BIOLOGY 3250: Comparative Animal Physiology I.
2020 Serial
Instructor: Dr. Robert J. Omeljaniuk, CB-4013.

NOTE: As a consequence of altered operations at Lakehead University this course, and others, are being conducted differently from their historical patterns. Thank you for your consideration and patience with these temporary changes.

This proposed course outline is subject to change in response to changing conditions and to developments in lecture delivery methods, and in response to novel developments in the evaluation of student progress such as testing paradigms.

Thank you again for your thoughtful understanding.

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.

2. MARKING SCHEME.

a. 20% of the Final Mark is allocated to Laboratory Exercises as defined and evaluated by Mr. Michael Moore and his teaching staff. Details to be confirmed and promulgated by Mr. Moore.

b. Mid-Term Tests.
(1) Term Test #01: 30% Final Mark. 30 Sep 2020; and
(2) Term Test #02: 50% Final Mark. 23 Nov 2019.

NOTES.

1. The administration of tests is yet to be determined as this is a novel distance education course. Currently, tests will be long answer, hand-written, and accompanied by hand-drawn figures and tables. Nonetheless, the final nature of the tests remains to be conclusively determined.
2. Tests will be conducted on dates identified and during allocated class times; test papers must be submitted prior to the conclusion of the class time. Some time allowance (minutes) for electronic transmission may be allocated. Please note that you may need to have access to a scanner to submit your test electronically and you should be well versed in its operation.
3. Actual submission protocol for test papers remains to be determined.

In plain language, there is still a lot to get figured out. In the event that you can defer taking this course to the next academic year, there may be some practical merit in considering that course of action in anticipation that regular in-house classes will resume.

3. LABORATORIES.

20% of the Final Mark is allocated to Laboratory Exercises as defined and evaluated by Mr. Michael Moore and his teaching staff. Details to be confirmed and promulgated by Mr. Moore.

4. TENTATIVE LECTURE OUTLINE.

a. Endocrinology. Lectures 1 to 18.

b. Neurophysiology: Lectures 19 to 36.

c. Intracellular signaling: dispersed throughout as appropriate.

5. TEXTBOOKS.

a. Boron, W.F. and Boulpaep, E.L. 2015. Medical Physiology, 3rd ed. Revised. 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.

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.