8 key ideas in Ecology

1. **Autecology – Organismas try to maintain constant internal conditions.**
    a. Salt-water balance (2)
    b. Light capture by plants (3)
    c. Gas exchange (3)
    d. Temperature relations (3)
2. **Populations – Organisms tend to grow in numbers in predictable ways**
    a. Growth (handouts)
        i. Exponential
        ii. Exponential with age classes
        iii. Logistic
    b. Metapopulation models (10)
    c. Life Tables (11)
3. **Symbiosis (14) - Organisms can interact in extremely intimate ways**
    a. Mutualism
    b. Parasitism
    c. Commensalism
    d. Evolution of symbiosis
4. **Predator-Prey – Predator and Prey populations affect each other in ways that can be predicted and modeled.**
    a. Models (15)
    b. Adaptations to avoid predation (17):
        i. Crypsis
        ii. Aposematism
        iii. Defenses
5. **Competition (16) – A major force in many ecosystems and in the distribution of organisms is the competition by organisms for limited resources.**
    a. Competitive Exclusion
    b. Models
    c. Types
6. **Communities (18) – Communities of organisms are assembled primarily based on feeding relationships.**
    a. Feeding relationships
    b. Stability
    c. Control
    d. Development (19)
7. **Energy Flow (22) – The feeding relationships in a community account for the movement of energy through the system; this movement is an important parameter controlling community structure.**
    a. Primary Production
    b. Loss of energy
    c. Models
    d. Productivity, Assimilation and Biomes
8. **Nutrient Flow (23, 24) – Like the flow of energy, the movement of nutrients has important implications for community structure.**
    a. Biogeochemical Cycles
    b. Biomagnification

Plus: Understand Biomes and why/where they occur

Learning Goals

1. Autecology – Organismas try to maintain constant internal conditions.

- Students will understand the concept of the niche as an attempt to simultaneously achieve a balance of acceptable environmental conditions (both internal and external) by an organism.
- Students will understand the physical and chemical basis for all of the environmental conditions covered, integrating knowledge first acquired in chemistry and introductory biology
- Students will be able to give and explain examples of strategies organisms use to survive, particularly in extreme environments.
- Students will understand that it is impossible to optimize all environmental conditions simultaneously because optimization of some parameters will oppose optimization of others.
- Students will begin to explore the concept of continua in the guise of environmental conditions as responses to those conditions.

1. Salt-water balance (2)
    - Understand why water is the basis for life
    - Understand the thermal properties of water and how these are important to organisms
    - Understand the importance of density/viscosity
    - Understand the role of water as a chemical solvent
    - Understand the nature of pH
    - Understand the role of soil structure in water availability on land
    - Understand the basis of osmosis in diffusion
    - Understand water flow in plants
    - Understand water and salt balance in plants
        - Cypress and mangroves as examples
        - Desert plants as examples
    - Understand how freshwater fish, saltwater fish and sharks achieve osmotic balance
    - Understand the linkage of nitrogen excretion and water balance
    - Understand the role of the 3 excretory molecules
2. Light capture by plants (3)
    - Understand the electromagnetic spectrum
    - Understand how the spectrum is changed from the top of the atmosphere to underwater
    - Understand the PAR
    - Be able to differentiate the 3 forms of photosynthesis in terms of how they operate and the ecological significance of the differences in the 3 types
    - Understand the linkage between photosynthesis and water loss, particularly the link between light absorption and overheating and the link between carbon dioxide uptake and transpiration
3. Gas exchange (3)
    - Understand the concept of boundary layer as it applies to water loss in desert plants and CO_2 uptake in aquatic plants
    - Be able to explain the relationship between atmospheric carbon dioxide and the forms it takes in water
    - Understand how oxygen can be toxic in large amounts and limiting in many environments
4. Temperature relations (3)
    - Understand the relationship between temperature and metabolic activity
    - Be able to give examples of how organisms tolerate sub-feezing temperatures

- Understand the concept of optimal temperature in terms of enzyme structure and function
- Be able to extend the concept of an optimum to pH, salinity and other factors based on knowledge of enzyme structure and function
- Understand the process of acclimatization from a genetic/enzymatic standpoint
- Be able to list and explain the 4 avenues of heat loss/gain
- Understand the relationship between body size, surface area, volume and thermal inertia
- Be able to distinguish between homeotherms and poikilotherms, and between ectothermic and endothermic heat acquisition
- Understand the concept of countercurrent circulation in terms of heat and gas exchange

2. Populations – Organisms tend to grow in numbers in predictable ways.

- Understand the mathematical basis by which populations grow
- Understand the ecological assumptions and implications of each growth model
- Gain a firm basis for mathematical analysis of population growth that may later be applied to analysis of competition and predation

1. Growth (handouts)
    i. Exponential
    - Be able to calculate population growth from first principles of a population growing exponentially
    - Be able to use a spreadsheet to construct an iterative model of exponential population growth given population growth parameters
    - Be able to recognize the exponential growth equation and use it to calculate population size of a population growing exponentially
    - Be able to recognize normal and semi-log graphs of a population growing exponentially
    - Be able to give examples of populations that would be expected to grow exponentially

    ii. Exponential with age classes
    - Be able to use the model for a population growing exponentially with age classes
    - Be able to use a spreadsheet to construct an iterative model of exponential population growth with age classes given population growth parameters
    - Be able to determine the stable age distribution for a population with age classes growing exponentially both from iterative data and by supplied equation

    iii. Logistic
    - Be able to use a spreadsheet to construct an iterative model of exponential population growth given population growth parameters
    - Be able to identify a normal or semi-log graph of logistic growth
    - Be able to determine key population parameters such as K, MSY, etc. from a graph of logistic growth
    - Be able to articulate the ecological factors which would cause growth to switch from density independent to density dependent
    - Understand the concept of R_0 and its effect on population growth over the range 0-4.
    - Understand what non-linear models are and how the logistic model demonstrates non-linear and chaotic behavior at certain values of R_0
    - Understand the concept of density dependent growth in sufficient detail to later apply this knowledge to competition and predation models.

2. Metapopulation models (10)
    - Understand the implications of fragmented habitats
    - Understand the terminology associated with distribution – range, habitat, territory, dispersion, etc.
    - Understand the 3 dispersion patterns, be able to give examples of each and explain why each develops.
    - Understand the ideal free distribution and why it develops.
    - Understand the 3 main metapopulation models
    - Understand the difference between a source and a sink in a metapopulation model

- Understand the relationship between local extinction and migration as the basis for the overall persistence of a metapopulation
- Understand how ecologists estimate population size and density
- Understand the importance of the matrix in the persistence of a metapopulation

3. Life Tables (11)
    - Understand what a life table is
    - Understand the two main types of life table
    - Be able to set up either type of life table in a spreadsheet from raw data
    - Understand the connection of life tables to population models

3. Symbiosis (14) - Organisms can interact in extremely intimate ways

- Know the 3 types of symbiosis
- Be able to complete a matrix showing the benefits/costs to both parties in each type of symbiosis
- Be able to supply the technical terms for each of the members in each of the symbiotic relationships
- Be able to give examples of each type of symbiosis
- Be able to examine an association of two species and specify which, if any of the symbioses is represented
- Be able to explain why a species association fits the definition for a symbiosis or why it does not

a) Mutualism
b) Parasitism
c) Commensalism
d) Evolution of symbiosis
    - Be able to explain how/why any symbiotic relationship would develop over time

4. Predator-Prey – Predator and Prey populations affect each other in ways that can be predicted and modeled.

1. Models (15)
    - Understand that predator and prey populations often cycle
    - Understand that predators control prey populations and vice versa
    - Understand the nature of predator/prey population cycles
    - Understand the mathematical models of simple predator/prey interactions
    - Understand the similarities between predator/prey and pathogen/host interactions
    - Understand the differences between functional and numerical responses by predators
    - Be able to list and identify the 3 types of functional response
    - Understand how differences in functional response affect predator/prey models
    - Understand the stabilizing factors in predator/prey interactions
2. Adaptations to avoid predation (17):
    - Be able to list and discuss various types of defenses against predation
    - Know the two types of mimicry and be able to give multiple examples of each
    - Understand the mathematical arguments underpinning the two types of mimicry
    - Be able to recognize and give examples of defenses

    iv. Crypsis
    v. Aposematism
        - Know why aposematism exists and what it tells you about the threats faced by an organism

    vi. Defenses

5. Competition (16) – A major force in many ecosystems and in the distribution of organisms is the competition by organisms for limited resources.

- Know the two types of competition; be able to explain why intraspecific competition is stronger than interspecific competition
- Understand the concept of resources
    i. Be able to distinguish between resources and conditions
    ii. Be able to distinguish between renewable and non-renewable resources
- Understand the concept of a limiting resource and the problems associated with employing it

1. Competitive Exclusion
    - Understand the origins of the competitive exclusion principle
2. Models
    - Understand the basis of the Lotka/Volterra/Gause models in the logistic equation
    - Be able to use basic parameters to draw competitor isoclines on a graph
    - Be able to use a graph of competition isoclines to predict the outcome of competition
3. Types and methods
    - Be able to distinguish between the TYPES of competition – intraspecific and interspecific
    - Be able to distinguish between the METHODS of competition – exploitative and interference
    - Understand asymmetric competition
    - Understand allelopathy as a form of competition
    - Understand the role of predators in influencing the outcome of competition

6. Communities (18) – Communities of organisms are assembled primarily based on feeding relationships.

- Understand the basic definitions of a community and an ecosystem
- Be able to differentiate between the holistic and individualistic concepts of a community
- Be able to differentiate between closed (holistic) and open (individualistic) community concepts
- Extend the continua concept to include worldviews and theoretical constructs
- Understand the concept of an ecotone
- Understand measures of community structure

1. Feeding relationships
    - Understand the various systems for organizing information about feeding relationships in a community
    - Understand the differences between food chains and webs
    - Understand the relationship between species diversity and food web complexity
2. Stability
    - Understand the different food web types and the kinds of information that can be gleaned from them
    - Understand the concepts of constancy and resilience
3. Control
    - Understand how predation and production interact to control abundance at different trophic levels
    - Understand the concept of trophic cascades
4. Development (19)
    - Understand the concept of succession
    - Understand and be able to give examples of seres
    - Understand the differences between pioneer and climax communities
    - Be able to distinguish between primary and secondary succession and give examples of each
    - Be able to distinguish the alternative roles of facilitation, inhibition and tolerance in succession
    - Understand the concepts of r and K adapted species in terms of succession
    - Understand transient and cyclic climaxes
    - Understand the relationship between succession and biomes
    - ***By this point in the semester you should know all the major biomes; where on Earth they are found, and be able to list some characteristic plants and animals for each.***

7. Energy Flow (22) – The feeding relationships in a community account for the movement of energy through the system; this movement is an important parameter controlling community structure

- Understand that ecosystems function according to the laws of thermodynamics
- Understand why a pyramid of energy develops in ecosystems
- Understand how a pyramid of energy leads to pyramids of biomass and numbers

1. Primary Production
    - Understand what affects primary production
    - Be able to distinguish between net and gross primary production
    - Understand how productivity is measured or estimated
    - Understand the relationship between light intensity and production
2. Loss of energy
    - Understand the concepts of ecological and assimilation efficiency
    - Understand the difference between net and gross production efficiency
3. Models
    - Be able to construct a basic model of energy flow through an ecosystem from first principles
4. Productivity, Assimilation and Biomes
    - Understand the differences between and importance of grazing and detritus based food chains
    - Understand the concept of residence time
    - Understand the concept of biomass accumulation ratio

8. Nutrient Flow (23, 24) – Like the flow of energy, the movement of nutrients has important implications for community structure.

- Understand how energy and nutrient movement through ecosystems are similar, and how they are different
- Understand how ecosystem models can be constructed by theoretical division of the environment into compartments linked by processes

1. Biogeochemical Cycles
    - Be able to reproduce the main elements of the water, carbon, nitrogen and phosphorous cycles
    - Be aware of the key roles of microorganisms in these cycles, particularly decomposing bacteria and fungi, nitrogen fixing bacteria and mycorrhizae
    - Understand the importance and differences in chemoautotrophic systems
    - Understand how nutrient cycling differs in aquatic ecosystems
2. Biomagnification
    - Understand how the basic process of nutrient accession and retention can lead to bioaccumulation of potentially toxic chemicals
    - Understand how bioaccumulation and biomagnifications can be used intentionally to remediate contaminated sites