Brief Outline of Material for Exam 1

This study guide covers most of the material that will be covered on the exam.
Questions types may include multiple choice, matching, fill-in-the-blank, and short essay.

What is Ecology?
- Oikos + Logos
- Definitions
  - Haekel (1869) first
  - Elton, Odum, Andrewartha, Krebs
  - Molles: the study of relationships between organisms and their environment
- Levels of ecological organization
  - Organism, organismal ecology
  - Population, population ecology
  - Community, community ecology
  - Ecosystem, ecosystem ecology
  - Landscape, landscape ecology
  - Biosphere, global ecology
- Approaches to study of ecology
  - Descriptive
  - Functional
  - Evolution
- History of Ecology
  - Non-science views
  - Early scientific approaches (esp. populations)
  - Modern ecology
    - identification of key problems
    - development of statistical analysis
    - experimental field approach
  - Environmental Science

Biomes & Climate
- Global climate patterns
  - Uneven heating due to shape of earth
  - Seasonal variation due to tilt of axis
  - Cyclic patterns of air movement
    - rising air at equator cools, produces rain
    - falling air at ±30°, warms, is very dry
    - 3 sets of cells/hemisphere
  - Surface winds
    - Coriolis effect
- Local climates
  - Effect of plant transpiration
  - Water moderates temperature
  - Rain shadows
- Climate diagrams
  - *Be able to read and interpret*
  - *Be able to match to type of biome*
- Soil
  - O, A, B, C horizons
  - Variation in soil types

The Biomes:
- *Know general locations, climatic conditions, typical soil, plant structure for each*
- Tropical Rainforest
- Tropical Dry Forest
- Savanna (Tropical Grassland)
- Desert
  - hot vs cold deserts
- Mediterranean Scrub (chaparral, etc)
- Temperate Grasslands (prairie, etc.)
- Temperate Forest
  - temperate deciduous forest
  - temperate coniferous (rain) forest
- Boreal Forest (Taiga)
- Tundra
- Mountain regions
- Climate Variation

Aquatic Biomes
- 71% of earth surface
- 97% salt water (oceans)
- Hydrological Cycle
  - Evaporation (oceans, lakes)
  - Transpiration (plants)
  - Precipitation
  - Surface flow & Groundwater
- Aquatic biomes defined by physical, chemical: light; temperature; movement; salinity; O_2
- Oceans
  - Largest biome; ≈4km deep ave.
  - Salinity 34-36.5‰
  - O_2 0.9%
  - Oceanic Zone
    - Pelagic vs Benthic
    - Epipelagic Zone
    - Mesopelagic Zone
    - Bathypelagic Zone
    - Abyssal & Hadal Zone
  - Separation of nutrients and sunlight
    - low productivity
  - Near-shore waters
    - Neritic Zone
    - Littoral (intertidal) Zone
  - Coral Reefs
    - shallow tropical water
    - built by corals with endosymbiotic algae
    - high productivity, diversity
    - associated sea grass beds

Aquatic Biomes, continued
- Kelp Forests
  - 25-40 m deep water with rocky bottoms
  - temperate coasts
- Intertidal Zone
  - rocky vs sandy intertidal
  - steep environmental gradients
  - variable environment
- Salt Marshes
  - temperate shores
  - currents produce complex structure
  - high productivity
- Mangrove Forests
  - trees with butressed roots
  - resist erosion
- Estuaries

Rivers
- Variable conditions
- Characteristics change along length
  - headwater streams
  - downstream rivers
- Structure along width:
  - wetted & active channels, riparian zone
- Vertical structure:
  - water column, benthic zones, etc

Lakes
- Very variable, in size, etc.
  - salinity from 0 - 200‰
- Thermal stratification (summer, winter)
  - mixes in spring, fall
- Oligotrophic lakes
- Eutrophic lakes; eutrophication

Wetlands
- swamp, marsh, bog
- ecotone

Evolutionary Genetics

Natural Selection
- Obs 1: Produce excess young
- Obs 2: Populations stable
- Obs 3: Resources limited
  - Inf 1: Struggle for existence
- Obs 4: Individual variations
  - Inf 2: Survival of fittest/Natural selection
- Obs 5: Inheritance
  - Inf 3: Population evolves

Adaptation

Modern synthesis
- population genetics
- allele frequencies

Hardy-Weinberg Equilibrium
- $p + q = 1$
- $p^2 + 2pq + q^2 = 1$

Evolutionary Genetics, continued
- H-W Assumptions (evolutionary mechanisms)
  - No mutation
  - No gene flow
  - Random mating
  - Large/infinite population size
  - No selection

Genetic drift
- Esp. small populations
- Loss of genetic variation

Gene flow
- Reduces population differences
- Prevents local adaptations

Natural selection
- Fitness
- Directional selection
- Stabilizing selection
- Disruptive selection

Sources of variation
- Genetic vs environmental
- Transplant/common environment experiments
- Heritability: $h^2 = V_G/(V_G+V_E)$
- Parent-offspring regression

Beak evolution in soapberry bugs

Ecological Physiology: Temperature
- Optimal operating temperature of enzymes
- Performance vs temperature
  - e.g., prokaryotes; plants
- Tolerance limits: temperate vs tropical
- Acclimation

Regulating temperature
- Square-cube law
- Poikilothermy vs homeothermy
- Ectothermy vs endothermy

Heat Exchange
- Conduction
- Convection
- Radiation
- Evaporation (cooling only)

Thermoregulation
- Selecting microclimates (e.g. cactus wren)
- Orientation to sun
- Change body shape (flatten, spread wings)
- Change color

Endothermy
- benefits vs costs
- metabolic rate of endotherms vs ectotherms
- insulation
- counter-current exchange

Torpor
- Hibernation
- Estivation
- “Torpor” in ectotherms

Ecological Physiology: Water Relations

- Osmosis
  - Semipermeable membranes
  - Iso-osmotic: marine invertebrates, etc.
    - no net gain/loss of water
  - Hypo-osmotic: marine bony fish
    - drink sea water; sparse urine
    - gills, kidneys pump ions out
  - Hyperosmotic: fresh water organisms
    - don't drink; copius, dilute urine
    - take up, recover salts in gills, kidneys
- Water Availability on Land
  - Relative humidity
    - density vs partial pressure
  - Saturation pressure vs temperature
  - Vapor pressure deficit
- Uptake by plants
  - Water potential gradient
    - transpiration/evaporation by leaves
    - resistance in plant and soil
  - Loss by plants: transpiration, some via nectar
  - Uptake by plants: soil, some water from air
    - root development in taiga vs desert
    - root growth as adaptation for dry habitats
- Strategies of desert plants
  - Drought evasion
    - Annual plants grow in wet season
    - Dormant as seeds when dry
    - Few physiological adaptations to drought
  - Drought tolerance
    - Shrubs, trees become dormant when dry
    - Metabolic rates near 0
    - Extensive, deep roots
    - Slow to respond to rain
    - Adaptations:
      - microphylly; deciduous
      - light-colored hairs; vertical leaves
  - Succulence
    - Store water
    - Extensive, shallow root systems
    - Remain metabolically active
    - Respond quickly to rain
    - Adaptations:
      - thick, waterproof, or reduced leaves
      - spines, toxins
      - close stomata in day
- Photosynthesis and water conservation
  - Open stomata required for gas exchange
  - Light reactions & Calvin-Benson cycle
  - Types of phototsynthesis
    - C_3 photosynthesis
      - standard-CO_2 binds directly to RuBP
    - C_4 photosynthesis
      - CO_2 binds to PEP in separate cell

Water Relations, continued

- **Types of photosynthesis, continued**
  - CAM photosynthesis
    - CO_2 binds to PEP at night
- Water balance in animals
  - Gain water by: drinking, water in food, metabolic water, absorb from air
  - Lose water by: evaporation
    - secretions (feces, urine)
  - Evaporative cooling by Desert cicada
- Water Conservation in Desert Animals
  - Water budgets of Namib desert beetle, k-rat
  - Seeking cooler microclimates
  - Increasing body temperature
  - Reducing water loss in urine: kangaroo rats
  - Waterproof cuticle

Ecological Physiology: Nutrition

- Sources of Energy
- Sources of Carbon
- Nutritional Modes
  - Phototrophs vs Chemotrophs
  - Autotrophs vs Heterotrophs
  - Photosynthetic autotrophs
  - Chemosynthetic autotrophs
  - Photoheterotrophs
  - (Chemo)heterotrophs
- Photosynthesis
  - P_{max} higher for species from sunny environ.
- Chemosynthesis
  - Deep-sea volcanic vent communities
  - Chemoautotrophic bacteria use H_2S for energy
  - Nitifying bacteria
    - $NH_4 \rightarrow NO_2 \rightarrow NO_3$
- Heterotrophs
  - Herbivores; carnivores; omnivores; detritivores
- Herbivory
  - Plants have high C:N ratio
  - Can't digest cellulose, lignin
  - Plant defenses
    - high cellulose/lignin content
    - spines, hairs, silica
    - chemical defenses (prevent digestion, toxic)
- Carnivory
  - Prey defenses
    - spines, shells, cryptic coloration
    - chemical defenses, aposematism
    - startle, distraction displays
    - Müllerian vs Batesian mimicry
- Optimal foraging
  - Economic, cost/benefit approach
  - Oystercatcher mussel-size preferences
  - Bluegill sunfish optimal prey size
  - Lizard predator avoidance

General Review & Practice Questions

These questions are to help you study. Some of these may require long answers, but some can be answered in just a few words. You will also have short-answer questions such as fill-in-the-blank and matching questions.

- What is Ecology? How have the definitions changed over time? (know especially Haekel, Krebs, and your text's definitions).
- Rank the levels of ecological organization from least to most complex & from best to least understood.
- How do the subjects and questions of organismal, population, community, and ecosystem ecology differ from one another?
- Compare and contrast descriptive ecology, functional ecology, and evolutionary ecology.
- Briefly outline the history of ecological thought, from prehistoric knowledge, early ecological observations, to the beginnings as a scientific discipline.
- What characteristics sets modern ecology appart from earlier approaches (in 1800s)?
- Describe the primary causes of geographic variation in climate. Include the role of the shape and tilt of the earth and the role of air movements.
- How is climate altered at the local level by plant density, bodies of water, and mountains?
- Why don't surface winds move due north and south?
- Be able to read and interpret climate diagrams. Identify relatively wet and relatively dry periods. You may be asked to match climate diagrams to their biome (don't worry, I'll avoid ambiguous choises).
- Briefly describe the 4 main soil horizons. Which of these contains the most nutrients? Know the major differences in soil types between biomes, especially tropical rainforest, desert, temperate forest, and temperate grassland.
- Be able to list all of the terrestrial biomes discussed in class. For each, indicate its geographic distribution, climatic conditions (hint: tropical and temperate climates can usually be distinguished by seasonality in temperature), and general soil characteristics (depth/nutrient content). Also be able to describe or match physical descriptions of the plant community to the biome. Note other distinctive features such as if fire or grazing mammals are important. See table below.
- How do plant communities change as one increases in elevation up a mountain?
- Why are there no cold, wet climates?
- Describe the hydrological cycle.
- What characteristics are usually used to categorize aquatic biomes?
- What effect does the availability of light have on biological processes in aquatic systems. Which areas get most of the light?
- How does salinity vary among aquatic biomes? Which biomes are more variable?
- How does oxygen availabity compare between terrestrial and aquatic ecosystems. Consider both average amounts and variation.
- What are the major verticle zones of the the oceanic zone? How do they differ in their physical and biological processes?
- Why does the oceanic zone have such low productivity compared to the neritic zone?
- The intertidal zone is often considered one of the most physiologically challenging environments for organisms. Why is this so?

- Where are coral reefs found, both geographically and type of environment? How are they formed? What are some key biological characteristics (diversity, productivity, etc.) or coral reefs?
- What do biomes such as tropical rainforests, salt marshes, and coral reefs have in common?
- Where are kelp forests found? What do they look like?
- Describe salt marshes and mangrove forests. Where are they found? Why are both of these communities important to the fisheries industry?
- Describe how a river differs between its headwaters and the downstream portions. What factors contribute to this difference? How might a river running through a forest differ from one in a desert?
- In what ways are lakes similar to oceans and in what ways do they differ?
- Describe the patterns of season mixing and thermal stratification in a typical lake.
- Compare and contrast oligotrophic and eutrophic lakes.
- Describe the basic observations and the inferences from those observations that lead to the idea of evolution by natural selection.
- What is an allele? What is meant by allele frequencies? If given the number of individuals of each phenotype in a population, you should be able to determine the frequencies of each allele.
- If given the frequencies of two alleles for a gene, determine the expected hardy-Weinberg equilibrium genotype frequencies.
- What are the assumptions of the Hardy-Weinberg equilibrium? Why are these important for understand the mechanisms of evolutionary change?
- How does small population size lead to evolutionary change? How does this usually affect genetic variation? Discuss an example.
- Why does gene flow prevent populations from adapting to their local environment? Discuss an example.
- How can we differentiate variation caused by environmental differences from genetic variation? Discuss an example.
- Define heritability both verbally and mathematically. How can heritability be estimated in natural populations.
- What are the three modes of natural selection? What kind of phenotypic change is produced by each?
- Describe the evolution of beak length in the soapberry bug.
- Why does temperature matter to organisms? Give examples.
- Give two examples of different pairs of species that are adapted to different temperature regimes. How do their performances at various temperatures differ?
- Give an example of a species that is capable of acclimating to different temperature conditions. How might this acclimation accomplished at the biochemical level?
- What is the square-cube law and why is it important to all organisms? Be able to compare the total and relative surface area and volume of two organisms of different size.
- Compare poikilothermy and homeothermy. Give some examples of organisms that use each strategy.
- Compare endothermy and ectothermy. Give some examples of organisms that use each strategy. How do these terms relate to poikilothermy and homeothermy? How do these strategies differ in maintaining activity levels and in overall energy costs?

- Why do most aquatic organisms not regulate their body temperature? Why do many terrestrial organisms regulate their body temperature?
- Briefly describe the four ways in which organisms exchange heat with the environment. What additional source of heat, besides these four mechanisms, is also available to organisms?
- Describe some of the ways in which ectotherms regulate their body temperature.
- Why are ectothermic reptiles so successful in desert environments?
- How and why does metabolic rate vary with body size?
- What are the means used by endotherms to conserve body heat?
- What is torpor? What kinds of organisms use torpor and under what conditions?
- How does hibernation differ from daily torpor? Describe the process of hibernation in an animal such as a ground squirrel.
- Which way does water move if an organism is hyperosmotic relative to its environment? Hypo-osmotic? Iso-osmotic?
- How do salt water and fresh water fishes differ in the osmotic stress that they face? How do they their osmoregulating mechanisms differ?
- Describe how plants take up water. What is the water pressure deficit that drives this process?
- How do root systems of plants relate to climate? Give examples of variation within & between species.
- What are the three main strategies used by plants to endure desert environments? What are the characteristics and adaptations of the plants that use each of these?
- Briefly compare C_3, C_4 and CAM photosynthesis. In what environments/types of plants are these processes found?
- From what sources do animals gain water and in what ways do they lose water?
- What are some mechanisms used by desert animals to reduce water loss? Give examples.
- Compare autotrophs, chemotrophs, autotrophs, and heterotrophs. Which terms refer to where organisms get their energy and where they get their carbon?
- Compare photosynthetic and chemosynthetic autotrophs. How do they differ and in what ways are they the same (in terms of basic nutritional mode). What types of organisms are found in each category?
- How does P_{max} differ for plants from low light and high light environments?
- What is the energy source that drives deep-sea hydrothermal vent communities?
- What do nitrifying bacteria do and why are they important?
- What is meant by C:N ratio and how does id differ between plants and animals and among differnt parts of the plant?
- Describe the various kinds of defenses used by plants to prevent herbivory.
- Describe some of the defenses used by animals to prevent predation.
- Compare Müllerian and Batesian mimicry.
- Do oystercatchers forage in a manner predicted by optimal foraging theory? Why or why not?
- How does predation risk affect foraging habits of garden skinks?

Fill in the following table:

Biome	Latitude range	Temperature & variation	Rainfall & variation	Soil	Plant characteristics	Other
Tropical rain forest						
Tropical dry forest						
Savanna						
Desert						
Mediterranean Scrub						
Temperate grassland						
Temperate deciduous forest						
Temperate coniferous forest						
Boreal forest						
Tundra						

PRACTICE QUESTIONS FOR EXAM 1

Notes:
- The following are questions from a previous exam, to give you a feel for what the exam will be like and what kinds of questions you should expect.
- Your actual test will provide more space for written answers than is available here.

Multiple choice. *Select the best answer to each question.*

1. The branch of ecology studying the interactions among different species in an area is:
   A. community ecology B. ecosystem ecology C. biosphere ecology
   D. organismal ecology E. population ecology

2. The first person to define ecology as a discipline was:
   A. Charles Darwin B. Ernst Haekel C. Charles Elton D. Charles Krebs

3. Which of the following is arranged from the least complex to the most complex?
   A. community → population → landscape → biosphere → ecosystem
   B. population → community → ecosystem → landscape → biosphere
   C. population → community → landscape → ecosystem → biosphere
   D. community → population → ecosystem → landscape → biosphere

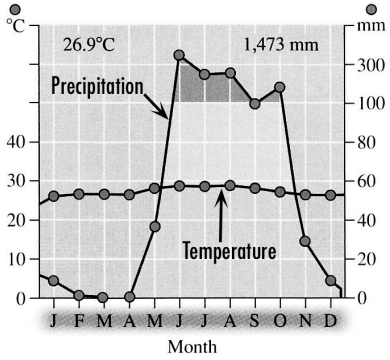
4. Seasonal variation in temperature is due primarily to:
   A. the tilt of the earth's axis B. earth's spherical shape
   C. uneven heating of the earth's oceans D. geographic features such as mountain ranges

5. If you started your journey at the equator and traveled north, what is the correct sequence of biomes you would encounter?
   A. Tropical Rain Forest — Desert — Temperate Forest — Taiga — Tundra
   B. Tropical Rain Forest — Desert — Taiga — Temperate Forest — Tundra
   C. Desert — Temperate Forest — Taiga — Tropical Rain Forest — Tundra
   D. Tundra — Temperate Forest — Taiga — Desert — Tropical Rain Forest

6. The daily decrease in body temperature to conserve energy during non-feeding periods is known as:
   A. estivation B. hibernation C. sleeping
   D. temporary ectothermy E. torpor

7. The transfer of heat between an organism and flowing air or water is called:
   A. conduction B. convection C. evaporation D. radiation

8. Which biome is represented by the climate diagram at right (temperature and precipitation curves are indicated)?
   A. boreal forest
   B. desert
   C. temperate deciduous forest
   D. tropical dry forest

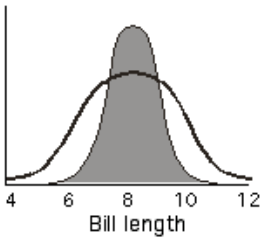


9. As the linear length of an animal doubles (but its shape remains the same), its volume:
   A. doubles B. remains the same
   C. increases four-times D. increases eight-times

10. Which of the following climatic conditions does **not** exist on earth?
   A. cold temperatures and low precipitation B. cold temperatures and high precipitation
   C. warm temperatures and low precipitation D. warm temperatures and high precipitation

11. As the body temperature of garter snakes increases, performance:
   A. decreases continuously B. decreases initially and then increases
   C. increases continuously D. increases initially and then decreases

12. In the figure at right, the open curve indicates the initial distribution of bill lengths in a population of birds, while the shaded curve shows the distribution of bill length following a period of natural selection. Which type of selection is illustrated in this figure?
    A. directional selection
    B. disruptive selection
    C. stabilizing selection



13. Based just on the observations that organisms produce more young than needed to maintain stable population sizes and that resources are limited, we can infer that:
    A. evolutionary change will occur
    B. one of these observations must be incorrect
    C. organisms refrain from reproducing in order to prevent overpopulation
    D. survival and reproduction is completely random
    E. there is a struggle for existence

14. In soapberry bugs, an evolutionary change in beak length came about as a result of:
    A. the introduction of a new food source
    D. the introduction of a new predator
    C. a change in the overall color of the environment
    B. a prolonged drought

15. Heritability is a measure of:
    A. the number of loci that control a particular trait
    B. the overall heterozygosity within a population
    C. the proportion of an individuals traits that exhibit heterozygosity
    D. the proportion of a trait's variation in a population that is due to genetic variation
    E. whether or not a trait is genetically determined

16. Fresh water fishes:
    A. drink lots of water and produce copious dilute urine
    B. drink lots of water and produce scant, concentrated urine
    C. do not drink and produce copious dilute urine
    D. do not drink and produce scant, concentrated urine

17. The similar appearance of two different distasteful or toxic species is an example of:
    A. crypticity
    B. divergent evolution
    C. Müllerian mimicry
    D. Batesian mimicry

18. In __ photosynthesis, carbon is fixed as a 4-C acid at night and released for photosynthesis in the day.
    A. C_3
    B. C_4
    C. CAM

19. Marine bony fishes are __to sea water.
    A. hyperosmotic
    B. hypo-osmotic
    C. iso-osmotic

20. Matching. *Match the soil horizons with their best description. Each choice is used only once.*

_____ A-horizon	A. contains clay and leached organic material
_____ B-horizon	B. layer of fallen organic material such as leaves
_____ C-horizon	C. mixture of mineral and organic materials; contains most nutrients
_____ O-horizon	D. weathered bedrock

21. Matching. *Match each of the biomes with the best description. Each letter is used only once.*

_____ Desert	A. Dominated by coniferous trees; short growing season
_____ Tundra	B. Fires, grazing mammals & termites are important
_____ Savanna	C. Permafrost prevents water drainage; vegetation stunted
_____ Boreal forest	D. Plants are widely spaced and adapted to arid conditions
_____ Tropical rain forest	E. The most complex, diverse, and species-rich biome

True or False. *Indicate if the following statements are true or false.*

22. Large endotherms (> 5 kg) are unable to hibernate
23. If a population is at Hardy-Weinberg equilibrium, its allele frequencies will never change.
24. The effect of genetic drift is most pronounced in large populations
25. Some reptiles are able to deliberately amputate part of their tail

Fill in the blanks.

26. _____ are traits that have evolved by natural selection for a particular function.

27. The deflection of surface winds to the east or west is due to the _____ effect.

28. In a population of flowers, the following genotypes are present at the indicated frequencies:

freq(**AA**) = 0.60 freq(**Aa**) = 0.30 freq(**aa**) = 0.10

A. What are the allele frequencies (p and q) in this population?

B. What will be the expected genotype frequencies after one generation of random mating if the population is at Hardy-Weinberg equilibrium ? (Hint: $p^2 + 2pq + q^2 = 1$)

29. State the 5 assumptions of the Hardy-Weinberg equilibrium model.

30. Why does the oceanic zone generally have such low productivity?

31. Describe the major causes of global patterns of precipitation.

32. Species that maintain a body osmolarity that is identical to its environment are referred to as _____

33. The deflection of surface winds to the east or west is due to the _____effect.

34. How do nitrifying bacteria obtain their energy, and why are they important to ecosystems?

35. List four ways in which desert plants reduce water loss.

36. Definitions. Define the following terms.

Pelagic Bog Homeothermy Aposematism Transpiration Detritivore