

# 1 - Evolution

September 13, 2016 11:32 AM

Evolution is changes in allelic or genotypic frequencies from one generation to the next

1. Microevolution: changes in allelic or genotypic frequencies within a population from one generation to the next

Occurs below the species level

2. Macroevolution: evolutionary change on a grand scale, involving major evolutionary trends

Speciation

Microevolution - Natural Selection

Darwin's theory of natural selection, four key observations

- 1) Overproduction
  - a. All species tend to produce excessive numbers
- 2) Resources are limited
  - a. Struggle for existence
- 3) Individual variation
  - a. Heritable variation
- 4) Differential reproductive success
  - a. Some trait are more successful in the local environment --> leave more fertile offspring
    - i. Leads to adaptation

Mutations - the ultimate source of all genetic variation within species and population

i.e. cancer is an accumulation of mutations

Adaptation in flowers, mutation

Gene flow

Populations exchange alleles - allelic frequencies change

Can counteract natural selection by decreasing differences between populations

i.e. pollen drifting in the wind --> very similar trees in the different areas

i.e. stray dogs

Genetic drift

Change in allelic frequency due to CHANCE (random)

i.e. depending on which alleles get pass on to the next generation through reproduction

Bottleneck effect

Original population very diverse--> something happens where only certain alleles survive --> known individuals are genetically identical

I.e. Wollemi Pine

Founder effect

New arrivals in a location do not represent the diversity of the population they came from

Non-random mating

Self-pollination or 'selfing'

Individual fertilizes itself

Can lead to inbreeding - frequency of homozygotes increases

Inbreeding

Also common in plants because they do not move --> mate with neighbours

Origin of Plant Species

Species = Latin meaning 'kind' or 'appearance'

Morphological species concept

Biological species concept

Group of interbreeding natural populations that are entirely reproductively isolated from other groups

Implies no cross species breeding with fertile offspring

Hybridization

Crossing of unlike parents, can be within species or different species

I.e. the London plane tree hybrid, parents found in different countries

Phylogenetic species concepts

Statistically significant difference in diagnostic traits from isolated evolution

Gradualistic model

Extrapolation of microevolution, ancestor species to fork into two intermediate forms turning into species

Punctuated equilibrium

## Mechanisms of speciation

For a species to evolve, need a reproductive barrier for genetic isolation

Two modes of speciation

### 1) Allopatric

- i. Most common
- ii. Some kind of usually physical barrier
- iii. Population becomes geographically separated
  - 1) Evolves through natural selection and or genetic drift
- iv. Liriodendron tree
  - 1) Continuous deciduous forest isolated by global cooling
  - 2) One species in China, one species in east coast North America
  - 3) At first was one large forest, global cooling caused the trees to push south, separated into two countries
- v. Sugar maple vs red maple
  - 1) Separated with an allopatric barrier, became sympatric again but cannot interbreed, sympatric distribution
- vi. Pinus pine cone
  - 1) Separated on two sides of a mountain, one side more wet, more side more dry
  - 2) Long vs fat cones
- vii. Adaptive radiation
  - 1) Silverswords in Haweewee
  - 2) More than 28 species evolved from a single sunflower family
  - 3) Lack of competition, adapted widely to the environment
- viii. Exceptional rates of plant diversification after uplift of the Andes

### 2) Sympatric

- i. Happens in the middle of population
- ii. Much rarer in animals, but can happen with plants
- iii. Genetic change produces a reproductive barriers between mutants and parent population
- iv. Plant evolution - polyploidy
  - 1) Presence of three or more chromosome sets in an organism (i.e. greater than the diploid number  $2n$ )
  - 2) Very common in plants, up to 80% of flowering plant ancestors
  - 3) i.e. 630 chromosome pairs or  $2n = 1260$  chromosomes per cell
  - 4) Mitosis
    - a)  $2n$  cell makes two diploid identical to mother
  - 5) Meiosis
    - a)  $2n$  cell makes 4 haploid different than mother
  - 6) Polyploid types are termed according to number of chromosome sets in nucleus
    - a) Triploid, three sets = infertile
    - b)  $4x$  = fertile
    - c)  $5x$  = infertile
    - d)  $6x$  = fertile
    - e) Meiosis will not happen in a cell with odd number of chromosomes, cannot evenly divide
  - 7) Instant speciation = genetic isolation immediate
    - a) Autopolyploidy = multiple sets of chromosomes from a single species
    - b) Allopolyploidy = multiple sets of chromosomes from different species (two or more)

- i) More common
    - c) Polyploids tend to be bigger
  - v. Sympatric speciation by allopolyploidy in plants
    - 1) Instant speciation
      - a) Originated from accidents from cell division (nondisjunction)
  - vi. Is an example of hybrid speciation
    - 1) *t. dubius*  $2n=12$  + *t. pratensis*  $2n=12$  = *t. miscellus*  $2n=24$
  - vii. Domesticated plants i.e. wheat, are the results of sympatric speciation (an artificial selection)
    - 1) First domesticated wheat (14 chromosomes), mix with other plant, sterile hybrid, error, self fertilization --> next step
    - 2) Bread wheat now (42 chromosomes)
    - 3) Making seedless plants (infertile) i.e. watermelon
      - 1) Make a tetraploid watermelon + colchicine (inhibits chromosome segregation during meiosis)
      - 2) Create triploids (seedless)
        - i)  $4x = 2n$  egg,  $2n$  pollen (male)
        - ii)  $3x = 2n$  pollen +  $1n$  egg
        - iii)  $2x = 1n$  egg,  $1n$  pollen (male)
      - 3) Plant triploid and diploid seeds together
      - 4) Haploid pollen needed from diploid needed to induce fruit growth
        - i) Triploids do not produce viable pollen
    - 4) Plants can reproduce sexually and asexually
      - 1) Asexual reproduction can produce identical plants quickly and efficiently
        - i) i.e. garlic bulbs, redwood, creosote bushes (these bushes are perennial, survive each year, higher chance of survival), same genetic genome
          - Difficult to live environments
      - 2) Trouble with tribbles/clones
        - i) Potatoes: introduced in 16th century, potatoes have been cultivated widely across Europe
          - Can be cloned very easily, use one root/eye to make more
          - (potato is a stem not a root)
        - ii) Can be wiped out by one disease, more susceptible to environmental changes due to lack of genetic diversity
          - 1840s, fungus like organism (oomycete) infests Irish potatoes
          - Potato was food for family and food for animals -- > fungus causes great famine
            - Entire crop fails in 1845, 1846 and 1848
            - 1,000,000 die, 1,000,000 leave Ireland
            - Many starve while fleeing or die in quarantine
        - iii) Bananas
          - Bananas are triploid - have no seeds, wild diploid banana have lots of hard seeds and not much sweet flesh
          - All commercial bananas reproduced by vegetative reproduction, asexually
          - Can also be wiped out
          - Shipped around green and hard, when a shipment is needed, amount is put into a hormone gas chamber
        - iv) Apomixes
          - Formation of seeds with embryos that are produced without fertilisation (embryos are CLONES OF MOTHER)
          - i.e. dandelions
            - Hundreds of distinct races can form, producing gradational series of 'microspecies'

- ◆ Because of accumulation of mutations, small variations
- Practical applications
  - Apomictic corn research at International maize and wheat improvements centre in Mexico (CIMMYT)
  - Wild relatives of corn are apomictic (seed is genetically similar to female parent)
    - ◆ Commercial corn is not apomictic
  - Transfer of apomixis to corn would allow rapid propagation of best hybrid varieties without need for tedious genetic crosses used now