POPULATION GENETICS

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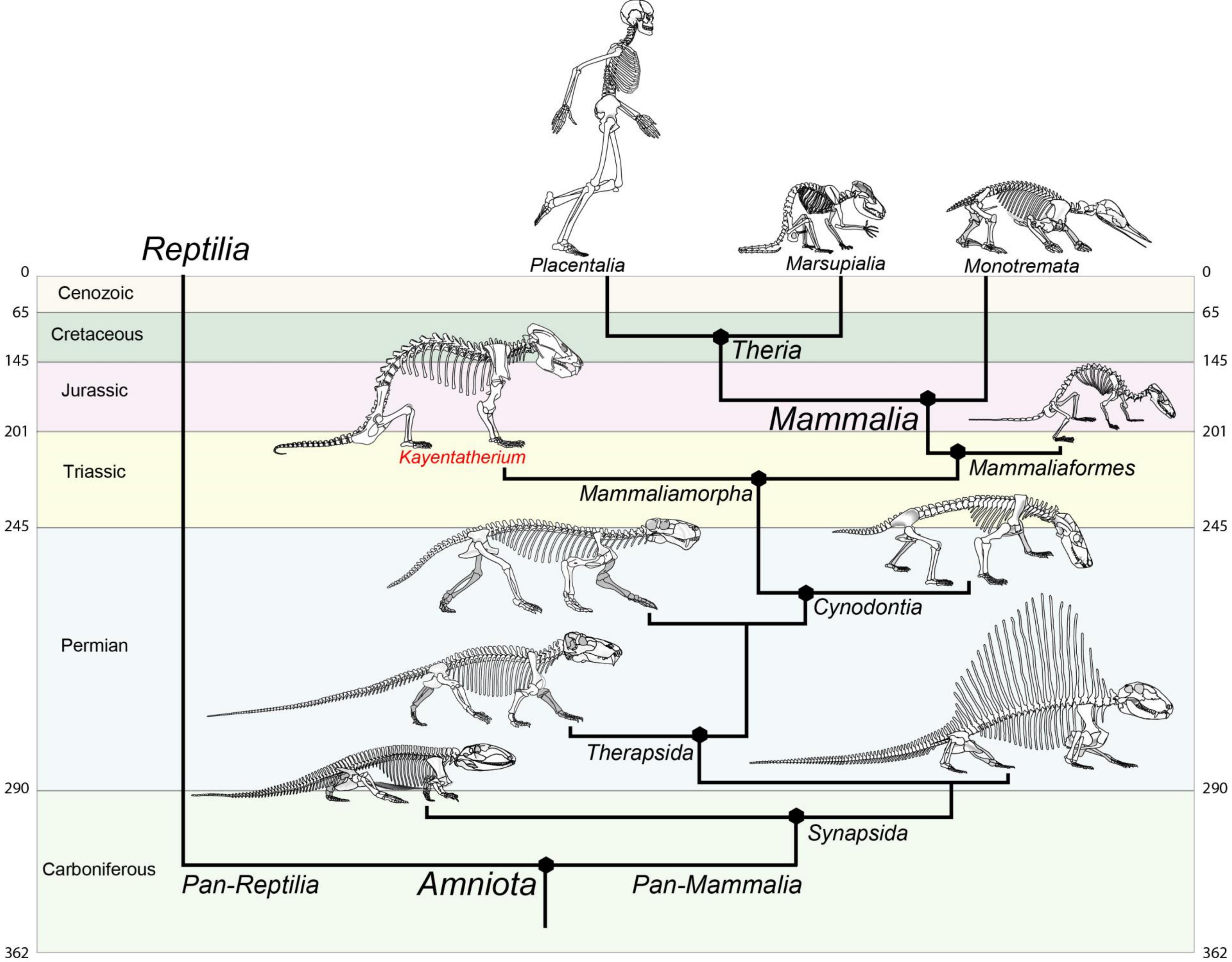


Reptilia
Placentalia
Marsupialia
Monotremata
0
65
145
201
245
290
362
Cenozoic
Cretaceous
Jurassic
Triassic
Permian
Carboniferous
Theria
Mammalia
Kayentatherium
Mammaliaformes
Mammaliamorpha
Cynodontia
Therapsida
Synapsida
Pan-Reptilia
Amniota
Pan-Mammalia

OBJECTIVES

1. Understand the mechanisms of evolutionary change
2. Apply the Hardy-Weinberg Principle
3. Analyze patterns of genetic variation

HOW DO YOU DEFINE SPECIES AND POPULATION?

TERMINOLOGIES

- **Species**

  Organisms of the same type that may not be living at the same place

- **Population**

  A group of individuals that belong to the same species and live in the same area (and are reproducing together)

- **Gene pool**

  The combined genetic information of all the members of a population

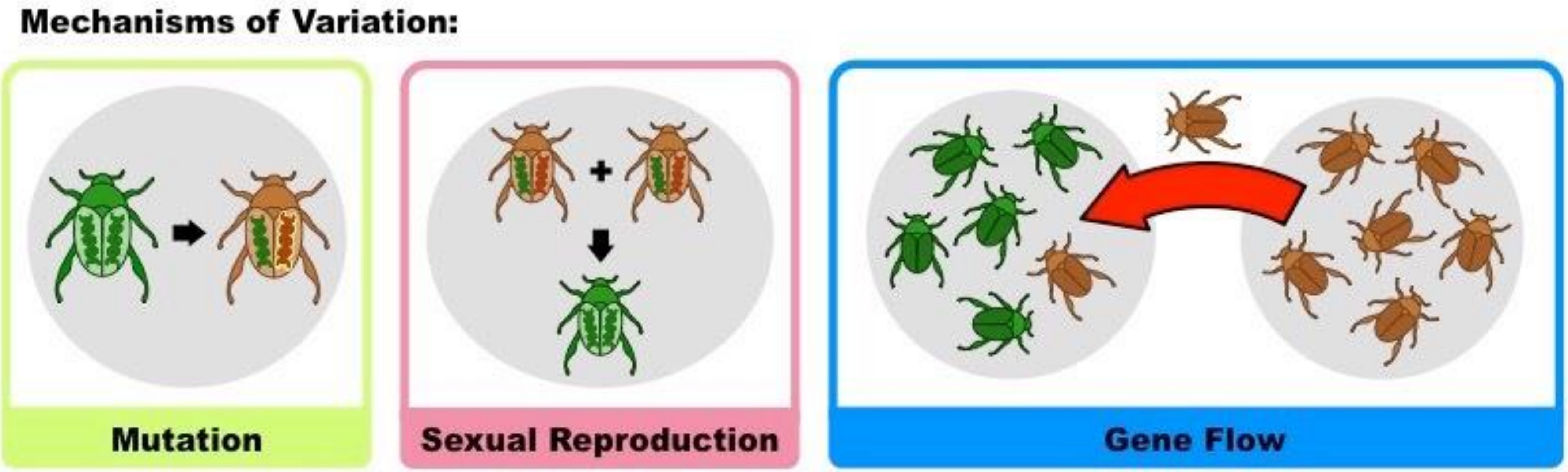
HOW MANY SPECIES, POPULATION AND GENE POOL IS THERE IN THE FOLLOWING:

1. Human are usually identified based on geographical locations as Europeans, Americans, Africans and Asians.
2. Species of dogs usually depends on their environment. Huskies are found in large numbers in Alaska or very cold countries while Beagles may easily survive in tropical countries like the Philippines.
3. Narra, Mahogany, Gmelina and Acacia trees abound the forests of Southeast Asian countries such as the Philippines, Malaysia, Indonesia and Thailand.

SOURCES OF VARIATION

1. **Mutations** – ultimate source of all variation on earth (can change at the level of populations or entire species)
2. ***Natural selection*** – is the process by which alleles that confer a survival or reproductive advantage increase in frequency in a population over generations
3. ***Genetic drift* –** is the random change in allele frequencies in a population from one generation to the next, due to chance events rather than natural selection
4. **Gene flow** – describes movement of genetic information in <u>population</u>
5. ***Recombination*** – *mixing of genetic information through sexual reproduction; variation in <u>individuals</u> (mixing of genetic information)*

MECHANISMS OF VARIATION



GENETIC DEFINITION OF EVOLUTION

- **Evolution** is any change in the relative frequencies of alleles in a population's gene pool

- Things to be reminded of:
  1. Evolution occurs in populations, not in individuals.
  2. Variation occurs in genotypes, but natural selection acts on phenotypes.
  3. Variation is random. Selection is not random.

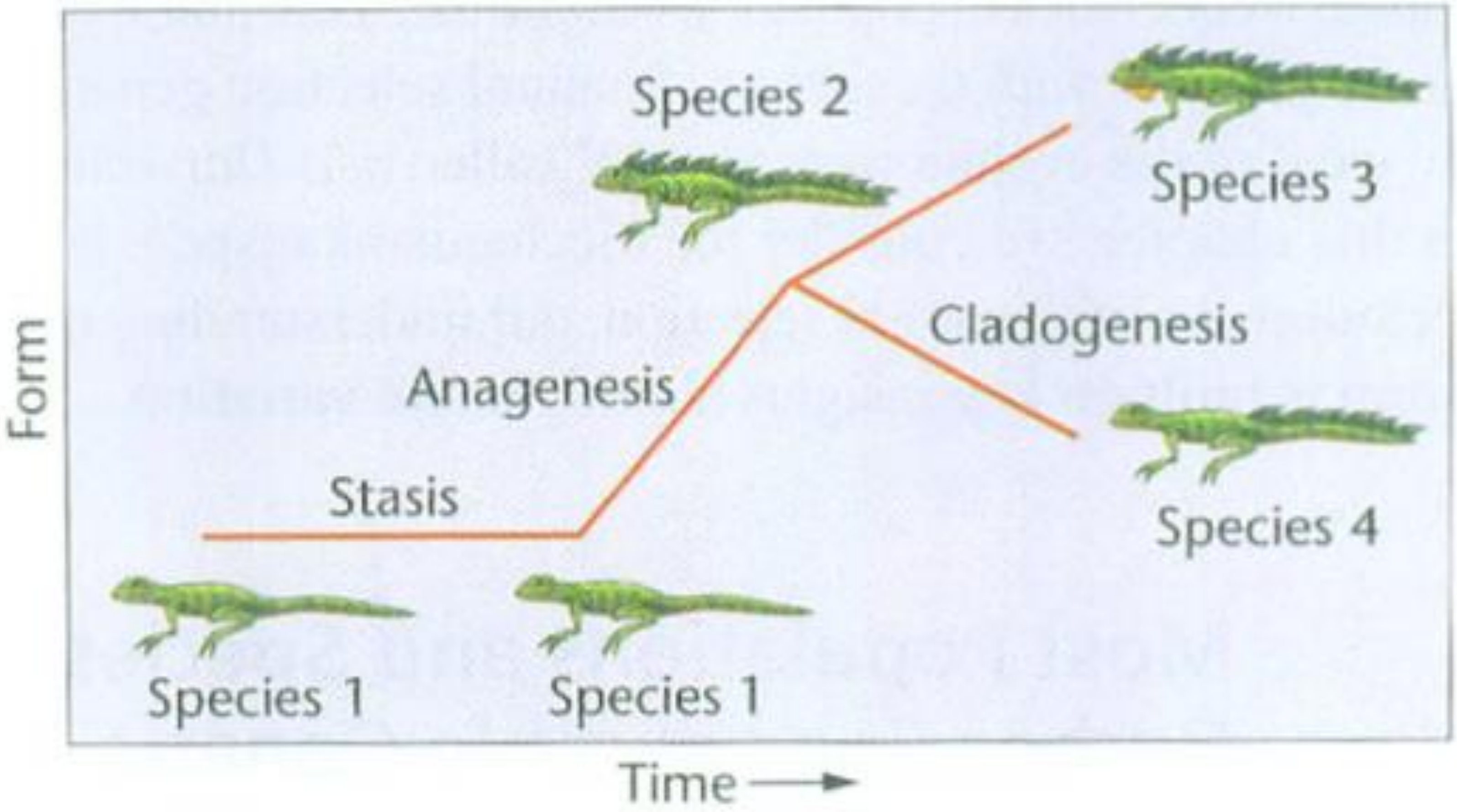


FIGURE 26–1 In phyletic evolution, or anagenesis, one species is transformed over time into another species. At all times, only one species exists. In cladogenesis, one species splits into two or more species.

HOW TO DETERMINE THE ALLELE FREQUENCIES

<u>Hardy-Weinberg Equations</u>

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

$$p + q = 1$$

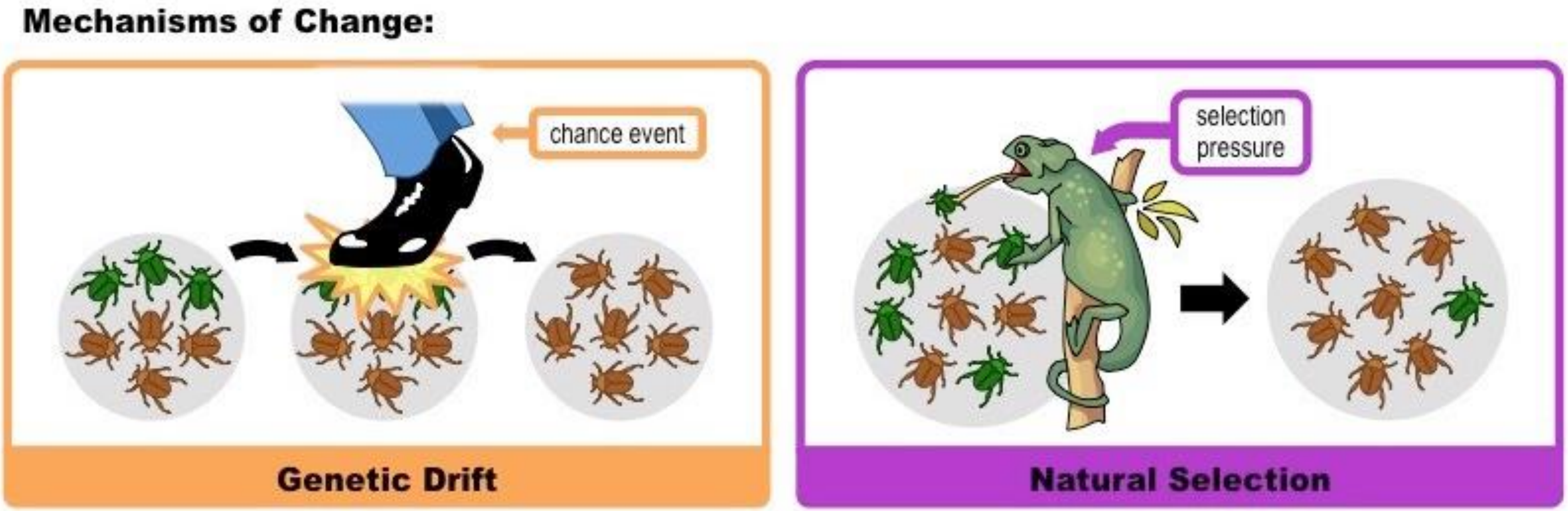
p = frequency of the dominant allele in a population

q = frequency of the recessive allele in a population

SAMPLE PROBLEMS:

1. A certain plant population has 289 individuals, some bearing white flowers, other red flowers. The red allele is dominant over the white allele. Of the 289 plants, 246 have red flowers. Assuming the population is in equilibrium
   a. What is the frequency of the white allele?
   b. How many of the red plants are expected to be heterozygous?
2. A healthy 27-year-old female presents to the physician for genetic counseling with her husband. They would like to become pregnant in the near future, but have concerns that their offspring may develop cystic fibrosis. The wife's sister has cystic fibrosis, an autosomal recessive disorder with an incidence of approximately 1/90,000 in this particular population. The husband's history is non-contributory. What is the probability of the husband being a carrier?

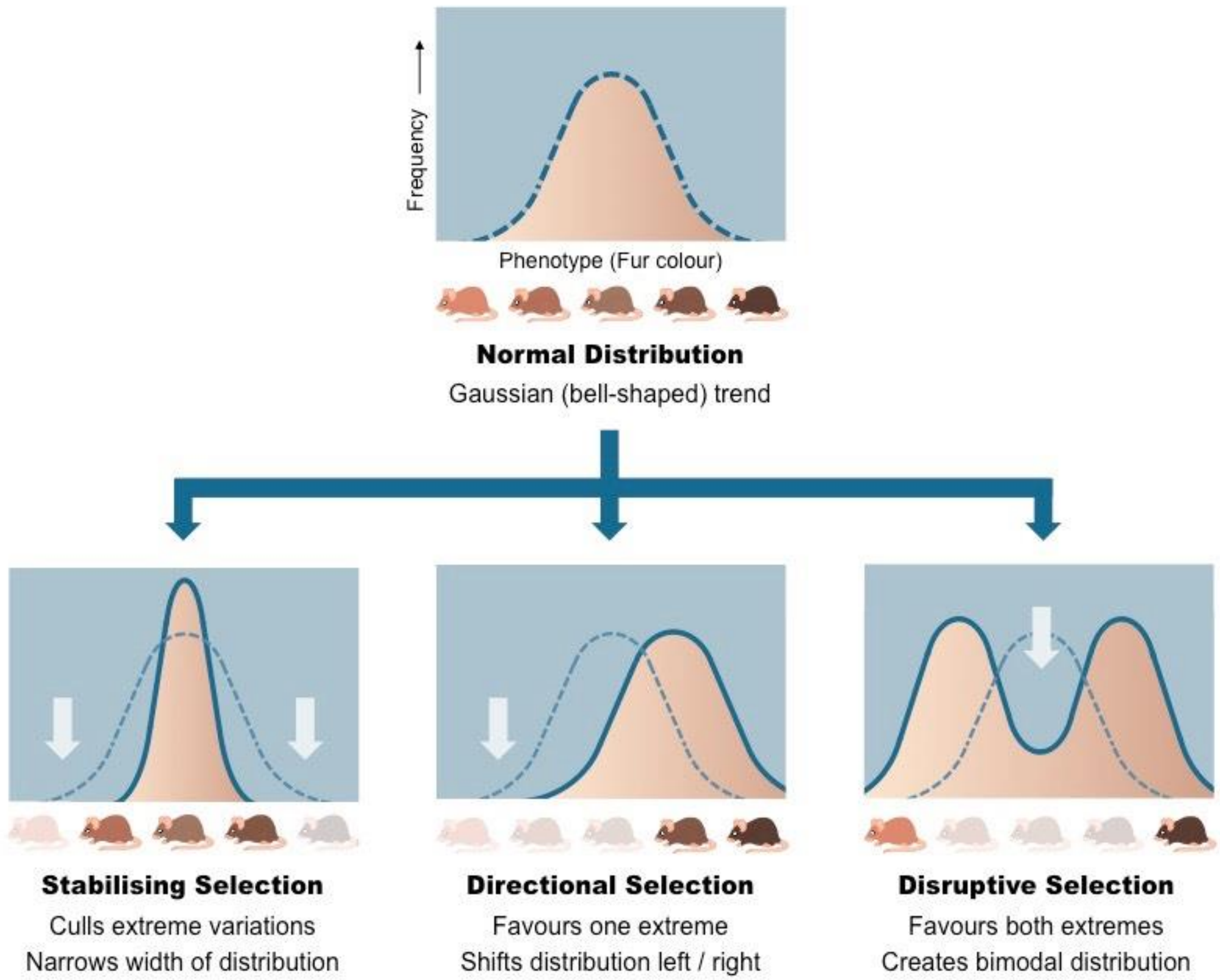
MECHANISMS OF CHANGE/EVOLUTION



THE WALLACE-DARWIN CONCEPT OF NATURAL SELECTION

1. Individuals of a species exhibit variations in phenotype—for example, showing differences in size, agility, coloration, defenses against enemies, ability to obtain food, courtship behaviors, flowering times, etc.
2. Many of these variations, even small and seemingly insignificant ones, are heritable and passed on to offspring.
3. Organisms tend to reproduce in an exponential fashion. More offspring are produced than can survive. This causes members of a species to engage in a struggle for survival, competing with other members of the community for scarce resources. Offspring also must avoid predators, and in sexually reproducing species, adults must compete for mates.
4. In the struggle for survival, individuals with particular phenotypes will be more successful than individuals with others, allowing the former to survive and reproduce at higher rates.

TYPES OF SELECTION



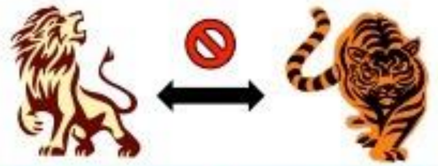
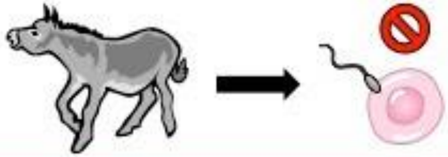
Pre-zygotic Isolating Mechanisms		**Example**	
Temporal	Occurs when two species mate at different times of year	Frogs live in same pond but breed during different seasons (summer vs spring)	
Ecological	Occurs when two species occupy different habitats	Lions and tigers can potentially interbreed, but usually occupy different habitats	
Behavioural	Occurs when two species have different courtship behaviours	Certain groups of birds will only respond to species-specific mating calls	
Mechanical	Occurs when physical differences prevent copulation / pollination	Certain breeds of dog are morphologically incapable of mating due to size	
Post-zygotic Isolating Mechanisms		**Examples**	
Hybrid Inviability	Hybrids are produced but fail to develop to reproductive maturity	Certain types of frogs form hybrid tadpoles that die before they can become a frog	
Hybrid Infertility	Hybrids fail to produce functional gametes (sterility)	Mules are sterile hybrids resulting from mating between a horse and a donkey	
Hybrid Breakdown	F_1 hybrids are fertile, but F_2 generation fails to develop properly	The offspring of hybrid copepods have less potential for survival or reproduction	

Table 26.2 Reproductive Isolating Mechanisms

Prezygotic Mechanisms (prevent fertilization and zygote formation)

1. **Geographic or ecological:** The populations live in the same regions but occupy different habitats
2. **Seasonal or temporal:** The populations live in the same regions but are sexually mature at different time
3. **Behavioral (only in animals):** The populations are isolated by different and incompatible behavior befor
4. **Mechanical:** Cross-fertilization is prevented or restricted by differences in reproductive structures (genita in plants)
5. **Physiological:** Gametes fail to survive in alien reproductive tracts

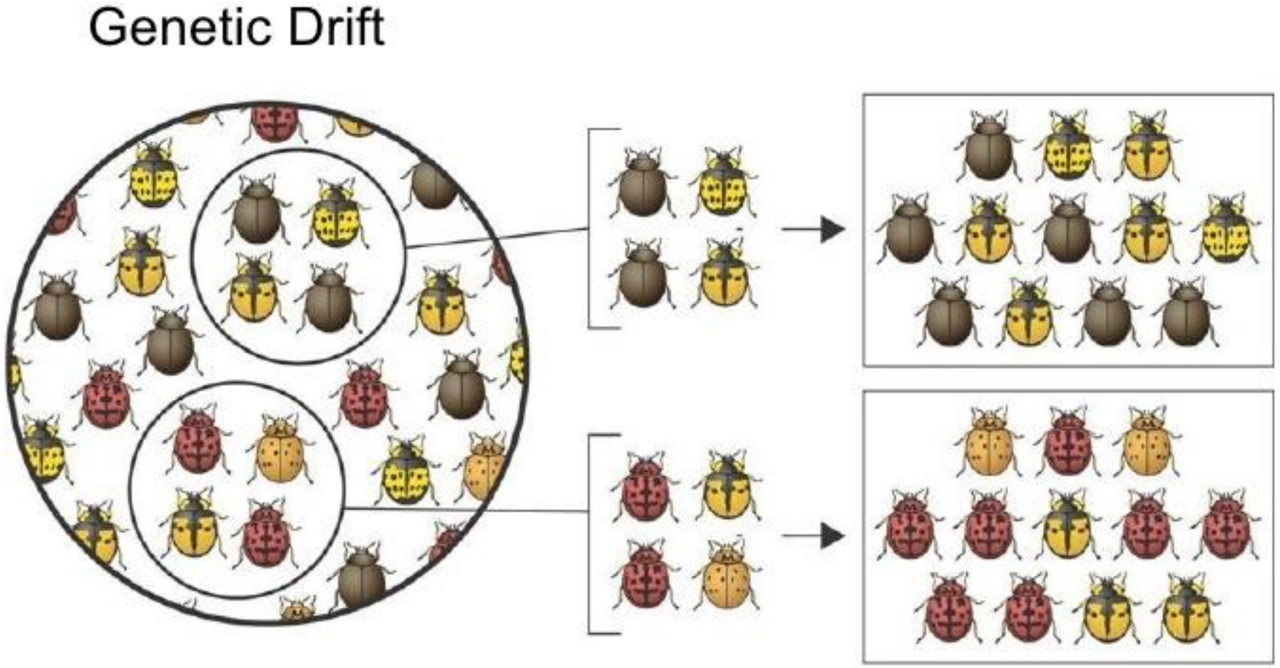
Postzygotic Mechanisms (fertilization takes place and hybrid zygotes are formed, but these are n to weak or sterile hybrids)

1. **Hybrid nonviability or weakness**
2. **Developmental hybrid sterility:** Hybrids are sterile because gonads develop abnormally or meiosis break completion
3. **Segregational hybrid sterility:** Hybrids are sterile because of abnormal segregation into gametes of who chromosome segments, or combinations of genes
4. **F_2 breakdown:** F_1 hybrids are normal, vigorous, and fertile, but the F_2 contains many weak or sterile indi

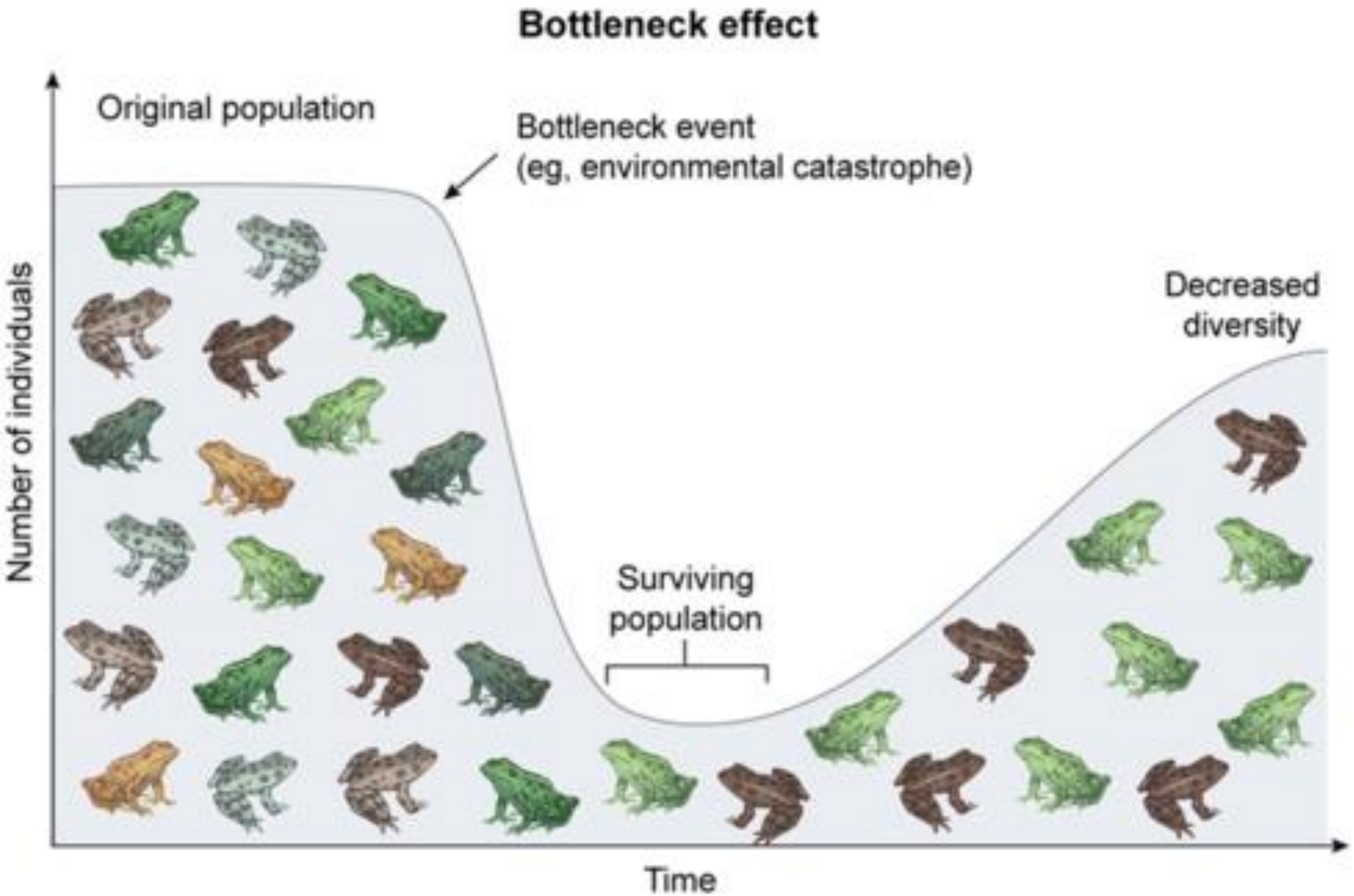
GENETIC DRIFT

1. **Genetic drift** – refers to the random changes in allele frequency (not natural selection) due to chance
   a. *Genetic bottleneck* – occurs when population size is sharply reduced results in genetic diversity loss
   b. *Founder effect* – small group of individuals colonizes a new habitat

GENETIC DRIFT: FOUNDER EFFECT



GENETIC DRIFT: BOTTLENECK



GENETIC EQUILIBRIUM

FACTORS FAVORING STABILITY

1. Random mating
2. Large population
3. No migration
4. No mutations
5. No natural selection

FACTORS FAVORING CHANGE

1. Sexual selection
2. Small populations
3. Migration (gene flow)
4. Mutations
5. Selection

WHY IS GENETIC DIVERSITY IMPORTANT?

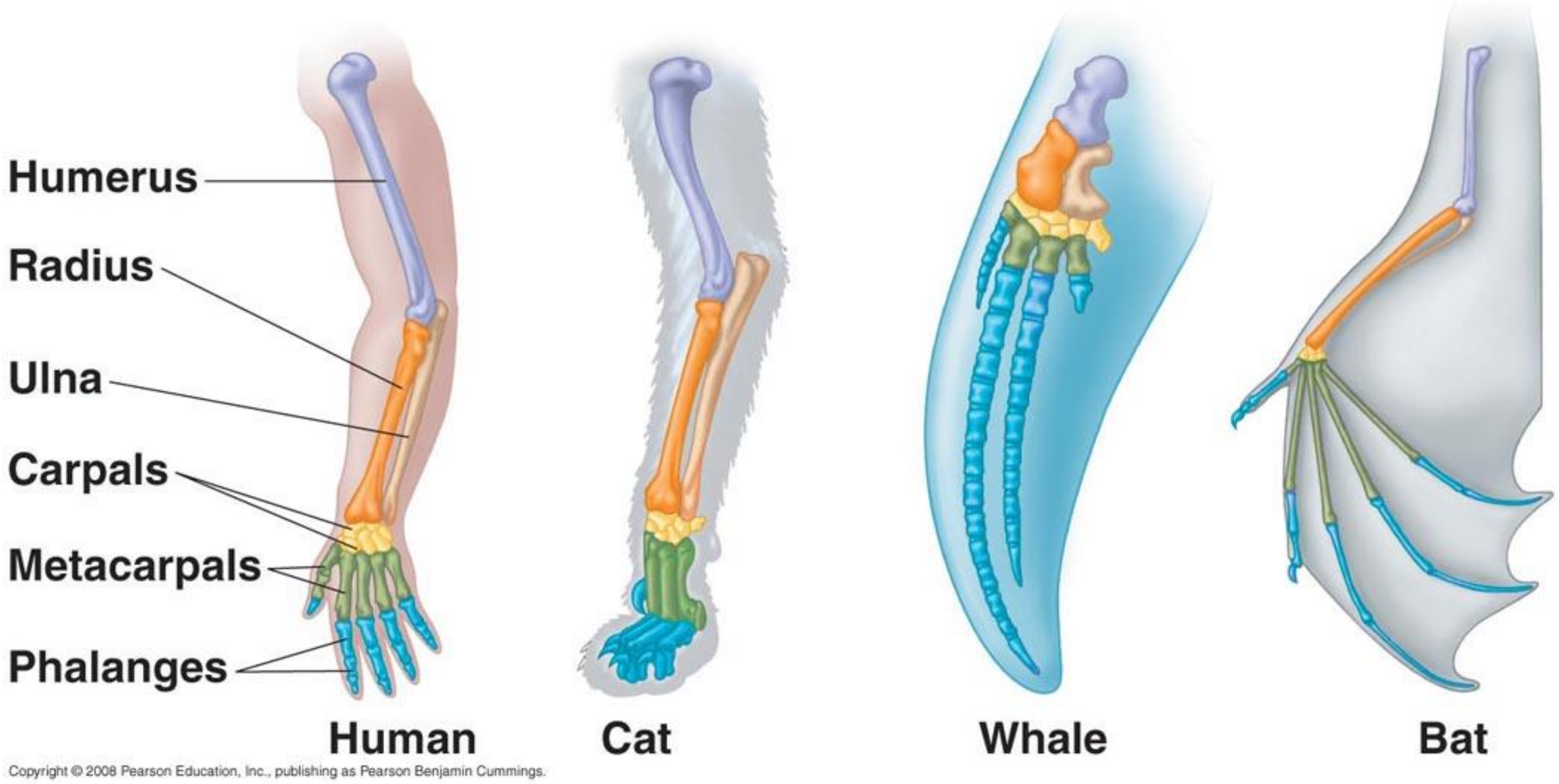
RATE OF EVOLUTION

- **Evolution** = (variation + natural selection) / Time

Where;

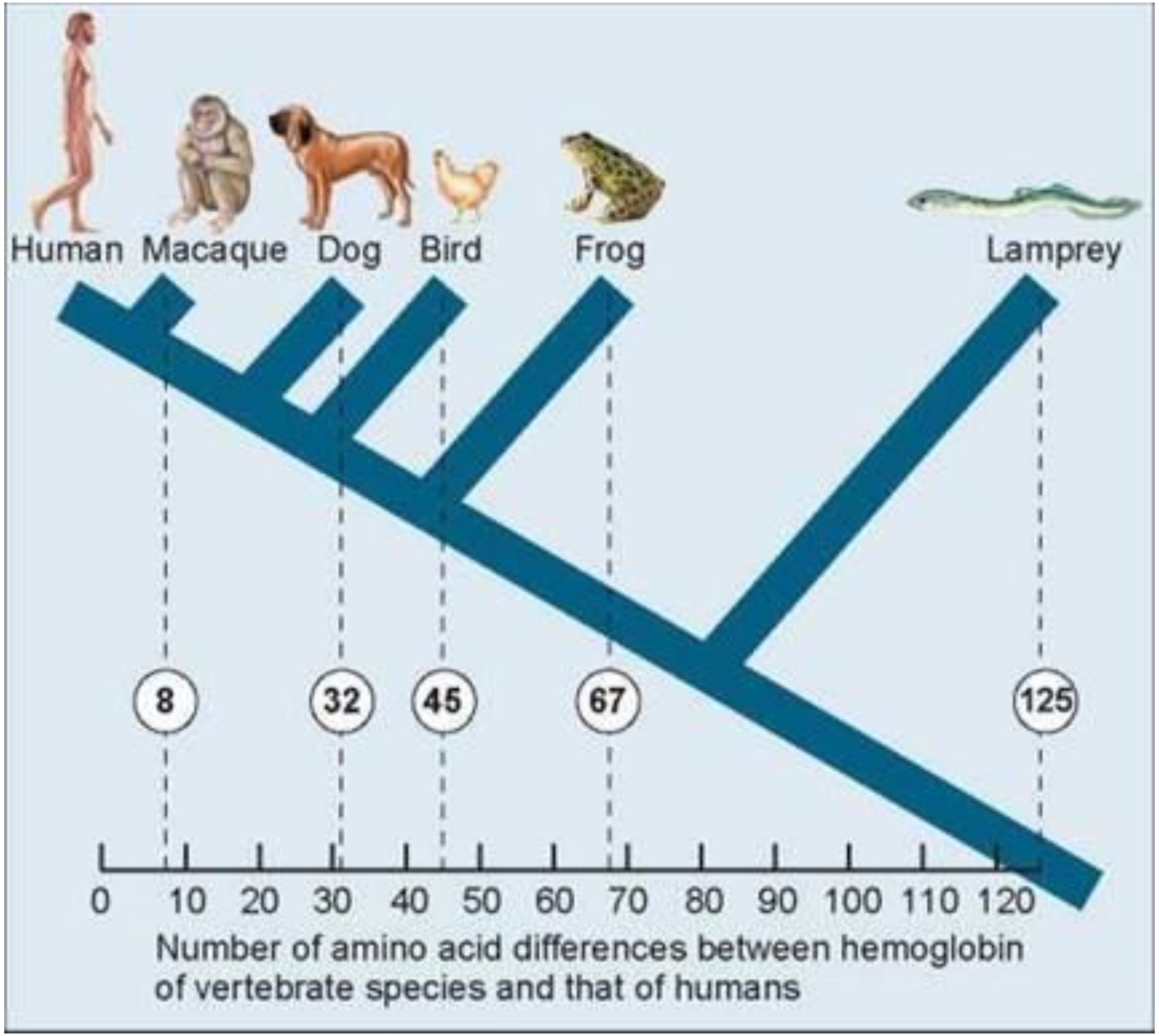
- *Variation depends on*: generation time and reproduction rate
- *Selection depends on*: rate and extent of environmental change and selection strength

EVIDENCES OF EVOLUTION: ANATOMY



Anatomy

EVIDENCE: MOLECULAR BIOLOGY



(a)

	Human	Chimp	Gorilla	Siamang	Gibbon
Human	–				
Chimp	1.628	–			
Gorilla	2.267	2.21	–		
Siamang	4.7	5.133	4.543	–	
Gibbon	4.779	4.76	4.753	1.95	–

(c)

	Hu-Ch	Gorilla	Siamang	Gibbon
Hu-Ch	–			
Gorilla	2.2385	–		
Siamang	4.9165	4.543	–	
Gibbon	4.7695	4.753	1.95	–

(e)

	Hu-Ch	Gorilla	Si-Gi
Hu-Ch	–		
Gorilla	2.239	–	
Si-Gi	4.843	4.648	–

(g)

	Hu-Ch-Go	Si-Gi
Hu-Ch-Go	–	
Si-Gi	4.778	–

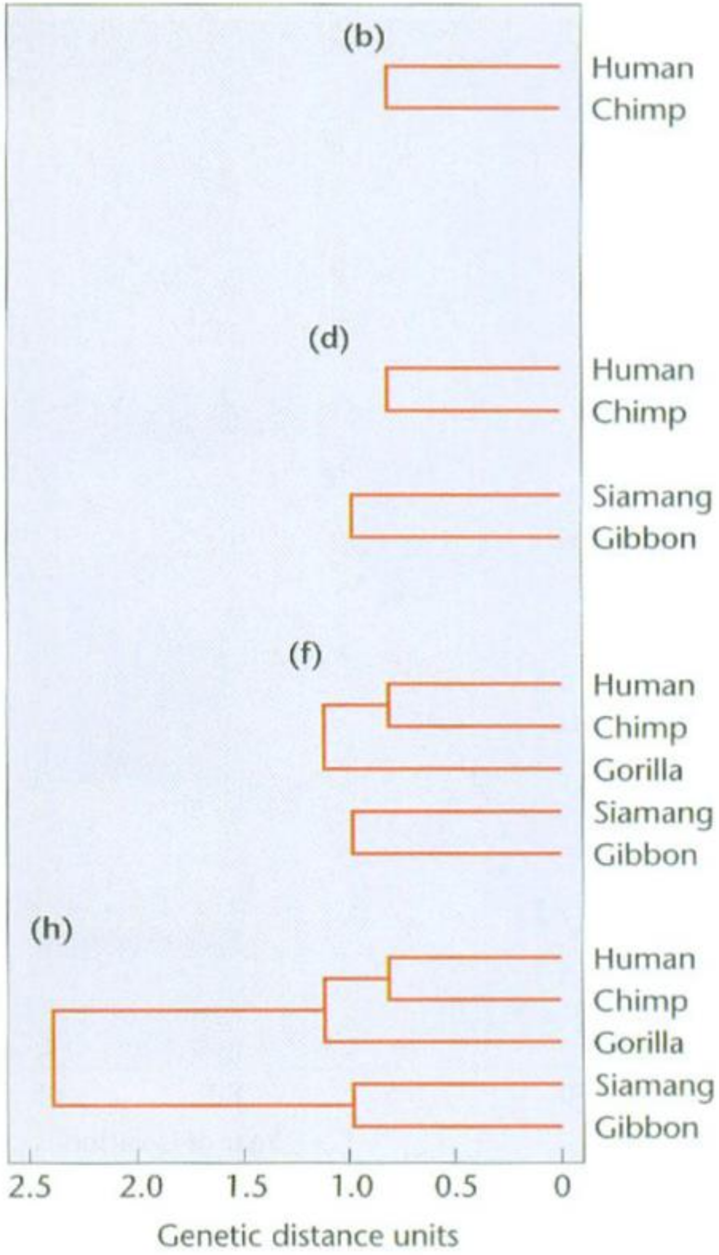
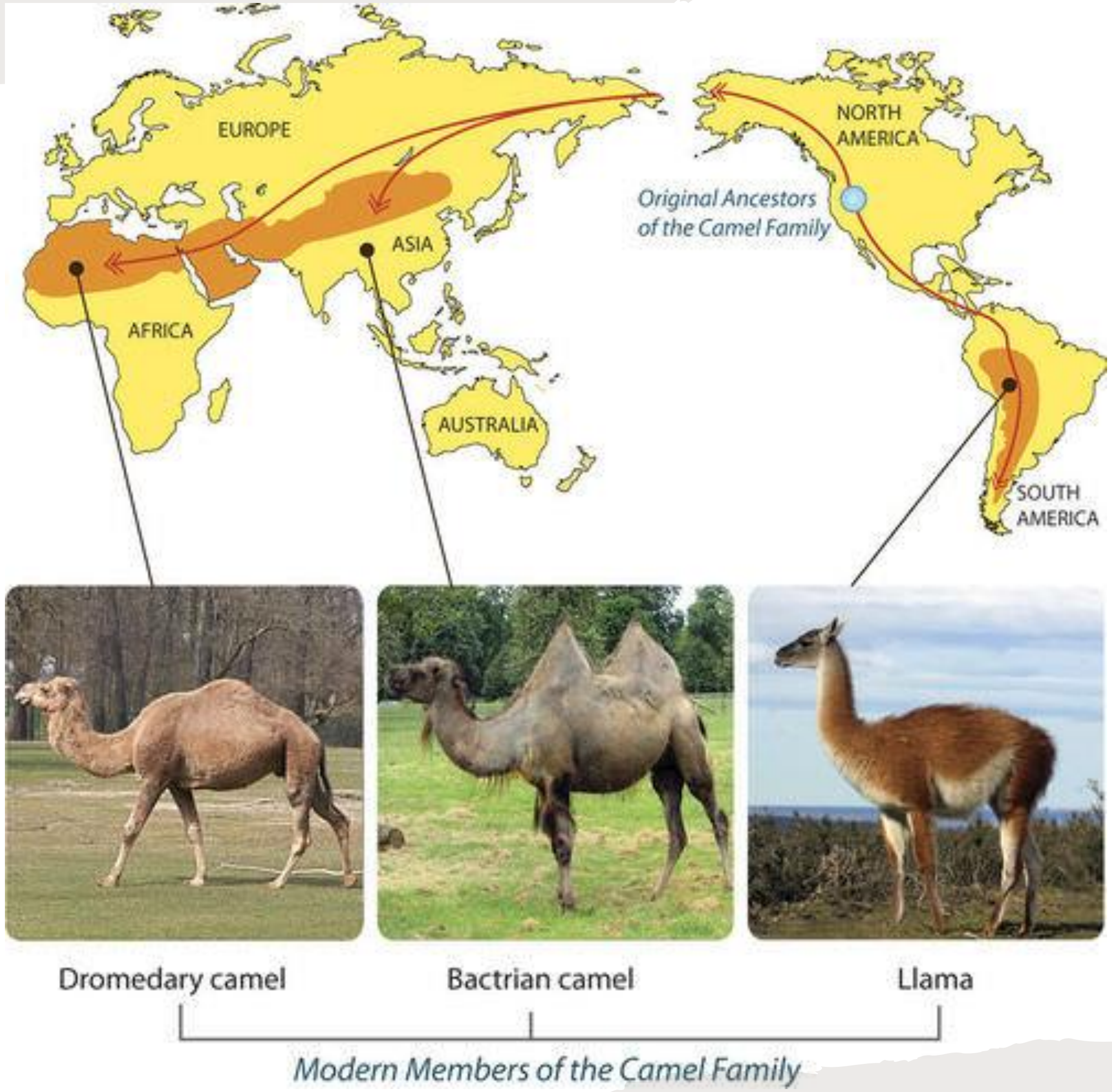
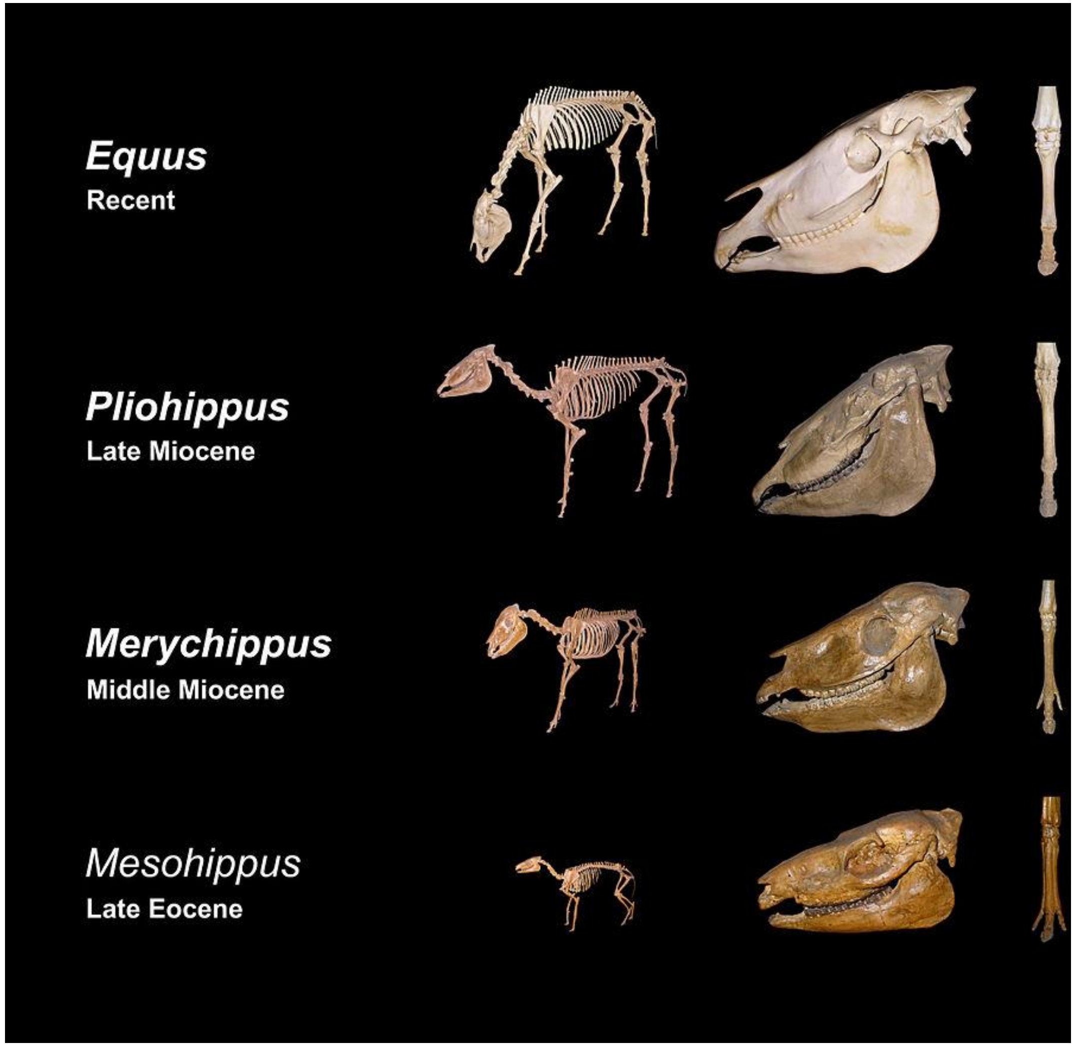


FIGURE 26–19 Phylogeny reconstruction by UPGMA.

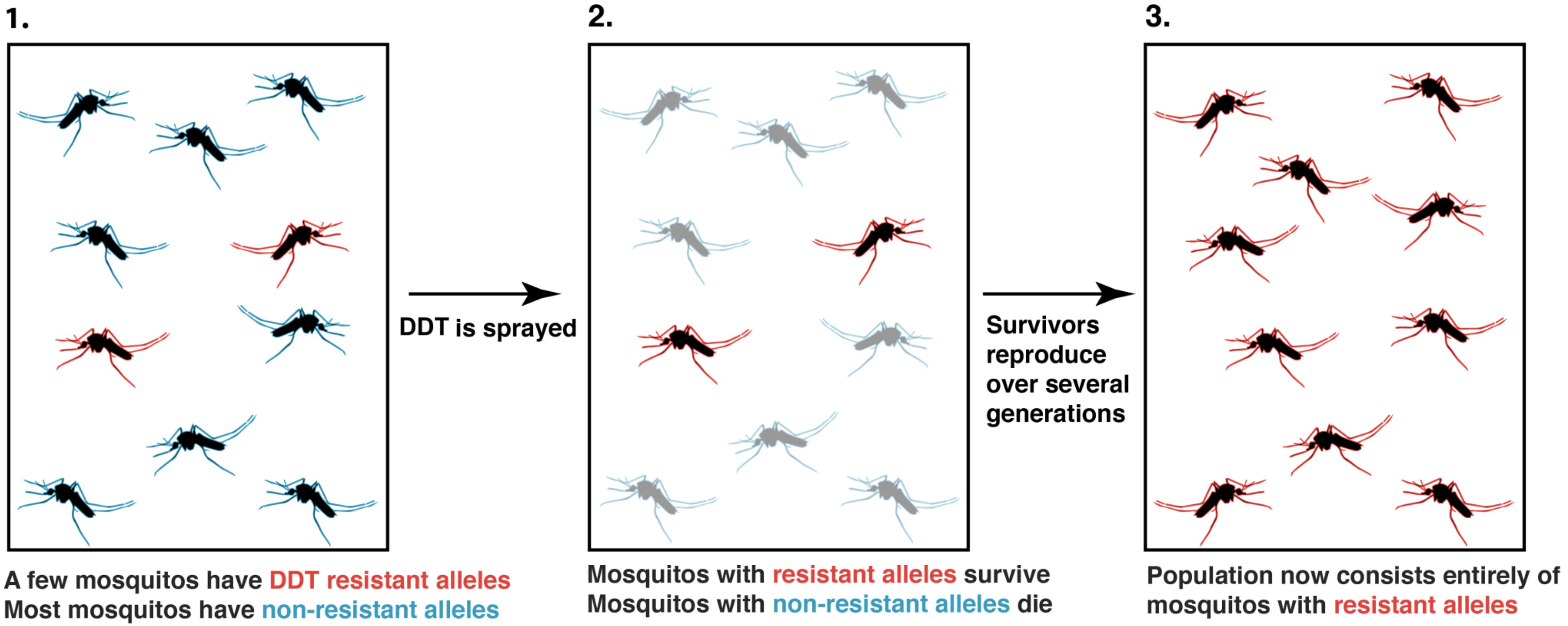
EVIDENCE: BIOGEOGRAPHY



EVIDENCE: FOSSIL RECORDS



EVIDENCE: DIRECT OBSERVATION



Consider population (70% EE, 28% Ee, and 2% ee). Reasoning from genotypic frequencies, does this population appear to be at Hardy-Weinberg equilbrium?

a) Yes, the genotypic frequencies are very close to those expected.
b) No, there are way too many EE organisms.
c) No, there are way too many Ee organisms.
d) No, there are way too few ee organisms.

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0 – 1

E e

0 – 100%

$p + q = 1$

$0.84 + 0.16 = 1$

EE Ee ee

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

ob

$0.70 + 0.28 + 0.02 = 1$

0.14 0.14

$p^2 = 0.84^2 = 0.71$

$2pq = 2(0.84 \times 0.16) = 0.27$

In a sample of mushrooms from a forest floor, three genotypes controlled by 2 alleles (A and B) at one locus showed the following numbers in the population; AA = 15, AB = 80, BB = 5. Are these numbers what you would expect if this population was in Hardy-Weinberg equilibrium?