

شرح الجهاز الغطائي: الأنسجة وطبقات الجلد



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المزيد من مادة
فيزياء:

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التواصل الاجتماعي بحسب الصف الثاني عشر المتقدم



صفحة المناهج
الإماراتية على
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الرياضيات

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المواد على تلغرام

المزيد من الملفات بحسب الصف الثاني عشر المتقدم والمادة فيزياء في الفصل الأول

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أينشتاين العرب

INTEGUMENTARY, SKELETAL, AND MUSCULAR SYSTEMS



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SECTION 1

The Integumentary System

Structure of the Skin and Animal Tissues

The **skin** is an organ made up of several layers that covers and protects the body, and it is the **main organ** of the **integumentary (epithelial) system**. The skin is classified as an organ because it brings together **four main tissue types** working together:

Tissue	Its function in the skin
Epithelial tissue	Covers the external surfaces of the body and provides protection and covering , and resistance to dehydration.
Connective tissue	Provides support and structure , and gives the skin flexibility and strength while preventing it from tearing.
Muscle tissue	Helps move parts of the skin, such as the fibers attached to hair follicles, and regulates blood vessel dilation.
Nervous tissue	Responsible for sending impulses , transmitting signals, and receiving sensory stimuli

Question 1: What is the main function of **epithelial tissue**?

- ☐ (a) Movement
- ☐ (b) Protection and covering
- ☐ (c) Support and structure
- ☐ (d) Signal transmission

Question 2: Which type of tissue is responsible for **sending electrical impulses** throughout the body?

- ☐ (a) Connective tissue
- ☐ (b) Muscle tissue
- ☐ (c) Nervous tissue
- ☐ (d) Epithelial tissue

Complete: Complete the following statements by choosing the appropriate tissue name:

(**Epithelial tissue – Connective tissue – Muscle tissue – Nervous tissue**)

Statement	Tissue name
Forms the body's communication network .	
Helps move the body .	
Provides support and protection .	
Covers the body surfaces .	

Question 3: What is the **main organ** of the integumentary system?

- ☐ (a) Nails
- ☐ (b) Hair
- ☐ (c) Skin
- ☐ (d) Bones

Question 4: Which of the following is **NOT** a type of tissue found in the skin?

- (a) Epithelial tissue
- (b) Connective tissue
- (c) Nervous tissue
- (d) Cartilage tissue

✓ Enrichment: Fingerprints

The skin at the fingertips is formed of **thick curved ridges** that make up fingerprints, first used forensically in 1860 by the Scottish physician **Henry Faulds**. Every person has a **unique fingerprint that never repeats** — this is the basis for its use in criminal investigations.



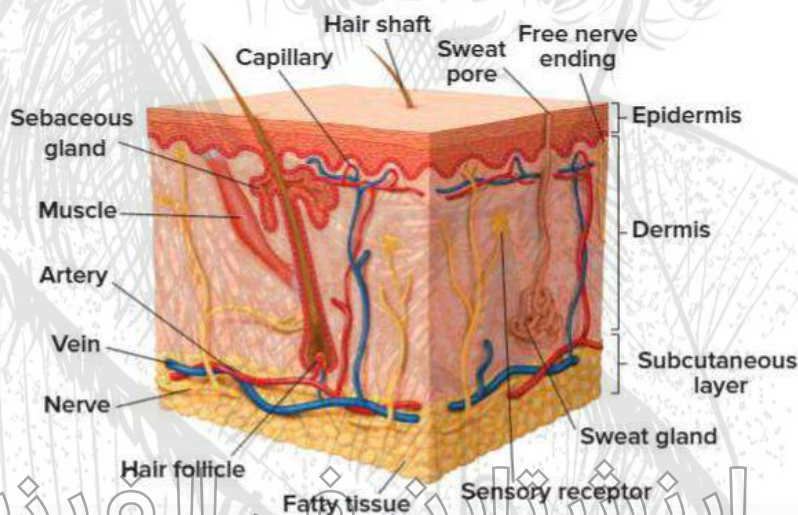
The Basic Layers of the Skin

1. Epidermis

- ✓ The **outer surface layer** of the skin, **10 to 30 cells** thick (roughly the thickness of a page in a book).
- ✓ **Outer layer: dead** epithelial cells that continually shed and contain the waterproof protein **keratin**, which protects the inner tissues; the shed remains feed **dust mites**.
- ✓ **Inner layer: living** cells that undergo **mitosis** to replace dead cells, and include the **melanocytes**, which produce the pigment **melanin** to absorb **ultraviolet rays**, protect DNA, and determine skin color.



Skin color varies with the amount of melanin produced by the melanocytes.



A section of the skin showing the epidermis, the dermis and the hypodermis with their blood vessels, nerves, glands and hair follicles.

Question 5: What is the **outer layer** of the skin?

- (a) Dermis
- (b) Epidermis
- (c) Hypodermis
- (d) Sub-dermis

Question 6: What protein makes the outer skin cells **waterproof** and strong?

- (a) Collagen
- (b) Melanin
- (c) Keratin
- (d) Elastin

Question 7: What pigment **absorbs ultraviolet rays** to protect skin cells?

- (a) Carotene
- (b) Melanin
- (c) Hemoglobin
- (d) Keratin

Question 8: Which cells in the epidermis **produce the pigment** that gives skin its color?

- (a) Keratinocytes
- (b) Melanocytes
- (c) Fibroblasts
- (d) Adipocytes

2. Dermis

- ✓ The **thicker inner layer** of the skin, lying directly beneath the epidermis and **15 to 40 times** thicker than it.
- ✓ Made of **connective tissue** that keeps the skin flexible and prevents it from tearing.
- ✓ The dermis contains: **blood vessels**, **nerve cells** and **sensory receptors** (for touch, pressure, and pain), **sweat glands**, **sebaceous glands**, and **hair follicles**.

Question 9: The thicker inner layer of the skin that contains **blood vessels and nerves** is called:

- (a) Epidermis
- (b) Dermis
- (c) Stratum corneum
- (d) Sub-dermis

Question 10: Which tissue layer contains **sensory receptors** for touch, pressure, and pain?

- (a) Epidermis
- (b) Dermis
- (c) Hypodermis
- (d) Stratum corneum

3. Hypodermis

- ✓ Lies **directly beneath the dermis**.
- ✓ Made of connective and fatty tissue whose function is to **store fat** and help **maintain body temperature**.

Question 11: Which layer **stores fat** and helps maintain body temperature?

- (a) Epidermis
- (b) Dermis
- (c) Hypodermis
- (d) Papillary layer

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Skin Appendages (Hair and Nails)

1. Hair and Sebaceous Glands

- ✓ **Hair follicles** arise from pockets in the **dermal layer**; cells at their base divide, pushing cells upward so the hair grows.
- ✓ **Sebaceous glands** secrete an **oily** substance that gives hair and skin softness and moisture.
- ✓ Oil production increases during puberty due to **rising hormone levels**; the build-up of oil and dead cells can **block pores** and cause **acne**.



A hair follicle and its sebaceous gland.

Question 12: Where do hair follicles **arise from**?

- ☐ (a) Epidermis
- ☐ (b) Dermis
- ☐ (c) Hypodermis
- ☐ (d) Stratum corneum

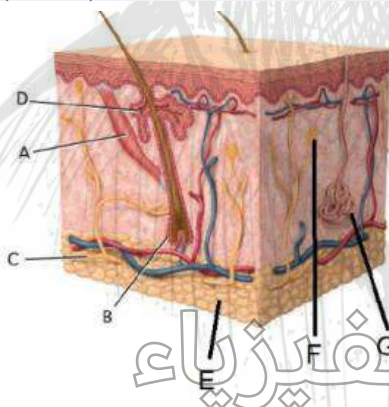
Question 13: What do **sebaceous glands** produce?

- ☐ (a) Sweat
- ☐ (b) Oil
- ☐ (c) Keratin
- ☐ (d) Melanin

Question 14: Why does oil production **increase during puberty**?

- ☐ (a) Increased sun exposure
- ☐ (b) Rising hormone levels
- ☐ (c) Collagen loss
- ☐ (d) Decreased sweat gland activity

Name the parts: Based on the diagram of the skin section, write the name of the structure that each letter (A to G) refers to.



A	
B	
C	
D	
E	
F	
G	

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2. Nails

- ✓ Nails are made primarily of the hard protein **keratin**.
- ✓ Finger- and toenails grow from specialized epithelial cells at the base of the nail (the **nail matrix**) at a rate of **0.5 to 1.2 mm** per day.



Question 15: Nails are made primarily of which **protein**?

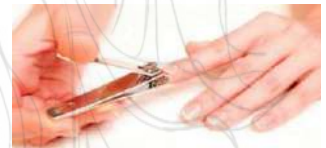
- ☐ (a) Collagen
- ☐ (b) Keratin
- ☐ (c) Fibrin
- ☐ (d) Elastin

Question 16: Where do finger- and toenails **grow from**?

- ☐ (a) Nail bed
- ☐ (b) Nail matrix
- ☐ (c) Stratum corneum
- ☐ (d) Sebaceous gland

△ Correcting a misconception

The idea that hair and nails **keep growing after death** is a **myth**; the real reason is that the **surrounding tissue shrinks** due to water loss.



Functions of the Integumentary System and Homeostasis

Regulating Body Temperature

- ✓ **When temperature rises (hot):** the body releases heat by **sweating** and **dilating** blood vessels in the dermis.

Question 17: How does the skin help **lower body temperature** when you feel hot?

- ☐ (a) By contracting muscles
- ☐ (b) By sweating and dilating blood vessels
- ☐ (c) By producing more melanin
- ☐ (d) By constricting blood vessels

Question 18: What is the main role of **sweat glands**?

- ☐ (a) Keeping hair soft
- ☐ (b) Cooling the body
- ☐ (c) Protection from ultraviolet rays
- ☐ (d) Storing fat

- ✓ **When temperature drops (cold):** the body conserves heat by **constricting blood vessels** and contracting dermal muscles, causing **goosebumps**, while the fat in the hypodermis acts as the main heat insulator.



Question 19: What response occurs in the **dermal blood vessels** when the body needs to **conserve heat** in a cold environment?

- (a) Constriction
- (b) Dilation
- (c) Rupture
- (d) Increased blood flow

Vitamin D Production

✓ **Vitamin D** is synthesized in the skin upon **exposure to sunlight**, and is essential for increasing **calcium absorption** in the blood for healthy bone formation.

Question 20: Which vitamin is synthesized in the skin upon **exposure to sunlight**?

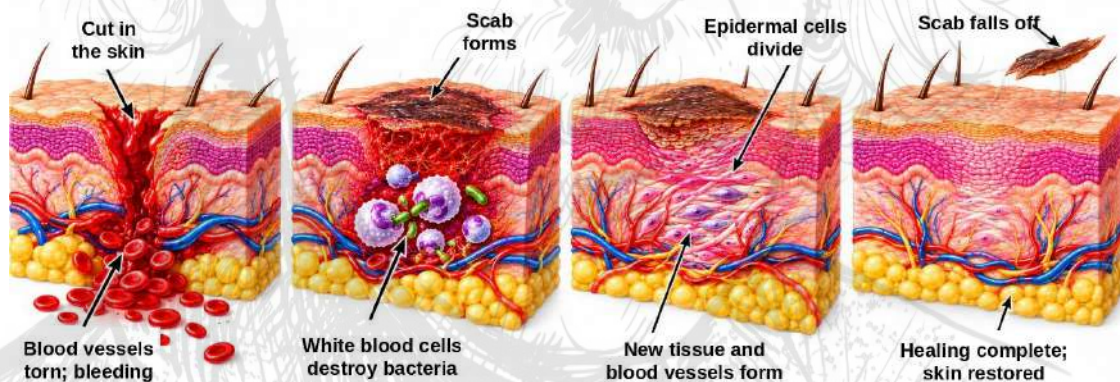
- (a) Vitamin A
- (b) Vitamin C
- (c) Vitamin D
- (d) Vitamin K

Protection and Senses

✓ The skin **prevents the entry of microbes** and fluid loss, while dermal **receptors** detect touch, pressure, pain, and heat stimuli.

Wound Healing and Skin Damage

- ✓ **Minor scratch:** affects **only the epidermis**, and is repaired by rapid division of cells deep in the epidermis.
- ✓ **Deep wound:** causes bleeding; immediately after the injury, **blood clots to form a scab** that closes the wound, **white blood cells** attack bacteria to prevent infection, and cells beneath the scab then multiply to repair the tissue.



The four stages of deep-wound healing, from bleeding to complete recovery.

Question 21: What happens in the skin **immediately after a deep injury** occurs?

- (a) New cells form
- (b) Blood clots to form a scab
- (c) Collagen breaks down
- (d) Melanin increases

✓ **Aging:** **collagen** production decreases and tissues lose their **elasticity**, leading to the appearance of **wrinkles**.

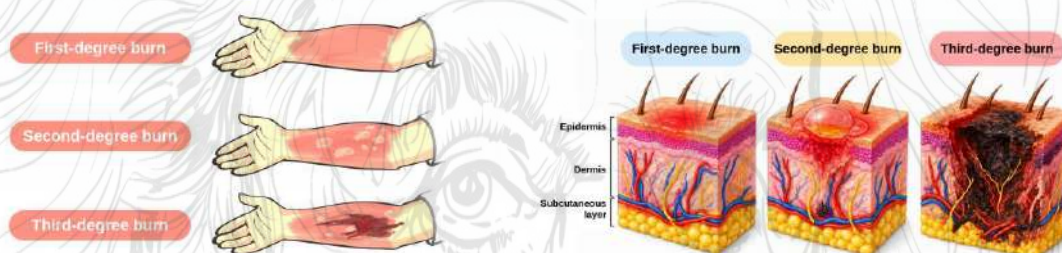
Question 22: What causes **wrinkles** to appear as skin ages?

- (a) Increased fat under the skin
- (b) Reduced collagen and loss of elasticity
- (c) Excess melanin secretion
- (d) Increased epidermal thickness

Burns and Skin Cancer

1. Classification of Burn Degrees

Burn degree	Tissue damage	Impact and symptoms
First degree	Epidermal cells are damaged and may die.	Redness and swelling; mild pain.
Second degree	Cells in the deeper layers of the epidermis die, and dermal cells are damaged and may die.	Blisters appear; pain.
Third degree	Cells in the epidermis and dermis die, and nerve and muscle cells are damaged.	Loss of skin function; need for a healthy skin graft ; no pain due to nerve cell damage.



The three burn degrees and how deep the damage reaches in the skin layers.

Question 23: Which degree of burn affects **only the outer layer** of the skin (the epidermis)?

- ☐ (a) First-degree burn
- ☐ (b) Second-degree burn
- ☐ (c) Third-degree burn
- ☐ (d) Fourth-degree burn

Question 24: Which type of burn damages **both the epidermis and the dermis** and causes **blisters**?

- ☐ (a) First-degree burn
- ☐ (b) Second-degree burn
- ☐ (c) Third-degree burn
- ☐ (d) Fourth-degree burn

2. Skin Cancer

- ✓ Its main cause is exposure to **ultraviolet rays** and damage to the genetic material (**DNA**) in cells.
- ✓ Its **most dangerous type** is **melanoma**, due to its ability to spread rapidly to internal organs and the lymphatic system; teenagers are at risk because of how quickly their cells divide during growth.



A comparison between a normal mole (left) and melanoma (right).

Question 25: What is the **main factor** causing skin cancer?

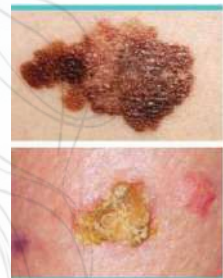
- (a) Bacterial infection
- (b) Ultraviolet rays
- (c) Vitamin D deficiency
- (d) Excess sweating

Question 26: What is the **most dangerous** type of skin cancer?

- (a) Basal cell carcinoma
- (b) Squamous cell carcinoma
- (c) Melanoma
- (d) Dermatitis

✓ **Warning signs:** moles **changing** and exceeding the **diameter of a pencil**.

✓ **Prevention:** avoid midday sun (**10 a.m. to 4 p.m.**) and use sunscreen of at least **SPF 15**.



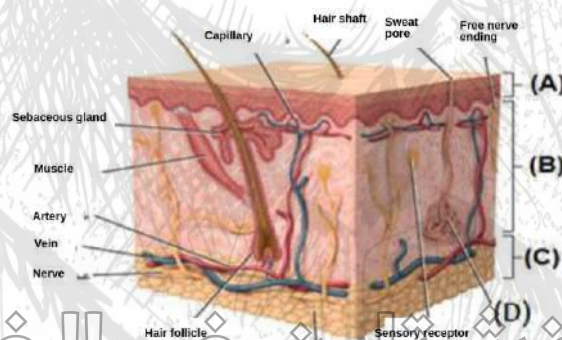
Warning signs of melanoma.

Previous Ministerial Exam Questions

Question 27: When do **blackheads** form?

- (a) When dirt accumulates in epidermal cells
- (b) When hair follicles grow inward instead of outward
- (c) When excess keratin is produced
- (d) When sebaceous glands become blocked

Question 28: Referring to the microscopic skin section, which symbol refers to the location that **stores fat** and helps the body maintain temperature?



- (a) A (epidermis)
- (b) B (dermis)
- (c) C (hypodermis)
- (d) D (capillaries)

MODULE 22 INTEGUMENTARY, SKELETAL, AND MUSCULAR SYSTEMS

Question 29: Referring to the same microscopic skin section, which symbol refers to the location containing waterproof **keratin**?

- (a) A (epidermis)
- (b) B (dermis)
- (c) C (hypodermis)
- (d) D (blood vessels)

Question 30: Which of the following structures is **NOT** found in the dermis?

- (a) Sweat glands and sebaceous glands
- (b) Muscles
- (c) Nerve cells
- (d) Fat cells

Question 31: What can be inferred when the epidermis **tans**?

- (a) Tanning enhances skin elasticity, making it firmer
- (b) Tanning gives the skin a youthful appearance
- (c) Tanning may indicate sun damage to the skin
- (d) Sun exposure for tanning produces healthier skin

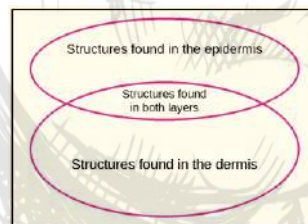
Question 32: In the dermis, which of the following is responsible for **preventing the skin from tearing** and helping it return to its normal state when stretched?

- (a) Epithelial tissue
- (b) Muscle tissue
- (c) Nervous tissue
- (d) Connective tissue

Question 33: How does the skin help regulate body temperature on **hot days**?

- (a) By increasing sweat secretion
- (b) By retaining water
- (c) By producing vitamin D
- (d) By regulating the fat content of the epidermis

Question 34: Based on the **Venn diagram** comparing skin structures, which of the following is found in and extends across **both the epidermis and the dermis**?



- (a) Sweat glands, hair
- (b) Sebaceous glands, nervous tissue
- (c) Epithelial cells, keratin
- (d) Fat cells, muscles

Question 35: In the figure below, which letter refers to **a part of the integumentary system**?



- (a) A
- (b) B
- (c) C
- (d) D

SECTION 2

The Skeletal System

Structure of the Skeletal System and Its Divisions

The skeleton provides a **structural framework** that preserves the body's shape and **protects vital internal organs** such as the heart, lungs, and brain. The adult human body contains **206 bones**, and the skeleton is divided into **two main parts**:



1. The Axial Skeleton

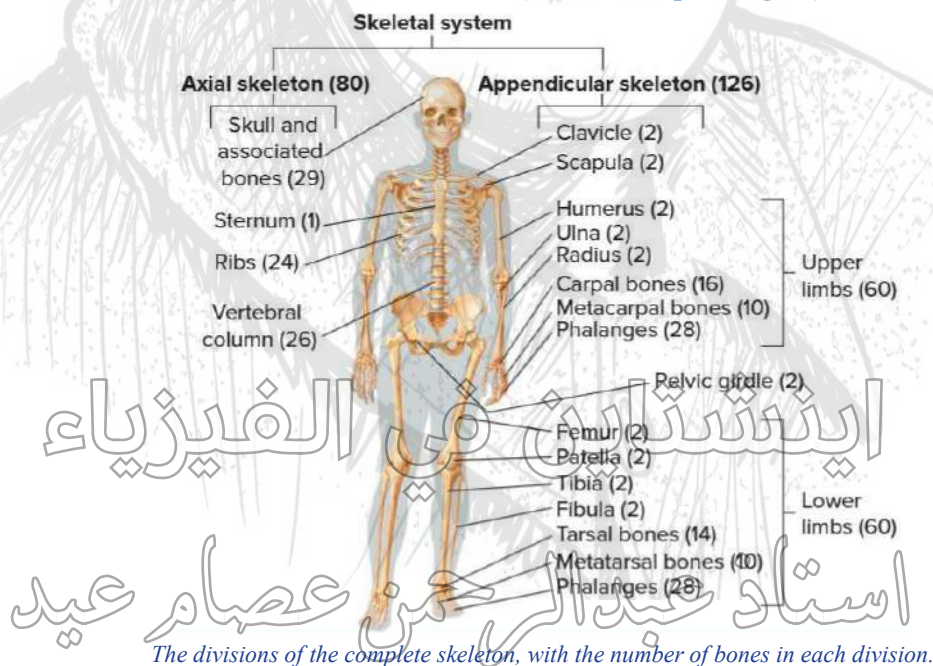
Includes the bones of the body's **vertical axis** (head, chest, and back), consisting of:

- ✓ **The skull and its associated bones:** protect the brain and the sensory organs.
- ✓ **The sternum** (one bone): located in the middle of the rib cage, connecting the ribs at the front.
- ✓ **The ribs** (**24 ribs** / 12 pairs): form the rib cage to protect the heart and lungs.
- ✓ **The vertebral column** (**26 vertebrae**): runs the length of the back to protect the spinal cord and support the body.

2. The Appendicular Skeleton

Mainly associated with **limb movement** and mobility, consisting of:

- ✓ **Shoulder and upper limb bones:** the **clavicle** (2), the **scapula** (2), the **humerus** (2), the **ulna** (2), the **radius** (2), the **carpal** bones (16), the **metacarpal** bones (10), and the **phalanges** (28 in the fingers).
- ✓ **Pelvic and lower limb bones:** the **pelvic** bones (2), the **femur** (2), the **patella** (2), the **tibia** (2), the **fibula** (2), the **tarsal** bones (14), the **metatarsal** bones (10), and the **phalanges** (28 in the toes).



Question 36: The **total number of bones** in an adult's skeleton is:

- (a) 120 bones
- (b) 180 bones
- (c) 206 bones
- (d) 300 bones

Question 37: Among the following bones, the one belonging to the **axial skeleton** is:

- (a) Femur
- (b) Sternum
- (c) Clavicle
- (d) Scapula

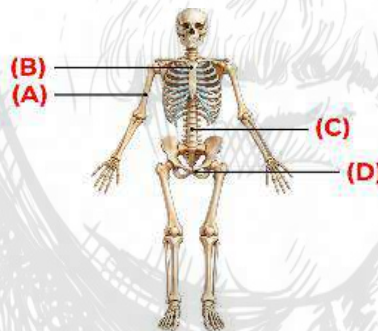
Question 38: The number of **vertebral column** bones in an adult is:

- (a) 12 bones
- (b) 24 bones
- (c) 26 bones
- (d) 33 bones

Question 39: Which of the following is **NOT** part of the axial skeleton?

- (a) Skull
- (b) Ribs
- (c) Hip bone
- (d) Vertebral column

Question 40: The figure below shows a skeleton coded with letters A–D. Which letter refers to the **vertebral column**?



- (a) A
- (b) B
- (c) C
- (d) D

Question 41: Based on the skeleton diagram, which of the following parts belongs to the **appendicular skeleton**?

- (a) The arm
- (b) Skull
- (c) Vertebral column
- (d) Neck bones

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Question 42: The vertebral column and sternum belong to a part of the skeleton called:

- (a) The appendicular skeleton
- (b) The axial skeleton
- (c) Shoulder girdle
- (d) Pelvic girdle

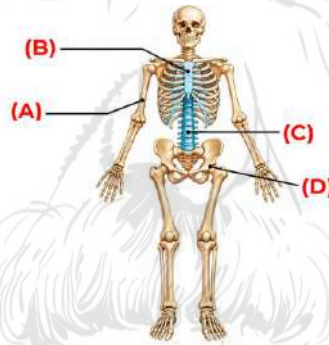
Question 43: Which of the following parts is part of the **appendicular skeleton**?

- (a) The clavicle
- (b) The skull
- (c) The sternum
- (d) The vertebral column

Question 44: Which of the following parts is part of the **skeletal system**?

- (a) Muscle
- (b) Skin
- (c) Organ
- (d) Joint

Question 45: The figure below shows the human skeleton coded with letters A–D. Which letter refers to a bone belonging to the **axial skeleton**?



- (a) A
- (b) C
- (c) D
- (d) Hand extremity

Bone Shapes and Classification

Bones are classified by their **shape and size** into four types:

Bone type	Examples
Long bones	Bones of the arm (humerus) and leg (femur and tibia).
Short bones	Bones of the wrist (carpals) and ankle.
Flat bones	Bones of the skull, the sternum, and the ribs.
Irregular bones	The facial bones and the vertebrae.

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Question 46: The **skull bones and the sternum** are classified by shape as:

- (a) Long
- (b) Short
- (c) Flat
- (d) Irregular

Question 47: The **facial bones and vertebrae** are classified as:

- (a) Long
- (b) Flat
- (c) Irregular
- (d) Short

Question 48: What type of bones are classified as **irregular**?

- (a) Leg bones
- (b) Skull
- (c) Vertebrae
- (d) Wrist bones

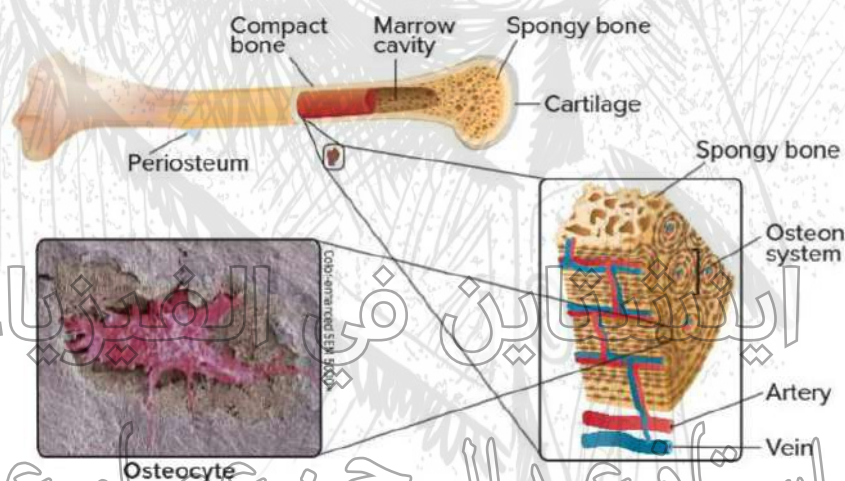
Bone Structure (from the Outside In)

1. The Outer Layer: Compact Bone

- ✓ A **thick, strong** tissue that gives bone strength, rigidity, and protection.
- ✓ Contains cylindrical, tube-like structures known as **osteons** or **Haversian systems**.
- ✓ Running inside the Haversian systems are **blood vessels** that supply oxygen and nutrients to living **bone cells**, and **nerves** that transmit nerve impulses.

2. The Inner Layer: Spongy Bone

- ✓ A **less dense** tissue than compact bone, characterized by **cavities** and porous networks filled with bone marrow.
- ✓ **Contains no Haversian systems.**
- ✓ Found at the **center of short and flat bones**, and at the **ends of long bones**, always surrounded by a layer of compact bone.



The structure of bone from the outside in, and the living bone cell inside the Haversian system.

Question 49: The microscopic **tubular structures** that run through compact bone and contain blood vessels and nerves are known as:

- (a) Osteons
- (b) Spongy marrow
- (c) Ligaments
- (d) Bursae

Question 50: Spongy bone differs from compact bone in that it is:

- (a) Thicker and harder
- (b) Less dense and contains cavities
- (c) Forms the outer surface
- (d) Contains Haversian canals

Question 51: Bone that contains many **spaces filled with bone marrow** is called:

- (a) Compact bone
- (b) Spongy bone
- (c) Osteon
- (d) Periosteum

Question 52: **Living bone cells** residing within the Haversian systems are called:

- (a) Osteoblasts
- (b) Osteoclasts
- (c) Osteocytes
- (d) Chondrocytes

3. Bone Marrow Cavity

Bone marrow resides inside bone cavities and is of two types:

- ✓ **Red bone marrow:** responsible for producing **red blood cells, white blood cells, and platelets**. Found in the humerus, femur, sternum, ribs, vertebrae, and pelvis. Children's bones contain **more red marrow** compared to adults.
- ✓ **Yellow bone marrow:** found in the cavities of many other bones and consists mainly of **stored fat** as an energy source. The body can convert it back to red marrow in cases of **severe blood loss or anemia**, and it gradually replaces part of the red marrow after the age of **seven**.

Question 53: Red blood cells, white blood cells, and platelets are produced in:

- (a) Yellow marrow
- (b) Red marrow
- (c) Haversian canals
- (d) Articular cartilage

Question 54: When the body experiences **severe bleeding or extreme anemia**, the skeletal system responds by:

- (a) Increasing bone breakdown
- (b) Converting yellow marrow to red marrow
- (c) Stopping osteoblasts
- (d) Dissolving ligaments

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Question 55: The substance inside the cavities of the wrist bones that **stores fat** is called:

- (a) Red marrow
- (b) Yellow marrow
- (c) Compact bone
- (d) Periosteum

Question 56: What is the **difference** between red and yellow bone marrow?

- (a) Red stores fat, while yellow produces new blood cells
- (b) Red produces new blood cells, while yellow stores fat
- (c) Red is in the middle of long bones, while yellow is at their ends
- (d) Red contains Haversian systems, while yellow contains nerve cells

4. Comparison of Compact Bone and Spongy Bone

Point of comparison	Compact bone	Spongy bone
Location	The hard outer layer of every bone	Center of short and flat bones, and ends of long bones
Density and structure	Thick, very strong, and solid	Less dense and contains porous cavities
Haversian systems (osteons)	Present — blood vessels and nerves within their canals	Entirely absent
Internal content	Living bone cells nourished through the canals	Cavities filled with bone marrow

5. Comparison of Red and Yellow Bone Marrow

Point of comparison	Red bone marrow	Yellow bone marrow
Nature of the tissue	Cells that generate blood cells and platelets	Fatty tissue that stores energy
Vital function	Production of red and white blood cells and platelets	Energy storage; converts to red marrow during bleeding or anemia
Locations	Humerus, femur, sternum, ribs, vertebrae, and pelvis	Cavities of other bones (more common after age 7)

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Bone Growth and Renewal

1. Bone Formation (Ossification)

- ✓ The embryonic skeleton begins as flexible **cartilage** tissue.
- ✓ During fetal development, cartilage cells develop into cells called **osteoblasts**, responsible for bone growth and renewal.
- ✓ The process by which osteoblasts form bone is known as **ossification**.
- ✓ The adult skeleton becomes entirely hard bone, except for four sites: the **tip of the nose**, the **outer ear**, the **discs between the vertebrae**, and the **lining of movable joints**.

Question 57: In their early developmental stages, **fetal skeletons** begin as:

- | | |
|--|--|
| ☐ (a) Compact bone | ☐ (b) Cartilage tissue |
| ☐ (c) Spongy bone | ☐ (d) Yellow marrow |

Question 58: The process by which cartilage turns into living bone through the action of osteoblasts is called:

- | | |
|---|--|
| ☐ (a) Healing | ☐ (b) Ossification |
| ☐ (c) Calcification | ☐ (d) Replacement |

Question 59: Among the parts that **remain made of cartilage** in an adult:

- | | |
|--|---|
| ☐ (a) Metacarpal bones | ☐ (b) Tip of the nose and outer ear |
| ☐ (c) Sternum | ☐ (d) Radius and ulna |

2. Bone Remodeling

A **continuous, lifelong** process in which old cells are replaced by new ones:

- ✓ **Osteoclasts: break down** old and damaged bone cells to remove them.
- ✓ **Osteoblasts: build** new, strong bone tissue to replace it.
- ✓ Factors affecting bone growth: **nutrition** and **physical exercise**.
- ✓ Calcium deficiency leads to **osteoporosis**, making bones weak, brittle, and easily fractured.

Question 60: The bone cells responsible for **breaking down** old and damaged bone cells are:

- | | |
|---|---------------------------------------|
| ☐ (a) Osteoblasts | ☐ (b) Osteoclasts |
| ☐ (c) Keratinocytes | ☐ (d) Fibroblasts |

Question 61: A severe deficiency of **calcium** leads to:

- | | |
|--|--|
| ☐ (a) Osteoporosis | ☐ (b) Osteoarthritis |
| ☐ (c) Bursitis | ☐ (d) Sprain |

Question 62: What are the cells called that **remove** old and damaged bone tissue?

- (a) Osteoblasts
- (b) Osteocytes
- (c) Osteoclasts
- (d) Bone enzymes

Fractures and Stages of Bone Healing

1. Classification of Fractures

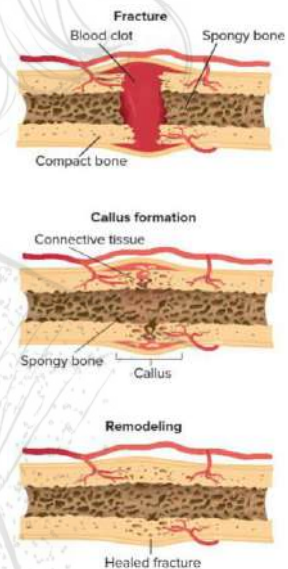
Fracture type	Description
Simple fracture	The broken bone does not protrude outside the skin.
Compound fracture	The broken bone protrudes outward through the skin.
Stress fracture	A small, fine crack in the bone caused by pressure.

Question 63: A fracture in which the broken bone **does not protrude** outside the skin is called:

- (a) Compound fracture
- (b) Simple fracture
- (c) Stress fracture
- (d) Open fracture

2. Stages of Bone Renewal and Healing

- Immediate response: endorphin** compounds (the brain's natural painkillers) are released at the injury site to reduce pain, and the area becomes inflamed and swollen.
- Blood clot formation:** a **blood clot** forms between the two ends of the broken bone within roughly **8 hours**, and new bone formation begins.
- Callus formation (bone scar):** a **soft callus** initially forms from cartilage and connective tissue (the bone must be immobilized because this tissue is weak).
- Bony callus formation:** after roughly **3 weeks**, osteoblasts produce a callus of **spongy bone** surrounding the fracture.
- Complete remodeling:** osteoclasts remove the spongy bone, while osteoblasts produce stronger **compact bone**.



Stages of fracture healing.

Question 64: Chemical substances released by the brain to **naturally relieve pain** during fractures are called:

- (a) Insulin
- (b) Endorphin
- (c) Keratin
- (d) Melanin

Question 65: A **blood clot** forms between the two ends of a broken bone within:

- (a) Two hours (b) 8 hours
(c) Two weeks (d) Three weeks

Question 66: The **bony callus** tissue that forms after roughly 3 weeks is initially composed of:

- (a) Compact bone (b) Spongy bone
(c) Yellow fat (d) Hard keratin

✓ **Healing time:** children's bones heal faster than adults'; a child's fracture takes **4 to 6 weeks**, while an adult's takes roughly **6 months**.

✓ **Medical immobilization methods:** splints, casts, or traction are used; broken fingers are immobilized by taping them to the **adjacent finger**.

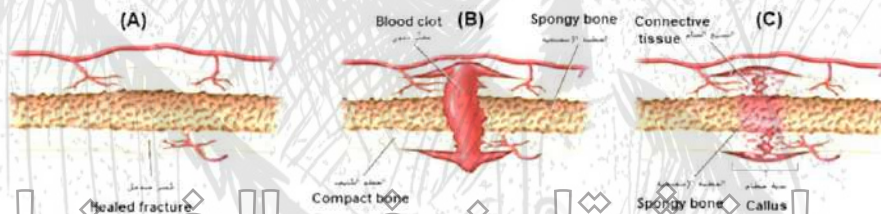
Question 67: Bone fracture healing in **young children** takes a period ranging between:

- (a) One to two weeks (b) 4 to 6 weeks
(c) 6 months (d) A full year

Question 68: Which of the following represents the **correct sequence** for the repair and healing of a bone fracture?

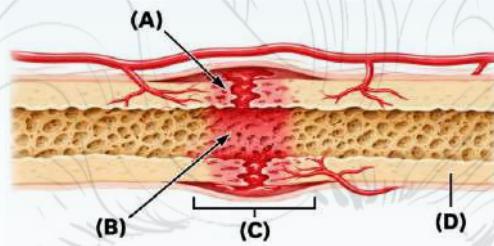
- (a) Blood clot → bony callus → soft callus → remodeling
(b) Blood clot → soft callus → bony callus → remodeling
(c) Soft callus → blood clot → bony callus → remodeling
(d) Remodeling → blood clot → soft callus → bony callus

Question 69: The figure below shows the steps of bone renewal coded with letters A, B, and C. Which of the following represents the **correct sequence** of these steps?



- (a) A → B → C (b) B → C → A
(c) C → B → A (d) B → A → C

Question 70: The figure below shows the structure of a bone during its renewal, coded with letters A–D. Which letter refers to the **bone scar (callus)**?



- (a) C
- (b) A
- (c) B
- (d) D

Question 71: Which of the following is part of the process of **healing a broken bone**?

- (a) Formation of a temporary blood clot to increase myosin fibers
- (b) Inflammation caused by endorphins to increase the sensation of pain
- (c) Osteoblasts forming solid structures to stabilize the fracture site
- (d) Removal of dead bone cells by osteoclasts and cleaning the injury site

Joints and Their Disorders

1. Definition of a Joint, Ligaments and Tendons

Term	Definition
Joint	The point where two or more bones of the skeleton meet.
Ligaments	Strong bands of connective tissue that connect one bone to another at joints to stabilize them.
Tendons	Strong bands of connective tissue that connect muscles to bones .

Question 72: Strong bands of connective tissue that connect **one bone to another** at a joint are known as:

- (a) Tendons
- (b) Ligaments
- (c) Muscles
- (d) Bursae

2. The Five Joint Types

- ✓ **Ball-and-socket joint:** a spherical surface fits into a cup-shaped cavity, providing **the widest range of motion in all directions**, such as swinging and rotation (e.g., the **shoulder** and the **hip**).
- ✓ **Pivot joint:** its main motion is **rotational** around a single axis, allowing twisting (e.g., where the **radius and ulna** meet at the elbow area of the lower arm).
- ✓ **Hinge joint:** a convex surface fits into a concave surface, allowing **forward-and-backward** motion in a single plane, like a door hinge (e.g., the **elbow** and the **knee**).
- ✓ **Gliding joint:** limited motion in which bone surfaces **slide** forward, backward, and side to side (e.g., the **wrist**, the **ankle**, and the joints between the **vertebrae**).

- ✓ **Suture joint: completely immovable** joints connecting the 22 skull bones with fibrous sutures (fully fused at around **3 months** of age), except for the **mandible (lower jaw)**, which remains movable.

Name of Joint	Ball-and-Socket	Pivot	Hinge	Gliding	Sutures
Example					

The five types of joints with an example of each.

Joint type	Nature of allowed motion	Examples in the body
Ball-and-socket	Widest range of motion in all directions	Shoulder, hip
Pivot	Rotational motion around a single axis	Where the radius and ulna meet in the lower arm
Hinge	Forward-and-backward motion in a single plane	Elbow, knee
Gliding	Limited sliding forward, backward, and side to side	Wrist, ankle, between vertebrae
Suture	Completely immovable (fixed)	The 22 skull bones (except the mandible)

Question 73: The **widest range of motion** in all directions is provided by which joint?

- ☐ a Hinge
☐ b Ball-and-socket
☐ c Gliding
☐ d Pivot

Question 74: The elbow joint, at the point where the **radius and ulna** meet, represents a:

- ☐ a Pivot joint
☐ b Ball-and-socket joint
☐ c Hinge joint
☐ d Suture joint

Question 75: The **knee joint** allows forward-and-backward motion only in a single plane, and is therefore classified as a:

- ☐ a Gliding joint
☐ b Hinge joint
☐ c Ball-and-socket joint
☐ d Pivot joint

Question 76: The joints between the **vertebrae** of the spine and the **wrist joint** are:

- ☐ a Suture joints
☐ b Gliding joints
☐ c Ball-and-socket joints
☐ d Pivot joints

Question 77: The fixed, immovable **skull joints** fully fuse in children at the age of:

- (a) Two weeks
- (b) Roughly 3 months
- (c) A full year
- (d) 7 years

Question 78: The **only movable bone** in an adult human skull is:

- (a) Frontal bone
- (b) Mandible (lower jaw)
- (c) Nasal bone
- (d) Temporal bone

3. Joint Disorders and Injuries

- ✓ **Osteoarthritis:** a painful condition resulting from the **deterioration and wearing away of cartilage** in movable joints (such as the knees, hips, neck, and back); its incidence increases with age and affects about **10%** of people.
- ✓ **Rheumatoid arthritis:** **does not result from cartilage wear**; rather, joints lose their strength and function and become severely inflamed and swollen, causing **finger deformity**.



Finger deformity caused by rheumatoid arthritis.

Question 79: The disorder resulting from the **deterioration and wearing away of cartilage** covering the ends of bones is:

- (a) Rheumatoid arthritis
- (b) Osteoarthritis
- (c) Ligament sprain
- (d) Stress fracture

Question 80: A joint disease **not caused by cartilage wear**, but which causes severe inflammation and **deformities in finger shape**:

- (a) Rheumatoid arthritis
- (b) Osteoarthritis
- (c) Osteoporosis
- (d) Bursitis

- ✓ **Bursitis:** inflammation affecting the **bursae** (fluid-filled sacs that act as cushions reducing friction between bones and tendons); its well-known example is **"tennis elbow"**, and its treatment is resting the affected joint.
- ✓ **Sprains:** result from **damage and tearing of ligaments** due to a joint bending or stretching excessively, accompanied by pain, swelling, and tenderness.

Question 81: The **fluid-filled sacs** that act as cushions reducing friction between bones and tendons are known as:

- (a) Ligaments
- (b) Bursae
- (c) Haversian canals
- (d) Cartilage discs

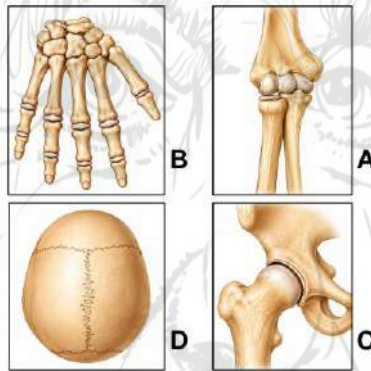
Question 82: The injury known as "tennis elbow" is a form of:

- (a) Osteoarthritis
- (b) Bursitis
- (c) Ligament sprain
- (d) Stress fracture

Question 83: A **sprain** in the joints occurs as a result of a tear or damage to:

- (a) Ligaments
- (b) Tendons
- (c) Compact bone
- (d) Yellow marrow

Question 84: The figure below shows four joints coded A–D. What is the joint indicated by symbol **B** (the wrist and hand bones) called?



- (a) Gliding
- (b) Pivot
- (c) Suture
- (d) Hinge

Question 85: Referring to the same figure, which of the following joints is found **only in the skull**?

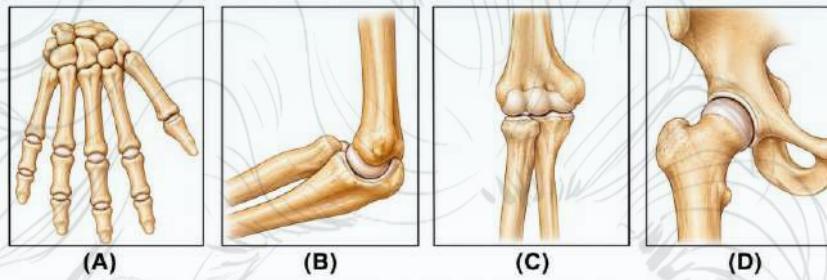
- (a) A
- (b) B
- (c) C
- (d) D

Question 86: Which of the following term pairs is **NOT** compatible with each other?

- (a) Shoulder, ball-and-socket joint
- (b) Knee, hinge joint
- (c) Skull, sutures
- (d) Ankle or wrist, pivot joint

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Question 87: The figure below shows some joints of the skeletal system coded with letters A–D. Which letter refers to the type of joint found in the **human knee**?



- ☐ (a) A
- ☐ (b) B
- ☐ (c) C
- ☐ (d) D

Question 88: Referring to the same figure, which letter refers to the type of joint found in the **hips and shoulders**?

- ☐ (a) A
- ☐ (b) B
- ☐ (c) C
- ☐ (d) D

Question 89: Referring to the same figure, which letter refers to the **ball-and-socket** joint?

- ☐ (a) A
- ☐ (b) B
- ☐ (c) C
- ☐ (d) D

Question 90: Referring to the same figure, which letter refers to a **gliding** joint?

- ☐ (a) A
- ☐ (b) B
- ☐ (c) C
- ☐ (d) D

Question 91: Based on the picture of the **elbow joint** (bent arm), where might you expect to find the type of joint shown in the figure?

- ☐ (a) Hip
- ☐ (b) Vertebrae
- ☐ (c) Elbow
- ☐ (d) Skull

Question 92: Which of the following term pairs **are compatible** with each other?

- ☐ (a) Knee, ball-and-socket joint
- ☐ (b) Wrist, hinge joint
- ☐ (c) Skull, sutures
- ☐ (d) Shoulder, suture joint

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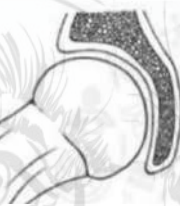
Question 93: Which of the following term pairs is **NOT** compatible with each other?

- (a) Shoulder, ball-and-socket joint
- (b) Knee, hinge joint
- (c) Skull, sutures
- (d) Wrist, pivot joint

Question 94: **Gripping a tennis ball** in the palm of the hand is made possible by:

- (a) Gliding joints
- (b) Hinge joints
- (c) Pivot joints
- (d) Suture joints

Question 95: Based on the diagram of the **ball-and-socket joint** below, where is this type of joint found?



- (a) The elbow and knee
- (b) Fingers and toes
- (c) The hip and shoulder
- (d) The wrist and ankle

Question 96: The type of **immovable (fixed)** joint found in the skull is:

- (a) Gliding joint
- (b) Hinge joint
- (c) Pivot joint
- (d) Suture joint

Question 97: The type of joint that allows a person to **bend their knee** forward and backward in a single plane is:

- (a) Gliding joint
- (b) Hinge joint
- (c) Pivot joint
- (d) Suture joint

Question 98: The type of joint that allows a person to **bend their trunk** (found between the vertebrae of the spine) is:

- (a) Gliding joint
- (b) Hinge joint
- (c) Pivot joint
- (d) Suture joint

Question 99: What type of joint helps you **type** when using a computer?

- (a) Gliding
- (b) Hinge
- (c) Pivot
- (d) Suture

Question 100: What is the effect of **losing cartilage tissue** in the knee?

- (a) Reduces leg strength
- (b) Causes leg bones to lose their connection
- (c) Causes muscles to lose their strength
- (d) Reduces its flexibility

Question 101: The **femur and tibia** bones are connected together at the knee joint by:

- (a) Tendons
- (b) Ligaments
- (c) Muscles
- (d) Bursae

Functions of the Skeletal System and Homeostasis

- ✓ **Support:** bearing the body's weight (legs, pelvis, and spine), supporting the teeth in the lower jaw, and supporting muscles and soft organs.
- ✓ **Protection:** the **skull** protects the brain, the **vertebrae** protect the spinal cord, and the **rib cage** protects the heart and lungs.
- ✓ **Blood cell formation:** red bone marrow produces red blood cells at a rate exceeding **two million cells per second**, alongside white blood cells and platelets.

Question 102: Red blood cells are produced in red bone marrow at an enormous rate exceeding:

- (a) A thousand cells per second
- (b) A hundred thousand cells per second
- (c) Two million cells per second
- (d) Five million cells per second

- ✓ **Storage and homeostatic regulation:** bones act as the body's main reservoir for storing **calcium and phosphorus**.
- ✓ When blood calcium levels **drop**: calcium stored in the bones is **released** into the bloodstream.
- ✓ When blood calcium levels **rise**: the excess calcium is **stored** within bone tissue.
- ✓ **Movement:** muscles pull on the bones they are attached to in order to generate movement, and the movement of the ribs and diaphragm enables normal breathing.

Question 103: The skeletal system helps maintain **calcium homeostasis**; when blood calcium levels drop:

- (a) The surplus is stored in the bones
- (b) Calcium is released from the bones into the blood
- (c) Red marrow stops functioning
- (d) Cartilage turns into bone

Question 104: Which of the following is **NOT** a function of the appendicular skeleton?

- (a) Produces blood cells
- (b) Bears the body
- (c) Protects the spinal cord
- (d) Stores calcium and phosphorus

Question 105: Which of the following is **NOT** considered a function of bones?

- (a) Support and organ protection
- (b) Blood cell formation
- (c) Storage of calcium and phosphorus
- (d) Vitamin D production

SECTION 3

The Muscular System

The Three Types of Muscle Tissue

Muscle is made up of specialized cells or fibers capable of **contracting** and producing movement. Muscles are classified, according to their structure, location, and function, into **three main types**:

1. Smooth (Visceral) Muscle

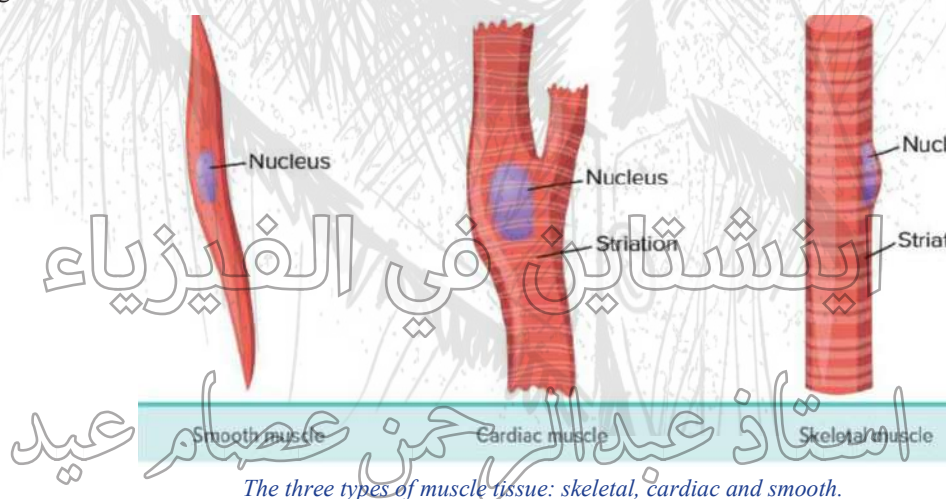
- ✓ **Location:** lines the walls of hollow internal organs, such as the **stomach**, **intestines**, **esophagus**, **bladder**, **uterus**, and **blood vessels**.
- ✓ **Nature of movement:** **involuntary** muscle, not under conscious control (such as the peristaltic movement that pushes food through the digestive tract).
- ✓ **Structure:** individual **spindle-shaped** cells, **non-striated** and not arranged in bundles, each cell containing a **single central nucleus**.
- ✓ **Contraction:** slow and irregular.

2. Cardiac Muscle

- ✓ **Location:** found exclusively in the **wall of the heart** to keep it beating continuously.
- ✓ **Nature of movement:** self-regulating **involuntary** muscle.
- ✓ **Structure:** **striated** cells arranged in a **branching network**, connected via **gap junctions** that allow extremely rapid spread of the nerve impulse, giving the heart a **regular, strong contraction**; each cell usually has a **single nucleus**.

3. Skeletal Muscle

- ✓ **Location:** makes up most of the body's muscles, and is anchored to the skeleton to move the bones of the face, limbs, and trunk.
- ✓ **Nature of movement:** **voluntary** muscle, under conscious control.
- ✓ **Structure:** long cylindrical **striated** cells arranged in bundles, appearing as a **multinucleated syncytium** with **peripheral (lateral) nucle**
- ✓ **Contraction:** fast, strong, and irregular.
- ✓ **Tendons:** strong bands of connective tissue that connect skeletal muscles to bones to transmit pulling force and generate movement.



4. Comprehensive Comparison of the Three Types

Point of comparison	Smooth muscle	Cardiac muscle	Skeletal muscle
Location	Walls of the stomach, intestines, and vessels	Wall of the heart only	Anchored to the skeleton
Type of movement	Involuntary	Involuntary	Voluntary
Striation	Non-striated	Striated	Striated, arranged in bundles
Cell shape	Individual spindle shape	Branching network with gap junctions	Cylindrical with fused nuclei
Nuclei	Single, central nucleus	Usually a single nucleus	Multiple, peripheral nuclei
Contraction	Slow and irregular	Regular and strong	Fast, strong, and irregular

Question 106: The type of muscle that lines the walls of the **stomach, intestines, and blood vessels** is:

- (a) Skeletal muscle
- (b) Smooth muscle
- (c) Cardiac muscle
- (d) Voluntary muscle

Question 107: Cardiac muscle cells are arranged in a network and connect to each other through:

- (a) Tendons
- (b) Gap junctions
- (c) Ligaments
- (d) Z lines

Question 108: Skeletal muscle cells form a cellular syncytium whose **nuclei** are arranged in the:

- (a) Central position
- (b) Peripheral (lateral) position
- (c) Internal position
- (d) Absent position

Question 109: Strong bands of connective tissue that connect **skeletal muscles to bones** are called:

- (a) Ligaments
- (b) Tendons
- (c) Cartilage
- (d) Joints

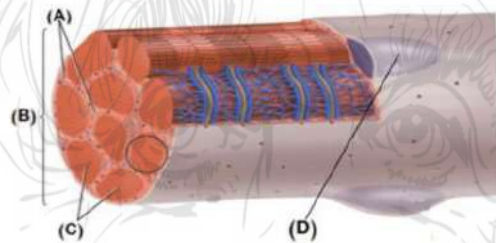
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Question 110: The figure below represents three types of muscle coded with letters A, B, and C. Which of them is classified as a **voluntary** muscle?



- (a) Muscle A
- (b) Muscle B
- (c) Muscle C
- (d) All the muscles

Question 111: The figure below represents the structure of a muscle fiber coded with letters A–D. Which letter refers to the **nucleus** of the muscle cell?



- (a) A
- (b) B
- (c) C
- (d) D

Question 112: Which of the following is true regarding **striation** in muscle types?

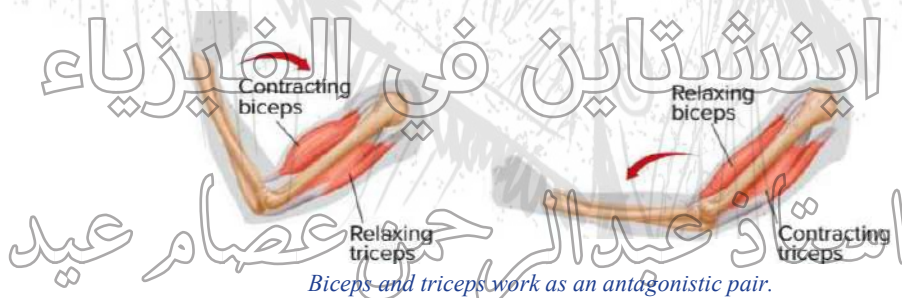
- (a) Smooth and cardiac muscle are striated
- (b) Cardiac and skeletal muscle are striated
- (c) Smooth and skeletal muscle are striated
- (d) Only skeletal muscle is striated

Skeletal Muscle Contraction and Its Fine Structure

1. Muscles in Opposing (Antagonistic) Pairs

Most skeletal muscles are arranged in **opposing pairs** that work against each other to produce movement:

- ✓ **Raising the forearm (bending the arm):** the **biceps contracts**, while the **triceps relaxes**.
- ✓ **Lowering the forearm (extending the arm):** the **triceps contracts** (at the back of the arm), while the **biceps relaxes**.



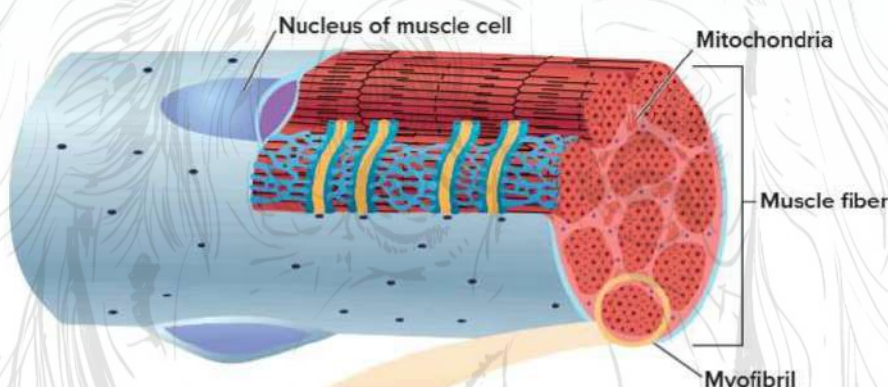
Question 113: When the forearm is **lowered** and the arm is extended downward, what occurs is:

- (a) Biceps contraction
- (b) Triceps contraction
- (c) Contraction of both muscles together
- (d) Relaxation of both muscles together

2. Levels of Organization in Skeletal Muscle

Muscle → Bundles of muscle fibers → Myofibrils → Sarcomeres → Actin and myosin filaments

- ✓ **Muscle fibers:** fused muscle cells that form the bundles.
- ✓ **Myofibrils:** smaller cylindrical units composed of interlocking protein filaments:
- ✓ **Myosin** filaments: **thick** protein filaments with mobile heads.
- ✓ **Actin** filaments: **thin** protein filaments containing special sites for binding myosin heads.



A muscle fiber is made of myofibrils; the protein filaments actin and myosin form myofibrils.

Question 114: What are the **protein filaments** that make up the myofibril?

- (a) The sarcomere and the nucleus
- (b) Myosin and actin
- (c) Z lines and A bands
- (d) Mitochondria and actin

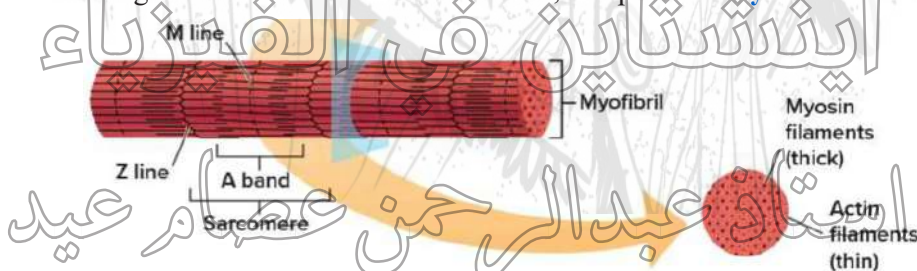
3. The Sarcomere

The **sarcomere** is the basic **functional unit** of the myofibril and the actual part that **contracts**.

Explain: why do skeletal muscle fibers appear striated under the microscope?

Answer: The striation appears due to the **repetition of sarcomeres** extending from one **Z line** to the next.

- ✓ **Z line:** the region where the thin **actin** filaments attach and anchor.
- ✓ **A band:** a dark band produced by the **overlap of actin filaments with myosin filaments**.
- ✓ **M line:** the dividing line at the center of the sarcomere, composed of **myosin filaments only**.



The structure of the sarcomere: the Z line, the M line and the A band.

Question 115: The basic **functional unit** and the part that contracts within the myofibril is called:

- ☐ (a) The A band
- ☐ (b) The sarcomere
- ☐ (c) The myosin filament
- ☐ (d) The myofibril

Question 116: The dark **A band** in the sarcomere results from the overlap of:

- ☐ (a) Actin filaments only
- ☐ (b) Myosin filaments only
- ☐ (c) Actin and myosin filaments
- ☐ (d) Z lines with calcium

Question 117: The **M line** at the center of the sarcomere is composed exclusively of:

- ☐ (a) Myosin filaments only
- ☐ (b) Actin filaments only
- ☐ (c) Actin and myosin together
- ☐ (d) Gap junctions

Question 118: Based on the sarcomere figure, which of the following indicates the place where **actin filaments attach**?

- ☐ (a) Z line
- ☐ (b) M line
- ☐ (c) A band
- ☐ (d) Myofibril

Question 119: Based on the sarcomere figure, which of the following consists of **myosin filaments only**?

- ☐ (a) Z line
- ☐ (b) M line
- ☐ (c) A band
- ☐ (d) Sarcomere

Question 120: Based on the sarcomere figure,

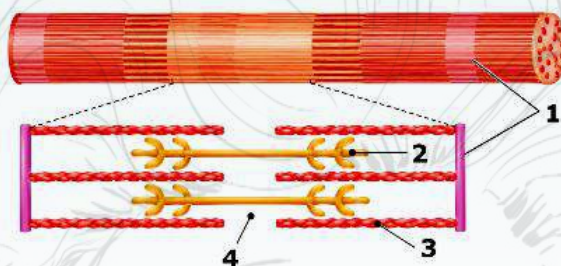
what results from the **overlap** of actin filaments and myosin filaments?

- ☐ (a) Z line
- ☐ (b) M line
- ☐ (c) A band
- ☐ (d) Cross bridges

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Question 121: The figure below represents a muscle fiber coded with numbers.

Which number indicates the **Z line**?



-
- The drawing shows a person's head and shoulders in profile, tilted back. Four points are marked with letters in circles: (a) is at the top of the head, (b) is at the forehead, (c) is at the chin, and (d) is at the neck.

Question 122: Referring to the same figure, the number that indicates the **myosin filaments** is:

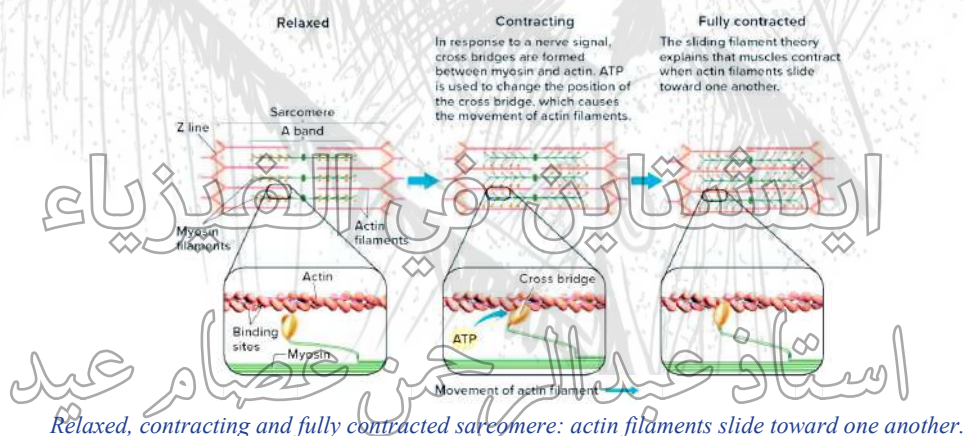
- 
- (a) 1
 (b) 2
 (c) 3
 (d) 4

The Sliding Filament Theory

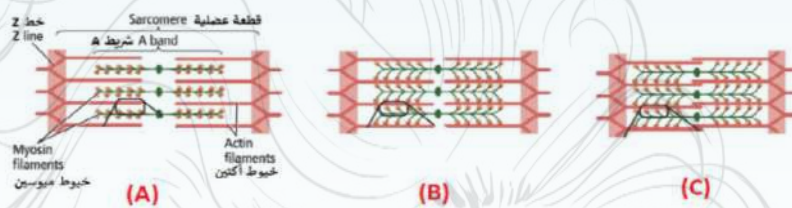
This theory states that when a nerve signal reaches the muscle fiber, **the actin filaments slide toward each other**, toward the center of the sarcomere, **while the myosin filaments remain stationary**.

Steps of Contraction at the Molecular Level

1. **Calcium release:** the arrival of the nerve impulse causes **calcium** ions to be released into the cytoplasm of the myofibrils.
2. **Cross-bridge formation:** calcium ions bind to sites on actin, allowing the myosin heads to attach to actin and form **cross bridges**.
3. **Pulling actin and consuming energy:** **ATP** is used to change the angle of the cross bridge, pulling the actin filaments toward the **M line** at the center.
4. **Full contraction:** the actin filaments move closer together, causing the **Z lines to converge** and the **sarcomere to shorten**.
5. **Relaxation:** releasing the cross bridges and pumping calcium back out of the myofibrils requires **new ATP** molecules, so the filaments return to their original positions and the muscle relaxes.



Question 123: The figure represents the stages of sarcomere contraction: (A) filaments fully apart, (B) during contraction, (C) fully contracted. What does letter (A) indicate?

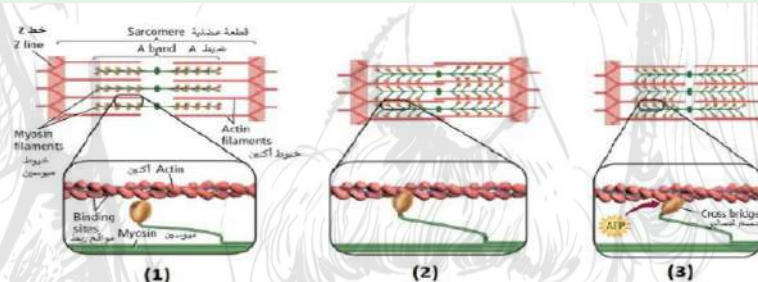


- (a) A relaxed sarcomere
- (b) A sarcomere during contraction
- (c) A fully contracted sarcomere
- (d) A muscle in rigor mortis

Question 124: According to the **sliding filament theory**, when a muscle contracts, the:

- (a) Myosin filaments slide while actin remains stationary
- (b) Actin filaments slide while myosin remains stationary
- (c) Myosin and actin filaments both shorten
- (d) Z lines move apart

Question 125: The figure shows the molecular mechanism of cross-bridge movement: (1) binding sites free, (2) cross bridge forms, (3) actin is pulled and ATP is consumed. Which represents the **correct sequence** of the steps?



- (a) 1 → 2 → 3
- (b) 3 → 2 → 1
- (c) 2 → 1 → 3
- (d) 2 → 3 → 1

Question 126: The **ion** released inside the myofibrils to bind myosin to actin and form cross bridges is:

- (a) Sodium
- (b) Potassium
- (c) Calcium
- (d) Iron

Question 127: Changing the angle of the cross bridge to pull actin, and relaxing the muscle, requires the availability of:

- (a) Lactic acid
- (b) Keratin
- (c) ATP
- (d) Myoglobin

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Question 128: Which of the following requires the presence of adenosine triphosphate (ATP)?

- (a) Muscle contraction only
- (b) Muscle relaxation only
- (c) Both muscle contraction and relaxation
- (d) Neither contraction nor relaxation

Question 129: Which of the following **proteins** is found in muscle?

- (a) Actin
- (b) Keratin
- (c) Melanin
- (d) Insulin

Question 130: The scientist who replaced muscles with threads on cadavers to prove that they **contract to pull on bones** is:

- (a) Henry Faulds
- (b) Robert Hooke
- (c) Leonardo da Vinci
- (d) Louis Pasteur

Energy for Contraction and Rigor Mortis

1. Energy Metabolism in Muscles

- ✓ **Aerobic cellular respiration:** occurs in the presence of **oxygen** inside the **mitochondria** to produce abundant amounts of **ATP**.
- ✓ **Anaerobic respiration (lactic acid fermentation):** used when not enough oxygen reaches the muscles.

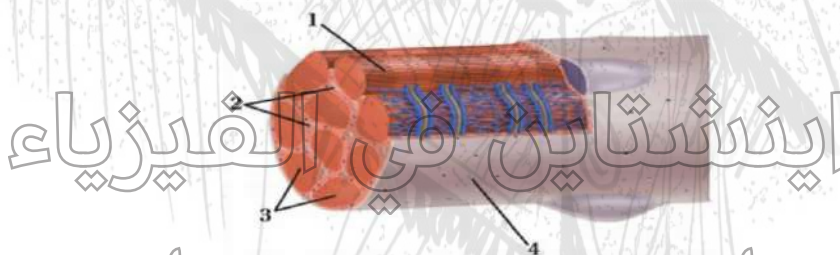
Explain: why does muscular fatigue occur during intense exercise?

Answer: After intense effort, not enough oxygen may reach the muscles, so they resort to **anaerobic metabolism** to produce ATP, which causes **lactic acid** to accumulate in the cells, causing **fatigue**.

Explain: why do breathing movements speed up after strenuous exercise?

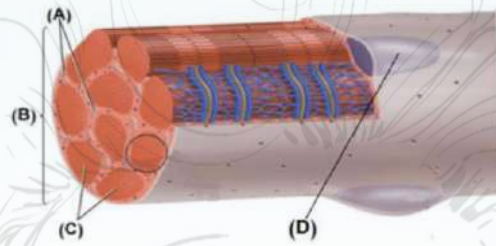
Answer: To make up for the acute **shortage of oxygen**; after rest, oxygen stores are replenished, the accumulated lactic acid breaks down, and the muscles return to their normal state.

Question 131: The figure below illustrates a muscle fiber coded with numbers 1–4. Which part is used for **cellular respiration**?



- (a) 1
- (b) 2
- (c) 3
- (d) 4

Question 132: The figure below represents the structure of a muscle fiber coded with letters A–D. Which letter refers to the **mitochondria**?



- (a) A
- (b) B
- (c) C
- (d) D

Question 133: Muscular strain and **fatigue** during intense exercise occur due to the buildup of:

- (a) Lactic acid
- (b) Calcium
- (c) Oxygen
- (d) Glucose

2. The Phenomenon of Rigor Mortis

Rigor mortis is a state of permanent muscular **stiffness and contraction** that occurs in the bodies of organisms after death.

Explain: why do muscles stiffen after death (rigor mortis)?

Answer: Pumping calcium out of the myofibrils and releasing the cross bridges requires **ATP**; since a dead body **cannot produce ATP**, calcium remains trapped inside the myofibrils and the muscles stay **contracted**.

What happens 24 hours after death?:

Answer: The muscle cells and tissues begin **self-digestion (autolysis)** by enzymes; the rigidity disappears and the fibers can no longer remain contracted.

Question 134: The cause of **rigor mortis** after death is:

- (a) Breakdown of actin filaments
- (b) Absence of ATP to pump calcium out of the myofibrils
- (c) Lack of lactic acid
- (d) Z lines moving apart

Question 135: Rigor mortis **disappears** from a corpse after 24 hours because of:

- (a) The onset of cell and muscle tissue decomposition
- (b) Production of new ATP
- (c) Calcium leaving spontaneously
- (d) Skin shrinkage

Question 136: What causes the body to become **fatigued** after running a long distance?

- Ⓐ Accumulation of lactic acid in the muscles
- Ⓑ Decreased energy produced by fermentation
- Ⓒ Increased amount of ATP
- Ⓓ Occurrence of aerobic metabolism

Muscle Strength and Types of Muscle Fibers

Explain: why don't some people's bodies grow like bodybuilders no matter how much they train, and why does a sprinter tire quickly in a long-distance race?

Answer: The reason lies in **the ratio between slow-twitch and fast-twitch fibers**, a ratio that is determined **genetically** in each person.

1. Slow-Twitch Fibers

- ✓ **Characteristics:** contract slowly, and have **very high endurance** and resistance to fatigue.
- ✓ **Structure:** rich in **mitochondria** for aerobic respiration, and contain the oxygen-storing molecule **myoglobin**, which gives them a **dark color**.
- ✓ **Suitable sports:** long-distance running (marathons), swimming, cycling, and triathlons.
- ✓ **Effect of training:** increases the number of mitochondria, but the increase in muscle size is modest.

2. Fast-Twitch Fibers

- ✓ **Characteristics:** contract quickly and provide **large, explosive power**, but **reach fatigue easily and quickly**.
- ✓ **Structure:** fewer mitochondria and little myoglobin, giving them a **lighter color**; they rely mainly on **anaerobic respiration**, which builds up lactic acid.
- ✓ **Suitable sports:** weightlifting and short sprint races (100 meters).
- ✓ **Effect of training:** increases the number of myofibrils, leading to a clear **increase in muscle diameter** and mass.



Endurance sports rely on slow-twitch fibers; power sports rely on fast-twitch fibers.

3. Examples of Fiber Ratios in Human Muscles

- ✓ **The soleus muscle (leg):** raises the foot while standing, and has the **highest** proportion of slow-twitch fibers (**87%**) to resist fatigue and gravity.
- ✓ **The orbicularis oculi muscle (face):** closes the eyelids, and has the **lowest** proportion of slow-twitch fibers (**15%**) for rapid blinking.

4. Comparison of Slow-Twitch and Fast-Twitch Fibers

Point of comparison	Slow-twitch fibers	Fast-twitch fibers
Contraction speed	Slow	Fast
Endurance	Very high , resists fatigue	Lower , reaches fatigue easily
Respiratory pathway	Aerobic respiration	Anaerobic metabolism (lactic fermentation)
Mitochondria	Very many; increase with exercise	Few
Myoglobin	Abundant (oxygen reservoir)	Little
Muscle color	Dark	Light
Example sports	Marathon, swimming, cycling	Weightlifting, sprinting
Effect of training	More mitochondria (modest enlargement)	More myofibrils and larger muscle diameter

Question 137: Slow-twitch muscle fibers are characterized by being:

- ☐ (a) Quick to fatigue
- ☐ (b) Rich in mitochondria and resistant to fatigue
- ☐ (c) Lacking in oxygen
- ☐ (d) Pale white in color

Question 138: The **dark color** of slow-twitch fibers is due to the abundance of mitochondria and the molecule:

- ☐ (a) Collagen
- ☐ (b) Myoglobin
- ☐ (c) Keratin
- ☐ (d) Elastin

Question 139: Athletes in **marathon** and long-distance swimming events have a high proportion of:

- ☐ (a) Slow-twitch fibers
- ☐ (b) Fast-twitch fibers
- ☐ (c) Smooth fibers
- ☐ (d) Oxygen-free fibers

Question 140: The sport suited to individuals with a high proportion of **fast-twitch** fibers is:

- ☐ (a) Long-distance cycling
- ☐ (b) Long-distance swimming
- ☐ (c) Weightlifting and sprinting
- ☐ (d) Race walking

Question 141: **Weightlifting** training of fast-twitch fibers leads to:

- ☐ (a) Increasing the number of mitochondria only
- ☐ (b) Increasing the number of myofibrils and the muscle's diameter
- ☐ (c) Converting them into dark fibers
- ☐ (d) Reducing lactic acid buildup

Question 142: The muscle with the **highest** proportion of slow-twitch fibers (87%) in the human body is:

- (a) The orbicularis oculi muscle
- (b) The soleus muscle in the leg
- (c) The deltoid muscle
- (d) The triceps muscle

Question 143: The muscle with the **lowest** proportion of slow-twitch fibers (15%) and the highest proportion of fast-twitch fibers is:

- (a) The soleus muscle
- (b) The thigh muscle
- (c) The orbicularis oculi muscle
- (d) The pectoral muscle

Question 144: **Wild turkeys** are able to fly longer distances than domestic turkeys because their muscles contain:

- (a) A higher proportion of oxygen-rich dark meat
- (b) A higher proportion of anaerobic light meat
- (c) More fat
- (d) Fewer sarcomeres

Question 145: How do **fast-twitch** fibers differ from slow-twitch fibers?

- (a) Fast-twitch fibers are smaller in size
- (b) They obtain their energy from oxygen
- (c) They reach fatigue more quickly
- (d) They are used in non-intense exercise

Question 146: Which of the following causes **fatigue** in the body of a long-distance runner?

- (a) Accumulation of lactic acid in the muscles
- (b) Abundance of oxygen
- (c) Increased number of mitochondria
- (d) Calcium flow

Question 147: Which of the following is a characteristic of **fast-twitch** muscle?

- (a) High endurance capacity
- (b) Contains little myoglobin
- (c) Abundant mitochondria
- (d) Resists fatigue

Question 148: Which of the following is a feature of **fast-twitch** muscle fibers?

- (a) Contain more mitochondria
- (b) Contain fewer mitochondria than slow-twitch fibers
- (c) Require huge amounts of oxygen
- (d) More Golgi apparatus

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Question 149: Wild turkeys that **fly long distances** are characterized by having:

- (a) Light meat
- (b) Fast-twitch muscles
- (c) Slow-twitch muscles
- (d) A small number of mitochondria

Question 150: An athlete competing in a **3500-meter race** is likely to have more:

- (a) Slow-twitch muscle fibers
- (b) Fast-twitch muscle fibers
- (c) Anaerobic muscle fibers
- (d) Relaxed muscle fibers

Question 151: Which of the following is a feature of **fast-twitch** muscle fibers?

- (a) Contain a larger amount of myoglobin
- (b) Resist fatigue
- (c) Contain fewer mitochondria
- (d) Require large amounts of oxygen

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