Sample Questions for the Biology Written Comprehensive Exam

INTRODUCTORY ESSAYS (note: the exam also includes short answer and multiple choice questions):

130/131 ESSAY

Compare and contrast the life cycles of animals, flowering plants and fungi. Explain how these life cycles are relevant to understanding ecology of the following local communities: (i) an ephemeral pond, (ii) a sandstone outcrop, (iii) an oak-hickory forest, (iv) a stream.

132 ESSAY

For a cell and its organelles, structure and function are intimately related. If one is changed, the other is affected. What do you think would happen if mitochondria had a structure like lysosomes? Give specific details in your discussion.

UPPER DIVISION QUESTIONS:

INSTRUCTIONS:

Answer three questions. You may answer no more than more two upper level questions from classes taken from the same professor. Each of your answers should be typed on a separate piece of paper and each should have your name and course written clearly across the top. Please sign this question sheet and return it with your answers. All answers are to be in the form of an essay unless otherwise instructed. Be sure to read and answer the entire question and provide graphs and diagrams as indicated. You have four hours to complete this exam. Good luck!

Biology 200: Entomology

Many species of insects have both aquatic and terrestrial stages in their life histories. Construct an essay that addresses the following questions: What structures are characteristic of aquatic forms? Are these different in immatures and adults? How do aquatic insects that inhabit lentic waters from those found in lotic waters (include behavioral differences as well as morphological differences)? What insect orders have high affinities for water?

Biology 201: Ornithology

Answer both:
(a) How and why are bird feathers colored in such diverse ways? Include in your answer information about the development of feathers, the mechanisms by which color is produced, and evolutionary explanations for why different colors have arisen.
(b) Describe the structure and function of the syrinx.

Biology 202: Invertebrate Zoology
Describe the processes of torsion and coiling in gastropod molluscs. Explain why these phenomena enabled the gastropods to be such a successful group. Are these two events coupled? Discuss advantages and disadvantages of torsion. Why do most gastropods exhibit asymmetrical coiling?

**Biology 203: Comparative Vertebrate Anatomy**

Any group of organisms that makes the change from living in water to living on land must alter most anatomical and physiological systems. This was true for plants and invertebrates as well as the vertebrates. Describe specific changes that occurred within the skeletal system of the vertebrates that allow for life on land. (Be specific regarding the acquisition or loss of specific bones, who has these bones, changes in the vertebral column, and the functional explanation behind each change you describe.)

**Biology 206: Plant Ecology**

Discuss resource competition among plants. What types of evidence suggest that plants compete for resources? What resources do plants compete for? What effects can resource competition have on the performance of individual plants and on the distributions of plant species? What other interactions among plants can lead to results similar to resource competition? How have researchers attempted to experimentally distinguish the effects of these other processes from the effects of resource competition?

**Biology 208: Neurobiology**

Give and explain the evidence that transduction across the synapse is chemical. Who did the work, what did they do, how were the data interpreted? Be thorough.

**Biology 209: Conservation Biology**

Deborah Rabinowitz has proposed that there are 7 different ways that a species may be rare. What are the different forms that rarity can take, and what are the consequences for each type of rarity for risk of extinction of a species? Under what circumstances is rarity not likely to be associated with a high risk of extinction?

**Biology 210: Ecology**

Answer all parts.

a) What is an ecological community?

b) How might one quantify the diversity of a community?

c) Why do some communities have higher diversity than others?

d) What is the relationship between diversity and stability? (You may also discuss the relationship between diversity and community structure and function if you prefer)

**Biology 211: Biodiversity: Pattern and Process**

Explain how the practice of biodiversity conservation can benefit from an understanding of (i) the genetics of individuals within populations, (ii) the mechanisms of speciation, and (iii) the
major climatic changes of the past 65 million years. For each of (i), (ii) and (iii), give examples to explain how and why knowledge in each area is important to conservation.

**Biology 213: Evolution**

Describe, using examples, how selection may act at the level of genes, individuals, demes, and clades. How does a multi-level view of selection enhance our understanding of biology?

**Biology 215: Fungi**

(Note: If you have taken both Fungi and Plant Growth and Development (each as a half class), you may answer just one question from these two classes (e.g., if you choose to answer the Fungi question you may not answer the Plant Growth and Development question)

In a broad-based essay, incorporate answers to the following questions relating to fungi.

a) How are fungi distinctive from all other organisms?
b) What is the difference between fungal hyphae and fungal mycelia?
c) How is the basic fungal body of lower fungi different from that of higher fungi?
d) What basic criteria are used to distinguish between the two main groups (classes) of higher fungi? (You need to name the groups, of course.)
e) What is a “form class” and how does the idea of a “form” group relate to fungi? (Again, name the form class.)

**Biology 302: Plant Growth and Development**

(Note: If you have taken both Fungi and Plant Growth and Development (each as a half class), you may answer just one question from these two classes (e.g., if you choose to answer the Fungi question you may not answer the Plant Growth and Development question)

Plant growth may ultimately be seen as a matter of cellular enlargement, and some plant physiologists believe that auxins play a critical role in that process. Write an essay on auxin-mediated cellular changes that would control/allow cellular elongation. Include the ideas of appositional change, multinet theory, and acid growth.

**Biology 219: Molecular Revolution in Medicine**

Pick one disease from each of the follow three mechanisms of inheritance: dominant, recessive, and X-linked and describe how it can be diagnosed and the molecular mechanism action. Next design a targeted drug that would treat one of these diseases. Include what pharmacodynamic impact your drug will have. Lastly, describe the stages you would have to go through to get you drug approved by the FDA (Be specific).

**Biology 221: Environmental Physiology of Plants**

For each of the following functional types listed below, provide an example of a plant that fits within the group, and describe the environmental conditions to which these plants are adapted as
well as the specific traits and physiological mechanisms that help them survive stressful conditions: a) metalophyte b) halophyte c) hydrophyte d) xerophyte.

Biology 232: Human Health and the Environment

Using Haiti as a model, draw a comprehensive diagram outlining the interacting factors that underlie poverty, environmental degradation and poor health. Using specific examples, discuss how some of these problems are being (or might be) addressed, as well as the challenges facing these efforts. What are some similar challenges facing residents of our own community and why do you think they exist?

Biology 233: Intermediate Cell and Molecular Biology

The extracellular matrix and growth factors work in conjunction with one another to promote cell survival and proliferation. Discuss the production of these proteins and their functions. How and what do they regulate to promote cell survival and proliferation?

Biology 250: Molecular Evolution
A. Draw hypothetical phylogenetic trees illustrating monophyletic, paraphyletic, and polyphyletic groups.
B. What is homoplasy in phylogenetic analysis and what is its significance?
C. Distinguish between the two items in each pair:
   1. cladistics and phenetics
   2. UPGMA and maximum parsimony
   3. Protein fingerprinting and DNA fingerprinting

Biology 280: Molecular Genetics

Draw a diagram of a gene, include all regulatory regions that can impact transcription initiation. Then add the chromatin structure, making sure that the nucleosomes are equally spaced. Now, describe the process of how a gene is actively expressed starting with transcription initiation and ending with a protein product (be specific about each step). Lastly, describe three different mechanisms of regulation of this process and the possible outcomes of each.

Biology 301: Genetics

A scientist sets up 100 vials of fruit flies (Drosophila melanogaster), each with 10 flies (5 males and 5 females) and initial p and q values of 0.5 each. When a new generation of flies emerge, only 10 (again, 5 of each sex) were placed (randomly chosen, i.e., chosen for sex but without attention to other features) in a new vial to perpetuate the 100 “lines” begun in each of the initial vials. After 6 generations, 50 of the “lines” were found to be genetically “fixed”. In about half of them, p was 1; in the rest, p was 0.

A. Define evolution and explain whether this work provides a good illustration of evolutionary change.
B. Define Hardy-Weinberg equilibrium and tell whether such an equilibrium is in effect in these populations.
C. What factor was most likely responsible for the change observed in the lines that are now fixed? Explain your answer.

D. Name three other factors which might, in theory, have caused this kind of change and explain on what basis you have decided against each of those possibilities.

E. How does this work relate to the concept of adaptation and adaptionistic thinking?

**Biology 306: Biochemistry**

Distinguish clearly between the following pairs of items; you may omit one:

1. the metabolic roles played in cells by the coenzymes NAD$^+$ and NADP$^+$
2. gluconeogenesis and glycolysis
3. fatty acid oxidation and fatty acid synthesis
4. serine proteases and zinc proteases
5. acidic amino acid vs. basic amino acid (at neutral pH)
6. SDS polyacrylamide electrophoresis and isoelectric focusing
7. PCR and RFLP analysis
8. Competitive and noncompetitive enzyme inhibitors

**Biology 310: Plant Evolution and Systematics**

Compare and contrast spores and seeds as dispersal mechanisms for plants, including descriptions of each. What taxa of plants utilize each method of dispersal? What adaptive advantages do seeds possess?

**Biology 312/314: General and Human Physiology**

Explain the difference between a parameter in chemical balance versus being in homoeostasis. Give an example of each, explaining the mechanisms by which homeostasis is maintained on the one hand, and how chemical balance is maintained on the other hand. Also explain how it makes a difference for the organism if something is kept in chemical balance versus homeostasis.

**Biology 313: Ecosystems and Global Change**

Choose one of Earth’s four interacting spheres (atmosphere, biosphere, hydrosphere, lithosphere) and discuss its hypothesized origin, how it has been altered by human activities, and how these alterations have affected its interaction with the other spheres, creating environmental challenges for humans. Of the four spheres, which do you believe is the most “fragile” and why?

**Biology 321: Cellular Biology**

The word “protein” means of first importance.

A. Describe the structure of proteins beginning with the primary structure and ending with the highest order structure. Discuss how protein structure is related to the function of any three of the following: a) a particular enzyme, b) an IgG molecule, c) the sarcomere, d) the Na$^+$, K$^+$ pump.

B. Where in the cell are any four of the following five of the following human proteins synthesized and how do they reach their final destination? a) insulin (describe only its
pathway within the cell in which it is synthesized), b) a cytoplasmic hydrolytic enzyme with acid pH optimum, c) membrane proteins of the Golgi apparatus, d) histones, and e) proteins in the lumen of the peroxisome.

**Biology 330/331: Immunology**

In the 1880s–1890s there were 2 schools of thought on how the immune system functioned. Metchnikoff believed that cellular immunity protected animals from infection while Von Behring led the school of thought that held that humoral immunity was primarily responsible for vertebrate immunity. We now know that both cellular and humoral immunity must be tightly coordinated to mount a proper immune response. Discuss as many components as possible involved in activation an immune response describing their functions, coordination with other components, and whether or not the component is part of the innate or acquired response. Finish your discussion by explaining the mechanisms that modulate the immune response such that autoimmune disorders are the exception rather than the rule.

**Biology 333: Developmental Biology**

Describe the events that occur during mammalian spermatogenesis. Compare and contrast mammalian spermatogenesis and oogenesis by describing two key similarities and two key differences between these two processes.

**Biology 340/339: Microbiology**

A great deal is made of the inappropriate use of antibiotics for controlling the growth of bacteria and all the antibiotic resistant strains of bacteria that now exist. People frequently forget that there are many chemical and physical methods that are applicable to controlling the growth or spread of microorganisms. Discuss two chemical and two physical methods that can be used to control bacteria. Be sure to discuss their modes of action. Include in your discussion, an explanation of whether or not the method is effective in controlling viruses.

**Biology 350/351: Environmental Physiology and Biochemistry of Animals**

Scaling is an important concept in physiology, especially when trying to compare physiologies of different species. Distinguish clearly between isometric and allometric scaling. While most parameters scale allometrically with body size, graphing versus body size is still most often used. Explain the variables in the equation for a line that defines the allometric relationship of some parameter Y with body mass M:
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\log Y = \log a + b \log M_b
\]
Explain what ‘a’ and ‘b’ are, and how they are important in making comparisons between groups.

**Biology 380: Genomics**

We have a cyclical expression pattern for cortisol that occurs everyday at roughly the same time. Explain how a scientist can mimic this interesting expression pattern of a gene of their choice. Compare this mechanism of synthetic regulation of cortisol to toggle switches. How would the expression pattern change. Lastly explain what synthetic biology is and how it can be used.