Unit: Organismal Physiology (all "Kingdoms")

- **Big Idea 2**
  - *Feedback mechanisms (positive/negative)*
  - *Endocrine System*
  - *Immune System*
  - *Cell Differentiation (Homeotic genes)*
  - *Plants:*
    - *Defense; Transpiration; Photoperiod; Phototropism; Leaf Structure*

- KEY EXAMPLES: Insulin, Acetylcholine, HIV, Steroid Hormones, Ocytocin, fight or flight response, Temperature regulation, Ethylene, Phototropism, short-day/long-day plants
- *KEY MATH SKILLS: Water potential, solute potential*
- *KEY LABS: Transpiration #11*

Enduring understanding 2.C: Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis.

Essential knowledge 2.C.1: Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.

a. Negative feedback mechanisms maintain dynamic homeostasis for a particular condition (variable) by regulating physiological processes, returning the changing condition back to its target set point.

b. Positive feedback mechanisms amplify responses and processes in biological organisms. The variable initiating the response is moved farther away from the initial set-point. Amplification occurs when the stimulus is further activated which, in turn, initiates an additional response that produces system change.

c. Alteration in the mechanisms of feedback often results in deleterious consequences.

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Essential knowledge 2.C.2: Organisms respond to changes in their external environments.

a. Organisms respond to changes in their environment through behavioral and physiological mechanisms.

Enduring understanding 2.D: Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.

Essential knowledge 2.D.2: Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.

a. Continuity of homeostatic mechanisms reflects common ancestry, while changes may occur in response to different environmental conditions. [See also **1.B.1**]

b. Organisms have various mechanisms for obtaining nutrients and eliminating wastes.

c. Homeostatic control systems in species of microbes, plants and animals support common ancestry. [See also **1.B.1**]

Essential knowledge 2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis.

a. Disruptions at the molecular and cellular levels affect the health of the organism.

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Essential knowledge 2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis.

a. Disruptions at the molecular and cellular levels affect the health of the organism.

Essential knowledge 2.D.4: Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis.

a. Plants, invertebrates and vertebrates have multiple, nonspecific immune responses.
b. Mammals use specific immune responses triggered by natural or artificial agents that disrupt dynamic homeostasis.
    1. The mammalian immune system includes two types of specific responses: cell mediated and humoral.
    2. In the cell-mediated response, cytotoxic T cells, a type of lymphocytic white blood cell, "target" intracellular pathogens when antigens are displayed on the outside of the cells.
    3. In the humoral response, B cells, a type of lymphocytic white blood cell, produce antibodies against specific antigens.
    4. Antigens are recognized by antibodies to the antigen.
    5. Antibodies are proteins produced by B cells, and each antibody is specific to a particular antigen.
    6. A second exposure to an antigen results in a more rapid and enhanced immune response.

Enduring understanding 2.E: Many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination.

Essential knowledge 2.E.1: Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms.

a. Observable cell differentiation results from the expression of genes for tissue-specific proteins.
b. Induction of transcription factors during development results in sequential gene expression.
    1. Homeotic genes are involved in developmental patterns and sequences.
    2. Embryonic induction in development results in the correct timing of events.
    3. Temperature and the availability of water determine seed germination in most plants.
    4. Genetic mutations can result in abnormal development.
    5. Genetic transplantation experiments support the link between gene expression and normal development.
    6. Genetic regulation by microRNAs plays an important role in the development of organisms and the control of cellular functions.
c. Programmed cell death (apoptosis) plays a role in the normal development and differentiation.

Essential knowledge 2.E.2: Timing and coordination of physiological events are regulated by multiple mechanisms.

a. In plants, physiological events involve interactions between environmental stimuli and internal molecular signals. [See also **2.C.3**]

1. Phototropism, or the response to the presence of light
2. Photoperiodism, or the response to change in length of the night, that results in flowering in long-day and short-day plants

b. In animals, internal and external signals regulate a variety of physiological responses that synchronize with environmental cycles and cues.

c. In fungi, protists and bacteria, internal and external signals regulate a variety of physiological responses that synchronize with environmental cycles and cues.

Essential knowledge 2.E.3: Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.

a. Individuals can act on information and communicate it to others.

1. Innate behaviors are behaviors that are inherited.
2. Learning occurs through interactions with the environment and other organisms.

b. Responses to information and communication of information are vital to natural selection. [See also **2.C.3**]

1. In phototropism in plants, changes in the light source lead to differential growth, resulting in maximum exposure of leaves to light for photosynthesis.
2. In photoperiodism in plants, changes in the length of night regulate flowering and preparation for winter.
3. Behaviors in animals are triggered by environmental cues and are vital to reproduction, natural selection and survival.
4. Cooperative behavior within or between populations contributes to the survival of the populations.

Can You Questions:

1. Describe homeostasis and explain how it is maintained?
2. Explain how positive and negative feedback systems function in organisms? Identify and discuss at least one positive and negative feedback system in a specific organism.
3. Identify specific examples and discuss how organisms exchange nutrients and wastes with their environment?
4. Explain how regulatory mechanisms are crucial in cell differentiation?
5. Describe how homeotic genes control the pattern of body formation?
6. Explain embryonic induction?
7. Explain apoptosis and its purpose in abnormal and normal development?
8. Explain how photoperdiodism is unique to specific types of plants? Discuss the difference between long day and short day plants?
9. Explain how phototropism works?
10. Discuss the different metabolic and reproductive strategies plants and animals use to maximize free energy (endothermic vs exothermic, perennial vs biennial vs annual)?
11. Compare and contrast protein hormones and steroid hormones?

Big Idea 2 multiple choice questions: 5, 7, 8, 12-15, 17

Unit: Organismal Physiology (all "Kingdoms")

- **Big Idea 3**
  - *Nervous system*
  - *Gene expression*

- KEY EXAMPLES: action potentials, apoptosis, HOX genes

Enduring understanding 3.D: Cells communicate by generating, transmitting and receiving chemical signals.

Essential knowledge 3.D.1: Cell communication processes share common features that reflect a shared evolutionary history.

d. In multicellular organisms, signal transduction pathways coordinate the activities within individual cells that support the function of the organism as a whole.

Essential knowledge 3.D.2: Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.

a. Cells communicate by cell-to-cell contact.

b. Cells communicate over short distances by using local regulators that target cells in the vicinity of the emitting cell.

c. Signals released by one cell type can travel long distances to target cells of another cell type.

1. Endocrine signals are produced by endocrine cells that release signaling molecules, which are specific and can travel long distances through the blood to reach all parts of the body.

Essential knowledge 3.D.4: Changes in signal transduction pathways can alter cellular response.

a. Conditions where signal transduction is blocked or defective can be deleterious, preventative or prophylactic.

Enduring understanding 3.E: Transmission of information results in changes within and between biological systems.

Essential knowledge 3.E.2: Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.

a. The neuron is the basic structure of the nervous system that reflects function.

1. A typical neuron has a cell body, axon and dendrites. Many axons have a myelin sheath that acts as an electrical insulator.

2. The structure of the neuron allows for the detection, generation, transmission and integration of signal information.

3. Schwann cells, which form the myelin sheath, are separated by gaps of unsheathed axon over which the impulse travels as the signal propagates along the neuron.

b. Action potentials propagate impulses along neurons.

1. Membranes of neurons are polarized by the establishment of electrical potentials across the membranes.

2. In response to a stimulus, Na^+ and K^+ gated channels sequentially open and cause the membrane to become locally depolarized.

3. Na^+/K^+ pumps, powered by ATP, work to maintain membrane potential.

c. Transmission of information between neurons occurs across synapses.

1. In most animals, transmission across synapses involves chemical messengers called neurotransmitters.

2. Transmission of information along neurons and synapses results in a response.
3. The response can be stimulatory or inhibitory.
d. Different regions of the vertebrate brain have different functions.

Enduring understanding 4.A: Interactions within biological systems lead to complex properties.

Essential knowledge 4.A.3: Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.

a. Differentiation in development is due to external and internal cues that trigger gene regulation by proteins that bind to DNA. [See also **3.B.1, 3. B.2**]
b. Structural and functional divergence of cells in development is due to expression of genes specific to a particular tissue or organ type. [See also **3.B.1, 3.B.2**]
c. Environmental stimuli can affect gene expression in a mature cell. [See also **3.B.1, 3.B.2**]

Essential knowledge 4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts.

a. Interactions and coordination between organs provide essential biological activities.
b. Interactions and coordination between systems provide essential biological activities.

Enduring understanding 4.B: Competition and cooperation are important aspects of biological systems.

Essential knowledge 4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter.

a. Organisms have areas or compartments that perform a subset of functions related to energy and matter, and these parts contribute to the whole. [See also **2.A.2, 4.A.2**]
2. Within multicellular organisms, specialization of organs contributes to the overall functioning of the organism.
3. Interactions among cells of a population of unicellular organisms can be similar to those of multicellular organisms, and these interactions lead to increased efficiency and utilization of energy and matter.

Can you Questions:

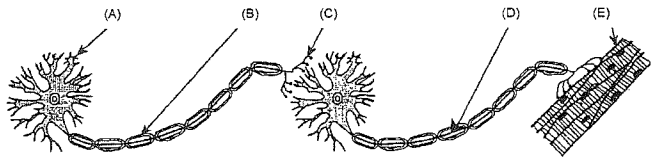
1. Discuss how the mammalian nervous system is adapted to maintain homeostasis?
2. Discuss the anatomy of a neuron?
3. Describe the mechanisms of impulse transmission in a neuron?
4. Describe the process that leads to release of neurotransmitter, and what happens at the synapse?

Big Idea 3 multiple choice questions: 1-4, 6, 9-11, 16

1. Which of the following sequences describes the passage of an action potential in the neuron?

   A) dendrite, cell body, axon, synaptic cleft
   B) dendrite, synaptic cleft, cell body, axon
   C) synaptic cleft, axon, cell body, dendrite
   D) synaptic cleft, axon, dendrite, cell body
   E) axon, cell body, dendrite, synaptic cleft

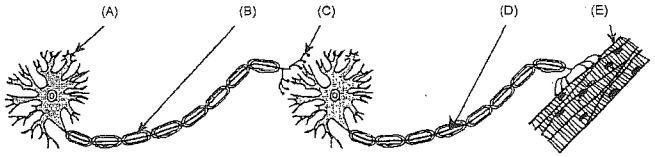
2. Base your answer on the diagram below.



This structure is a dendrite.

A) E B) C C) B D) A E) D

3. Base your answer on the diagram below.



Acetylcholine is released from the synaptic vesicles located at this site.

A) C B) B C) E D) A E) D

4. The pump responsible for maintaining the ionic differences in and out of a neuron functions to

   A) transport K^+ out of the cell using ATP
   B) concentrate K^+ inside the cell and Na+ outside
   C) concentrate Cl^- inside the cell
   D) concentrate Na^+ inside the cell and K^+ outside
   E) transport Na^+ into the cell using ATP

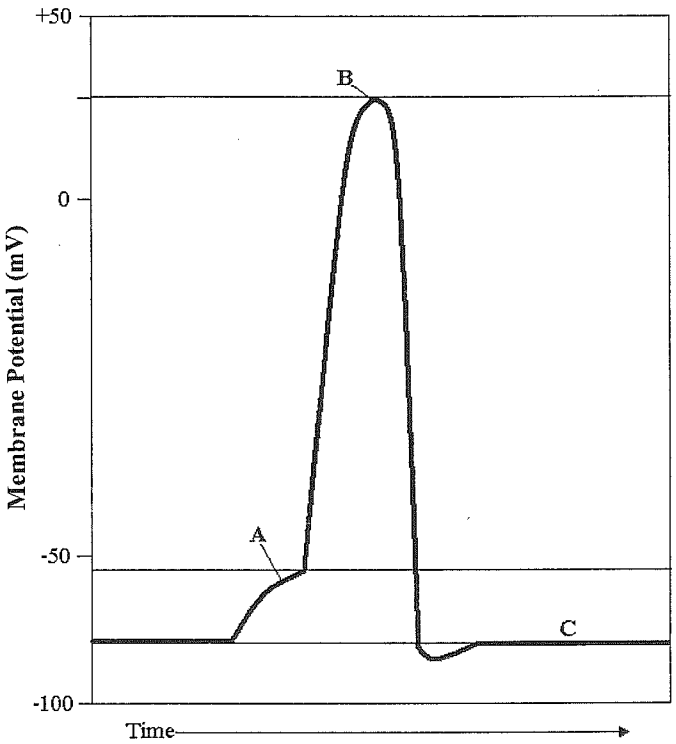
5. The following results were obtained from an experiment with water fleas:

Temperature of Environment (degrees Celcius)	Heartbeat/minute
25	20
45	80

What is the Q_{10} for this experiment?

A) 4 B) 3 C) 2 D) 1.0 E) 0.5

6. Base your answer to the following question on the image below.



The threshold potential indicated by letter A requires which of the following?

   A) ATP to open K^+ channels.
   B) Opening of gated Na^+ channels.
   C) Diffusion of Na^+ up its chemical gradient.
   D) Closed Na^+ channels.
   E) Diffusion of K^+ out of the cell.

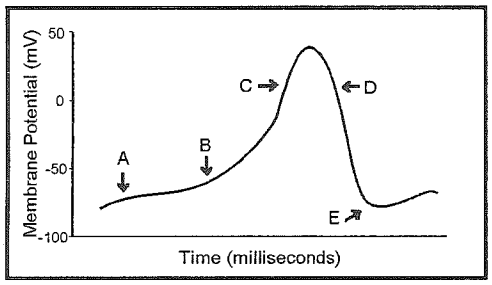
7. How would a plant respond to the stress of overwatering?

   A) The triple response attempts to evade the saturated soil.
   B) Gibberellin increases the growth rate of the plant.
   C) Apoptosis creates air tubes, providing oxygen to the drowning roots.
   D) Cork grows from the base of the stem in attempts to absorb excess water.
   E) Transpiration increases allowing more water to escape through guttation.

8. In the presence of light, the plant hormone, auxin, migrates to

A) the light side of the plant stem and causes elongation of those cells. This results in the plant bending toward the light.
B) the light side of the plant stem and causes reduction in the size of those cells. This results in the plant bending toward the light.
C) the light side of the plant stem and causes elongation of these cells. This results in the plant bending toward the light.
D) the dark side of the plant stem and causes elongation of these cells. This results in the plant bending towards the light.
E) the dark side of the plant stem and causes elongation of the these cells. This results in the plant bending away from the light.

Base your answers to questions **9** through **11** on the diagram below of an action potential in a neuron.



9. Hyperpolarization of the neuron

A) A B) B C) C D) D E) E

10. Resting potential

A) A B) B C) C D) D E) E

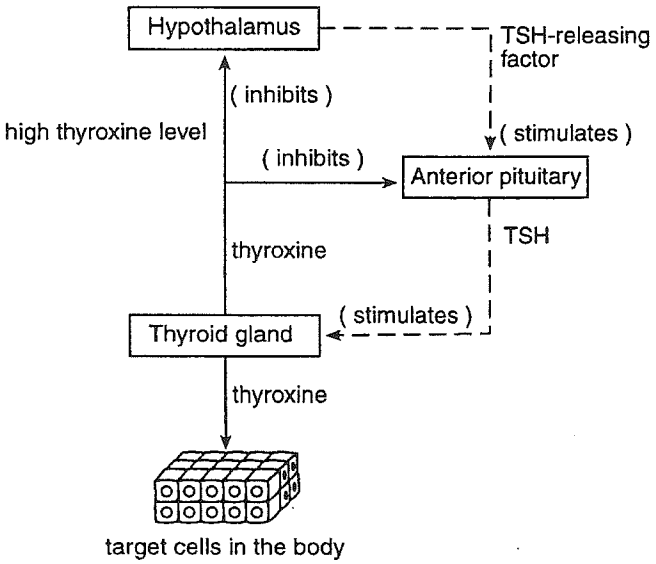
11. Repolarization of the neuron

A) A B) B C) C D) D E) E

12. Transpiration refers to the loss of water vapor from plant parts that are exposed to the air. To decrease this process during hot, dry weather, the plant must

A) open their stomata to catch free water molecules
B) decrease potassium intake by the cell
C) close their stomata to conserve water
D) retreat into the soil until environmental conditions are favorable
E) remove xylem tissue from the stem and leaves

13. Base your answer to the following question on Base your answer on the diagram below.



As thyroxine levels in the circulatory system increase, eventually

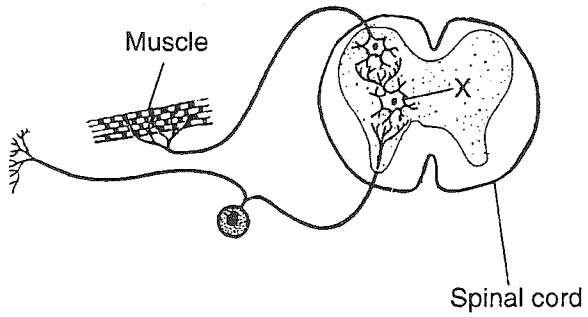
A) the hypothalamus releases more TSH-releasing factor due to a positive feedback loop
B) the anterior pituitary stops releasing TSH due to a positive feedback loop
C) the anterior pituitary stops releasing TSH due to a negative feedback loop
D) the anterior pituitary stops releasing TSH-releasing factor due to a negative feedback loop
E) the hypothalamus inhibits TSH due to a negative feedback loop

14. The response of plants to changes in the relative length of daylight and night is

A) gravitropism B) thigmotropism
C) photoperiodism D) phototropism
E) negative feedback

15. a.) Explain the differences between negative feedback and positive feedback.
b.)An individual just ate a 5 jelly donuts. Describe how the body reacts when the blood glucose level is too high.
c) A hungry calf hasn't been fed in 2 days. Describe how its body reacts when its blood glucose level is too low.

6.



The structure labeled X is

A) grey matter
B) a motor neuron
C) a sensory neuron
D) an interneuron
E) white matter

17. a) Describe how differences in water potential affect the transport of water from roots to stems to leaves.
b) What are some adaptations enabling plants to decrease water loss via the leaves?

Answer Key
Physiology

1. A
2. D
3. A
4. B
5. B
6. B
7. C
8. D
9. E
10. A
11. D
12. C
13. C
14. C
15. (essay)
16. D
17. (essay)

Answer Key
Physiology

15. a) Homeostasis is a dynamic state of equilibrium that works to regulate and stabilize the internal environment of an organism even while the external environment is changing.
Most homeostatic mechanisms in animals operate on the principle of negative feedback. In this control circuit, a change in a physiological variable that is being monitored by the body causes a response that counteracts the initial fluctuation. These mechanisms prevent small changes from becoming too overwhelming.
The physiological control mechanism whereby a change in certain variable cause mechanisms that amplify the change is known as positive feedback.
b) After a meal is digested, glucose is absorbed into the blood from the digestive tract. If the level of glucose in the blood rises above a set point, the pancreas secretes the hormone insulin into the blood. Insulin facilitates the transport of glucose into body cells and stimulates the muscle and liver cells to store glucose in the form of glycogen. As a result, the blood glucose level drops and this helps restore homeostasis.
c) When glucose level falls below a certain level in the blood, the pancreas secretes glucagon which opposes the effect of insulin. Glucagon facilitates the breakdown of glycogen and release of glucose into the bloodstream This increases blood glucose level and helps restore homeostasis.

17. a)The transport of water up from the roots in the xylem tissue is governed by differences in water potential. These differences account for water movement over long distances within the plant and from cell to cell.

In a root, minerals transported from the soil gather in the xylem vessels of the vascular tissue of the stele. This plus the negative pressure in the xylem tissues, lowers the water potential of the xylem. Water moves into the xylem by osmosis, forcing fluid up the xylem vessels. This upward movement results in root pressure, but this pressure can only move water a short distance up the xylem.
Transpiration pulls dissolved minerals and water in the xylem upward. The stomatal openings of a leaf lead to a maze of internal air spaces that surround the mesophyll cells of the leaf. The moist air in these spaces has a higher water potential than the air outside the leaf. Gaseous water vapor tends to evaporate from the leaf surface via the stomata moving from an area of higher water potential to an area of lower water potential. The cohesion of water due to hydrogen bonding facilitates transpiration to pull water up the xylem vessels and tracheids.

b) - Guard cells (which surround the stoma) control the diameter of the stoma by changing shape widening or narrowing the gap between the two cells. When guard cells become flaccid, they cause the stoma to close and this decreases water loss via the leaves.
- In C3 plants, if carbon dioxide increases inside the cell, the stomas close and water loss decreases.
- As heat increases, carbon dioxide need increases, the stoma close, and respiration is stimulated.
-When the plant is living in a water deficient environment, guard cells loose turgor and close the stomata.
- As water decreases in the cell, abcissic acid hormone levels produced in mesophyll cells signal guard cells to close stoma.