

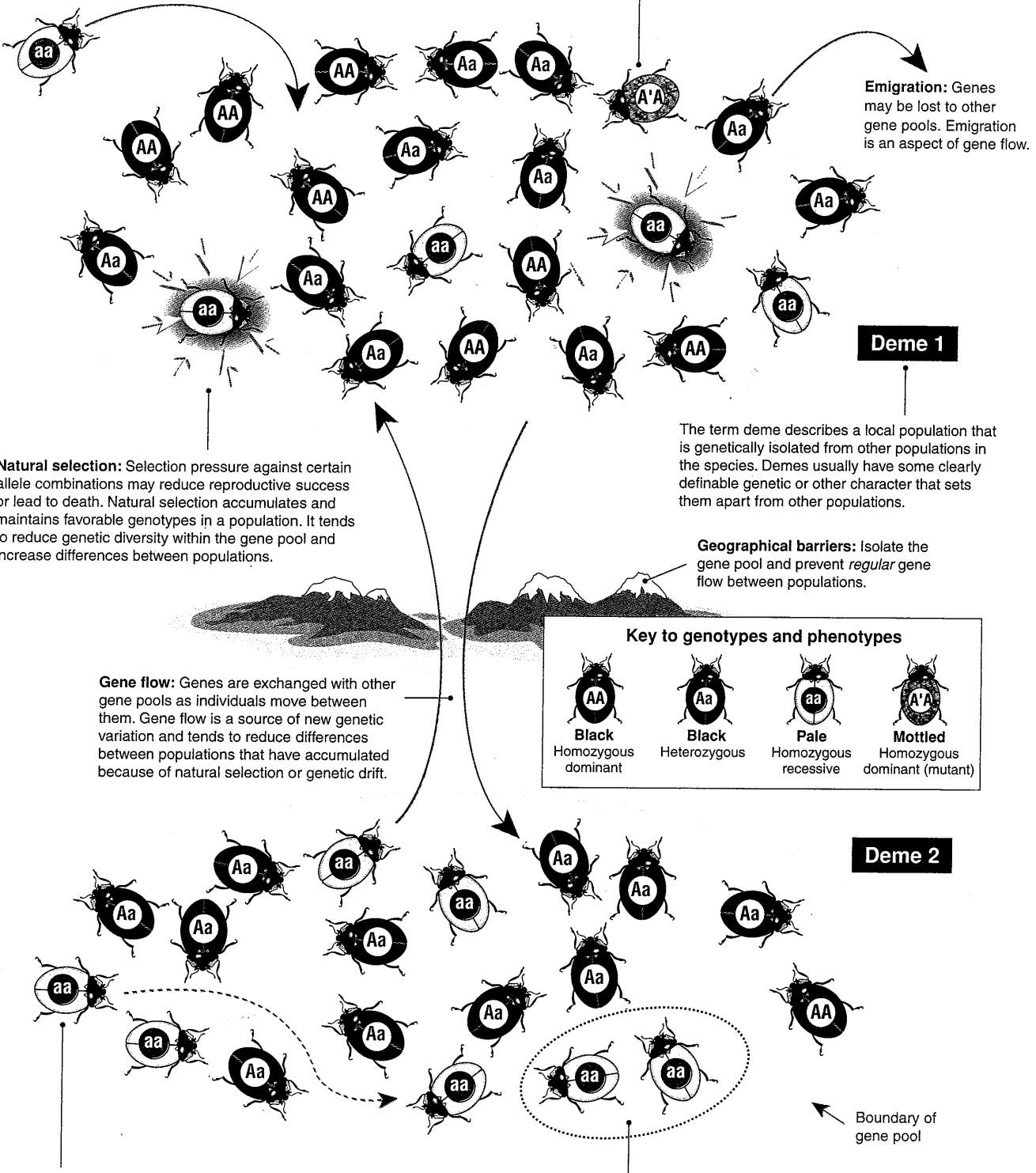
Gene Pools and Evolution

This activity illustrates the dynamic nature of **gene pools**. It portrays two populations of one hypothetical beetle species. Each beetle is a 'carrier' of genetic information, represented here by the alleles (A and a) for a single gene that controls colour and has a dominant/recessive inheritance pattern. There are

normally two phenotypes: black and pale. Mutations may create other versions of the phenotype. Some of the microevolutionary processes that can affect the genetic composition (**allele frequencies**) of the gene pool are illustrated. See *Gene Pool Exercise* for cut-out beetles to simulate this activity.

Immigration: Populations can gain alleles when they are introduced from other gene pools. Immigration is one aspect of gene flow.

Mutations: Spontaneous mutations can develop that alter the allele frequencies of the gene pool, and even create new alleles. Mutation is very important to evolution, because it is the original source of genetic variation that provides new material for natural selection.



Natural selection: Selection pressure against certain allele combinations may reduce reproductive success or lead to death. Natural selection accumulates and maintains favorable genotypes in a population. It tends to reduce genetic diversity within the gene pool and increase differences between populations.

Emigration: Genes may be lost to other gene pools. Emigration is an aspect of gene flow.

The term **deme** describes a local population that is genetically isolated from other populations in the species. Demes usually have some clearly definable genetic or other character that sets them apart from other populations.

Geographical barriers: Isolate the gene pool and prevent *regular* gene flow between populations.

Gene flow: Genes are exchanged with other gene pools as individuals move between them. Gene flow is a source of new genetic variation and tends to reduce differences between populations that have accumulated because of natural selection or genetic drift.

Key to genotypes and phenotypes

| | | | |
|-------------------------------------|------------------------------|-------------------------------------|--|
| | | | |
| Black Homozygous dominant | Black Heterozygous | Pale Homozygous recessive | Mottled Homozygous dominant (mutant) |

Mate choice (non-random mating): Individuals may not select their mate randomly and may seek out particular phenotypes, increasing the frequency of these "favored" alleles in the population.

Genetic drift: Chance events can cause the allele frequencies of small populations to "drift" (change) randomly from generation to generation. Genetic drift can play a significant role in the microevolution of very small populations. The two situations most often leading to populations small enough for genetic drift to be significant are the **bottleneck effect** (where the population size is dramatically reduced by a catastrophic event) and the **founder effect** (where a small number of individuals colonize a new area).



1. For each of the two demes shown on the previous page (treating the mutant in deme 1 as a AA):

(a) Count up the numbers of **allele types (A and a)**.

(b) Count up the numbers of **allele combinations (AA, Aa, aa)**.

2. Calculate the frequencies as percentages (%) for the allele types and combinations:

| Deme 1 | | | Deme 2 | | |
|---------------------|----------------|---|---------------------|----------------|---|
| | Number counted | % | | Number counted | % |
| Allele types | A | | Allele types | A | |
| | a | | | a | |
| Allele combinations | AA | | Allele combinations | AA | |
| | Aa | | | Aa | |
| | aa | | | aa | |

3. One of the fundamental concepts for population genetics is that of **genetic equilibrium**, stated as: "For a very large, randomly mating population, the proportion of dominant to recessive alleles remains constant from one generation to the next". If a gene pool is to remain unchanged, it must satisfy all of the criteria below that favour gene pool stability. Few populations meet all (or any) of these criteria and their genetic makeup must therefore be continually changing. For each of the five factors (a-e) below, state briefly **how** and **why** each would affect the allele frequency in a gene pool:

(a) Population size: _____

(b) Mate selection: _____

(c) Gene flow between populations: _____

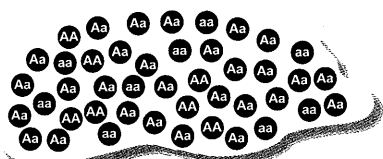

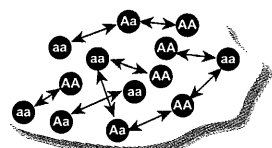
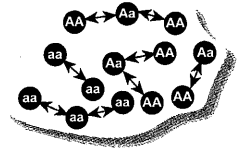
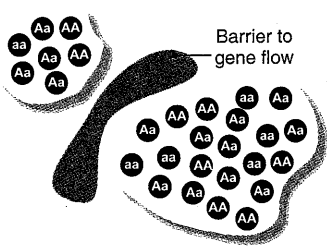
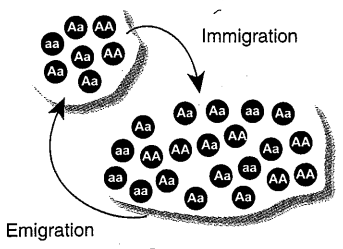
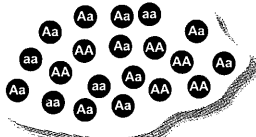
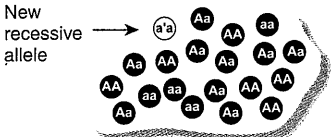
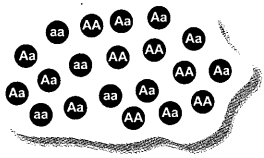
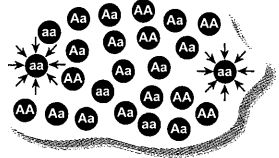
(d) Mutations: _____

(e) Natural selection: _____

4. Identify the factors that tend to:

(a) Increase genetic variation in populations:

(b) Decrease genetic variation in populations:

| Factors Favouring Gene Pool Stability | Factors Favouring Gene Pool Change |
|---|--|
|  Large population |  Small population |
|  Random mating |  Assortative mating |
|  No gene flow |  Gene flow |
|  No mutation |  Mutations |
|  No natural selection |  Natural selection |

Changes in a Gene Pool

The diagram below shows an hypothetical population of beetles undergoing changes as it is subjected to two 'events'. The three phases represent a progression in time (i.e. the same gene pool, undergoing change). The beetles have two phenotypes (black

and pale) determined by the amount of pigment deposited in the cuticle. The gene controlling this character is represented by two alleles **A** and **a**. Your task is to analyse the gene pool as it undergoes changes.

Phase 1: Initial gene pool

Calculate the frequencies of the allele types and allele combinations by counting the actual numbers, then working them out as percentages.



| | A | a | AA | Aa | aa |
|-----|--------------|---|---------------------|----|----|
| No. | 27 | | 7 | | |
| % | 54 | | 28 | | |
| | Allele types | | Allele combinations | | |

Phase 2: Natural selection

In the same gene pool at a later time there was a change in the allele frequencies. This was due to the loss of certain allele combinations due to natural selection. Some of those with a genotype of **aa** were eliminated (poor fitness).

Calculate as for above. Do not include the individuals surrounded by small white arrows in your calculations; they are dead!

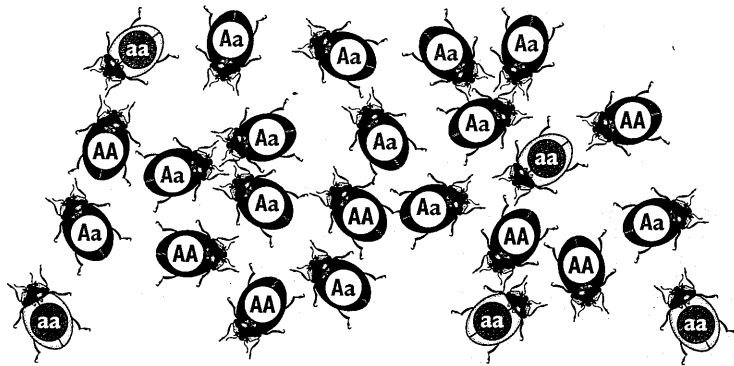
| | A | a | AA | Aa | aa |
|-----|---|---|----|----|----|
| No. | | | | | |
| % | | | | | |

Phase 3: Immigration and emigration

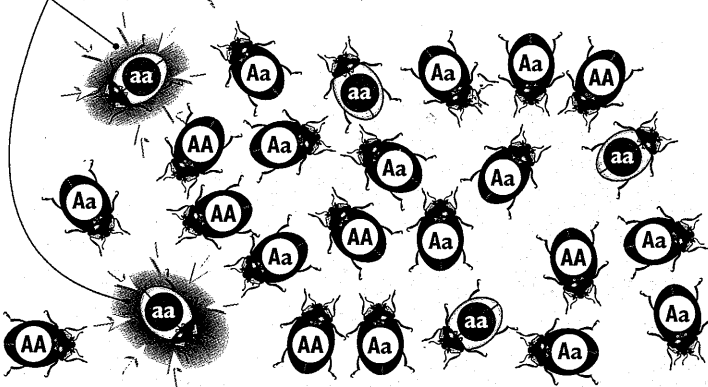
This particular kind of beetle exhibits wandering behaviour. The allele frequencies change again due to the introduction and departure of individual beetles, each carrying certain allele combinations.

Calculate as above. In your calculations, include the individual coming into the gene pool (**AA**), but remove the one leaving (**aa**).

| | A | a | AA | Aa | aa |
|-----|---|---|----|----|----|
| No. | | | | | |
| % | | | | | |

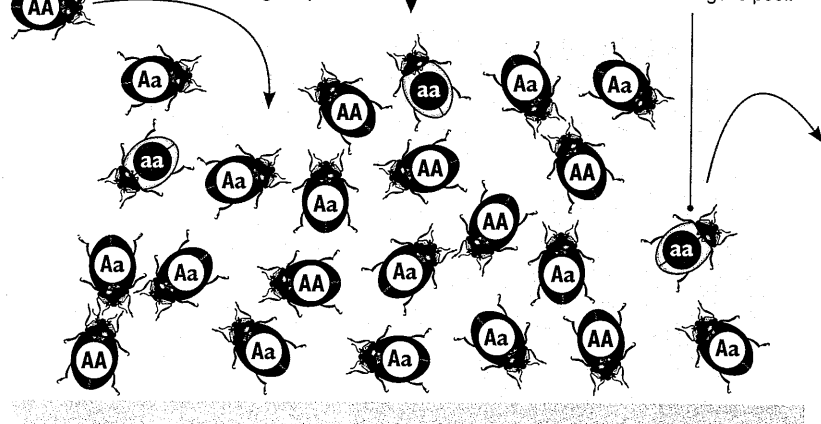


Two pale individuals died and therefore their alleles are removed from the gene pool.



This individual is entering the population and will add its alleles to the gene pool.

This individual is leaving the population, removing its alleles from the gene pool.



1. Explain how the number of dominant alleles (**A**) in the genotype of a beetle affects its phenotype:

2. For each phase in the gene pool above (place your answers in the tables provided; some have been done for you):

- Determine the relative frequencies of the two alleles: **A** and **a**. Simply total the **A** alleles and **a** alleles separately.
- Determine the frequency of how the alleles come together as allele pair combinations in the gene pool (**AA**, **Aa** and **aa**). Count the number of each type of combination.
- For each of the above, work out the frequencies as percentages:

$$\text{Allele frequency} = \frac{\text{No. counted alleles}}{\text{Total no. of alleles}} \times 100$$

Gene Pool Exercise

Cut out each of the beetles on this page and use them to reenact different events within a gene pool as described in this topic

pages: *Gene Pools and Evolution, Changes in a Gene Pool, The Founder Effect, Population Bottlenecks, Genetic Drift.*

