–28

6. Why is the chance of survival low if the fetus is born by the end of the second trimester?

- A) Because fingerprints have not yet formed
- B) Because the mother cannot feel movements yet
- C) Because the lungs are not fully developed and body temperature is unstable
- D) Because the brain stops forming nerve cells

7. What happens during the third trimester regarding brain development?

- A) Brain nerve cells form at a rate of about 250,000 cells per minute
- B) The brain stops growing
- C) The fetus begins to suck its thumb
- D) The eyes remain closed until birth

8. What is the purpose of fat accumulating under the skin during the third trimester?

- A) To help the fetus move more easily
- B) To provide an insulating layer at birth
- C) To help the fetus hear sounds
- D) To form fingerprints

9. Which fetal testing method is performed during the first trimester?

- A) Amniocentesis
- B) Ultrasound only
- C) Chorionic villus sampling (CVS)
- D) Karyotyping after birth

10. What is one risk associated with Chorionic Villus Sampling (CVS)?

- A) It cannot detect abnormalities
- B) It is only used to determine sex
- C) It carries a risk of miscarriage
- D) It must be done in the third trimester

11. Which method uses sound waves that reflect off the fetus to produce images on a screen?

- A) Amniocentesis
- B) Chorionic villus sampling (CVS)
- C) Ultrasound (sonography)
- D) DNA sequencing

12. What can amniocentesis detect through karyotyping or DNA analysis?

- A) Only the sex of the fetus
- B) Abnormal chromosome numbers and enzyme levels
- C) The rate of brain cell formation
- D) The mother's blood type

13. During which trimester is amniocentesis typically performed?

- A) First trimester
- B) Second trimester
- C) Third trimester
- D) After birth

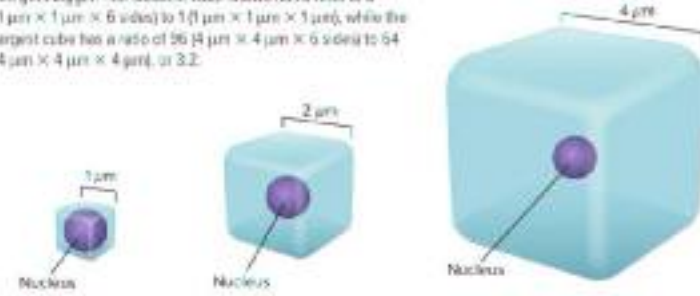
14. Which of the following is mentioned as a development that occurs during the second trimester?

- A) Formation of all body systems
- B) Fingerprints begin to form
- C) The fetus can suck its thumb and may experience hiccups
- D) Fat accumulates under the skin

15. Why can many fetal abnormalities be diagnosed before birth?

- A) Because all abnormalities are visible from the first month
- B) Because early diagnosis increases chances of appropriate medical treatment and quality of life
- C) Because the fetus can communicate its condition
- D) Because abnormalities only appear in the third trimester

Figure 1 The ratio of surface area to volume decreases as a cell gets bigger. The smallest cube shown has a ratio of 6 ($1 \mu\text{m} \times 1 \mu\text{m} \times 6$ sides) to 1 ($1 \mu\text{m} \times 1 \mu\text{m} \times 1 \mu\text{m}$), while the largest cube has a ratio of 96 ($4 \mu\text{m} \times 4 \mu\text{m} \times 6$ sides) to 64 ($4 \mu\text{m} \times 4 \mu\text{m} \times 4 \mu\text{m}$), or 3:2.



If the cubic cell grows to 2 μm per side, as represented in Figure 1, the surface area becomes 24 μm^2 and the volume is 8 μm^3 . The ratio of surface area to volume is now 3:1, which is less than it was when the cell was smaller. If the cell continues to grow, the ratio of surface area to volume will continue to decrease, as shown by the third cube in Figure 1. As the cell grows, its volume increases much more rapidly than the surface area. This means that the cell might have difficulty supplying nutrients and expelling enough waste products. By remaining small, cells have a higher ratio of surface area to volume and can sustain themselves more easily.

- The surface area-to-volume (SA:V) ratio dictates a cell's ability to survive. Cells rely on their outer membrane to import nutrients and expel wastes.
- Because volume grows faster than surface area as a cell expands, larger cells suffer from a lower SA:V ratio, leading to starvation and toxic waste accumulation.
- To maintain healthy metabolic function, cells must either remain small (maximizing the ratio) or develop structural adaptations to increase their surface area

Which statement correctly analyzes the relationship between the physical growth shown and the calculated transport efficiency?

- The 1 μm cube represents the least efficient cell because its small volume limits the amount of cytoplasm available for vital chemical reactions.
- The 2 μm cube has a ratio of 3:1, making it twice as efficient at expelling metabolic wastes as the smallest 1 μm model.
- The 4 μm cube has the lowest surface area to volume ratio, illustrating why large cells must divide to maintain efficient exchange across the plasma membrane.
- The structural shift from the first cube to the third cube proves that surface area grows at an identical rate to internal volume.

Q1: What mathematical change occurs to the surface area to volume ratio as a cell increases in size?

- A) It increases proportionally.
- B) It remains constant.
- C) It decreases.
- D) It doubles with every micrometer of growth.

Q2: What is the surface area to volume ratio of a cubic cell with a side length of 1 μm ?

- A) 1:1
- B) 3:1
- C) 3:2
- D) 6:1

Q3: As a cell grows, which mathematical dimension increases much more rapidly than the other?

- A) Surface area increases faster than volume.
- B) Volume increases faster than surface area.
- C) Both dimensions increase at identical geometric rates.
- D) Uterine dimensions increase faster than volume.

Q4: What primary physiological challenge does a cell face if its volume becomes too large relative to its surface area?

- A) DNA replication halts entirely.
- B) It experiences difficulty supplying nutrients and expelling enough waste products.
- C) The nucleus starts to shrink and disappears.
- D) Cellular respiration speeds up beyond control.

Q5: Why does remaining small allow cells to sustain themselves much more easily?

- A) Small cells contain multiple nuclei to manage waste.
- B) Small cells have a higher ratio of surface area to volume for efficient transport.
- C) Small cells do not require any nutrients from the outside environment.
- D) Small cells have a thicker plasma membrane that stops diffusion.

Q6: A spherical cell expands its structural boundaries during an intense growth phase, causing its total volume to jump from 1 μm^3 to 8 μm^3 .

If the cell does not divide or modify its shape, what is the most direct consequence on its internal transport mechanisms?

- A) The rate of diffusion through the membrane will automatically speed up to compensate for the large volume.
- B) Waste products will begin to accumulate inside because the cell membrane surface area is now insufficient to support the large volumetric demands.
- C) The cell will require less energy because a larger volume naturally stores more nutrients without needing external supply.
- D) Metabolic reactions will completely stop because enzymes can only function in cells with a side length of exactly 1 μm .

BIO.3.1.03.024 Describe the events that occur during each of the stages of the cell cycle (interphase (mitosis and cytokinesis)

Figure 4

Interphase

Interphase is the stage during which the cell grows, develops into a mature, functioning cell, duplicates the DNA in its nucleus, and prepares for division. Interphase is divided into three stages as shown in **Figure 4**: G_1 , S, and G_2 , also called Gap 1, synthesis, and Gap 2. When these activities are completed, the cell begins mitosis.

Gap 1 (G_1) The first stage of interphase, G_1 , is the period immediately after a cell divides. During G_1 , a cell is growing, carrying out normal cell functions, and preparing to replicate DNA. Some cells, such as muscle and nerve cells, exit the cell cycle at this point and do not divide again.

Synthesis (S) The second stage of interphase, S, is the period when a cell copies its DNA in preparation for cell division.

Gap 2 (G_2) The G_2 stage follows the S stage and is the period when the cell prepares for the division of its nucleus. A protein that makes microtubules for cell division is synthesized at this time. During G_2 , the cell also takes inventory and makes sure it is ready to continue with mitosis.

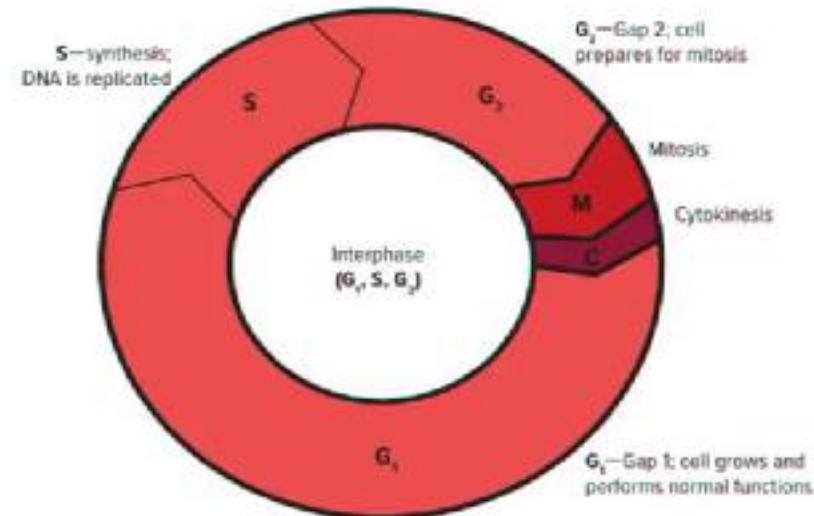


Figure 4 The cell cycle involves three stages—interphase, mitosis, and cytokinesis. Interphase is divided into three substages.

Hypothesize why cytokinesis represents the smallest amount of time that a cell spends in the cell cycle.

Prophase	Prometaphase	Metaphase	Anaphase	Telophase	Cytokinesis
- Chromosomes condense and become visible - Spindle fibers emerge from the centrosomes - Nuclear envelope breaks down - Nucleolus disappears	- Chromosomes continue to condense - Kinetochores appear at the centromeres - Mitotic spindle microtubules attach to kinetochores - Centrosomes move toward opposite poles	- Mitotic spindle is fully developed, centrosomes are at opposite poles of the cell - Chromosomes are lined up at the metaphase plate - Each sister chromatid is attached to a spindle fiber originating from opposite poles	- Cohesin proteins binding the sister chromatids together break down - Sister chromatids (now called chromosomes) are pulled toward opposite poles - Non-kinetochore spindle fibers lengthen, elongating the cell	- Chromosomes arrive at opposite poles and begin to decondense - Nuclear envelope material surrounds each set of chromosomes - The mitotic spindle breaks down	- Animal cells: a cleavage furrow separates the daughter cells - Plant cells: a cell plate separates the daughter cells

MITOSIS

Which substage of interphase is characterized by the replication of cellular DNA in preparation for division?

- A) Gap 1 (G_1)
- B) Synthesis (S)
- C) Gap 2 (G_2)
- D) Mitosis (M)

What protein structure necessary for the division of the nucleus is synthesized during the Gap 2 (G_2) stage of interphase?

- A) Cohesin proteins
- B) Microtubules
- C) Kinetochores
- D) Cleavage furrows

During which specific phase of mitosis do the sister chromatids separate and get pulled toward opposite poles of the cell?

- A) Prophase
- B) Metaphase
- C) Anaphase
- D) Telophase

Which mitotic phase involves the condensation of chromosomes, breakdown of the nuclear envelope, and disappearance of the nucleolus?

- A) Prophase
- B) Prometaphase
- C) Metaphase
- D) Telophase

How does cytokinesis differ fundamentally between animal cells and plant cells?

- A) Animal cells form a cell plate, while plant cells form a cleavage furrow.
- B) Animal cells utilize a cleavage furrow to separate cells, while plant cells develop a cell plate.
- C) Animal cells divide the cytoplasm during prophase, while plant cells divide during anaphase.
- D) Plant cells completely skip cytokinesis and retain a single large nucleus.

What is the primary characteristic of cells, such as mature muscle and nerve cells, regarding the cell cycle?

- A) They continuously repeat the S phase without dividing.
- B) They exit the cell cycle at the G_1 stage and do not divide again.
- C) They spend most of their existence in the mitotic anaphase stage.
- D) They lack a nuclear envelope during their entire life cycle.

A laboratory researcher treats a culture of rapidly dividing human epithelial cells with a chemical agent that completely blocks the breakdown of cohesin proteins binding sister chromatids together. If these cells are allowed to cycle through interphase normally and enter mitosis, at which specific stage will the mitotic progression be permanently halted?

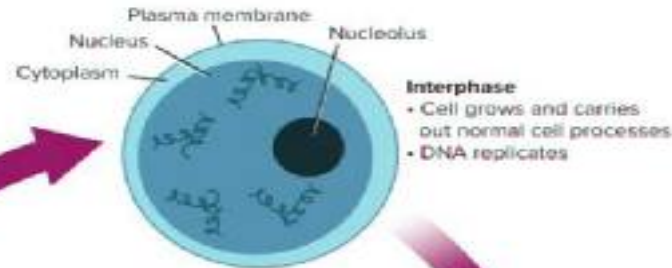
- A) Prometaphase, because chromosomes will fail to attach to the spindle fibers.
- B) Metaphase, because chromosomes will align at the plate but the chromatids cannot separate into independent chromosomes.
- C) Anaphase, because sister chromatids will have already reached opposite poles.
- D) Telophase, because the nuclear envelope requires broken cohesin to reform around sets of chromosomes.

Figure 6 Visualizing the Cell Cycle

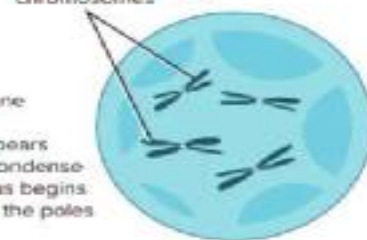
The cell cycle begins with interphase. Mitosis follows, occurring in four stages—prophase, metaphase, anaphase, and telophase. Mitosis is followed by cytokinesis, then the cell cycle repeats with each new cell.

Cytokinesis

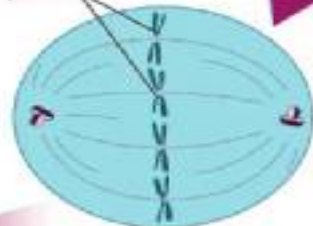
Plant cells: Cell plate forms, dividing daughter cells.
Animal cells: Cleavage furrow forms at equator of cell and pinches inward until cell divides in two.

**Prophase**

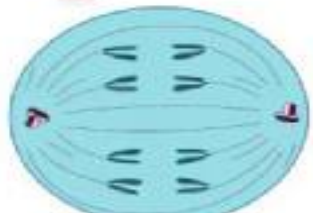
- Nuclear membrane disintegrates
- Nucleolus disappears
- Chromosomes condense
- Spindle apparatus begins to form between the poles

**Metaphase**

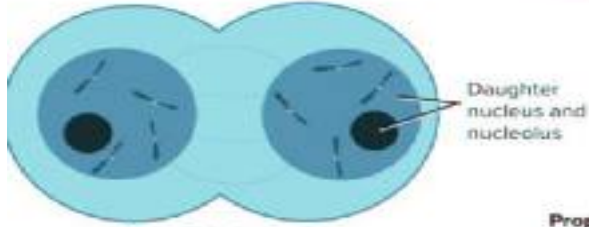
Chromosomes align on equator
 Chromosomes attach to spindle apparatus and align along equator of cell

**Anaphase**

Microtubules shorten, moving chromosomes to opposite poles

**Telophase**

- Chromosomes reach poles of cell
- Nuclear envelope reforms
- Nucleolus reappears
- Chromosomes decondense



Q1: Which of the following events characterizes the prophase stage of mitosis?

- A) Chromosomes align perfectly along the equator of the cell.
- B) The nuclear membrane disintegrates and the nucleolus disappears.
- C) Microtubules shorten, pulling sister chromatids to opposite poles.
- D) A cell plate begins to form dividing the two daughter cells.

Q2: What primary event takes place during the interphase stage of the cell cycle?

- A) The spindle apparatus attaches to the centromeres of sister chromatids.
- B) Chromosomes reach the poles of the cell and decondense.
- C) The cell grows, carries out normal metabolic processes, and replicates its DNA.
- D) The cytoplasm pinches inward at the equator to divide the cytoplasm.

Q3: During which stage of mitosis do sister chromatids separate and move toward opposite poles of the cell?

- A) Metaphase
- B) Anaphase
- C) Telophase
- D) Prophase

Q4: A primary difference between cytokinesis in plant cells and animal cells is that:

- A) Plant cells form a cleavage furrow, whereas animal cells form a cell plate.
- B) Animal cells form a cleavage furrow that pinches inward, whereas plant cells form a rigid cell plate.
- C) Plant cells undergo cytokinesis during prophase, while animal cells undergo it during metaphase.
- D) Animal cells replicate their DNA during cytokinesis, while plant cells do not.

Q5: Which structural rearrangement occurs during telophase?

- A) Chromosomes condense and become visible under a light microscope.
- B) Homologous chromosomes cross over to exchange genetic material.
- C) The nuclear envelope reforms around the chromosomes at each pole, and the nucleolus reappears.
- D) Spindle fibers contract and pull sister chromatids to the center line.

Q6: What is the specific role of the spindle apparatus during metaphase?

- A) Replicating the DNA strands before the cell splits.
- B) Rebuilding the plasma membrane at the end of the cell cycle.
- C) Attaching to the chromosomes and aligning them precisely along the cell equator.
- D) Synthesizing the proteins needed to form a plant cell plate.

Q7: A research scientist treats a culture of rapidly dividing human skin cells with a chemical agent that completely inhibits the shortening of microtubules. When analyzing the treated cells under a microscope several hours later, at which stage of the cell cycle will the majority of the cells be arrested?

- A) Prophase
- B) Metaphase
- C) Anaphase
- D) Telophase

Q8: A cell culture is exposed to a chemical inhibitor during the G2 phase of interphase that completely prevents the duplication of centrosomes (spindle poles). If this cell is allowed to transition into mitosis, what will be the most direct consequence on the mitotic structures?

- A) The DNA will fail to decondense during telophase.
- B) The sister chromatids will replicate a second time.
- C) The spindle apparatus will fail to form correctly between two distinct poles.
- D) The cell plate will immediately form at the beginning of prophase.

Q9: A mutation in a specific plant cell line prevents the formation and fusion of Golgi-derived vesicles at the equator during the final stages of nuclear division. How will the outcome of this mutation differ from a similar failure of cytokinesis in an animal cell?

- A) The plant cell will fail to form a cleavage furrow, while the animal cell will successfully divide using a cell plate.
- B) The plant cell will fail to build a dividing cell plate, whereas the animal cell would fail to form a cleavage furrow.
- C) The plant cell will remain stuck in interphase, while the animal cell will immediately enter anaphase.
- D) The plant cell will eliminate its cell wall, whereas the animal cell will develop a rigid outer covering.

Cytokinesis

Toward the end of mitosis, the cell begins **cytokinesis** (si toh kih NEE sis) by which a cell's cytoplasm divides. This results in two cells with identical nuclei. In animal cells, cytokinesis is accomplished by using microfilaments to constrict, or pinch, the cytoplasm, as shown in **Figure 10**. The area where constriction occurs is called the furrow.

Plant cells have a rigid cell wall. Instead of pinching in half, a new structure called a cell plate forms between the two daughter nuclei. Cell walls then form on either side of the cell plate. Once this new wall is complete, there are two genetically identical cells.

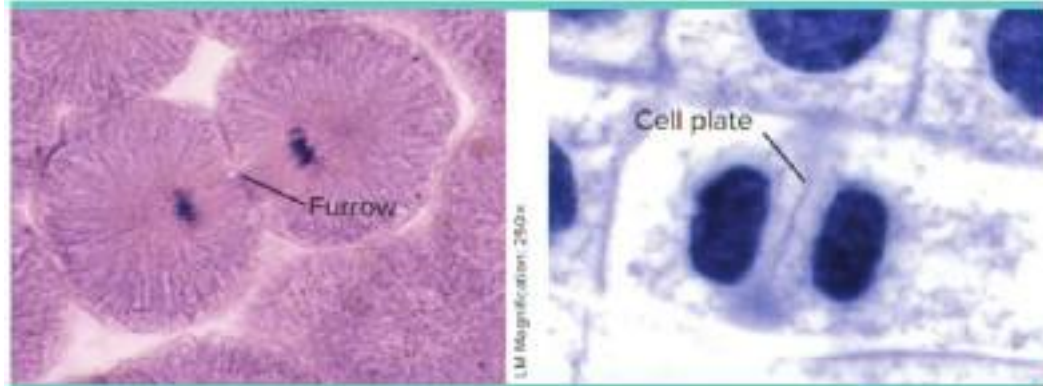


Figure 10 Left: In animal cells, cytokinesis begins with a furrow that pinches the cell and eventually splits the two cells apart. Right: Plant cells build a cell plate that divides the cell into the two daughter cells.

Q1: Which structure is responsible for constricting and pinching the cytoplasm during cytokinesis in animal cells?

- A) Cell plate
- B) Microfilaments
- C) Rigid cell wall
- D) Golgi vesicles

Q2: What is the area called where the constriction occurs during animal cell division?

- A) Furrow
- B) Cell plate
- C) Equator
- D) Spindle pole

Q3: Why can plant cells not split down the middle by pinching inward like animal cells?

- A) They lack genetically identical nuclei.
- B) They do not contain microfilaments in their cytoplasm.
- C) They possess a rigid cell wall that prevents constriction.
- D) Their cytoplasm divides completely during prophase.

Q4: What new structure must form between the two daughter nuclei in a plant cell before the cell walls are built?

- A) A furrow
- B) A cell plate
- C) A spindle fiber
- D) A centromere

Q5: What is the immediate result of a successfully completed cytokinesis stage?

- A) Two cells with completely different genetic material.
- B) A single cell with two separate nuclei trapped inside.
- C) Two distinct cells with genetically identical nuclei.
- D) Disintegration of the original cellular plasma membrane.

Q6: A mutation in a strain of cultured animal cells completely destroys the functionality of cytoplasmic microfilaments right after telophase completes. What cellular anomaly will a scientist observe when inspecting these mutated cells?

- A) The cells will contain a single nucleus but will be completely missing a plasma membrane.
- B) The cells will successfully build a cell plate instead of using a cleavage furrow.
- C) The cells will become multinucleated because the nuclei divided but the cytoplasm failed to split.
- D) The cells will immediately revert to the prophase stage to rebuild their chromosomes.

Q7: Consider the two distinct cellular mechanisms shown in Figure 10. If an experimental chemical blocks vesicle transportation to the equator, which cellular process shown in the visual figures will be completely halted, and in which cell type?

- A) Furrow formation on the left; animal cells.
- B) Cell plate formation on the right; plant cells.
- C) Nuclear disintegration on the left; animal cells.
- D) Chromosome condensation on the right; plant cells.

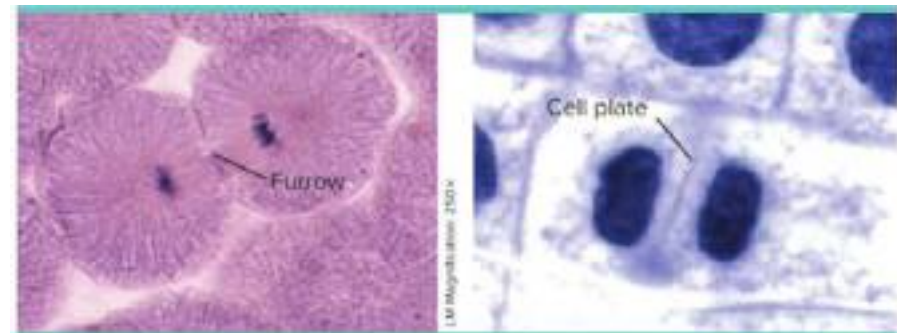


Figure 10 Left: In animal cells, cytokinesis begins with a furrow that pinches the cell and eventually splits the two cells apart. Right: Plant cells build a cell plate that divides the cell into the two daughter cells.

Quality control checkpoints The cell cycle has built-in checkpoints that monitor the cycle and can stop it if something goes wrong. For example, a checkpoint near the end of the G_1 stage monitors for DNA damage and can stop the cycle before it enters the S stage of interphase. There are other quality control checkpoints during the S stage and after DNA replication in the G_2 stage. Spindle checkpoints also have been identified in mitosis. If a failure of the spindle fibers is detected, the cycle can be stopped before cytokinesis. **Figure 11** shows the location of key checkpoints in the cell cycle.

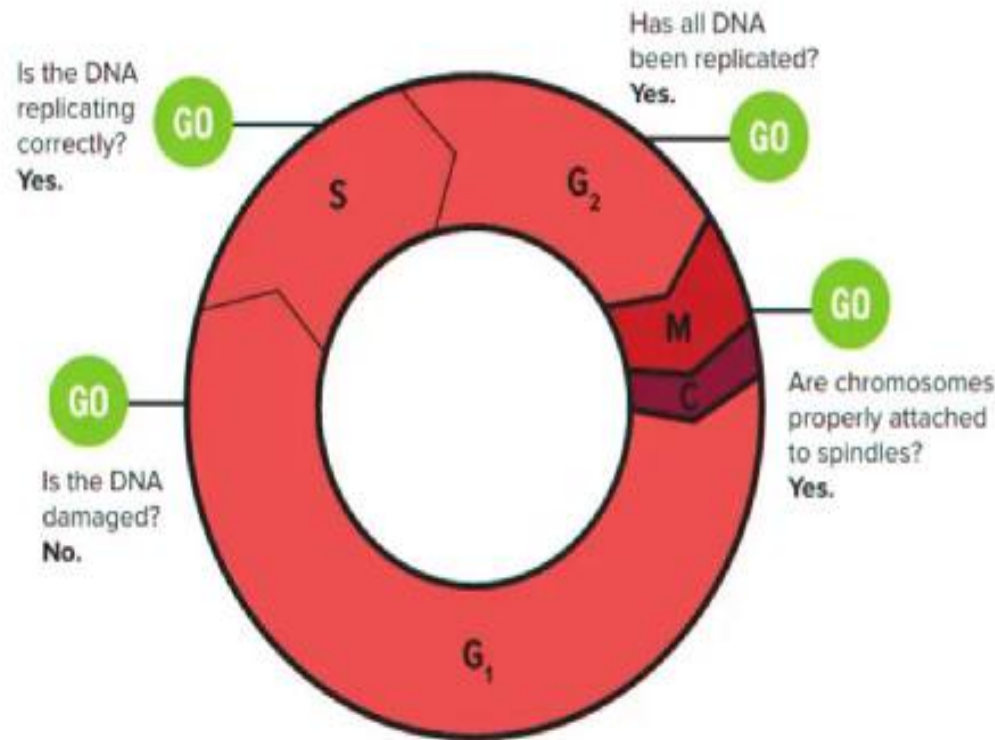


Figure 11 Signaling molecules made of a cyclin bound to a CDK kick off the cell cycle and drive it through mitosis. Checkpoints monitor the cell cycle for errors and can stop the cycle if an error occurs.

- Checkpoints act as quality control inspectors that ensure the cell cycle halts if conditions are unfavorable or DNA is damaged.
- They prevent the division of compromised or mutated cells.
- The cell cycle is driven forward by the interaction of two main groups of proteins:

Cyclins: Regulatory proteins whose levels fluctuate throughout the cell cycle.

Cyclin-Dependent Kinases (CDKs): Enzymes that remain at a constant concentration but are inactive on their own.

1. The G_1 Checkpoint (Restriction Point)

- Occurs near the end of the G_1 phase.
- Checks for cell size, nutrients, growth factors, and DNA damage.

2. The G_2 Checkpoint

- Occurs at the transition from the G_2 phase to the M phase.
- Checks for DNA replication completeness and DNA damage.

3. The M Checkpoint (Spindle Checkpoint)

- Occurs during metaphase of mitosis.
- Checks that all sister chromatids are correctly attached to spindle microtubules.

Question 1

What is the primary role of the quality control checkpoints throughout the cell cycle?

- A) Synthesizing phospholipids to expand the plasma membrane surface area.
- B) Monitoring the cycle for specific cellular errors and halting progression if something goes wrong.
- C) Forcing the cell to immediately skip interphase and enter active division.
- D) Duplicating the nucleolus to ensure rapid protein synthesis during mitosis.

Question 2

Which specific cellular issue is monitored near the end of the G_1 stage of interphase?

- A) The complete alignment of chromosomes down the equator line.
- B) The total volume of the plant cell plate structure.
- C) The presence of DNA damage before entering the synthesis stage.
- D) The premature separation of sister chromatids during anaphase.

Question 3

What molecular combination forms the signaling molecules that actively drive the cell cycle through its various stages?

- A) Golgi vesicles bound tightly to microtubule microfilaments.
- B) A cyclin protein bound to a cyclin-dependent kinase (CDK).
- C) Ribosomal RNA subunits linked to plasma membrane receptor channels.
- D) Active centromeres linked directly to carbohydrate cellular walls.

Question 4

A checkpoint during the G_2 stage of interphase is biologically responsible for confirming which event?

- A) The physical disintegration of the nuclear membrane.
- B) The successful and complete replication of all genetic DNA.
- C) The alignment of centrioles at a single cellular pole.
- D) The physical pinching of the cytoplasm via microfilaments.

Question 5

What is the primary target monitored at the spindle checkpoint during mitosis (M stage)?

- A) Whether the original cell wall has dissolved completely.
- B) Whether the metabolic growth rate has doubled inside the nucleolus.
- C) Whether chromosomes are properly attached to the spindle fibers.
- D) Whether the Golgi apparatus has synthesized enough dividing vesicles.

Question 6

If a serious failure of the spindle fibers is successfully detected during mitosis, what immediate action can the checkpoint take?

- A) The cycle can be stopped before the cell undergoes cytokinesis.
- B) The cell will immediately duplicate its genomic material a second time.
- C) The cell wall will instantly expand to form a defensive outer layer.
- D) The chromosomes will be forced to decondense back into interphase layout.

Question 7

An experimental cancer drug introduces a mutated, hyperactive version of a specific Cyclin-Dependent Kinase (CDK) into a healthy cell line. This mutated CDK remains continuously active and signals constantly, regardless of whether it is bound to a cyclin protein or whether DNA damage is present. What is the most likely long-term consequence of this molecular alteration on the cell line?

- A) The cells will arrest permanently in the G_1 phase and undergo immediate cellular death.
- B) The cell cycle will proceed unchecked and rapidly divide without repairing critical errors, potentially leading to tumor formation.
- C) The cells will transform into plant-like structures by developing a rigid outer cell wall.
- D) The spindle apparatus will completely lose its ability to attach to any centromeres.

An environment contains a chemical toxin that specifically inhibits the execution of Checkpoint 2 while leaving Checkpoint 1 and Checkpoint 3 fully functional. If a cell sustains massive replication errors during the S stage, how will this cycle respond to the damage?

- A) The cell will be safely halted right at the end of the G_1 stage before any synthesis occurs.
- B) The cell will fail to halt at the G_2 stage, allowing damaged and incompletely replicated DNA to transition directly into mitosis.
- C) The spindle checkpoint will immediately fix the sequence mutations on the chromosomes during prophase.
- D) The cell will instantly trigger cytokinesis to bypass nuclear division entirely.

Abnormal cell cycle: cancer

When cells do not respond to the normal cell cycle control mechanisms, a condition called **cancer** can result. **Cancer** is the uncontrolled growth and division of cells—a failure in the regulation of the cell cycle. When unchecked, cancer cells can kill an organism by crowding out normal cells, resulting in the loss of tissue function. Cancer cells spend less time in interphase than do normal cells, which means cancer cells grow and divide unrestrained as long as they are supplied with essential nutrients. **Figure 12** shows how cancer cells can intrude on normal cells.



Figure 12 Cancer cells often have an abnormal, irregular shape compared to normal cells. In this image some cancer cells are entering vessels, which might carry them to another part of the body. This is one way cancer can spread from one body part to another.

Causes of cancer Cancer does not just occur in a weak organism. In fact, cancer occurs in many healthy, active, and young organisms. The changes that occur in the regulation of cell growth and division of cancer cells are due to **mutations** or changes in the segments of DNA that control the production of proteins, including proteins that regulate the cell cycle. Often, the genetic change or damage that occurs is repaired. But if the repair systems fail, cancer can result. Various environmental factors can affect the occurrence of cancer cells. Substances and agents that are known to cause cancer are called **carcinogens** (kar SIHnuh junz).

- The primary difference between cancerous and non-cancerous cells is that healthy cells divide strictly when instructed by the body, whereas cancer cells multiply uncontrollably due to DNA mutations.
- Normal cells have built-in stop signals, limited life spans, and obey density-dependent inhibition, while cancer cells exhibit replicative immortality and ignore these limits.

NORMAL CELLS			CANCER CELLS
Small, uniformly shaped nuclei Relatively large cytoplasmic volume			Large, variable shaped nuclei Relatively small cytoplasmic volume
Conformity in cell size and shape Cells arranged into discrete tissues			Variation in cell size and shape Disorganised arrangement of cells
May possess differentiated cell structures Normal presentation of cell surface markers			Loss of normal specialised features Elevated expression of certain cell markers
Lower levels of dividing cells Cell tissues clearly demarcated			Large number of dividing cells Poorly defined tumor boundaries

Q1: What is the primary definition of cancer in terms of cellular biology?

- A) The programmed and controlled destruction of old cellular tissues.
- B) The uncontrolled growth and division of cells resulting from a regulatory failure.
- C) The rapid synthesis of cell walls within an animal vascular structure.
- D) The extension of the interphase stage to prevent genetic mutations.

Q2: How do the growth patterns of cancer cells fundamentally damage an organism?

- A) They secrete excessive nutrients that overfeed healthy surrounding tissues.
- B) They expand the cell wall of normal tissues until the original structures burst.
- C) They crowd out normal cells, eventually resulting in the complete loss of tissue function.
- D) They accelerate DNA repair mechanisms until cells stop dividing entirely.

Q3: How does the duration of the cell cycle stages in cancer cells differ from that of healthy cells?

- A) Cancer cells spend significantly less time in interphase than normal cells do.
- B) Cancer cells remain trapped in interphase for multiple consecutive cycles.
- C) Cancer cells completely bypass mitosis and divide using only cytokinesis.
- D) Cancer cells expand the G1 stage to maximize overall protein production.

Q4: What basic requirement must be continuously supplied for cancer cells to grow and divide unrestrained?

- A) Extracellular rigid plate building blocks.
- B) Essential environmental nutrients.
- C) Bipolar spindle organizing centrioles.
- D) Heavy concentrations of active carcinogens.

Q5: What are substances and environmental agents that are explicitly known to cause or trigger cancer called?

- A) Cyclins
- B) Carcinogens
- C) Microfilaments
- D) Kinases

Q6: What underlying structural event directly triggers the alteration of cell cycle regulation in cancer?

- A) The physical thickening of the outer plasma membrane layer.
- B) Mutations or changes in the segments of DNA that control regulatory proteins.
- C) The complete disappearance of Golgi vesicles from the cellular cytoplasm.
- D) A massive increase in the rate of normal protein repair operations.

Q7: A biopsy sample reveals a collection of cells with highly irregular shapes that are actively entering nearby blood vessels. Genetic sequencing indicates that these cells failed to repair several critical errors during the synthesis stage, yet continued to divide rapidly. Which cellular control mechanism failed first in this scenario, and what is the immediate risk to the patient?

- A) The plant cell plate assembly mechanism failed; risking a loss of cell wall defense.
- B) The interphase quality control checkpoint failed; risking the spread of cancer to other body parts.
- C) The mitotic spindle fiber shortening process failed; risking a total arrest in metaphase.
- D) The microfilament contraction mechanism failed; risking the development of multinucleated tissues.

Haploid and diploid cells

In order to maintain the same chromosome number from generation to generation, an organism produces **gametes**, which are sex cells that have half the number of chromosomes. Although the number of chromosomes varies from one species to another, in humans each gamete contains 23 chromosomes. The symbol n can be used to represent the number of chromosomes in a gamete. A cell with n number of chromosomes is called a **haploid** cell. Haploid comes from the Greek word *haploos*, meaning *single*.

The process by which one haploid gamete combines with another haploid gamete is called **fertilization**. As a result of fertilization, the cell now will contain a total of $2n$ chromosomes— n chromosomes from the female parent plus n chromosomes from the male parent. A cell that contains $2n$ number of chromosomes is called a **diploid** cell.

Notice that n also describes the number of pairs of chromosomes in an organism. When two human gametes combine, 23 pairs of homologous chromosomes are formed.

Sex determination

Each cell in your body, except for gametes, contains 46 chromosomes, or 23 pairs of chromosomes. One pair of these chromosomes, the **sex chromosomes**, determines an individual's sex. There are two types of sex chromosomes—X and Y. Individuals with two X chromosomes are genetically classified as female, and individuals with an X and a Y chromosome are genetically classified as male. The other 22 pairs of chromosomes are called **autosomes**. The offspring's sex is determined by the combination of sex chromosomes in the egg and sperm cell, as shown in **Figure 14**.



Figure 14 Left: The individual on the left has an X chromosome and a Y chromosome. This individual is male. Right: The individual on the right has two X chromosomes. This individual is female.

Q1: A human zygote contains 46 chromosomes. How many chromosomes were contributed by the sperm cell during fertilization?

- 23
- 46
- 92
- 12

Q2: Which statement accurately describes the genetic composition of a newly formed zygote?

- A. It has a diploid set of chromosomes, with equal numerical contribution from both parents.
- B. It inherits all of its nuclear DNA exclusively from the maternal gamete.
- C. It contains double the number of chromosomes found in a standard somatic cell.
- D. It receives a random percentage of chromosomes from each gamete, totaling 100%.

Q3: If an animal species has a diploid number of chromosomes ($2n = 64$), how many chromosomes will be present in its female gamete and its zygote respectively?

- A. 32 in the egg cell, 64 in the zygote
- B. 64 in the egg cell, 64 in the zygote
- C. 32 in the egg cell, 32 in the zygote
- D. 64 in the egg cell, 128 in the zygote

Q4: What is the primary mechanism that prevents the chromosome number from doubling in each subsequent generation of sexually reproducing organisms?

- A. The reduction of chromosome number during gametogenesis followed by fertilization.
- B. The replication of DNA during the interphase of mitotic cell division.
- C. The elimination of paternal chromosomes immediately after fertilization occurs.
- D. The fusion of two diploid somatic cells to form a temporary tetraploid structure.

Q5: A human cell contains 22 pairs of autosomes and two X chromosomes. What is the correct biological classification of this individual?

- A. A female individual
- B. A male individual
- C. A haploid gamete
- D. An abnormal zygote

Q6: Which cellular process is directly responsible for restoring the diploid chromosome number from two haploid cells?

- A. Fertilization
- B. Meiosis
- C. Mitosis
- D. Cytokinesis

Q7: An ecologist is studying a rare species of fern that undergoes sexual reproduction. Lab analysis reveals that a mature zygote of this fern contains 1200 chromosomes. During a localized environmental disaster, a chemical pollutant blocks the normal separation of chromosomes only during the formation of the paternal gametes, causing them to remain diploid. If one of these abnormal paternal gametes successfully fertilizes a normal maternal gamete, how many chromosomes will the resulting embryo contain?

- A. 1800
- B. 1200
- C. 2400
- D. 600

Q8: The diagram illustrates the chromosome configuration determining sex in an offspring.



What conclusion can be drawn regarding the genetic outcome shown in Zygote Z?

- A. The offspring is biologically male because it inherited a Y chromosome from the paternal gamete.
- B. The offspring inherited two identical sets of sex chromosomes from the maternal gamete.
- C. The total number of autosomes in Zygote Z is half the amount found in a standard somatic cell.
- D. The sex of the offspring was determined entirely by the chromosomal contribution of the egg cell.

Notice that in Figure 17 the red and green chromosomes have exchanged segments. This exchange occurs during synapsis. **Crossing over** is a process during which chromosomal segments are exchanged between a pair of homologous chromosomes. Crossing over is a process that increases genetic variation.

As prophase I continues, centrioles move to the cell's opposite poles. Spindle fibers form and bind to the sister chromatids at the centromere.

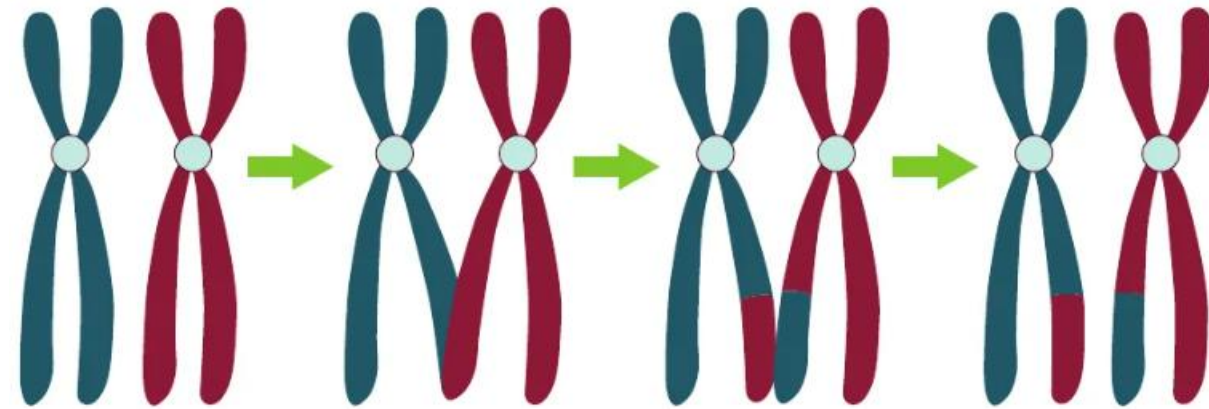


Figure 17 The results of crossing over are new combinations of genes.

- Meiosis generates genetic variation through two primary mechanisms: **crossing over** and the **random (independent) assortment of chromosomes**.
- These processes ensure that every gamete (sperm or egg cell) produced contains a unique combination of genetic material from both parents.

Q1: During which specific phase of meiosis does the exchange of chromosomal segments between a pair of homologous chromosomes occur?

- Prophase I
- Metaphase I
- Prophase II
- Metaphase II

Q2: What is the primary evolutionary benefit of the crossing over process that occurs during meiosis?

- It increases genetic variation by producing new combinations of alleles.
- It ensures that all gametes receive an identical set of maternal genes.
- It reduces the total number of chromosomes in a cell from diploid to haploid.
- It repairs broken DNA strands before sister chromatids separate.

Q3: How does random assortment during metaphase I contribute to genetic diversity in gametes?

- Homologous chromosome pairs align randomly at the cell equator, resulting in unique maternal and paternal combinations.
- Sister chromatids are split symmetrically by spindle fibers to ensure equal cell size.
- Non-homologous chromosomes fuse together to create completely new types of genes.
- The nuclear envelope breaks down at varying speeds depending on cell energy levels.

Q4: A cell undergoes meiosis without any crossing over or random assortment occurring. What will be the most likely characteristics of the resulting gametes?

- A. They will show significantly lower genetic variation compared to normal gametes.
- B. They will fail to form a functional cell wall or nuclear membrane during cytokinesis.
- C. They will contain double the normal haploid number of chromosomes.
- D. They will be genetically identical to the original somatic diploid cell.

Q5: Which structure binds to the sister chromatids at the centromere as prophase I continues?

- A. Spindle fibers
- B. Centrioles
- C. Homologous chromosomes
- D. Nuclear envelopes

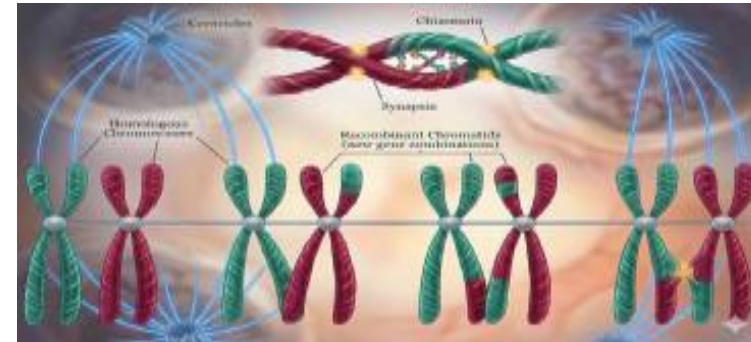
Q6: If a species has 3 pairs of homologous chromosomes, how many different genetic combinations can result solely from random assortment during meiosis?

- A. 8
- B. 6
- C. 3
- D. 9

Q7: A geneticist treats a line of developing germ cells with a chemical agent that allows synapsis to occur normally but entirely prevents the physical breakage and swapping of non-sister chromatid segments. The cell line completes meiosis successfully. Which statement best predicts the genetic outcome of the gametes produced from these treated cells?

- A. The gametes will still exhibit variation due to random assortment in metaphase I, but lack the intra-chromosomal recombination from crossing over.
- B. The gametes will be completely identical to one another because synapsis failed to mix any maternal and paternal alleles.
- C. The gametes will all be diploid because the absence of crossing over prevents homologous chromosomes from separating.
- D. The gametes will carry mutations where autosomes are incorrectly classified as sex chromosomes.

Q8: The diagram shows the sequence of events involving a pair of homologous chromosomes during meiosis.

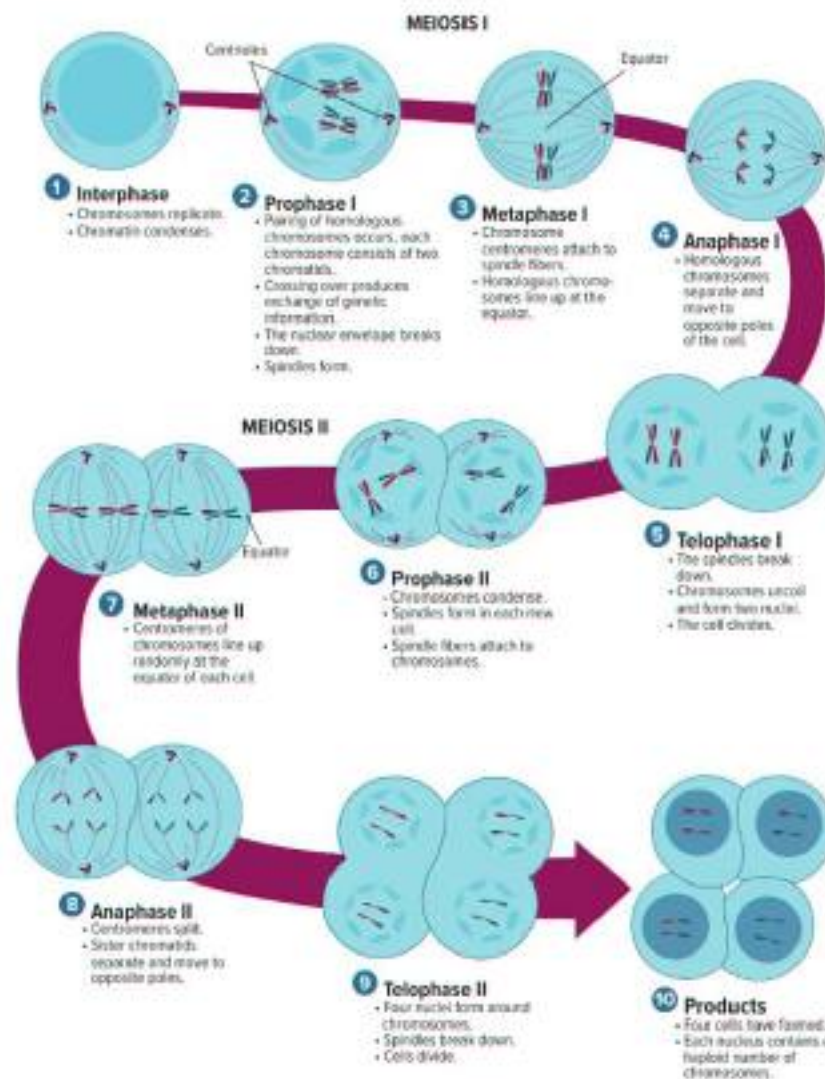


What is the biological significance of the chromosomal regions observed at Stage 3?

- A. Recombinant chromosomes are formed, representing a permanent mixture of maternal and paternal genetic material.
- B. Sister chromatids have failed to separate, leading to a mutation in the sex determination of the cell.
- C. The chromosome number has doubled because segments were added without any loss of original material.
- D. Homologous chromosomes have been completely destroyed by cellular enzymes during synapsis.

Figure 18 Visualizing Meiosis

Follow along the stages of meiosis I and meiosis II, beginning with interphase at the left.



Q1. Which of the following events occurs during Prophase I of meiosis to introduce genetic variation?

- A) Homologous chromosomes line up randomly at the equator.
- B) Homologous chromosomes pair up and exchange genetic information.
- C) Centromeres split and sister chromatids separate to opposite poles.
- D) Spindle fibers attach to the centromeres of individual chromosomes.

Q2. During which specific stage of meiosis do homologous chromosomes separate and move toward opposite poles of the cell while sister chromatids remain attached?

- A) Anaphase I
- B) Anaphase II
- C) Metaphase I
- D) Telophase I

Q3. What is the main structural difference between the chromosomes during Metaphase I and Metaphase II?

- A) Chromosomes in Metaphase I are single chromatids, while in Metaphase II they are pairs of sister chromatids.
- B) Chromosomes in Metaphase I form tetrads at the equator, while in Metaphase II individual chromosomes line up.
- C) Chromosomes in Metaphase I are uncoiled chromatin, while in Metaphase II they are fully condensed.
- D) Chromosomes in Metaphase I lack centromeres, while in Metaphase II centromeres are clearly present.

Q4. What is the total number of daughter cells produced at the end of Telophase II, and what is their chromosome condition compared to the parent cell?

- A) Two cells, each containing a diploid number of chromosomes.
- B) Two cells, each containing a haploid number of chromosomes.
- C) Four cells, each containing a diploid number of chromosomes.
- D) Four cells, each containing a haploid number of chromosomes.

Q5. Which stage is characterized by the formation of four nuclei around chromosomes, followed by the complete division of the cells into distinct products?

- A) Telophase I
- B) Telophase II
- C) Prophase II
- D) Anaphase II

Q6. What happens to the genetic material during the Interphase that precedes Meiosis I?

- A) Chromosomes condense without replicating.
- B) Chromosomes replicate and chromatin condenses.
- C) Homologous chromosomes cross over and swap segments.
- D) Spindle fibers immediately attach to uncoiled DNA strands.

Q7. A biotechnology researcher treats a culture of dividing reproductive cells with a chemical agent that completely inhibits the splitting of centromeres.

If these cells are undergoing meiosis, which specific transition between stages will be directly blocked by this chemical treatment? A)

- From Prophase I to Metaphase I
- B) From Metaphase I to Anaphase I
- C) From Metaphase II to Anaphase II
- D) From Telophase I to Prophase II

Q8. If a mutation prevents the process occurring in stage 2 but allows the rest of the cycle to proceed, what will be the most likely characteristic of the four cells shown in stage 10?

- A) The cells will contain double the normal amount of cytoplasm.
- B) The cells will have identical genetic combinations without variation.
- C) The cells will completely lack a nuclear envelope and cell membrane.
- D) The cells will remain diploid instead of reaching a haploid state.

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Karyotypes

The study of genetic material does not involve the study of genes alone. Scientists also study whole chromosomes by using images of chromosomes stained during metaphase. The staining bands identify or mark identical places on homologous chromosomes. During metaphase of mitosis, each chromosome has condensed greatly and consists of two sister chromatids. The pairs of homologous chromosomes are arranged in decreasing size to produce a micrograph called a **karyotype** (KER ee uh tipe). Karyotypes of a human female and a human male, shown in **Figure 20**, each have 23 pairs of chromosomes: 22 autosomes and nonmatching sex chromosomes. Females will have two X chromosomes while males will have one X chromosome and one Y chromosome.

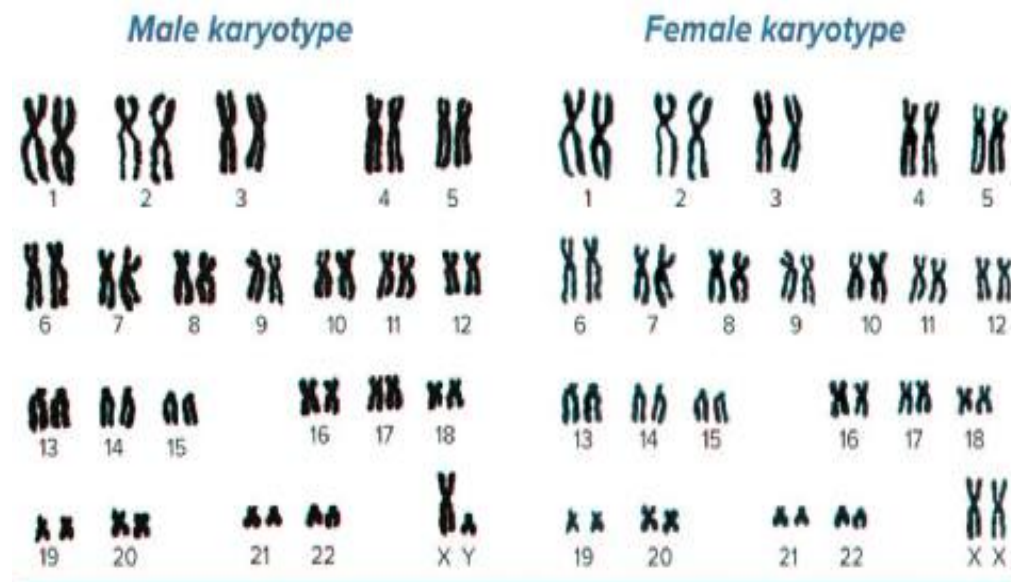


Figure 20 Karyotypes arrange the pairs of homologous chromosomes in order of decreasing size.

Autosomes Autosomes are chromosomes that are not sex chromosomes. Humans have 22 pairs of autosomes. Down syndrome, Patau Syndrome, and Edward's syndrome are all examples of nondisjunction in autosomes.

One of the earliest known human chromosomal disorders is Down syndrome. It is the result of an extra chromosome 21, shown in **Figure 22**. Therefore, Down syndrome often is called trisomy 21. Many individuals with Down syndrome can live 60 or more years. The characteristics of Down syndrome include distinctive facial features, short stature, heart defects, and mental disability, as shown in **Figure 22**. The frequency of children born with Down syndrome in the United States is approximately one out of 800.

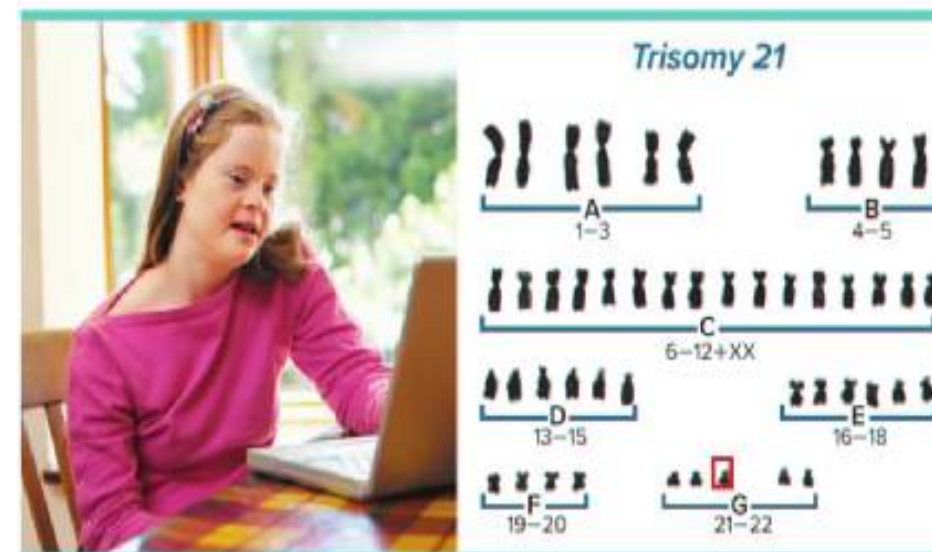


Figure 22 A person with Down syndrome has distinctive features and will have a karyotype that shows three copies of chromosome number 21.

1. Which phase of mitosis is most suitable for capturing images to construct a karyotype due to the highly condensed state of chromosomes?

- A) Prophase
- B) Metaphase
- C) Anaphase
- D) Telophase

2. How are homologous chromosome pairs arranged when scientists organize a human karyotype?

- A) In increasing order of genetic content
- B) In decreasing order of physical size
- C) Based on the order of cell division
- D) Randomly by their staining intensity

3. What specific feature allows scientists to identify and match identical locations on homologous chromosomes during karyotyping?

- A) The total mass of the chromatids
- B) The unique pattern of staining bands
- C) The orientation of the spindle fibers
- D) The location of the nuclear envelope

4. How many pairs of autosomes are typically found in a standard human karyotype?

- A) 1 pair
- B) 23 pairs
- C) 22 pairs
- D) 46 pairs

5. A karyotype of a normal human male displays which configuration of sex chromosomes?

- A) Two identical X chromosomes
- B) Two nonmatching Y chromosomes
- C) One X chromosome and one Y chromosome
- D) A single X chromosome without a partner

6. What component of genetic material is primarily analyzed when using a karyotype to detect disorders?

- A) Individual nucleotide sequences
- B) The presence of specific gene mutations
- C) The structure and number of whole chromosomes
- D) The rate of protein synthesis in the cell

7. A clinical geneticist evaluates a fetal tissue sample and observes that the micrograph contains 47 chromosomes in total, with three copies of chromosome 21. What primary conclusion can the geneticist draw from this presentation?

- A) A gene mutation occurred during the replication of autosomes.
- B) A non-disjunction event resulted in an abnormal chromosome number.
- C) The fetus developed nonmatching sex chromosomes abnormally.
- D) The cell cycle was arrested during the early stages of prophase.

1. Which genetic disorder is caused by nondisjunction occurring specifically in autosomes?

- A) Turner syndrome
- B) Klinefelter syndrome
- C) Patau syndrome
- D) Hemophilia

2. What is the precise chromosomal abnormality that results in Down syndrome?

- A) An extra copy of chromosome 21
- B) A missing copy of chromosome 18
- C) A deletion on the X chromosome
- D) A duplication of chromosome 13

3. What is the approximate frequency of children born with Down syndrome in the United States?

- A) One out of 100
- B) One out of 500
- C) One out of 800
- D) One out of 1500

4. Which condition is another term used by scientists to describe Down syndrome due to its specific chromosomal count?

- A) Monosomy 21
- B) Trisomy 21
- C) Monosomy 18
- D) Trisomy 13

5. Which pair of syndromes both represent examples of nondisjunction involving human autosomes?

- A) Down syndrome and Turner syndrome
- B) Patau syndrome and Edward's syndrome
- C) Klinefelter syndrome and Edward's syndrome
- D) Turner syndrome and Klinefelter syndrome

6. What general physiological or developmental characteristics are associated with individuals who have Down syndrome?

- A) Tall stature, increased muscle mass, and perfect cardiac function
- B) Distinctive facial features, short stature, and heart defects
- C) Absence of autosomes, severe physical scaling, and short lifespan
- D) High risk of respiratory failure within the first few days of life

7. A genetic counselor reviews a patient's medical history and notes a clinical presentation involving distinctive facial structures, short physical stature, a history of congenital heart defects, and a lifespan extending past 60 years. Which specific genetic mechanism is responsible for this condition?

- A) Failure of sex chromosomes to separate during meiosis II
- B) Nondisjunction leading to three copies of chromosome number 21
- C) A translocation mutation between chromosome 13 and chromosome 15
- D) An inversion mutation on the maternal copy of chromosome 18

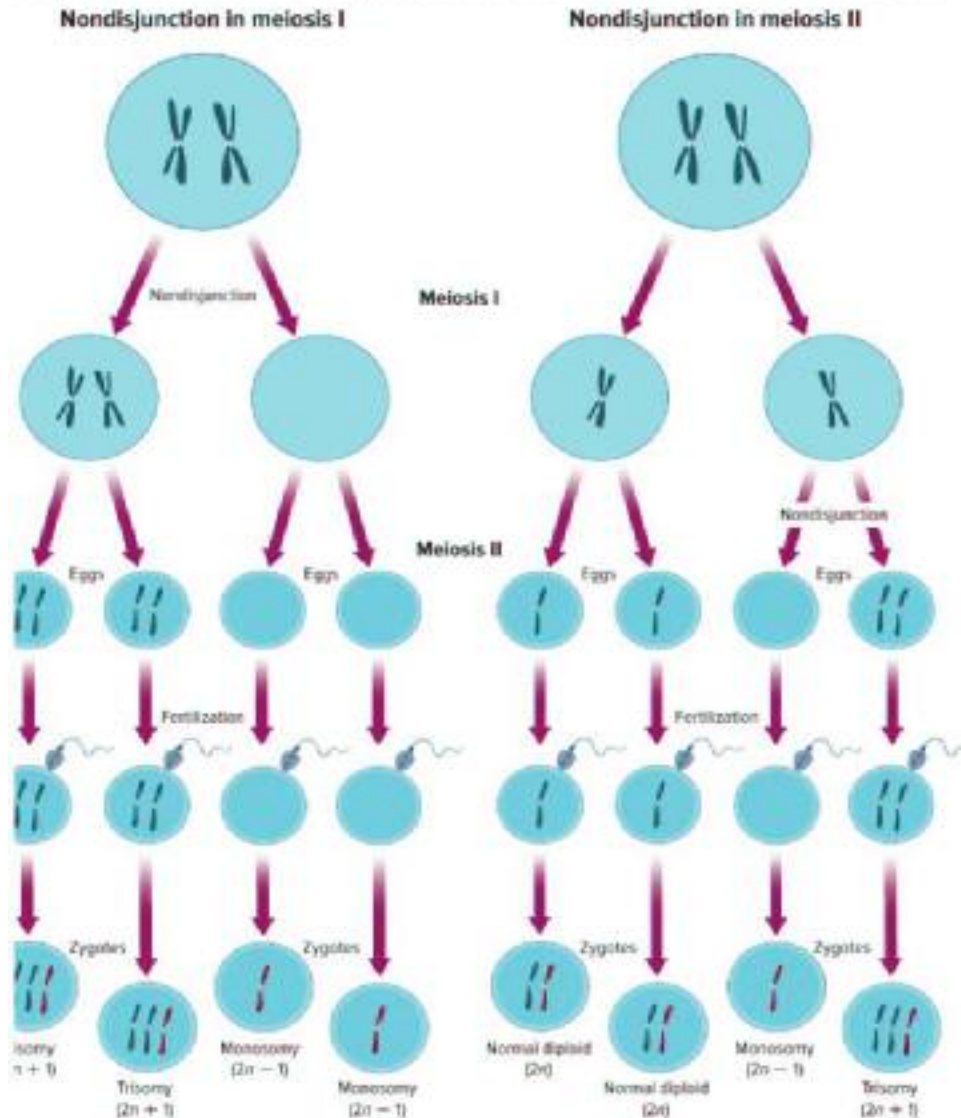
8. A human karyotype displays 22 distinct groups of chromosomes arranged in decreasing size. Group G, which contains chromosomes 21 and 22, shows a total of three individual chromosomes at position 21 instead of a homologous pair.

What biological conclusion is supported by this karyotype?

- A) The individual has Edward's syndrome due to autosomal duplication.
- B) The individual is a normal female with nonmatching sex chromosomes.
- C) The individual has Down syndrome resulting from an extra autosome.
- D) The individual has Patau syndrome caused by a meiotic deletion.

Figure 21 Visualizing Nondisjunction

Gametes with abnormal numbers of chromosomes can result from nondisjunction during meiosis. The orange chromosomes come from one parent, and the blue chromosomes come from the other parent.



Nondisjunction

During cell division, the chromosomes separate, with one of each of the sister chromatids going to opposite poles of the cell. Therefore, each new cell has the correct number of chromosomes. Cell division during which sister chromatids fail to separate properly, which does happen occasionally, is called **nondisjunction**.

If nondisjunction occurs during meiosis I or meiosis II, the resulting gametes will not have the correct number of chromosomes, as shown in **Figure 21** on the next page. When one of these gametes fertilizes another gamete, the resulting offspring will not have the correct number of chromosomes. **Figure 21** shows that nondisjunction can result in extra copies of a certain chromosome or only one copy of a particular chromosome in the offspring. Having a set of three chromosomes of one kind is called trisomy (TRI so me). Having only one of a particular type of chromosome is called monosomy (MAH nuh some). Nondisjunction can occur in any organism in which gametes are produced through meiosis. In humans, alterations of chromosome numbers are associated with serious human disorders, which are often are fatal.

- Nondisjunction is the failure of paired chromosomes or sister chromatids to separate properly during cell division.
- This error leads to an unequal distribution of DNA, resulting in daughter cells with an abnormal number of chromosomes (a condition called aneuploidy).

1. What cellular event defines the phenomenon known as nondisjunction during cell division?

- A) The premature replication of homologous pairs before cytokinesis
- B) The failure of sister chromatids or homologous chromosomes to separate properly
- C) The degradation of spindle fibers during the final stages of telophase
- D) The random crossing over of genetic material during prophase I

2. What is the expected chromosomal outcome in gametes if nondisjunction occurs globally during meiosis I?

- A) All resulting gametes will carry an abnormal number of chromosomes.
- B) Half of the gametes will be completely normal while half will be abnormal.
- C) Every single gamete will completely lack any genetic material.
- D) All gametes will maintain a perfectly balanced haploid number.

3. Which condition describes a zygote that contains a set of three chromosomes of one specific kind instead of a pair?

- A) Monosomy
- B) Haploidy
- C) Trisomy
- D) Diploidy

4. What term refers to a genetic condition where a zygote inherits only a single copy of a particular chromosome?

- A) Trisomy
- B) Monosomy
- C) Polyploidy
- D) Disomy

5. If a single nondisjunction event takes place during meiosis II, what proportion of the resulting gametes is expected to have an abnormal chromosome number?

- A) 100 percent
- B) 75 percent
- C) 50 percent
- D) 25 percent

6. In which organisms can chromosomal alterations due to nondisjunction occur?

- A) Only in human populations experiencing genetic mutations
- B) In any organism that produces gametes through meiosis
- C) Exclusively in multicellular plants undergoing mitosis
- D) Only in unicellular organisms reproducing simple traits

7. A medical laboratory analyses a zygote and discovers it has a chromosomal composition of $2n - 1$. Further tracking shows the sperm cell involved was completely normal (n).

What mechanism explains the origin of the abnormal egg cell?

- A) Successful separation of all sister chromatids during anaphase II
- B) Nondisjunction in the maternal cell leading to an egg lacking that chromosome
- C) A duplication event that doubled the chromosomes in the paternal lineage
- D) The dynamic crossing over of non-sister chromatids during metaphase I

8. Consider a diagram tracking cell division where a pair of homologous chromosomes moves entirely to one pole during meiosis I, while the opposite pole receives no copies of that chromosome. Following a normal meiosis II and subsequent fertilization with a normal gamete, what specific zygotes will be produced?

- A) Two normal diploid zygotes and two trisomy zygotes
- B) Two monosomy zygotes and two trisomy zygotes
- C) Four normal diploid zygotes with varying traits
- D) Four monosomy zygotes lacking genetic variation

BIO.3.1.03.037 Differentiate between the two types of stem cells (embryonic and adult) and their potential uses

Figure 24

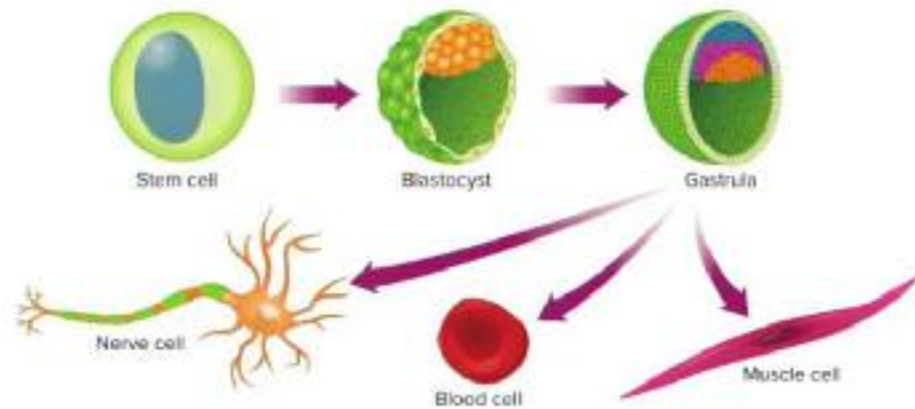
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Figure 24 Visualizing Stem Cells

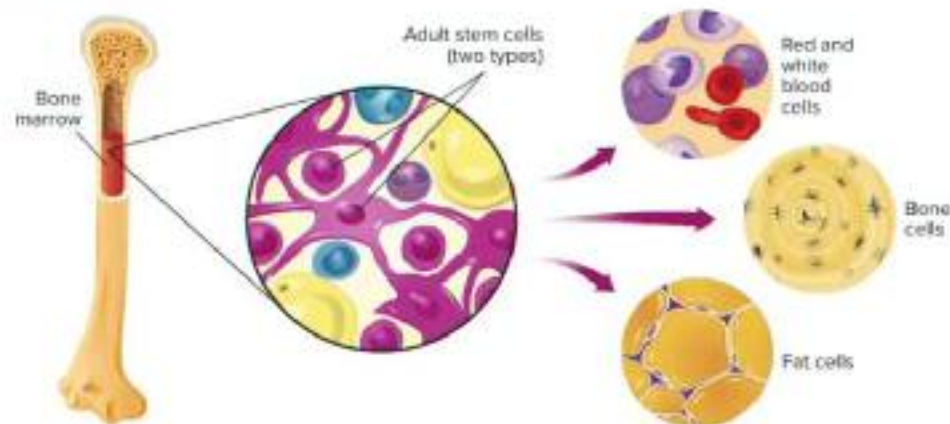
Because stem cells are not locked into becoming one particular type of cell, they might be the key to curing many medical conditions and genetic defects.

Explain how stem cells could be used to cure nerve damage.

Embryonic Stem Cells



Adult Stem Cells



Adult stem cells are found in differentiated tissues, but they remain undifferentiated

Adult stem cell-based therapies (ACT) have more advantages compared to embryonic stem cell-based therapies

They cannot be differentiated into any kind of a specialized cell; thus they are multipotent

Stem cells in bone marrow are the most studied type of cells

They can be found in skeletal muscle, liver, pancreas, brain, eye, dental pulp, skin, bone marrow, blood and the lining of the gastrointestinal tract in humans

Embryonic stem cells are found in the three germ layers of the embryo

Embryonic stem cell-based therapies are not as safe as ACT since embryonic stem cells are more prone to develop into cancerous cells

They have the potential of differentiation into various cell types; thus they are pluripotent

Various types of stem cells are studied in the embryo

Inner cell mass of the embryo contains embryonic stem cells, which give rise to the three germ layers

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Q1: Which process allows an unspecialized cell to develop into a cell with a defined structure and function?

- A) Cellular respiration
- B) Cellular differentiation
- C) Binary fission
- D) Translation

Q2: Approximately how many cells make up the mass of unspecialized cells shortly after a sperm fertilizes an egg?

- A) 10–50 cells
- B) 100–150 cells
- C) 500–600 cells
- D) Millions of cells

Q3: Why is research involving embryonic stem cells a subject of ongoing global debate?

- A) Embryonic stem cells lack a complete set of DNA.
- B) Ethical concerns exist regarding the source of the cells.
- C) These cells can only differentiate into blood tissue.
- D) They are completely identical to adult nerve cells.

Q4: What triggers specific embryonic stem cells to commit to becoming specialized cells during development?

- A) Direct physical contact with external physical barriers
- B) Signals received by DNA to produce specific RNA molecules
- C) An immediate decrease in the cytoplasm volume
- D) Total elimination of the parent cell's nuclear membrane

Q5: Why is research utilizing adult stem cells generally considered less controversial than embryonic stem cell research?

- A) Adult stem cells contain significantly more total DNA.
- B) They can be obtained with the voluntary consent of donors.
- C) They are completely incapable of undergoing any mitotic division.
- D) They can easily revert back into a fertilized egg.

Q6: What is the primary biological role of adult stem cells naturally found within animal tissues?

- A) To produce gametes for sexual reproduction
- B) To maintain and repair the specific kind of tissue where they reside
- C) To coordinate overall hormonal balances across organ systems
- D) To completely replace embryonic development pathways

Q7: A medical research team is attempting to develop a therapeutic strategy to repair cardiac muscle tissue in a patient who recently suffered a severe heart attack. The team chooses to harvest adult stem cells from the patient's own bone marrow, culture them in a laboratory setup, and manipulate them to generate functioning cardiomyocytes.

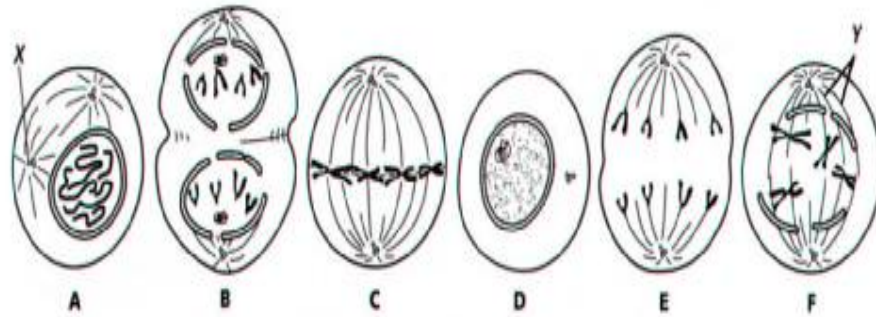
What is a potential limitation or characteristic of using these adult stem cells compared to embryonic stem cells for this procedure?

- A) The adult stem cells are completely locked into becoming nerve tissue only.
- B) The adult stem cells lack the necessary genes required to form cardiac muscle.
- C) The adult stem cells are generally pre-programmed to differentiate into the specific surrounding cell types of their origin tissue, making multi-lineage manipulation more limited.
- D) The adult stem cells will be aggressively rejected by the patient's immune system upon reinjection.

Q8: Which statement correctly evaluates the developmental potential demonstrated by the embryonic lineage compared to the adult stem cell lineage?

- A) The embryonic lineage shows a narrow differentiation potential, producing only bone-related tissues.
- B) The gastrula cells can give rise to highly diverse specialized cell types, including nerve, blood, and muscle cells.
- C) The adult stem cells in the bone marrow differentiate directly into a blastocyst stage before forming fat cells.
- D) Both embryonic and adult pathways produce identical unspecialized gastrula structures inside the bone marrow cavity.

The Animal Cell Cycle - Phases are out of order



Which two components combine to control the cell cycle/ cellular reproduction process?

- A. Cyclins
- B. Carcinogens
- C. Chromosomes
- D. Cyclin-dependent kinases

1. In 1879, the cytologist Edouard van Beneden was surprised to find varying chromosome numbers in roundworms. Gametes had two chromosomes, while all other cells had four. Which explanation correctly explains this observation?

- A) Gametes in roundworms are defective and lack the full number of chromosomes.
- B) Gametes will go through an extra round of DNA replication just before fertilization, restoring the diploid number.
- C) Gametes will fuse and join their chromosomes with another gamete, which requires them to have half the diploid number.
- D) Gametes in roundworms are not used for sexual reproduction.

2. Which is the best description of homologous chromosomes?

- A) chromosomes that are identical and come from the same parent
- B) chromosomes that are identical but come from different parents
- C) chromosomes that are similar and come from the same parent
- D) chromosomes that are similar and come from different parents

6. The processes of mitosis and meiosis have many similarities. Which event does NOT occur in both mitosis and meiosis?

- A) homologous pairs align in the center of the cell
- B) chromosomes condense and become visible
- C) sister chromatids separate
- D) cytokinesis

9. Down syndrome is also called trisomy 21, a reference to the presence of an extra 21st chromosome. What error results in the presence of this extra chromosome?

- A) crossing-over
- B) euploidy in metaphase I
- C) nondisjunction during mitosis
- D) nondisjunction during meiosis

17. If fertilization occurred without meiosis, the chromosome number would:
- Remain $2n$
 - Double to $4n$
 - Reduce to n
 - Become $3n$
18. The significance of Crossing Over is to:
- Ensure identity
 - Increase genetic variation
 - Prevent nondisjunction
 - Repair DNA
19. Which feature of Meiosis explains why you look different from siblings?
- Two divisions
 - Lining up at equator
 - Non-identical haploid cells
 - Set formation
20. A karyotype with 22 pairs of autosomes and 'XY' is:
- Female/Down
 - Normal Male
 - Klinefelter Male
 - Turner Female
21. Nondisjunction in Meiosis I results in how many normal (n) gametes?
- 0
 - 2
 - 4
 - 1
22. Monosomy vs Trisomy:
- 47 vs 45
 - Autosome vs Sex
 - 1 copy vs 3 copies
 - Both are binary fission
23. Karyotype showing three copies of chromosome 21 confirms:
- Patau
 - Edward
 - Down Syndrome
 - Turner

26. Why does 'OY' genotype result in death?

- Y is too large
- Lacks essential X-info
- Extra chr 21
- Umbilical failure

27. Difference between Anaphase I and Anaphase II:

- I-Sister/II-Homologous
- I-Homologous/II-Sister
- Crossing over
- DNA replication

28. Ethical debate in stem cells centers on:

- Source (embryo)
- Cost
- Inability to differentiate
- Telomere cancer

29. If human $2n = 46$, how many in sperm after Meiosis II?

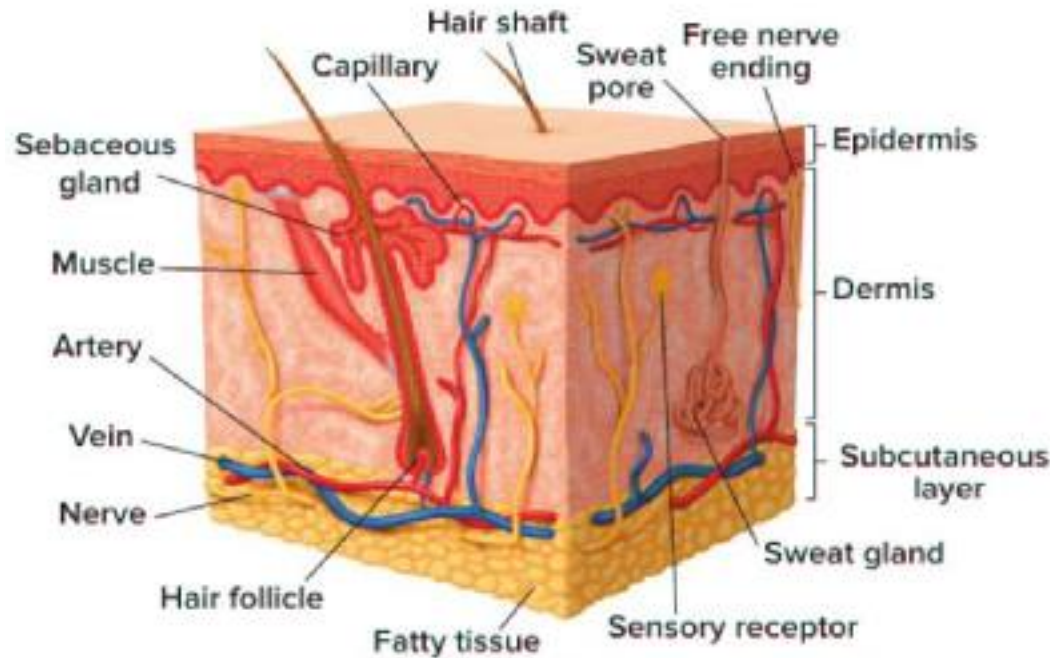
- 46
- 23
- 92
- 22

30. Short telomeres indicate:

- Young embryo
- Aging/Cancer cell
- Middle Prophase I
- Haploid gamete

Table 2 Nondisjunction in Sex Chromosomes

Genotype	XX		XXX		XXY		
Example							
Phenotype		Female with Turner's syndrome		Genetically classified as male		No phenotypic affect	Results in death



- The integumentary system is the body's outer covering and first line of defense against infection, injury, and dehydration.
- It comprises the skin, hair, nails, and exocrine glands. For a complete breakdown of how these components work together.
- The skin is the largest organ in the human body, accounting for roughly 16% of total body weight.
- It consists of three primary layers:

•**Epidermis:**

- The outermost, protective, and waterproof layer.
- It lacks blood vessels and is primarily made of cells called keratinocytes, along with melanocytes (which produce skin pigment).

•**Dermis:**

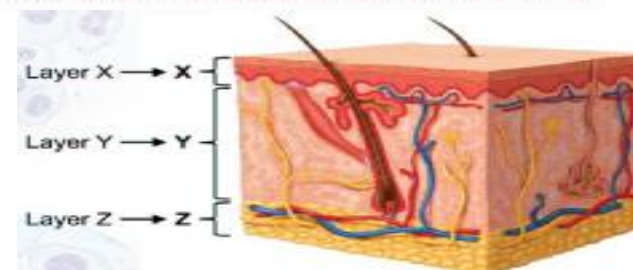
- The thick, core layer of the skin beneath the epidermis.
- It is composed of connective tissue and contains blood vessels, lymphatic vessels, nerves, hair follicles, and glands.

•**Hypodermis (Subcutaneous Tissue):**

- The deepest layer, composed mostly of fat and loose connective tissue.
- It serves as a shock absorber, energy store, and insulator

- 1 Which layer of the integumentary system is primarily composed of fat cells and fatty tissue that help insulate the body?
A) Epidermis
B) Dermis
C) Subcutaneous layer
D) Sebaceous gland
- 2 Which structure is responsible for producing an oily secretion that lubricates the skin and hair?
A) Sweat gland
B) Sebaceous gland
C) Hair follicle
D) Capillary
- 3 Which blood vessels found in the dermis are responsible for direct gas and nutrient exchange with surrounding tissue cells?
A) Arteries
B) Veins
C) Capillaries
D) Lymphatics
- 4 Which layer contains the majority of the skin's accessory structures such as muscles, nerves, sweat glands, and hair follicles?
A) Epidermis
B) Dermis
C) Subcutaneous layer
D) Outer keratinized stratum
- 5 What is the primary function of the sweat pore opening at the surface of the epidermis?
A) Secreting sebum to prevent water loss
B) Releasing sweat to aid in thermoregulation
C) Housing sensory receptors for deep pressure
D) Supplying oxygenated blood directly to the hair shaft

- 6 Which components of the dermal layer detect environmental changes like temperature, touch, and pain?
A) Sebaceous glands and fatty tissues
B) Hair shafts and sweat pores
C) Sensory receptors and free nerve endings
D) Arteries and veins
- 7 A individual sustains a severe thermal burn that completely destroys both the epidermis and the entire depth of the dermis, leaving the underlying subcutaneous fatty tissue exposed. Which physiological consequence will this individual experience due to the specific structural damage sustained by the dermal layer?
A) Increased production of sebum due to hyperactivity of intact superficial epithelial cells
B) Loss of sensation and inability to regulate local blood flow because nerve endings and capillaries are destroyed
C) Accelerated hair growth stimulated by the exposure of deeper fat cells to atmospheric oxygen
D) Hyperactive sweating caused by the direct exposure of subcutaneous tissue to external heat sources
- 8 Examine the anatomical cross-section of the skin.



- Which statement correctly correlates a structural feature shown in the diagram with its biological classification or functional limit?
- A) Layer X is highly vascularized with thick arteries and veins to provide structural support to the hair shaft.
- B) The muscle tissue originating in Layer Y is an involuntary smooth muscle associated with the hair follicle.
- C) Layer Z consists entirely of dead epithelial cells forming a waterproof barrier against bacterial invasion.
- D) The sweat gland located in Layer Z opens its duct directly into the sebaceous gland to dilute oil secretions.



Figure 4 Muscles in the skin cause the hair of some mammals to stand on end, and cause “goose bumps” on human skin.

Fingernails and toenails grow from specialized epithelial cells at the base of each nail. As cells at the base of a nail divide, older dead cells are compacted and pushed out. Nails grow about 0.5 to 1.2 mm per day. You might have heard that nails and hair continue to grow for several days after death. This is a myth; cells surrounding the nail and hair cells dehydrate causing the cells to shrink and pull away from nails and hair. This makes both appear longer.

Functions of the Integumentary System

Skin serves several important functions including regulation of body temperature, production of vitamin D, protection, and perception of one’s surroundings.

Temperature regulation

What happens when a person is working outside on a hot summer day? In order to regulate body temperature, the person sweats. As sweat evaporates it absorbs body heat, thereby cooling the body. What happens to skin when a person gets cold or frightened? “Goose bumps” are caused by the contraction of muscle cells in the dermis. In other mammals, when these muscles contract, the hair (fur) stands on end.

Notice the frightened cat in **Figure 4**. The cat appears larger, perhaps as a way to scare off enemies. This also is a mechanism for trapping air, which insulates or warms the mammal. Humans do not have as much hair as most other mammals, but “goose bumps” are caused by the same type of muscles that make a cat’s fur stand on end. Humans rely on fat in the subcutaneous layer instead of hair to keep warm.

Vitamin production

Skin also responds to exposure to ultraviolet light rays from the Sun by producing vitamin D. Vitamin D increases absorption of calcium into the bloodstream and is essential for proper bone formation. Many food products, such as milk and orange juice, are now fortified with vitamin D.

Protection and senses

Intact skin prevents the entry of microorganisms and other foreign substances. Skin helps maintain body temperature by preventing excessive water loss. Melanin in the skin protects against ultraviolet rays. Information about changes in the environment, such as pain, pressure, and temperature changes, is relayed to the brain.

Q1: Which list correctly identifies four main functions of the human integumentary system?

- A) Digestion, vitamin D production, protection, and communication.
- B) Regulation of body temperature, waste filtration, sensory perception, and hormone transport.
- C) Protection, vitamin D production, perception of surroundings, and regulation of body temperature.
- D) Gas exchange, energy storage, immune response, and mechanical movement.

Q2: What is the direct consequence of ultraviolet (UV) light exposure on the integumentary system?

- A) Absorption of calcium into the bloodstream is immediately stopped.
- B) Cells in the skin are stimulated to produce vitamin D.
- C) Muscle cells in the dermis contract, creating "goose bumps."
- D) Intact skin is hardened to prevent microorganism entry.

Q3: Describe how a person's body cools down on a hot summer day through a change in the integumentary system.

- A) Melanin in the skin forms a barrier to trap cool air against the body.
- B) Muscle cells in the dermis contract to release stored cool water.
- C) Melanin increases production, leading to a darker skin color that reflects heat.
- D) Sweat evaporates from the skin's surface, absorbing body heat and cooling the body.

Q4: Identify the true biological mechanism behind the growth of fingernails.

- A) Specialized muscle cells at the base of each nail contract to push the nail forward.
- B) Cells at the base of the nail dehydrate and shrink, pulling away from the fingertips.
- C) Compacted and pushed-out older, dead cells continue growing in length.
- D) Specialized epithelial cells at the nail base divide, with older dead cells compacted and pushed out.

Q5: Which statement describes the function of melanin?

- A) Melanin increases calcium absorption in the bloodstream.
- B) Melanin relays information about pain and pressure changes to the brain.
- C) Melanin protects the body against ultraviolet rays.
- D) Melanin prevents excessive water loss through the skin.

Q6: Humans do not have as much hair as most other mammals. What primary reliance for warmth do humans have in place of abundant hair?

- A) Contraction of muscle cells in the epidermis to generate heat.
- B) Melanin deposits in the dermis layer.
- C) Fat in the subcutaneous layer.
- D) Vitamin D production to insulate the body.

Q7: A pediatrician is treating a child who presents with symptoms of poor bone formation and low calcium levels in their bloodstream. The child spends almost all of their daylight hours inside playing video games, and the family is noted to consume a very restricted diet.

Based on the biological information provided, identify the most probable pathway of failure that connects the child's sedentary indoor lifestyle to their bone condition.

- A) Lack of physical exercise on hot summer days prevents the sweating that stimulates calcium release from skin.
- B) Insufficient UV light exposure inhibits the skin's production of vitamin D, which in turn reduces calcium absorption into the bloodstream.
- C) Minimal communication with the brain regarding surroundings prevents the activation of muscle cells needed for proper bone structure.
- D) Reduced perception of surroundings directly stops the base cells of nails from creating compacted dead cells for bone formation.

Table 1 Classification of Burns

Severity of burn	Damage	Effect
First-degree	Cells in the epidermis are injured and may die.	• Redness and swelling • Mild pain
Second-degree	Cells deeper in the epidermis die. Cells in the dermis are injured and may die.	• Blisters • Pain
Third-degree	Cells in the epidermis and dermis die. Nerve cells and muscle cells are injured.	• Skin function lost • Healthy skin needs to be transplanted • No pain because of nerve cell damage

Skin damage can vary in severity, and the main types include:

1.Physical damage

Scrapes, cuts, bruises, and blisters from injury or friction.

2.Sun & environmental damage

Wrinkles, dark spots, and sun-related skin changes that can become serious over time.

3.Inflammatory conditions

Such as eczema, psoriasis, acne, and rosacea.

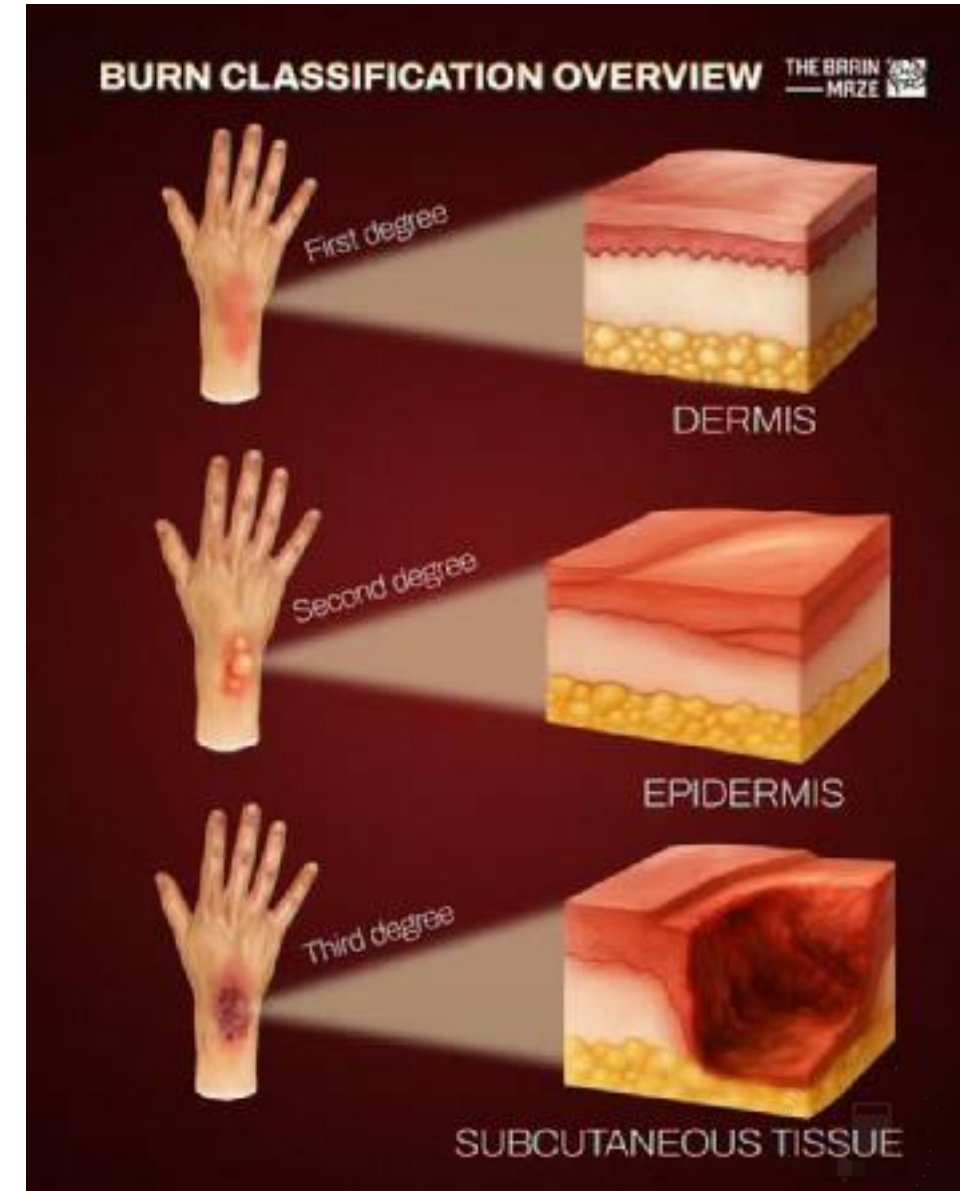
4.Moisture & barrier issues

Dryness, flaking, or damage from too much moisture.

5.Infections & irritations

Allergic reactions to substances or infections caused by bacteria, fungi, or viruses.

In short: Skin damage can result from injury, sun exposure, medical conditions, dryness, or irritants.



Q1: Which burn severity is characterized by the injury and potential death of cells restricted only to the epidermis?

- A) First-degree
- B) Second-degree
- C) Third-degree
- D) Fourth-degree

Q2: What is a primary clinical effect seen in a second-degree burn?

- A) Complete loss of skin function
- B) Formation of blisters
- C) Total absence of pain
- D) Immediate need for skin transplantation

Q3: Which structures are explicitly noted as injured during a third-degree burn besides the epithelial cells?

- A) Sebaceous glands and hair shafts
- B) Nerve cells and muscle cells
- C) Adipose tissue and elastic fibers
- D) Red and white blood cells

Q4: Why does a patient with a third-degree burn experience no pain in the heavily burned area?

- A) The brain shuts down sensory pathways completely.
- B) Nerve cells are damaged in that layer.
- C) Blisters cover the surface and protect the receptors.
- D) Dead muscle cells release natural anesthetic chemicals.

Q5: What type of cell death and damage occurs specifically in a second-degree burn?

- A) Cells in the epidermis and dermis die while nerve cells are completely destroyed.
- B) Cells in the epidermis are injured, but no cells die in any layer.
- C) Cells deeper in the epidermis die, and cells in the dermis are injured and may die.
- D) Only muscle cells die, leaving the overlying epidermis completely intact.

Q6: Which medical intervention is typically required for a third-degree burn due to the complete destruction of skin tissue?

- A) Application of cold water only to heal blisters
- B) Transplantation of healthy skin
- C) Exercising the underlying injured muscle cells
- D) Blocking light rays to stop vitamin D production

Q7: A patient accidentally spills boiling water on their forearm. Within an hour, the affected area becomes highly inflamed, turns bright red, and develops large fluid-filled blisters accompanied by intense, sharp pain. Based on the biological symptoms and the layers involved, which classification does this damage fall under, and what is happening at the cellular level?

- A) First-degree burn; cells in the outermost epidermis are merely injured but none have died.
- B) Second-degree burn; cells deeper in the epidermis have died, and cells in the dermis are injured or dying.
- C) Third-degree burn; skin function is lost, and nerve endings are fully destroyed, eliminating local sensations.
- D) Second-degree burn; all nerve cells and underlying skeletal muscle cells have completely died.

Compact and spongy bone

Bone is a connective tissue that has many shapes and sizes. Bones are classified as long, short, flat, or irregular. Refer to **Figure 6** on the previous page. Arm and leg bones are examples of long bones, and wrist bones are examples of short bones. Flat bones make up the skull. Facial bones and vertebrae are irregular bones.

The outer layers of all bones are composed of compact bone. **Compact bone** is dense and strong; it provides strength and protection. Running the length of compact bones are tube-like structures called osteons, or Haversian systems, which contain blood vessels and nerves. The blood vessels provide oxygen and nutrients to **osteocytes**—living bone cells. The centers of bones can differ greatly, as illustrated in **Figure 7**. As the name suggests, **spongy bone** is less dense and has many cavities that contain bone marrow. Spongy bone is found in the center of short or flat bones and at the end of long bones. Spongy bone is surrounded by compact bone and does not contain Haversian systems.

There are two types of bone marrow—red and yellow. Red and white blood cells and platelets are produced in **red bone marrow**. Red bone marrow is found in the humerus bone of the arm, the femur bone of the leg, the sternum and ribs, the vertebrae, and the pelvis. The cavities of an infant's bones are composed of red marrow. Children's bones have more red marrow than adult bones. **Yellow bone marrow**, found in many other bones, consists of stored fat. The body can convert yellow bone marrow to red bone marrow in cases of extreme blood loss or anemia.

Formation of bone

The skeletons of embryos are composed of cartilage. During fetal development, cells in fetal cartilage develop into bone-forming cells called **osteoblasts**. The formation of bone from osteoblasts is called **ossification**. Except for the tip of the nose, outer ears, discs between vertebrae, and the lining of movable joints, the human adult skeleton is all bone. Osteoblasts also are the cells responsible for the growth and repair of bones.

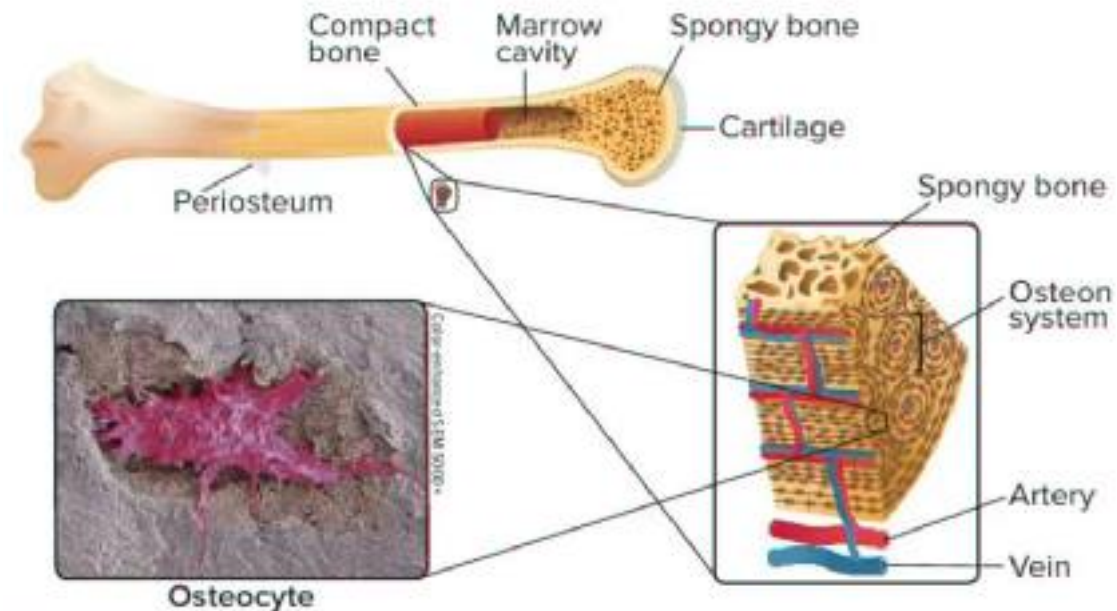


Figure 7 Bone is either compact bone or spongy bone.

Question 1

Which structural component is uniquely present in compact bone but completely absent in spongy bone?

- A) Osteocytes
- B) Haversian systems
- C) Blood vessels
- D) Connective tissue

Question 2

Where is spongy bone typically located within the human skeletal framework?

- A) Running exclusively along the entire outer shaft layer of all long bones
- B) Forming the structural outer plates of the skull and facial bones
- C) In the center of short or flat bones and at the ends of long bones
- D) Surrounding the central marrow cavity of an infant's long bones only

Question 3

What is the functional biological role of the blood vessels found within the osteon systems of compact bone?

- A) They manufacture red and white blood cells directly inside the dense matrix.
- B) They provide vital oxygen and nutrients to living bone cells called osteocytes.
- C) They store excess lipids and convert yellow bone marrow into red marrow.
- D) They act as flexible cartilage templates during embryonic skeletal development.

Question 4

Which type of bone tissue is correctly matched with its anatomical location or primary functional trait?

- A) Yellow bone marrow — Houses the primary site of white blood cell production in adults
- B) Red bone marrow — Found predominantly inside the wrist bones of short skeletons
- C) Compact bone — Dense and strong tissue that provides structural strength and protection
- D) Spongy bone — A dense, cavity-free tissue layer located on the extreme outer surface of long bones

Question 5

During human development, what occurs during the physiological process known as ossification?

- A) Osteocytes degrade the surrounding dense matrix to release stored calcium into the blood.
- B) Living bone cells revert back into flexible cartilage templates to allow rapid growth.
- C) Cells in fetal cartilage develop into bone-forming cells called osteoblasts to build bone.
- D) Yellow bone marrow converts into red bone marrow to combat instances of acute anemia.

Question 6

Anatomists categorize bones based on their distinct shapes and dimensions. Which of the following pairs accurately matches a bone classification with its correct anatomical example?

- A) Long bone — Wrist bones
- B) Short bone — Arm and leg bones
- C) Flat bone — Bones making up the skull
- D) Irregular bone — Sternum and ribs

Question 7

A clinical patient suffers a severe traumatic accident resulting in acute, extreme internal blood loss, leading to life-threatening anemia. How will the patient's skeletal marrow cavities most likely respond homeostatically to restore physiological balance?

- A) Osteoblasts at the tip of the nose and outer ears will rapidly undergo ossification to synthesize new red blood cells.
- B) Spongy bone cavities will completely dissolve their surrounding compact bone layer to release stored oxygen into the bloodstream.
- C) Yellow bone marrow, which consists of stored fat, will convert into red bone marrow to elevate blood cell production.
- D) Red bone marrow located inside the humerus and femur will transform into yellow bone marrow to conserve metabolic energy.

Question 8

If a developmental genetic mutation completely inhibits the normal function of osteoblasts during fetal development while leaving cartilage cells unaffected, what will be the most direct consequence on the skeletal system?

- A) The embryo's skeleton will remain composed entirely of cartilage because ossification cannot proceed.
- B) The compact bone will form normally, but it will lack Haversian systems and blood vessels.
- C) Yellow bone marrow will prematurely replace all red bone marrow cavities within the embryonic pelvis.
- D) The skull and vertebrae will develop as long bones instead of flat and irregular bones.

28	BIO.3.1.01.049 Sequence the steps that occur during bone repair	Figure 8	112
29	BIO.3.1.01.064 Sequence the steps that occur during bone repair	Get it	112

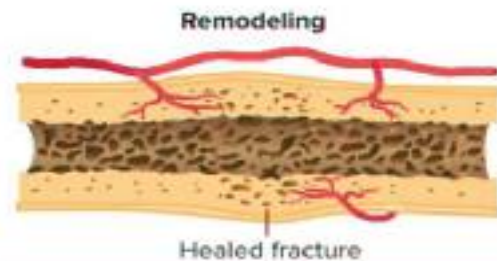
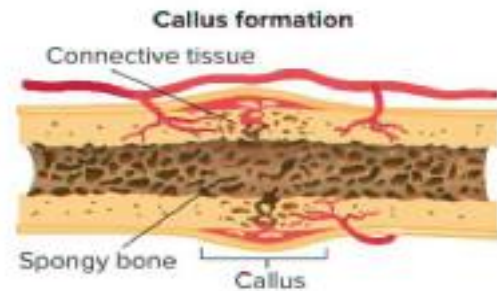
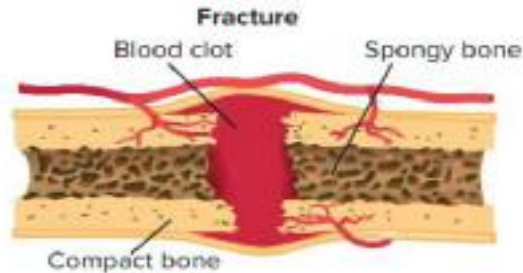


Figure 8 Bone repair requires several steps. First, a mass of clotted blood forms in the space between the broken bones. Then connective tissue fills the space of the broken bone. Eventually, osteoblasts produce new bone tissue.

Repair of bone

Fractures are common bone injuries. When a bone breaks but does not come through the skin, it is called a **simple fracture**. A **compound fracture** is one in which the bone protrudes through the skin. When a bone is fractured, repair begins immediately. **Figure 8** illustrates the repair of a broken bone.

Fracture Upon injury, endorphins, chemicals produced in the brain that help to relieve pain, flood the area of the injury to reduce pain temporarily. The injured area becomes inflamed, or swollen. Within about eight hours, a blood clot forms between the broken ends of the bone and new bone begins to form. The release of endorphins and formation of the blood clot are examples of how feedback mechanisms help the body respond to changes in homeostasis. The tissues in the body send communication signals that help the body maintain homeostasis. The fracture repair begins with a soft callus, or mass, of cartilage forming at the location of the break. This tissue is weak, so the broken bone must remain in place.

Callus formation About three weeks later, osteoblasts form a callus made of spongy bone that surrounds the fracture. The spongy bone is then replaced by compact bone. Osteoclasts remove the spongy bone while osteoblasts produce stronger, compact bone. Splints, casts, and sometimes traction can ensure that the broken bone remains in place until the compact bone tissue has formed.

Remodeling Bones require different amounts of time to heal. Age, nutrition, location, and severity of the break are all factors. A lack of calcium in a person's diet will slow down bone repair. Bones of younger people usually heal more quickly than bones of older people. For example, a fracture might take only four to six weeks to be repaired in a toddler, but it might take six months in an adult.

Q1: Which response represents the immediate chemical defense mechanism initiated by the brain following a bone fracture to alleviate discomfort?

- A) Production of cartilage matrices at the injury site
- B) Release of endorphins into the vascular system
- C) Secretions of calcium compounds by working osteoclasts
- D) Immediate vascular conversion of yellow marrow to red marrow

Q2: What is the approximate timeframe for a blood clot to establish itself between the broken ends of a fractured bone?

- A) Within about eight hours of the injury
- B) Exactly three weeks after the initial trauma
- C) Between four to six months post-fracture
- D) Within the first thirty minutes of cartilage formation

Q3: What cellular event characterizes the callus formation stage that occurs roughly three weeks following a bone fracture?

- A) Osteoclasts build a temporary framework made entirely of elastic cartilage fibers.
- B) Osteoblasts form a localized callus composed of spongy bone around the fracture site.
- C) Blood vessels completely withdraw from the area to let connective tissue dry and harden.
- D) The soft fibrocartilage callus transforms directly into dense yellow bone marrow storage.

Q4: Which biological process takes place during the final remodeling stage of bone healing?

- A) Osteoclasts remove spongy bone while osteoblasts produce stronger compact bone.
- B) Fetal cartilage cells multiply rapidly to completely replace injured osteocytes.
- C) Vascular networks permanently close down to compress the newly formed medullary cavity.
- D) Endorphins are continuously synthesized within the bone matrix to prevent future fractures.

Q5: Which clinical scenario will result in a significantly slowed rate of bone repair and remodeling?

- A) An elevated concentration of endorphins circulating through the neural pathways
- B) A severe nutritional deficiency of calcium in an individual's regular diet
- C) The fracture occurring in a younger individual rather than an older adult
- D) A simple fracture where the injured bone remains entirely underneath the skin

Q6: How does a compound fracture differ anatomically from a simple fracture?

- A) A compound fracture involves only cartilage templates and lacks any blood clot formation.
- B) A compound fracture occurs when the broken bone protrudes through the skin.
- C) A compound fracture heals within four days in adults due to immediate callus placement.
- D) A compound fracture completely lacks a remodeling phase involving osteoclastic cells.

Q7: A clinical study monitors the healing progress of two separate patients. Patient A is a toddler who sustained a simple tibial fracture, while Patient B is an adult who sustained an identical injury. What is the most likely outcome regarding their healing rates?

- A) Patient B will heal faster because adult bones contain significantly larger amounts of active red marrow.
- B) Patient A will heal more quickly, potentially taking only four to six weeks compared to months for Patient B.
- C) Both patients will exhibit identical healing timelines because the repair steps follow fixed biological durations.
- D) Patient A will experience delayed remodeling because osteoclasts do not function in skeletons before adolescence.

Q8: An experimental drug blocks the cellular differentiation of osteoclasts at a fracture site but leaves osteoblasts fully functional. What will be the direct consequence during the sequential phases of bone repair?

- A) The initial blood clot will fail to form within the first eight hours following the trauma.
- B) A soft callus cannot be produced because osteoclasts are solely responsible for laying down early cartilage.
- C) The spongy bone of the callus will not be efficiently removed or replaced to form organized compact bone.
- D) Endorphin production will cease completely, causing unmitigated pain throughout the entire healing process.

When a bone breaks, the body uses **feedback mechanisms (mainly negative feedback)** to detect damage and trigger healing:

1.Detection of injury

Cells at the injury site release chemical signals when the bone is broken.

2.Inflammatory response

These signals attract immune cells, causing swelling and increased blood flow. This helps remove damaged tissue and prevent infection.

3.Repair phase

Cells called osteoblasts start building new bone tissue, forming a soft callus that later hardens.

4.Regulation (negative feedback)

As healing progresses, the signals that triggered inflammation decrease, stopping further immune response once it's no longer needed.

5.Remodeling

The bone gradually reshapes back to its normal structure, and activity returns to normal levels.

In short: The body detects damage → activates repair → then reduces the response once healing is underway (negative feedback).

Joints

Joints occur where two or more bones meet. They can be classified according to the movement they allow and the shapes of their parts. Table 2 identifies five kinds of joints: ball-and-socket, pivot, hinge, gliding, and sutures. Study Table 2 to identify the type of movement that each kind of joint allows and also the bones involved in each example.

Not all joints are movable. The joints between some skull bones, called sutures, are fixed. They are joined together by fibrous tissue. At birth, however, skull bones are not all fused together. This flexibility helps avoid damage to the brain during birth. They become fused by the time a baby is about three months old. Gliding joints, like those found in the wrists and ankles have limited movement. Other joints, such as the hinge joint of the elbow and knee, and the pivot joint in the lower arm and neck, allow back-and-forth movement and twisting. The ball-and-socket joints of the hips and shoulders have the widest range of motion.

The bones of joints are held together by tough bands of connective tissue called **ligaments**.

Table 2 Some Joints of the Skeletal System

Name of Joint	Ball-and-Socket	Pivot	Hinge	Gliding	Sutures
Example					
Description	In a ball-and-socket joint, the ball-like surface of one bone fits into a cuplike depression of another bone. The joints of the hips and shoulders are ball-and-socket joints. They allow a person to swing their arms and legs.	The primary movement at a pivot joint is rotation. One example of a pivot joint is the elbow joint, where two bones of the lower arm meet. This joint allows a person to twist the lower arm.	In a hinge joint, the convex surface of one bone fits into the concave surface of another bone. Elbows and knees are hinge joints. They allow back-and-forth movement like that of a door hinge.	Gliding joints allow side-to-side and back-and-forth movement. The joints in wrists and ankles are gliding joints. The joints of vertebrae also are gliding joints.	Sutures are joints in the skull that are not movable. There are 22 bones in an adult skull. All skull bones except the lower jaw bone are joined at sutures.

Q1 Which structural type of joint is held together by fibrous tissue and is classified as completely fixed or immovable in adults?

- A) Gliding joint
- B) Hinge joint
- C) Suture
- D) Pivot joint

Q2: What is the evolutionary benefit of the unfused sutures found in the skull bones of a human newborn infant?

- A) They allow the lower arm and neck to twist freely in multiple geometric planes.
- B) They help avoid damage to the brain by providing flexibility during birth.
- C) They accelerate the conversion of yellow bone marrow into red blood cell factories.
- D) They provide a wide ball-like surface that fits into a cuplike depression.

Q3: Which joint type is characterized by allowing a distinct back-and-forth movement similar to the operation of a mechanical door hinge?

- A) Ball-and-socket joints of the hips
- B) Gliding joints of the wrists and ankles
- C) Hinge joints of the elbows and knees
- D) Pivot joints of the lower arm and neck

Q4: What anatomical structures are defined as tough bands of connective tissue that hold the individual bones of a joint together?

- A) Osteocytes
- B) Ligaments
- C) Osteons
- D) Haversian systems

Q5: Which structural configuration describes the mechanical operation of a ball-and-socket joint found in the shoulders and hips?

- A) A convex surface of one bone fits into a concave surface of another bone.
- B) A ball-like surface of one bone fits into a cuplike depression of another bone.
- C) Flat bone surfaces slide past one another to permit limited side-to-side motion.
- D) Fibrous connective bands permanently lock twenty-two distinct bones together.

Q6: Aside from the wrists and ankles, which anatomical structures in the human skeletal system rely on gliding joints to permit limited side-to-side and back-and-forth movement?

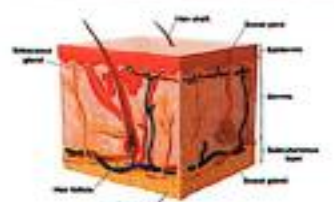
- A) Vertebrae
- B) Cranial bones
- C) Femur and pelvis
- D) Humerus and radius

Q7: A professional athlete suffers a traumatic injury that severely hyperextends the knee, resulting in a complete tear of the tough bands of connective tissue that anchor the femur directly to the tibia. Which specific structure has been compromised, and what will be the functional outcome?

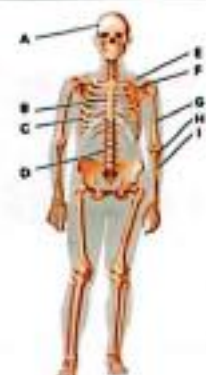
- A) The suture tissue is torn, causing twenty-two bones of the lower limb to separate entirely.
- B) The cartilage template is destroyed, inducing an immediate shift from compact bone to spongy bone.
- C) The ligaments are torn, leading to severe instability and a loss of alignment between the interacting bones.
- D) The Haversian systems are severed, halting the delivery of endorphins to the central brain stem.

Q8: An adult patient exhibits an extremely rare genetic mutation where all skull bones remain completely unfused and flexible past the age of three months, failing to form hard sutures. What is the most significant clinical risk associated with this condition in adulthood?

- A) The patient will lose the ability to perform rotational twisting movements of the neck and lower arm.
- B) The lower jaw bone will fuse completely to the cranium and prevent any basic chewing motion.
- C) The underlying brain tissue will lack necessary rigid physical protection against external mechanical impacts.
- D) Spongy bone cavities within the skull will stop manufacturing essential red and white blood cells.

Question		13
The image below represents the skin layers. Which of the following contains the keratin layer?		
		
A		Epidermis
B		Dermis
C		Sweat gland
D		Fatty tissue

Question		14
In the image below, what causes the cat's fur to stand on end (goose bumps)?		
		
A		Hair
B		Bones
C		Muscles
D		Fatty tissue

Question		15
Which of the following letters represents the clavicle in the skeleton image below?		
		
A		A
B		D
C		E
D		I

The figure shows a pair of homologous chromosomes.

Which of the following refers to the process in which homologous chromosomes bind tightly together during prophase I of meiosis?

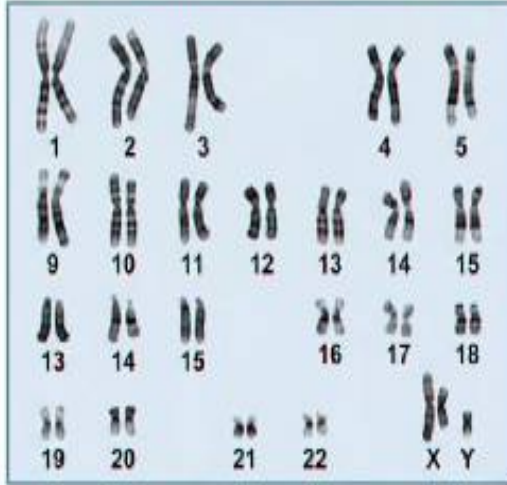
- (A) Synapsis
(B) Crossing over
(C) Fertilization
(D) Chiasmata



Which of the following is a correct explanation for why some species reproduce sexually while others reproduce asexually?

- (A) Because the rate of beneficial mutation accumulation is faster when species reproduce sexually compared to those that reproduce asexually.
(B) Because the rate of beneficial mutation accumulation is faster when species reproduce asexually compared to those that reproduce sexually.
(C) Because beneficial genes replicate faster during asexual reproduction compared to those that reproduce sexually.
(D) Because genetic diversity is lower when species reproduce sexually compared to those that reproduce asexually.

Third: The attached figure shows a human karyotype:



18- What is the gender (Male – Female) shown in the figure?
Justify your answer:
.....

19- Explain: Why does the loss of segments from the X or Y chromosome pose a major problem in males more than in females?

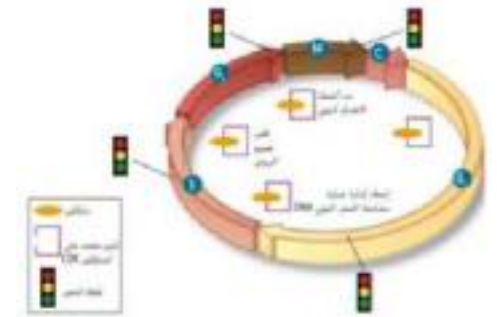
19- Explain: Why does the loss of segments from the X or Y chromosome pose a major problem in males more than in females?

20- Karyotypes are of great importance in studying genetic disorders. Explain why.
.....

21- Create a karyotype for a female living organism that has ($2n = 10$) showing monosomy in chromosome number (4).

Which of the following is not a function of the checkpoints shown in the cell cycle figure below?

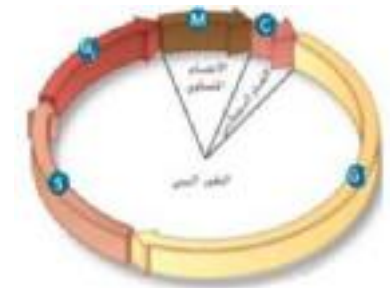
- (A) Halting the cycle if an error occurs
- (B) Monitoring the cell cycle
- (C) Checking for errors during the cell cycle
- (D) Giving a signal to prepare for the initiation of the cell cycle



The accompanying figure shows that the cell cycle consists of three stages: interphase, mitosis, and cytokinesis.

Which of the following represents the duration of the cell cycle in most actively dividing normal animal cells?

- (A) Approximately 24 to 48 hours
- (B) Approximately 12 to 24 hours
- (C) Approximately 48 to 72 hours
- (D) Approximately 72 to 96 hours



First: Underline the correct alternative following each of the following statements: First

: Down syndrome is called -22

- Disomy 21 -

- Trisomy 21 -

- Trisomy 12 -

- Monosomy 12 -

What is the genotype of a female with Turner syndrome? -23

XY -

XO -

XXX -

XX -

Which of the following is not one of the risks of Chorionic Villus Sampling (CVS)? -24

Amniotic fluid leakage -

Exposure of the fetus to limb deformities -

Miscarriage -

Infection -

What is the name of the cell resulting from the fertilization of a sperm (n) of an egg (n-1) in terms of -25

Polyploid -

Triploid -

Diploid -

Haploid -

a male with Klinefelter syndrome what is the cause -26

Dosage compensation -

Non-disjunction -

Gene superiority -

Gene amplification -

What is the purpose of human reproduction?

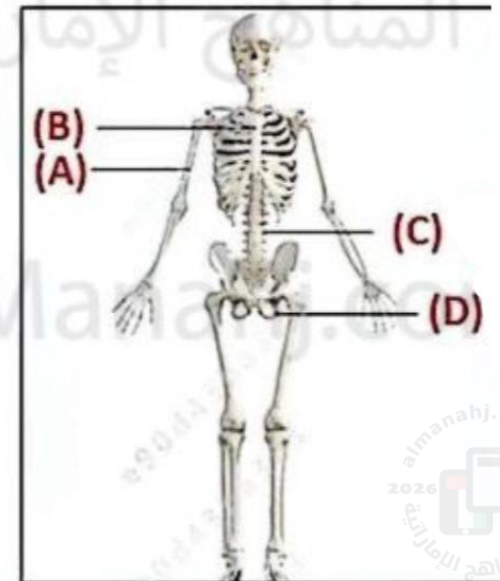
- (A) Distinguishing between males and females
- (B) Ensuring the continuation of human evolution
- (C) Building stronger marital bonds
- (D) Continuance of the human species

What would happen if the testes were located inside the body cavity?

- (A) Hormones from the testes would have difficulty entering the bloodstream.
- (B) Seminal vesicles would no longer be needed.
- (C) Testosterone levels would increase because of the higher temperature.
- (D) Sperm production would stop because the temperature is too warm.

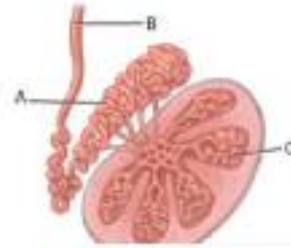
The figure below shows the human skeleton.

Which of the following letters refers to the vertebral column?



What occurs inside the structure labeled (C) in the diagram below?

- (A) Sugar secretion
- (B) Sperm storage and maturation
- (C) Production of follicle-stimulating hormone (FSH)
- (D) Sperm production



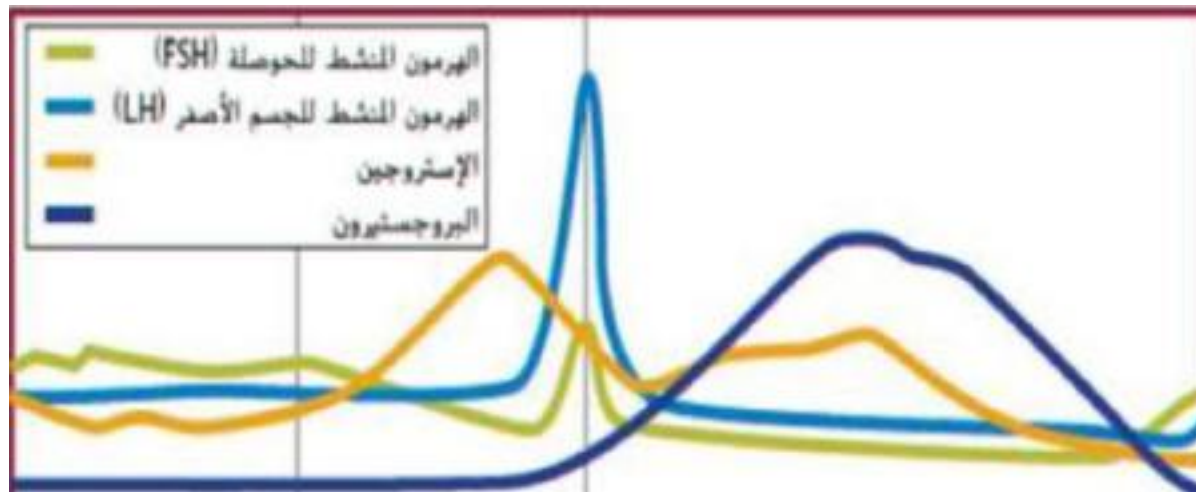
Which of the following is the correct sequence of structures that sperm passes through or encounters on its journey from inside the body to the outside?

- (A) Seminiferous Tubule → Epididymis → Vas Deferens → Urethra
- (B) Urethra → Epididymis → Seminiferous Tubule → Vas Deferens
- (C) Urethra → Vas Deferens → Epididymis → Seminiferous Tubule
- (D) Seminiferous Tubule → Epididymis → Vas Deferens → Urethra

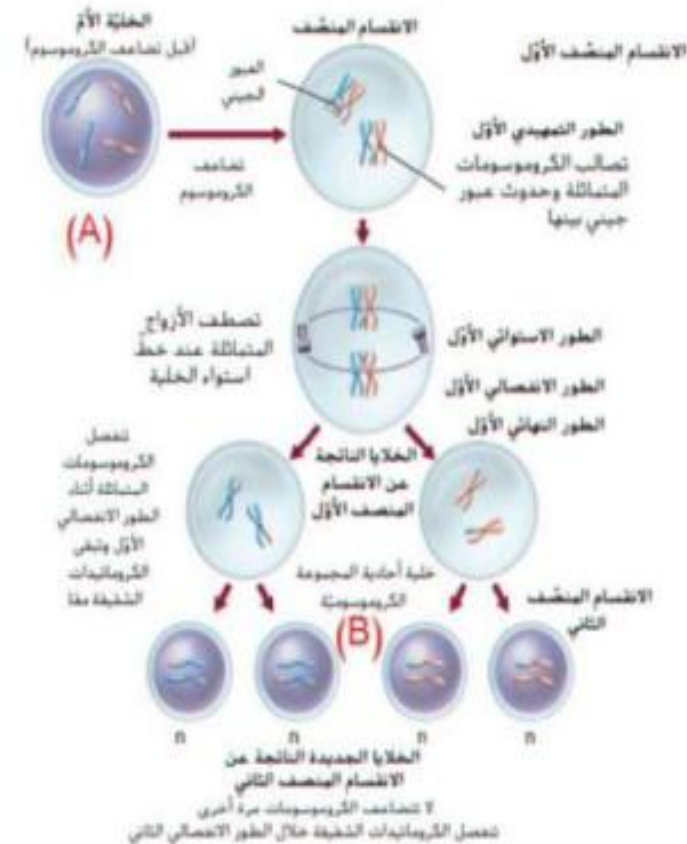
The graph below shows the changes in hormone levels in females during the menstrual cycle.

Which of the following explains why a new egg is not fertilized during pregnancy?

- (A) Due to increased production of follicle-stimulating hormone (FSH)
- (B) Due to a decrease in the levels of progesterone and estrogen
- (C) Due to the levels of progesterone and estrogen remaining high
- (D) Due to increased production of luteinizing hormone (LH)



Which of the following correctly represents the values indicated by letters (A) and (B)?



$$n = 2 \text{ and } (B) 2n = 4 \text{ (A) (A)}$$

$$n = 4 \text{ and } (B) 2n = 2 \text{ (A) (B)}$$

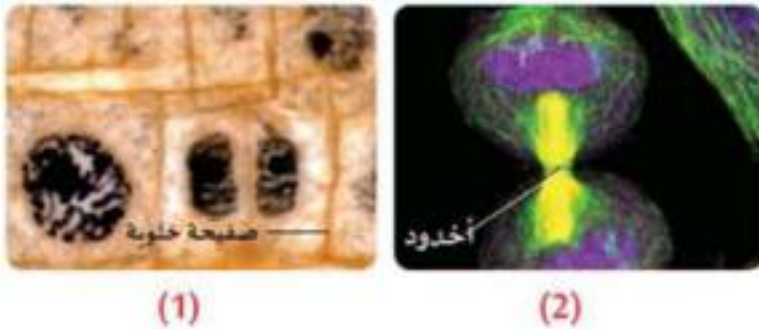
$$n = 4 \text{ and } (B) 2n = 6 \text{ (A) (C)}$$

$$n = 6 \text{ and } (B) 2n = 2 \text{ (A) (D)}$$

The figure below shows two types of cytokinesis in some cells, indicated by numbers (1) and (2).

Which of the following is correct regarding the type of cells in which each process occurs?

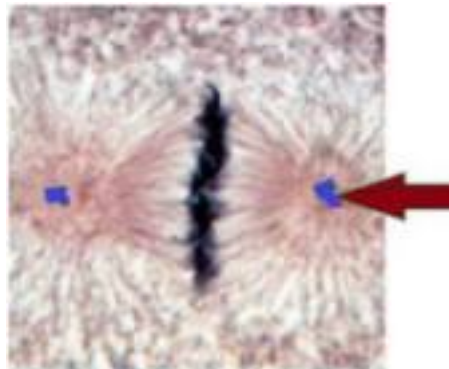
- (A) (1) occurs in bacteria, and (2) occurs in a plant stem.
- (B) (1) occurs in a plant stem, and (2) occurs in an animal cell.
- (C) (1) occurs in prokaryotes, and (2) occurs in a muscle cell.
- (D) (1) occurs in an animal cell, and (2) occurs in a plant cell.



The figure below shows one of the stages of mitosis in an animal cell, where one of the cell structures has been colored blue.

Which of the following is indicated by the arrow?

- (A) Centromere
- (B) Spindle fibers
- (C) Sister chromatids
- (D) Centrioles



Which of the following is not a characteristic of adult stem cells?

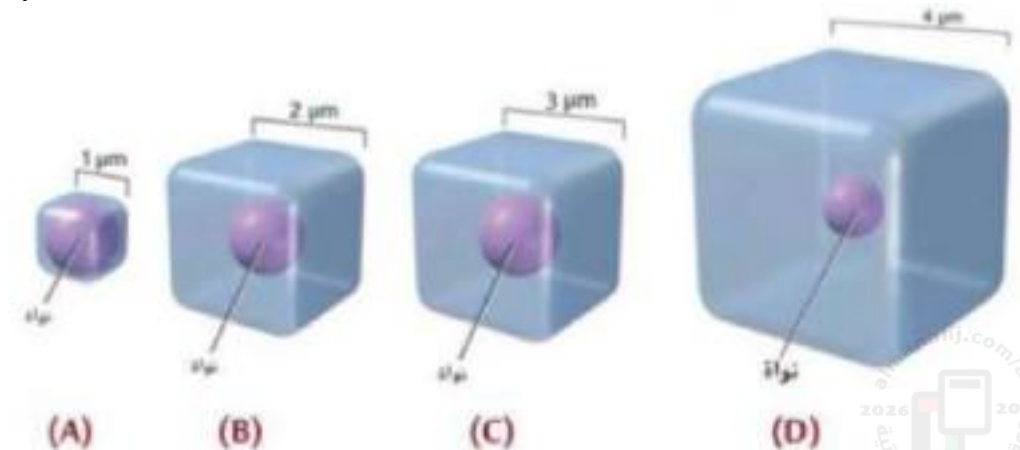
- (A) Less controversial than embryonic stem cells
- (B) Some have the ability to differentiate into different types of cells
- (C) Can be obtained with the consent of the donor
- (D) Found only in adult individuals

Which of the following organisms reproduces both sexually and asexually depending on environmental conditions?

- (A) Bacteria
- (B) Prokaryotes
- (C) Most protists
- (D) Most highly evolved animals

Which letter refers to a cell that has a large surface area-to-volume ratio compared to the other cells?

- (A) (A)
- (B) (B)
- (C) (C)
- (D) (D)

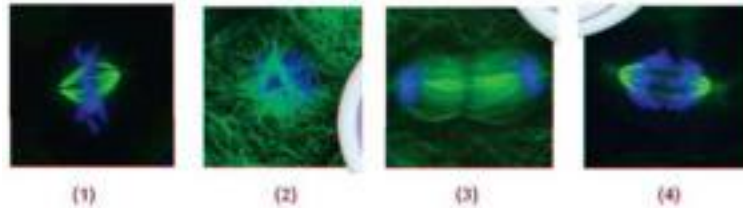


Which of the following is a characteristic of meiosis?

- (A) Provides genetic variation in organisms
- (B) Daughter cells are genetically identical
- (C) Occurs during growth to replace damaged cells
- (D) Occurs in somatic cells only

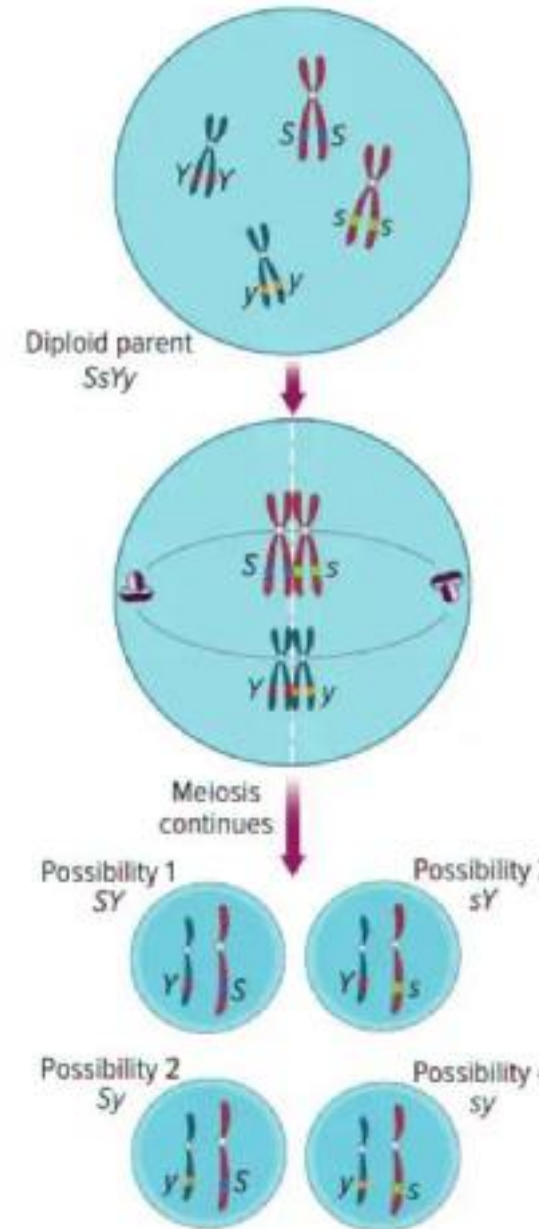
The figure below shows the stages of mitosis in an unsorted order. Which number indicates anaphase?

- (A) (1)
- (B) (2)
- (C) (3)
- (D) (4)



Which of the following is not a characteristic of cancer cells?

- (A) Spend less time in interphase than normal cells
- (B) Spend more time in interphase than normal cells
- (C) Grow and divide uncontrollably as long as they receive essential nutrients
- (D) Have an abnormal and irregular shape compared to normal cells



The accompanying figure shows the arrangement in which homologous chromosome pairs line up to produce genetic variation in sex cells. When meiosis continues, it yields possible types of haploid gametes. Which of the following is not a possible type of gamete?

- (A) First probability: SY
- (B) Second probability: Sy
- (C) Fourth probability: yy
- (D) Third probability: sY