BIOLOGY 3251WA – COMPARATIVE ANIMAL PHYSIOLOGY II
DR. R. OMELJANIUK

1. Calendar Description.

Comparative Animal Physiology II
0-0;3-3
A comparative study of organ system physiology in invertebrates and vertebrates. Areas to be discussed include osmotic and ionic regulation, circulation, respiration, nervous regulation and endocrine regulation.
Students with a general interest in physiology, and not intending to pursue graduate or professional studies may, with the permission of the instructor elect to submit an assigned term paper in lieu of participation in the laboratory component of the course.

2. Marking Scheme.

a. Lab reports: 4 X 12.5% = 50% of final mark;
b Final Exam: 50% of final mark; and
c. Optional Term Paper:
(1) 50% of final Mark in lieu of laboratory participation;
(2) This assignment will constitute a critical review of the primary literature on a topic fundamental to the material covered in the course. Typically, topics will be assigned; however, proposed topics of relevance and academic merit will be considered.
(3) Critical timings.
(a) Submission of initial proposal no later than 19 Jan;
(b) Submission of detailed proposal no later than 02 Feb;
(c) Submission of penultimate draft no later than 02 Mar; and
(d) Submission of the final version no later than 23 Mar.

3. Laboratories.

a. Lab coordinator: Mr. Michael Moore, CB-3020A; 346-7739.

b. Schedule:
Lab schedule is subject to change in accordance with availability of animal preparations and instrumentation.
(1) Week of January 19: Neurophysiology Phase I: Introduction to instrumentation.
Week of January 26: Neurophysiology Phase II: Experiment. Formal report due Week of February 11.
(2) Week of February 02: Muscle physiology. Formal report due week of February 23.
(3) Week of February 23: Circulatory physiology-heart function. Formal report due March 09.
(4) Week of March 09: Kidney function. Formal report due week of March 23.

c. Lab Reports.
(1) Due in lab period as indicated in laboratory schedule and are to be submitted to the lab teaching assistant;

(2) Late reports will not be accepted without medical or compassionate explanations.
(3) Reports will be marked and returned the following week.
(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) Reference material for reports located in library in regular stacks and on reserve.
(7) Report Marks.

(a) Introduction: Provides the scientific basis for the work performed: P/F. Failure results in Report returned not marked.
(b) Results: Drafted figures, tables and a textual summary of experimental findings: 2.5 marks and P/F. Failure results in Report returned not marked.
(c) Discussion: Discussion of the scientific and biological relevance of the data, and comparison of the results with published findings; this section also includes appropriate presentation of cited references; 10 marks.

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. Berne, R.M., Levy, M.N., Koeppen, B.M., and Stanton, B.A. Physiology (6th ed.) Mosby Year Book. Toronto. 2004, 1014 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

NOTE: QUOTED REFERENCES ARE FOR THE FIFTH EDITION. REVISED CITATATIONS TO FOLLOW.

I. PREPARATORY READING.
Students will be conversant with the principles of cell physiology and communication via primary messengers such as hormones and neurotransmitters and the principles of ligand:receptor interaction. Information covering these topics may be found in the course text as indicated below. There will not be direct examination of this material. This material is not assigned but is indicative of the level of knowledge required to assist students in continuing successfully in this course.

a. Chapter 01. Cellular membranes and transmembrane transport of solutes and water;

b . Chapter 02. Ionic equilibria and resting membrane potentials;
c. Chapter 39. General principles of endocrine physiology; and
d. Chapter 03. Generation and conduction of action potentials.

II. MUSCLE PHYSIOLOGY

1. Muscle physiology general references.

a. Chapter 17. Contractile mechanism of muscle cells. pp: 269-281;
b . Table 17.1. Muscle classification;
c. Fig 17.2. Three dimensional relationships between membrane elements and the filament lattice;
d. Fig 17.3. Sarcomere microstructure;
e. Fig 17.4. Molecular structure of actin filaments;
f. Fig 17.6. Molecular structure of myosin filaments; and
g . Fig 17.7. Molecular basis of crossbridge cycling.

2. Comparative organization and anatomy of

a. Skeletal (striated) muscles and cells.
References
(1) Chapter 18. Skeletal muscle physiology. pp: 282 to 299;
(2) Fig 18.3. Subcellular and temporal aspects of myoplasmic [Ca^{++}];
(3) Fig 18.4. Twitch summation and tetanic contraction;
(4) Fig 18.5. Metabolic pathways in muscle; and
(5) Fig 18.10. Neuroanatomy of motor units.

b. Smooth muscles and cells.
References
(1) Chapter 19. Smooth muscle. pp: 300 to 315;
(2) Fig 19.6. Control systems of smooth muscle;
(3) Fig 19.8. Regulation of smooth muscle myosin interactions with actin by Ca++stimulated phosphorylation; and
(4) Fig 19.11. Principal mechanisms determining the myoplasmic Ca++ concentrations in smooth muscle.

c. Cardiac muscles and cells.
References.
(1) Chapter 22. Electrical activity of the heart. pp: 329 to 359;
(2) Fig 22.1. Electrical activity of fast and slow-response cardiac muscle cells;
(3) Fig 22.7. Changes in Vm, gNa^{+}, gCa^{++}, and gK^{+} in a cardiac myocyte;
(4) Fig 22.19. Comparative electrophysiology of ventricular, SA Nodal, and atrial cells;
(5) Fig 22.25. The cardiac conduction system; and
(6) Fig 22.33. The important deflections and intervals of a typical scalar electrocardiogram.

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. <u>CIRCULATORY PHYSIOLOGY</u>

1. Vertebrate heart.

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

2. Blood vessels references.

    a. Chapter 21. The circuitry. pp: 325 to 328;
    b. Fig 21.1. Physical components of various blood vessel walls;
    c. Fig 21.2. Variations in pressure among blood vessels;
    d Table 21.1. Vascular dimensions in a 20 kg dog; and
    e. Fig 21.4. Schematic diagram of the parallel and series arrangement of the vessels composing the circulatory system.

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

4. Capillaries.

    a. References.
        (1) Chapter 27. The microcirculation and lymphatics. pp: 429 to 441; and
        (2) Fig 27.8. Schematic representation of the factors responsible for filtration and absorbtion across the capillary wall and the formation of lymph.
    b. Structure;
    c. Exchange mechanisms: diffusion, pinocytosis, diapedesis, ultrafiltration;
    d. Ultrafiltration-mechanical basis; and
    e. 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. References.
        Chapter 26. The arterial system. pp: 415 to 428; and
        Fig 19.6. Control systems of smooth muscle cells.
    b. Elastic arteries;
    c. Muscular arteries and arterioles;
    d Regulation of blood flow: resistance, vasoconstriction, vasodilation; and
    e. 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.
   a. Chapter 32. Structure and function of the respiratory system. pp: 517 to533;
   b. Chapter 35. Transport of oxygen and carbon dioxide: tissue oxygenation. pp: 561 to 571;
   c. Fig 35.1. The normal hemoglobin-oxygen (Hb02) equilibrium curve;
   d, Fig 35.2. Effects of $C0_2$, $[H^+]$ and 2,3-DPG on hemoglobin: oxygen interaction; and
   e. Fig 35.8. $C0_2$ exchange between the lung and blood in the pulmonary capillaries.

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.

V. EXCRETION AND OSMOREGULATION

1. References.
   a. Chapter 40. Elements of renal function. pp: 677 to 698;
   b. Fig 40.1. Structure of the human kidney;
   c. Fig 40.2. Nephron structure and organization;
   d. Fig 40.4. Anatomy of the renal corpuscle and juxtaglomerular apparatus;
   e. Chapter 41. Solute and water transport along the nephron: tubular function. pp 699 to 714;
   f. Chapter 44. Role of the kidneys in the regulation of acid-base balance. pp: 763 to 775; and
   g. Fig 44.2. Cellular mechanism for reabsorbtion of filtered $HC0_3^-$ by cells of the proximal tubule.

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.

    a. Chapter 38. Gastrointestinal secretions. pp: 617 to 646;
    b. Fig 38.1. Structure of the human submandibular gland;
    c. Fig 38.2. Schematic representation of the cellular morphology of a secretory end piece of a serous salivary gland;
    d. Fig 38.8. Gross and fine structure of the gastric mucosa;
    e. Fig 38.12. Postulated model of the major ionic transport processes involved in the secretion of H^+ and Cl^- by parietal cells;
    f. Table 38.1. Major mechanisms for stimulation of gastric acid secretion;
    g. Table 38.2. Major mechanisms for inhibition of gastric acid secretion;
    h. Fig 38.20. Locations of important transport processes involved in the elaboration of pancreatic juice;
    i. Fig 38.21. Postulated cellular ion transport mechanisms for secretion of bicarbonaterich fluid by epithelial cells of pancreatic extralobular ducts;
    j. Fig 38.24. Diagrammatic representation of a hepatic lobule;
    k. Fig 38.28. Postulated mechanisms for uptake and secretion of bile acids by hepatocytes;
    l. Fig 39.14. Cellular mechanisms of Ca++ absorption in the small intestine; and
    m. Fig 39.16. Current view of the mechanism of iron absorption by the epithelial cells of the small intestine.

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.