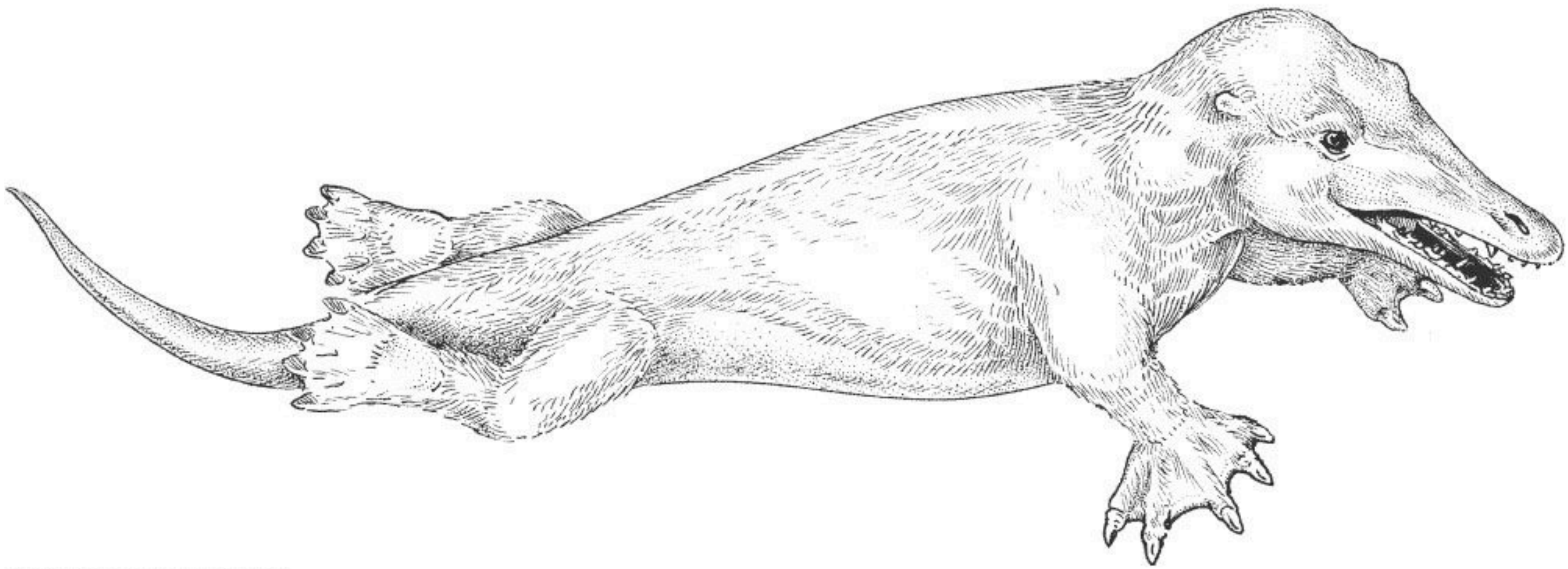


Evidence for Evolution

The fossil record

Homologous structures (including DNA)

Local adaptations (Response to selection in agriculture, for example)

Evolution in Populations

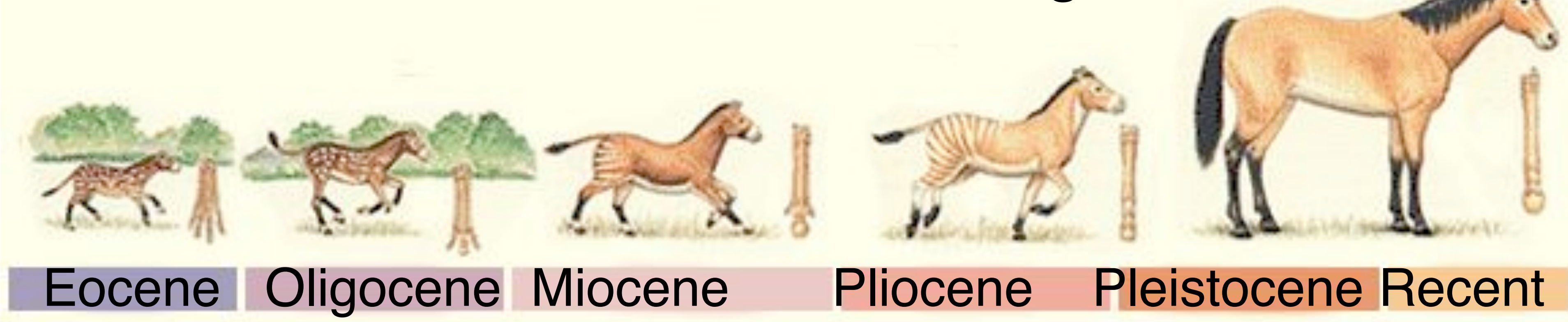
Hardy-Weinberg Equilibrium

Evolution is about change over time

one consequence is common ancestry


WAFFLE
HOUSE
RUBY
TUESDAY
1763
ToGo!
AUTO
TITLE &
LOANS

Evolution of the modern horse and its leg bone



40-50 million yrs ago

10,000 yrs ago

www.darwinday.org

Homologous structures

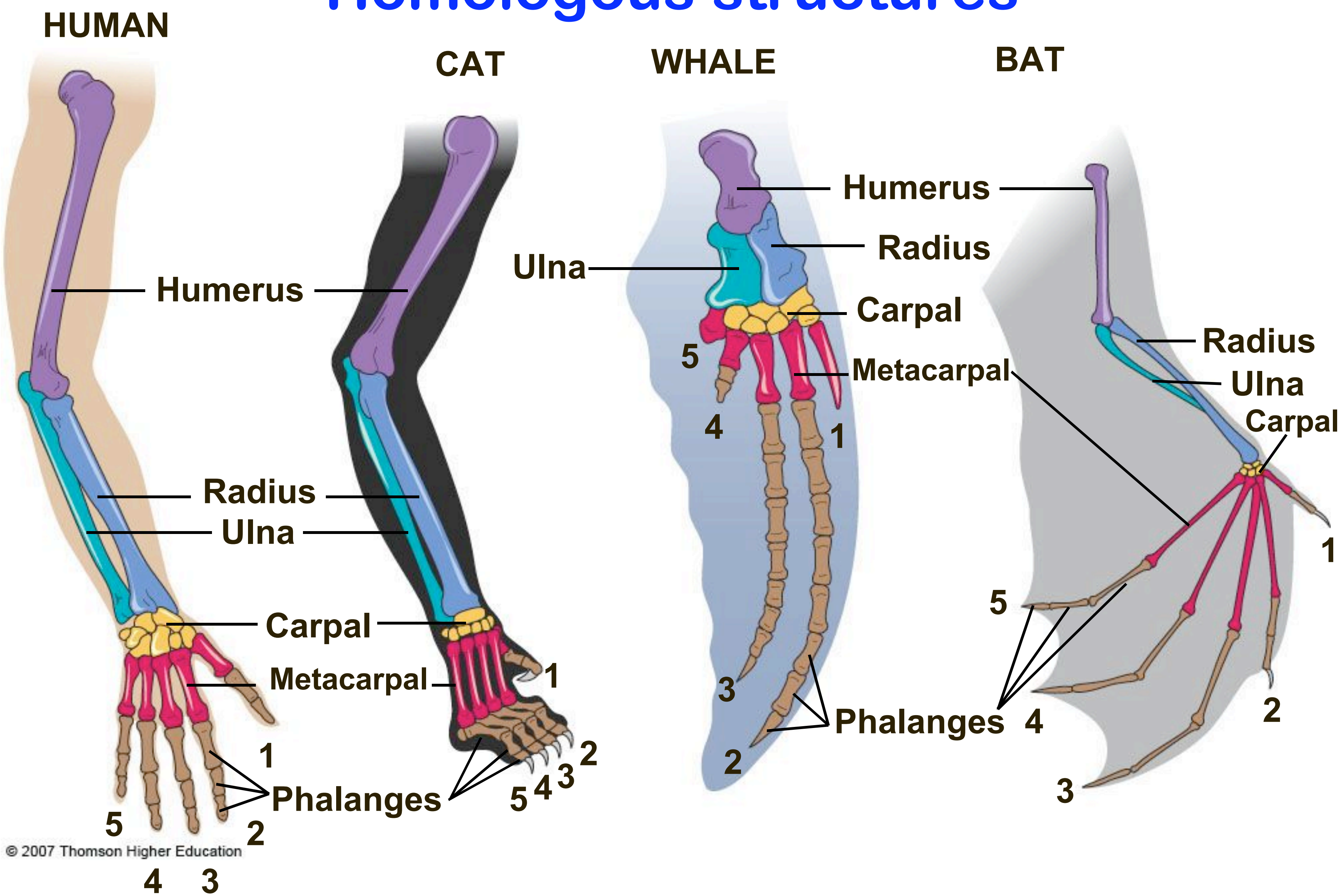


Fig. 18-10, p. 401

TABLE 18-1

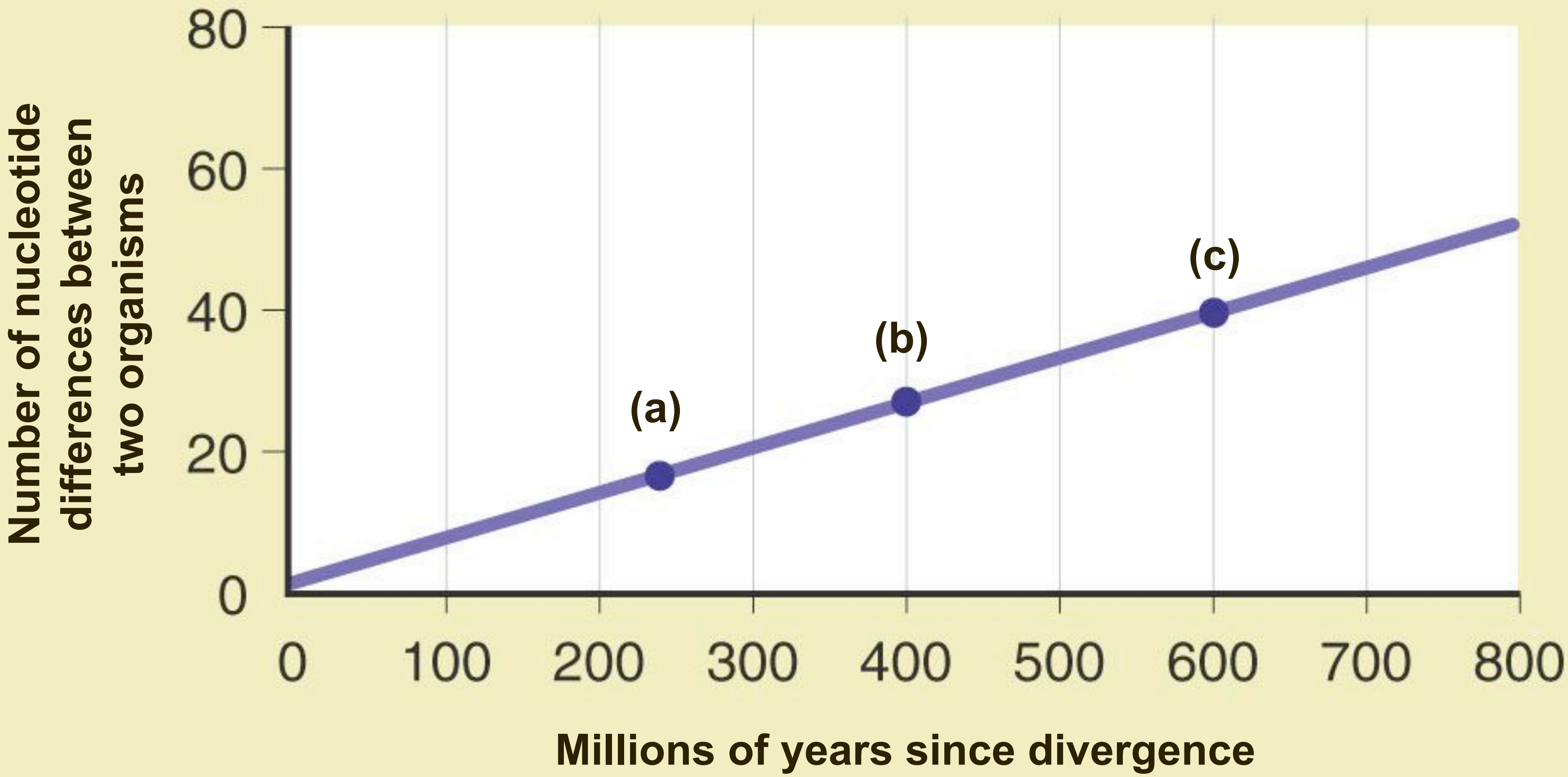
Differences in Nucleotide Sequences in DNA as Evidence of Phylogenetic Relationships

Primate Species Pairs	Percent Divergence in a Selected DNA Sequence
Human–chimpanzee	1.7
Human–gorilla	1.8
Human–orangutan	3.3
Human–gibbon	4.3
Human–rhesus monkey (Old World monkey)	7.0
Human–spider monkey (New World monkey)	10.8
Human–tarsier	24.6

Source: From M. Goodman et al., "Primate Evolution at the DNA Level and a Classification of Hominoids," *Journal of Molecular Evolution*, Vol. 30, 1990.

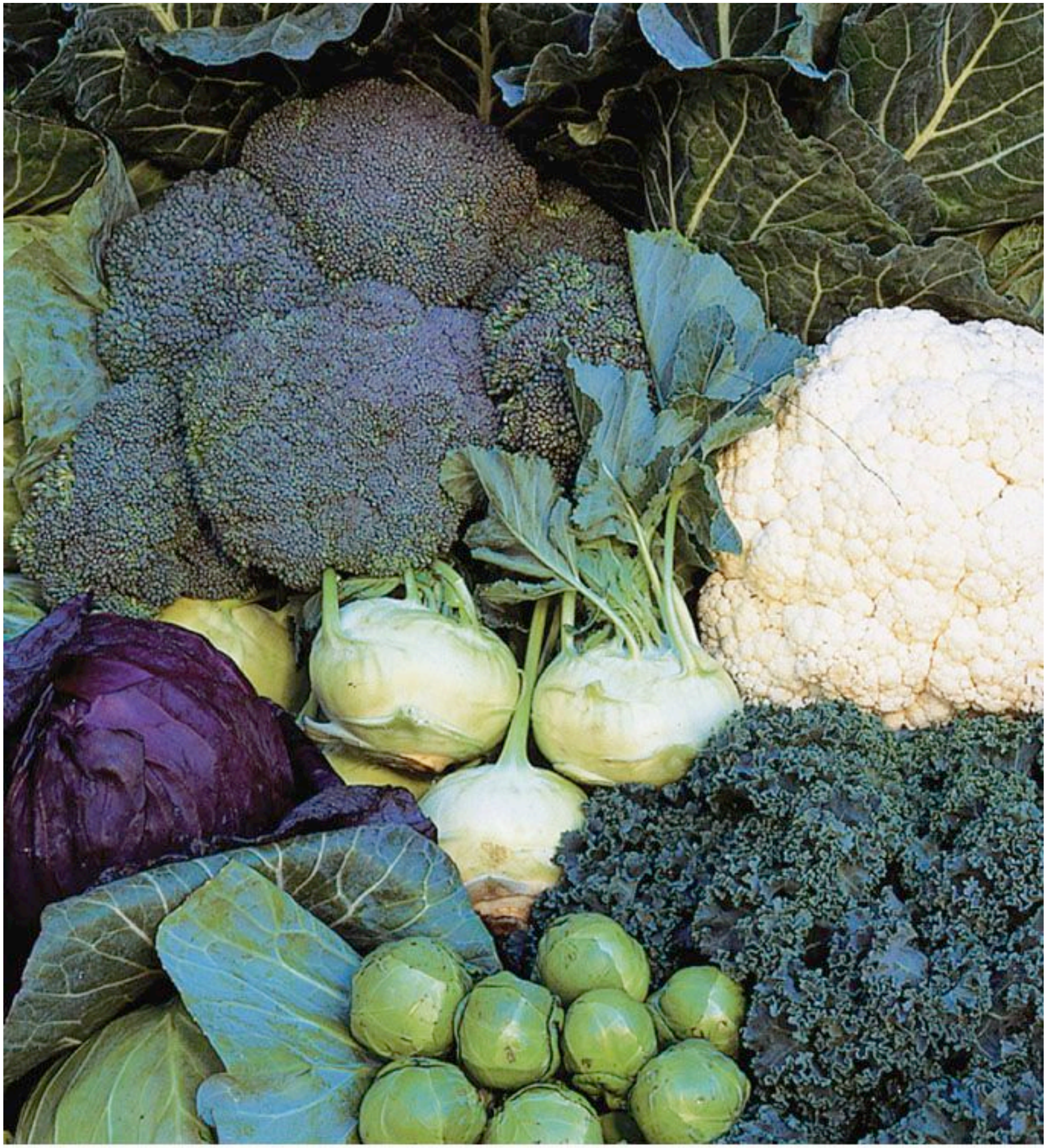
Note: *Percent divergence* refers to how different the base sequences are for the same gene in different organisms. In this example, humans and chimpanzees have a 1.7% difference in their DNA base sequences, which means that 98.3% of the DNA examined is identical. The data shown are for the noncoding sequence of the β-globin gene.

Molecular Clock



(a) Divergence of birds and reptiles
(b) Divergence of reptiles and fish
(c) Divergence of fish and insects

Responses To Selection



Brassica oleracea

=

Kale
Brocoli
Brussels Sprouts
Kohlrabi
Cabbage
Cauliflower

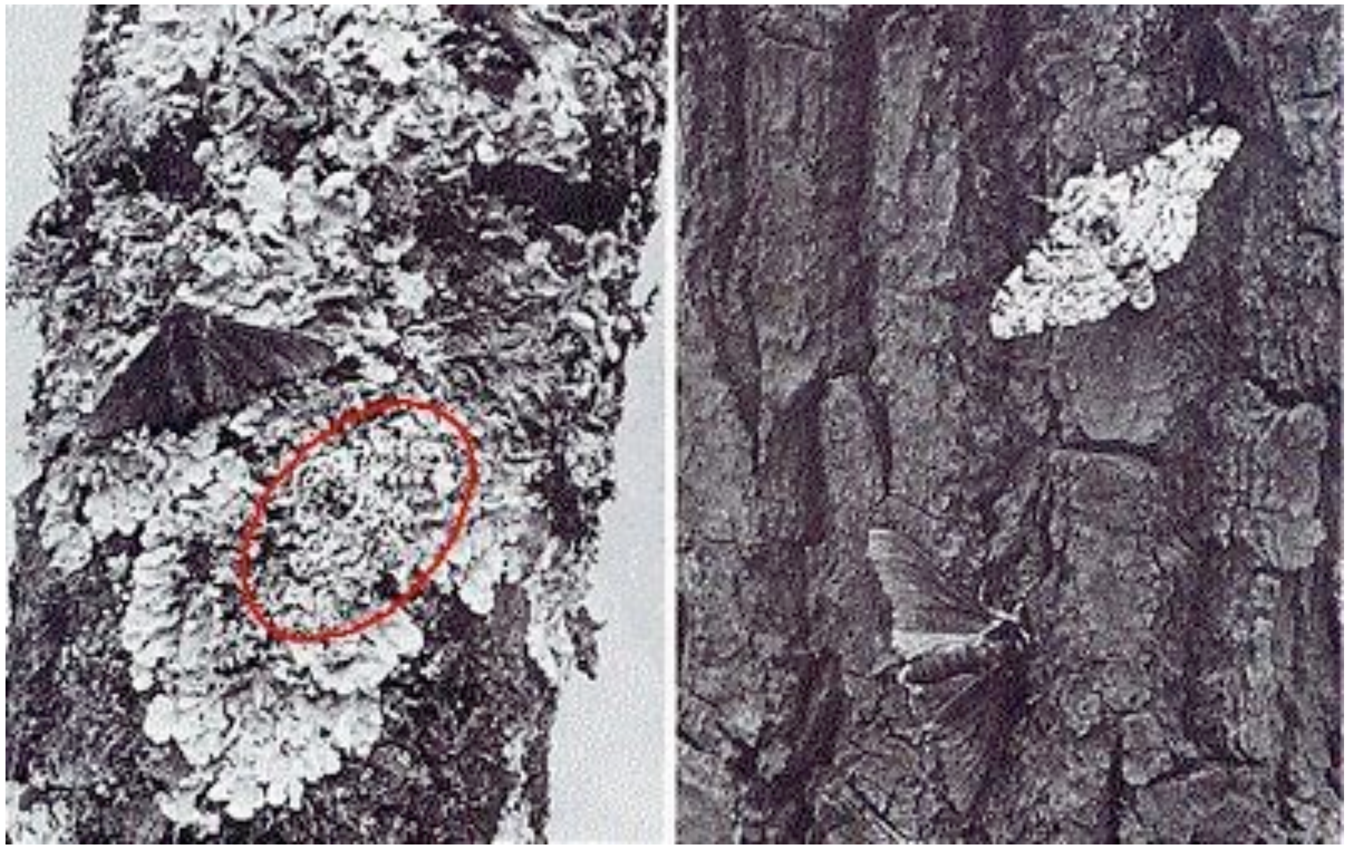
All evolved within the past 8000 yrs due to artificial selection

Fig. 18-2, p. 393

http://www.pigeons.biz/pigeons/photogallery/

http://www.cals.ncsu.edu/course/ent425/tutorial/Ecology/survival.html

http://sandwalk.blogspot.com/2007/09/peppered-moths-and-confused-idiots.html



http://www.cals.ncsu.edu/course/ent425/tutorial/Ecology/survival.html

http://sandwalk.blogspot.com/2007/09/peppered-moths-and-confused-idiots.html

Adaptation

Any change in the structure or functioning of an organism that makes it better suited to its environment.

Oxford Dictionary of Science

The quest for a mechanism to explain evolutionary processes -

Jean-Baptiste Pierre Antoine de Monet Chevalier de **Lamarck**
1744-1829

http://www.nndb.com/people/275/000057104/

1. "Life by its proper forces tends continually to increase the volume of every body possessing it, and to enlarge its parts, up to a limit which it brings about."

2. "The production of a new organ in an animal body results from the supervention of a new want (*besoin*) continuing to make itself felt, and a new movement which this want gives birth to and encourages."

3. "The development of organs and their force of action are constantly in ratio to the employment of these organs."

4. "All which has been acquired, laid down, or changed in the organization of individuals in the course of their life is conserved by generation and transmitted to the new individuals which proceed from those which have undergone those changes."

1. "Life by its proper forces tends continually to increase the volume of every body possessing it, and to enlarge its parts, up to a limit which it brings about."

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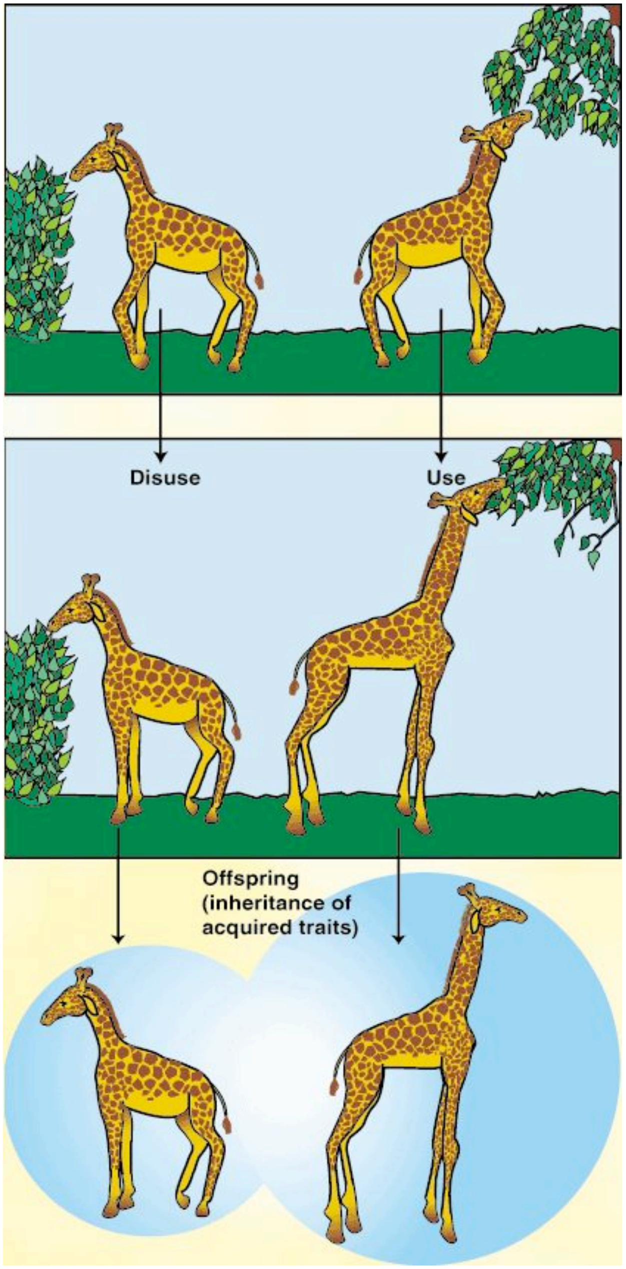
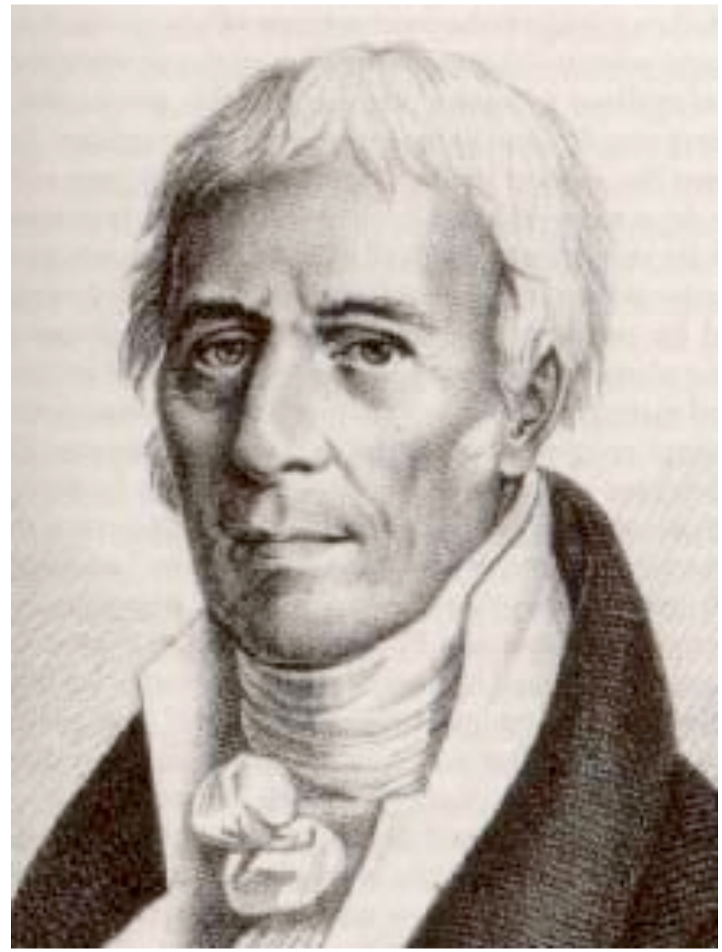


http://www.sparknotes.com/biology/evolution/lamarck/section2.rhtml



Charles Darwin
1809-1882

Alfred Russell Wallace
1823-1913

Thomas Malthus

1766-1834

We will suppose the means of subsistence in any country just equal to the easy support of its inhabitants. The constant effort towards population... increases the number of people before the means of subsistence are increased. The food therefore which before supported seven millions must now be divided among seven millions and a half or eight millions. The poor consequently must live much worse, and many of them be reduced to severe distress.

Charles Darwin
1809-1882

Alfred Russell Wallace
1823-1913

Darwin / Wallace - Four Conditions for Natural Selection

1) Variation within populations

2) Overproduction

3) Limited resources

4) Differential reproductive success

Three major kinds of selection (for now…)

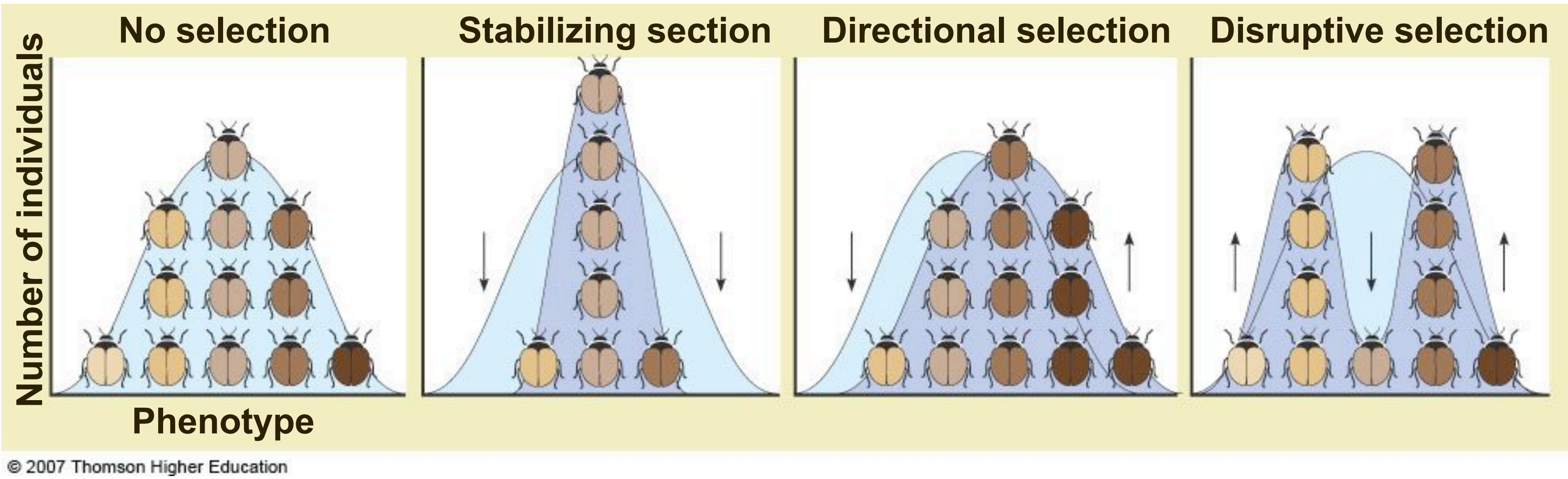
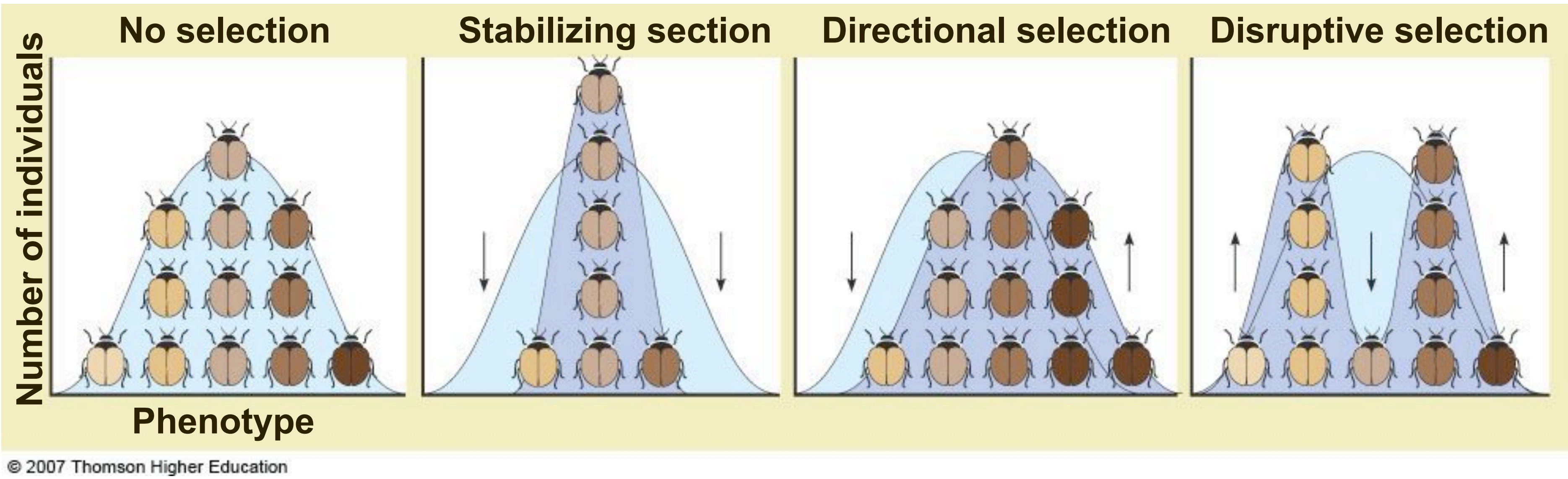


Fig. 19-4, p. 419

Three major kinds of selection (for now…)



Selection operates on Phenotypes

Fig. 19-4, p. 419

G. H. Hardy (1908)

Hardy-Weinberg Equilibrium

‘I have, of course, considered only the very simplest hypothesis possible. Hypotheses other than that of purely random mating will give different results, or if …[the character]*…has an influence on fertility, the whole question may be greatly complicated’*

Allele frequencies will remain constant in a population unless altered by selection, non-random mating, migration or genetic drift. (credit also to C. Castle and W. Weinberg)

$$p^2 + 2pq + q^2 = 1$$

p^2	+	$2pq$	+	q^2	=	1
Frequency of *AA*		Frequency of *Aa*		Frequency of *aa*		All individuals in the population

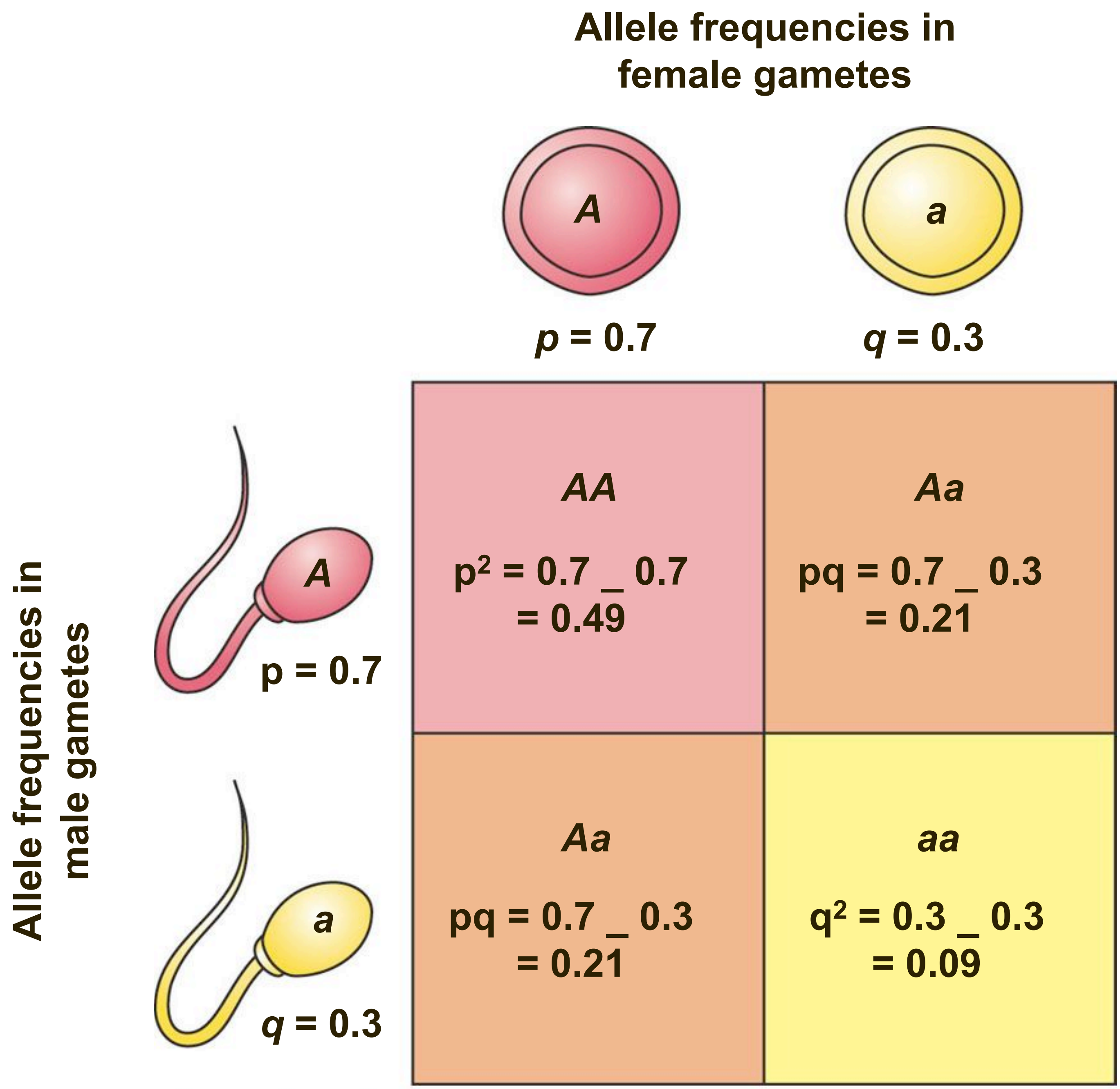


Fig. 19-1b, p. 414

Hardy-Weinberg Equilibrium

Holds true only if:

1 - No Mutation

2 - No immigration / emigration

3 - No Selecton (no differential survival of genotypes)

If these are violated, then evolution occurs

Evidence for Evolution (review)

The fossil record

Homologous structures (including DNA)

Local adaptations (Response to selection in agriculture, for example)

Evolution II-

Revisit Hardy Weinberg Equilibrium

Micro-Evolution - antibiotic resistance in bacteria

Neo-Darwinism (Modern synthesis)

Macro-Evolution - speciation

Revisit Hardy Weinberg Equilibrium

Genotype and Allele frequencies will stay the same, forever if…

- Random Mating
- No Mutations
- No Genetic Drift
- No Migration
- No Selection

Revisit Hardy Weinberg Equilibrium

Genotype and Allele frequencies will stay the same, forever if...

- Random Mating
- No Mutations
- No Genetic Drift
- No Migration
- No Selection

If all this is true, No Evolution Occurs

Random Mating - often violated, some individuals reproduce much better than others

No Mutations - “rare”, but constant

No Genetic Drift - happens in smaller, isolated populations - *sampling*

No Migration often happens

No Selection selective environments change often (physical and biotic changes)

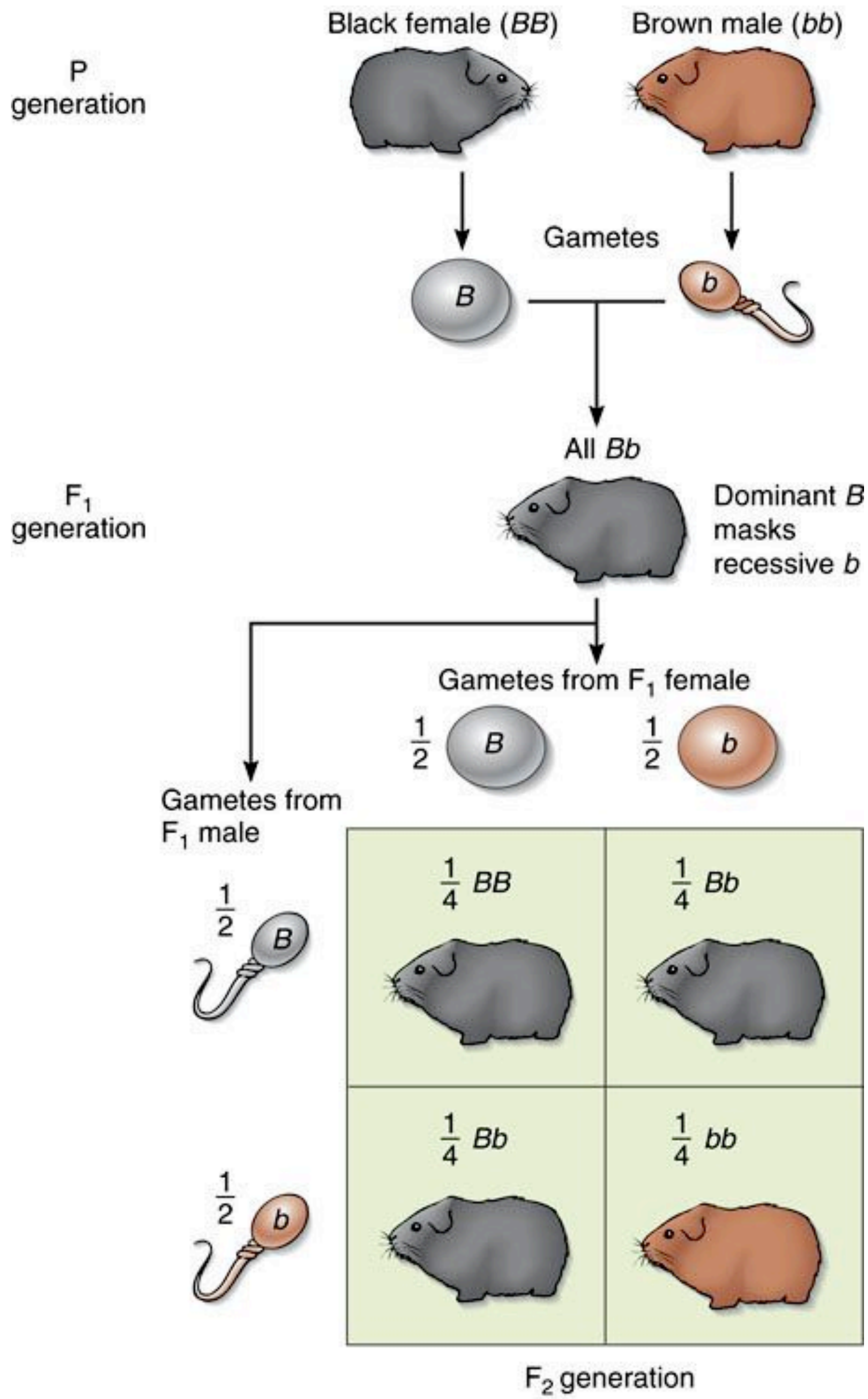
Therefore, evolutionary change is likely

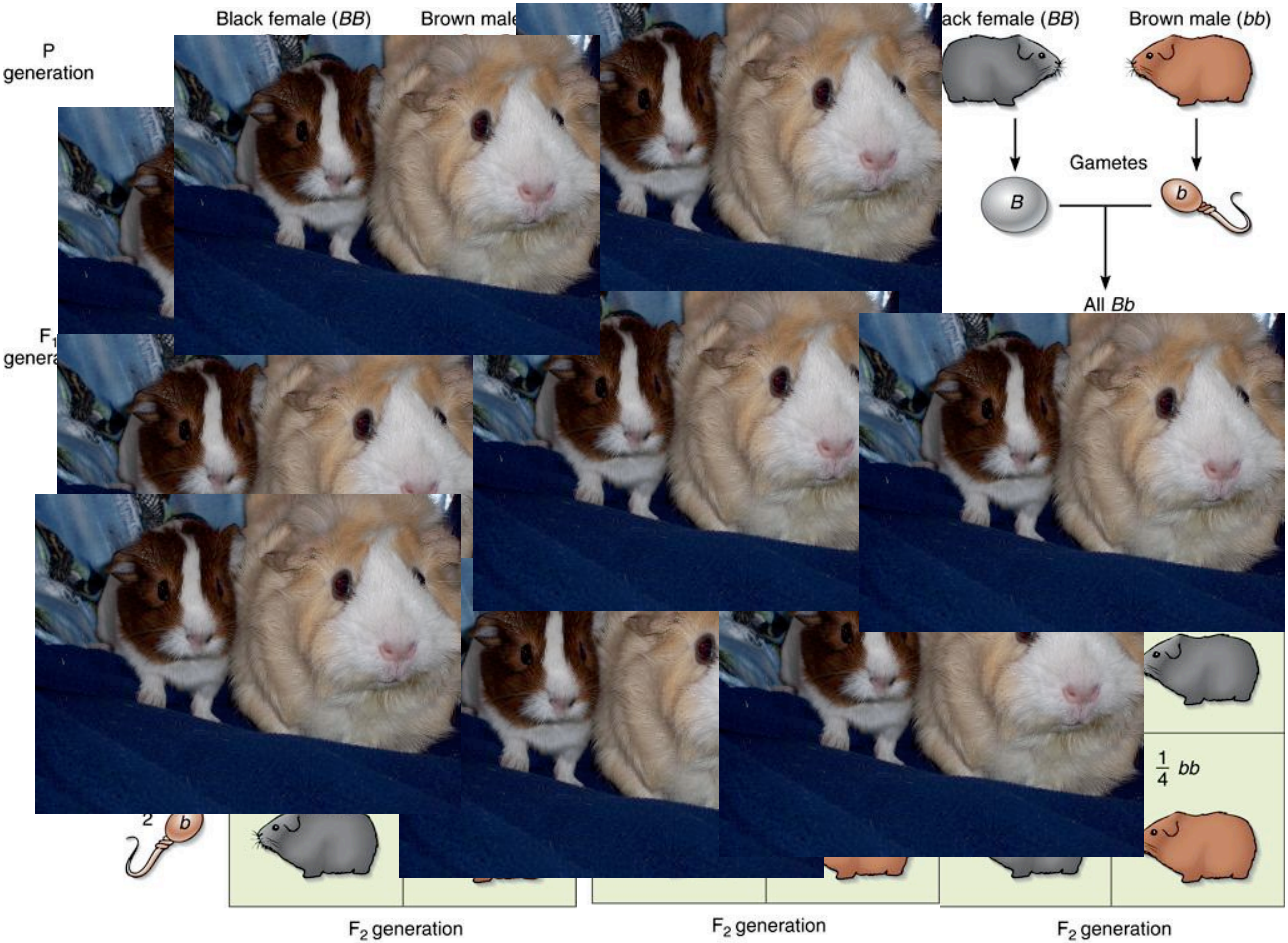
$$p^2 + 2pq + q^2 = 1$$

p^2	$2pq$	q^2	1
Frequency of *AA*	Frequency of *Aa*	Frequency of *aa*	All individuals in the population

p. 414

Imagine a population of guinea pigs….




Black female (BB)
Brown male
P generation
ack female (BB)
Brown male (bb)
Gametes
B
b
All Bb
1/4 bb
F2 generation
F2 generation
F2 generation

We observe that half the population is

Black (genotypes BB or Bb) and half the population is brown (bb)

What will the next generation look like under HWE?

First step, estimate frequencies of B and b

alleles

Half the population is Black (genotypes BB or Bb)

We can't do much with this info yet, since we only know phenotypes, not genotypes

Half the population is brown (bb)

We can work with this, because we know that genotypes conform to the HWE.

p = the frequency of one allele (B)
q = the frequency of the other (b)

We know that half the individuals are bb, half are Bb or BB.....

---

p^2	+	$2pq$	+	q^2	=	1
Frequency of *BB*		Frequency of *Bb*		Frequency of *bb*		All individuals in the population

p = the frequency of one allele (B)
q = the frequency of the other (b)

We know that half the individuals are bb, half are Bb or BB.....

p^2	+	$2pq$	+	q^2	=	1
Frequency of *BB*		Frequency of *Bb*		Frequency of *bb*		All individuals in the population

p = the frequency of one allele (B)
q = the frequency of the other (b)

We know that half the individuals are bb, half are Bb or BB.....

p^2	+	$2pq$	+	q^2	=	1
Frequency of *BB*		Frequency of *Bb*		Frequency of *bb*		All individuals in the population

q^2 **=**

Frequency of *bb*

q^2 = the frequency of the bb genotype

q = the frequency of the b allele

Therefore, the square root of q^2 = the frequency of the b allele

1 - the frequency of the b allele = the frequency of the B allele

q^2 =

Frequency of *bb*

q^2 = the freqency of the bb genotype

q = the frequency of the b allele

Therefore, the square root of 0.5 = the frequency of the b allele (=0.71)

1 - 0.71 = 0.29 = the frequency of the B allele

$p = 0.29$

$q = 0.71$

Black Phenotype | Brown Phenotype

$p^2 + 2pq + q^2 =$

Frequency of *BB = 0.08*

Frequency of *Bb = 0.42*

Frequency of *bb = 0.5*

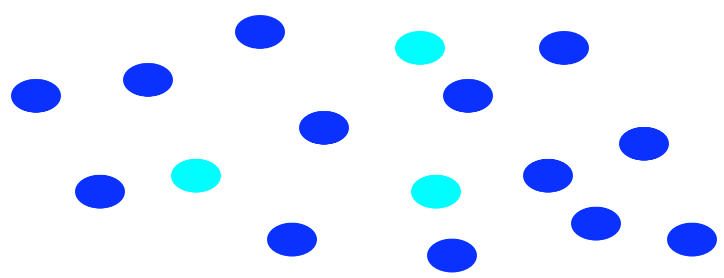
Rapid Evolution case study…

Antibiotic resistance in bacteria

Rapid Evolution case study...

Antibiotic resistance in bacteria

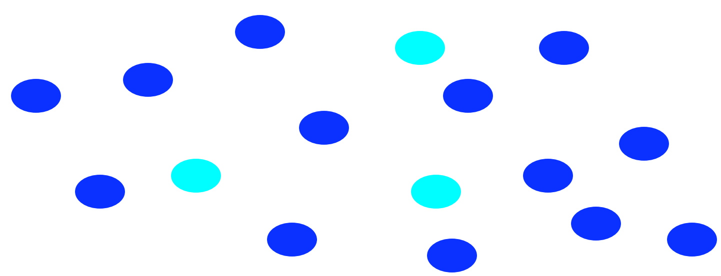
Imagine a bacterial population with some variation...



Rapid Evolution case study…

Antibiotic resistance in bacteria

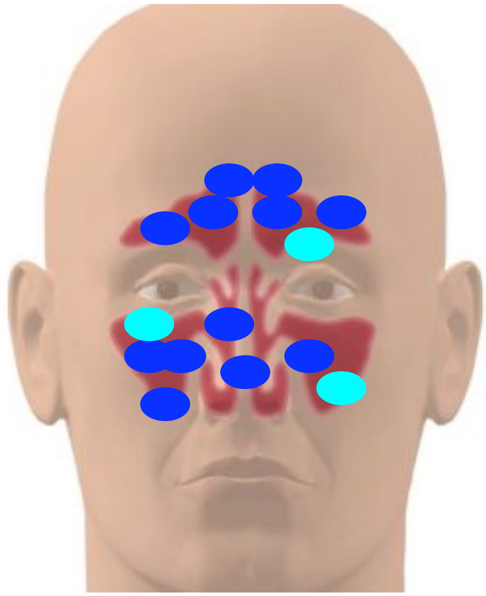
Imagine a population with some variation…



Rapid Evolution case study…

Antibiotic resistance in bacteria

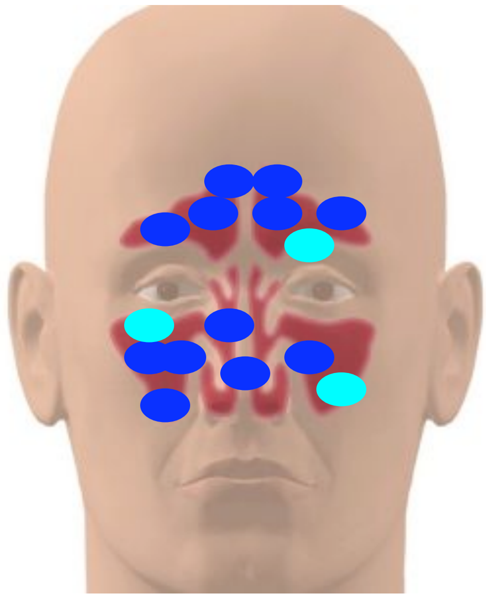
Imagine a population with some variation…



Rapid Evolution case study…

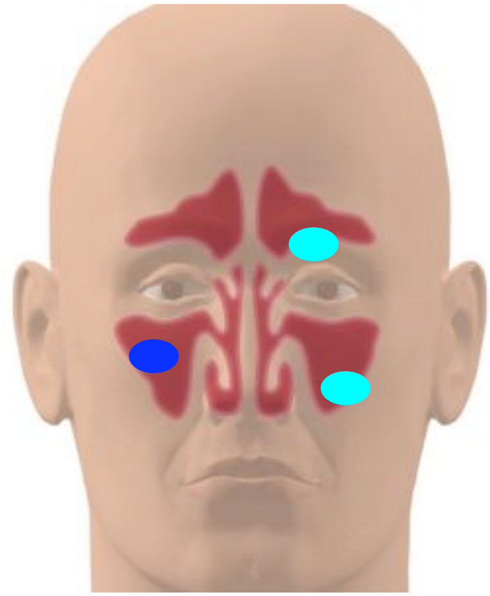
Antibiotic resistance in bacteria

Imagine an antibiotic that kills off most of the bacteria, but some of the light blue ones are less succeptable



Rapid Evolution case study…

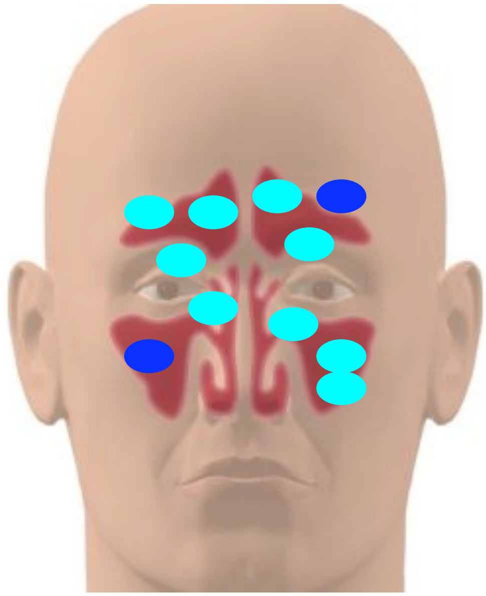
Antibiotic resistance in bacteria



Rapid Evolution case study…

Antibiotic resistance in bacteria

After the patient stops taking antibiotics, the more resistant bacteria can take over, making it harder to treat the infection next time



Rapid Evolution case study...

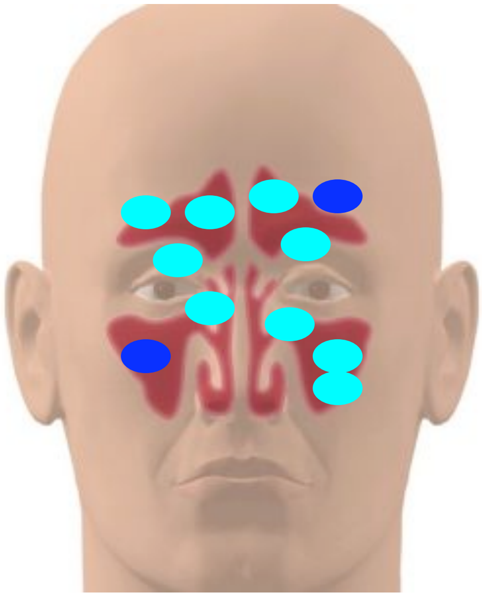
Bacteria can evolve rapidly for several reasons -

1 - huge population size

2 - rapid mutation rate

2 - rapid reproduction

3 - horizontal gene transfer



Rapid Evolution case study…

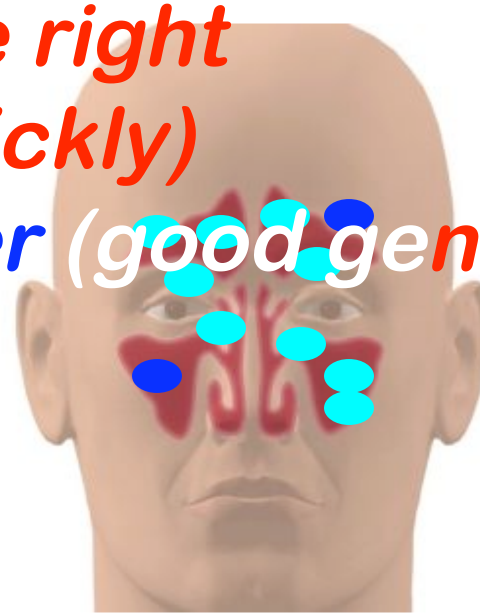
Bacteria can evolve rapidly for several reasons -

1 - huge population size (greater chance of getting the right phenotype)

2 - rapid mutation rate (less DNA repair, haploid, etc)

2 - rapid reproduction (the right phenotype can spread quickly)

3 - horizontal gene transfer (good genes can be shared)



Neo-Darwinism (the Modern Synthesis)

Combines the Darwin-Wallace model of evolution via Natural Selection
&
Mendelian and Biochemical Genetics
&
Population Genetics

(From Wikipedia)

The modern synthesis bridged the gap between experimental geneticists and naturalists; and between both and palaeontologists, stating that

1. All evolutionary phenomena can be explained in a way consistent with known genetic mechanisms and the observational evidence of naturalists.

2. Evolution is gradual: small genetic changes, recombination ordered by natural selection. Discontinuities amongst species (or other taxa) are explained as originating gradually through geographical separation and extinction (not saltation).

.....

(From Wikipedia)
3.Selection is overwhelmingly the main mechanism of change; even slight advantages are important when continued. The object of selection is the phenotype in its surrounding environment. The role of genetic drift is equivocal; though strongly supported initially by Dobzhansky, it was downgraded later as results from ecological genetics were obtained.

4.The primacy of population thinking: the genetic diversity carried in natural populations is a key factor in evolution. The strength of natural selection in the wild was greater than expected; the effect of ecological factors such as niche occupation and the significance of barriers to gene flow are all important.

5.In palaeontology, the ability to explain historical observations by extrapolation from micro to macro-evolution is proposed. Historical contingency means explanations at different levels may exist. Gradualism does not mean constant rate of change.

Neo-Darwinism has a major impact in how we think about SPECIATION

Historical view - species were unchanging entities, created once for all eternity.

Modern view - species are fluid, new ones evolve regularly, others go extinct.

What is a SPECIES???

What is a SPECIES???

Multiple definitions - two in your book

1 - The Biological Species Concept

A species is 1 or more interbreeding populations in nature.

2 - The Evolutionary Species Concept

A species exists if enough evolution has occurred between two groups for statistically detectable traits to have emerged.

What is a SPECIES???

Multiple definitions - two in your book

1 - The Biological Species Concept
A species is 1 or more interbreeding populations in nature.
2 - The Evolutionary Species Concept
A species exists if enough evolution has occurred between two groups for statistically detectable traits to have emerged.
Neither definition is 100% adequate

The Biological Species Concept

A species is 1 or more interbreeding populations in nature.

The BSC relies on Reproductive Isolation (RI)

RI can be pre-zygotic or post-zygotic

RI can be pre-zygotic or post-zygotic

~before mating/after mating

Post Zygotic examples -

Horse x Donkey = mule. Mules are healthy, but infertile, probably due to chromosomal differences.

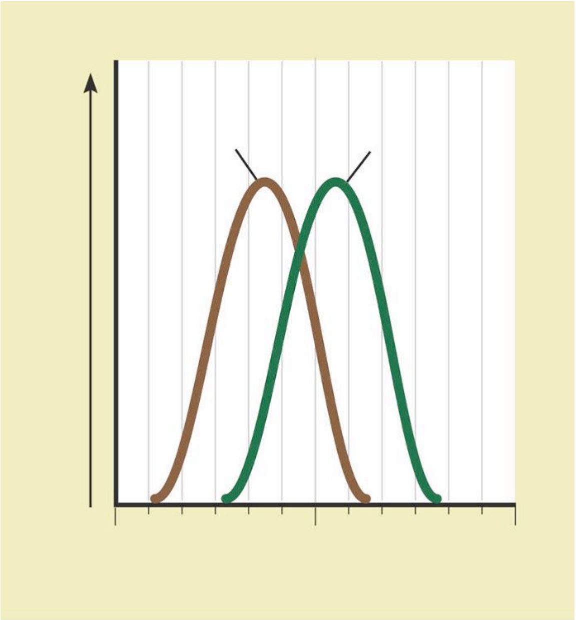
Under the BSC, horses and donkeys are distinct species.

Pre-Zygotic examples -

Different mating signals, timing, behaviors etc.

Temporal Variation -

Wood Frogs and Leopard Frogs mate at different times



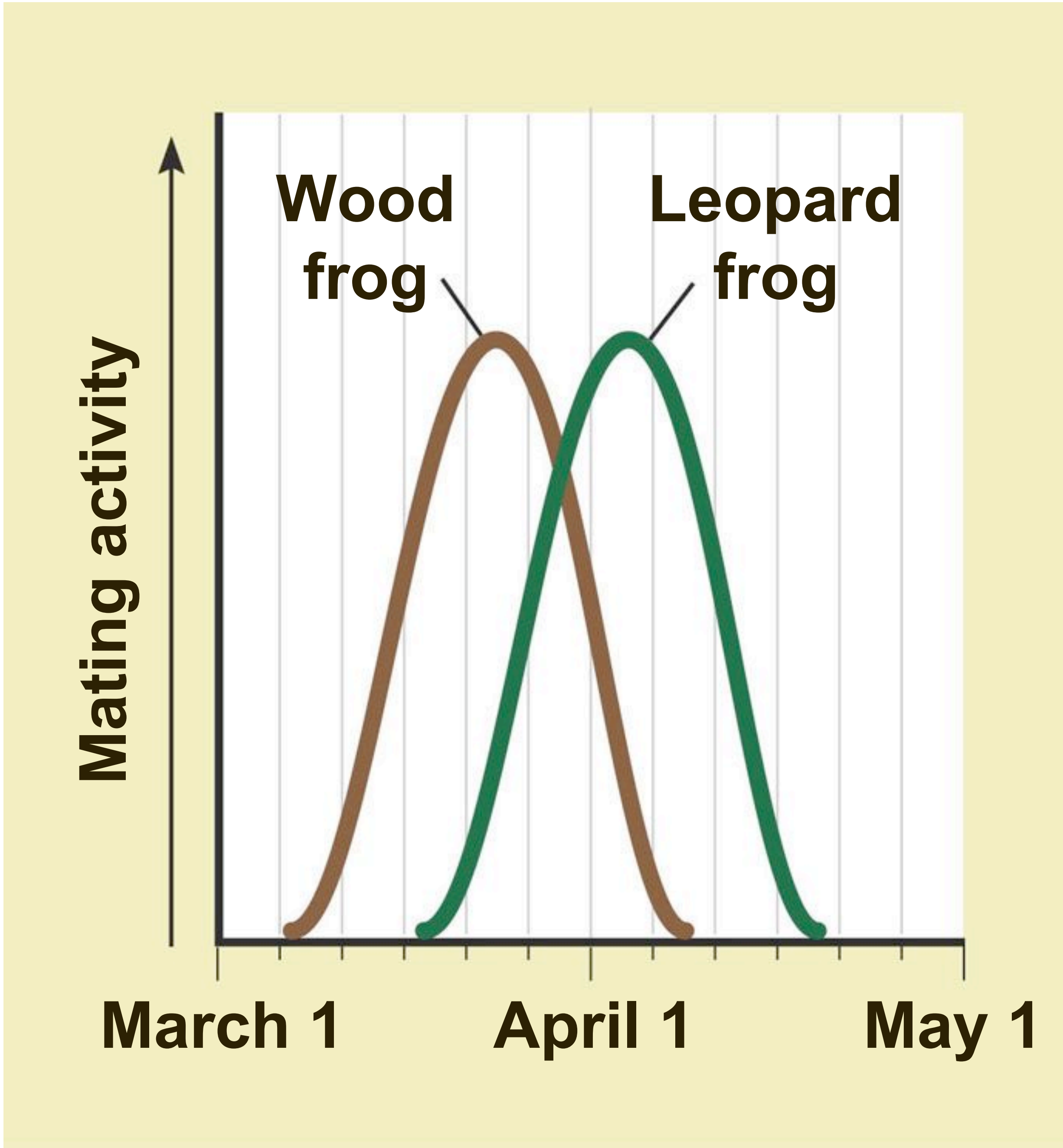


Fig. 20-2c, p. 430

Pre-Zygotic examples -

Different mating signals, timing, behaviors etc.

Mate recognition -
Wood Frogs and Leopard Frogs sing different songs -

http://allaboutfrogs.org/files/sounds/wood.wav

http://allaboutfrogs.org/files/sounds/sleaprd.wav

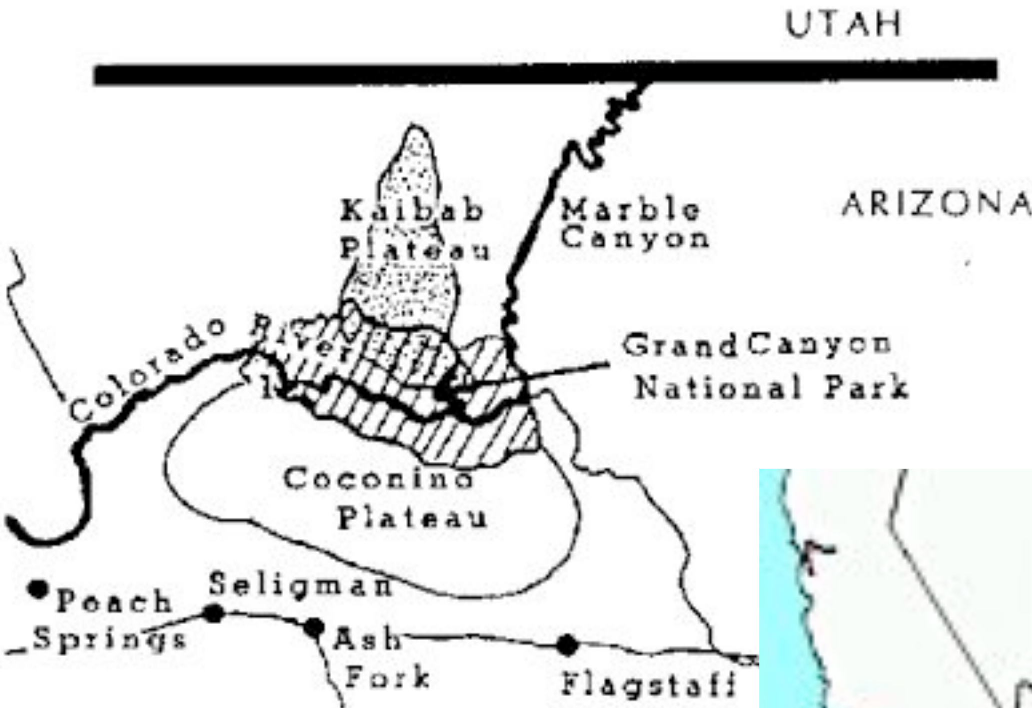
How does speciation start ?

One way is through allopatry (‘different fatherlands”)

Consider the Kaibab squirrel

Consider the Kaibab squirrel

(a) The Kaibab squirrel, with its white tail and gray belly, is found north of the Grand Canyon.


UTAH
ARIZONA
Kaibab Plateau
Marble Canyon
Colorado River
Grand Canyon National Park
Coconino Plateau
Peach Springs
Seligman
Ash Fork
Flagstaff


(a) The Kaibab squirrel, with its white tail and gray belly, is found north of the Grand Canyon.

(b) The Abert squirrel, with its gray tail and white belly, is found south of the Grand Canyon.