

SciOly Summer Study Session

Anatomy and Physiology

Answer Key

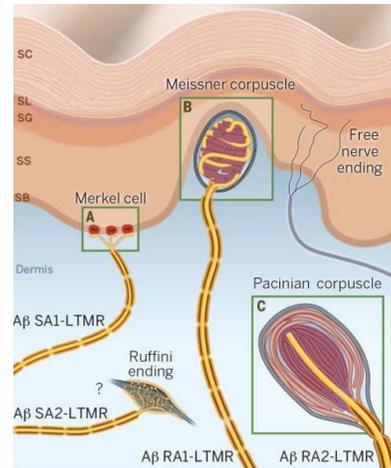
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Instructions

- 1) This test is based on the Division C 2019-2020 rules for Anatomy and Physiology. All content included fits within the scope of the rules up to the national level. Much of the content within this test is unlikely to be asked about in real competitions. However, it may help you take your studying of Anatomy and Physiology a step further.
- 2) Individual point values are stated in each question. The point total for this test is 170.
- 3) All content in this test is supported by published medical articles, studies, and textbooks. Please reach out to me if you would like resources regarding any content on this test.
- 4) If you have any questions or need to contact me, please reach out to hawkenupperscioly@gmail.com.

1.) [4] Match the sensory fibers, associated with each letter as shown on the diagram, with the cutaneous sensory receptors that they innervate. An image is provided to assist you in answering this question.

- A) **Merkel corpuscle**
- B) **Meissner corpuscle**
- C) **Pacinian corpuscle**
- D) **Ruffini ending**



2.) [3] Briefly explain what each of the following terms refers to above.

- A) $A\beta$: **refers to type II sensory fibers**
- B) SA/RA: **refer to slowly-adapting or rapidly-adapting LTMRs**
- C) LTMR: **refers to low-threshold mechanoreceptors**

3.) [3] A real study conducted by N. A. Barnicot sampled 118 hair specimens from young adult males. These hair specimens were examined for the presence of trichosiderin, an iron-containing pigment, by acid extraction. It was found that higher levels of trichosiderin were found almost exclusively in a specific color of hair, but that the level of trichosiderin found in said hair color varied greatly. What can you conclude about the relationship between trichosiderin and red hair given this study?

Trichosiderin contributes to the coloration of red hair, albeit in a negligible quantity (weak positive correlation).

4.) [3] A real study conducted in Japan recruited 23 healthy participants to a 10-week double-blind placebo-controlled study in which participants were either given a capsule containing 4 mg of astaxanthin (a reddish pigment associated with seafood) or the placebo. The results showed that the participants given the astaxanthin showed an increased minimal erythema dose (amount of UV light needed to produce minimal erythema) compared with the placebo. They also had a reduced loss of skin moisture in the area exposed to UV light. What can you conclude about the relationship between astaxanthin and UV damage given this study?

Astaxanthin protects the skin against UV damage and helps maintain healthy skin (negative correlation).

5.) [3] Fas and fas ligand interact in a death receptor/death ligand system. This system has long been viewed to mediate apoptosis induction in order to reduce the risk of sun-linked skin cancer. Another function of these molecules is to eliminate virus-infected cells and cancer cells. This gave a reason for scientists to consider using fas and fas ligand in cancer therapy. However, they were recently recognized to have another purpose that makes this inadvisable. Briefly explain how fas and fas ligand actually contribute to the survival of cancer cells.

Fas and fas ligand protect cancer stem cells and promote their activity.

6.) [2] Briefly describe the function of loricrin in the stratum corneum.

Loricrin contributes to the protective barrier function of the skin.

7.) [3] Briefly explain how the amount of cysteine found in keratin determines whether it is hard or soft.

Cysteine contains sulfur, which is present in keratin in the form of disulfide bonds. The amount of cysteine in keratin, therefore, determines the strength of the disulfide bonds, making keratin hard or soft.

8.) [6] Fill in the following table for total body surface area estimations in normal patients (rule of nines), obese patients (rule of fives), and infants (rule of eights).

| | Head / Neck | Trunk | Each Leg | Each Arm |
|--------|-------------|-------|-----------|----------|
| Normal | 9% | 36% | 18% | 9% |
| Obese | 2% - 6% | 50% | 15% - 20% | 5% - 7% |
| Infant | 20% | 32% | 16% | 8% |

9.) [2] In recent years it has come to light that the bite of the lone star tick transmits a sugar molecule into one's body, initiating an Immunoglobulin E response. Which sugar molecule is responsible for mediating this response?

Alpha-gal.

10.) [3] What are the 3 main factors that contribute to the T-cell immunogenicity of skin cancers?

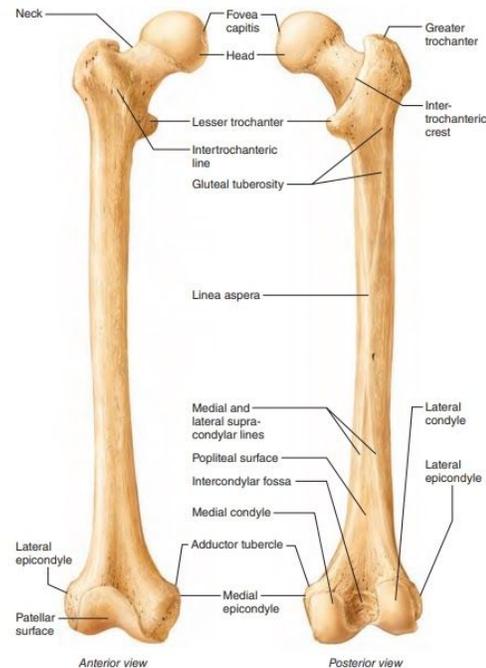
Tumor-associated antigens, neoepitopes arising from mutations, and oncoproteins.

11.) [2] You have been asked to develop a therapeutic HPV vaccine. Which 2 HPV oncoproteins would you ideally target in order to develop an effective HPV vaccine against cervical cancer?

HPV oncoproteins E6 and E7.

12.) [14] Label the diagram of the surface anatomy of the femur bone.

- A) **Fovea capitis**
- B) **Greater trochanter**
- C) **Lesser trochanter**
- D) **Intertrochanteric crest**
- E) **Intertrochanteric line**
- F) **Gluteal tuberosity**
- G) **Linea aspera**
- H) **Supracondylar lines**
- I) **Lateral condyle**
- J) **Intercondylar fossa**
- K) **Lateral epicondyle**
- L) **Medial condyle**
- M) **Adductor tubercle**
- N) **Medial epicondyle**



13.) [6] Identify which pelvis belongs to a male and which pelvis belongs to a female. Next, explain the differences between a male and a female pelvis.

The male pelvis is on the top. It is taller (higher iliac crest), narrower (ischium bones are closer), a deeper pelvic cavity, and a pubic angle of 50-82°. The female pelvis is on the bottom. It is shorter (lower iliac crest), wider (ischium bones are farther), a shallower pelvic cavity, and a pubic angle of 90-100°.



14.) [3] Approximate the amount of motion that the sacroiliac joint is normally capable of. Next, explain what causes the increased mobility of the sacroiliac joint during pregnancy.

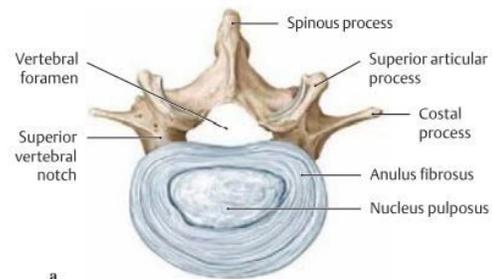
The sacroiliac joint normally allows for 2-4 mm of movement in any direction. The increased mobility of the sacroiliac joint during pregnancy is caused by an increase in hormones, such as relaxin, which lead to laxer ligaments.

15.) [6] Estimate the minimum range of motion, in degrees, for elbow flexion, forearm rotation, and wrist flexion-extension needed to complete all basic ADLs. Basic activities of daily living include ambulating, feeding, dressing, personal hygiene, continence, and toileting. You are encouraged to pretend to perform some of these actions to grasp a more accurate estimate.

Basic ADLs require a minimum range of motion of about 0° to 120° for elbow flexion, -50° to 10° for forearm rotation, and -40° to 40° for wrist flexion-extension.

16.) [7] Label the diagram given of the intervertebral disk.

- A) Vertebral foramen
- B) Spinous process
- C) Superior articular process
- D) Superior vertebral notch
- E) Costal process
- F) Annulus fibrosus
- G) Nucleus pulposus



17.) [2] Osteocytes are responsible for secreting many factors involved in bone formation, bone resorption, and phosphate homeostasis. What two important bone resorption factors (that are produced by osteocytes) are receptors of RANKL (a.k.a TNFSF11, TRANCE, OPGL, ODF)?

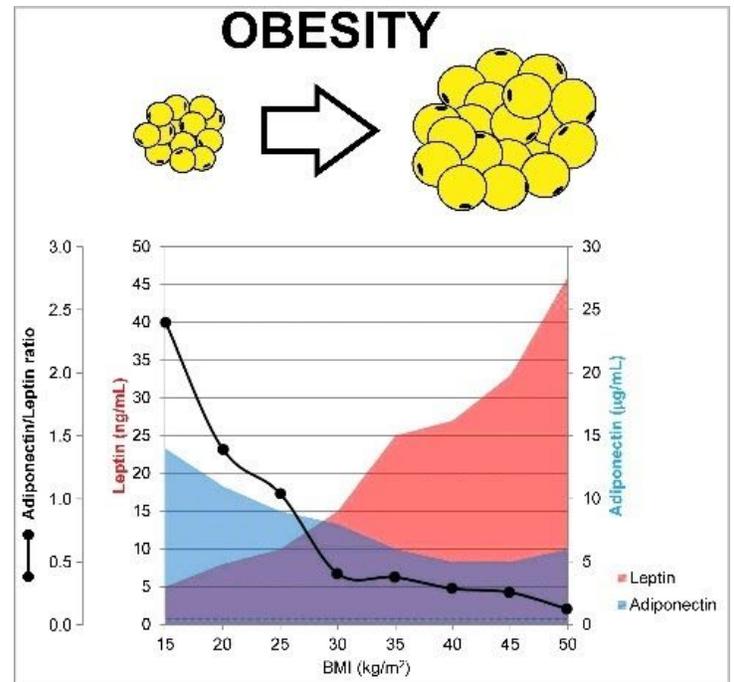
RANK (a.k.a TNFRSF11A, TRANCE receptor) and OPG (a.k.a TNFRSF11B, OCIF) are receptors of RANKL.

18.) [4] Adipocytes can be classified as brown, white, and beige. The body may convert white adipocytes into beige adipocytes as a form of adaptation. What causes may be responsible for initiating this process?

Increased thermogenic demand, exercise, thermal injury, and cancer.

19.) [4] Give a possible explanation for the notable decrease in the ratio of adiponectin/leptin in the bloodstream as BMI increases.

As BMI increases with obesity, adipose tissue expands. Due to the expansion of adipose tissue, the expression and secretion of adiponectin decreases, which lowers the levels of adiponectin found in the blood. The expansion of adipose tissue also causes the expression and secretion of leptin to increase, boosting the levels of leptin found in the blood.

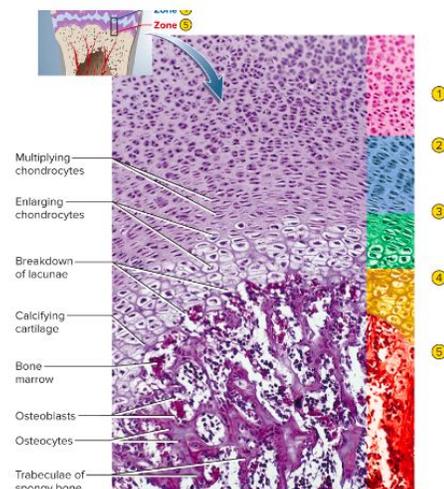


20.) [3] As one grows older, their red bone marrow is replaced with yellow bone marrow. By the time they reach adulthood, red bone marrow is found only in a few select bones. However, the body can convert yellow bone marrow back to red bone marrow. In what extreme case would the body perform this process?

The body can convert yellow bone marrow back to red bone marrow in cases of severe blood loss. The red bone marrow can thus function as a backup source of hemopoiesis.

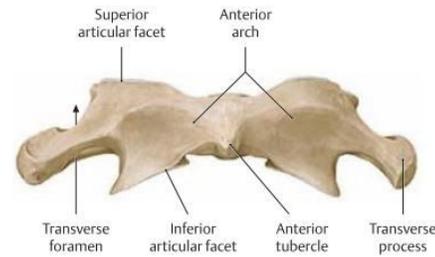
21.) [2] The Indian hedgehog ligand, IHH, plays an important role in endochondral ossification. Which of the labels on the left of the diagram given describes the role played by IHH?

IHH stimulates the multiplication of chondrocytes in the proliferation zone.



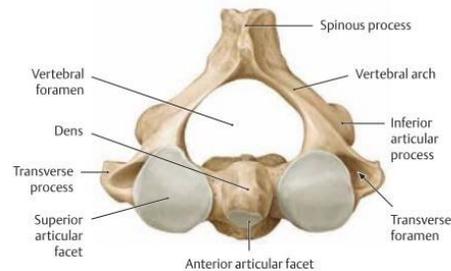
22.) [2] Identify the vertebrae shown in the picture to the right.

Atlas (C1).



23.) [2] Identify the vertebrae shown in the picture to the right.

Axis (C2).



24.) [6] What prevalent chronic disease is characterized by joint pain, tenderness, crepitus, stiffness, and limitation of movement? Why is this disease notably more prevalent in women than men?

Osteoarthritis is more prevalent in women due to many reasons: they have less baseline cartilage and lose a greater volume of cartilage as they age, they have extra stress on the knee due to having wider hips, they have a greater history of knee injuries, and they have decreased estrogen levels post-menopause.

25.) [2] The diagnosis of a Jones fracture includes palpating the peroneus brevis tendon to see if it is intact, as well as demonstrating if the area is tender. In which bone does this fracture occur?

A Jones fracture occurs between the base and mid-portion of the fifth metatarsal.

26.) [6] Briefly describe the process of measuring a Cobb's angle in a patient who has screened positive in the forward-bending test, starting with the X-ray.

An X-ray of the spinal column is taken. The apical vertebra, the most laterally deviated vertebra, is located. Then, the most tilted vertebrae at the top and bottom of the curve are located. A line is extended from the vertebral endplates, from which a perpendicular line is drawn. The intersecting lines form the Cobb's angle, which runs vertically.

27.) [2] What spinal condition is the most common reason for spinal surgery in patients over 65 years of age?

Lumbar spinal stenosis.

28.) [3] Describe the important role of osteoclasts in the development and metastasis of osteosarcoma.

Osteoclasts contribute to an environment in which the growth and expansion of osteosarcoma are supported. This environment is destroyed in later stages of the disease, allowing for tumor cells to egress and metastasize.

29.) [2] What type of muscle fibers—fast oxidative, slow oxidative, or fast glycolytic—would be best suited for maintaining posture?

Slow oxidative fibers.

30.) [2] What type of muscle fibers—fast oxidative, slow oxidative, or fast glycolytic—would be best suited for a short sprint?

Fast glycolytic fibers.

31.) [2] What type of skeletal muscle contraction—concentric, isometric, or eccentric—generates the most force with the least amount of energy?

Eccentric muscle contractions.

32.) [3] What is the function of titin in the contraction of skeletal and cardiac muscle?

Titin connects the Z line to the M line in the sarcomere. It helps transmit force at the Z line and contributes to the passive stiffness of muscle.

33.) [2] What is the essential function of the neuromuscular junction?

The neuromuscular junction converts action potentials in motor neurons into muscle contractions.

34.) [2] What is the primary function of the orbicularis oculi muscle?

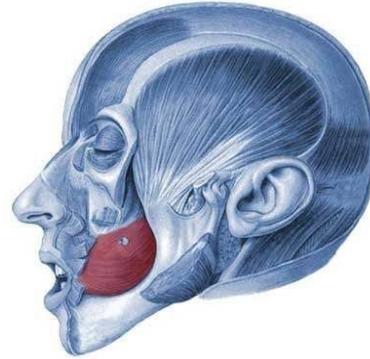
The orbicularis oculi functions to close the eye.

35.) [2] What is the primary function of the orbicularis oris muscle?

The orbicularis oris functions to close the lips.

36.) [4] Identify the muscle highlighted in red on the picture to the right. Identify the origin and insertion of this muscle.

The origin of the buccinator muscle is the alveolar processes of the maxilla and the mandible. The insertion of the buccinator muscle is the orbicularis oris.

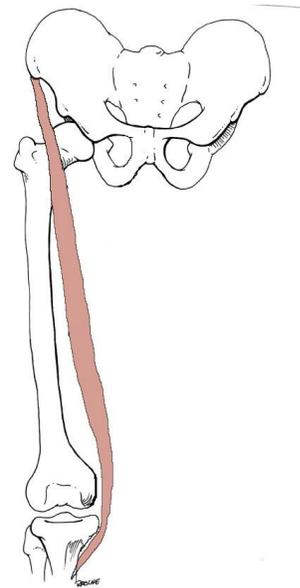


37.) [2] What muscle is the prime mover of arm flexion?

The pectoralis major muscle.

38.) [6] Identify the muscle highlighted in red on the picture to the right. Identify the nerve supplying this muscle. List the action that this muscle performs.

The nerve supplying the sartorius is the femoral nerve. The sartorius flexes, abducts, and laterally rotates the thigh.



39.) [3] As one exercises, their muscle fibers undergo eccentric contraction, causing small tears in the muscle fibers. This is partially responsible for the muscle soreness that one experiences after exercise. Explain how this muscle damage actually leads to an increase in muscle mass.

The mechanical tension applied to muscle fibers, when detected by mechanoreceptors, triggers a signaling pathway that leads to muscular hypertrophy.

40.) [3] Briefly explain why ankle sprains are so common.

The ankle is designed for a limited range of movement. Sudden changes in direction or sudden bursts of movement may result in ankle sprains.

- 41.) [4] Describe the major concern associated with the oral polio vaccine.
People who receive the oral polio vaccine may shed the virus, infecting others. Over time, the virus may evolve. These evolved viruses are called vaccine-derived polioviruses and are capable of causing poliomyelitis.
- 42.) [3] List the muscles that can be affected by ocular myasthenia gravis.
The orbicularis, levator, and extraocular muscles.
- 43.) [4] Describe what happens to a newborn who is infected with neonatal tetanus that is left untreated.
The newborn stops feeding, their body becomes stiff, and they experience severe muscle contractions and spasms. In most cases, death follows.
- 44.) [5] What diagnostic tests are likely to be performed in the process of diagnosing polymyositis in a patient presenting with muscle weakness?
Blood tests (neurological vs muscular, indicate muscle damage), muscle biopsies or skin biopsies (help diagnose), MRIs (identify biopsy site), electromyograms (identify affected area), or nerve conduction velocity studies (rule out neurological) may be conducted.
- 45.) [3] Which ligament is cut during carpal tunnel surgery? Why is it cut?
The transverse carpal ligament is cut during carpal tunnel surgery, releasing pressure on the median nerve and relieving symptoms.
- 46.) [2] What percentage of people with untreated botulism die?
More than 50% of people with untreated botulism may die.
- 47.) [3] What is the role of proprioceptors in the maintenance of body posture?
Proprioceptor reflex circuits allow one to unconsciously make minute muscle adjustments to maintain body posture. Proprioceptors also regulate reciprocal inhibition in muscles.
- 48.) [3] Describe the basic function of muscle spindles.
Muscle spindles inform the central nervous system about each muscle's contractile status, which allows for movement and posture stabilization.
- 49.) [2] What is the principal mechanotransduction channel for proprioception?
The Piezo2 channel.