Summer Assignment for Seniors 2017 :)

1. Notes: Notes will be expected from AP OR IB text with the following sections:
   - Assignment will correspond with AP text chapter 22 and 23 (not Hardy Weinberg)

     OR IB Text 5.1, IB Text 5.2, IB Text 10.3 (not Hardy Weinberg)

2. Handouts: a packet of information relating to the above chapters
3. Videos: view videos for further understanding.

Part 1 https://www.youtube.com/watch?v=f0OXbu1Ax0E

Part 2 https://www.youtube.com/watch?v=IxOPSnGyLwA

Part 1 https://www.youtube.com/watch?v=235TedhH-N0

Natural Selection https://www.youtube.com/watch?v=Tnb-togE4I4

Name ______________________________ Period __________

AP Biology Date ______________________

CHAPTER 22 GUIDED NOTES: THE EVIDENCE FOR EVOLUTION

IB 5.1, 5.2 and/or 10.3

1. What is the primary mechanism that is responsible for evolutionary change? ____________

____

2. How did Darwin's observations of the finches of the Galapagos islands influence the development of his theory of evolution by natural selection?

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3. What was the driving force behind the evolution of the 14 species of finches on the Galapagos?

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4. What three conditions must be met in nature to drive natural selection?

   a. ____

   b. ____

   c. ____

5. Briefly describe how the research on beak size of medium ground finches (undertaken by Drs. Peter and Rosemary Grant) offers supportive evidence for evolution by natural selection.

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6. Briefly explain industrial melanism and describe how this phenomenon supports the principle of evolution by natural selection.

7. List and briefly describe two cases in which artificial selection has created substantial change in a species.

   a.

   b.

8. How does artificial selection provide support for the principle of evolution by natural selection.

9. List and briefly describe two cases in which the fossil record supports the principle of evolution by natural selection.

   a.

   b.

15. How does diploidy preserve variation?

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____

16. What is "balanced polymorphism?"

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17. How can parasites contribute to balanced polymorphism?

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18. In a biological sense, what is fitness?

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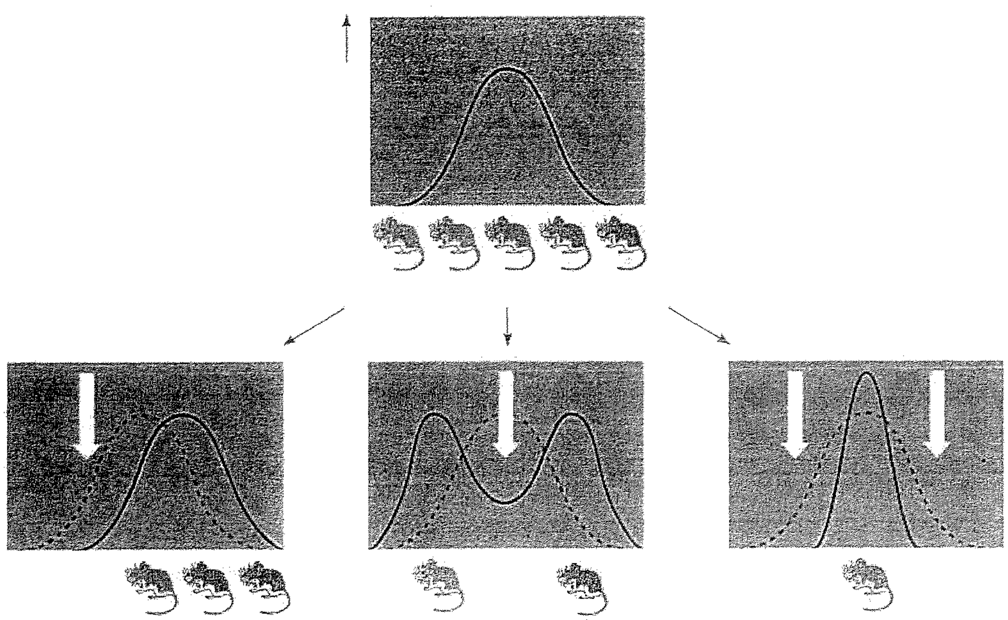
19. Label the following graphs of variation in color with the type of selection.



20. What is the effect of sexual selection?

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____

21. For each of the following, give an example or describe what is meant by the statement.

a. Natural selection cannot fashion perfect organisms: ______________________

____

b. Evolution is limited by historical constraints: ______________________

____

c. Adaptations are often compromises: ______________________

____

d. Not all evolution is adaptive: ______________________

____

e. Selection can only edit existing variations: ______________________

____

HALF-LIFE WORKSHEET Name ______________________

Use Reference Table on side to assist you in answering the following questions.

Equations:

½ lifes:
As-81 = 33 seconds
Au-198 = 2.69 days
C-14 = 5730 years

1 How long does it take a 100.00g sample of As-81 to decay to 6.25g?

2. How long does it take a 180g sample of Au-198 to decay to 1/8 its original mass?

3. What percent of a sample of As-81 remains un-decayed after 43.2 seconds?

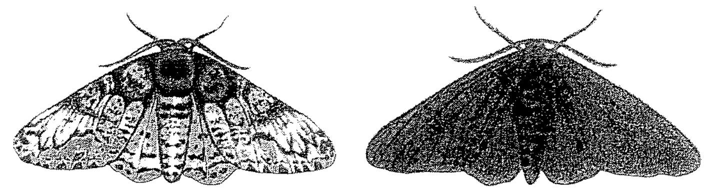
4. What is the half-life of a radioactive isotope if a 500.0g sample decays to 62.5g in 24.3 hours?

5. How old is a bone if it presently contains 0.3125g of C-14, but it was estimated to have originally contained 80.000g of C-14?

Natural selection may act on the frequencies of phenotypes (and hence genotypes) in populations in one of three different ways (through stabilizing, directional, or disruptive selection). Over time, natural selection may lead to a permanent change in the genetic makeup of a population. The increased prevalence of melanic forms of the peppered moth, *Biston betularia*, during the Industrial Revolution, is one of the best known examples of directional selection following a change in environmental conditions. Although the protocols used in the central experiments on *Biston*, and the conclusions drawn from them, have been queried, it remains one of the clearest documented examples of phenotypic change in a polymorphic population.

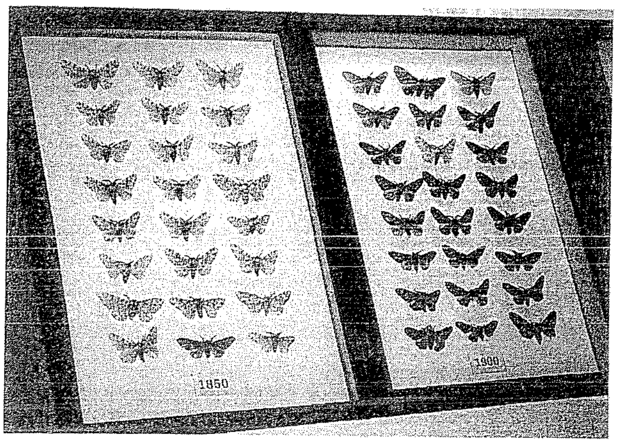
Industrial Melanism in Peppered Moths, *Biston betularia*

The **peppered moth**, *Biston betularia*, occurs in two forms (morphs): the gray mottled form, and a dark melanic form. Changes in the relative abundance of these two forms was hypothesized to be the result of selective predation by birds, with pale forms suffering higher mortality in industrial areas because they are more visible. The results of experiments by H.D. Kettlewell supported this hypothesis but did not confirm it, since selective predation by birds was observed but not quantified. Other research indicates that predation by birds is not the only factor determining the relative abundance of the different color morphs.



Gray or mottled morph: vulnerable to predation in industrial areas where the trees are dark.

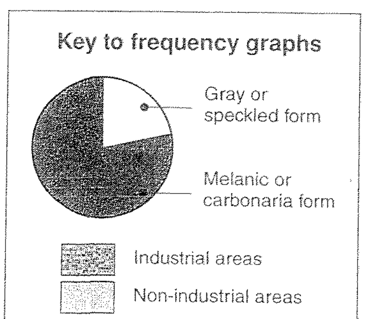
Melanic or carbonaria morph: dark color makes it less vulnerable to predation in industrial areas.

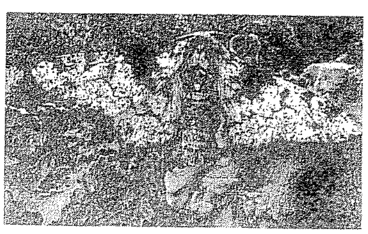


Museum collections of the peppered moth made over the last 150 years show a marked change in the frequency of the melanic form. Moths collected in 1850 (above left), prior to the major onset of the industrial revolution in England. Fifty years later (above right) the frequency of the darker melanic forms had greatly increased. Even as late as the mid 20th century, coal-based industries predominated in some centers, and the melanic form occurred in greater frequency in these areas (see map, right).

Frequency of peppered moth forms in 1950

This map shows the relative frequencies of the two forms of peppered moth in the UK in 1950; a time when coal-based industries still predominated in some major centers.



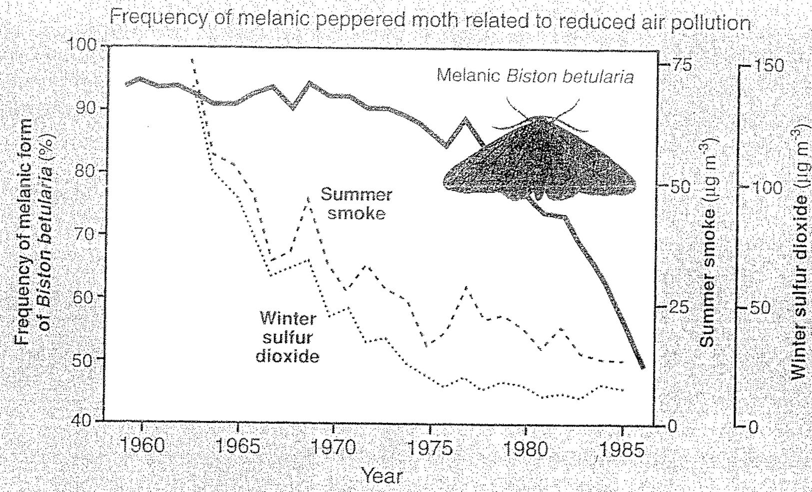


A gray (mottled) form of *Biston*, camouflaged against a lichen covered bark surface. In the absence of soot pollution, mottled forms appear to have the selective advantage.

A melanic form of *Biston*, resting on a dark branch, so that it appears as part of the branch. Note that the background has been faded out so that the moth can be seen.

Changes in frequency of melanic peppered moths

In the 1940s and 1950s, coal burning was still at intense levels around the industrial centers of Manchester and Liverpool. During this time, the melanic form of the moth was still very dominant. In the rural areas further south and west of these industrial centers, the gray or speckled forms increased dramatically. With the decline of coal burning factories and the Clean Air Acts in cities, the air quality improved between 1960 and 1980. Sulfur dioxide and smoke levels dropped to a fraction of their previous levels. This coincided with a sharp fall in the relative numbers of melanic moths.



1. The populations of peppered moth in England have undergone changes in the frequency of an obvious phenotypic character over the last 150 years. Describe the phenotypic character that changed in its frequency:

____

2. (a) Identify the (proposed) selective agent for phenotypic change in *Biston*: _______________

   (b) Describe how the selection pressure on the light colored morph has changed with changing environmental conditions over the last 150 years:

____

____

3. The industrial centers for England in 1950 were located around London, Birmingham, Liverpool, Manchester, and Leeds. Glasgow in Scotland also had a large industrial base. Comment on how the relative frequencies of the two forms of peppered moth were affected by the geographic location of industrial regions:

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4. The level of pollution dropped around Manchester and Liverpool between 1960 and 1985.

   (a) State how much the pollution dropped by: _______________

   (b) Describe how the frequency of the darker melanic form changed during the period of reduced pollution:

____

____

5. In the example of the peppered moths, state whether the selection pressure is disruptive, stabilizing, or directional:

____

6. Outline the key difference between natural and artificial selection: _______________

____

7. Discuss the statement "the environment directs natural selection": _______________

____

____

Heterozygous Advantage

There are two mechanisms by which natural selection can affect allele frequencies. Firstly, there may be selection against one of the homozygotes. When one homozygous type (for example, aa), has a lower fitness than the other two genotypes (in this case, Aa or AA), the frequency of the deleterious allele will tend to decrease until it is completely eliminated. In some situations, both homozygous conditions (aa **and** AA) have lower fitness than the heterozygote; a situation that leads to **heterozygous advantage** and may result in the stable coexistence of both alleles in the population (**balanced polymorphism**). There are remarkably few well-documented examples in which the evidence for heterozygous advantage is conclusive. The maintenance of the sickle cell mutation in malaria-prone regions is one such example.

The Sickle Cell Allele (Hb^S)

Sickle cell disease is caused by a mutation to a gene that directs the production of the human blood protein called hemoglobin. The mutant allele is known as **Hb^S** and produces a form of hemoglobin that differs from the normal form by just one amino acid in the β-chain. This minute change however causes a cascade of physiological problems in people with the allele. Some of the red blood cells containing mutated hemoglobin alter their shape to become irregular and spiky; the so-called **sickle cells**.

Sickle cells have a tendency to clump together and work less efficiently. In people with just one sickle cell allele plus a normal allele (the heterozygote condition **Hb^SHb**), there is a mixture of both red blood cell types and they are said to have the sickle cell trait. They are generally unaffected by the disease except in low oxygen environments (e.g. climbing at altitude). People with two Hb^S genes (**Hb^SHb^S**) suffer severe illness and even death. For this reason Hb^S is considered **a lethal gene**.

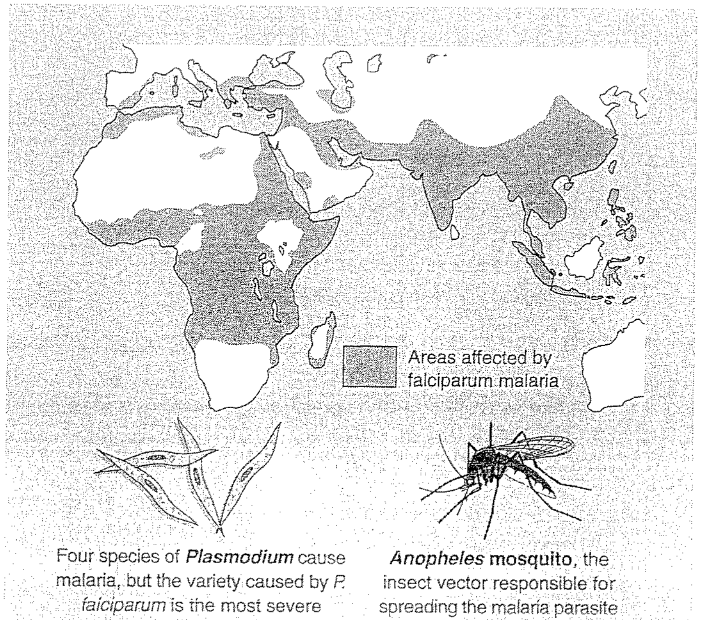


Fig. 1: Incidence of falciparum malaria

Heterozygous Advantage in Malarial Regions

Falciparum malaria is widely distributed throughout central Africa, the Mediterranean, Middle East, and tropical and semi-tropical Asia (Fig. 1). It is transmitted by the *Anopheles* mosquito, which spreads the protozoan *Plasmodium falciparum* from person to person as it feeds on blood.

SYMPTOMS: These appear 1-2 weeks after being bitten, and include headache, shaking, chills, and fever. Falciparum malaria is more severe than other forms of malaria, with high fever, convulsions, and coma. It can be fatal within days of the first symptoms appearing.

THE PARADOX: The Hb^S allele offers considerable protection against malaria. Sickle cells have low potassium levels, which causes plasmodium parasites inside these cells to die. Those with a normal phenotype are very susceptible to malaria, but heterozygotes (**Hb^SHb**) are much less so. This situation, called **heterozygous advantage**, has resulted in the Hb^S allele being present in moderately high frequencies in parts of Africa and Asia despite its harmful effects (Fig. 2). This is a special case of balanced polymorphism, called a **balanced lethal system** because neither of the homozygotes produces a phenotype that survives, but the heterozygote is viable.

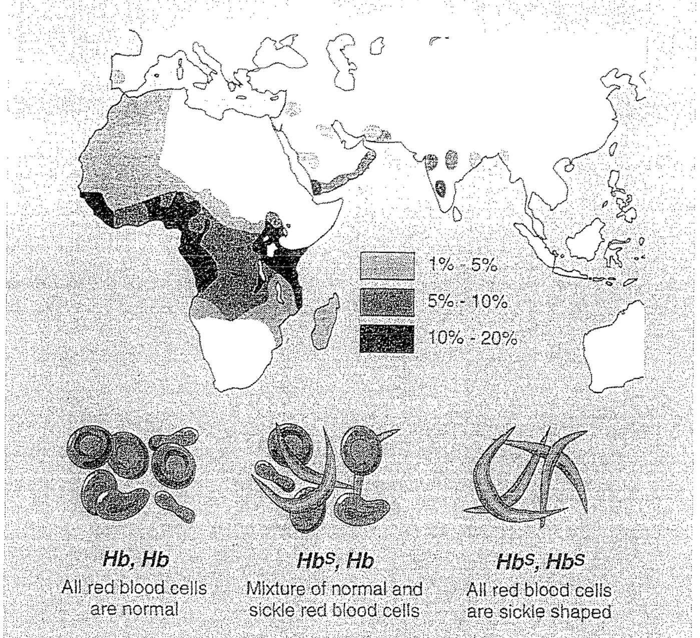


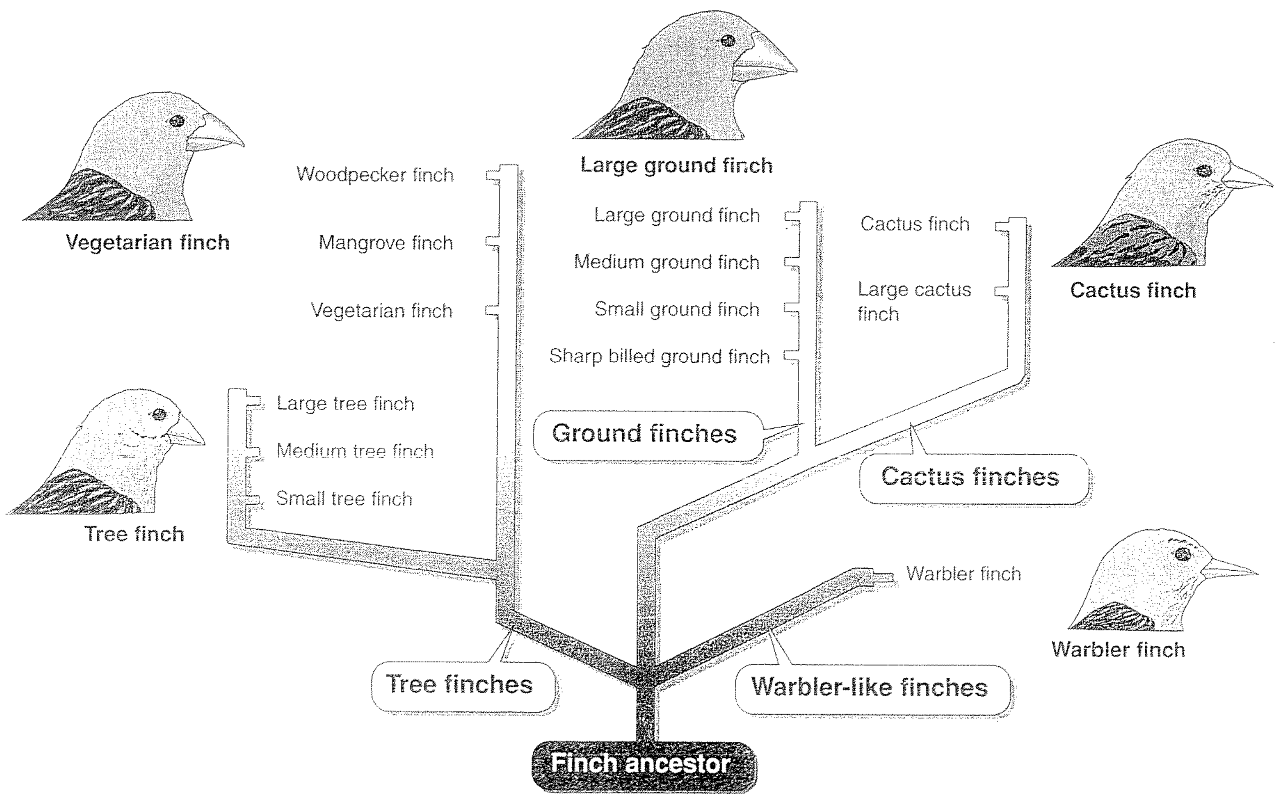
Fig. 2: Frequency of the sickle cell allele

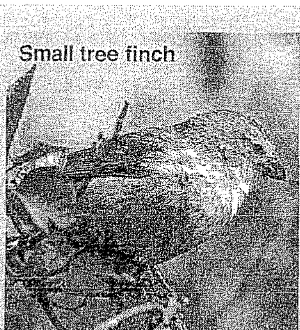
1. With respect to the sickle cell allele, explain how **heterozygous advantage** can lead to **balanced polymorphism**:

Darwin's Finches

The Galapagos Islands, 920 km off the west coast of Ecuador, played a major role in shaping Darwin's thoughts about evolution. While exploring the islands in 1835, he was struck by the unique and peculiar species he found there, in particular, the island's finches. The Galapagos group is home to 13 species of finches in four genera. This variety has arisen as a result of evolution from one ancestral species. Initially, a number of small finches, probably grassquits, made their way from South America to the Galapagos Islands. In the new environment, which was relatively free of competitors, the colonizers underwent an adaptive radiation, producing a range of species each with its own unique feeding niche. Although similar in their plumage, nest building techniques, and calls, the different species can be distinguished by the size and shape of their beaks. Each species has a beak adapted for a different purpose, such as crushing seeds, pecking wood, or probing flowers. Between them, the 13 species of this endemic group fill the roles of seven different families of South American mainland birds. DNA analyses have confirmed Darwin's insight and have shown that all 13 species evolved from a flock of about 30 birds arriving a million years ago.

The Evolution of Darwin's Finches

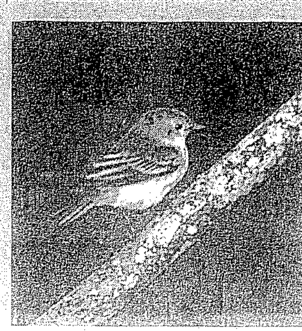




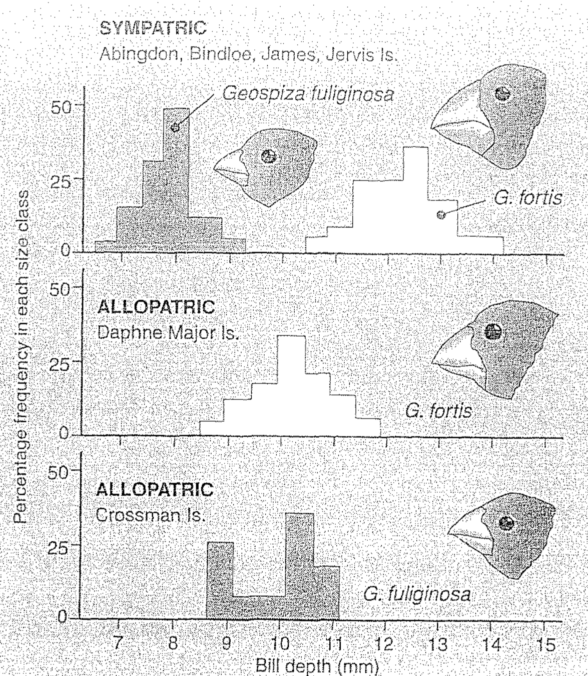
As the name implies, **tree finches** are largely arboreal and feed mainly on insects. The bill is sharper than in ground finches and better suited to grasping insects. Paler than ground or cactus finches, they also have streaked breasts.

There are four species of **ground finches** with crushing-type bills used for seed eating. On Wolf Island, they are called vampire finches because they peck the skin of animals to draw blood, which then they drink (see left).

Cactus finches have most probably descended from ground finches. They have a probing beak and feed on insects on the cactus or the cactus itself. On islands where there are no ground finches, there is more variation in beak size than on the islands where the species coexist.



The **warbler finch** is named for its resemblance to the unrelated warblers. The beak of the warbler finch is the thinnest of the Galapagos finches. It is also the most widespread species, found throughout the archipelago. Warbler finches prey on flying and ground dwelling insects.



The effect of sympatry and allopatry on bill size in *Geospiza fuliginosa* (small ground finch) and *G. fortis* (medium ground finch)

Sympatry and Character Displacement

There is good evidence that finch evolution appears to be driven by a combination of allopatric and sympatric events. Coexisting species of ground finches on four islands (top graph) show large differences in bill sizes, enabling each species to feed on different sized seeds. However when either species exists in the absence of the other on different islands (lower graphs), it possesses intermediate bill sizes (about 10 mm) enabling it to feed without partitioning seed resources. This phenomenon, whereby competition causes two closely related species to become more different in regions where their ranges overlap, is referred to as **character displacement.**

Character displacement is evident in other populations of finches as well. There are well-studied populations of the large cactus finch (*G. conirostris*) on Genovesa and Espanola Islands, but their bill sizes are quite different. On Genovesa, the large ground finch (*G. magnirostris*) coexists with the large cactus finch. In these sympatric populations, the variability in bill size *within* each species is minimal but there is little overlap *between* the species with respect to this trait. On Espanola, where the large ground finch either never arrived, or became extinct, the situation is quite different. With no competition on Espanola, the large cactus finch displays a greater variability in bill size. Its bill is somewhat intermediate between the two finches on Genovesa, and it can feed equally well in both niches all year round.

Data based on an adaptation by Strickberger (2000)

1. Describe the main factors that have contributed to the adaptive radiation of Darwin's finches: ______________________

2. (a) Explain what is meant by **character displacement**: ______________________

   (b) Discuss how the incidence of character displacement observed in the Galapagos finches supports the view that their adaptive radiation from a common ancestor has been driven by a combination of allopatric and sympatric events:

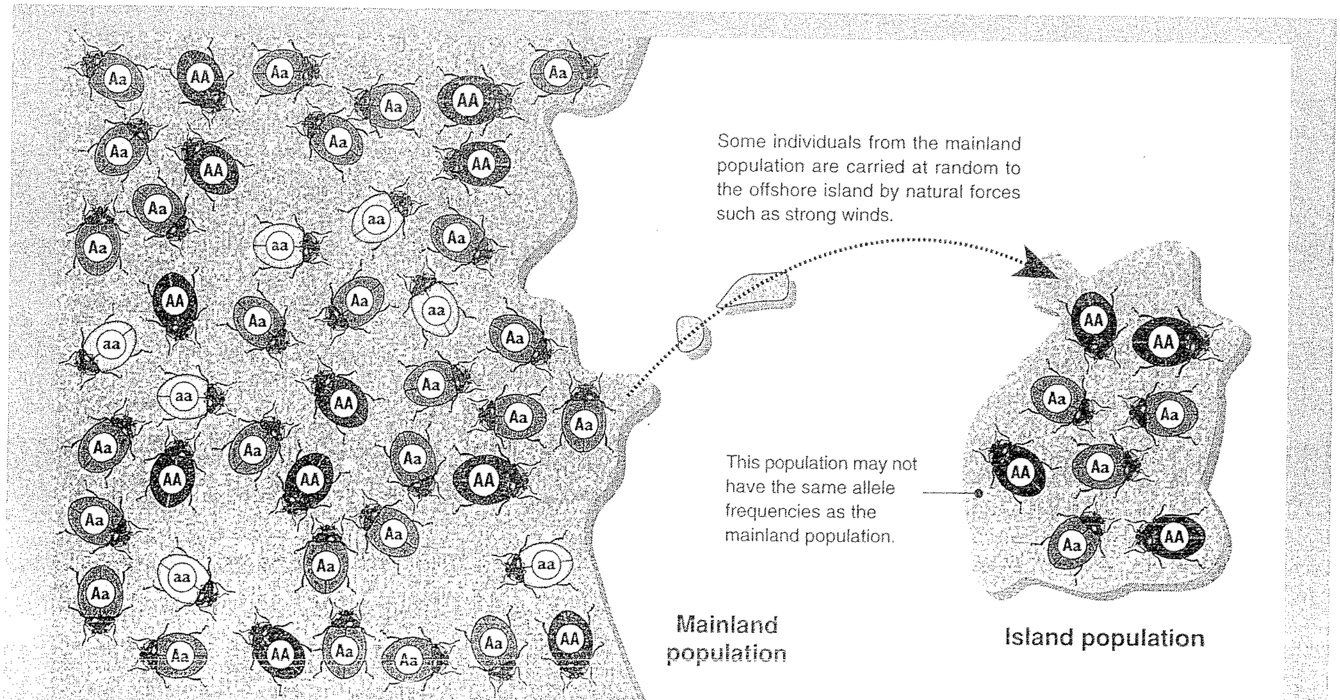
3. The range of variability shown by a phenotype in response to environmental variation is called **phenotypic plasticity**.

   (a) Discuss the evidence for phenotypic plasticity in Galapagos finches: ______________________

   (b) Explain what this suggests about the biology of the original finch ancestor: ______________________

The Founder Effect

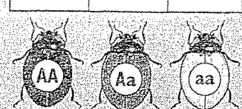
Occasionally, a small number of individuals from a large population may migrate away, or become isolated from, their original population. If this colonizing or 'founder' population is made up of only a few individuals, it will probably have a *non-representative sample* of alleles from the parent population's gene pool. As a consequence of this **founder effect**, the colonizing population may evolve differently from that of the parent population, particularly since the environmental conditions for the isolated population may be different. In some cases, it may be possible for certain alleles to be missing altogether from the individuals in the isolated population. Future generations of this population will not have this allele.



Mainland population

	Allele frequencies: Actual numbers	Allele frequencies: Calculate %
Allele A		
Allele a		
Total		

Phenotype frequencies: Black	Dark	Pale



Colonizing island population

	Allele frequencies: Actual numbers	Allele frequencies: Calculate %
Allele A		
Allele a		
Total		

Phenotype frequencies: Black	Dark	Pale

1. Compare the mainland population to the population which ended up on the island (use the spaces in the tables above):

   (a) Count the **phenotype** numbers for the two populations (i.e. the number of black, dark and pale beetles).

   (b) Count the **allele** numbers for the two populations: the number of dominant alleles (A) and recessive alleles (a). Calculate these as a percentage of the total number of alleles for each population.

2. Describe how the allele frequencies of the two populations are different: ______________________

   ____

3. Describe some possible ways in which various types of organism can be carried to an offshore island:

   (a) Plants: ______________________

   (b) Land animals: ______________________

   (c) Non-marine birds: ______________________

4. Since founder populations are often very small, describe another process that may further alter the allele frequencies:

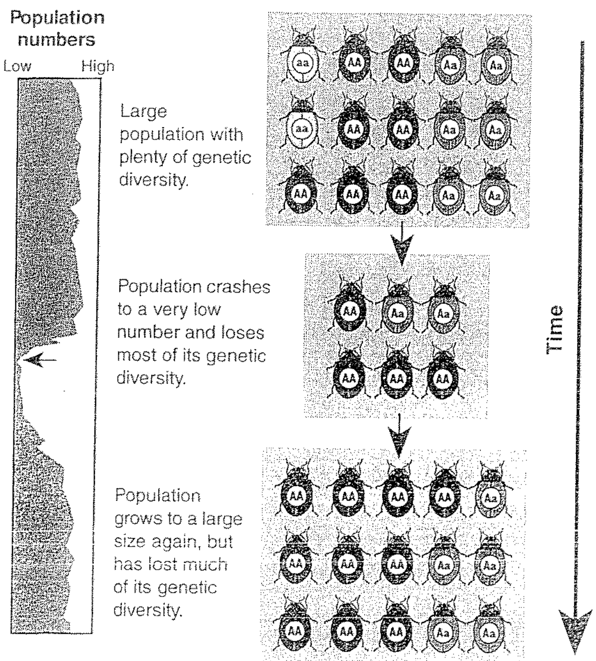
   ____

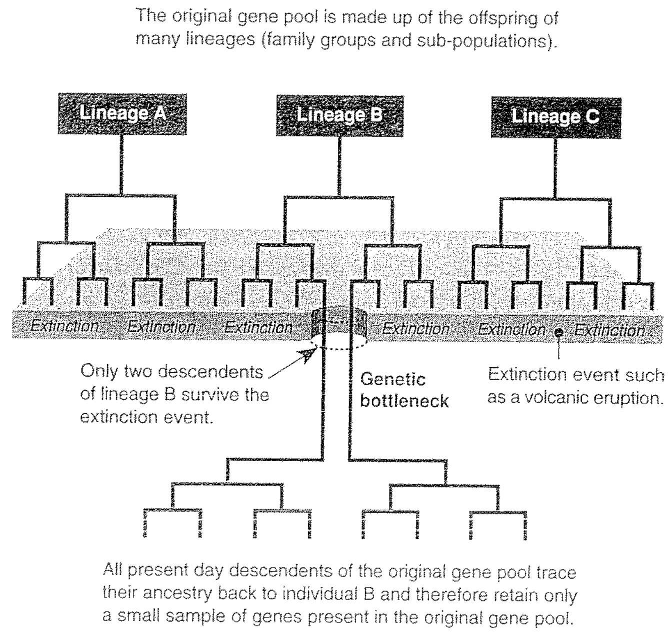
   ____

Population Bottlenecks

Populations may sometimes be reduced to low numbers by predation, disease, or periods of climatic change. A population crash may not be 'selective': it may affect all phenotypes equally. Large scale catastrophic events (e.g. fire or volcanic eruption) are examples of such non-selective events. Humans may severely (and selectively) reduce the numbers of some species through hunting and/or habitat destruction. These populations may recover, having squeezed through a 'bottleneck' of low numbers.

The diagram below illustrates how population numbers may be reduced as a result of a catastrophic event. Following such an event, the small number of individuals contributing to the gene pool may not have a representative sample of the alleles in the pre-catastrophe population, i.e. the allele frequencies in the remnant population may be altered. Genetic drift may cause further changes to allele frequencies. The small population may return to previous levels but with a reduced genetic diversity.





Modern Examples of Population Bottlenecks

Cheetahs: The world population of cheetahs currently stands at fewer than 20 000. Recent genetic analysis has found that the entire population exhibits very little genetic diversity. It appears that cheetahs may have narrowly escaped extinction at the end of the last ice age, about 10-20 000 years ago. If all modern cheetahs arose from a very limited genetic stock, this would explain their present lack of genetic diversity. The lack of genetic variation has resulted in a number of problems that threaten cheetah survival, including sperm abnormalities, decreased fecundity, high cub mortality, and sensitivity to disease.

Illinois prairie chicken: When Europeans first arrived in North America, there were millions of prairie chickens. As a result of hunting and habitat loss, the Illinois population of prairie chickens fell from about 100 million in 1900 to fewer than 50 in the 1990s. A comparison of the DNA from birds collected in the mid-twentieth century and DNA from the surviving population indicated that most of the genetic diversity has been lost.

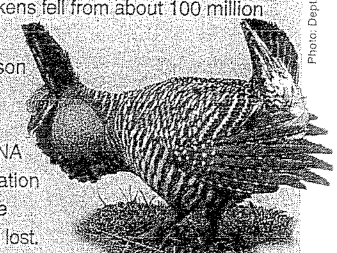


Photo: Dept. of Natural Resources, Illinois

1. Endangered species are often subjected to population bottlenecks. Explain how population bottlenecks affect the ability of a population of an endangered species to recover from its plight:

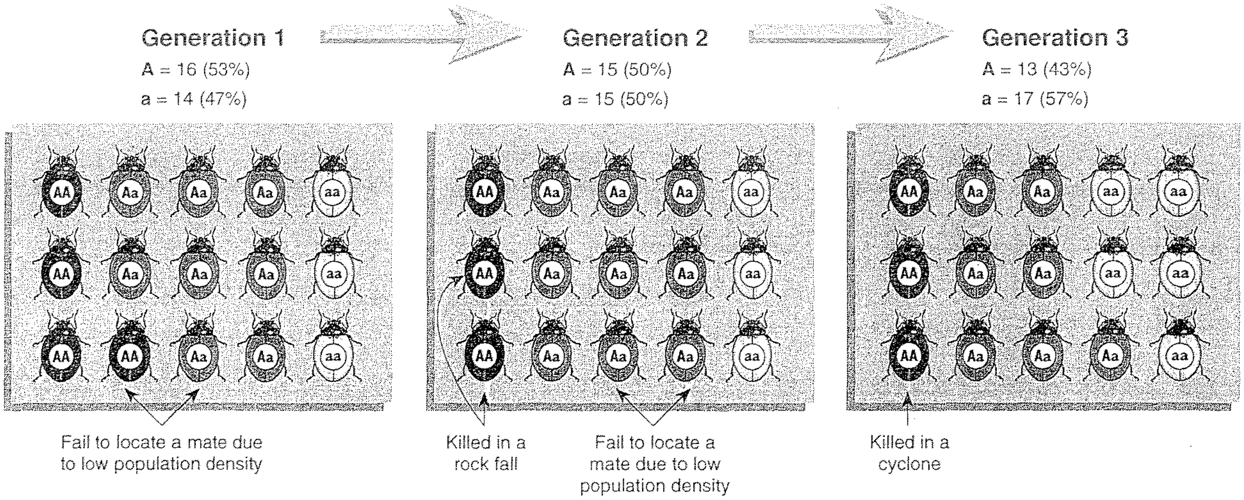
2. Explain why the lack of genetic diversity in cheetahs has increased their sensitivity to disease:

3. Describe the effect of a population bottleneck on the potential of a species to adapt to changes (i.e. its ability to evolve):

Genetic Drift

Not all individuals, for various reasons, will be able to contribute their genes to the next generation. **Genetic drift** (also known as the Sewell-Wright Effect) refers to the *random changes in allele frequency* that occur in all populations, but are much more pronounced in small populations. In a small population, the effect of a few individuals not contributing their alleles to the next generation can have a great effect on allele frequencies. Alleles may even become **lost** from the gene pool altogether (frequency becomes 0%) or **fixed** as the only allele for the gene present (frequency becomes 100%).

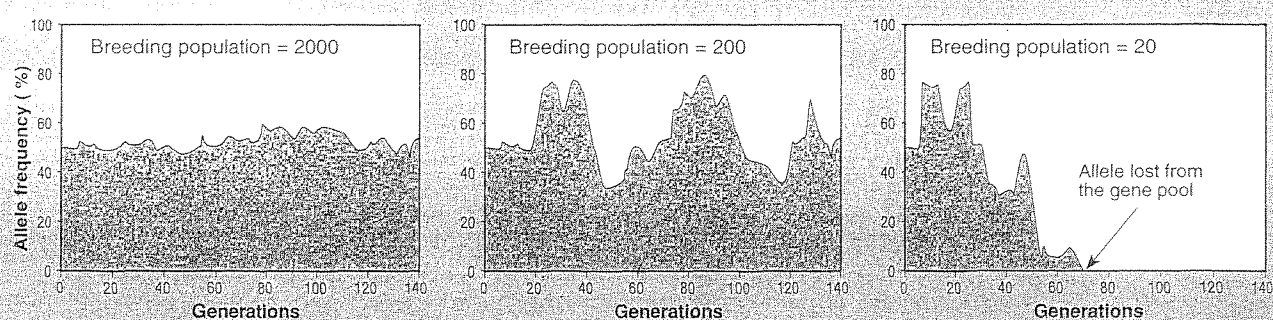
The genetic makeup (allele frequencies) of the population changes randomly over a period of time



This diagram shows the gene pool of a hypothetical small population over three generations. For various reasons, not all individuals contribute alleles to the next generation. With the random loss of the alleles carried by these individuals, the allele frequency changes from one generation to the next. The change in frequency is directionless as there is no selecting force. The allele combinations for each successive generation are determined by how many alleles of each type are passed on from the preceding one.

Computer Simulation of Genetic Drift

Below are displayed the change in allele frequencies in a computer simulation showing random genetic drift. The breeding population progressively gets smaller from left to right. Each simulation was run for 140 generations.



Large breeding population
Fluctuations are minimal in large breeding populations because the large numbers buffer the population against random loss of alleles. On average, losses for each allele type will be similar in frequency and little change occurs.

Small breeding population
Fluctuations are more severe in smaller breeding populations because random changes in a few alleles cause a greater percentage change in allele frequencies.

Very small breeding population
Fluctuations in very small breeding populations are so extreme that the allele can become fixed (frequency of 100%) or lost from the gene pool altogether (frequency of 0%).

1. Explain what is meant by **genetic drift**: ______________________________

____

2. Describe how genetic drift affects the amount of genetic variation within very small populations: ______________________________

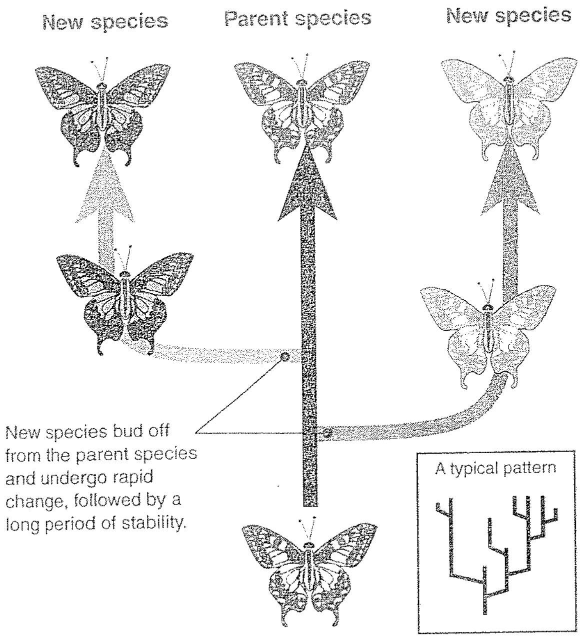
____

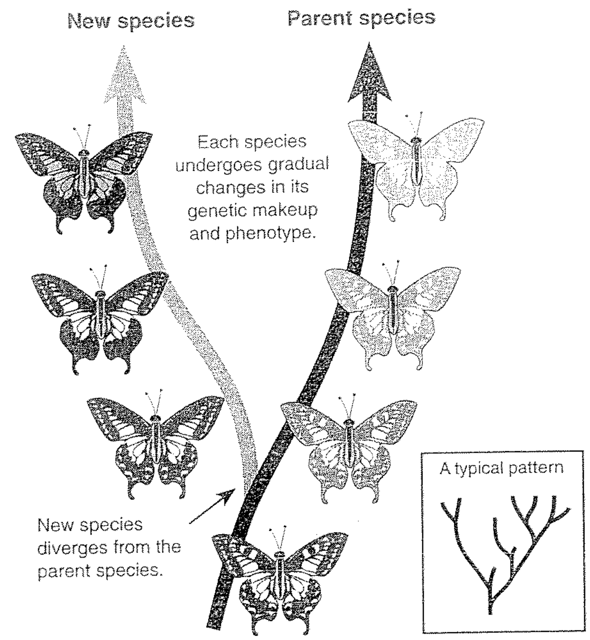
____

____

3. Identify a small breeding population of animals or plants in your country in which genetic drift could be occurring:

The pace of evolution has been much debated, with two models being proposed: **gradualism** and **punctuated equilibrium**. Some scientists believe that both mechanisms may operate at different times and in different circumstances. Interpretations of the fossil record will vary depending on the time scales involved. During its formative millennia, a species may have accumulated its changes gradually (e.g. over 50 000 years). If that species survives for 5 million years, the evolution of its defining characteristics would have been compressed into just 1% of its (species) lifetime. In the fossil record, the species would appear quite suddenly.





Punctuated Equilibrium

There is abundant evidence in the fossil record that, instead of gradual change, species stayed much the same for long periods of time (called stasis). These periods were punctuated by short bursts of evolution which produce new species quite rapidly. According to the punctuated equilibrium theory, most of a species' existence is spent in stasis and little time is spent in active evolutionary change. The stimulus for evolution occurs when some crucial factor in the environment changes.

Gradualism

Gradualism assumes that populations slowly diverge from one another by accumulating adaptive characteristics in response to different selective pressures. If species evolve by gradualism, there should be transitional forms seen in the fossil record, as is seen with the evolution of the horse. Trilobites, an extinct marine arthropod, are another group of animals that have exhibited gradualism. In a study in 1987 a researcher found that they changed gradually over a three million year period.

1. Suggest the kinds of environments that would support the following paces of evolutionary change:

   (a) Punctuated equilibrium: ______________________________

   ____

   ____

   (b) Gradualism: ______________________________

   ____

   ____

2. In the fossil record of early human evolution, species tend to appear suddenly, linger for often very extended periods before disappearing suddenly. There are few examples of smooth inter-gradations from one species to the next. Explain which of the above models best describes the rate of human evolution:

   ____

3. Some species apparently show little evolutionary change over long periods of time (hundreds of millions of years).

   (a) Name two examples of such species: ______________________________

   (b) State the term given to this lack of evolutionary change: ______________________________

   (c) Suggest why such species have changed little over evolutionary time: ______________________________

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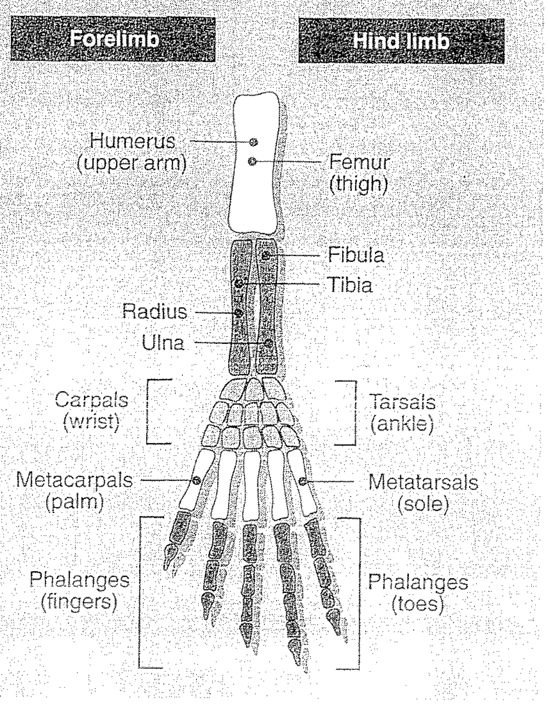
Comparative Anatomy

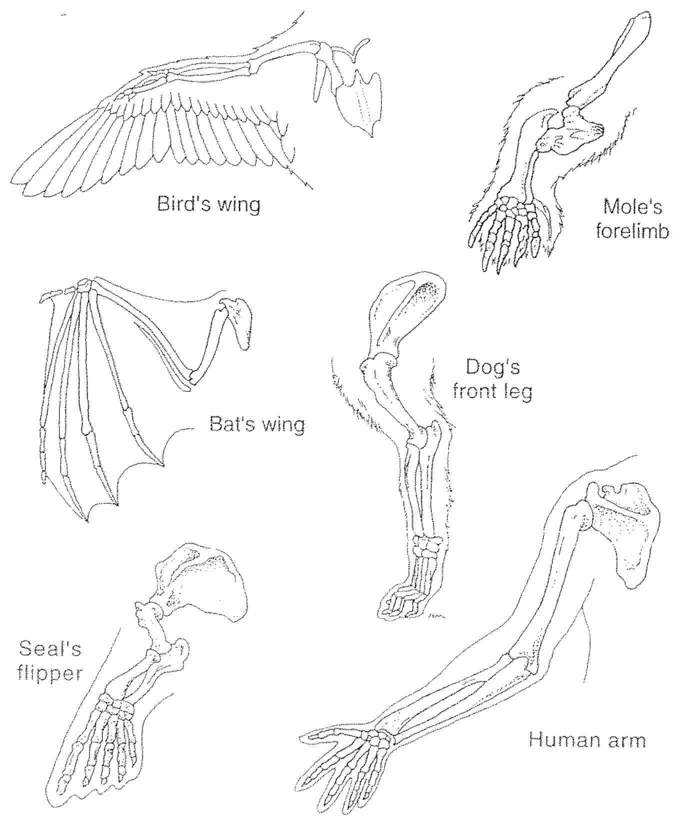
The evolutionary relationships between groups of organisms is determined mainly by structural similarities called **homologous structures** (homologies), which suggest that they all descended from a common ancestor with that feature. The bones of the forelimb of air-breathing vertebrates are composed of similar bones arranged in a comparable pattern. This is indicative of a common ancestry. The early land vertebrates were amphibians and possessed a limb structure called the **pentadactyl limb**: a limb with five fingers or toes (below left). All vertebrates that descended from these early amphibians, including reptiles, birds and mammals, have limbs that have evolved from this same basic pentadactyl pattern. They also illustrate the phenomenon known as **adaptive radiation**, since the basic limb plan has been adapted to meet the requirements of different niches.

Generalized Pentadactyl Limb

The forelimbs and hind limbs have the same arrangement of bones but they have different names. In many cases bones in different parts of the limb have been highly modified to give it a specialized locomotory function.



Specializations of Pentadactyl Limbs



1. Briefly describe the purpose of the major anatomical change that has taken place in each of the limb examples above:

   (a) Bird wing: Highly modified for flight. Forelimb is shaped for aerodynamic lift and feather attachment.

   (b) Human arm: ____________________

   (c) Seal flipper: ____________________

   (d) Dog foot: ____________________

   (e) Mole forelimb: ____________________

   (f) Bat wing: ____________________

2. Describe how homology in the pentadactyl limb is evidence for adaptive radiation: ____________________

3. Homology in the behavior of animals (for example, sharing similar courtship or nesting rituals) is sometimes used to indicate the degree of relatedness between groups. Suggest how behavior could be used in this way: