Student Learning Outcomes for Biology

Outcomes Assessment Program Overview

- Lists of assessable concepts and skills assembled by Biology Major Assessment Committee (N=4)
- Biology faculty survey (N=9) ID’d those concepts and skills “essential...to assess”
- These linked to each of 6 core curriculum courses
  - GB I & II, Ecology, Genetics, Cell Biology, Developmental Bio
- Outcomes assessments initiated prospectively in General Biology II and retrospectively in Gen Bio I
  - Questions embedded in regular exams and quizzes
Biology faculty survey

Online Select Survey
- Ask faculty to use Likert scale (1-5) to rate how essential each concept and skill would be to assess in our students.
- Listed 4 outcomes for each of 30 conceptual topic areas broadly representing modern biology (total = 120 concepts).
- Listed additional outcomes for 9 areas of problem solving and practical skills (total = 41 skills).
- Examples:

Examples of Concepts in Survey

Cell Structure and Function: understanding the metabolic processes of cells in terms of cellular organelles, membranes and biological molecules.
- Explain the metabolic processes in cells in terms of enzyme catalyzed, coupled, endergonic and exergonic chemical reactions often involving the synthesis or catalysis of adenosine triphosphate.
- Explain the regulation of biological reactions in terms of concentrations of substrates, products and enzymes as well as the effects of temperature, pH, competitive and allosteric binding on enzyme kinematics.
- Describe the critical roles of organelles including the nucleus, ribosomes, endoplasmic reticulum, other membranous organelles and the cytoskeleton as sites for biological reactions and for transporting molecules.
- Using the fluid mosaic model and the concepts of diffusion and osmosis, explain how membranes control the flow of molecules and ions into and out of the cell or cellular compartments both actively and passively.
### Examples of Concepts in Survey

**Evolution of Populations:** understanding population genetics, microevolution, genetic variation and natural selection.
- Explain how natural selection adapts populations to the environment by acting on heritable traits that affect fitness
- Recognize that mutations are pre-existing and not induced nor directed by the environment
- Use the Hardy-Weinberg equation to predict the distribution of phenotypes and genotypes in the absence of selection.
- Identify that genetic drift, natural selection, non-random mating and mutation can all result in changes in allele frequency and that these changes cause evolution.

### Examples of Problem-Solving Skills in Survey

**Experimental Design:**
- Observation: student can notice and describe patterns or phenomena
- Thoroughly describe a problem or question with sufficient background in logical arrangement of topics. (e.g., in an Introduction)
- Propose testable hypotheses (=causes, mechanisms) that explain observed patterns or phenomena
- Design experimental treatments to test hypotheses. "Strong inference"!
- Identify means to collect data (e.g., understand need for replicates, sample strategically, avoid biases in sampling design, organize raw data, etc.)
- Recognize possible biases in a study design, or in an argument
- Describe how a study was done sufficiently to be repeatable (Methods)
Examples of Problem-Solving Skills in Survey

- **Data Analysis:**
  - Summarize numerical data in graphs, tables, or statistics
  - Describe and analyze patterns in data (graphs, tables, stats)
  - Interpret results in a Discussion, drawing conclusions from data about hypotheses. Or use numerical data to defend an argument.

Examples of Practical Skills in Biology

- **Lab Technique:**
  - Pipetting
  - Making solutions (molar, %)
  - Making serial dilutions
  - Interpreting pH
  - Performing electrophoresis
  - Performing spectrophotometry
  - Performing microscopy (compound, dissecting)
  - Performing dissection
  - Using dichotomous identification keys
  - Performing aseptic transfer of microbes
  - Preparing both dry and wet mount slides
Examples of Practical Skills in Biology

- **Field technique:**
  - Sampling in the field
  - Taking notes in the field
  - Minimizing field impact

- **Safety:**
  -Responding to an emergency in the lab or field
  -Handling chemical waste
  -Observing proper animal care

- **Literature:**
  -Locating a primary source
  -Using and misusing the Internet for literature searches
  -Writing a critical review of the scientific literature
  -Citing sources properly
  -Tracing the historical antecedents of current ideas in biology

Results of Survey

- **Focus on outcomes that met one of 2 criteria:**
  - 100% of faculty strongly agreed (=5) or agreed (=4)
  - 50% of faculty strongly agreed (=5)

- **Yield:**
  - 120 concepts \(\rightarrow\) **15 concepts**
  - 16 problem-solving skills \(\rightarrow\) **8 problem-solving skills**
  - 25 practical skills \(\rightarrow\) **5 practical skills**
Examples of Selected Outcomes from Survey

- **Cellular and Molecular Biology**
  - CELL STRUCTURE AND FUNCTION: 4.3, 33%, 67%
  - Using the fluid mosaic model and the concepts of diffusion and osmosis, explain how membranes control the flow of molecules and ions into and out of the cell or cellular compartments both actively and passively.
  - Gen Bio I, Cell Bio

- HARVESTING CHEMICAL ENERGY: 4.3, 56%, 22%
  - Compare and contrast aerobic respiration and fermentation as processes for releasing and storing the energy in biological molecules with an emphasis on the role of oxygen and other electron receivers in aerobic respiration.
  - Gen Bio I, Ecology

- THE CELL CYCLE: 4.6, 67%, 22%
  - Compare and contrast mitosis and meiosis in terms of their roles in biological systems, the stages involved in each and the conservation of genetic material in each process.
  - Gen Bio I, Genetics, Cell Biology, Dev. Biology

Examples of Selected Outcomes from Survey

- **Evolutionary and Organismal Biology and Ecology**
  - DARWINIAN REVOLUTION: 4.3, 50%, 25%
  - Describe how natural selection as a theory has evolved as we have gained a better understanding of biological inheritance.
  - Gen Bio II, Genetics

  - EVOLUTION OF POPULATIONS 1: 4.3, 33%, 67%
    - Explain how natural selection adapts populations to the environment by acting on heritable traits that affect fitness.
    - Gen Bio II, Ecology, Genetics

  - EVOLUTION OF POPULATIONS 2: 4.6, 56%, 44%
    - Identify that genetic drift, natural selection, non-random mating and mutation can all result in changes in allele frequency and that these changes cause evolution.
    - Gen Bio II, Genetics
Examples of Selected Outcomes from Survey

- **Problem Solving and Critical Thinking**
  - EXPERIMENTAL DESIGN 1: 4.6, 56%, 44%
  - Observation: student can notice and describe patterns or phenomena.
  - EXPERIMENTAL DESIGN 2: 5.0, 100%
  - Propose testable hypotheses (=causes, mechanisms) that explain observed patterns or phenomena.
  - EXPERIMENTAL DESIGN 3: 4.3, 56%, 33%
  - Design experimental treatments to test hypotheses. “Strong inference”!
  - EXPERIMENTAL DESIGN 4: 4.7, 67%, 33%
  - Identify means to collect data (e.g., understand need for replicates, sample strategically, avoid biases in sampling design, organize raw data, etc.)

Examples of Selected Outcomes from Survey

- **Practical Skills and Extended Knowledge**
  - LAB TECHNIQUE 1: 4.4, 67%, 11%
    - Making serial dilutions
  - LAB TECHNIQUE 2: 4.4, 44%, 56%
    - Interpreting pH
  - SAFETY: 4.4, 67%, 11%
    - Handling equipment, chemicals and chemical waste
  - LITERATURE 1: 4.6, 67%, 22%
    - Locating a primary source
  - LITERATURE 2: 4.4, 44%, 56%
    - Using and misusing the Internet for literature searches
Prospective Assessment for Gen Bio II (n=45)

- **Evolution of Populations 1**: Explain how natural selection adapts populations to the environment by acting on heritable traits that affect fitness.

4. __________ is the pressure exerted by the environment on a population, thereby selecting best adapted individuals.
   a. Sexual selection 0.0%
   b. Induced mutations 0.0%
   c. Reproductive advantage 8.9%
   d. Natural selection 91.1%

Prospective Assessment for Gen Bio II (n=45)

- **Evolution of Populations 1**: A __________ is a group of populations whose individuals have the potential to interbreed and produce fertile offspring.
  a. species 95.6%
  b. population 2.2%
  c. genus 2.2%
  d. hybrid 0.0%

7. **T/F**: Most species are found in concentrated localized population centers. 82.2%/17.8%
Evolution of Populations 2: Identify that genetic drift, natural selection, non-random mating and mutation can all result in changes in allele frequency and that these changes cause evolution.

12. Which form of natural selection is most favored in an unchanging environment (such as the great depths of the ocean)?
   - a. **stabilizing** 91.1%
   - b. disruptive 2.2
   - c. directional 0.0
   - d. sexual 6.7

16. The random (chance) change in allelic frequencies in a population is termed _____.
   - a. isolation barriers 2.2 %
   - b. migration 2.2
   - c. gene flow 35.6
   - d. **genetic drift** 60.0
Prospective Assessment for Gen Bio II (n=45)

- **Evolution of Populations 2:** Identify that genetic drift, natural selection, non-random mating and mutation can all result in changes in allele frequency and that these changes cause evolution.

19. What needs to be in place for establishment and maintenance of any new species?
   - a. reproductive barriers **31.1%**
   - b. geographic barriers **31.1**
   - c. time **15.6**
   - d. none of the above **22.2**

% Correct, Evo Pop 1 vs. 2 Outcomes, GB II
%Correct, Cell Outcomes, GB I