Scientific Method (introduced in Psychics &Scientists)

By the end of the course students should be able to:

- Identify the dependent and independent variables in any experiment and
  - decide which are the appropriate ones to use to test the hypothesis under investigation
  - decide to which axis each variable would be assigned in a graph presenting data from a test of a specific hypothesis

- Define, recognize, and write a proper hypothesis and prediction and
  - distinguish between hypothesis, prediction, and theory
  - identify which properly labels a particular statement

- Comfortably use the terms hypothesis, prediction, and theory in speaking and writing to properly refer to that which they identify.

- Distinguish among hypotheses offered and be able to select the best one to explain a set of observations or the one most likely to be supported by data from a particular test

- Distinguish among predictions and be able to select the one that would be most likely to occur under given experimental conditions in a test of a specific hypothesis

- Identify or describe the best control for an experiment to test a particular hypothesis when
  - only one control group is necessary for a particular experiment or
  - when more than one experimental or control group is necessary for a particular experiment

- Recognize situations in which no “control group” is possible and design a proper experiment where
  - one group must be tested repeatedly or
  - there can only be one group in which the experimental variable varies "naturally” among individuals

- Recognize that experimenters’ viewpoints can affect results and therefore that
  - one needs to be aware of your own biases when designing experiments
  - one needs to be aware of your own biases when interpreting data or conclusions

- Understand that even with supporting data, hypotheses and even theories may be wrong and therefore
  - many related experiments should be performed
  - many samples should be taken
  - all hypotheses are subject to revision or rejection

Gradients (introduced in Fire & Ice)

By the end of the course students should be able to:

- Explain what a gradient is
- Identify whether a chemical or energy gradient exists in previously unencountered situations
- Indicate the direction of energy or material flow under different conditions such as
    - Chemical concentrations
    - Temperature
    - Permeability of membranes
- Indicate the relative rate of energy or material flow under different conditions including
    - chemical concentrations
    - temperature
    - permeability of membranes
    - varied shape (surface-to-volume ratio)

Temperature Regulation (introduced in Fire & Ice)

By the end of the course students should be able to:

- Comprehend what is meant by endotherm, ectotherm, poikilotherm, and homeotherm when applied to an organism
- Identify organisms as endotherms, ectotherms, poikilotherms, and homeotherm based on
    - physical characteristics
    - behavior
    - metabolic changes
    - membership in taxonomic groups (birds & mammals v. all others)
    - body temperature changes
- Predict the effect of varying environmental temperatures on an organism's behavioral or metabolic responses including:
    - cellular respiration
    - photosynthesis
    - protein synthesis
    - enzyme activity
    - locomotion
    - nerve activity
    - body temperature

- Interpret data/graphs relate to the effect of varying environmental temperatures on an organism's behavioral or metabolic responses including:
    - cellular respiration
    - photosynthesis
    - protein synthesis
    - enzyme activity
    - locomotion
    - nerve activity
    - body temperature

- Design or critique simple experiments to test the effect of varying environmental temperatures on an organism's behavioral or metabolic responses including:
    - cellular respiration
    - photosynthesis
    - protein synthesis
    - enzyme activity
    - locomotion
    - nerve activity
    - body temperature

- Explain the modes of heat transfer (Conduction, Convection, Radiation, Evaporation) and
    - recognize when each is occurring or
    - how they might be altered bydifferent circumstances and
    - identify how various mechanisms of thermoregulation affect each mode of heat transfer

- Explain how various temperature regulation methods serve to heat or cool an organism including:
    - Avoidance
    - altering metabolic rate
    - behaviorally adjusting
        - posture
        - surface-to-volume ratio
        - location
    - insulation
    - vasoconstriction/vasodilation
        - including effects at extremeties
    - shivering
    - panting/sweating
    - counter-current exchangers
    - explain how surface-to-volume ratio is involved in heat retention or loss

- Explain why organisms thermoregulate

- Explain mechanisms of heat generation at the cellular level

Osmoregulation (introduced in Fire & Ice)

By the end of the course students should be able to:

- Explain in very general terms how the Loop of Henle (Nephron Loop) helps animals regulate their water balance including:
    - the source and destination of the water and salts entering the nephron
    - how the fluid in the loop becomes concentrated
    - how changes in permeability control the movments of salt and water
    - how active and passive transport play their roles in the movement of water and salts
    - what gradients are established, how and why

Natural Selection (introduced in Out of the Rainforest)

By the end of the course students should be able to:

- Explain what natural selection is and how it works including:
    - what is required for it to take place
    - on what does it work
    - in what will it result
- Cite examples of natural selection encountered during the semester
- Identify how natural selection is involved in new situations
- Explain how natural selection and sexual selection are related
- Explain how natural selection plays a role in evolution
- Propose reasonable hypotheses for how natural selection could lead to specific adaptations

Coevolution (introduced in Out of the Rainforest)

By the end of the course students should be able to:

- Explain what is meant by coevolution
- Describe the characteristics that define a coevolutionary relationship
- Identify situtations in which coevolution is likely to have occurred or to be occurring including:
    - predator-prey relationships
    - symbiotic relationships

Cellular Respiration (introduced in Out of the Rainforest)

By the end of the course students should be able to:

- Describe the events that make up the process of aerobic cellular respiration in general terms including:
    - listing the functions of Glycolysis, Krebs Cycle, Respiratory Chain (Electron Transport System, Chemiosmosis)
    - list the reactants and products of Glycolysis, Krebs Cycle, Respiratory Chain (Electron Transport System, Chemiosmosis)
    - explain the role of enzymes in these processes

- Decribe the roles of ATP, NADH, FADH2, O2, H+, C6H12O6 (glucose), H2O, CO2, Protons, electrons in Cellular Respiration including:
    - where they are produced
    - where they are used or broken down
    - what they provide
    - the effect of their increase, decrease or removal

- Describe how the mitochondrion is involved in cellular respiration
    - where it is found
    - what is its structure
    - what happens in it

- Describe how the Electron Transport System and Chemiosmosis function in producing ATP including:
    - the role of gradients
    - the function of pumping protons across the innermitochondrial membrane
    - the role of ATP synthase
    - the effect that temperature and chemicals poisons have on the function of this system including:
        - rate of proton pumping
        - rate of ATP production
        - rate of O2 use
    - their role in heat production

- Describe what happens in the absence of oxygen to
    - ATP production
    - Glycolysis
    - Krebs cycle
    - respiratory chain
    - allow for an alternate path (fermentation)

Cell Structure (introduced in Out of the Rainforest)

By the end of the course students should be able to:

- Identify the function of cell components, especially:
    - Nucleus
    - Mitochondria
    - Chloroplasts
    - Ribosomes
    - Rough Endoplasmic Reticulum
    - Smooth Endoplasmic Reticulum
    - Vesicles
    - Golgi
    - Cell Membrane
    - Cytoplasm
    - Cell Wall
    - Vacuoles

- Identify which components are found in
    - all cells
    - prokaryotes (Kingdoms Monera and Archaea)
    - eukaryotes
        - Kingdom Animalia
        - Kingdom Plantae
        - Kingdom Protista
        - Kingdom Fungae

- Predict the kingdom to which an unknown cell might belong depnding on its components

- Predict the possible functions of an unknown cell depending on its components

- Predict the abundance of particular organelles depending on a cell's functions

Function of Nerve (introduced in Chemical Defenses)

By the end of the course students should be able to:

- Identify basic neuron structures and their functions
    - cell body
    - axon
    - dendrite
    - synapse
    - axon bulb
    - pre-synaptic membrane
    - post-synaptic membrane

- Explain how nerves generate and conduct signals including:
    - Resting potential and the role of
        - sodium (Na+)
        - potassium (K+)
        - relative charge or potential across cell membrane
        - passive transport
        - sodium-Potassium pump and active transport
        - un-gated channels
    - Action Potential and the role of
        - Na+
        - K+
        - gates or (voltage-dependent) gated (ion) channels
        - relative charge or potential across cell membrane
        - ion movement
        - electrical charge
    - Chemical and electrical gradients

- Explain Synaptic Transmission (how nerve signals pass from nerve-nerve or nerve-muscle) including the role of
    - pre-synaptic membrane
    - vesicles
    - neurotransmitters (especially acetylcholine)
    - post-synaptic membrane
    - neurotransmitter receptors or chemically-mediated gated ion channels
    - mechanisms for terminating synaptic transmission (especially acetylcholinesterase)

- Explain how nerve actions result in paralysis and convulsions

- Predict which drugs or conditions would result in paralysis or convulsions

- Predict the mode of action of an unknown drug (i.e. what a drug is doing) depending on symptoms

- Predict the presence or absence of pre-synaptic or post-synaptic action potentials depending on the mode of action of a drug

- Propose hypotheses for the appearance of paralysis or convulsions under various conditions

Transport across Cell Membranes (introduced in Chemical Defenses)

By the end of the course students should be able to:

- Explain how processes of passive transport work including:
    - Osmosis
    - Diffusion

- Explain how mechanisms of active transport work including:
    - Sodium-Potassium Pump

- Explain how larger objects/molecules cross membranes incuding:
    - Exocytosis
    - Endocytosis
    - Phagocytosis

- Predict when each of these trasport mechanisms might be in use

- Predict the effect of various conditions on the effectiveness of each mechanism including
    - gradient conditions
    - temperature
    - ATP availability
    - changes in permeability

Cellular Secretion (introduced in Chemical Defenses)

By the end of the course students should be able to:

- Describe the function of cellular secretion including where and when it would occur

- Identify the structures involved in synthesis and export of molecules including:
    - Nucleus
    - DNA
    - RNA
    - Ribosomes
    - rough endoplasmic reticulum
    - smooth endoplasmic reticulum
    - vesicles
    - golgi
    - cell membrane

- Describe the functions of each structure in cellular secretion

- Identify which of these structures are involved in the production of
    - Proteins
    - Lipids
    - Carbohydrates

- Explain the relationship between cellular secretion and protein synthesis

- Define exocytosis and describe the process

- Predict the effect of the damage or inhibition of any of the structures or steps

- Identify the correct order of the steps or structures involved in cellular secretion

Evolution (introduced in Marooned on the Galapagos)

By the end of the course students should be able to:

- Define evolution and describe the processes involved, especially:
    - natural selection
    - mutation
    - sexual selection
    - genetic drift (founder effect)
        - When does it occur
        - What conditions make it more/less likely
- Define genetic variation and explain its role in evolution
- Define fitness and predict circumstances in which it increases and decreases
- Describe practical applications of evolutionary theory including:
    - antibiotic resistance
    - pesticide resistance
    - species conservation
    - species management

Speciation (introduced in Marooned on the Galapagos)

By the end of the course students should be able to:

- Define species and be aware of the limits of the definition
- Explain how mutation and natural selection lead to speciation
- Identify patterns of evolution including:
    - Divergence
    - Adaptive radiation
- Explain how islands like the Galapagos become populated with unique species

Color and Vision (introduced in Rainbow Connection)

By the end of the course students should be able to:

- Explain why objects appear as different colors
- Predict the colors of light that will be absorbed, transmitted, or reflected from particular colored object under various light conditions
- Explain how the vertebrate eye sees color

- Explain how the vertebrate eye receives and sends a signal
- Explain the evolutionary advantage of seeing color

Color and Photosynthesis (introduced in Rainbow Connection)

By the end of the course students should be able to:

- Explain why plants absorb different colors of light
- Predict under which light conditions plants will photosynthesize better or worse
- Explain the role of plant pigments in absorbing different colors of light
- Explain how photosynthetic organisms have adapted to the light conditions at various depths

Photosynthesis (introduced in Rainbow Connection)

By the end of the course students should be able to:

- Predict the effects of various factors on the rate of photosynthesis, e.g.
    - light intensity
    - color of light
    - temperature
    - pH (concentration of hydrogen ions)
    - presence of inhibitors
- Describe the function of photosynthesis
- Describe the components of the chloroplast and their roles in photosynthesis
- Describe the components of the light-dependent & light-independent portions of photosynthesis
- Identify the reactants (chemical inputs) and products (chemical outputs) of the light-dependent & light-independent portions of photosynthesis
- Describe how to measure photosynthesis in various ways
- Explain how the light-dependent & light-independent portions of photosynthesis work and their similarities to cellular respiration

Population Size and Growth (introduced in Emerging Diseases)

By the end of the course students should be able to:

- Calculate the size of a population for multiple years using
  - number of births
  - number of deaths
  - birth rate
  - death rate
  - carrying capacity
  - intrinsic rate of growth
- Calcualte population density
- Describe patterns (models) of population growth including:
  - Exponential
  - Logistic
  - boom-and-bust
- Predict which growth model might best fit a particular situation
- Identify whether a particular factor would have a density-dependent or density independent effect on a population
- Describe factors that affected human population growth in more and less well developed countries

Immune System (introduced in Emerging Diseases)

By the end of the course students should be able to:

- Describe the role of certain components related to immunity and disease including
  - B-Cells
  - Antigens
  - Antibodies
  - Macrophages
  - antigen receptors
- Explain how immunity develops in an individual
- Explain how immunity evolves in a population
- Explain how diseases emerge and spread
- Explain how population changes and other factors affect spread of diseases

Origin of Eukaryotes (introduced in Emerging Diseases)

By the end of the course students should be able to:

- Explain the Theory of Endosymbiosis
- Describe the evidence that supports the theory

Cell Cycle (Introduced in Family Reunion)

By the end of the semester the students should be able to:

- List the major stages of the cell cycle
- Describe the events that take place in each stage
- Predict the results of events that might alter a specific stage
- Explain the relationship between the cell cycle, cell division, and cancer

Cell division (Introduced in Family Reunion)

By the end of the semester the students should be able to:

- Explain what is meant by haploid and diploid and predict the corresponding cell types
- Describe and predict the results of mitosis and meiosis given different diploid numbers.
- Predict when mitosis and meiosis will occur and explain why
- Explain how meiosis leads to genetic variation

Molecular Genetics (Introduced in Family Reunion)

By the end of the semester the students should be able to:

- Describe the makeup of nucleic acids including:
    - DNA & RNA (their similarities and differences)
    - Nucleotide composition and the types of nitrogenous bases
    - The nature of a codon
- Explain the “Central Dogma” in general terms including:
    - Replication including
        - When and where it occurs
    - Transcription including

        - When and where it occurs
    - Protein Synthesis/Translation including
        - When and where it occurs
    - Genetic code (Captain America mRNA-to-Amino Acid Decoder Ring) including
        - How it works
        - What is meant by Start and Stop codons

- Predict
    - the amino-acid sequence made from a given DNA or RNA sequence
    - DNA or RNA sequence that coded for a particular amino-acid sequence
    - the number of amino-acids, nucleotides, or codons present, given one of the other components.
    - The effect of mutations, including base-substitutions, insertions, or deletions, on the resulting DNA, RNA, protein (polypeptide), or phenotype.

Chromosomes (Introduced in Family Reunion)

By the end of the semester the students should be able to:

- Explain the relationships (including size and number) among
    - Homologous Pair
    - Chromosomes (autosome, X, Y)
    - genes
    - alleles
    - DNA
    - Codon

- Predict the location of a gene or allele given
    - its placement on a specific chromosome
    - an individual's phenotype or genotype

Inheritance (Introduced in Family Reunion)

By the end of the semester the students should be able to:

- Predict characteristics of offspring or parents including
    - Genotype
    - Phenotype
        - Ratios (percentages, proportions, probabilities) of specific phenotypes or genotypes

    for
    - crosses involving Single Gene Traits or combinations of single gene traits including those that are
        - Autosomal Dominant
        - Autosomal Recessive
        - X-Linked Dominant
        - X-Linked Recessive (e.g. Red-Green colorblindness, hemophilia)
        - Co-Dominant (e.g. Blood Type)

        - Multiple alleles (e.g. Blood Type)

- Solve genetics problems involving the above types of traits and
    - written descriptions (phenotypes) of the parents, grandparents, or offspring
    - given genotypes

Biogeochemical Cycles (introduced in Hogs and Chickens and More)

By the end of the course students should be able to:

- Explain what a biogeochemical is, including What are the generalized components
    - What is meant by biotic and abiotic components
    - What is meant by organic and inorganic components
    - Explain why nutrients cycle by energy flows

- Describe the workings of each of the major cycles, including:
    - Hydrologic, Carbon, Nitrogen, Phosphorus
    - Identify how each element enters the biotic and abiotic portions of the cycles
    - Describe the role of bacteria and cyanobacteria in each cycle
    - List major differences among the cycles
    - Explain what is meant by a limiting resource
    - Identify the direct and indirect sources of these nutrients for different autotrophs and heterotrophs including decomposers
    - Predict when each cycle may be limiting factor in an ecosystem

- Provide examples of where the elements C,H,O,N,P are used in living systems

- Explain how human interference with each cycle can have an impact on the environment, including such situations
    - Eutrophication and its affects on freshwater systems
    - Use of fossil fuels and air and water quality
    - Agriculture

Energy Pyramids and Trophic Levels (introduced in Hogs and Chickens and More)

By the end of the course students should be able to:

- Define what is meant by an energy pyramid and its components including
    - Trophic level
    - Heterotroph
    - Autotroph
    - Primary, Secondary, Tertiary, etc. consumer
    - Producer
    - Primary productivity

- Explain how energy flows through an ecosystem including:
    - Application of 1st and 2nd Laws of Thermodynamics
    - Why energy availability is not infinite
    - Why energy pyramids rarely exceed 5 levels
    - 10% rule
    - Roles of Cellular Respiration and Photosynthesis

- Apply concepts of energy flow to predict
    - Numbers of organisms at each trophic level
    - Amount of biomass at each trophic level
    - Relative environmental impact of humans because of their trophic level

Eutrophication (introduced in Hogs and Chickens and More)

By the end of the course students should be able to:

- Define Eutrophication

- Predict when eutrophication may occur including:
    - Natural eutrophication
    - Cultural eutrophication (human)

- Describe/predict the effect of eutrophication on
    - Dissolved oxygen
    - N & P levels of lake
        - Organic form
        - Inorganic form
    - Chlorophyll content of stream or lake
    - Populations of
        - Bacteria
        - Cyanobacteria
        - Algae
        - Fish and aquatic invertebrates
    - Biodiversity

Biomagnification/Bioaccumulation (introduced in Hogs and Chickens and More)

By the end of the course students should be able to:

- Explain how biomagnification works, including:
    - Why it occurs
    - What characteristics of substance allows for it
    - Which trophic levels have the least/most accumulation of a substance that can be bioaccumulated
    - How and why biomagnification "pyramids" are different than those of nutrients, energy, biomass, and numbers

Biodiversity (introduced in Hogs and Chickens and More)

By the end of the course students should be able to:

- Defined biodiversity
- Explain why biodiversity is beneficial to human and environment
- Predict when biodiversity may be high or low
- Explain the impact of the introduction of non-native species on biodiversity