Integrating Evolution: An ENSI-Based Teaching Sequence

An Overall Course Outline, Incorporating **Evolution** and the **Nature of Science** as Themes Throughout the Course.

Nature of Science (about 2-3 weeks); focus on correcting MISconceptions: What science is NOT, vs what it IS, including its limits and basic uncertainty, and the important elements of inference, bias, criteria, social context, and processes of science. Recognize examples of pseudoscience and where there are political, economic, or religious distortions of good science.

Intro to the Science of Biology: Cells, Survey of Life, and Classification (about 4 weeks); intro to use of scopes, intro to cytology; overview of the living world (microscopic and macroscopic); introduce Lynn Margulis' hypothesis that the mitochondria, chloroplast and other eukaryotic organelles originated as endosymbionts of prokaryotic cells - an idea widely tested and confirmed in many ways; intro to classification concepts and terminology, the how and why of biological systematics being different from the categorizations of non-biological assemblages, and ending with "problem organisms" that don't fit cleanly into distinct categories, and possess a mix of traits typical of 2 major groups, e.g. *Peripatus*, platypus, coelacanth, archaeopteryx), suggesting a history of transitions.

Intro to Evolution (about 4-5 weeks); beginning with students comparing hominoid skulls, and discovering the chronological trend from mostly ape-like features to mostly modern human features, noting mosaic nature of change over time; focus on popular MISconceptions about evolution: what it is NOT vs what it IS; exploring some of the many clear examples of micro and macro evolution, and an introduction to Darwin and Natural Selection (vs Lamarck and his evolution mechanism); be sure to bring out the cumulative aspect, and the mix of random with non-random elements; introduce phylogenetic trees and cladograms; do the "Becoming Whales" lesson, with its elements of prediction and "gap-filling" with transitional forms.

Intro to Molecular Biology, Origin of Life Hypotheses, and the Evolution of Key Life-Processes (about 6-8 weeks); examine the distinction between the tenuous "origin of life" hypotheses, the reality of biological evolution, and the different hypotheses about the HOW of evolution; take a look at a few of the currently popular origin of life scenarios, and the likely emergence sequence of fermentation, photosynthesis, and respiration, and an intro to the biochemistry necessary to deal with those processes. In this context, explore some of the gross anatomy and physiology associated with those processes. New familiarity with proteins enables students to compare amino acid sequences in proteins from different groups to shed light on likely degrees of relationship. Do "Tutorial: Using Online Databases.." lesson.

DNA Structure and Function (about 4 weeks); include the current topics of biotech and genomics; provide lab experience in some DNA lab techniques; DNA in forensics; genomes, and comparisons of DNA sequences in different groups to shed light on likely degrees of relationship, build phylogenetic trees; include examples of tracing the evolution of viruses in fighting HIV and indluenza.

Reproduction and Development (about 3 weeks); includes mitosis, meiosis, examples of evolution patterns in plant reproduction, different patterns in animal reproduction and comparative embryology (and their significance to survival); provide emphasis on less familiar but critical aspects of human reproduction, including potential ease of conception, unreliability of menstrual cycle timing, and potential pitfalls of the many contraceptive methods; explore the emerging field of "Evo-Devo."

Genetics (about 4-5 weeks); intro to Mendelian inheritance and chromosomal changes, with some examples and experiences in mechanisms of macroevolution. Look at chromosome comparison, gene duplications, pseudgogenes and speciation.

Behavior (about 2 weeks); focusing on genetically influenced behavior vs learned behavior, evidence for the evolution of behavior; explore primate studies on the critical importance of positive and supportive parenting, from both mother and father. Consider doing the Footsteps in Time lesson here.

Ecology: Populations, Societies, and Ecosystem Interrelationships (about 2 weeks); including how human populations, and continued population growth, especially in our industrialized societies, excessively impact the world ecosystems. Could easily include some elements of public health and modern medicine from the perspective of evolution (see Moalem's *Survival of the Sickest*. 2007). Refer to environmental pressures and their influence on natural selection.

Organ Systems (Vertebrate Anatomy & Physiology) Elements of this topic are incorporated into other units as appropriate. The Blocks & Screws lesson works well here.

Throughout the course, numerous opportunities arise in which evolution uniquely provides reasonable explanations for otherwise puzzling phenomena or features. There are many examples of morphological and biochemical features variously referenced as "imperfections", "contrivances", "adaptive compromises", "preadaptations", "atavisms", "pseudogenes" and by other terms, depending on their nature and/or circumstances. Pointing these out where appropriate in the course will bring attention to their easy expectation in an evolutionary context. Consider a visit to a zoo or aquarium to look for **contrivances**, rather than adaptations: structures typically associated with one function, but being used for another, e.g. the elongated wrist bone used for a thumb by pandas, or the elephant's trunk used for grasping, or a sea horse's tail used for grasping.