Form & Function: Homeostasis, Neurophysiology, and Sensory Physiology

ANSWERS

Animal Structure and Function

1. Have a member of your Learning Community Define the term **HOMEOSTASIS.....**

The steady-state physiological condition of the body..... the term homeostasis refers to the maintenance of the internal environment of the body within narrow and rigidly controlled limits. The major functions important in the maintenance of homeostasis are fluid and electrolyte balance, acid-base regulation, thermoregulation, and metabolic control. The concept of homeostasis, that all living things maintain a constant internal environment, was first suggested by Claude Bernard, a 19th-century French physiologist, who stated that "all the vital mechanisms, varied as they are, have only one object: that of preserving constant the conditions of life." As originally conceived by Bernard, homeostasis applied to the struggle of a single organism to survive. The concept was later extended to include any biological system from the cell to the entire biosphere, all the areas of the Earth inhabited by living things.

2. Name the 2 types of epithelia illustrated in the figures to the right. One of these forms the outer skin and the other lines the digestive tract. Explain why each would be found at its location?

A. Stratified squamous epithelia; outer layer of skin; thick layer is protective and new cells are reproduced near basement membrane to replace those sloughed off.

B. Simple columnar epithelia; linings of digestive tract; columnar cells with large cytoplasmic volumes are specialized for secretion or absorption; single layer is better for absorption purposes.

Some epithelia are specialized for absorption or secretion. **Mucous membranes** lining the gut and the air passages secrete mucus. **The** small intestine lining also releases digestive enzymes and absorbs nutrients. Cilia on epithelium lining the trachea sweep particles trapped in mucus away from the lungs.

3. Identify the types of vertebrate muscle cells depicted in the pictures. What are the dark bands in fig. a, and what is their function? see text page 838

a. cardiac; the dark bands are intercalated discs that relay electrical impulses from cell to cell during heart beat.

b. smooth muscle

3. Identify the types of Connective Tissue and their components in the 3 figures to the right. see text 837

a. Haverian system	b. central canal	c. lacuna	d. bone
e. macrophage	f. fibroblast	g. collagenous fiber	h. elastic fiber
i. reticular fiber	j. loose connective tissue	k. white blood cells	l. red blood cells
m. platelet	n. blood		

Loose connective tissue attaches epithelia to underlying tissues and holds organs in place. Its loosely woven fibers are of three types: **Collagenous fibers** are made of collagen and have great tensile strength that resists stretching. **Elastic fibers,** made of the protein elastin, can stretch and provide resilience. Branched and thin **reticular fibers** are composed of collagen and form a tightly woven connection with adjacent tissues. The most common types of cells embedded in loose connective tissue are **fibroblasts,** which secrete the protein of the extracellular fibers, and **macrophages,** amoeboid cells that engulf bacteria and cellular debris by phagocytosis.

Adipose tissue is a special form of loose connective tissue that pads and insulates the body and stores fuel reserves. Adipose cells each contain a large fat droplet.

Fibrous connective tissue, with its dense arrangement of parallel collagenous fibers, is found in **tendons,** which attach muscles to bones, and in **ligaments,** which join bones together at joints.

Cartilage is composed of collagenous fibers embedded in a rubbery ground substance called chondroitin sulfate, both secreted by **chondrocytes** found in **scattered** lacunae in the ground substance. Cartilage is a strong but somewhat flexible support material, making up the skeleton of sharks and vertebrate embryos.

Bone is a mineralized connective tissue formed by **osteocytes** that deposit a matrix of collagen and calcium phosphate, which hardens into hydroxyapatite. **Haversian** systems consist of concentric layers of matrix deposited around a central canal containing blood vessels and nerves. Osteocytes are located in lacunae within the matrix and are connected to one another by thin cellular extensions. In long bones, the hard outer region is compact bone, whereas the interior is a spongy bone tissue filled with bone marrow. Red bone marrow, near the ends of long bones, manufactures blood cells.

Blood is a connective tissue that has a liquid extracellular matrix called plasma, containing water, salts, and dissolved proteins. Erythrocytes (red blood cells) carry oxygen, leukocytes (white blood cells) function in defense, and cell fragments called platelets are involved in the clotting of blood.

5. There are 11 organ systems in mammals. How many of them can your Learning Community name? see table 40.1 pg 840

Circulatory, Digestive, Endocrine, Excretory, Immune and Lymphatic, Integumentary, Muscular, Nervous, Reproductive, Respiratory, and Skeletal

6. Have one member each, in turn, fill-in the table below, which details the structure and function of the four major types of vertebrate animal tissues.

Tissue	Structural Characteristics	General Functions	Specific Examples
Epithelial	Tightly packed cells; basement membrane, cuboidal, columnar, squamous shapes; simple of stratified.	Protection, absorption, secretion, lines body surfaces	Mucous membranes, maybe ciliated, lining of blood vessels
Connective	some cells that secrete extracellular matrix of protein fibers in liquid, gel or solid ground substance	Connects and supports other tissues	Loose connective tissue; adipose; fibrous connective tissue; cartilage; bone
Muscle	Long cell fibers with myosin and many microfilaments of actin	Contraction, movement	skeletal (voluntary control); smooth muscle (involuntary control)
Nervous	Neurons with cell bodies, axons, and dendrites	Sense stimuli, conduct impulses	Nerves and Brain, CNS & PNS

Bioenergetics is fundamental to all animal functions

Metabolic rate can be measured by placing an animal in a calorimeter and measuring heat production. The rate of oxygen consumption, also a measure of metabolic rate, can be determined with a **respirometer**.

Metabolic rates are influenced by age, sex, size, activity level, time of day, and other variables. Endothermic animals (birds and mammals) require more energy to sustain minimal life functions than do ectotherms that do not use metabolic heat to maintain a constant body temperature.

Metabolic rates during intense physical exercise may be five to ten times the BMR or SMR.

Body Size and Metabolic Rate: The energy required to maintain each gram of body weight is inversely related to body size. Smaller animals have higher metabolic rates, breathing rates, blood volume, and heart rates. With a greater surface-to-volume ratio, small animals may have a higher energy cost to maintain a stable body temperature. The fact that ectotherms also show this inverse relationship indicates that other factors must contribute to its cause.

7. (a) Which animal, a rabbit or a bear, would have a higher BMR? RABBIT

(b) which animal would have a higher SMR ? FROG, since a rabbit is an endotherm.

(c) which animal, a rabbit or a bear, would consume the most cal/gm of body weight?, and RABBIT

(d) which animal, rabbit, bear, or frog would consume the most total calories? BEAR

8. Indicate whether the following are **osmoregulators** or **osmoconformers**, and whether they are **isosmotic**, **hyperosmotic**, or **hypoosmotic** to their environment

Animal	Osmoregulator or Osmoconformer ?	Osmotic Relation to Environment
marine invertebrates	conformer	isosmotic
Sharks	regulator	slightly hyperosmotic
marine fish	regulator	hypoosmotic
freshwater fish	regulator	hyperosmotic
freshwater protozoan	regulator	hyperosmotic
terrestrial animal	regulator	hyperosmotic

Cells require a balance between water uptake and loss. Whether an animal lives in salt water, fresh water, or on land, water gain must balance water loss in body cells. Interstitial fluid must be in osmotic balance with the cytosol. Osmosis is the diffusion of water across a selectively permeable membrane that separates two solutions differing in **osmolarity** (moles of solute per liter). Osmolarity is expressed in units of milliosmoles per liter (10-3 moles/L). Isosmotic solutions are equal in osmolarity, and there is no net osmosis between them. There is a net flow of water across a membrane from a hypoosmotic (more dilute) to a hyperosmotic (more concentrated) solution.

Most animals are **stenohaline,** able to tolerate only small changes in external osmolarity. Animals that are **euryhaline** can survive in different osmotic environments by conforming or by maintaining a constant internal osmolarity.

Maintaining Water Balance in Different Environments. Most marine invertebrates are osmoconformers, whereas most marine vertebrates are osmoregulators. Sharks have an internal salt concentration lower than that of seawater because their rectal glands pump salt out of the body. They maintain an osmolarity slightly higher than that of seawater, however, by retaining urea (a nitrogenous waste product) and trimethylamine oxide (which protects proteins from the damaging effects of urea) within their bodies. They dispose of excess water in urine produced in kidneys.

Many marine bony fishes, having evolved from freshwater ancestors, are hypoosmotic to seawater and must drink large quantities of seawater to replace the water they lose by osmosis. Excess salts are pumped out through salt glands and other ions are excreted in the scanty urine.

Freshwater animals constantly take in water by osmosis. Protozoa use contractile vacuoles to pump out excess water. Freshwater animals excrete large quantities of dilute urine. Salt Supplies are replaced from their food or, in some **fish,** by active uptake of ions across the gills.

Some animals are capable of **anhydrobiosis,** or cryptobiosis-surviving dehydration in a dormant state. Anhydrobiotic roundworms produce large quantities of trehalose, a disaccharide that replaces water around membranes and proteins during dehydration. Adaptations to prevent dehydration in terrestrial animals include water-impervious coverings, drinking and eating food with high water content, nervous and hormonal control of thirst, behavioral adaptations such as nocturnal lifestyles, and water-conserving excretory organs.

9. Complete the concept map below on the regulation of blood glucose levels.

a. insulin
b. glucagon
c. movement of glucose
d. glycogen hydrolysis in liver
e. islets of Langerhans in pancreas
f. glycogen hydrolysis in liver
g. blood glucose level

Insulin lowers blood glucose levels by prom the movement of glucose into body cells fro blood, by slowing the breakdown of glycogen in the liver, and by inhibiting the conversion of amino and fatty acids to sugar. Glucagon raises glucose concentrations by stimulating the liver to increase glycogen hydrolysis, convert amino acids and fatty acids to glucose, and release glucose to the blood.

In **diabetes mellitus**, the absence of insulin in the bloodstream or the loss of response to insulin in target tissues reduces glucose uptake by cells. Glucose accumulates in the blood and is excreted in the urine. The body must use fats for fuel, and acidic metabolites from fat breakdown may lower blood pH.
Type I diabetes mellitus, also known as in dependent diabetes, is an autoimmune disorder in which pancreatic *cells* are destroyed. This type of diabetes is treated by regular injections of genetically engineered human insulin. More than 90% of diabetics have **type II diabetes mellitus,** or non-insulin-dependent diabetes, characterized either by insulin deficiency or reduced responsiveness of target cells. Exercise and dietary control are often sufficient to manage this disease.

10. Have one member, each in turn, identify the label in the following diagrams of neuronal systems.

10A.

a. dendrites	b. cell body	c. axon hillock	d. axon
e. myelin sheath	f. Schwann cell	g. Node of Ranvier	h. synaptic terminal

10B.

a. Ca++	b. synaptic terminal
c. synaptic vesicle	d. presynaptic membrane
e. postsynaptic membrane	f. receptor with bound neurotransmitter
g. ion channel	h. synaptic cleft

10C.

a. sodium channel	b. Na+	c. potassium channel
d. K+	e. sodium activation gate	
f. sodium inactivation gate	g. membrane potential (mV)	h. time (mSec)