BIOLOGY 3250: Comparative Animal Physiology I.
2009 Serial
Instructor: Dr. Robert J. Omeljaniuk, CB-4013.

1. CALENDAR DESCRIPTION.

Comparative Animal Physiology I. 3-3; 0-0.
An introduction to organismal and cellular communication emphasizing endocrine, neural and intracellular signal transduction mechanisms. Laboratory exercises involve practical experience in the use of *in vivo* and *in vitro* techniques.
Students with a general interest in physiology, and who do not intend 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 assignments. 2 X 5% = 10% of final mark.

b. *Lab reports. 1 X 10% = 10% of final mark.

*All tables and figures are to be rendered by hand in accordance with direction and style of the Canadian Journal of Zoology. For purposes of training in data presentation, computer generated tables and figures are not authorized.

c. Laboratory Exercise Briefing Notes and Class Briefing. 2 X 5% = 10% of final mark.

Students will prepare briefing notes for submission on each lab exercise and will present two briefings to their lab section throughout the course of the term. Each briefing note and presentation will be scored out of 5 final marks.

c. CCAC Experimental Animal Handling Test. Pass or Fail.

Date: TBA. Administered by Research Office.

All students are required to successfully complete this test in order to continue in BIOL 3250 and participate in BIOL 3251

d. Mid-Term Exam. 30% of final mark 09 October 09.

e. Final Exam. 40% of final mark; scheduled by Scheduling Office.

f. Optional Term Paper. 30% Final Mark in lieu of laboratory participation.

This assignment will constitute a major, critical review of the primary literature on a topic fundamental to the material covered in the course. Topics will be assigned. Critical timings are:

(1) Submission of detailed proposal no later than 25 September 09;

(2) Submission of penultimate draft no later than 23 October 09; and

(3) Submission of the final version no later than 20 November 09.

3. LABORATORIES.

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

b. Schedule.*

(1) Week of 14 September. Both Sections A and B attend simultaneously. Tutorial on data management and lab reports.

No assignment but attendance is mandatory in order to continue in the course.

(2) Week of 21 September. Introductory lab-Basic lab skills and data management. Lab Sections A.
Lab assignment must be submitted in next lab period.

Week of 28 September. Introductory lab-Basic lab skills and data management. Lab Sections B.
Lab assignment must be submitted in next lab period.

(3) Week of 05 October. pH and physiological buffers. Lab Section A.
Lab assignment must be submitted in next lab period.

Week of 12 October. pH and physiological buffers. Lab Section B.
Lab assignment must be submitted in next lab period.

(4) Week of 19 October. Erythrocyte hemolysis and membrane permeability. Lab Section A.
Formal report must be submitted in lab period, week of 26 October.

Week of 26 October. Erythrocyte hemolysis and membrane permeability. Lab Section B.
Formal report must be submitted in lab period, week of 02 November.

(5) Week of 02 November. Neurophysiology Overview and Instrument Familiarization. Lab Sections A.

Week of 09 November. Neurophysiology Overview and Instrument Familiarization. Lab Sections B.

(6) Week of 16 November. Neurophysiology instrumentation performance check. Lab Sections A.

Pass/Fail. Students must pass this component in order to be eligible to participate in BIOL 3251 Labs

Week of 23 November. Neurophysiology instrumentation performance check. Lab Sections B.
Pass/Fail. Students must pass this component in order to be eligible to participate in BIOL 3251 Labs

* LAB SCHEDULE IS SUBJECT TO CHANGE IN ACCORDANCE WITH AVAILABILITY OF ANIMAL PREPARATIONS AND INSTRUMENTATION. BE PREPARED TO RECEIVE ADDITIONAL INSTRUCTIONS FOR LAB EXERCISES AS THE LAB MANUAL IS BEING REVISED.

c. Lab Assignments/Reports.

(1) To be submitted to Teaching Assistant in lab periods unless otherwise directed by the course instructor.

(2) Due as indicated. Late reports will not be accepted without documented medical or compassionate explanations.

(3) Format.

(a) Neatly word-processed according to the manuscript requirements for CANADIAN JOURNAL OF ZOOLOGY, without exception. See CJZ Instructions to Authors.

(b) Illegible reports will not be accepted. Plagiarism, to any extent, will not be accepted; any plagiarism will result in a report mark of 0 and potentially a course mark of 0. (Reference: LU Calendar for Academic Dishonesty).

(c) Reference material for reports may be provided as available and located in library as 2-hour reserve material. Students are required to search the literature for pertinent material in support of Lab Report Discussion Sections.

(4) Lab Report Marks*.

(a) Introduction.

Provides the scientific basis for the work performed. 1 mark.

(b) Results.

Drafted figures, tables and a narrative summary of experimental findings. 4 marks.

(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. 5 marks.

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

4. TENTATIVE LECTURE OUTLINE.

a. Endocrinology. Lectures 1 to 15.

b. Neurophysiology: Lectures 16 to 30.

b. Intracellular signal transduction. Lectures 31 to 36.

5. TEXTBOOKS.

a. Boron, W.F. and Boulpaep, E.L. 2009. Medical Physiology. Saunders – Elsevier, Philadelphia PA. 1337 pp..

b. Biology 3250/3251 Laboratory Manual. Available at the Lakehead University Alumni Bookstore.

6. ATTENDANCE TO LABORATORIES AND EXAMINATIONS.

Attendance to laboratories and examinations is mandatory. In the event of significant extenuating circumstances, including serious illness or bereavement of an immediate family member, students are to contact the instructor at their earliest convenience to explain their situation and request in writing for consideration. Likewise, students are strongly encouraged to consult their Instructor in advance whenever unusual circumstances are foreseeable.

Biology 3250: Comparative Animal Physiology I.
Proposed Curriculum

1. INTRODUCTION TO PHYSIOLOGY.

   a. Homeostasis vs Rheostasis.

   b. Communicative mechanisms within animals.

      (1) Comparison of acute (knee-jerk reflex) vs chronic (insulin regulation of blood glucose) homeostatic regulatory mechanisms.

      (2) Comparison of schizophrenia and parkinsonism; both originate from altered neurotransmission of the same neuronal population.

      (3) Integration of neural, endocrine and immune systems in stress response physiology.

   c. Internal communication.

      (1) Autocrine eg. POMC-peptides.

      (2) Paracrine. eg. somatostatin and α- and β-cells in pancreatic islets.

      (3) Neuroendocrine. eg. GnRH stimulation of LH stimulation in fish.

      (4) Endocrine. eg. adrenalin release and peripheral actions.

      (5) Neural.

2. ENDOCRINOLOGY.

   a. Definition of a hormone, and hormone properties.

   b. Categorization systems for hormones.

      (1) Tissue of origin.

      (2) Function.

      (3) Chemical structure.

   c. Formal definition of an endocrine gland (with examples).

   d. Endocrine tissue types.

      (1) Follicle plan.

      (2) Cell cord plan.

      (3) Islet form.

(4) Isolated cells.

(5) Neurosecretory cells.

e. Evolution of the structure and cellular constituents, secretions, and functions of pituitary hormones (a class handout accompanies this section).

f. Academic discrimination between neurotransmitters, neuromodulators, neurohormones, and glandular hormones.

g. Chemical structure of hormones.

(1) Peptide/protein hormones.

(a) Description.
(b) Synthesis.
(c) Metabolism.
(d) Receptors.
(e) Synthetic and genomic modification of structure/function and evolutionary considerations (eg. neurohypophysial hormones).

(2) Steroid hormones.

(a) Description.
(b) Synthesis.
(c) Metabolism.
(d) Receptors.

(e) Evolution of steroid hormone function based on modification of -R groups.

(3) Amino acid derivatives.

(a) Description.
(b) Synthesis.
(c) Metabolism.
(d) Receptors.
(e) Comparison of thyroid- with catecholamine-hormones.

h. Invertebrate Endocrine Systems.

(1) Endocrine tissues.

(2) Ecdysone vs juvenile hormone.

(a) Structure.
(b) Function.
(c) Metabolism.

3. HORMONE AND NEUROTRANSMITTER RECEPTORS.

a. Definition and required criteria.

b. Localization.

c. Identification.

d. Functions of hormone receptors.

(1) Hormone site of action.

(2) Confers specificity to hormone (-agonists, super-agonists, and -antagonists).

(3) Regulates bioactivity of hormone, also susceptible to up- and down-regulation.

e. The interaction of a hormone with its receptor.

(1) Tagging/tracing the hormone.

(a) Radiochemicals.
(b) Flourescence.
(c) Radioopaque tags.

f. Analysis of hormone (ligand):receptor interaction.

(1) Tissue dependence.

(2) Associability (k_{+1}), dissociability (k_{-1}).

(3) Equilibrium binding conditions ($Kd=k_{-1}/k_{+1}$).

(4) Saturability.

(5) Displaceability (relationship between IC_{50}-value and K_d).

(6) Specificity and stereospecificity.

(7) Appropriate tissue distribution (a potential red-herring).

g. Comparison of plasma-membrane and steroid hormone receptors.

h. Evolution of steroid receptor structure and function.

4. INTRACELLULAR SIGNAL TRANSDUCTION.

a. Commonality of endocrine and neuroendocrine regulatory mechanisms.

b. The concept and evolution of post-receptor theory (from the black-box, to adenyl cyclase to inositol lipid metabolism and beyond).

c. Fundamental advantages of hierarchical organization of secondary messenger systems.

(1) Signal amplification-eg. glucagon/insulin regulation of glucose metabolism.

(2) Reduction of number of 2^0-messengers for multiple 1^0-messengers.

(3) Integration of multiple 1^0-signals.

d. Guanine-nucleotide binding proteins (G-proteins).

(1) Definition of G_s, G_i, G_o, G_p, G_t.

(2) Activation and mechanism of action -stimulation of cAMP production.

(3) Pharmacological manipulation by G-nucleotide analogues.

(4) Modulation of G-protein function by cholera- and pertussis- toxin.

(5) Biological relevance of G-proteins.

(6) Detailed examples of G-protein function: regulation of ion-channel activity, regulation of phospholipase C and intracellular phospholipid metabolism.

e. Cyclic nucleotides as 2^o-messengers.

(1) cAMP and cGMP.

(2) Origin

(3) Structure.

(4) Bioactivity.

(5) Metabolism.

f. Inositol lipid metabolites as 2^o-messengers.

(1) The plasma membrane as a phospholipid substrate.

(2) Phospholipid metabolic path.

(3) Structural relationships of inositol-lipid metabolites.

(4) Structure and regulation of phospholipase C.

(5) IP_3 and DAG as 2^o-messengers.

g. Participation of extracellular and intracellular Ca^{++} pools in regulation of cell activity.

1. Ca^{++}-channels.

(a) Distribution.

(b) Activation/inactivation

(c) Regulation of activity.

h. The role of protein-phosphorylation/dephosphorylation as an intracellular signal transducing mechanism.

(1) Proteins Kinase.

(a) Structure.
(b) Activation/inactivation.
(c) Functions.
(d) Protein kinase A.
(e) cGMP-dependent protein kinase.
(f) Ca^{++}-activated protein kinases.
Calmodulin-dependent protein kinases vs protein kinase C.

(2) Proteins Phosphatase.

(a) Structure.
(b) Activation/inactivation.
(c) Functions.
(d) ATP,Mg^{++}-dependent protein phosphatase.
(e) Calcineurin.
(f) Mg^{++}-dependent phosphoprotein phosphatase.
(g) Polycation-stimulated phophoprotein phosphatase.

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.

(2) Special senses.

(3) The hair cell as an example of a sensory receptor.

(a) Structure.

(b) Function-electrical events.

(c) Evolutionary adaptations.

v. The retina, visual fields and collateral inhibition.