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SECTION 1 - INTRODUCTION: STRUCTURE AND PHYSIOLOGICAL CONTROL SYSTEMS

EXERCISE 1.1 MICROSCOPIC EXAMINATION OF CELLS

Approximate Time for Completion: 1–1½ hours

Introduction

This exercise introduces students to the microscope, preparation of a slide, and dimensional analysis (international system of metric units). Based on this, students are able to estimate the size of microscopic objects. This exercise introduces students to the structures of a cell and to the organelles found within a cell. Functions of each organelle are introduced, as is the concept of cell division (mitosis and meiosis).

Materials

1. Compound microscopes
2. Prepared microscope slides: including whitefish blastula (early embryo), clean slides, and cover slips
   Note: Slides with dots, lines, or the letter ***e*** can be prepared with dry transfer patterns used in artwork.
3. Lens paper and lens cleaner
4. Methylene blue stain
5. Cotton-tipped applicator sticks or toothpicks
6. Glass slides and coverslips
7. Immersion oil

Textbook Correlations: Chapter 3 – Cytoplasm and Its Organelles; DNA Synthesis and Cell Division

Answers to Review Activities Questions

1. a. 100× (40×, this may vary, depending on the microscope)
   b. 450× (430×, this may vary, depending on the microscope)
   c. 1,000×

2. a. one gram
   b. 0°C
   c. one liter

3. a. centriole
   b. mitochondria
   c. endoplasmic reticulum
   d. nucleus
   e. lysosome
   f. ribosome

4. 1. d
   2. a
   3. c
   4. b

5. Mitosis is cell division that occurs in almost all tissues, resulting in the growth and repair of tissues and organs. Meiosis, by contrast, occurs only in the gonads. Within the gonads are germinal cells that, after

puberty, result in the production of haploid gametes (sperm and ovum). In the testes, spermatogenesis results in the formation of four haploid spermatozoa from one diploid parent cell. In the ovaries, oogenesis results in the formation of a single large haploid egg cell (ovum or oocyte) and a much smaller polar body, that will degenerate. At the conclusion of mitosis, two identical diploid daughter cells are produced, whereas in meiosis the daughter cells are haploid and can be used in sexual reproduction to produce a newly diploid fertilized egg cell, or zygote.

6. In mitosis, the major benefit of lining up homologous chromosomes single-file is to ensure that sister chromatids are separated cleanly by the spindle fibers and are moved to opposite sides of the dividing cell. Each daughter cell receives one exact and complete copy of the original genome. In meiosis however, side-by-side alignment of homologous chromosomes allows the physical exchange of DNA regions (crossing over). This results in genetic recombination and ensures that the gametes produced are genetically unique. Furthermore, the attachment of spindle fibers to the maternal and paternal members and, therefore, the assortment of each homologous pair, are random. This "shuffling of the deck" promotes genetic recombination and species diversity that contributes to survival of species over evolutionary time.

7. The metric system is the preferred international system of measurement. Based on powers of ten, all measurements of length, weight, volume, and temperature can easily be converted from one order of magnitude to another simply by moving the decimal point right or left the correct number of spaces. When both systems are used, as is true in the United States, the lack of common expression of measurement leads to public confusion and miscommunication as well as difficulties in exchange of information with the rest of the metric-based world.

8.
1. c
2. a
3. d
4. b

EXERCISE 1.2 MICROSCOPIC EXAMINATION OF TISSUES AND ORGANS

Approximate Time for Completion: 1–2 hours

Introduction

This exercise helps students improve their microscopic technique while introducing them to histology. This can be a short introduction or it can be lengthened by a more detailed consideration of the microscopic anatomy of a representative organ, such as the intestine or skin. A strong understanding of the functions of various tissues will help students to understand the functions of various organs and organ systems introduced later.

Materials

1. Compound microscopes
2. Lens paper and lens cleaner
3. Prepared microscope slides of tissues

Textbook Correlations: Chapter 1 – The Primary Tissues; Organs and Systems

Answers to Review Activities Questions

1. A tissue is an aggregation of similar cells that work together to perform a specialized activity.

2. An organ is a group of two or more tissues that occur and function together.

3. a. A simple squamous membrane is composed of a single layer of flattened epithelial cells. An example is the endothelium of blood vessels.

b. A stratified squamous membrane is composed of a number of cell layers with squamous cells at the top layer. An example is the epidermis of the skin.

c. A columnar epithelium is composed of a single layer of epithelial cells in which each cell is taller than it is wide. This membrane is found in the gastrointestinal tract.

d. A pseudostratified membrane is composed of a one-cell layer, but it appears stratified because the nuclei of adjacent cells are located at different levels. This membrane is found in the respiratory passages.

4. All connective tissues are characterized by the fact that the cells are not close together, but instead are separated by an abundant amount of intercellular material (matrix).

5. a. tendons, ligaments

b. dense irregular

c. articular surface of bones, the trachea and bronchi, the nose, and the costal cartilages

d. symphysis pubis and the intervertebral discs

6. striated muscle

7. smooth muscle

8. a. The epithelium of the skin is a stratified squamous keratinized epithelium. This structure grants protection against abrasion and desiccation. The epithelium of the intestine is a simple columnar epithelium. This structure permits the rapid absorption of the products of digestion.

b. Cardiac muscle is made of short, branched striated muscle cells interconnected by intercalated discs and controlled by a single nucleus. Because of this arrangement, all the cells in the cardiac mass contract as a single unit, allowing the heart to function as an effective pump. In multinucleated skeletal muscles the individual muscle cells are long, cylindrical, and separate from each other. This permits some muscle cells to contract while others do not; a graded and controlled muscle contraction can thus be performed.

9. Connective tissues are characterized by abundant amounts of extracellular material, or matrix. Connective tissue cells are spread out creating large extracellular spaces that provide room for blood vessels, nerves, and lymphatic vessels.

There are 5 major types of connective tissues:

1. mesenchyme – an undifferentiated tissue found primarily during embryonic development.
2. connective tissue proper – loose (areolar); dense (tendons/ligaments); elastic; reticular; and adipose. All of these have a matrix of fibers.
3. cartilage – hyaline (trachea, nose, bone ends); elastic (epiglottis); fibrous (symphysis pubis) All of these have a gel matrix.
4. bone – osseous; osteocytes in calcium phosphate matrix. Bone as a solid matrix called lamellae.
5. blood – erythrocytes, leukocytes, thrombocytes in a fluid matrix (plasma). Blood has a liquid matrix called plasma.

10. The muscles of the tongue are striated muscles. This might be expected since people have voluntary control of their tongue. Similarly, one would expect the muscles of the diaphragm to be skeletal as well since breathing can be voluntarily influenced. Despite the fact that the diaphragm can be operated subconsciously by the brainstem, such as while asleep, this muscle is still striated.

11. Blood vessels and nerves are not found between the cells of epithelial membranes becasue there is no room between epithelial cells that are very closely packed and joined together by junctional complexes (tight

junctions, adherens junctions, or desmosomes) that connect adjacent epithelial cells. In this way, epithelial cells form an effective border along body surfaces. The underlying connective tissue, by contrast, has characteristically large intercellular spaces that easily accommodate blood vessels and nerves.

Yes, we would expect to see strands of connective tissue in both the liver and pancreas. Both the liver and pancreas are exocrine glands and therefore derived from glandular epithelium. The release of exocrine (and hormone) secretions from these glands, however, is regulated in part by nerves and by other hormones arriving via the blood vessels. Strands of connective tissue, such as loose (or areolar) connective tissue composed of collagen fibrous proteins would be expected. The large spaces between fibers would easily accommodate such blood vessels and nerves.

EXERCISE 1.3 HOMEOSTASIS AND NEGATIVE FEEDBACK

Approximate Time for Completion: 30–45 minutes

Introduction

This exercise introduces students to homeostasis and negative feedback, regarding regulating temperature and regulating pulse rate. Negative feedback is a concept, which appears often in physiology but can be hard to understand, so this exercise is appropriate to illustrate these concepts. This exercise also includes data collection and analysis with the participation of the entire class. These concepts, therefore, may be presented either in lecture or laboratory.

Materials

1. Watch or clock with a second hand
2. Hot plate; beaker; thermometer; crushed ice; constant temperature water bath

Textbook Correlations: Chapter 1–Negative Feedback Loops; Feedback Control of Hormone Secretion

Answers to Review Activities Questions

1. Homeostasis can be defined as the dynamic constancy of the internal environment as maintained by negative feedback mechanisms.

2. The set point is that body value that is "most normal." Much like a thermostat in the house for normal temperature, the body has many such set points for temperature, blood glucose concentration, the tension on a tendon, and so on.

3. Homeostasis, the constancy of the internal environment, is maintained by negative feedback mechanisms. In this process, a specific body *sensor* senses a deviation from the normal set point, relays messages to an *integrating center* (such as the brain, spinal cord, or even gland cells) that activates an *effector*. The effector, in turn, acts to directly counter or oppose any deviations from a set point and to restore the normal value.

4. This cause and effect relationship can be displayed by drawing a negative feedback loop for a water bath, where a fall in temperature activates a sensor (thermostat and integrating center), which in turn stimulates the effector (a heating unit) to turn on. As the heater warms to the upper limit of the temperature range (sensitivity) the sensor acts to turn off the heater, resulting in a drop in temperature to the lower limit of the temperature range (sensitivity) - only to activate the sensor once again.

5. Negative feedback mechanisms describe the cause-and-effect mechanisms that lead to changes in the opposite direction of some disturbance in order to restore homeostasis. Positive feedback acts to increase or accelerate changes or deviations from homeostasis. In the body, injury to blood vessels causes an avalanche-like sequence of changes that ends in the formation of a blood clot. The formation of the clot, however, stops the blood loss and is, therefore an example of negative feedback. The events leading to the

expulsion of the mature egg cell from the ovary is another example of positive feedback.

6. The up-and-down variation in successive pulse rate measurements that alternately rise above and then below a set point suggests that resting pulse rate is an example of homeostasis that is under negative feedback control.

7. A flow diagram can be drawn to show the negative feedback neural control of heart rate when someone is experiencing a fall in blood pressure (stimulus). This diagram should include blood pressure receptors (sensors), the medulla oblongata (integrating center) and effectors — simultaneous sympathetic nerve activity rising and parasympathetic activity declining causing the pulse rate to rise in the attempt to correct a fall in blood pressure. A feedback loop demonstrating the negative feedback response to a drop in blood pressure should reveal a fall below the set point for blood pressure (approx. 93 mmHg) triggering an increase in sympathetic stimulation with a concomitant decrease in parasympathetic activity to the heart resulting in a compensatory faster heart rate. [The sensor (aortic and carotid baroreceptors) signals the drop in pressure to the integrating center (medulla oblongata) producing the observed negative feedback response.]

8. The normal range for a given measurement is obtained by taking measurements from a large sample of people who are believed to be normal for the measurement during a specified time period. There is always a range of values obtained, and this range, and its average, will vary with the group of people tested and will vary among groups of different ages. This is why normal ranges of a particular measurement for one population of people may be different from normal ranges for another population. As time passes, the world changes as people's lifestyles, working environments, eating habits, and other variables are altered over time. For this reason these values have to be remeasured and updated periodically.

9. The patient's body temperature and pulse rate are above the normal range. Since the body temperature is high, this might suggest the presence of a pathogen. An increase in body temperature represents a positive feedback mechanism at work in an effort to kill the pathogens.

10. Body temperature: One way that norm al body temperature is maintained is via the alternation of sweating and shivering.

    Pulse rate: If the pulse rate drops, the sympathetic nerves are activated thus increasing the pulse rate. If the pulse rate is too high, the parasympathetic nerves are activated thus decreasing the pulse rate.

    Fasting blood glucose: When blood glucose levels drop, the pancreatic islets of the pancreas release glucagon. Glucagon targets the liver cells and causes them to begin releasing glucose into the bloodstream, thus raising blood glucose levels.

Appendix

Answers to Test Your Knowledge Questions

Chapter 1

1.	d	5.	d	9.	a
2.	d	6.	c	10.	c
3.	b	7.	b	11.	c
4.	b	8.	b	12.	c

Chapter 2

1.	c	6.	b	11.	d
2.	b	7.	c	12.	b
3.	a	8.	d	13.	b
4.	d	9.	d	14.	d
5.	c	10.	b		

Interactive Case Studies and the Human Body (1-10)

The Female Body

Case Study 1

Hematology

AIDS

Answers:

1. This individual has Acquired Immunodeficiency Syndrome (AIDS) caused by the Human Immunodeficiency Virus (HIV).
2. The hematocrit abnormality is caused by the dehydration.
3. Some current treatments include: AZT (Zidovudine) and ddI (Didanosine), both antiretroviral agents which slow the replication of the virus, prevent occurrence or recurrence of opportunistic infections, and boost the immune system.
4. The individual is experiencing hypokalemia prior to treatment.
5. This abnormal potassium level could cause cardiac arrhythmias due to the hyperpolarization of the resting membrane potential.

Case Study 2

Gastrointestinal

Hiatal Hernia

Answers:

1. The disorder is a hiatal hernia. This is a structural defect in which a weakened diaphragm allows a portion of the stomach to pass through the esophageal diaphragmatic opening into the chest when intra-abdominal pressure increases.
2. Adequate lower esophageal pressure at the lower esophageal sphincter normally prevents gastric reflux into the esophagus when lying down or bending over.
3. The parasympathetic division of the autonomic nervous system (cholinergic) innervates the lower esophageal sphincter (LES). Therefore, cholinergic agonists would increase LES contraction, preventing gastric reflux. Anticholinergic agents would decrease LES pressure.
4. Histamine (H2) antagonists are recommended because they reduce gastric acidity by selectively blocking the H2 receptors (which mediate gastric secretion).
5. Elevation of the head of the bed is recommended to encourage gravitational flow of the gastric contents toward the pyloric end of the stomach.
6. The normal pH of the esophagus is 6-7.
   The normal pH of the stomach is 2-5.