BIOLOGY 3UU3 - Winter Term II - 2013

Animal Physiology: Regulatory Systems

Instructor: **C. David Rollo (rollocd@mcmaster.ca)**

Lectures: T, Th, Fr 11:30-12:20
BSB 147

Course *Coordinator*: George Bijelic (gbijel@mcmaster.ca)

Teaching Assistant: **Chris DeJong (dejonc@mcmaster.ca)**

If the course is full, I cannot help you to get a seat. If the course is close to capacity I do not provide permissions for those with prerequisite deficiencies.

There is no textbook but a courseware package available from the bookstore is required.

Grading:	Course Quiz	15% (before midterm break)
	Midterm	35% (early March)
	Final Examination	50%

There **may** be a bonus participation grade for contributions to the electronic learning environment depending on available TAs and electronic support **(TBA)**

Course Content

The key focus of this course is regulatory systems associated with major features and functions of animals (e.g. feeding, reproduction, thermoregulation, growth, stress, sleep, aging). Other emphases include neuroendocrinology, evolution, vertebrates and ecology.

There is really only one way for human minds to handle the daunting amount of information associated with the form, functioning and evolution of animals, and (other than building computer simulations) that is to find frameworks and patterns that allow prediction and generalization. Some major themes of this course intended to do so are outlined below.

Commonality of Problems and Regulation. When we consider what an animal does, we can separate many aspects of form and function into discrete subsets. Each of these represents a major problem(s) being solved, and usually one or several dedicated fields of biology. What we are most interested in is integrative regulation and control. Table 2 provides a framework denoting key functions. Even considering only eleven major functions, we already have 55 potential direct interactions. We need some framework and conceptual tools to approach such complexity. Firstly, most of these interactions can be understood in the context of tradeoffs and synergisms – a framework known as the "Principle of Allocation" developed in evolutionary ecology. Secondly, most key functions are associated with one or a few dominant hormones and neurotransmitters (Table 1). Thirdly, most of the decision making (e.g., relative allocation of energy) related to particular functions and their integration with others takes place in a central microprocessor (the hypothalamus and associated brain areas). Fourthly, a considerable amount of organization is achieved by separating various functions across time, simplifying understanding (e.g., waking versus sleeping). Central coordination extends to peripheral cellular receptor systems, cell transduction networks and ultimately, gene transcription. Thus, a unified framework can be discerned that extends from higher levels of integration (ecological) to DNA (from the phenotype to the genome). Finally, recent mapping of the mouse genome reveals that perhaps 99%

of all mouse genes have human analogues. This not only highlights enormous "Unity Amidst Diversity", but suggests that large differences in form and function do not trace so much to the basic regions coding for RNA and proteins, but to how these genes are regulated.

The Allometry of Body Size. Simple physics dictates that as organisms change in size, the relationships between surface area, volume and mass change in fairly predictable ways. Although not strictly "control" in the operational sense, most features of animals, including metabolic rates, growth rates and longevities can be predicted by body size. Perhaps more surprisingly, things like sleep, enzyme concentrations, vocalization and hearing frequencies, mitochondrial numbers and territory sizes are also predictable. The mathematical study of relative changes among various features across size scales is known as allometry, and this provides another unifying framework for understanding.

A course like this needs not only frameworks and conceptual tools but exciting theme(s) to further link everything together. Several such themes include development, aging and gender. The latter represents a dichotomous specialization seen in nearly all forms of multicellular life. The reasons for this are not as obvious as one might think.

SPECIFIC COURSE CONTENT (The order of topics and what gets covered will change according to class interests and time constraints).

- Fundamental principles of evolution and organization relevant to integrative regulatory physiology.
- Clocks, sleep and fundamental anabolic-catabolic regulatory organization
- Gender-specific regulation of various features.
- Fundamental endocrinological organization: Waking, sleeping, clocks, stress hormone-growth hormone balance. Evolution and regulation of sleep and associated functions.
- Body size, allometry, and regulation of lean growth.
- Stress: from the general adaptation syndrome to integrated cellular response systems.
- Reproduction: a general energetic framework and regulatory mechanisms.
- Feeding regulation: ecological and physiological aspects. Obesity, diabetes
- Endocrine-immune integration (emphasis on stress, growth and aging).
- Cognition, with special attention to memory, neurotransmitters and neurodegeneration.
- Thermoregulation, metabolism and mitochondria
- Aging, cancer and apoptosis: reactive oxygen species, mitochondria, antioxidants, dietary restriction, neuroendocrinology and cellular signal transduction, interventions.
- Evolution of integrated control systems.

Grading Issues: I do not release or provide old examinations. The relative weighting of the quiz, midterm and final examination grades will NOT be adjusted on an individual basis. The quiz and midterm are scheduled in class time as posted above and you are expected to be able to attend (multiple choice format). If you have a valid excuse to miss the quiz the accommodation will be a 50% Midterm and 50% final. If you miss only the midterm the accommodation will be an 85% final. If you miss the quiz and midterm, with valid excuses the accommodation will be a 100% final. The final examination will cover the entire year's work and readings with some weighting on material not covered on the midterm. The possible bonus for electronic participation is based on quality and quantity of content. Grading of participation is entirely subjective and is not open to appeal.

Your participation indicates your acceptance of this arrangement.

There is no laboratory. The courseware package of required readings represents a tutorial that you can do on your own time, keeping in mind that this is considered equivalent to a full tutorial (i.e., several hours per week are recommended). You will be graded on ALL the courseware content. Questions pertaining to these readings will be included on the quiz, midterm and final examination. Your TA will be available online to facilitate discussion and help you out.

Electronic Medium: Important course information, TA contact and discussions/review relevant to studying will be facilitated via an electronic learning environment. Use of such electronic media may reveal private information such as first and last names, program affiliation, etc. Continuation in this course will be deemed consent to disclose of such information. Consequently, if you do not wish to participate you should not take this course.

As a student enrolled in this course you have been granted permission to access an online learning management system. This is considered an extension of the classroom and usage is provided as a privilege subject to the same code of conduct expected in a lecture hall (see relevant section of the student code of conduct below). This privilege allows participation in course discussion forums and access to supplementary course materials. Please be advised that all areas of the electronic learning environment are owned and operated by McMaster University. All members of the McMaster community are obligated to use computing resources in ways that are responsible, ethical and professional. I expect collegial interaction. Possible interactions in the electronic learning environment are intended exclusively for academic enthusiasm (i.e., negativity and complaints have no place here and detract from the learning experience).

Copyright Issues: Restrictions have changed recently and remain in a state of flux. Changes will be applied accordingly (i.e., this may affect what can be posted on line). This may place considerable emphasis on attending class or assuring that someone is covering for any absence.

Flexibility: "The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the student to check their McMaster email and course websites weekly during the term and to note any changes."

Academic Honesty: You are expected to use honesty and academic integrity in all aspects of University participation. This extends to participation for any bonus mark for this course. Multiple postings of the same material (either yours or another's) under different titles, breaking down sources into pieces to gain the appearance of multiple postings, fabrication etc will be considered as cheating. Alternatively, for this exercise, you can post or discuss anything that may be of physiological interest (in the broadest sense to the class (even if it was obtained in another course) AS LONG AS YOU ACKNOWLEDGE WHERE YOU GOT IT.

Please refer to McMaster's Policy on Academic Integrity at:

http://www.mcmaster.ca/academicintegrity

Table 1
Association of major mammalian functions with specific signaling systems and tissues.

	Function	Central Coordination	Main Sites
1	Growth	Growth hormone/IGF-1	Liver/pituitary/hypothalamus
2	Metabolic Rate	TRH, TSH Thyroid Hormones (T3, T4)	Thyroid/pituitary/hypothalamus/brown fat
3	Reproduction/ Estrus Cycles	GnRH, sex steroids	Gonads/pituitary/hypothalamus
4	Fat Storage	Leptin Insulin	White adipose tissue/hypothalamus
5	Immune System	Cytokines	Immunocytes, microglia/hypothalamus/thymus/spleen/bone marrow/lymphatic system
6	Energy Supply	Insulin/Glucagon/TRH	Pancreas/hypothalamus/liver/white adipose tissue
7	Stress responses	CRH/Vasopressin/ACTH/ corticosterone/cortisol	Adrenals/hypothalamus/pituitary
8	Feeding/Digestion	NPY	Hypothalamus
9	Clock	Melatonin	Pineal/Hypothalamus/ Suprachiasmatic Nucleus
10	Thermogenesis	CRH, TRH, cytokines Uncoupling proteins	Brown Fat Sympathetic nervous system
11	Excretion/Ion/ Water balance	Vasopressin Mineralcorticoids	Hypothalamus/Adrenals/Kidneys
12	Sleep	CRH-GH	Hypothalamus
13	Exercise	CRH-insulin	Musculature, Cardiovascular System
14	Aging Repair/Replacement	CRH-GH	Body Generally/Hypothalamus
15	Cognition/Memory/ Emotion	CRH-GH Neurotransmitters Glutamate, GABA, ACh	Brain (Cortex, Hippocampus, Amygdala)
16	Lactation/Pregnancy	Prolactin/Dopamine	Ovaries/Hypothalamus/uterus, mammary glands

CRH: Corticotropin releasing hormone or factor, IGF-1: Insulin-like growth factor, GnRH: Gonadotropin releasing hormone, NPY: Neuropeptide Y, TRH: Thyrotropin releasing hormone, TSH: Thyroid stimulating hormone; GH: Growth hormone.

Table 2 Eleven major categories of functions carried out by mammals have fifty-five potentially direct interactions.

		Interaction Matrix									
Trait	Code	L	R	G	T	B	W	S	I	C	F
Maintenance	M	1	2	3	4	5	6	7	8	9	10
Longevity Assurance	L		11	12	13	14	15	16	17	18	19
Reproduction	R			20	21	22	23	24	25	26	27
Growth	G				28	29	30	31	32	33	34
Thermoregulation	T					35	36	37	38	39	40
Behavioural Activity	B						41	42	43	44	45
Water/Ion Balance	W							46	47	48	49
Storage	S								50	51	52
Defense and Immunity	I									53	54
Information Processing and Cognition	C										55
Feeding and Digestion	F										