Ecology and Evolution

09 February 2007
13th class meeting

Dillard, Quammen
(26 Feb Creativity Topic)

09 February READINGS:
Annie Dillard book Chapter
Quammen reading, (Mayr Interview)
Monday 12 Feb:
Exam 1 through 05 Feb material

Lab 07/09 Feb:
Meet in lab, then outside
See assignment on webpage
Lab 14/16 Feb:
Meet in lab;
Data analysis and graphing

Environmental Biology (ECOL 206)
University of Arizona, spring 2007

Kevin Bonine, Ph.D.
Anna Tyler, Graduate TA

http://eebweb.arizona.edu/courses/Ecol206/206_Page2007.html

Department of Planetary Sciences
Lunar and Planetary Laboratory
University of Arizona

LPL Evening Lecture Series
Presents

"Global Warming: Global Climate Change and the Human Condition"

Professor Emeritus Robert Strom
Lunar and Planetary Laboratory

Tuesday, February 27, 2007, 7:30 PM
Kuiper Space Sciences Lecture Hall (room 308)

Global warming is extremely complex because it deals with so many different characteristics of the Earth and their complex interactions. It is addressed by almost all sciences including many aspects of astronomy, geosciences, atmospheric, the biological and planetary sciences. It has recently become the concern of other diverse disciplines such as economics, agriculture, medicine and engineering. This talk will address these complex interactions, integrate them, and derive meaningful conclusions and possible solutions.

http://www.lpl.arizona.edu/COLPL

Indicator Species
-migratory birds
-amphibians

Rana pipiens
Northern Leopard Frog

Keystone Species
-top predators
-key pollinators

Umbrella Species
-their protection helps protect other components of ecosystem

Native Species
vs.
Nonnative, exotic, alien

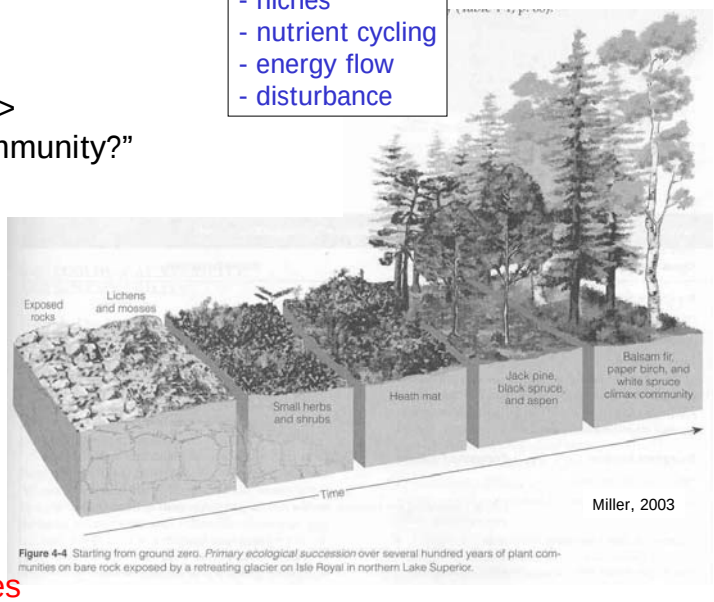
3

Ecological Succession

- diversity
- structure
- niches
- nutrient cycling
- energy flow
- disturbance

1. Primary
bare rock -->
"climax community?"

2. Secondary



Miller, 2003

Figure 4-4 Starting from ground zero. *Primary ecological succession* over several hundred years of plant communities on bare rock exposed by a retreating glacier on Isle Royal in northern Lake Superior.

Assembly Rules

Distribution of Organisms ~Community Composition

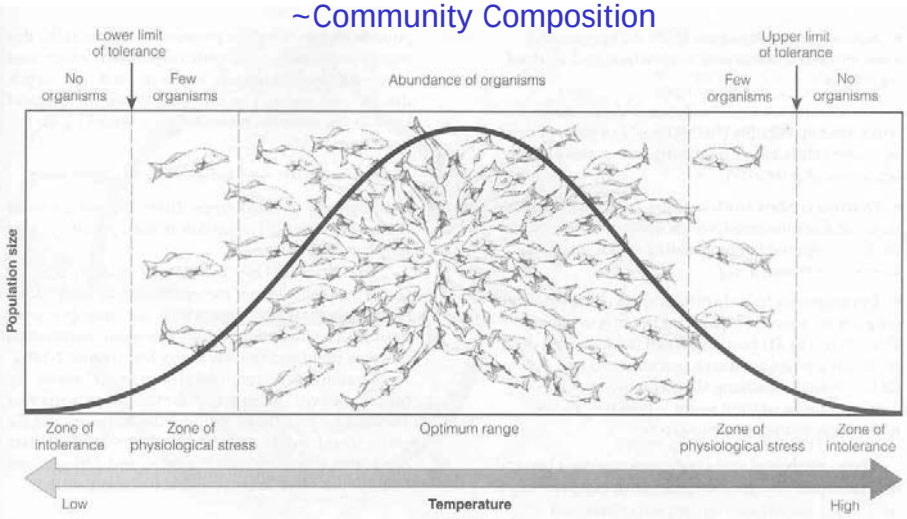


Figure 2-16 *Range of tolerance* for a population of organisms to an abiotic environmental factor—in this case, temperature.

Miller, 2003

Range of tolerance of abiotic factor(s)

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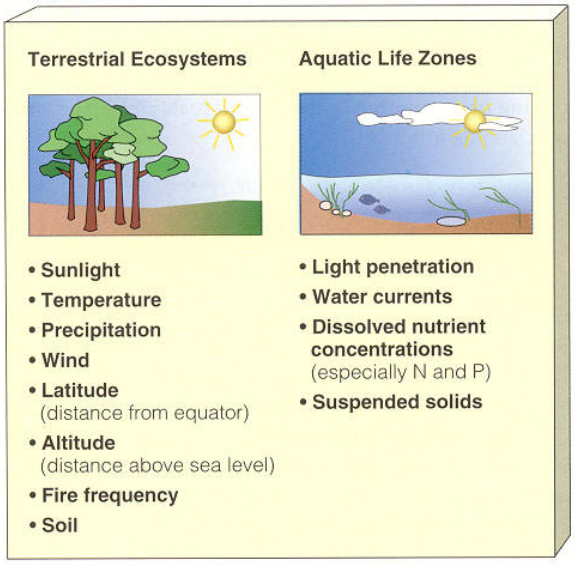
Distribution and Abundance



Other Miller 2003

Figure 4-12 Key physical and chemical or abiotic factors affecting terrestrial ecosystems (left) and aquatic life zones (right).

Annie Dillard 1974
Pilgrim at Tinker Creek
Fecundity

- Reproduction
- Exponential Growth

- 9,000 vs. 3 train engines
  "It's a hell of a way to run a railroad"

- Animal vs. Plant

- Age of Reproduction
- Role of old age?
  Gall gnat (fly)
  Miastor (fly)

-Aphids (1/10 inch long)
in one year 2,500 light years

- Role of the individual?
- What evolves? Is death necessary?

- Emotions and values (humans vs. nature)

7

Logistic growth (S vs. exponential J)

Population growth limited
at Carrying capacity (K)

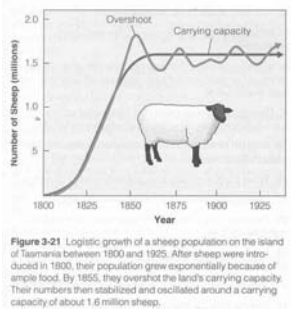


Figure 3-21 Logistic growth of a sheep population on the island of Tasmania between 1800 and 1925. After sheep were introduced in 1800, their population grew exponentially because of ample food. By 1855, they overshot the land's carrying capacity. Their numbers then stabilized and oscillated around a carrying capacity of about 1.6 million sheep.

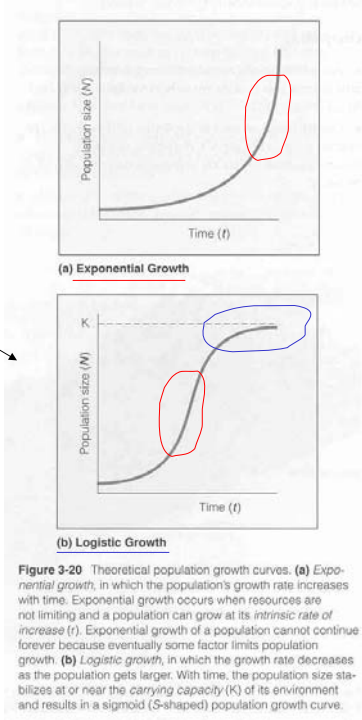


Figure 3-20 Theoretical population growth curves. **(a)** *Exponential growth*, in which the population's growth rate increases with time. Exponential growth occurs when resources are not limiting and a population can grow at its *intrinsic rate of increase* (*r*). Exponential growth of a population cannot continue forever because eventually some factor limits population growth. **(b)** *Logistic growth*, in which the growth rate decreases as the population gets larger. With time, the population size stabilizes at or near the *carrying capacity* (K) of its environment and results in a sigmoid (*S*-shaped) population growth curve.

Fig 4-6,7,8 in Miller 2005

r = intrinsic rate of increase

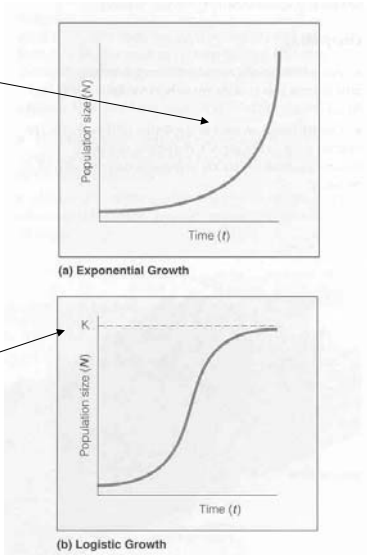
Rate that population could grow with unlimited resources

"r-selected" organisms:
1. Reproduce early and often
2. Short generation times
3. Many offspring

K = carrying capacity

1. Limited by
   - resources
   - competition
   - predators

Therefore have intraspecific competition.



Miller 2003

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Darwin and elephants

There is no exception to the rule that every organic being naturally increase at so high a rate that if not destroyed, the earth would soon be covered by the progeny of a single pair .... The Elephant is reckoned to be the slowest breeder of all known animals, and I have taken some pains to estimate its probable minimum rate of natural increase: it will be under the mark to assume that it breeds when thirty years old, and goes on breeding till ninety years old, bringing forth three pairs of young in this interval; if this be so, at the end of the fifth century there would be alive fifteen million elephants, descended from the first pair
- (*Darwin, 1859,* On the Origin of Species, p.64)

Shortly after this, the eminent physicist William Thompson (later Lord Kelvin) pointed out that Darwin got the math wrong. After about 500 years, there should only be about 16 thousand elephants, not 15 million. Indeed, the engineer Fleeming Jenkin referred to another of Darwin's calculations as guessing at the half and multiplying by two (*fide Burchfield, 1990* p.74). The basic problem, however, remains, **a few elephants can produce lots of elephants**.

http://www.athro.com/evo/elframe.html

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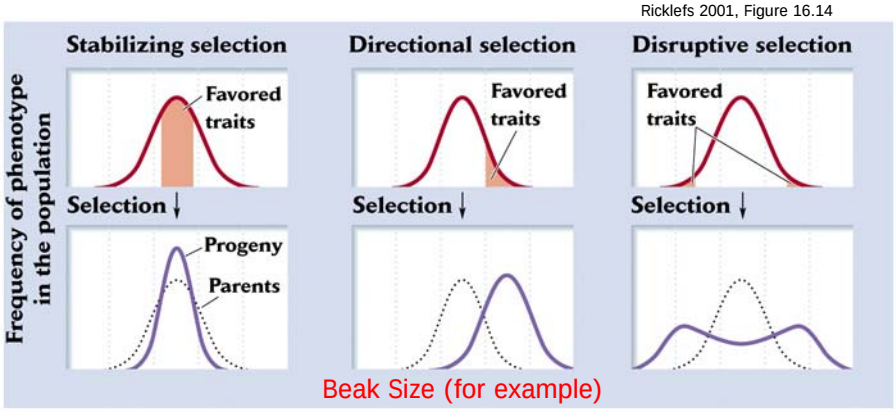
Natural Selection:

Ricklefs 2001, Figure 16.14



Favors
Average Traits

Favors
One Extreme

Favors
Both extremes

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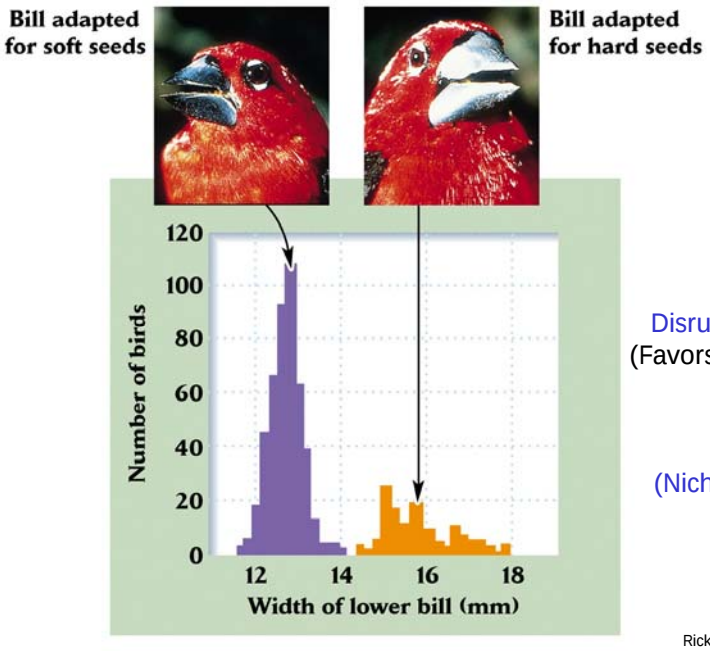

Result of
Disruptive Selection
(Favors Both extremes)

(Niche Partitioning)

Ricklefs 2001, Figure 16.15

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Selection for Human Birth Weight

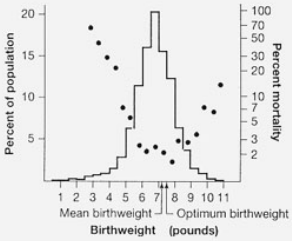
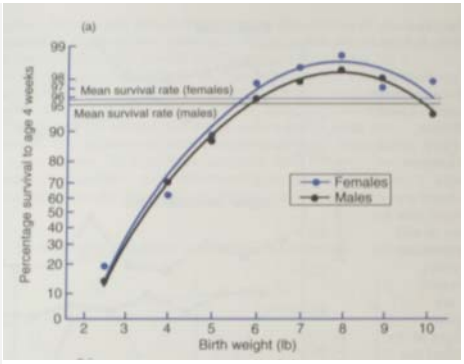


Figure 6.24 **Stabilizing selection on birthweight in humans** The horizontal axis represents birthweight. The left vertical axis and the histogram show the distribution of birthweights in a sample of 13,730 babies. The average birthweight is about 7 pounds. The right vertical axis and the data points with best-fit curve show mortality rate as a function of birthweight (on a logarithmic scale). The mortality rate is much higher among very small and very large babies than among babies of average size. (Note that in this figure, fitness is plotted as probability of mortality, whereas in Figure 6.23, fitness is plotted as probability of surviving.) The optimum birthweight is that with the lowest mortality rate. It is very close to the population average. Natural selection on birthweight in this population tends to hold the population average at a constant value. From Cavalli-Sforza and Bodmer (1971) and reference therein.



Ridley 1996

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Stalk Eyed Flies

Sexual Selection

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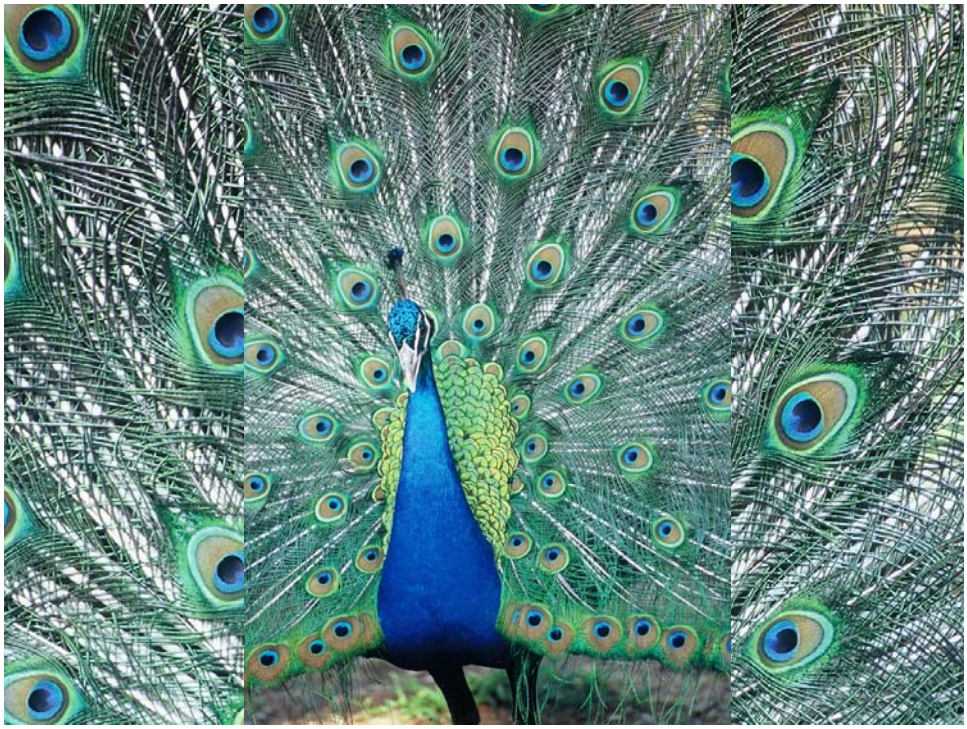

Modern Synthesis (Evolutionary Synthesis), 1930s

Mendel
(genetics, 1865)
+
Darwin
(natural selection, 1859)
+
Paleontology
(speciation, extinction, plate tectonics [Lyell Geology])
+
etc.

-Ernst Mayr (1942 *Systematics and the Origin of Species*)
-Theodosius Dobzhansky
-George Gaylord Simpson
-G. Ledyard Stebbins

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Species = ?

Biological Species Concept (Mayr)
"a group of interbreeding populations that are reproductively isolated from other such groups"

2-morphological/typological species concept (plants)
3-evolutionary species concept
4-genetic species concept
5-paleontological species concept
6-cladistic species concept

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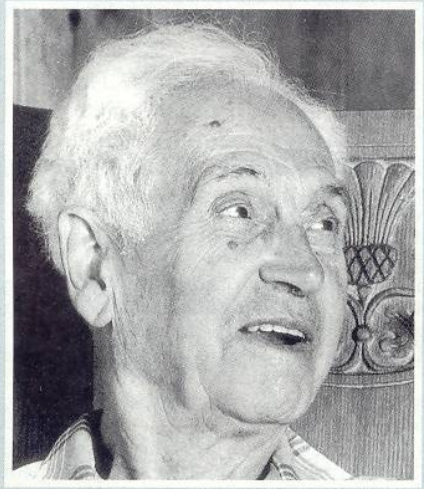

Ernst Mayr is one of the greatest influences on evolutionary biology since Darwin. Mayr was one of the architects of the evolutionary synthesis of the 1930s and 1940s, which unified biology by integrating Darwin's theory of natural selection with new discoveries in genetics, paleontology, and taxonomy. Mayr based his views on evolution mainly on relationships among bird species that he studied on Pacific islands. Now 89 years old, Mayr, Professor Emeritus at Harvard, is still going strong and generating exciting new ideas. His latest book, One Long Argument *(Harvard University Press, 1991), analyzes Darwin's theories. I interviewed Professor Mayr at his summer cottage in New Hampshire.*

Campbell 1993

Ernst Mayr (1904-2005)
Published papers for > 80 years

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Figure 22.3
Ernst Mayr in New Guinea, 1927. During his expedition, the naturalist (on the right, photographed with his guide) was struck by the almost exact match in how he and the native Papuans divided the birds of the Arafak Mountains into separate species. It was one of many experiences that led to Mayr's biological species concept, which emphasizes interbreeding within species and reproductive isolation between species.

You've also written that we humans have extraordinary responsibility because of our uniqueness as a species. Yes, humans are basically responsible for all the bad things that at the present time happen to our planet, and we are the only ones who can see all these things and do something about them. If we would stop the human population explosion, we would have already won two-thirds of the battle. That we live here just as exploiters of this planet is an ethic that does not appeal to me. Having become the dominant species on our planet, we have the responsibility to preserve the well-being of this planet. I feel that it should be a part of our ethical system that we should preserve and maintain and protect this planet that gave origin to us.

Ernst Mayr interviewed in Campbell 1993

Biological Species Concept

1. Testable and operational
2. Definition compatible with established legal concepts
3. Focus on level of biodiversity that agrees with tradition of conservation

Conserve Species as

TYPES

or as

EVOLUTONARY UNITS

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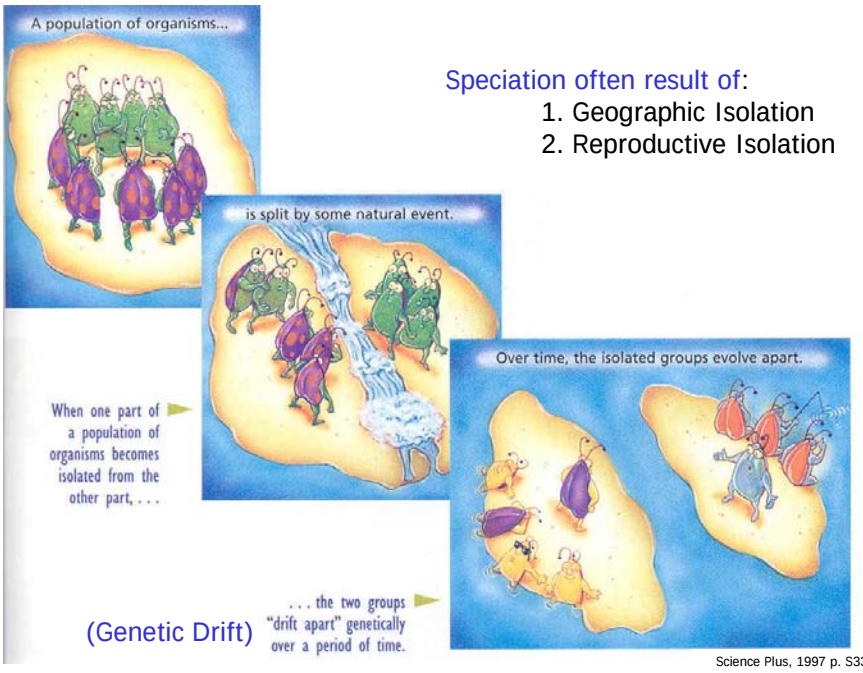


Science Plus, 1997 p. S33

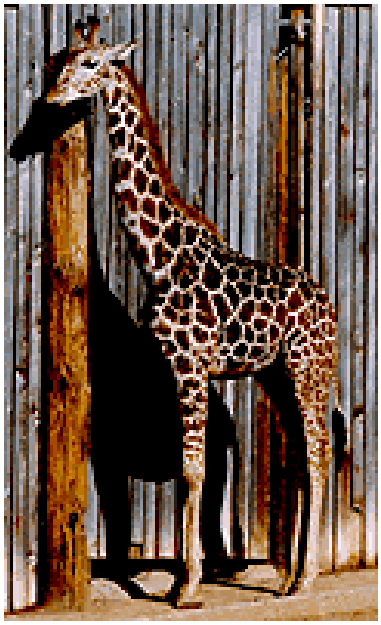
Speciation often result of:

1. Geographic Isolation
2. Reproductive Isolation

(Genetic Drift)

Evolution by Natural Selection

vs. Lamarck



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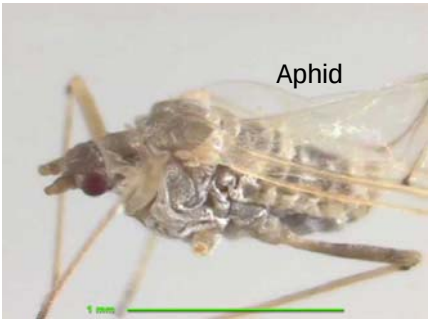
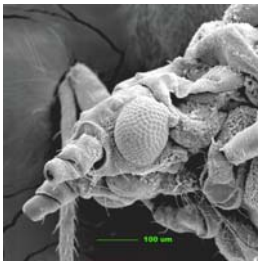
David Quammen 1985
Is Sex Necessary?
Natural Acts



- Parthenogenesis ("virgin birth")
- Asexual vs. Sexual Reproduction
- Recombination

Aphids are excellent opportunists (v. equilibrium 'K' species)
- Asexual (rapid, exploitation)
- Then Sexual (shuffle the genes once/year)

Maintain
- variability
- diversity
- adaptability



1 aphid, 6 generations, → 318,000,000

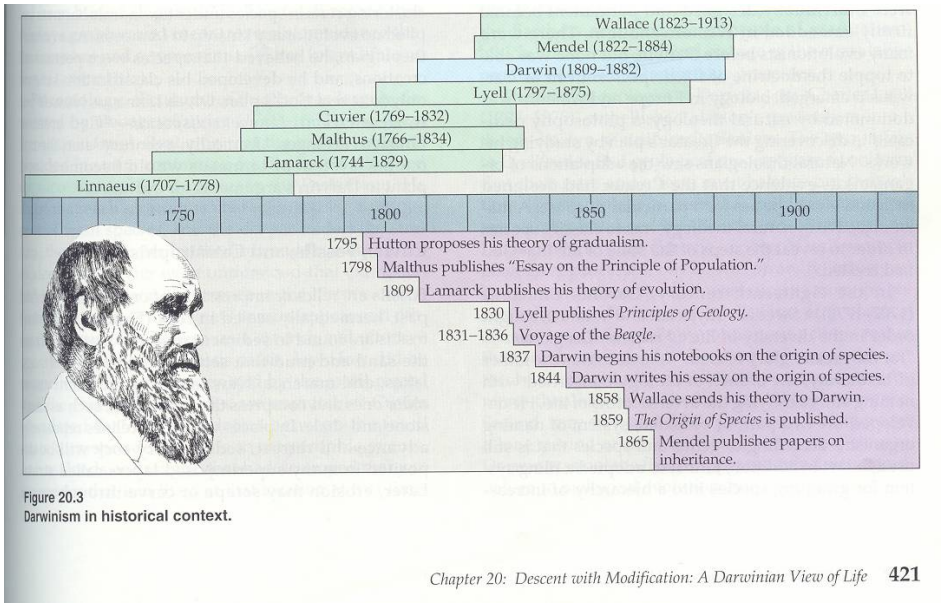


Figure 20.3
Darwinism in historical context.

Chapter 20: Descent with Modification: A Darwinian View of Life 421

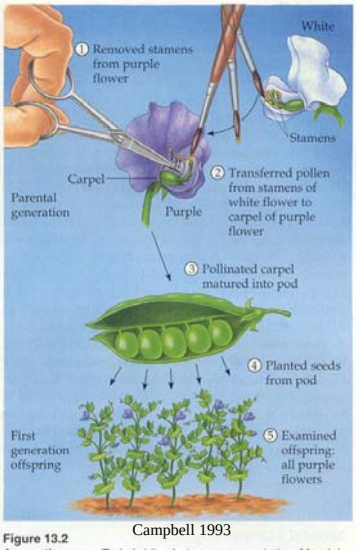
Campbell 1993

Mendelian Genetics

Figure 13.1
Gregor Mendel (1822–1884). Based on his experiments with garden peas, Mendel built a model of inheritance that became the foundation of modern genetics. His published records of these experiments provide a window to a great scientific mind. This chapter examines Mendel's experiments and conclusions and applies Mendelian concepts to human heredity.

Campbell 1993

258 *Unit Three: The Gene*



Campbell 1993

Figure 13.2
A genetic cross. To hybridize between pea varieties, Mendel used an artist's brush to transfer pollen. In this case, the character of interest is flower color, and the two varieties are purple versus white flowers. Seeds develop within the female organ, or carpel, which develops into the fruit (pod). Germination of the seeds produces the first generation hybrids, which all have purple flowers. The result is the same for the reciprocal cross, the transfer of pollen from purple flowers to white flowers.

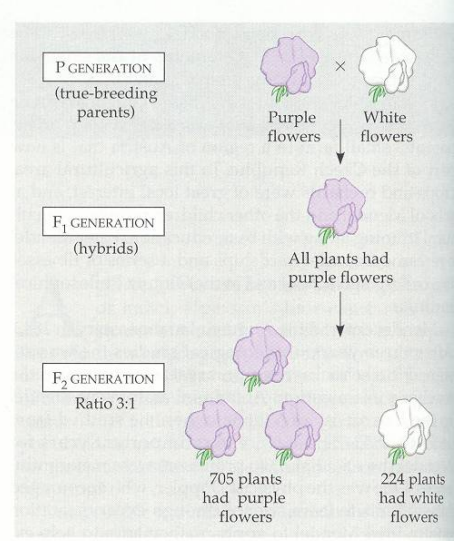


Figure 13.3
Mendel tracked heritable characters for three generations. When F_1 hybrids were allowed to self-pollinate, or when they were cross-pollinated with other F_1 hybrids, a 3:1 ratio of the two varieties occurred in the F_2 generation. An "×" sign symbolizes a genetic cross, or mating.

Campbell 1993

Mendelian Genetics

One gene
Two alleles

Dominant (purple)
Recessive (white)

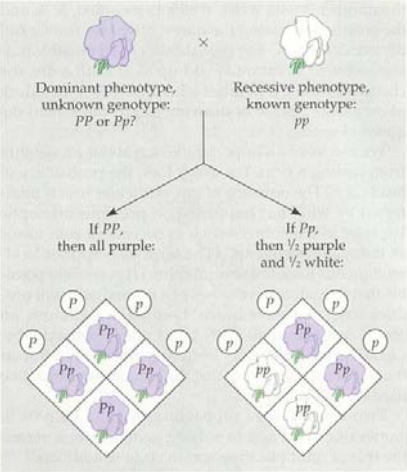


Figure 13.6
A testcross. A testcross is designed to reveal the genotype of an organism that exhibits a dominant trait, such as purple flowers in pea plants. Such an organism could be either homozygous or heterozygous for the dominant allele. The most efficient way to resolve the genotype is to cross the organism with an individual expressing the recessive trait. Since we know the genotype of the white-flowered parent (it must be homozygous for this trait to be expressed), we can deduce the genotype of the purple-flowered parent by observing the phenotypes of the offspring.

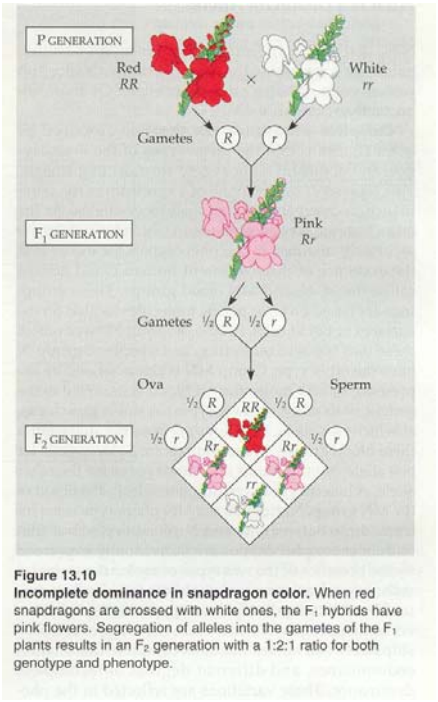
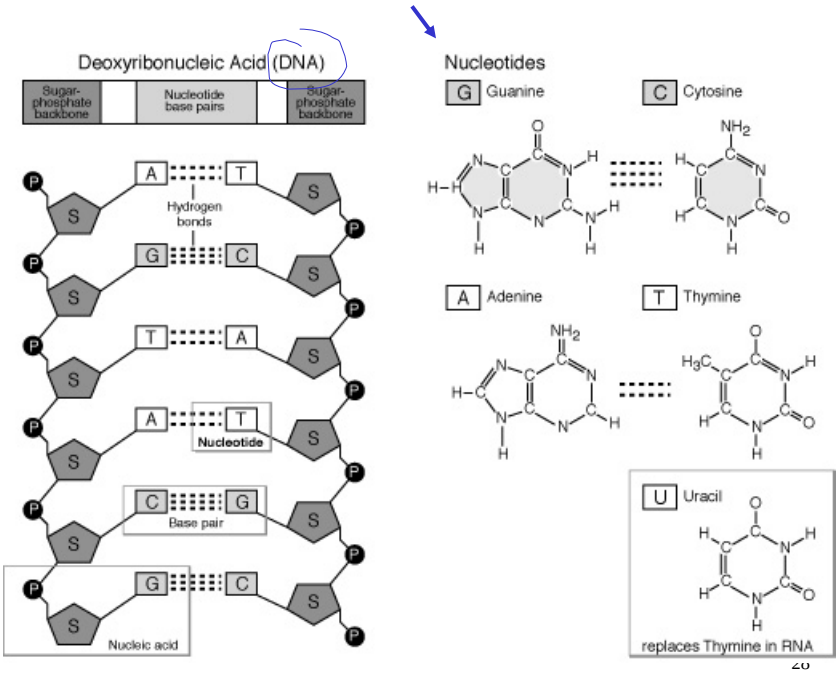


Figure 13.10
Incomplete dominance in snapdragon color. When red snapdragons are crossed with white ones, the F_1 hybrids have pink flowers. Segregation of alleles into the gametes of the F_1 plants results in an F_2 generation with a 1:2:1 ratio for both genotype and phenotype.



DNA sequence Codes for Proteins etc.

Genetic Code

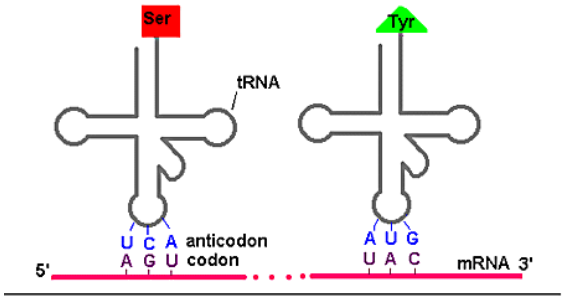
A (adenine),
T (thymine), [**U**(uracil)]
C (cytosine),
G (guanine)

(Coding, sense strand)
(5' -> 3') **ATGGAATTCTCGCTC**
(3' <- 5') **TACCTTAAGAGCGAG**
(Template, antisense strand)

(5' -> 3') **AUGGAAUUCUCGCUC**
(mRNA made from Template strand)

1-Transcription
2-Translation

Proteins of amino acids



2nd base in codon

1st base in codon	U	C	A	G	3rd base in codon
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	STOP	STOP	A
	Leu	Ser	STOP	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

The Genetic Code

Galapagos Finches

Brassica oleracea

Figure 17–8 A number of common vegetables are members of the same species, *Brassica oleracea*, including cauliflower, broccoli, cabbage, brussels sprouts, and kale. Artificial selection is responsible for the variation shown within this species. (Raymond Tschoepe)

Solomon et al. 1993

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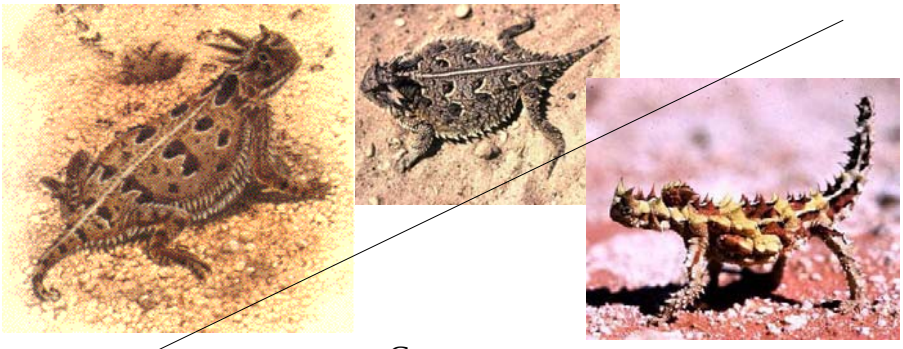
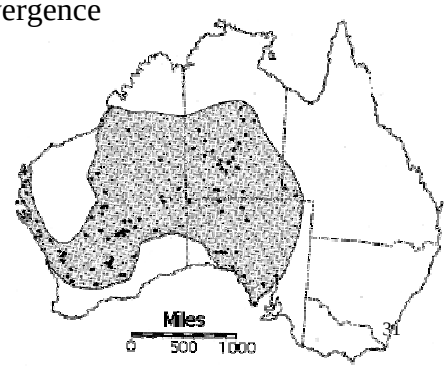
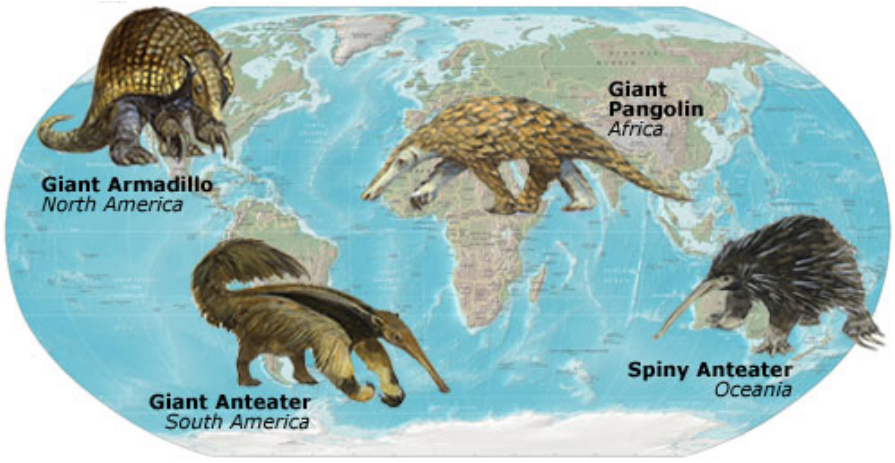


Convergence



Convergent Evolution



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