Chapter 5. Evolution of Biodiversity

I. Earth's tremendous diversity
   A. life comes in many forms
   B. Recall
      1. we can think of biodiversity in three ways
         a) genetic diversity
         b) species diversity
         c) ecosystem diversity
      2. a species s a distinct group of organisms that can interbreed with other individuals of the group to produce viable offspring
   C. How may species on Earth
      1. the number of species within a particular place is the most common measure of biodiversity
      2. estimating the total number of species is a challenge
         a) some are not easy to find
         b) some are only active at night
         c) some live in inaccessible locations
         d) some are microscopic
      3. approximately 2 million species have been cataloged thus far
      4. a varying number of estimates for total number of species exist
         a) range from 5 million to 100 million
         b) 10 million is the most accepted estimate
   D. Species Richness & Species Evenness
      1. number of species on Earth is not a functional value for understanding local species diversity
         a) because species are not uniformly distributed across the planet
      2. species richness
         a) number of species in a given area - a pond, tree canopy, plot of grassland, etc…
         b) gives an approximate sense of biodiversity at that particular place
      3. species evenness
         a) identifies if an ecosystem is dominated by a particular species
         b) high evenness = all species are represented by a similar number of individuals
         c) low evenness = one species has many individuals and other species have few individuals
      4. can be used to measure ecosystem change, if measures are known
   E. Evolutionary relationships between species

1. phylogenies
    a) the branching pattern indicating how closely related one species is to another , evolutionarily
2. phylogenetic tree
    a) diagram of phylogenies
3. relatedness is dependent of similarity of traits
    a) the more similar the traits of two species, the more closely related they are
    b) morphology
    c) behavior
    d) genetics

II. Evolution underlies biodiversity

A. Evolution

1. the change in a populations genetic composition over time
2. two types of evolution
    a) microevolution
        (1) varieties within a species develop
    b) macroevolution
        (1) genetic changes give rise to new species or larger categories of organisms

B. Creating genetic diversity

1. genes
    a) physical location on chromosomes within each cell of an organism
    b) determine a range of possible traits for the organism
2. mutation
    a) a random mistake made in copying DNA resulting in a change in the genetic code
    b) most are detrimental and reduce survival of the individual
    c) some improve an organism's chance for survival
3. recombination
    a) when a piece of one chomosome breaks off and reattahces to another chromosome
    b) does not creat new genes
    c) does create new combinations of genes
        (1) can bring about novel traits
4. genotypes vs. phenotypes
    a) genotype
        (1) complete set of genes in an individual

(2) serves as a "blueprint for a complete set of traits for an individual

b) phenotype

(1) the actual set of traits expressed by an individual

(2) many phenotypes are expressions of genes brought about due to the individual's environment combined with its genotype

C. Evolution by artifical selection

1. when humans determine which individuals breed in order to express particular desired traits

a) dogs (*Canis domesticus*)

(1) a single species with many different breeds

b) wild mustard (*Brassica oleracea*)

(1) brussels sprouts

(2) cauliflower

(3) broccoli

(4) cabbage

(5) kale

(6) kohlrabi

c) unintended artificial selection

(1) herbicide resistant weeds

(2) antibiotic-resistant bacteria

D. Evolution by natural selection

1. similar to evolution by artificial selection, except that the environment decides which individuals survive and reproduce

a) populations vary in their traits

b) certain traits make individuals better able to survive and reproduce

c) the genes that code for thos etraits tend to be more prevelent in the follwoing generation of individuals

2. key ideas:

a) individuals produce an excess of offspring

b) not all offspring can survive

c) individuals differ in their traits

d) differences in traits can be passed from parents to offspring

e) differences is the traits are associated with the ability to survive and reproduce

3. natural selection, thus, favors traits that improve an individual's "fitness"

a) fitness - ability to survive and reproduce within the conditions of a particular environment

4. adaptations

a) traits that improve and individual's fitness

E. Evolution by random processes (all are non-adaptive and random)
   1. mutation
   2. genetic drift
      a) a change in the genetic composition of a population due to random mating
      b) important in small population
         (1) random changes can have a larger influence on the overall population
   3. bottleneck effect
      a) a drastic reduction in a population size
         (1) lost individuals may cause the complete loss of particular genetic traits
      b) can cause
         (1) increased risk of disease
         (2) low fertility
         (3) lowered ability to adapt to future environmental changes
   4. founder effect
      a) when a few individuals colonize a new area, a separated form the remainder of the population and survive
      b) genetic traits are restricted to those of the few "founder" of the new population

III. Speciation and Extinction determine biodiversity
   A. speciation has given rise to millions of species present on Earth
   B. Allopatric vs. Sympatric speciation
      1. allopatric speciation ("other fatherland")
         a) geographic isolation
            (1) physically and permanently separating individuals from a larger population
         b) reproductive isolation
            (1) after a long enough time, if the physical separation is removed, the two populations might not be able to produce viable offspring
         c) thought to be the most common form of speciation
      2. sympatric speciation ("same fatherland")
         a) the evolution of one species into two species in the absence of geographic isolation
            (1) polyploid organisms form as a genetic mutation from diploid organisms; however, while they can interbreed with other

polyploid organisms they cannot interbreed with diploid organisms

C. Pace of evolution
    1. average global rate of evolution is ~1 new species every 3 million years
    2. depends upon
        a) rate of environmental change
            (1) to survive a rapid environmental change, species must evolve rapidly
        b) genetic variation
            (1) high genetic variation makes it more likely that individuals well suited for the new environment exist
            (2) large populations over widespread geographic regions ensures the best opportunity for adaptation to environmental changes
        c) population size
            (1) if a beneficial mutation occurs, it spreads more quickly in a small population
            (2) small populations are also more likely to undergo rapid evolution by random processes discussed earlier
        d) generation time
            (1) species with rapid reproductive maturity tend to evolve more rapidly
    3. Genetically modified organisms (GMOs)
        a) organisms who have artificially been produced by inserting the genetic material from one organism with a desired trait into another organism
            (1) done through genetic engineering
        b) when GMOs reproduce they pass on the inserted genes to their offspring

IV. Evolution shapes ecological niches and species distribution

A. Range of tolerance
    1. the limits to the abiotic conditions a species can tolerate
        a) extremes of
            (1) temperature
            (2) humidity
            (3) salinity
            (4) pH
        b) every species has an optimal environment with its range of tolerance

B. fundamental niche
    1. the suite of optimal abiotic conditions for a given species to survive and thrive in an environment

C. realized niche
    1. a more narrowly defined niche which takes into account biotic limitations
        a) biotic limitations in addition to fundamental niche
            (1) competitors
            (2) predators
            (3) disease
D. distribution
    1. area of the world in which a species lives
E. niche generalists
    1. species that can live in a variety of habitats or feed on a variety of species
    2. fare well under changing environmental conditions
F. niche specialists
    1. species that can only live in a specific habitat or feed on specific species
    2. are sensitive to changing environmental conditions (possibly vulnerable to extinction)
G. Environmental change and species distributions
    1. changes in environmental conditions have the potential to alter species distributions
        a) past environmental changes has led to altered distributions
    2. dependent upon a species mobility
    3. anthropogenic obstacles might be a new factor as environmental conditions change
H. Environmental change and species extinctions
    1. species that cannot adapt to changing environmental conditions or move, will eventually go extinct
    2. average life span of a species: ~1,000,000 to 10,000,000 years
    3. 99% of all species that have ever lived are now extinct
    4. why might a species go extinct?
        a) there may be no favorable environment nearby to which the species can move
        b) alternative favorable environments might already be occupied by another, more competitive, species with the same niche requirements
        c) environmental change might happen so quickly that teh species does not have time to evolve
    5. Fossil Record
        a) fossils
            (1) remains of organisms preserved in rock
        b) has provided us most of our knowledge of evolution
    6. Five Global Mass Extinctions

a) period when large numbers of genera whent extinct
b) causes vary
    (1) unknown
    (2) giant meteorite strike

7. The Sixth Mass Extinction
    a) currently occurring
    b) likely human caused
        (1) habitat destruct
        (2) overharvest
        (3) invasive species introductions
        (4) climate change
        (5) emerging diseases
8. Mass extinction recovery
    a) historically has taken about 10,000,000 years
        (1) 500,000 human generations