Appendix One. The hierarchical level of each concept, its coverage in the pre-workshop version of the course (1=covered; 0=not covered), its coverage in the Spring 2008 version of the workshop course (1=covered; 0=not covered), and a description of each concept is listed in this appendix.

Level	Pre	Post	Concept
1st	1	1	**Scientific knowledge** is based on the evaluation of tentative hypotheses through systematic observation of nature.
2nd	1	1	**Hypotheses** are claims which can be scientifically tested, and potentially disproved.
3rd	1	1	Exploration of initial observations and related knowledge contributes to *hypothesis generation*.
3rd	1	1	*Hypotheses-testing* includes using the hypothesis to generate a prediction, then making observations and comparing the prediction of the hypothesis to the observations.
3rd	1	1	Hypotheses can be tested with *controlled experiments* which have independent and dependent variables or through *natural experiments* which do not include the controlled manipulation of independent variables.
3rd	1	1	Quantitative patterns in observed results are often illustrated with *graphs*.
4th	1	1	All experiments make *assumptions* which may or may not be true.
4th	1	1	*Null hypotheses* can be disproved but not proved.
4th	1	1	*Inferential statistics* estimate the probability that the variation between the observations and prediction are simply due to chance.
4th	1	1	*Model systems* are often used in controlled experiments.
4th	0	1	Some hypotheses are represented with *mathematical models*.
2nd	1	1	The **level of acceptance** of hypotheses varies greatly as a result of the number and quality of tests of the hypothesis that have supported it.
2nd	1	1	**Scientific facts** are observations or hypotheses that have been supported so many times that they are assumed to be true.
3rd	1	1	Examples of scientific facts: cells exist; genes are coded into the structure of DNA; evolution happens.
2nd	1	1	**Theories** are major concepts which link together many observations and hypotheses.
1st	1	1	**Evolution** is the change in the frequency of heritable traits of a population across generations.
2nd			**Natural selection** can result in adaptive evolution.
3rd	1	1	Natural selection is *differential survival* of individuals within a population based on a variation in trait.
4th	1	1	Natural selection is an interaction between individuals and their environment.
3rd	1	1	Natural selection results in evolution if the selected trait is *heritable*.
3rd	1	1	*Populations not individuals* evolve.
3rd	1	1	Evolution cannot occur unless there is *heritable variation* for the trait in the population.
4th	1	0	Natural selection can result in *directional*, *stabilizing*, or *disruptive*

			changes in phenotypes.
4th	1	1	Natural selection *against a dominant allele* can result in rapid fixation of the recessive.
4th	1	1	Natural selection *against a recessive allele* does not result in fixation.
4th	1	1	Natural selection *favoring heterozygous* genotypes maintains a balance of the frequency of alleles in the population and maintains genetic diversity.
2nd	1	1	**Genetic Drift** is a random pattern of evolution due to bottlenecks and founder effects.
3rd	1	1	*Genetic drift* is due to random sampling error of a trait in association with mortality or dispersal.
3rd	1	1	*Genetic (or demographic) Bottlenecks* are random mortality relative to a trait.
3rd	1	1	*Founder effects* are random dispersal relative to a trait.
3rd	1	1	Genetic drift reduces *genetic diversity*.
3rd	1	1	Reduced genetic diversity can result in *inbreeding depression*.
4th	1	1	Genetic drift and inbreeding depression are problems for *endangered species*.
2nd	1	1	**Sexual selection** is due to differences in fitness due to variation in traits which influence mating success.
3rd	1	1	*Sexually dimorphic* traits are more pronounced in the sex which invests less energy in producing gametes and caring for offspring (typically males).
4th	1	1	Sexually dimorphic traits function as *armaments* and/or *ornaments*.
3rd	1	1	Mate choice can be influenced by pre-existing sensory bias, non-genetic benefits to offspring or female, genetic benefits to offspring.
2nd	1	1	**Speciation** occurs when gene flow between diverging populations is blocked.
3rd	1	1	*Microevolutionary processes* (natural selection, genetic drift, mutation, gene flow) contribute to speciation.
4th	1	1	Secondary contact *reinforces* speciation if hybrids are less fit.
3rd	1	1	Speciation can occur *rapidly or slowly*.
3rd	1	1	*Adaptive Radiations* are characterized by relatively rapid speciation and diversification within a taxa.
4th	1	1	Adaptive radiations are triggered by *opportunities* resulting from environmental or genetic change.
4th	1	1	Heritable variation associated with adaptive radiations is often associated with *regulatory genes*.
2nd	1	1	**Extinction** is the permanent loss of a species.
3rd	1	1	Mass extinctions are times of widespread and relatively rapid extinction rates.
4th	1	1	The *K-T mass extinction* resulted in reduced dominance of reptiles and gymnosperms and triggered the adaptive radiations of angiosperms, insects, birds, and mammals.
4th	1	1	The K-T mass extinction was due to an *asteroid* impact.
4th	0	0	Some mass extinctions may have been influenced by the effects of the arrangement of *continental plates on climate*.
4th	0	0	We are entering a mass extinction due to climate change, habitat

			destruction, and invasive species.
1st	1	1	**Biodiversity** is a result of historic patterns of speciation and extinction
2nd	1	1	**Phylogenies** are hypotheses about speciation and extinction within a taxa.
3rd	1	1	*Domains* indicate that 2/3 of the diversity of life is prokaryotic.
4th	1	1	The wide range of habitats colonized by *prokaryotes* is associated with their *diverse metabolism*.
3rd	1	1	The phylogenetic history of *plants* is associated with adaptation to terrestrial environments.
4th	1	0	The fundamental life history difference between plants and animals is mitotic growth during the haploid stage of plant life cycles to produce *gametophytes*.
3rd	1	1	*Fungi* are more closely related to *animals* than to plants.
4th	1	0	Fungi differ from animals in that they secrete enzymes, *externally digest* molecules including cellulose, and then absorb the nutrients.
3rd	1	1	*Animal Phyla* are associated with morphological, mobility, & perceptual adaptations
4th	1	1	Exo- and endo-skeletons enable precise muscle control of appendages
4th	1	1	Insect pollinators & herbivores co-evolved with angiosperms
1st	1	1	Phenotypes are determined by **genotypes** and the **environment**.
2nd	1	1	Genes are **discrete units** on information passed unchanged, except for rare mutations, from parents to offspring.
2nd	1	1	The genetic code is a result of the structure of **DNA** within chromosomes.
2nd	1	1	**Alleles** are versions of genes.
3rd	1	1	**Mutation** produces new alleles.
4th	1	1	Mutations can occur at many levels: point mutations, chromosomal rearrangements, and changes in ploidy.
2nd	1	1	**Genotypes** describe an individual's alleles.
2nd	1	1	**Phenotypes** describe observable traits of individuals.
2nd	1	1	Meiosis, fertilization, and gene expression underlie **Mendelian patterns of inheritance**.
3rd	1	1	Somatic cells are *diploid.*
3rd	1	1	*Meiosis* randomly separates homologs into haploid gametes.
3rd	1	1	Genes on nonhomologous chromosomes *sort independently* resulting in genetic variation among gametes.
3rd	1	1	*Crossing over* increases genetic variation by rearranging alleles of genes between homologs.
3rd	1	1	*Fertilization* combines haploid gamete genotypes into diploid zygotes.
3rd	1	1	*Dominance relationships* describe the phenotypic expression of heterozygotes.
4th	1	1	*Pleiotropic* genes influence more than one phenotypic trait.
4th	1	1	*Epistatic* interactions between gene products influence the expression of genotypes into phenotypes.
3rd	1	1	*Quantitative traits* are influenced by polygenic genes.
3rd	1	1	In humans, X-linked genes are hemizygous in males.
4th	1	1	Males inherit these genes from their mothers.

4th	1	1	Multiplicative probability describes the increased expression of recessive X-linked genes in males.
2nd	1	1	While mutation is the ultimate source of new alleles, **recombination** produces new combinations of alleles.
3rd	1	1	In *eukaryotes*, crossing over, independent assortment, and fertilization contribute to recombination.
3rd	1	1	In *prokaryotes*, horizontal gene transfer results in recombination.
1st	1	0	**Behavior**al traits evolve in response to **natural selection**.
2nd	1	0	Behavior is a **response** to a **stimulus**.
2nd	1	0	Behaviors range from innate fixed action patterns to complex learned behaviors.
2nd	1	0	Behaviors can be learned through a variety of processes (e.g. operant, habituation, classical conditioning, imprinting).
1st	1	1	**Populations** have dynamic spatial and temporal structures.
2nd	1	1	**Population's characteristics** are estimated with a variety of **sampling** techniques.
2nd	1	0	The **spatial boundaries** of populations are influenced by abiotic factors, as well as species interactions; both of these factors change through time.
3rd	1	1	*Invasive species* have moved out of their native region and are disturbing natural and human communities.
2nd	1	1	**Population size** and density varies through time.
3rd	1	1	Populations with a constant and positive per capita growth rate grow **exponentially**.
4th	1	1	All species have a positive *biotic potential*.
4th	1	1	*Birth rate, death rate, and migration* determine r.
4th	1	1	Birth rate is determined by *fecundity and age structure*.
4th	1	1	Death rate is determined by *life span and age structure*.
4th	1	1	Age structure causes *demographic momentum*.
3rd	1	1	*Density-dependent mortality* can regulate N at K.
3rd	1	1	The *global human metapopulation* has increased global K, reduced d through agricultural, medicinal, and scientific innovations, and reduced b through birth control but is still growing exponentially.
1st	1	1	**Species interactions** influence the evolution of traits, population growth, and community structure.
2nd	1	1	**Parasitism, predation, and herbivory** are + -.
2nd	1	1	**Competition** is - -.
3rd	1	1	*Intraspecific competition* results in density-dependent mortality and contributes to K.
3rd	1	1	Strong intraspecific competition can contribute to *coexistence*.
3rd	1	1	Interspecific competition can result in *competitive exclusion, niche differentiation, and habitat partitioning*.
3rd	1	1	Inter- and intra-specific competition can occur through *exploitation or interference*.
3rd	1	1	*keystone predators* can reduce interspecific competition and increase species diversity of prey species.
2nd	1	1	**Mutualism** is + +.
3rd	1	1	Mutualism can promote *coexistence* and expand niches.
1st	1	1	**Communities** change in response to biotic and abiotic factors.
2nd	1	1	*Primary succession* initially favors species with high dispersal and

			tolerance.
2nd	1	1	*Secondary succession* is promoted by facilitation; slowed by inhibition.
3rd	1	1	*Intermediate disturbance* can increase species diversity and productivity
2nd	1	1	*Species diversity* increases with decreasing *latitude*.
1st	1	1	Energy flows through **ecosystems**; nutrients cycle within ecosystems.
2nd	1	1	Atmospheric **nitrogen** is common, but nitrogen is often *limiting*.
3rd	1	1	Nitrogen fixation, nitrification, and denitrification depend on *bacteria*.
2nd	1	1	**Photosynthesis & cellular respiration** are important components of energy flow and carbon cycling.
3rd	1	1	Deforestation and burning fossil fuels influence carbon cycling, energy flow, and result in climate change.
4th	1	1	There are direct and indirect measures of increasing atmospheric carbon dioxide.
4th	1	1	There is theoretical and empirical evidence of the link between carbon dioxide and climate change.
4th	1	1	Climate change, along with invasive species and habitat destruction, is resulting in the disruption of natural communities.