BIOLOGY 3251

Animal Physiology - Organ System Operation and Regulation (2018)

Instructor: Dr. Robert J. Omeljaniuk, CB-4013, 343-8236

1. Calendar Description.

Animal Physiology - Organ System Operation and Regulation
0-0;3-3
A comparative study of animal organ system physiology. Areas to be discussed include the structure, operation and regulation of muscle, cardiovascular systems, osmotic and ionic regulation, respiratory- and gastrointestinal systems.
Notes: *Students who have previous credit in Biology 2035 may not take Biology 3250 or 3251 or 3253 for credit. An additional fee (see Miscellaneous Fees) is required for this course.*

2. Marking Scheme.

a. Lab reports: 4 X 10 % = 40% of Final Mark; and

b. Term Tests:

(1) Term test #01. Lab Period, Week of 12 Feb 2018. 30% Final Mark; and
(2) Term test #02. Lab Period, Week of 26 Mar 2018. 30% Final Mark.

3. Laboratories.

a. Lab coordinator: Mr. Michael Moore, CB-3011A; 343-8909.

b. Schedule:

Lab schedule and lab report submission dates are subject to change in accordance with availability of animal preparations and instrumentation. Please note that these dates may be hopelessly unrealistic, so, we'll likely have to do what works!

(1) Week of 15 January: Kidney function. Formal report due 31 January, in class.
(2) Week of 22 January: Neurophysiology. Formal report due 05 February, in class.
(4) Week of 29 January: Muscle physiology. Formal report 12 February in class.
(5) Week of 05 February. Cardiac physiology-heart function. Formal report due 26 February, in class.

c. Lab Reports.

(1) Due as indicated in laboratory schedule;
(2) Late reports will not be accepted without medical or compassionate explanations.
(3) Reports will be marked and returned as soon as possible.
(4) Format. Neatly written, typed, or word-processed according to the manuscript requirements for Canadian Journal of Zoology.
(5) Illegible reports will not be accepted; plagiarism, to any extent, will not be accepted.
(6) The textbook is the primary reference for lab reports. Websites are not authorized as references although peer-reviewed journals accessible on the internet are authorized and are to be appropriately cited in accordance with CJZ instructions.
(7) Report Marks.

(a) Introduction: Provides the scientific basis for the work performed: Pass/Fail. Failure results in Report returned, not marked, for a score of 0.0 Final Marks.
(b) Results: Drafted figures, tables and a textual summary of experimental findings: 3.0 Final Marks.
(c) Discussion: Discussion of the scientific basis and biological relevance of the data, and comparison of the results with published findings; this section also includes appropriate presentation of cited references; 7 Final Marks. **PAGE LIMIT OF 6 PAGES; OVERLENGTH DISCUSSIONS WILL BE REJECTED *in toto*. This page limit is quite tight; you will have to produce a very condensed discussion section. There is not a single character space for "baloney".**

ADVICE. Formal reports require significant effort for data presentation, reading and interpreting reference material, and incorporating relevant reference material into meaningful discussions.

4, Proposed curriculum: See attached pages.

5. Textbooks:

a. Boron, W.F. and E.L. Boulpaep. Medical Physiology, 2nd ed. (revised) 2012. Saunders, Philadelphia PA. (1337 pp).; and

b. Biology 3251 Lab Manual. Available as part of the Comparative Animal Physiology I & II Lab Manual in the LU Alumni Bookstore.

Proposed Curriculum

1. READING ASSIGNMENT.

a. There is a requirement for you to have an understanding and firm grasp of the aspects of renal physiology. As renal physiology is typically considered toward the end of the course and that lecture progress may prohibit my actually lecturing on this subject in depth you are required to independently (or collaboratively) review the material in

(1) Chapter 33. Organization of the urinary system;
(2) Chapter 34. Glomerular filtration and renal blood flow;
(3) Chapter 35. Transport of sodium and chloride;
(4) Chapter 36. Transport of urea, glucose, phosphate, calcium, magnesium, and organic solutes;
(5) Chapter 37. Transport of potassium;
(6) Chapter 38. Urine concentration and dilution;
(7) Chapter 39. Transport of acids and bases; and
(8) Chapter 40. Integration of salt and water balance.

b. Now, pay attention! There is too much material in these chapters to actually acquire an expert knowledge of it in the time allotted. Moreover, much of it is clinical (human) in its' focus. So, extract what is necessary from these chapters in order to be able to lucidly, and in detail, describe and discuss

(1) The gross (a) anatomy, (b) histology and (c) cytology of the kidney;
(2) The (a) structures, (b) forces and (c) regulation of filtration at the renal corpuscle without discussing the calculation of renal clearance rates;
(3) The cells, structures and mechanisms of reabsorption (and secretion where appropriate) of

(a) Na^+;
(b) K^+;
(c) Ca^{++};
(d) Cl^-;
(e) HCO_3^- and CO_3^{--};
(f) the phosphate anions; and
(g) glucose.

(4) Management and utility of urea; and
(5) The role of the kidney in regulating blood pH.

c. Task execution

(1) This is a parcel of material that is very large to consider in a very brief period of time. You should consider as a class to subdivide the task responsibly and consolidate your efforts in the intelligence analysis

phase. You are individually responsible for your knowledge of this material.

(2) In the event that the Renal Physiology Lab occurs as the first in the sequence of labs then you will find the material and outline identified above to be useful in considering how to frame your discussion section. Please note that your preparation of the Renal Physiology Lab discussion section is a direct preparation for your final exam; the better defined your discussion section is, the better prepared you will be to study for the final exam.

FOR WA 2017 SERIAL ONLY IN ITALICS/BOLD AND UNLESS OTHERWISE ADVISED

5. NEUROPHYSIOLOGY.

a. Functions of a nervous system.

(1) Acquisition of information from the external and internal environments.

(2) Integration and analysis of data.

(3) Directing action or effecting responses.

b. Review of Structural aspects of nervous systems.

(1) Glial cells.

(a) Generalized structure.

(b) Functions.

(c) Schwann cells.

(2) Neuroanatomy.

(a) Cell body.
(b) Axon.
(c) Axon terminal.
(d) Dendrites.

c. Variability in neuron morphology.

d. Review of the neuron membrane.

e. Classification of nerve fibres.

(1) A-fibres.

(a) α.
(b) β.
(c) γ.

(2) B-fibres.

(3) C-fibres.

f. Examples of neurally mediated mechanisms.

(1) Vertebrate skeletal muscle control.

(2) Crayfish tail flip response.

(3) Paramecium avoidance behaviour.

g. Electrical properties of neuronal membranes.

(1) Potential.

(2) Capacitance.

(3) Electrotonic potential.

(4) Resistance.

h. Determination of membrane voltage (V_m).

(1) Nernst equation.

(2) Goldman equation.

i. Selective regulation of membrane permeability to ions.

j. Biomolecular basis of membrane voltage potential.

(1) Diffusion.

(2) Chemical gradiants.

(3) Electrical gradiants.

(4) Active transport.

k. Na^+/K^+-ATPase.

(1) Structure.

(2) Function.

(3) Regulation.

l. Ion-channels.

(1) Structure.

(2) Function.

(3) Regulation.

(4) Evolutionary aspects.

(5) Na^{+}-channels.

(6) K^{+}-channels.

(7) Ca^{++}-channels.

(8) Cl^{-}-channels.

m. The action potential.

(1) Description.

(2) Summary of events.

(3) Properties.

n. Synapse.

(1) Ephapse-the electrical synapse.

(2) Synapse-the neurochemical synapse.

(a) Structure.

(b) Ionic-events.

(c) Neuropharmacology.

(d) Regulation of neuronal Ca^{++}-homeostasis.

o. Neurotransmitters and neuropharmacology.

(1) Acetylcholine.

(2) GABA.

(3) Adrenalin/noradrenalin.

p. Pharmacological modulation of synaptic neurotransmission.

(1) Competitive inhibition at receptor site.

(2) Modulation of spike initiation.

(3) Alteration of neurotransmitter release.

q. Nitric oxide: a novel neurotransmitter.

r. Synaptic integration.

(1) Facilitation.

(2) Summation.

(3) Antifacilitation.

(4) Spatial summation.

(5) Presynaptic inhibition.

(6) Presynaptic sensitization.

s. Macroscopic examination of the vertebrate nervous system.

(1) Spinal cord.

(2) Brain.

t. Autonomic nervous system.

(1) Sympathetic division.

(2) Parasympathetic division.

u. Sensory receptors.

(1) Somatic receptors.

II. MUSCLE PHYSIOLOGY

1. Muscle physiology general references.

2. Comparative organization and anatomy of

a. Skeletal (striated) muscles and cells.

b. Smooth muscles and cells.

c. Cardiac muscles and cells.

3. Vertebrate skeletal muscle.

a. Cell microanatomy;
b. Molecular organization of contractile filaments: actin and myosin filaments; and
c. Organization of: T-tubules, sarcoplasmic reticulum, terminal cisternae.

4. Regulation of skeletal muscle.

a. Innervation by
   (1) voluntary paths-role of motor cortex; and
   (2) involuntary paths-spinal reflex arcs.

b . Comparison of multiterminal and polyneuronal innervation.

c . Motor end plate
   (1) morphology;
   (2) physiology-electrical events, neurochemical events, receptor events; and
   (3) pharmacology.

d. Excitation:contraction coupling.

e. Sliding filament theory of muscle contraction: power stroke, recovery stroke, ionic and non-ionic mechanisms.

f. Neural and mechanical components of graded muscle contraction: clonus, tetany, facilitation.

g. Isometric and isotonic contraction: contractile component, series elastic component, parallel elastic component.

h. Relationship of lead (stretch) to form of contraction.

i. Energy transformations in muscle: ATP, phosphogens, glucose, glycogen.

j. Comparative anatomy and physiology of skeletal muscle.

5. Vertebrate smooth muscle.

   a. Cell microanatomy and molucular organization of contractile filaments;
   b. Organization of smooth muscle cells: visceral smooth muscle vs multiunit smooth muscle;
   c. Regulation of smooth muscle contraction; and
   d. Molecular basis of smooth muscle contraction.

6. Vertebrate cardiac muscle.

   a. Cell microanatomy and molecular organization of contractile filaments;
   b. Electrical properties of cardiac myocytes;
   c. Molecular basis of cardiac myocyte contraction; and
   d. Comparative anatomy and physiology of cardiac muscles: neurogenic vs myogenic hearts.

III. CIRCULATORY PHYSIOLOGY

1. Vertebrate heart.

   a. Anatomy;
   b. Electrical functions; and
   c. Regulation of heart function: neural, endocrine, mechanical mechanisms.

2. Blood vessels.

3. Overview of vascular system: pathway of blood flow, structure of blood vessels, compartment volumes.

4. Capillaries.
   a. Structure;
   b. Exchange mechanisms: diffusion, pinocytosis, diapedesis, ultrafiltration;
   c. Ultrafiltration-mechanical basis; and
   d. Regulation.

5. Lymphatic system.

   a. Gross organization;
   b. Cellular organization; and
   c. Function: uptake and movement of lymph, filtration of extracellular fluid, fat absorbtion from intestine.

6. Arterial system.

a. Elastic arteries;

b. Muscular arteries and arterioles;

c Regulation of blood flow: resistance, vasoconstriction, vasodilation; and

d. Regulation of vasoconstriction.

(1) direct: myogenic response, autoregulation, local regulators of blood flow;and

(2) indirect: neural (afferent paths, efferent paths), endocrine paths.

7. Venous system.

8. Regulation of heart productivity.

a. Stroke rate: vagus, sympathetic, endocrine; and
b. Stroke volume: Frank-Starling law, myocardial contractility, stroke rate, training.

IV. RESPIRATION. GAS-EXCHANGE AND BLOOD pH REGULATION

1. References (TBA).

2. Introduction-solubility of 0_2, $C0_2$.

3. Respiratory pigments.

a. Oxygen and hemoglobin (Hb).

(1) Hb-structure and function;
(2) Bohr effect, Haldane effect;
(3) Phylogenic variation; and
(4) Relationship between 0_2 tension and Hb:0_2 interaction.

b. $C0_2$ transport.

(1) Bicarbonate;

(2) Carbamino compounds; and

(3) Transfer of $C0_2$ between blood and tissues.

4. Regulation of pH.

   a. H^+-production and excretion; and
   b. Involvement of $C0_2$ and bicarbonate.

5. Special Topic: Respiration and high-altitude physiology.

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V. EXCRETION AND OSMOREGULATION

1. References. (TBA)

2. Metabolic wastes.
   Phylogenic organization of nitrogenous waste excretors: ammonioteles, ureoteles, uricoteles, guanoteles.

3 Gross morphology of mammalian kidney.

4. Nephron anatomy.

5. Filtration, reabsorbtion, secretion.

6. Endocrine regulation of nephron function. Participation of kidney in blood pH regulation. and if time permits.

VI. GASTROINTESTINAL PHYSIOLOGY

1. References. (TBA)

2. Detailed examination of structure and innervation of the mammalian gut.

3. Histology and cytochemistry of secretory cells and their products.

4. Neural and endocrine regulatory mechanisms for regulation of exocrine and endocrine gut secretions.

5. Liver structure, functions, and cytochemistry-biochemistry and regulatory mechanisms associated with bile production.

6. Water and electrolyte balance in the gut.