Biology Program Learning Outcomes Assessment Project 2005-2006

Biology is the study of life, its origins, diversity and intricacies. It emphasizes the relationship between structure and function in living systems and the processes, by which organisms grow, reproduce and interact with each other and their environment. The discipline is dynamic and rapidly advancing, particularly in the areas of biotechnology and information technology. The Biology Program provides its undergraduate and graduate students with a strong theoretical foundation in biology, combined with extensive hands-on laboratory experiences using state-of-the-art technology. Biology is an interdisciplinary science and this is reflected in the curriculum. Biology majors take core courses in Biology, Chemistry, Physics, Statistics and Math. Students then take Biology core courses which cover the major sub-fields in Biology and upper-division electives related to their area of interest. As a result, students are provided with substantive exposure to the content, methods and techniques that encompass the field of Biology.

CSUCI graduates will possess an education of sufficient breadth and depth to appreciate and interpret the natural, social and aesthetic worlds and to address the highly complex issues facing societies. Graduates will be able to:

- *Identify and describe the modern world and issues facing societies from multiple perspectives including those within and across disciplines, cultures and nations (when appropriate).*
- *Analyze issues, and develop and convey to others solutions to problems using the methodologies, tools and techniques of an academic discipline.*

Biology Program Student Learning Goals and Outcomes

The Biology program has formulated 7 broad learning goals. The first three goals address conceptual knowledge in Biology while the remaining goals deal with the attainment of skills and experiences. Biology students should be able to:

Explain the basic structures and fundamental processes of life at molecular, cellular and organismal levels.
Identify the evolutionary processes that lead to adaptation and biological diversity.
Describe the relationship between life forms and their environment and ecosystems.
Collect, organize, analyze, interpret and present quantitative and qualitative data and incorporate them into the broader context of biological knowledge.
Effectively apply current technology and scientific methodologies for problem solving.
Find, select and evaluate various types of scientific information including primary research articles, mass media sources and world-wide web information.
Communicate effectively in written and oral forms.

For the 2005-2006AY, the program selected the following learning goal to assess:

Describe the relationship between life forms and their environment and ecosystems.

From this broad learning goal, 10 learning outcomes were devised. Biology majors that understand the relationship between life forms and their environment and ecosystems should be able to:

1. Describe the world's major biomes.
2. Explain the principles and mechanisms that underlie evolutionary change
3. Explain how organisms are classified
4. Define the phylogenetic relationships and the principle anatomical features of the major animal phyla and be able to identify typical representatives of these phyla.
5. Define the principle anatomical features of the major plant groups and be able to identify typical representatives of these groups
6. Describe the major features of the Kingdom Fungi.
7. Describe factors affecting population growth (population ecology)
8. Explain how biological communities change over time
9. Describe species distribution patterns
10. Identify strategies influencing survival and reproduction (life history)

Data and Analysis

Assessment of the learning goal utilized embedded questions on examinations in two core Biology courses. Biology 200 is a lower-division Biology course which is the first course in a 1-year General Biology sequence that is required of all Biology majors. Biology 433 is an upper-division course which is required of most Biology students (only one of the Biology emphases does not require this course and currently only ~13 of ~300 Biology majors choose this emphasis). Multiple choice questions related to the learning outcomes were embedded on exams in both Biol 200 and Biol 433 and the percentage of students that correctly answered questions correctly for each learning outcome was determined (Table 1).

As indicated in Table 1., students correctly answered questions at least 60% of the time for all of the learning outcomes and for 7 of the 10 learning outcomes students correctly answered questions $\geq$74% of the time.

TABLE 1		
Learning outcome	Number of questions	Percent of students (avg of all questions related to a given learning outcome) answered correctly
1. Describe the world's major biomes.	3	84
2. Explain the principles and mechanisms that underlie evolutionary change	9	80
3. Explain how organisms are classified	2	85
4. Define the phylogenetic relationships and the principle anatomical features of the major animal phyla and be able to identify typical representatives of these phyla..	13	79
5. Define the principle anatomical features of the major plant groups and be able to identify typical representatives of these groups	3	90
6.Describe the major features of the Kingdom Fungi.	2	60.5
7. Describe factors affecting population growth (population ecology)	5	61
8. Explain how biological communities change over time	3	61
9. Describe species distribution patterns	4	76
10.Identify strategies influencing survival and reproduction (life history)	3	74
Summary	47	75

Conclusions and Implications for Program Modification

Based on the data available, a high percentage of Biology majors appear to have mastered this learning goal. Students correctly answered questions 75% of the time for all of the learning outcomes related to the overarching learning goal (Table 1). However, one weakness of this study is that data was not collected prior to exposure to the courses. Thus, we do not have data on student's baseline level of understanding of this learning goal. To address this problem, for AY 2006-2007, a pretest was administered in both Biology 200 and Biology 433. The pretest utilized the same questions used in this study and these same questions will once again be embedded on examinations throughout the Fall semester. By comparing the pre/post data we will have a more meaningful data set to draw conclusions from and a more reliable view of whether or not student mastery of this learning goal is occurring in these courses. The data obtained during AY 2006-2007 will then be used to direct any necessary program changes.

APPENDIX: Embedded exam questions used in this assessment project

I. BIOLOGY 200 ASSESSMENT #1 (n=38)

DESCRIBE THE WORLD'S MAJOR BIOMES.

The greatest diversity of plants and animals is found in which biome?

a. Temperate deciduous forest	1
b. Tropical rain forest	36 (95%)
c. Chaparial	0
d. Taiga	0
e. Savanna	0

A cold region with evergreen (coniferous) trees as the dominant vegetation is

a. Savanna	0
b. Tundra	5
c. Taiga	31 (82%)
d. Arctic	1
e. Chaparral	1

The vast treeless region near the Arctic Ocean is the

a. Savanna	1
b. Tundra	28 (74%)
c. Taiga	1
d. Permafrost	5
e. Grassland	3

EXPLAIN THE PRINCIPLES AND MECHANISMS THAT UNDERLIE EVOLUTIONARY CHANGE

Natural selection is based on:

A. differential survival among members of a population.	8
B. inheritance of acquired characteristics.	9
C. differential reproductive success among members of a population.	21 (55%)
D. raising the carrying capacity of a population.	0

In order for a segment of a population to diverge into something different (*i.e.*, the origin of a new species), what must happen?

a. climate must change	0
b. there must be extreme amounts of genetic mutation	2
c. a segment of the population must become genetically isolated from the remainder of the population	36 (95%)
d. all sexual reproduction must cease	0

A change in the genetic makeup of a population through time is:

A. Natural selection	1
B. Uniformitarianism	0
C. Artificial selection	1
D. evolution	36 (95%)
E. illegal in Kansas	0

When a species invades a new habitat and evolves into several new species to better exploit available and different resources (e.g., Darwin's Finches on the Galapagos Islands), what has occurred?

A. Phyletic speciation	0
B. Convergent evolution	3
C. Stabilizing selection	0
D. Polyploidy	0
E. Adaptive radiation	35 (92%)

The Kiabab squirrel lives on the north side of the Grand Canyon and the Albert squirrel lives on the south side. Even though these two populations are only miles apart, their gene pools are kept isolated most obviously through:

A. Mechanical incompatibility	0
B. Hybrid infertility	0
C. Geographic isolation	34 (89%)
D. Ecological isolation	1
E. Temporal isolation	3

Two populations of mountain dwelling salamanders are separated by a valley that is impassable to them. The populations are _____.

A. allopatric	31 (82%)
B. sympatric	1
C. divergent	4
D. founders	1
E. subspecies	1

EXPLAIN HOW ORGANISMS ARE CLASSIFIED

In a classification system, the largest or most inclusive group listed below is:

a. Class	1
b. Order	0
*c. Phylum	34 (89%)
d. Genus	3
e. Family	0

Your scientific name (assuming you are a human being), correctly presented is:

a. homo sapiens	0
b. *Homo Sapiens*	7
*c. *Homo sapiens*	31 (82%)
d. homo Sapiens	0
e. *Homer simpson*	0

II. **BIOLOGY 200 ASSESSMENT #2 (n=38)**

DEFINE THE PHYLOGENETIC RELATIONSHIPS AND THE PRINCIPLE ANATOMICAL FEATURES OF THE MAJOR ANIMAL PHYLA AND BE ABLE TO IDENTIFY TYPICAL REPRESENTATIVES OF THESE PHYLA.

All of these are characteristic of all animals except:

a. multicellular	0
b. heterotrophic	3
c. cell walls	31 (82%)
d. sexual reproduction	0
e. all are characteristic of all animals	4

Between the digestive tract and the body wall, complex animals (protostomes and deuterostomes) have a body cavity called:

a. cnidarian	0
b. mesoderm	9
c. mesoglea	0
d. coelom	29 (76%)
e. thorax	0

Which of these groups is characterized by a lac of symmetry (neither radial nor bilateral symmetry)?

a. sponges	35 (92%)
b. cnidarians	0
c. arthropods	1
d. flatworms	0
e. chordates	2

Which animal group below lacks true tissues?

a. rounds worms	1
b. tapes worms	1
c. insects	2
d. sponges	34 (89%)
e. sea cucumber	0

A jointed exoskeleton is characteristic of:

a. insects	26 (68%)
b. annelids	1
c. mammalia	0
d. a and b	9
e. all of the above	2

Members of which group are NOT deuterostomes?

a. chordates	0
b. vertebrates	2
c. echinoderms	10
d. arthropods	24 (63%)
e. urochordates	2

Which of the following is a trait found only in animals of the subphylum Vertebrata?

a. gastrovascular cavity	1
b. protostome level of development	1
c. deuterostome level of development	0
d. cranium with skull of some sort	26 (68%)
e. none of these is a unique vertebrate trait	10

"Class" Aves includes:

a. kangaroo	5
b. birds	30 (79%)
c. frogs	0
d. reptiles	2
e. dogs	1

Which of the following was/were development(s) was/were first seen in reptiles, allowing them to successfully inhabit truly terrestial habitats?

a. amniotic eggs	5
b. dead waterproof skin, with keratin	4
c. feathers	2
d. a coelom	0
e. A and B	27 (71%)

Mammals that have live births but continue to incubate newborns in a pouch are:

a. monotremes	0
b. marsupials	38 (100%)
c. primates	0
d. rodents	0
e. all fossil (i.e. no living forms)	0

The currents of water (containing food) that pass through a sponge are created by:

a. collar cells	23 (60.5%)
b. ganglia	2
c. medusa	0
d. osculum	2
e. water-vascular system	11

Sponges belong to the phylum _____.

a. Chordata	0
b. Porifera	37 (97%)
c. Nemertea	0
d. Cnidaria	1
e. Monoblastoidea	0

Phylum Chordata includes all these except:

a. fish	1
b. birds	3
c. amphibians	1
d. squids	33 (87%)
e. mammals	0

DESCRIBE THE MAJOR FEATURES OF THE KINGDOM FUNGI.

Fungi usually obtain food how?

a. by digesting it externally and then absorbing it	21 (55%)
b. by photosynthesis	2
c. by absorbing it and then digesting it within fungal cells	11
d. by chemosynthesis	4
e. by producing antibiotics that internally destroy bacteria	0

A mass of fungal hyphae is called a:

a. plant body	2
b. mycelium	25 (66%)
c. gametophyte	1
d. sporophyte	2
e. slime mold	8

DEFINE THE PRINCIPLE ANATOMICAL FEATURES OF THE MAJOR PLANT GROUPS AND BE ABLE TO IDENTIFY TYPICAL REPRESENTATIVES OF THESE GROUPS

Members of the Kingdom Plantae are:

a. photosynthetic	1
b. eucaryotic	0
c. multicellular	0
d. A and C	6
e. all of these	31 (82%)

Well-developed vascular tissues are absent in:

a. mosses & liverworts	35 (92%)
b. conifers	0
c. angiosperms	0
d. ferns	0
e. B, C and D	3

Seeds occur only in

a. so called "higher" vascular plants	37 (97%)
b. mosses	0
c. green algae	0
d. liverworts	0
e. ferns	1

III. BIOLOGY 433 ASSESSMENT #1 (n=29)

EXPLAIN THE PRINCIPLES AND MECHANISMS THAT UNDERLIE EVOLUTIONARY CHANGE

The development of resistance to cyanide poisoning in California citrus scale is an excellent example of evolution by natural selection. Which of the following characteristics of this situation were critical to the evolutionary process?

A) There was no variation in cyanide resistance among individuals.	0
B) There were differences in fitness related to variation in cyanide resistance.	26 (90%)
C) There was no inheritance of cyanide resistance.	2
D) None of the above were critical to the evolutionary process	1

Which of the following is relevant to the evolutionary process?

A) how fast sheep can run	0
B) whether running speed affects the ability of sheep to leave successful offspring	19 (66%)
C) both A and B	9
D) neither A nor B	1

DESCRIBE SPECIES DISTRIBUTION PATTERNS

Certain salamanders live in the moist microhabitat under fallen logs in the forest. Which of the following dispersion patterns characterizes the individuals of such species within a tract of forest?

A) clumped	22 (76%)
B) evenly spaced	3
C) random	3
B & C	1

(23) During the winter, large flocks of slate-colored juncos visit a well-established bird-feeding station. An experiment is conducted in which two adjacent feeding platforms, each 1 1 m in size, are provided with sunflower seeds. Whenever juncos are present, a metering device dispenses seeds at a "low" rate of 4 g/hr to one platform and a "high" rate of 16 g/hr to the other. A flock of 100 juncos arrives and the birds quickly establish an ideal free distribution. How many birds are feeding on the platform supplied at the "low" rate?

A) 20	20 (69%)
B) 40	8
C) 60	0
D) 80	0
E) 100	1

IDENTIFY STRATEGIES INFLUENCING SURVIVAL AND REPRODUCTION (LIFE HISTORY)

A female African elephant produces a single offspring at intervals of several years, caring for her young for an extended period before reproducing again. The elephant's reproductive life history is referred to as:

A) semelparous	9
B) nonparous	1
C) oddparous	0
D) evenparous	2
E) iteroparous	17 (59%)

You are studying a species of bird that is often monogamous but sometimes exhibits polygyny. You have the choice of studying this species in several different habitats. Which of the following will you choose if you want a high probability of finding polygyny?

A)a habitat in which territory qualities are nearly identical	5
B)a habitat in which territory qualities vary somewhat	3
C)a habitat in which territory qualities are highly variable	21 (72%)

Storm-petrels live 30 to 40 years. Thrushes rarely live beyond 3 to 4 years. Even if you knew nothing more about the life histories of these two species, could you make an educated guess about which species has the longer prereproductive period?

A)No information about maximum age is insufficient background for an educated guess.	0
B)Yes the longer-lived species (storm-petrel) probably has the longer prereproductive period.	26 (90%)
C)Yes the shorter-lived species (thrush) probably has the longer prereproductive period.	2
D) There would be no difference between the two species.	1

IV. BIOLOGY 433 ASSESSMENT #2

DESCRIBE FACTORS AFFECTING POPULATION GROWTH (POPULATION ECOLOGY)

Anyone watching a hummingbird feeder has observed that individual hummingbirds will chase away other hummingbirds, as well as insects, which attempt to visit the feeder. Such encounters are examples of:

A) interference competition	18 (67%)
B) exploitation competition	1
C) intraspecific competition	5
D) none of the above	3

In subantarctic waters, fish, squid, diving birds, seals, and whales all feed on shrimplike crustaceans called krill. When numbers of seals and penguins increased recently because of a decline in numbers of whales, researchers suggested _____ as the cause.

A)a reduction in predation on seals and penguins	4
B)a reduction in exploitation competition benefitting seals and penguins	17 (63%)
C)a reduction in interference competition benefitting seals and penguins	5
D)a reduction in allelopathy benefitting seals and penguins	0
E) ???	1

Human activities have been identified as the causal factor in numerous documented extinctions. Which of the following specific causes has been identified in the majority of cases examined?

A) habitat reduction and modification	19 (70%)
B) small population size	1
C) introduction of exotic species	4
D) overexploitation	3

You have been maintaining a list of the bird species that frequent your property. At the end of the year you have tallied eight seed eaters, one nectar sipper, three woodpeckers, six insectivores, four predators, and one carrion feeder. Which term best describes each of the categories you have used in your tally?

A)community	8
B) guild	16 (59%)
C) population	3
D) habitat	0
E) ecosystem	0

In the yucca-moth mutualism, female Tegeticula moths exercise restraint, laying so few eggs in a yucca ovary that the resulting larvae will consume no more than about 30% of the seeds in a developing fruit. Imagine that a "cheater" moth genotype arose, one that laid sufficient eggs to consume all the seeds in a yucca fruit. Why would the fitness of this "cheater" genotype, which could potentially produce more offspring per visit to a yucca flower, be lower than that of the typical genotype?

A)because yucca moths are subject to group selection-groups exercising reproductive restraint have greater fitness than groups not exercising restraint	5
B)because yuccas abort developing fruits that contain sufficient larvae to consume the majority of seeds	13 (48%)
C)because yuccas might eventually go extinct if the "cheater" genotype spread widely	7
D)None of the above.	2

EXPLAIN HOW BIOLOGICAL COMMUNITIES CHANGE OVER TIME

Why did wind- and water-dispersed plant species precede animal-dispersed plant species as the volcanic island of Krakatau was colonized following its 1883 explosion?

A)Wind and water are more effective dispersal agents than animals.	10
B)Animals have a very difficult time reaching Krakatau.	6
C)Animals were not attracted to the island until forests developed.	11 (41%)

Managers of power-line rights-of-way in the northeastern United States have discovered that dense shrub thickets, once established, can prevent establishment of forest trees. By maintaining shrubs under power lines, managers can greatly reduce the maintenance expenses (for mowing or herbicide application) normally associated with prevention of tree growth beneath power lines. Of which mechanism of succession are these managers taking advantage?

A) facilitation	2
B) inhibition	23 (85%)
C) tolerance	2

Which of the following is not a typical attribute of an early-successional species?

A)rapid growth	0
B)excellent dispersal ability	0
C)large seed size	15 (56%)
D)shade-intolerance	8
E)ability to colonize unexploited environments	4

DESCRIBE SPECIES DISTRIBUTION PATTERNS

Alfred Russel Wallace recognized six major biogeographic regions based on the distributions of animals he observed. Today we understand that these regions:

A)are distinctive because each biogeographic region has unique climates not found in any of the other regions.	4
B)are distinctive because the plants and animals in each region do not occur in any of the other regions.	5
C)are distinctive because they correspond to landmasses isolated millions of years ago by continental drift.	18 (67%)
D)are distinctive as reflections of the political map of Wallace's time but have little biological meaning	. 0

You are walking through a forest, and you soon discover that every other individual tree belongs to a different species. Based on this fact alone, in which of the following countries are you likely to be walking?

A)Ecuador	25 (93%)
B) United States	1
C) Canada	0
D) Sweden	1
E) Poland	0

EXPLAIN THE PRINCIPLES AND MECHANISMS THAT UNDERLIE EVOLUTIONARY CHANGE

Plants and animals of North and South American deserts resemble each other morphologically. What process is responsible for this similarity?

A)descent from common ancestors	0
B)convergence	16 (59%)
C)repeated migrations of plants and animals from one region to the other	2
D)all of the above	9