1. “Fight or flight” responses are a coordinated set of physiological changes that result in increased heart rate, breathing rate, and neuromuscular activity. The diagram below shows how a certain hormone, released during this response, affects a liver cell by causing it to rapidly release glucose into the bloodstream, preparing the body for immediate motion.

**Effects of Certain Hormone on Liver Cell**

The hormone affects nearly every cell in the body. Based on the information in the diagram, which statement describes how this hormone most likely affects the cells in a different organ?

(A) The hormone stimulates heart cells to contract more rapidly in order to supply other cells with increased glucose and oxygen.

(B) The hormone causes cells in the small intestine to absorb more nutrients in order to supply other cells with the amino acids needed for protein synthesis.

(C) The hormone causes smooth muscle cells in the lungs to constrict in order to decrease the rate at which oxygen is exchanged with the environment.

(D) The hormone inhibits release of insulin from the pancreas which reduces the ability of the body cells to take in glucose.
2. Human growth hormone (HGH) is produced in the pituitary gland and has many effects on the body. In children and adolescents, HGH signals the liver to release insulin-like growth factors (IGFs) into the blood, which stimulate bone and cartilage growth. In adults, HGH stimulates the release of fatty acids from fat tissue, stimulates the uptake of amino acids in cells, stimulates protein synthesis in cells, and directs cells to use fatty acids as an energy source during periods of fasting. The diagram below shows the organs targeted by HGH in the body.

Which statement predicts the most likely time when the pituitary gland would be stimulated to release HGH in an adult individual?

(A) When the individual has eaten excess fat, because more fatty acids are available to use as an energy source

(B) During a period of rest after exercise, because the body must produce more proteins to repair damaged muscles

(C) When the individual’s blood sugar levels are high, because cells are stimulated to use fatty acids as an energy source

(D) After eating a meal rich in protein, because the small intestine can absorb more amino acids and send them directly to cells
3. Muscle contractions are produced by the interaction of actin and myosin filaments in response to the neurotransmitter acetylcholine (ACh). The nervous system regulates muscle contraction by controlling which motor units are stimulated as well as the rate at which the muscles are stimulated. If the motor neuron increases the rate of stimulation, the contractions add together. When the rate is so high that the muscle cannot relax between stimuli, the contractions fuse into one sustained contraction. Tetanus bacteria produce a toxin that affects the neuromuscular junction, the synapse between a motor neuron and the muscle it stimulates. When introduced into muscular tissue, the tetanus toxin increases the chemical signal from the nerve to the muscle so that ACh is continuously released by the motor neuron.

Which statement best explains the effect of tetanus bacteria on muscle cells?

(A) Muscle cells are unable to contract because binding sites for the actin and myosin filaments are occupied by ACh, and this results in permanent muscle paralysis.

(B) Muscle cells contract very slowly because there is not enough ATP available until the ACh is removed, and this results in delayed reflexes.

(C) Muscle cells remain contracted for a longer period of time because actin and myosin filaments remain bound together until the ACh is removed, and this results in prolonged muscle spasms.

(D) Muscle cells remain contracted because the motor neuron is prevented from sending another signal to the muscle while ACh is present in the synapse, and this results in delayed muscle movement.
4. Countercurrent flow is a physiological adaptation found in many animals. Two examples of countercurrent flow are found in fish gills and whale fins. Fish gills are made up of gill filaments, and the filaments are comprised of structures called lamella. The lamellas contain capillaries and are the site of gas exchange, as shown below in diagram 1. The countercurrent flow helps fish remove the maximum amount of oxygen from the water. Whales and sea lions in cold water have arteries and veins aligned in their fins to reduce heat loss to the environment, as shown below in diagram 2.

Which changes could be made to these diagrams to best show the physiological advantage of the two countercurrent systems?

(A) Diagram 1 could show the oxygen concentration in the capillaries slowly increasing from near 0% O₂ saturation as oxygen enters the capillaries to near 100% O₂ saturation as oxygen exits the capillaries. Diagram 2 could show the blood getting colder as it flows away from the body as heat is lost to the environment.

(B) Diagram 1 could show the oxygen concentration in the capillaries increasing while the water flowing over the lamella shows a steady decrease, which provides a concentration gradient for O₂ to move into the blood. Diagram 2 could show the blood flowing in the artery decreasing in temperature as the blood that is returning in the veins slowly increases due to heat exchange with the warmer blood in the arteries.

(C) Diagram 1 could show the pH of the blood slowly increasing as the blood flows through the capillaries, because carbonic acid is being converted in CO₂ and diffuses out of the lamella. Diagram 2 could show that as the blood flows toward the tip of the fin, it loses heat to the environment and has a decrease in kinetic energy and velocity.
Diagram 1 could show the concentration of salt ions in the capillaries increasing in concentration while the water flowing over the lamella shows a steady decrease in salt ion concentration as salt ions diffuse through the lamella. Diagram 2 could show that when blood temperature gets too low, constriction of veins and arteries reduces blood to extremities and thereby reduces heat loss to the environment.