Terminology

locus - location on chromosome making up a gene (plural = loci)
alleles - alternative forms of a gene that can occur at a given locus
gene - is sometimes used to mean locus, sometimes to mean allele)

genotype - the set of alleles carried by an individual (diploids: two alleles per locus)
phenotype - the physical trait produced by intrxn between genotype and environment
heritability (h^2) proportion of variation in phenotype that is due to variation in genotype.
adaptation - n. any characteristic (trait) that increases an individual's likelihood of survival and reproduction relative to individuals that lack the trait, or have an alternative form of the trait.
convergence - process of adaptation in which different ancestral stocks experience similar environments and thus become more similar (produces *analogous* traits, which have different origins but look similar)

(Fig. 1.12 Begon et al - convergence of placentals and marsupials)

adaptive radiation - process of adaptation in which populations from same ancestral stock experience different environments and thus diverge (produces *homologous* traits, which have same origin but look different)

(Fig. 1.9 Begon et al - Darwin's finches, *Geospiza*: oldest e.g. of adaptive radiation)

Evolution - change in allele frequency within a population. Note: when allele frequency goes to 0 or 1 it is **fixed**.

Kruger AWD Population

Age	Females	Sx	lx
0	234	0.350427	1
1	82	0.45122	0.350427
2	37	0.783784	0.15812
3	29	0.724138	0.123932
4	21	0.761905	0.089744
5	16	0.4375	0.068376
6	7	0.857143	0.029915
7	6		0.025641
8	1		
9	0		
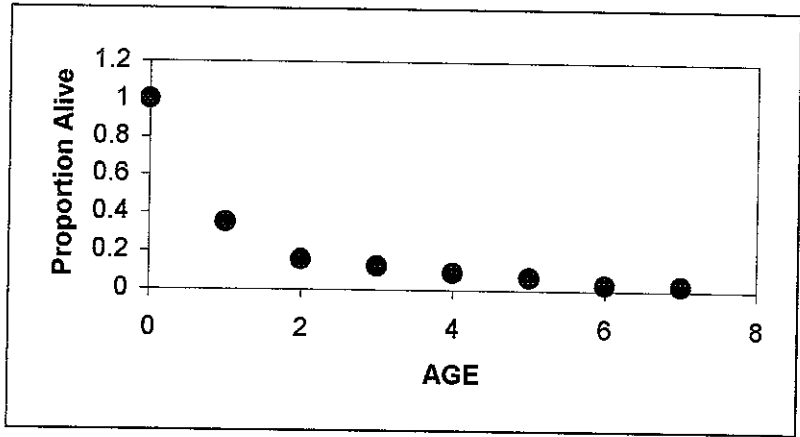
Selous AWD Population

Age	Females	Sx	lx
0	97	0.752577	1
1	73	0.835616	0.752577
2	61	0.786885	0.628866
3	48	0.75	0.494845
4	36	0.777778	0.371134
5	28	0.464286	0.28866
6	13	0.692308	0.134021
7	9	0.222222	0.092784
8	2	1	0.020619
9	2	1	0.020619
10	2	0	0.020619
11	0		0

<u>Proximate</u> vs. <u>Ultimate</u> Questions

↓   ↓

Mechanisms   Evolution
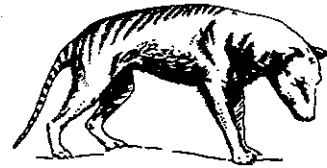
↓   ↓

How?   Why?
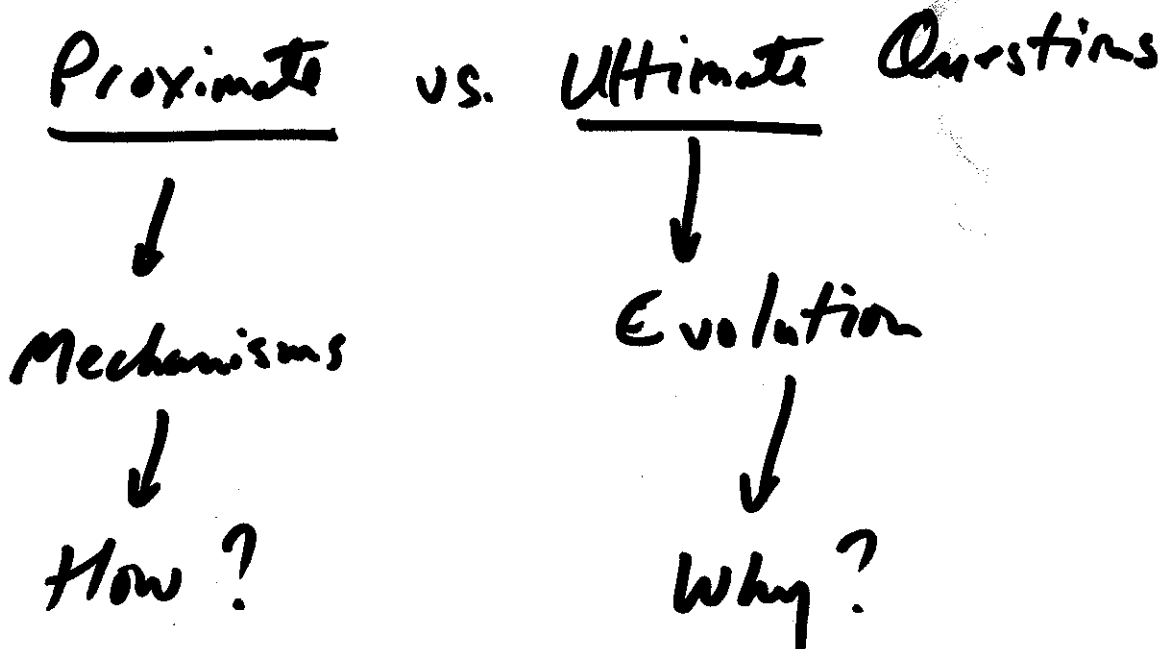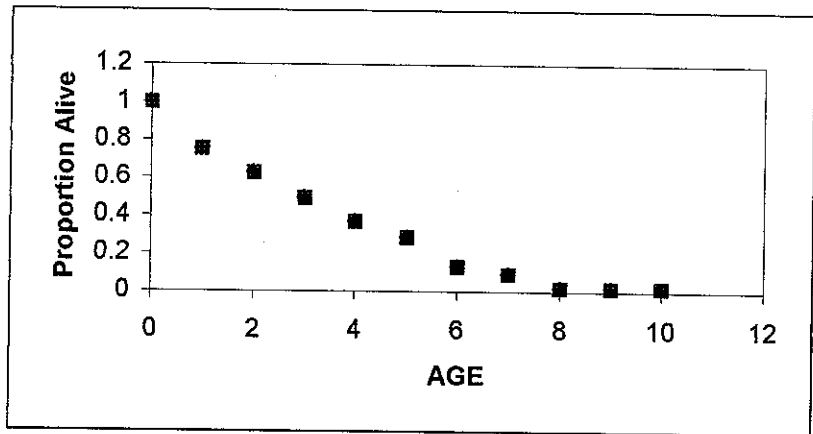
CONVERGENT EVOLUTION
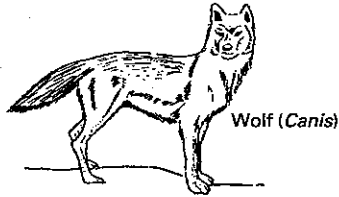- DIFT ANCESTORS + SIMILAR ENVIRONMENT
- ANALOGOUS TRAITS

(a)

Placentals	Marsupials

Dog-like carnivore

Wolf (*Canis*)

Tasmanian wolf (*Thylacinus*)

Cat-like carnivore

Ocelot (*Felis*)

Native cat (*Dasyurus*)

Arboreal glider

Flying squirrel (*Glaucomys*)

Flying phalanger (*Petaurus*)

Fossorial herbivore

Ground hog (*Marmota*)

Wombat (*Vombatus*)

Digging ant feeder

Anteater (*Myrmecophaga*)

Anteater (*Myrmecabius*)
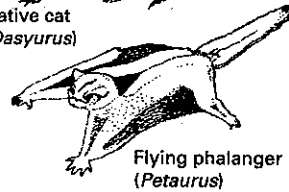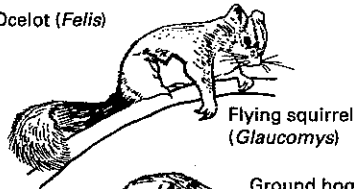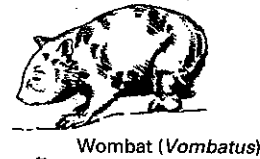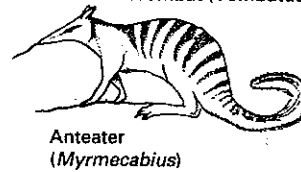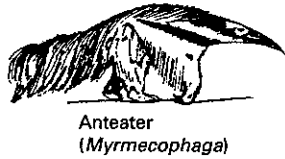
Subterranean insectivore

Common mole (*Talpa*)

Marsupial mole (*Notoryctes*)
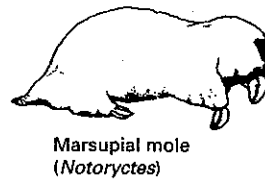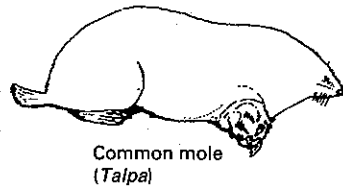
ADAPTIVE RADIATION IN GEOSPIZA

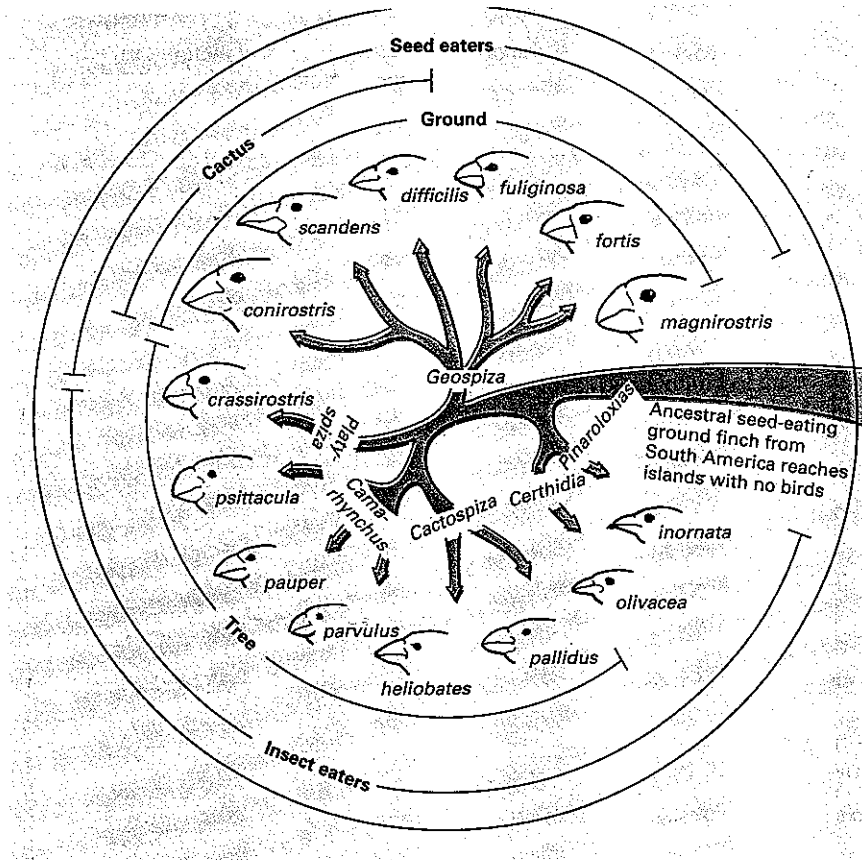- COMMON ANCESTOR, DIFF'T SELECTION PRESSURES
- HOMOLOGOUS TRAITS

Figure 1.9 (a) Darwin's finches exploit a diverse range of food types and habitats, and exhibit a diverse range of forms of beak, despite being closely related. (b) (*page 21*) The distribution of the different species on the Galapagos (and Cocos) islands. The number of species on each island is shown on the map. The distribution of species between the islands is shown in the table and within each species a different letter is used for each subspecies. (After Lack, 1969a. Island names from Harris, 1973.)

100 samples

1000 samples
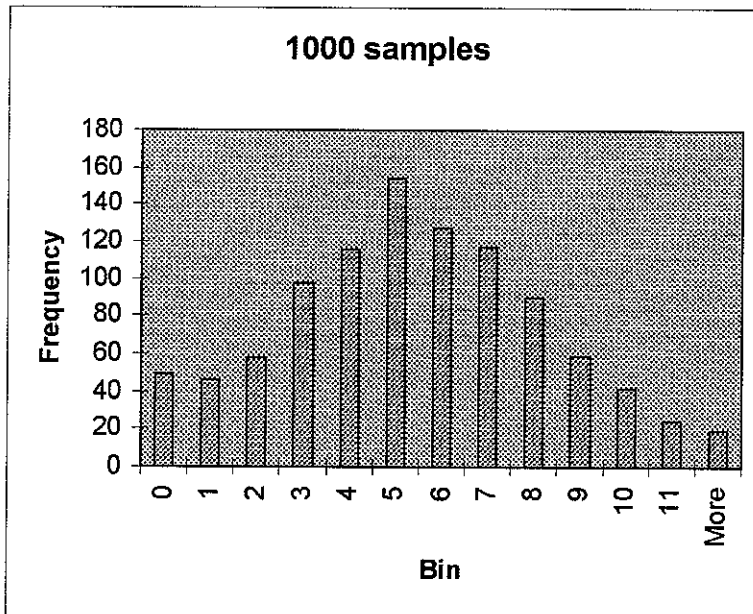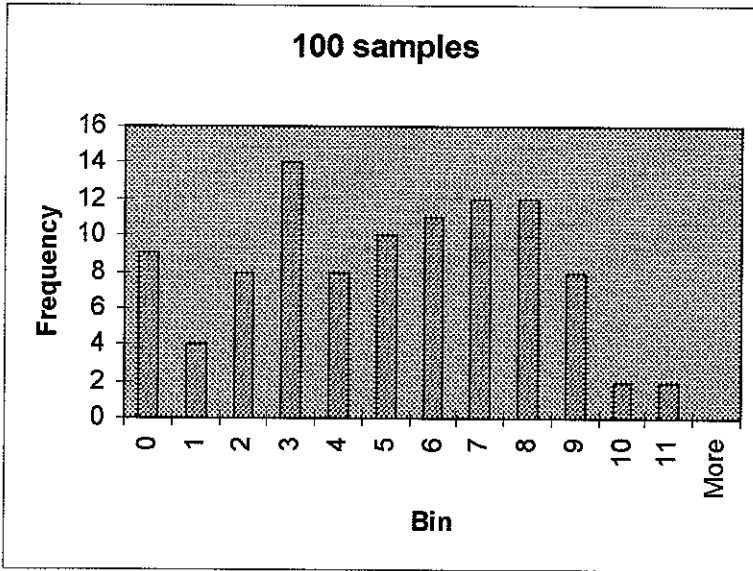
ISOLATION IN PICTURE - WINGED DROSOPHILA
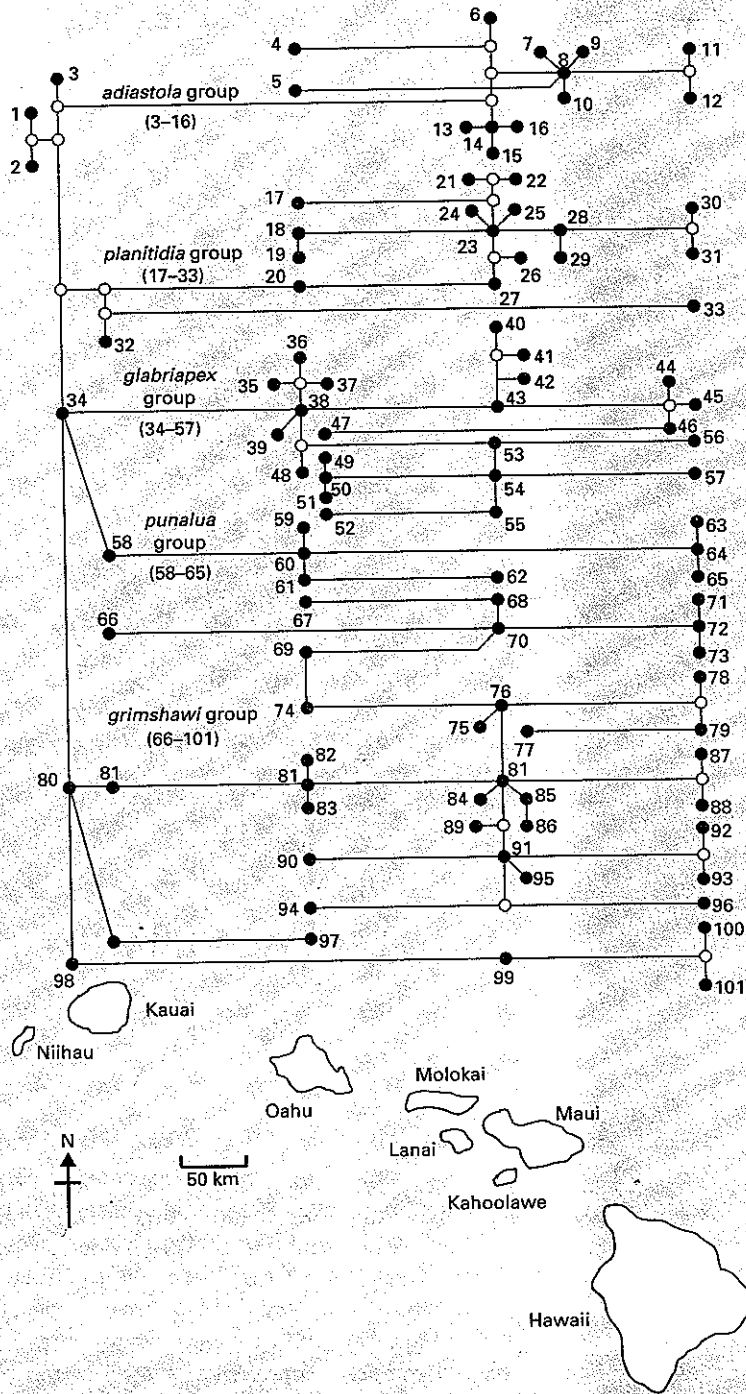

Figure 1.8 An evolutionary tree linking the picture-winged *Drosophila* of Hawaii, traced by the analysis of chromosomal banding patterns. The most ancient species are *D. primaeva* (species 1) and *D. attigua* (species 2), found only on the island of Kauai. Other species are represented by solid circles; hypothetical species, needed to link the present-day ones, are represented by open circles. Each species has been placed above the island or islands on which it is found (although Molokai, Lanai and Maui are grouped together). Niihau and Kahoolawe support no *Drosophila*. (After Carson & Kaneshiro, 1976; Williamson, 1981.) The first *Drosophila* colonist probably reached the Hawaiian archipelago 40 million years ago, before any of the present islands existed. (After Beverly & Wilson, 1985.)
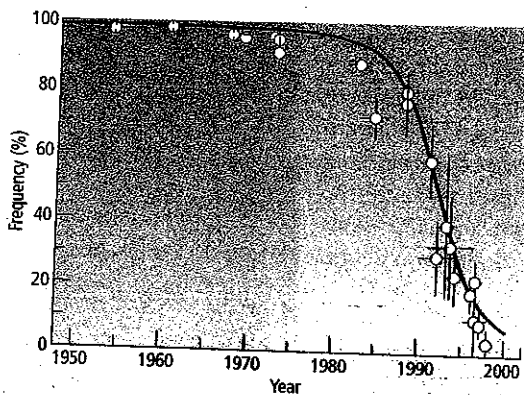
Figure 5.6

Decrease in frequency of the melanic form of the peppered moth in the region around Manchester. The decrease did not become really noticeable until about 1990. Redrawn, by permission of the publisher, from Cook et al. (1999).

Migration may explain why melanic moths are found in some unpolluted areas such as East Anglia and why light-colored moths persisted in polluted areas where they were less well camouflaged.

A second additional factor is that the two forms may differ in fitness independently of bird predation. Creed et al. (1980) collected all the measurements that had been made on survival to adulthood in the laboratory. They analyzed the results of 83 broods, containing 12,569 offspring; the original measurements had been made by many different geneticists in the previous 115 years. The viability of light-colored homozygotes, it turned out, was about 30% less on average than that of the melanic homozygote in the laboratory, where there is no bird predation — the reason is not known, but the fact alone implies there is some "inherent" advantage to the melanic genotype. The fitness advantage detected in the lab implies that melanic moths would replace light ones even without bird predation in polluted areas. In unpolluted areas, light-colored moths may remain only because birds eat more of the conspicuous melanic moths.

Some biologists have suggested that three factors — bird predation, inherent advantage to melanic genotypes, and migration — are needed to explain peppered moth evolution. The importance of migration in addition to bird predation is generally accepted, but the inherent advantage to the melanic form is controversial. Since the measurements compiled in Creed et al. (1980) were made, the decrease in the melanic form's frequency has been more and more widely documented. The decrease did not happen around the formerly industrial Manchester region until the 1990s (Figure 5.6). The decrease makes sense if the advantage to the melanic form depends on air pollution, but not if it has an inherent advantage. Therefore, other biologists explain the observations in terms of bird predation (supplemented by migration) alone, and rule out the inherent advantage.

In conclusion, the industrial melanism of the peppered moth is a classic example of natural selection. It can be used to illustrate the one-locus, two-allele model of selection. The model can be used to make a rough estimate of the difference in fitness between the two forms of moth using their frequencies at different times; the fitnesses can also be estimated from mark–recapture experiments. Good evidence exists that bird predation is at least partly the agent of selection, but some biologists suggest other factors are at work too.

The melanic form may have an "inherent" advantage

But the decrease in melanic frequency since the air became cleaner supports the classic explanation
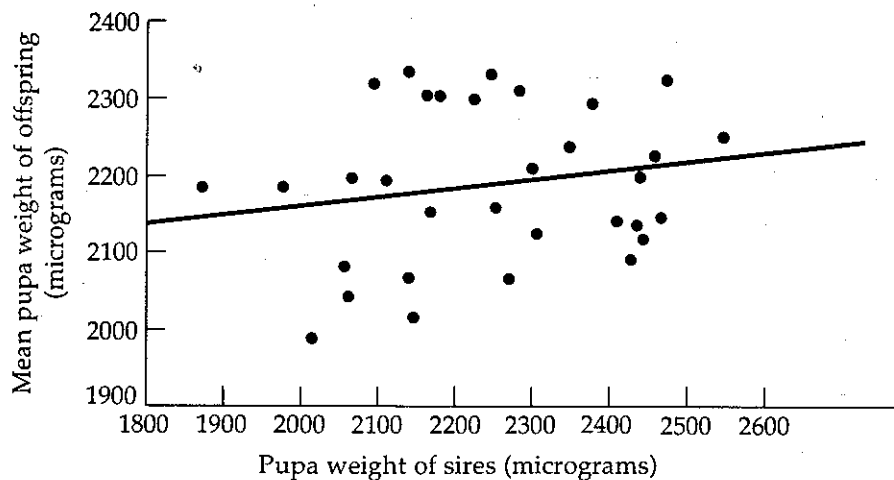
FIGURE 12. Mean weight of male pupae of the flour beetle, *Tribolium castaneum*, against pupa weight of father (sire). Each point is the mean of about eight male offspring. The regression coefficient of male offspring weight on sire's weight is $b = .11$, and h^2 is estimated as $2b$. (Courtesy of F. D. Enfield.)
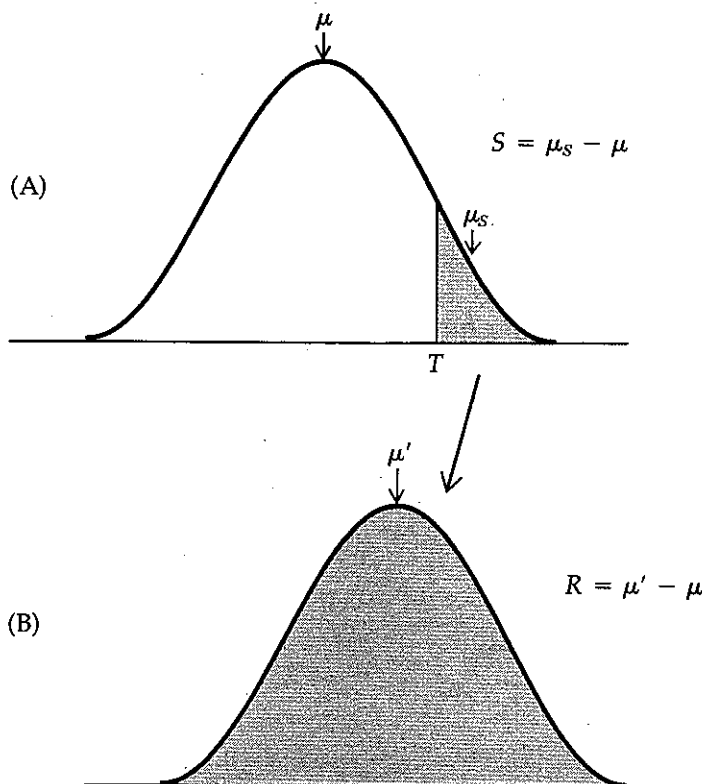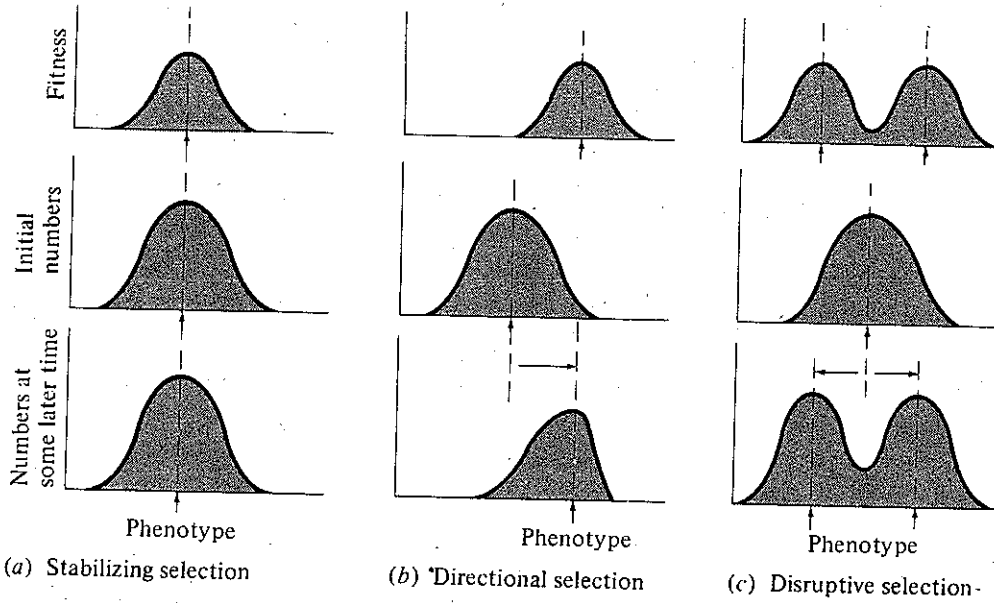

$S = \mu_S - \mu$

$R = \mu' - \mu$

FIGURE 4. Diagram of truncation selection. (A) Distribution of phenotypes in parental population, mean μ. Those individuals with phenotypes above the truncation point (T) are saved for breeding the next generation. The selected parents are denoted by the shading and their mean phenotype by μ_S. (B) Distribution of phenotypes in offspring generation derived from the selected parents. The mean phenotype is denoted μ'. Note that μ' is greater than μ but less than μ_S. The quantity S is called the selection differential, and R is called the response to selection.

MODES OF SELECTION

FITNESS

INITIAL NUMBERS

LATER NUMBERS (AFTER SELECTION)

(a) Stabilizing selection (b) Directional selection (c) Disruptive selection

STABILIZING

DIRECTIONAL

DISRUPTIVE