

BIOLOGY 3251

Animal Physiology - Organ System Operation and Regulation (2020)

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. Tentative Marking Scheme.

a. Lab reports:

(1) The availability of experimental animals to be used in laboratory exercises is tenuous; consequently, there is no certainty that they will be available. As a result, there are currently no laboratory exercises scheduled for this serial of the course; however, should animals become available, then selected laboratory exercises will take place.

(2) One laboratory exercise dealing with Kidney Function in which students would supply urine samples for analysis may take place; however, instrumentation for urine analysis is being mustered currently. There is, however, no guarantee that adequate instrumentation will be available in a timely fashion.

(3) Should laboratories take place then marks will be allocated to formal reports written as a consequence of these exercises; of course, mark allocation is not feasible at this time.

b. Term Tests:

As far as is possible, term tests will be written in laboratory periods in order to provide maximal time for careful completion of tests by students.

If a series of tutorials is offered in lieu of laboratory exercises, then students will be examined on the basis of tutorial content and an appropriate number of final marks will be assigned to this term test. This decision will be based on feedback from students within the first week of class.

Currently then,

(1) Term test #01. 18 Feb 2019. 40% Final Mark; and

(2) Term test #02. 24 Mar 2018. 60% 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.

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.**
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, 3rd ed. Saunders, Philadelphia PA.; 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.

I. 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 load (stretch) to form of contraction.
 - i. Energy transformations in muscle: ATP, phosphagens, glucose, glycogen.
 - j. Comparative anatomy and physiology of skeletal muscle.
5. Vertebrate smooth muscle.
- a. Cell microanatomy and molecular 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.

II. 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 absorption 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.

III. RESPIRATION. GAS-EXCHANGE AND BLOOD pH REGULATION

1. References (TBA).

2. Introduction-solubility of O_2 , CO_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 O_2 tension and Hb: O_2 interaction.
 - b. CO_2 transport.
 - (1) Bicarbonate;
 - (2) Carbamino compounds; and
 - (3) Transfer of CO_2 between blood and tissues.
4. Regulation of pH.
 - a. H^+ -production and excretion; and
 - b. Involvement of CO_2 and bicarbonate.
5. Special Topic: Respiration and high-altitude physiology.

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IV. 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.