Life Science 15 - Life: Concepts and Issues

Student Learning Objectives — Jay Phelan

Week	Topic
1	**Scientific thinking**
1-1	Explain the characteristics of scientific thinking and why it is an efficient way of elucidating natural causes for phenomena.
1-2	Apply the process of scientific thinking.
1-3	Produce and interpret graphs and other displays of quantitative information.
1-4	Recognize the relationship between science and society, providing examples.
1-5	Construct reasonable hypotheses, incorporating logical, testable, falsifiable scientific questions about their world.
1-6	Explain how scientific thinking depends on observations that can be confirmed.
1-7	Demonstrate the ability to identify dependent and independent variables and to articulate a "critical experiment."
1-8	Understand the concept of experimental controls and be able to evaluate them.
1-9	Dissect the concept of a "randomized, controlled, and double-blind" experimental design and its redundancies.
1-10	Evaluate evidence and formulate and defend alternative explanations on the basis of evidence.
1-11	Critique and evaluate claims of others based on evidence-based credibility and scientific accuracy
1-12	Advocate for the value of evidence in informing decision-making.
1-13	Understand the differences between scientific vs. non-scientific thinking.
2	**Evolution and natural selection**
2-1	Define biological evolution.
2-2	Assess Darwin's observations that influenced his theory of evolution by natural selection.
2-3	Explain the process and outcomes of natural selection, using examples.
2-4	Describe adaptation and relate it to natural selection.
2-5	Identify the mechanisms of evolution--genetic drift, selection, mutation, migration--and compare impact on genetic variation.
2-6	Contrast the world view relating to evolution prior to and after publication of The Origin of Species.
2-7	Distinguish the processes of artificial selection and natural selection.
2-8	Compare and contrast the inheritance of germline and somatic mutations.
2-9	Calculate allele frequencies based on phenotypic or genotypic data for a population and explain the underlying assumptions.
2-10	Model how random vs. non-random mating influence genotype frequencies and Hardy-Weinberg Equilibrium (HWE).
2-11	Assess whether HWE has been reached in a population and what that means.
2-12	Explain the concept of fitness and its impact on evolutionary processes.
2-13	Illustrate the ways in which fitness depends on abiotic and biotic factors.
2-14	Identify constraints that limit the evolution of optimal fitness.
2-15	Recognize that adaptation is not the result of organismal need and evolution is not goal-oriented.
2-16	Explain the variety of ways that phenotypes reflect the interactions between genotypes and the environment.
2-17	Plot a norm of reaction and describe its value in graphically representing the influence of the environment on phenotypes.
2-18	Interpret experiments to determine the relative influences of genes and the environment on a given phenotype.
2-19	Identify examples that demonstrate evolution as an ongoing process.
2-20	Describe sexual selection and, using examples, explain how it can lead to life-history trade-offs.

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3	**Genetic and environmental basis of traits**
3-1	Explain how Mendel formulated his ideas on heredity.
3-2	Relate Mendel's law of segregation to the phenomenon of inheritance.
3-3	Demonstrate how independent assortment of alleles during meiosis can lead to new combinations of alleles.
3-4	Connect Mendel's findings to Darwin's theory of evolution by natural selection.
3-5	Explain how genes can influence continuous traits in addition to discrete traits.
3-6	Use the concept of the test cross to determine a genotype.
3-7	Calculate the probability of a particular gamete being produced from an individual.
3-8	Estimate the probability of a particular offspring genotype resulting from a cross between two individuals.
3-9	Differentiate between meiosis and mitosis.
3-10	Distinguish between sister chromatids and homologous chromosomes.
3-11	Describe the sequence of events involving DNA in meiosis from chromosome duplication through segregation.
3-12	Discuss how errors in chromosome number can arise during meiosis.
3-13	Use a a pedigree to infer the mode of inheritance--dominant vs. recessive, autosomal vs. sex-linked--of a trait.
3-14	Create a pedigree based on narrative data and for a specific characteristic.
3-15	Calculate the expected frequencies of offspring genotypes and phenotypes using a pedigree.
3-16	Explain what a karyotype is and its diagnostic value.
4	**Evolution, cooperation, and human social behavior**
4-1	Define apparent altruism and explain why it presented a challenge to Darwin's theory of evolution.
4-2	Describe two mechanisms by which apparent altruism can evolve.
4-3	Differentiate between kin selection and reciprocal altruism and explain why they result from individual selection.
4-4	Distinguish inclusive fitness from direct fitness.
4-5	Calculate the coefficient of relatedness between individuals with common ancestors.
4-6	Use Hamilton's Rule to identify the conditions under which apparent altruism toward kin is favored by natural selection.
4-7	Relate kin recognition to kin selection.
4-8	Explain what behavioral "rules of thumb" are and the evidence for them.
4-9	Propose evidence supporting predictions of kin selection in humans.
4-10	Design an experiment to evaluate a prediction of kin selection theory.
4-11	Demonstrate how both haplodiploidy and inbreeding can increase the frequency and magnitude of apparent altruism.
4-12	Contrast reciprocal altruism theory with kin selection theory.
4-13	Describe the conditions conducive to the evolution of reciprocal altruism.
4-14	Explain the impact of cheaters on the evolution of cooperative interactions.
4-15	Compare the frequency of occurrence among animal species of reciprocal altruism vs. kin selection.
4-16	Derive avenues by which it's possible to enhance cooperation within a population.
4-17	Assess the role of reputations, gifts, punishment, and record-keeping in the occurrence of apparent altruism.
4-18	Explain the evolutionary significance of emotions underlying apparent altruism.
4-19	Describe group selection and why selfishness leads to higher fitness within a population.
4-20	Utilize the ultimatum game to evaluate the role of evolution in apparent altruism.

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5	**Modern genetics and biotechnology**
5-1	Distinguish between genes and DNA.
5-2	Illustrate how biotechnology can utilize genetic knowledge for practical purposes.
5-3	Explain the role of short tandem repeats in DNA fingerprinting.
5-4	Compare and contrast STR loci and gene loci.
5-5	Describe the polymerase chain reaction and why it has value in forensics and biotechnology.
5-6	Illustrate how an electrophoresis gel enables the separation of DNA fragments by size.
5-7	Evaluate the value and the challenges in using DNA fingerprints as individual identifiers.
6	**Nutrition, energetics, and health**
6-1	Connect food consumption with energy acquisition for organisms and for cells.
6-2	Describe and distinguish digestion and absorption as food moves through the stomach, intestine, and colon.
6-3	Explain the roles of mechanical and chemical processes in the first steps of digestion.
6-4	Identify how and where different nutrients are absorbed.
6-5	Recognize the role of hormones and enzymes in the digestive system.
6-6	Relate the chemical structure and associated properties for monosaccharides and and polysaccharides.
6-7	Demonstrate the relevance of molecule shape to function for artificial sweetners.
6-8	Relate the chemical structure and associated properties for amino acids and proteins.
6-9	Illustrate how the functional groups in component amino acids may affect protein function.
6-10	Explain the importance of shape to protein function.
6-11	Relate the chemical structure and associated properties for dietary lipids.
6-12	Describe three types of lipids--triglycerides, phospholipids, and steroids--and how their structures influences their functions.
6-13	List the essential human nutrients, describing the role of each in growth and metabolism.
6-14	Compare and contrast the role of vitamins and minerals with macromolecules in human diets.
6-15	Dissect how fiber can be both indigestible and essential in the human diet.
6-16	Evaluate the evidence and adaptive significance of food preferences.
6-17	Identify the value and limitations of the concept of basal metabolic rate.
7	**Reproduction, parental investment, and sexual selection**
7-1	Compare and contrast mitosis (for growth and repair) with meiosis (for gamete production).
7-2	Derive the roles of recombination and independent assortment in generating genetic variation.
7-3	Assess the impact of meiosis on genetic variation among gametes.
7-4	Propose the evolutionary source of conflict between parent and offspring and describe its manifestation.
7-5	Define mating systems and describe--with examples--how they vary across animal species.
7-6	Analyze the relationship between sexual dimorphism and animal mating systems.
7-7	Describe the causes, conditions for, and consequences of sperm competition.
7-8	Explain the value of comparing human behaviors across hunter-gatherer, agricultural, and industrial societies.
7-9	Identify physical constraints that influence male-female asymmetries in reproductive investment.
7-10	Derive the potential evolutionary consequences of male-female asymmetries in reproductive investment.
7-11	Describe the interaction between genetic and environmental factors in embryonic sexual development.

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8	**Hormones and physiological regulation**
8-1	Explain when and why hormones are released in mammals.
8-2	Describe the general mechanisms by which hormones influence gene expression.
8-3	Evaluate the evidence suggesting hormonal influence on complex behaviors.
8-4	Propose complementary experimental approaches to elucidating the impact of hormones on animal behaviors.
8-5	Identify the roles of hormones in animal reproduction and stress response.
8-6	Discuss the similarities and differences in hormonal control of male and female reproductive systems
9	**The nervous system, synapses, and brain functioning**
9-1	Compare and contrast the nervous and endocrine systems' roles in responding to environmental stimuli.
9-2	Illustrate the general structure of a neuron.
9-3	Relate the structural features of a neuron (i.e., dendrites, axons) to their functions.
9-4	Explain membrane potential and how it arises in neurons.
9-5	Describe the process by which an action potential is generated and propagated.
9-6	Dissect the process by which two neurons communicate at a synapse.
9-7	Predict how drugs in the synapse can inhibit or enhance signal transmission.
9-8	Interpret the evolutionary significance of reward systems in the brain.
9-9	Evaluate the relationship between genetic variation for neurotransmitter receptors and behavioral variation.
9-10	Describe the global organization of the human nervous system.
9-11	Explain how sensory neurons encode physical and/or chemical stimulation in action potentials.
9-12	Predict how changes in a sensory pathway will affect sensory perception.
9-13	Assess how the different senses are variations on a common functional theme.
10	**Adaptation, culture, and instincts**
10-1	Define culture and contrast it with the genetic transmission of information.
10-2	Evaluate the impact of culture on instincts and other biological constraints.
10-3	Explain the idea of evolutionary mismatch and how it can lead to maladaptive outcomes.
10-4	Identify the human environment of evolutionary adaptedness.
10-5	Describe human health & behavior challenges arising in environments different from those to which we are adapted.
10-6	Derive the practical applications of evolutionary medicine for medical practice.
10-7	Describe the evidence that emotions are are brain states that alter our behavior in ways beneficial to our genes.
10-8	Propose practical implications and insights arising from an evolutionary perspective of happiness.
10-9	Identify the naturalistic fallacy and its relevance to ethical, social, and environmental issues.