



ADAPTATIONS OF ORGANISMS



Diversity of flora and invertebrates at a proposed educational centre (Share Centre) on Upper Lough Erne



Dorman

13076043

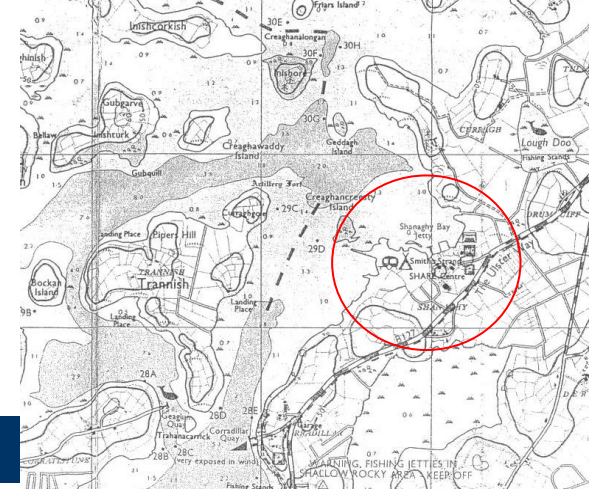


Introduction

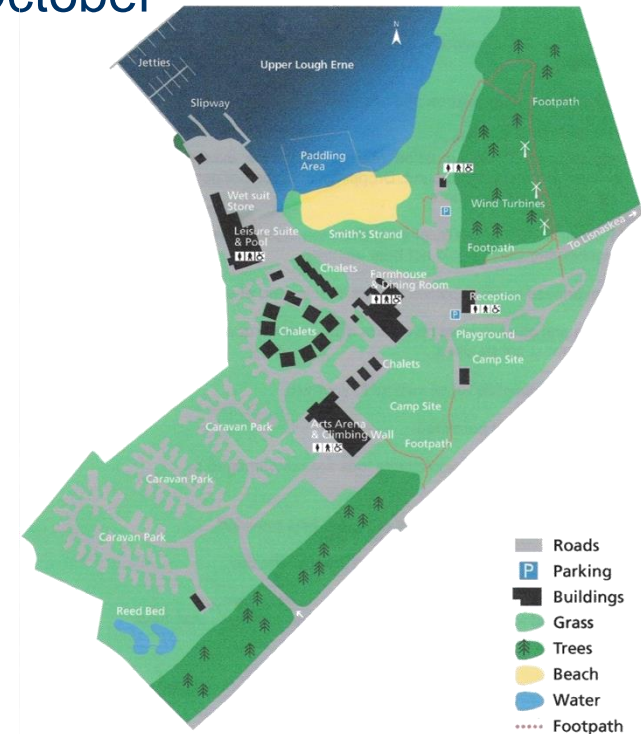


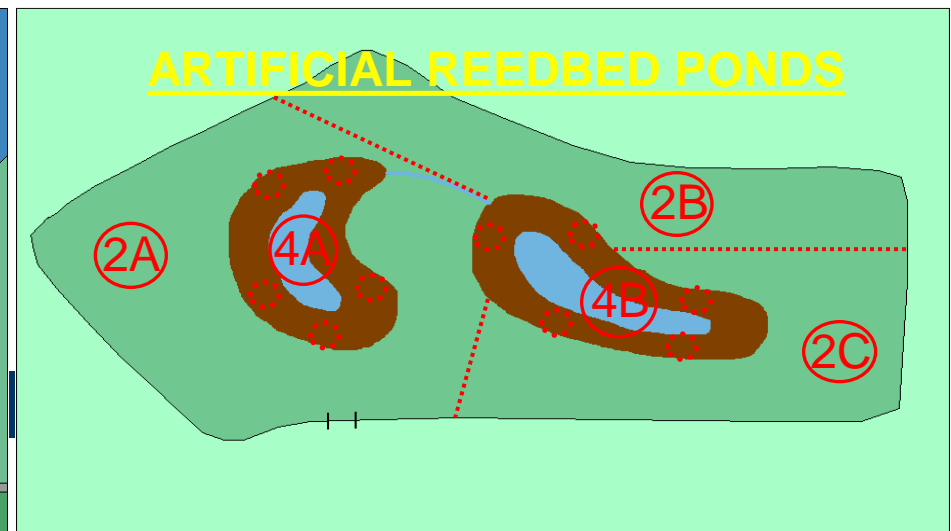
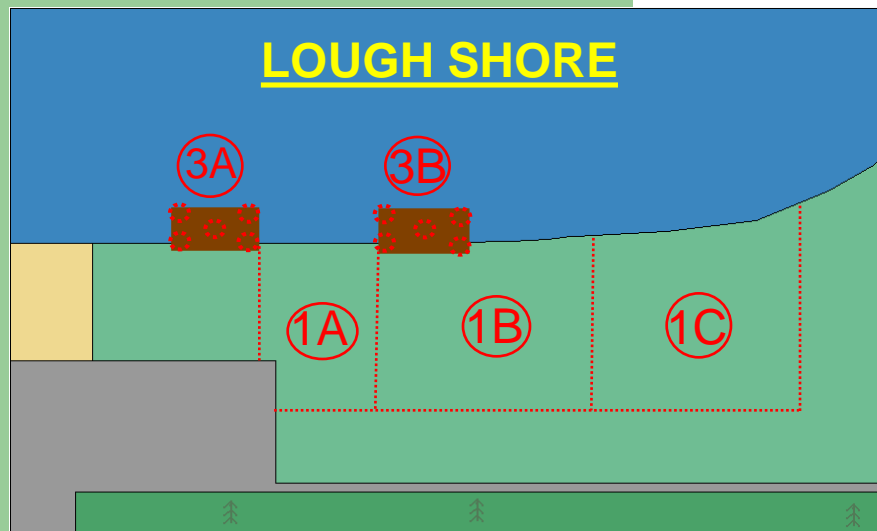
- Project was conducted at The Share centre (SHARE), situated on shores of Upper Lough Erne in Co. Fermanagh (www.sharevillage.org)
- 2 main components:
 - Information gathering for SHARE/ecological survey
 - Comparative survey of flora and invertebrates between natural and managed habitats
- Community analysis of the different habitats at SHARE using PRIMER programme

Methods



- SHARE location: H 33921 29515 (Irish Grid)
- Sampling conducted over 2 weekends in October
- 4 habitats:
 - LG: Lough Grassland
 - PG: Pond Grassland
 - NR: Natural Reedbed
 - AR: Artificial Reedbed





- Invertebrate sampling
- 3 replicates in grassland, 2 in reeds
- Grassland: 5 minute sweep net all over then pooter the inverts and place in 70% ethanol
- Reedbeds: 1 minute shaking reeds on to beating tray repeated 5 times

- Vegetation sampling
- Only did this for grassland, not reedbeds
- 5 minute walk collecting 1 sample of each species observed

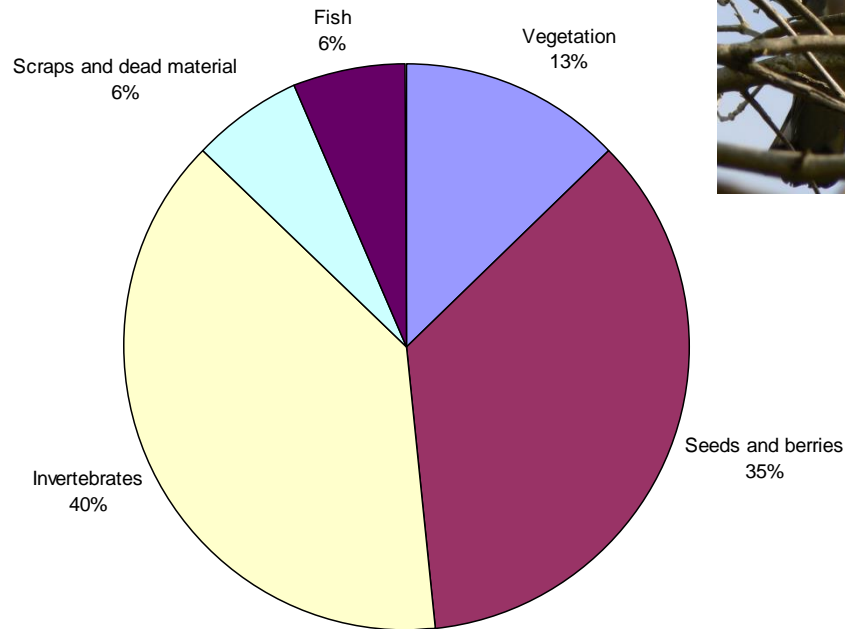


In lab



- Identified vegetation samples and invertebrate samples
- 49 plant species and 83 invertebrates (to Family level or lower)
- Data analysis: Used PRIMER to compare the similarity of the habitats in terms of species assemblages – outputs of spp. Richness, diversity and similarity matrixes

Feeding ecology of birds at SHARE



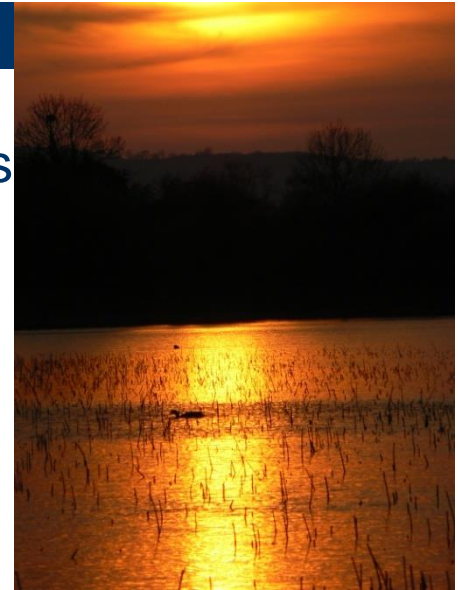
- Most food for birds is from invertebrates, then vegetation
- Reeds provide nursery grounds and refuge for fish, nesting sites and hunting grounds for water fowl

Other Information:

- SHARE and Trannish Island are ASSI and Ramsar designated
- Upper Lough Erne is an SPA and SAC
- CEDaR dataset shows 136 animals listed and 404 plants, with 12 species of conservation concern in Northern Ireland
- Site contains priority habitats designated in NI HAP's

Discussion

- Artificial/managed reeds had higher diversity and richness than natural – managing the Lough reeds may boost biodiversity
- Agrees with primary literature that has shown invertebrates benefiting from reed cutting
- Grassland highly variable and supports different invertebrate communities – mosaic of different assemblages
- Important to conserve this biodiversity
- These low trophic level communities which the flora habitats support have big effects on higher, characteristic species success e.g. important birds, otter
- SHARE centre and surrounding areas ideal for environmental education



Adaptations of organisms - *what do these key words mean?*

Organism

Biotic environment

Community

Habitat

Population

Abiotic environment

Ecological niche

Ecosystem

Species



"Organisms (living things) live in a habitat. They are part of an ecosystem which includes both their biotic environment (the other living organisms) and abiotic environment (physical and chemical factors) they interact with. Members of a certain species (*look similar and interbreed to produce fertile offspring*) form a population and, with other populations make up a community"

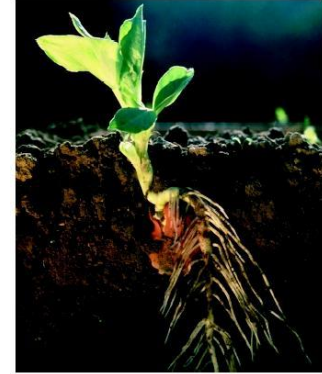


Each organism has an **ecological niche** that describes its role within the ecosystem

• *Qu: In what ways can an organism interact with its ecosystem?*

- **What it feeds on/preys on** (e.g. field mouse on wheat), and also how other nutrient needs are met (e.g. parrots at clay lick for salt, plants obtaining nitrates through their roots)

- **What feeds on/preys on it** (e.g. barn owl on field mouse)



- **Competition with other organisms** (e.g. grey and red squirrel competing for food resources, forest floor plants for light)
- Temperature, water and **other requirements it has** (e.g. how does it stay cool/warm, raise offspring safely, find shelter)



Ecological niche reminder...



- A population's **niche** refers to its role in its ecosystem; how it fits into its environment
- The niche would be described in terms of the abiotic aspects e.g. temperature range, soil pH, altitude etc, and also the biotic aspects of its ecology e.g. prey, predators, competition etc.
- A particular population's niche could be a producer, a predator, a parasite, a leaf-eater, etc
- E.g. Gerbils are desert seed-eating mammals; seaweed is an inter-tidal autotroph; fungi are asexual soil-living saprophytes

Relate the niche to a resource within the ecosystem that the particular organism exploits

What is the one overriding objective for all organisms: **TO SURVIVE AND REPRODUCE**

How they achieve this is by being **adapted** to receive their requirements from their habitat. These adaptations allow them to survive and reproduce in an ecosystem so they can fill their ecological niche

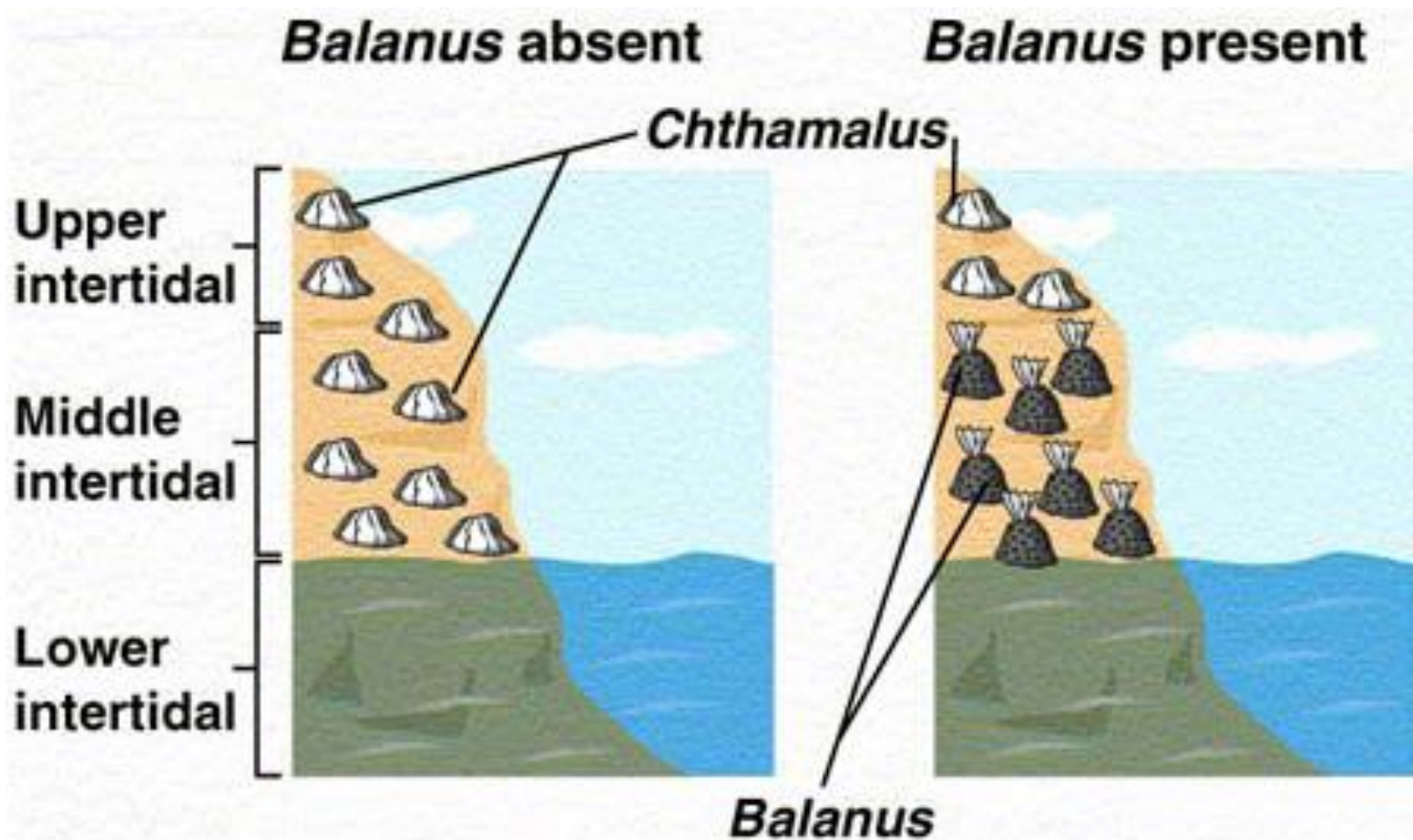


Qu: If an organism is not present,
does that mean it can't survive there?

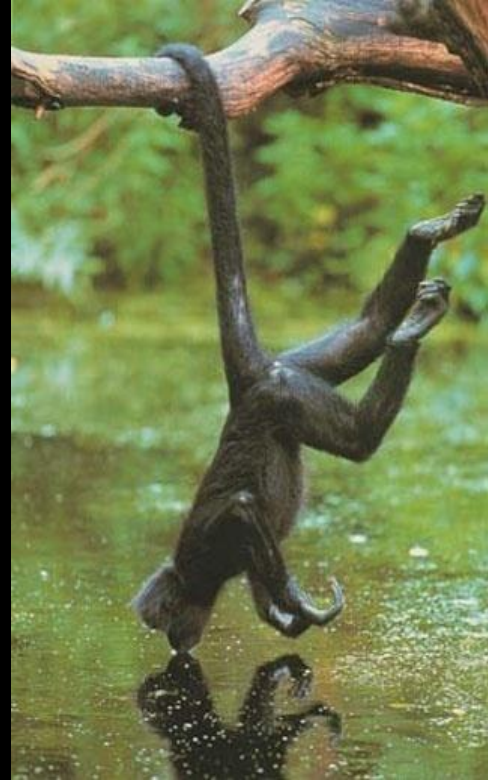


Just because an organism is not present in a habitat doesn't necessarily mean that it could not survive there; it may just be that it is out competed by another better adapted species for that space

If two organisms occupy the same ecological niche in a habitat, the one that is better adapted to that niche will out compete the other. This is called the **competitive exclusion principle**. The other organism becomes extinct in that location e.g. barnacles:



- All organisms have adaptations that help them survive in a particular habitat
- These adaptations are a combination of
 - Behavioural
 - Physiological/Biochemical
 - Morphological/Anatomical
- The adaptations provide the organism with a method of meeting a particular environmental challenge and of obtaining its requirements for survival (fill its niche)



Homework for tomorrow:

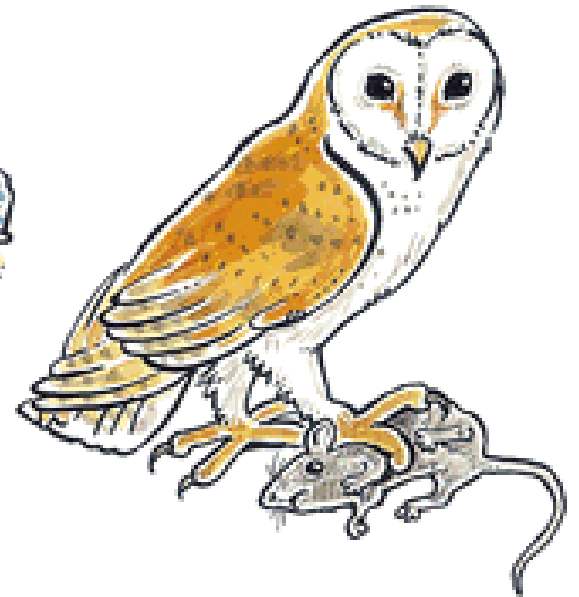
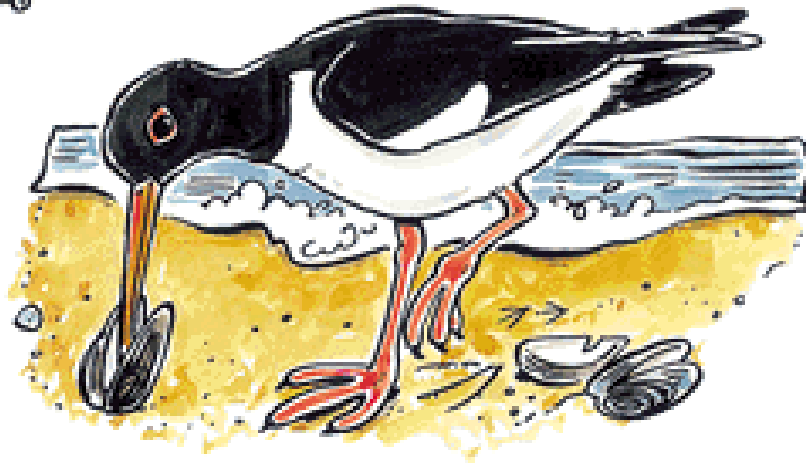
**Complete notes and read up to ecological niche
www.kdbio.weebly.com**

Behavioral adaptations i.e. things organisms do to survive and reproduce *e.g. bird calls to attract a mate; animal migration; seed dispersal*

Physiological/Biochemical adaptations i.e. a mechanical, physical or biochemical functioning of an organism or its cellular processes *e.g. the ability to make a particular amino acid or break down a specific waste product; the ability to respire anaerobically*

Morphological/Anatomical adaptations (of the anatomy) i.e. physical features/structures of an organism that enhance its survival *e.g. the spines on a cactus; the bill on a bird; the fur on a bear*

Amazing bill diversity within bird species:



Example 1

Kangaroo Rat

Habitat - desert

Problems to overcome

- Lack of water
- Extreme temperatures
- Sand
- Predation



Adaptations

- **Morphological**

Big ears to radiate heat and hear predators

Large feet for running in the sand

Pale colour - camouflage

- **Behavioural**

Stay in burrows during the day to avoid hot sun.

Feed at night when it's cool and less predators

- **Physiological**

Can convert dry seeds into water

Don't sweat

Their kidneys dispose of waste with very

little water being lost

Example 2

Limpet

Habitat - rocky shore

Problems to overcome

- Desiccation
- Removal from the rocks by wave action
- Food
- Predation



Adaptations

- **Morphological**

Cone shaped - prevents removal from rocks by waves

Rough tongue (radula) for scraping algae off rocks

- **Behavioural**

Only feed when tide is in preventing desiccation

Can "clamp down" against rock to prevent desiccation or removal from rock by wave action or predators

- **Physiological**

Have gills for removal of oxygen from the water for respiration



Amazing adaptation

One of the extraordinary adaptations which evolution generates in the extreme Antarctic cold is found in the ice fish.

It has evolved to have no red blood cells and no haemoglobin, meaning that its blood flows more freely. The oxygen which its muscles need simply dissolves in the blood.

(Image: J Gutt, Alfred Wegener Institute)

ARKive



Periwinkle adaptations...

XEROPHYTES AND THEIR ADAPTATIONS



Plants adapted to live in arid regions - they show a range of adaptations to allow them to reduce water loss. They continue to photosynthesise.

- **Leaf curvature** (rolled up) - the lower surface with stomata faces inwards. Humid air is trapped and reduces evaporation. In marram grass
- **Leaves are reduced to spines** - this reduces the surface area to volume ratio so less is lost by transpiration. In cacti the stem photosynthesises and the spines protect the stem
- **Stomata close** when water is scarce and open at night when transpirational water loss is reduced

You have these notes from Froggy on your hand out

- **Cuticular thickening** - thick waxy upper epidermis is impermeable to water (reduces evaporation)
- **Hairs** - outgrowths of leaf epidermal cells; they reduce the air movement around the stomata and trap damp air e.g. in marram grass
- **Sunken stomata** - found in grooves/crypts; they reduce air movement and trap humid air around the stomata (hydration shells) thereby reducing the water potential gradient for water to vapour to diffuse
- **Succulent tissues** - deep, fleshy leaves store water. Cacti have fleshy stems to store water
- **Deep roots** - to penetrate down to the deep water table. Can also have shallow roots e.g. most cacti, to quickly absorb rainfall or overnight condensation

Which ones are Behavioural, physiological, and Morphological adaptations?

All are morphological adaptations apart from "Stomata closing at night" which is a behavioural adaptation; and "Succulent tissues" which is a physiological adaptation

Not on spec.! HALOPHYTES AND THEIR ADAPTATIONS

Problems: High external salt concentration, lower external water potential, often lack of fresh water

Plants adapted to live in regions of high salt concentration e.g. estuaries, salty deserts, coastal dunes. Halophytes share some adaptations with xerophytes as water is usually scarce in salty habitats. Salt lowers the water potential of soil and draws water out of the plant; thus many halophytes have to absorb salt to lower their cell water potential, and absorb water to survive. They then tolerate or excrete the salt e.g. mangrove trees



- **Cells accumulate salt** - this lowers their water potential and allows water to be absorbed from surrounding salty water
- **Salt glands in leaves** - these excrete excess salt
- **Accumulate proline** in cell vacuoles - an amino acid that lowers the water potential
- **Show many xerophytic adaptations also as areas of high salt are often dry too**

Salt marsh grass



HYDROPHYTES AND THEIR ADAPTATIONS

Problems: Lack of oxygen and carbon dioxide, water will reduce light penetration



A flowering plant that is adapted to living in water (fully or partially submerged):

- **Stems contain aerenchyma**, a tissue that contains a mixture of cells and large, **air-filled spaces**. Aerenchyma provides bouyancy and the air spaces form a pathway for the diffusion of oxygen and carbon dioxide to parts of the plant underwater
- Leaves often float on the water surface with the **stomata on the upper surface** of the leaf

- **Support is provided by the water**; stems contain little if any of the woody tissue e.g. sclerenchyma, that supports larger, land-living plants
- **Reduced roots** (no need to get water or mineral ions). Sometimes "aerial roots" project out of water to get oxygen

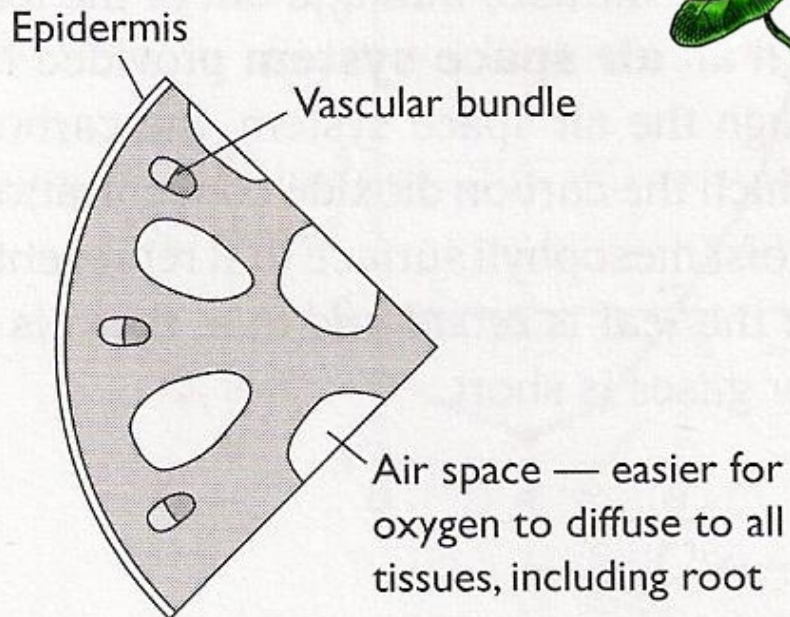


There is less oxygen dissolved in water than in the atmosphere. The stems and leaves of aquatic flowering plants (hydrophytes) have adaptations to facilitate the uptake of and movement of oxygen and carbon dioxide:

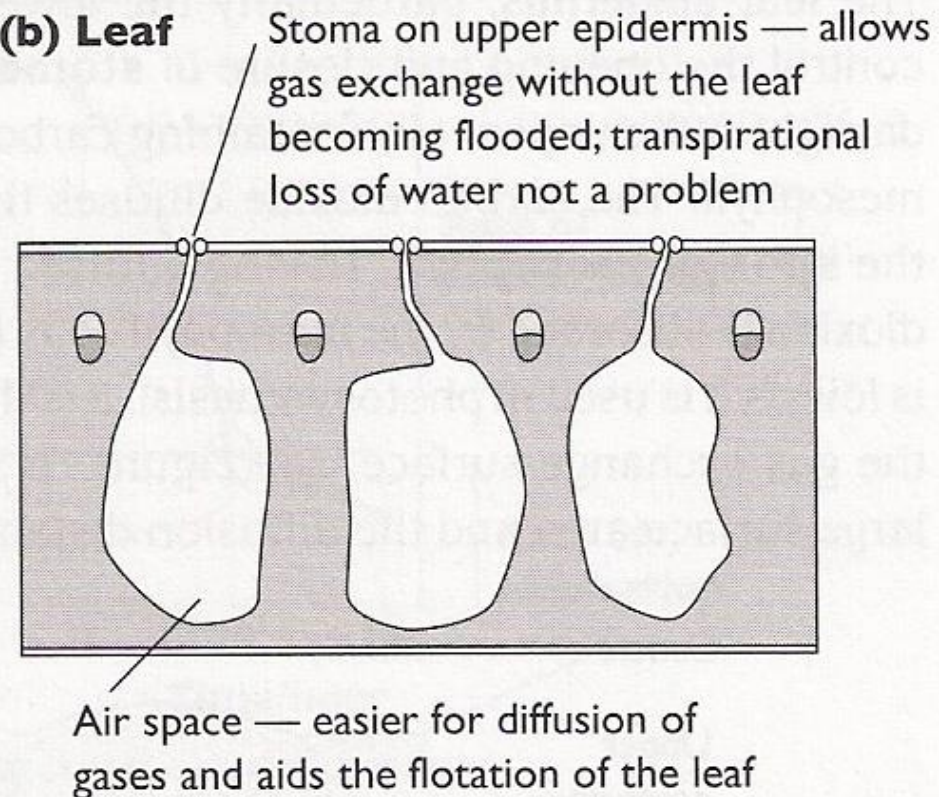
Hydrophyte adaptations

The stems and leaves of flowering aquatic plants (hydrophytes) are adapted to absorb and move as much oxygen and carbon dioxide as possible. The reason for this being that there is a lot less oxygen dissolved in water as there is present in the air. *Adaptations of hydrophyte stem and leaf are shown below:*

(a) Stem



(b) Leaf



10 minute challenge!

- ❑ Draw an animal
- ❑ Label 3 adaptations that allow it to fill its ecological niche - one **behavioural**, one **morphological**, one **physiological**



Homework for Monday 3/2/14:

- Read factors affecting distribution of organisms sheet
- Complete periwinkle PPQ

Try the Periwinkle PPQ...

Answer...

(a) Any three from

- retains the fertilised eggs inside the body preventing eggs being carried away as the tide goes out (making fertilisation more likely)/eggs protected from desiccation
- development of larval stage inside the body increases survival on the upper shore which is exposed for periods daily
- the gills are modified to absorb air and survival of up to a month out of water allows for long periods each day out of water/when the tide is out
- it has a high temperature tolerance which allows the periwinkle to survive higher temperatures when exposed to higher air temperature more sunlight
- in extremes of desiccation and temperature it cements itself to a rock providing a high tolerance to exposure to air (during periods of neap tides)

[3]

(b) *L. littorea* (the edible periwinkle) has gills which are more efficient in absorbing oxygen from seawater than the gills of *L. saxatilis* (the rough periwinkle)/*L. littorea* (the edible periwinkle) releases larvae which rapidly colonise the lower shore/*L. littorea* may have a lighter shell aiding locomotion (feeding)/when *L. saxatilis* is eaten all eggs are lost/*L. littorea* may be growing faster as they are free to feed/other appropriate competitive advantage

[1]

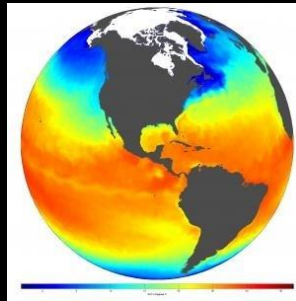
THE DISTRIBUTION OF ORGANISMS:

- Along with organism adaptations, **ecological factors** have an influence on the distribution of organisms (i.e. where they are found)
- They are either **abiotic** (physical factors) or **biotic** (living factors) and fall into 3 groups:
- **Climatic**
- **Edaphic**
- **Biotic**



Climatic factors:

- **Temperature ranges:** The temperature range within which life exists is relatively small, although if the range is large in a habitat then an organism needs to be adapted to survive both extremes. The sun is the main heat source for an ecosystem. At low temps. ice crystals form in cells and cause physical disruption e.g. destroy organelles and rupture cell membranes. At high temps. enzymes are denatured. In aquatic habitats, the high heat capacity of water buffers the effects of temperature changes, however in terrestrial (land) habitats, environmental temp. changes can be more extreme



• **Availability of water:** Water is essential for all living cells. E.g. needed as a solvent and for maintaining turgor of cells and creation of new ones. Water availability determines the distribution of terrestrial organisms. Many organisms have adaptations to conserve water e.g. waxy cuticle of flowering plants and some insects. A high wind speed or exposed area will heighten the rate of transpiration in plants and evaporation in animals. In marine environments, organisms can have adaptations to prevent water loss by osmosis e.g. mackerel and pollack. Some fish in freshwater have adaptations to reduce osmotic gain; some fish e.g. salmon and eels can tolerate both extremes during their life cycle (they are euryhaline)



• **Light intensity:** Light is the ultimate energy source for ecosystems and most life on earth. Most plants grow better with more light (higher intensity) though some are adapted to low intensity e.g. some ferns on the forest floor, or like blue bells, can grow before the tree canopy above develops. In aquatic systems the plants need to be near the surface as light is absorbed by the water. Light will also be absorbed by suspended particulates e.g. sediment, organic matter

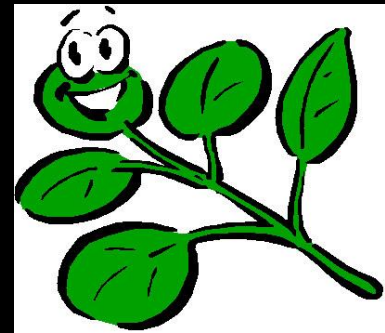


• **Light quality:** Green plants absorb more red and blue light and reflect mostly green light. Water will also influence which wavelengths of light penetrate. Blue light penetrates deeper because red light is absorbed more easily. Some marine algae, the red seaweeds contain extra red pigments so as to absorb more of the light at the blue end of the spectrum, and can thus live at deeper depths than other algae/seaweeds

•Length of day:

Longer daylight means more time for a plant to photosynthesis. Increased plant growth in summer is more to do with increased day length than with increased temperature. Day length also affects the flowering of plants. Increased sunlight hours also means more time for cold blooded organisms to warm up.

Plants need light of the correct intensity, wavelength and duration if they are to achieve optimum growth - it is the crucial factor affecting rate of photosynthesis



Edaphic factors



•pH values:

Most plants are restricted to certain pH ranges where they will grow healthily. The soil pH influences the availability of certain ions. Some plants prefer acidic soils e.g. heather, and some alkaline soils e.g. cowslip. Plants that tolerate extremes of pH can dominate areas by out competing plants less able to survive in these harsher conditions e.g. heathers on upland moors tolerate very low soil pH. Most plants prefer a soil with pH close to neutral

• Availability of macro and micro nutrients:

A range of ions are needed by plants. Those required in large supply are macronutrients: nitrate for amino acid and nucleic acid base synthesis; phosphate for the synthesis of nucleotides and phospholipids; calcium for the production of the middle lamella; sulphate for the synthesis of some amino acids; iron for the production of chlorophyll.

Micronutrients are required in minute amounts. Plant distribution is affected by the nutrient balance of the soil – the affect of this differs between species. Soil with more organic content and structure (humus) will contain more nutrients

- **Water content:** This varies markedly between soils and depends on the soil type e.g. sandy soil is free draining and does not retain water or nutrients well, whereas clay soils hold a lot of water. Waterlogged soils create anaerobic conditions which can prevent oxygen diffusing into roots, thereby reducing respiration and supported functions like active transport of soil nutrients. Rushes (*Juncus* spp.) and sedges (*Carex* spp.) can tolerate these conditions as they have air spaces within their root tissues so some oxygen can diffuse from aerial parts of the plant to the roots

• **Aeration of soil:** The space between soil particles is filled with air, from which roots obtain **respiratory oxygen by diffusion**. Soil air is also needed by the aerobic microorganisms in the soil that decompose the humus (larger organic material). Poorly aerated soil will encourage the growth of anaerobic denitrifying bacteria which will reduce the nitrate content of soils (needed to make amino acids)



Biotic factors

• **Competitors:** This can limit a population as well as affect the distribution of organisms. Organisms compete when they share a common resource e.g. food, water, light, ions, shelter, mates; and when that resource is in limited supply. There are 2 types of competition: **Interspecific** (between different species) and **intraspecific** (within the same species). e.g.:

***Interspecific:** Red and grey squirrel*

***Intraspecific:** Red and red squirrel*

Where two species occupy the same ecological niche, the interspecific competition will lead to the local extinction of one species; this is **the competitive exclusion principle**. This is currently occurring between red and grey squirrels in the UK



Graph of how competition between red and grey squirrels in Ireland has affected population size

Knock Wood

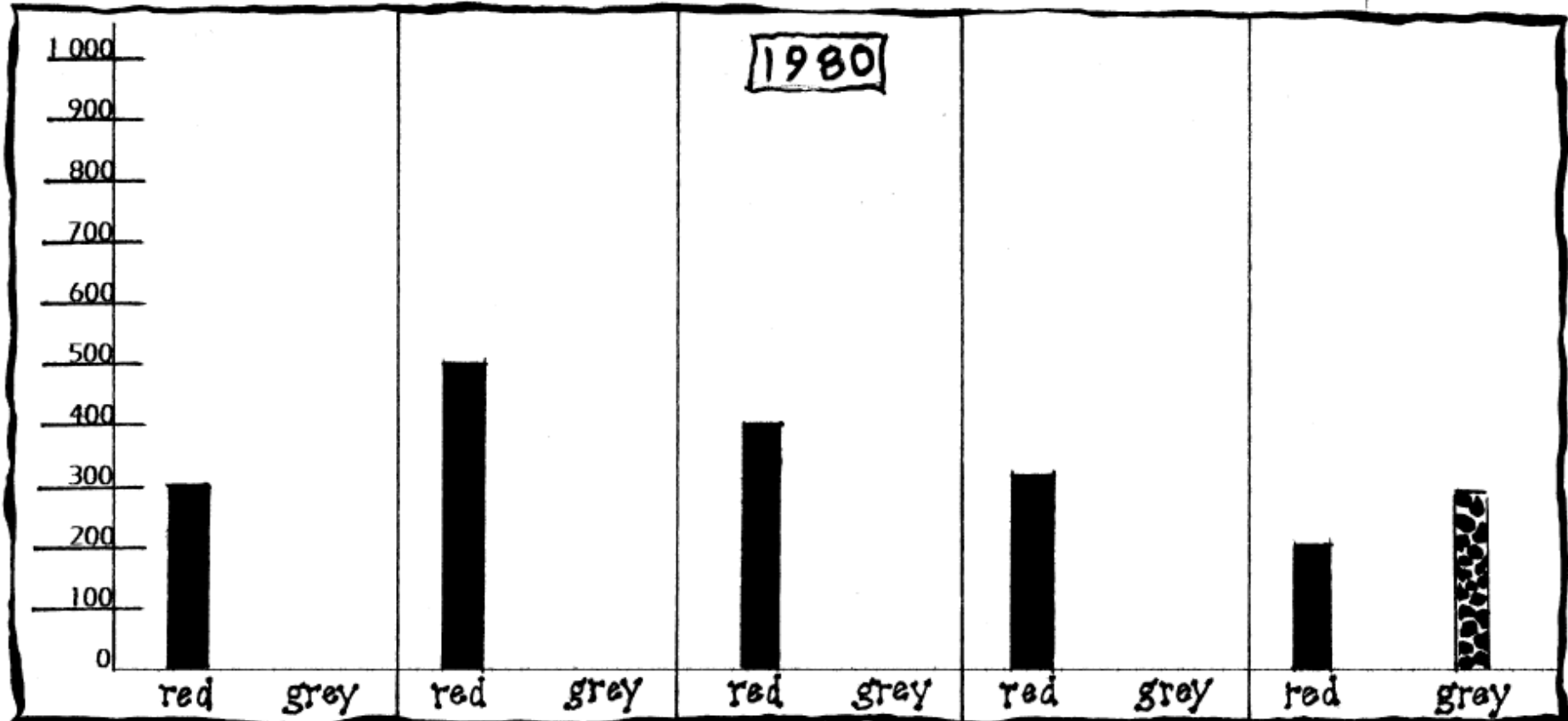
Killnua Wood

Dacrann Wood

Shankill Wood

Glendara Wood

1980



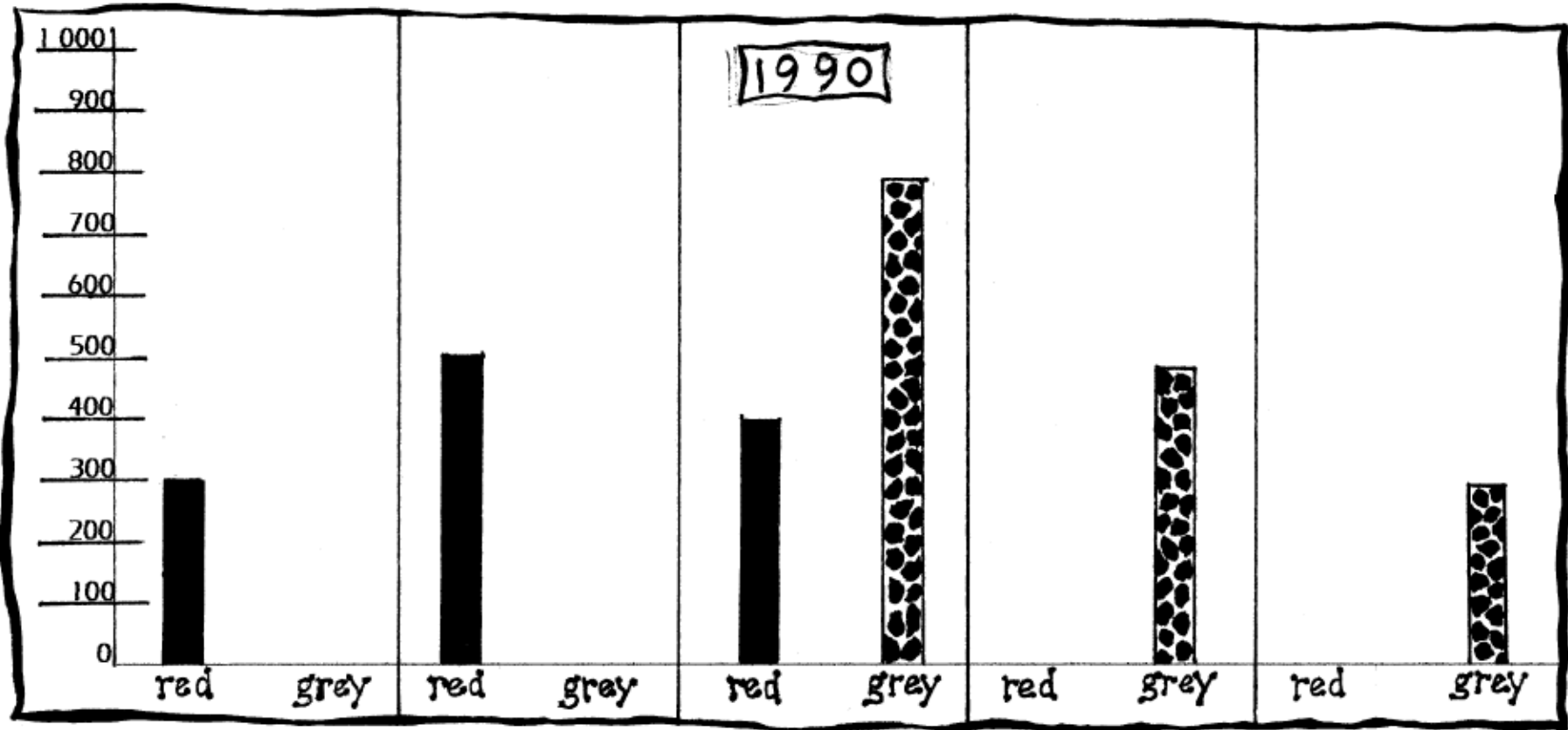
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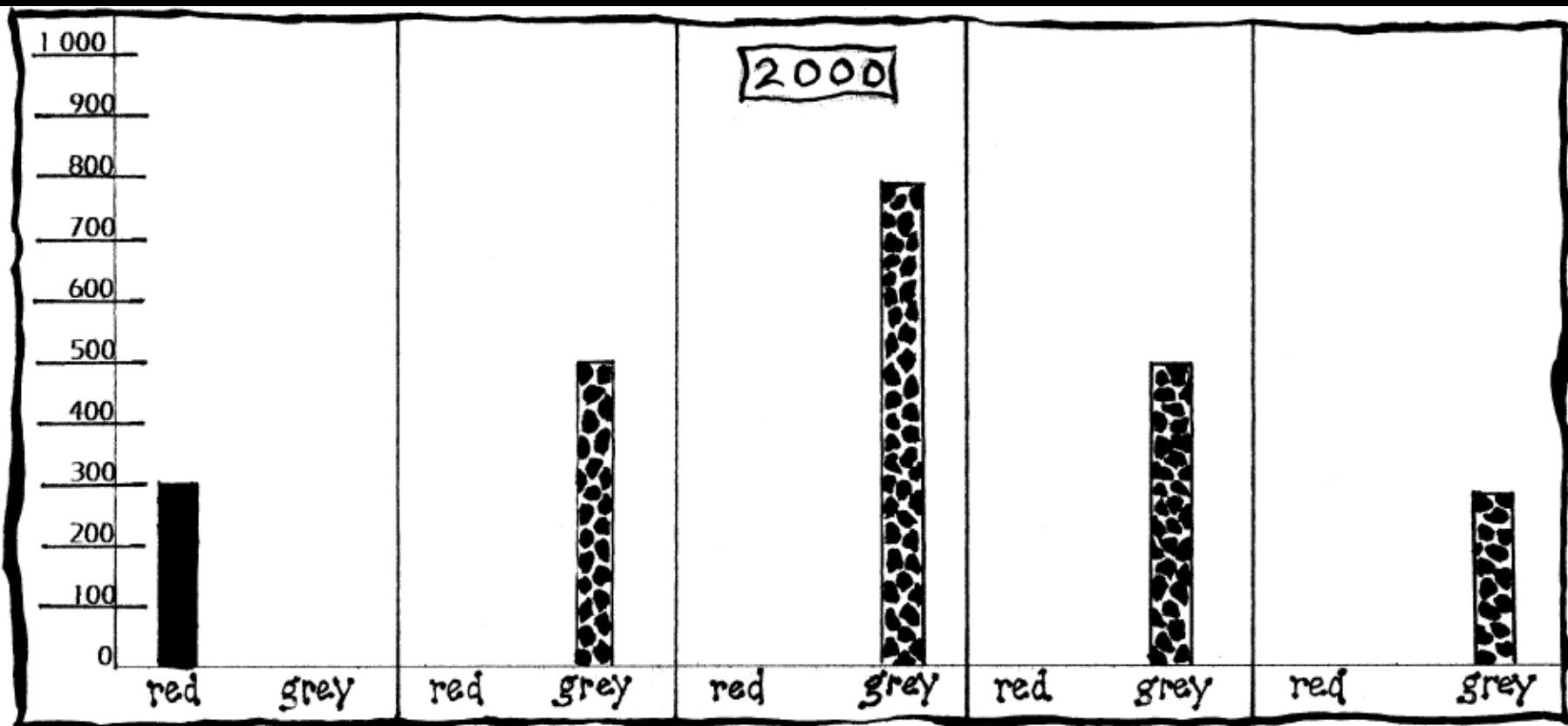


red squirrel numbers



grey squirrel numbers





•Predation:

The distribution of a predator is reliant on the presence of its prey species (i.e. If there is no prey in an area then the predator will not survive there). The population numbers of both predator and prey are interdependent (linked): when prey numbers are low, predator numbers decline, and when predator numbers become high (due to abundant prey), then prey numbers drop

See next slide...

The classic predator and prey relationship population graph

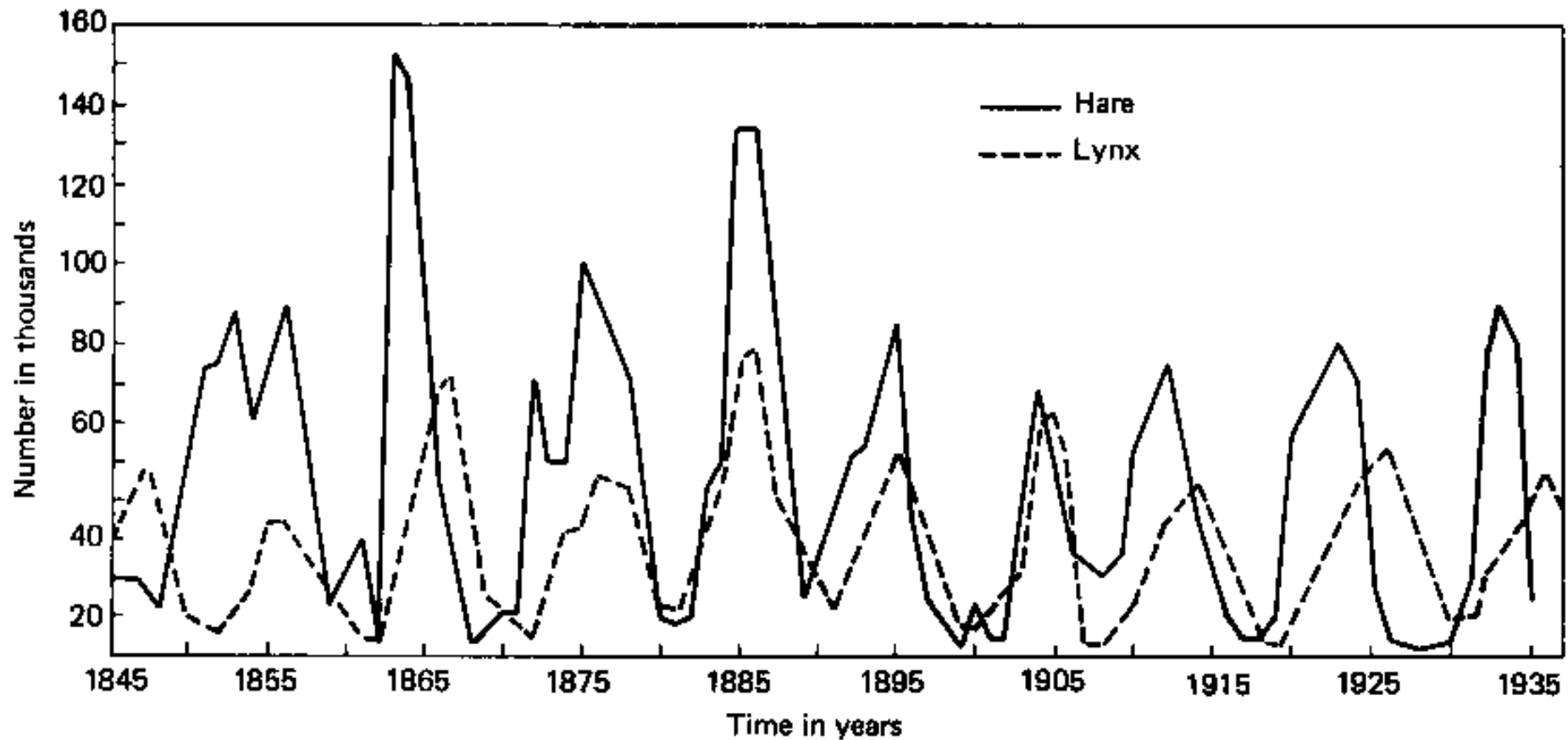
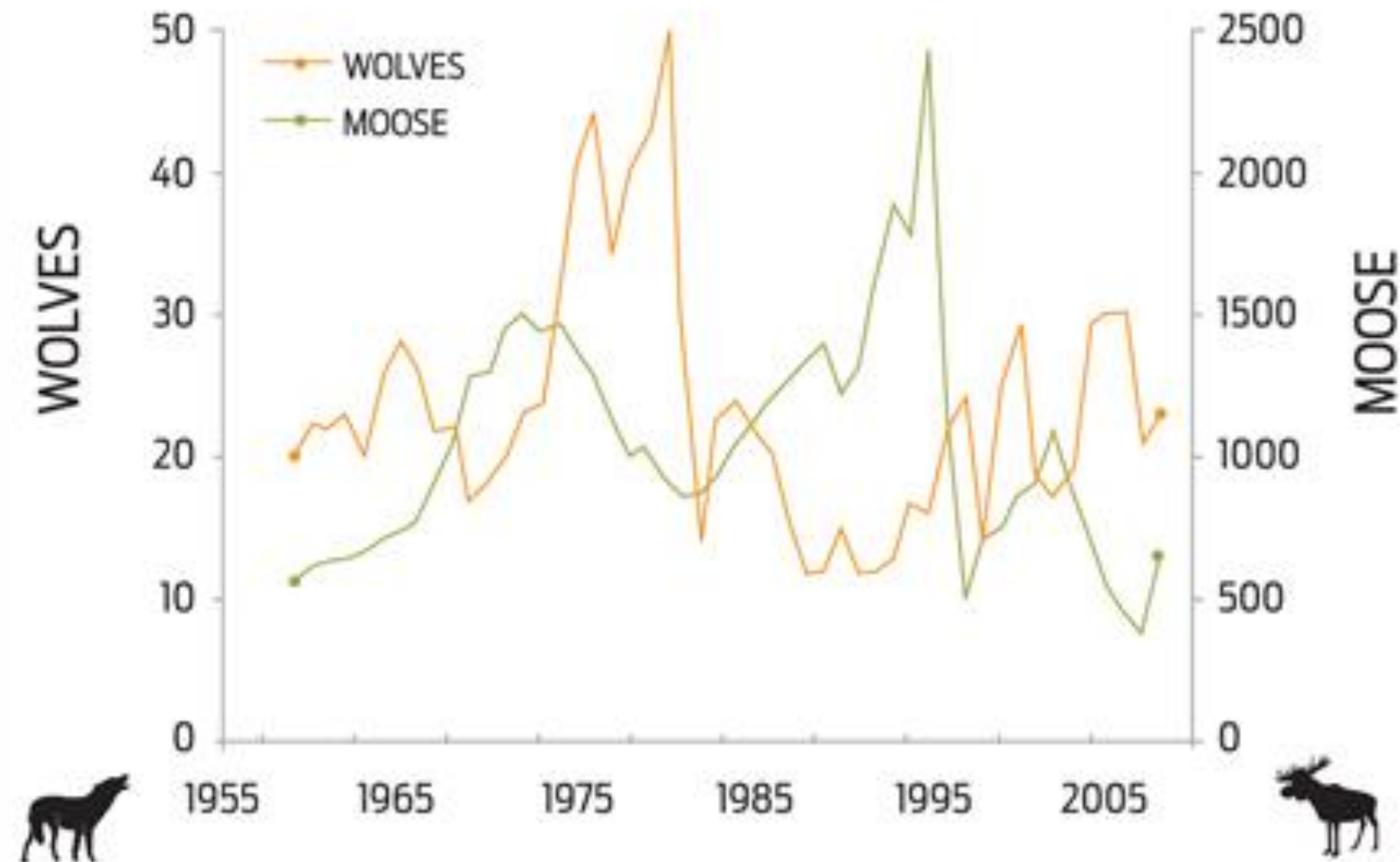


Figure 9-3. Changes in the abundance of the lynx and the snowshoe hare, as indicated by the number of pelts received by the Hudson's Bay Company. This is a classic case of cyclic oscillation in population density. (Redrawn from MacLulich 1937.)

ISLE ROYALE POPULATION CYCLES

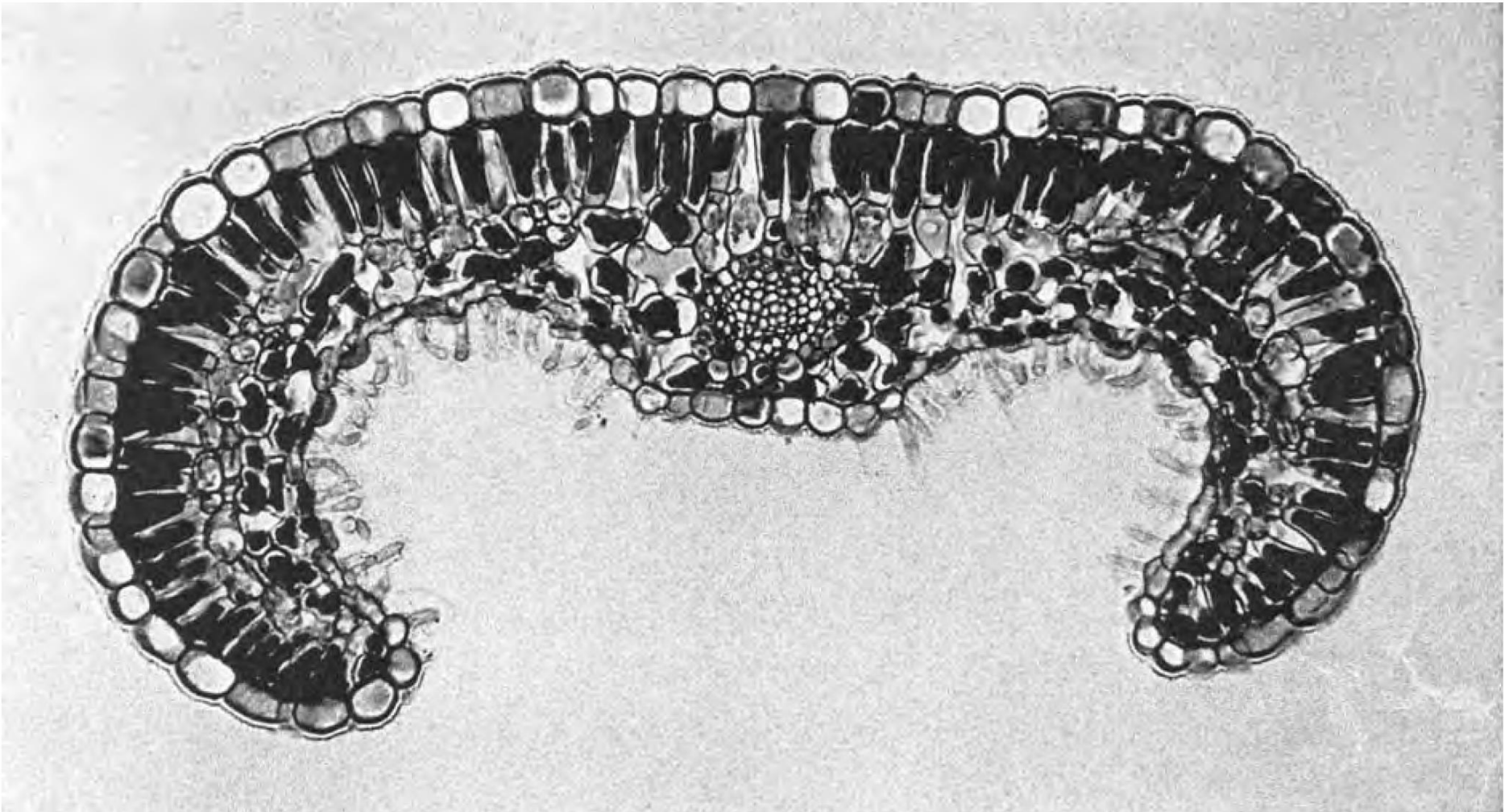


- **Accumulation of waste:**

The growth of microorganisms is frequently self limiting because the accumulation of waste products can be toxic e.g. in anaerobic conditions, yeast cell growth is inhibited by the production of their waste product ethanol. If levels reach aprox. 10% in their solution then the population dies

Photograph 2.4 shows a section through the leaf of a heather plant (*Erica*).

In the space below, draw a block diagram of the tissue layers in the leaf. Identify, in the drawing, **three** features which indicate that this is the leaf of a xerophytic plant and explain through annotation of the drawing how each feature acts as an adaptation.



Drawing skills:

block diagram shown (of leaf tissues);
accurate representation of the photograph;
quality of drawing (eg clear lines drawn, not sketchy);

[3]

Xerophytic features:

Any three from

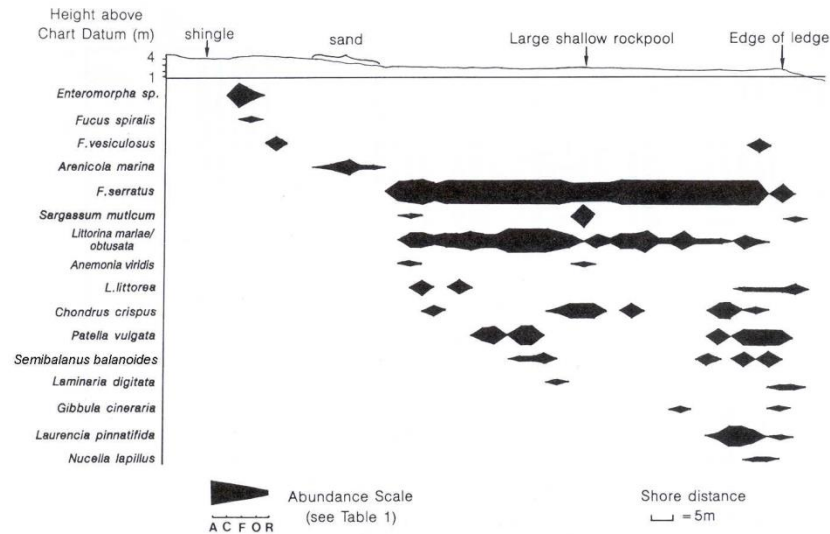
- thick waxy cuticle – reduces evaporation through the cuticle
- thick upper epidermal layer – reduces evaporation
- curvature of leaf (round lower surface) – maintains a high humidity immediately outside the stomata
- sunken stomata – maintains the high humidity
- epidermal hairs – maintains a high humidity immediately outside the stomata
- low density of stomata – reduces stomata evaporation
- few air spaces – reduces surface area for evaporation
- succulent mesophyll – stores water

[3]

See Pre-Magailigan notes:

- ❑ Xerophytic adaptations
- ❑ Sampling methods
- ❑ Kite diagrams

KITE DIAGRAMS



These show the percentage cover or abundance of a specific species along a transect, the X-axis is the distance, and the kite shapes represent the amount of that species at that set distance. A gradient of the sample area can also be plotted.

Kite diagram graph showing a belt transect study of a rocky shore:

Belt transect study of a rocky shore

plants

black lichen (*Verrucaria maura*)

channelled wrack (*Pelvetia canaliculata*)

spiral wrack (*Fucus spiralis*)

knotted wrack (*Ascophyllum nodosum*)

bladder wrack (*Fucus vesiculosus*)

serrated wrack (*Fucus serratus*)

oar weed (*Laminaria* sp.)

animals

nerite wrinkle (*Littorina neritoides*)

rough wrinkle (*Littorina rudis*)

edible wrinkle (*Littorina littorea*)

smooth wrinkle (*Littorina obtusata*)

dog whelk (*Nucella lapillus*)

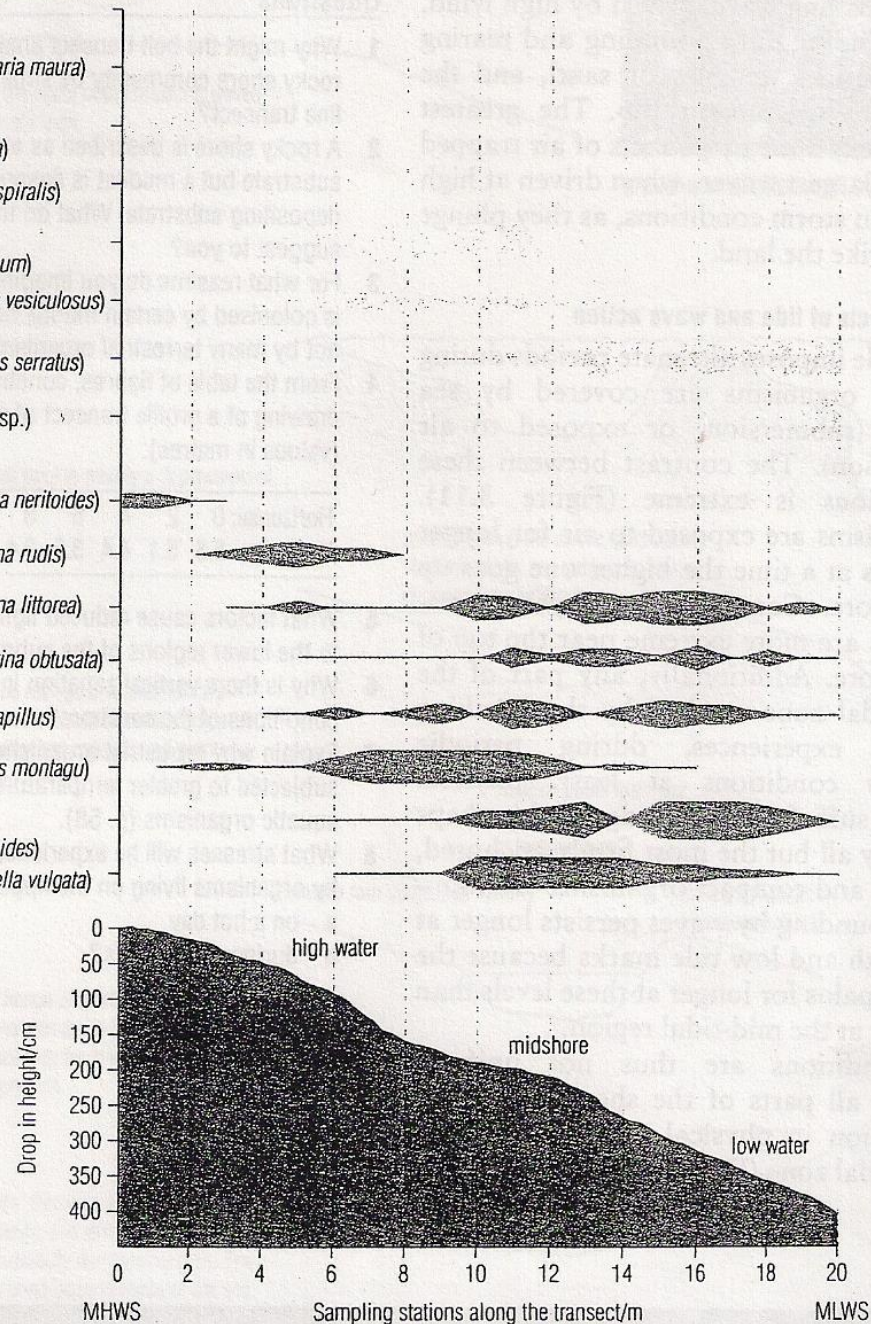
barnacle (*Chthamalus montagu*)

acorn barnacle (*Semibalanus balanoides*)

common limpet (*Patella vulgata*)

key

- rare
- ▬ occasional
- ▬ frequent
- ▬ abundant
- ▬ dominant



Try drawing the kite diagrams from your worksheet. Here are some guidelines:

- Cannot have continuous y axis; have separate mini ones all the way up
- On the y axis, place your zero in the middle of each species and rule that x axis across from each zero
- Plot the points either side of this so that the total adds up to the amount of species e.g. if there are 5 species then plot 2.5 either side of the zero line
- Bring your line back to zero at the next station
- Leave room at the bottom of your graph for drawing the height profile of the area sampled as shown in the previous slide (can't do this with this worksheet but something to consider for the coursework example)

	Distance (m)										
	0	1	2	3	4	5	6	7	8	9	10
<i>Agrostis</i>		2	3	3						2	
<i>Glyceria</i>		2	3	3	3	1				1	2
<i>Sparganium</i>				1	2			1	2	2	
<i>Lemna minor</i>					3	4	2	1	2		
<i>Potamogeton</i>					4	5	5	2	1		

This zero line should meet the y axis - there should be no gap between the y axis and the x axis zero

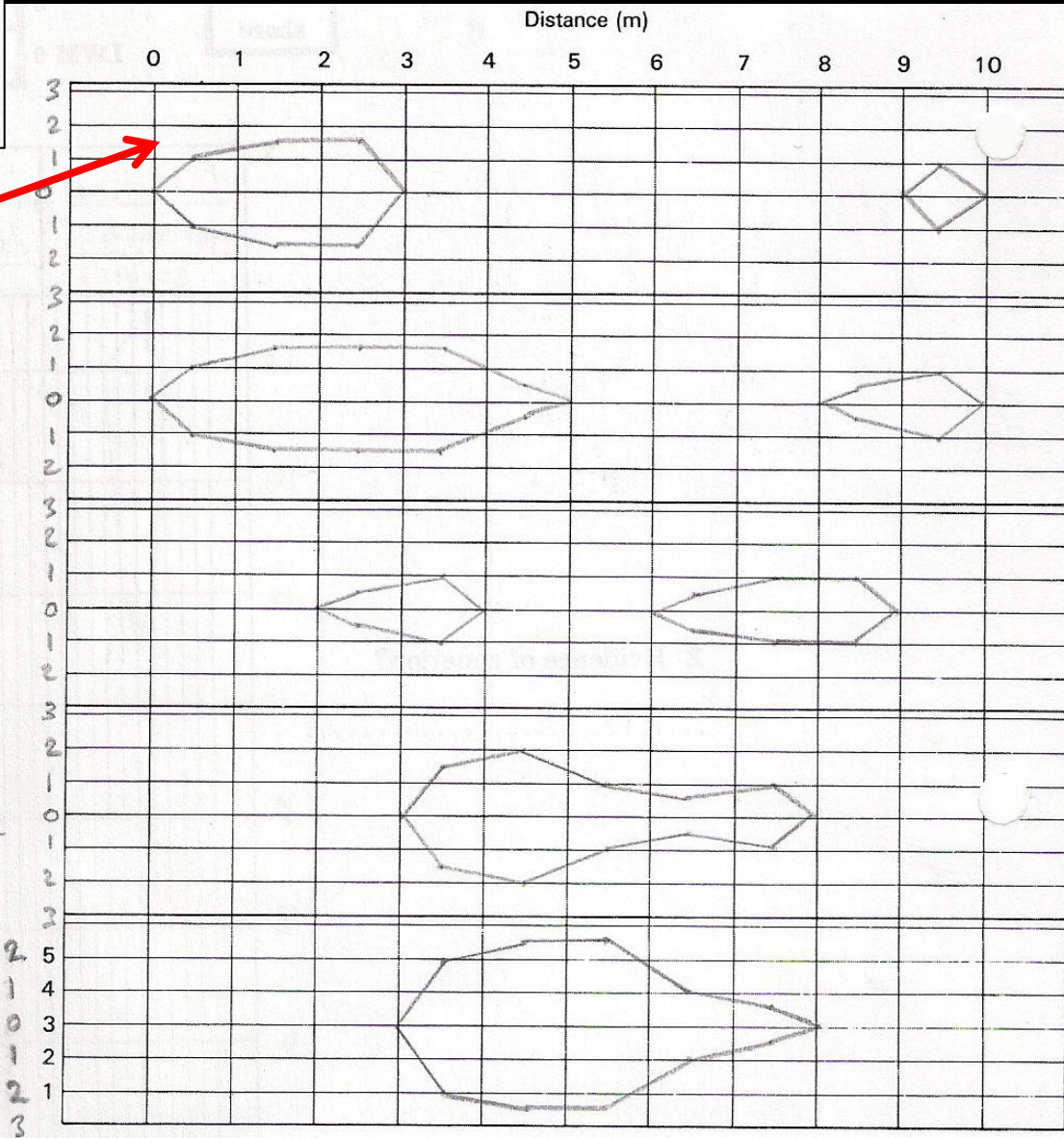
Agrostis

Glyceria

Sparganium

Lemna minor

Potamogeton



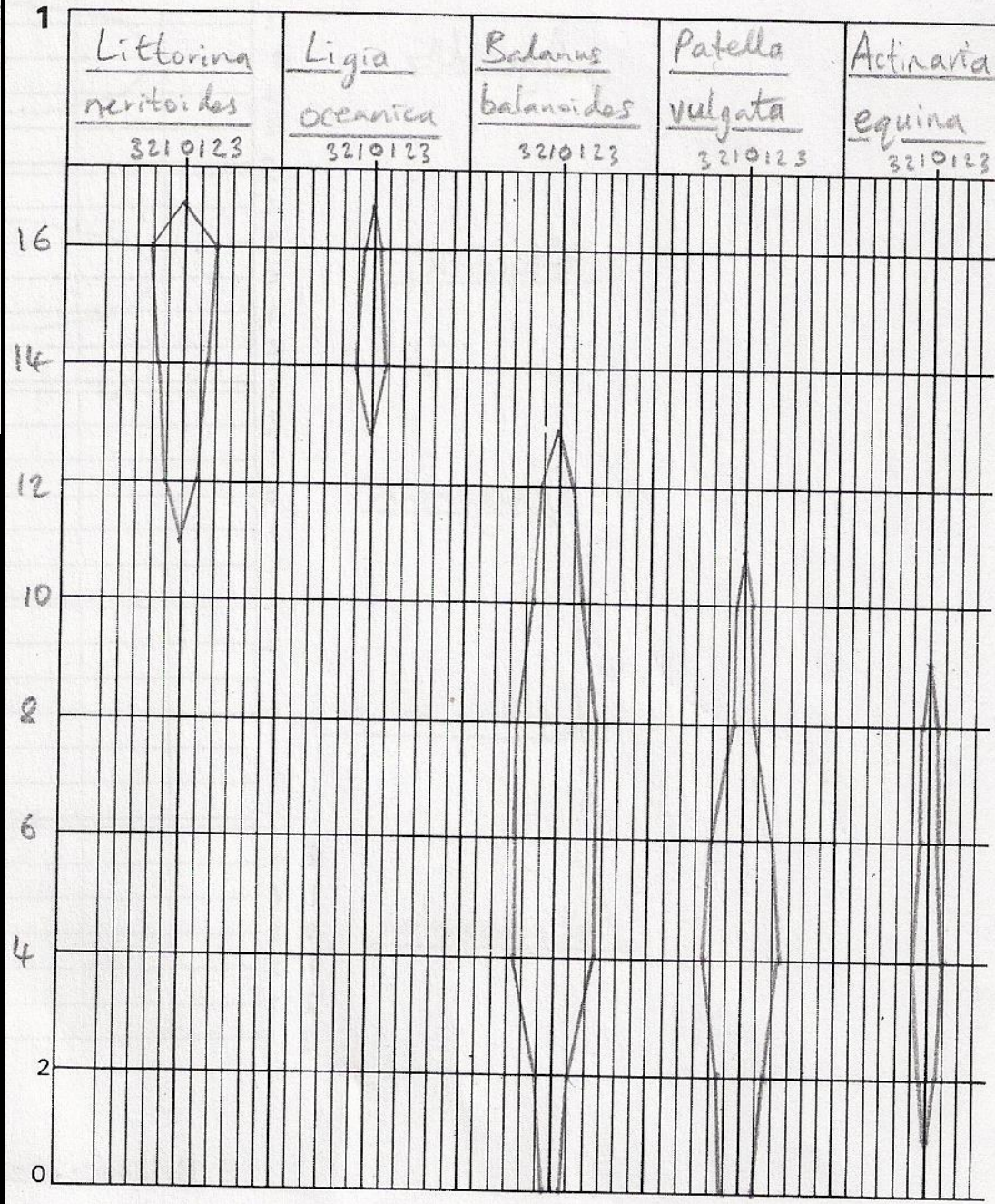
Splash zone
Upper shore
Middle shore
Lower shore

Distance from low water mark (m)

LWM 0

Species of animal				
<i>Littorina neritoides</i> (small periwinkle)	<i>Ligia oceanica</i> (sea slater)	<i>Balanus balanoides</i> (barnacle)	<i>Patella vulgata</i> (limpet)	<i>Actinia equina</i> (sea anemone)
16	4	1		
14	3	2		
12	2		2	
10		3	1	
8		5	1	1
6		5	4	1
4		5	5	2
2		2	3	1
0		1	2	

Another "not great" example - this time the kites are drawn vertically. The independent variable should not be placed on the y axis, as is the case here



Castle Park animal survey using randomly placed quadrats at 10m stations along a transect line:

The relationship between species abundance and distance from GCS

	<i>Distance/m</i>						
<i>Species</i>	0	10	20	30	40	50	60
Weasel	4	6	7	2	0	0	0
Emperor penguin	0	0	2	5	0	0	0
Duck	9	10	3	1	1	0	1
Giant Panda	0	0	0	0	0	1	3
Kangaroo	5	6	5	3	1	0	0
3 toed sloth	0	0	0	2	4	5	1

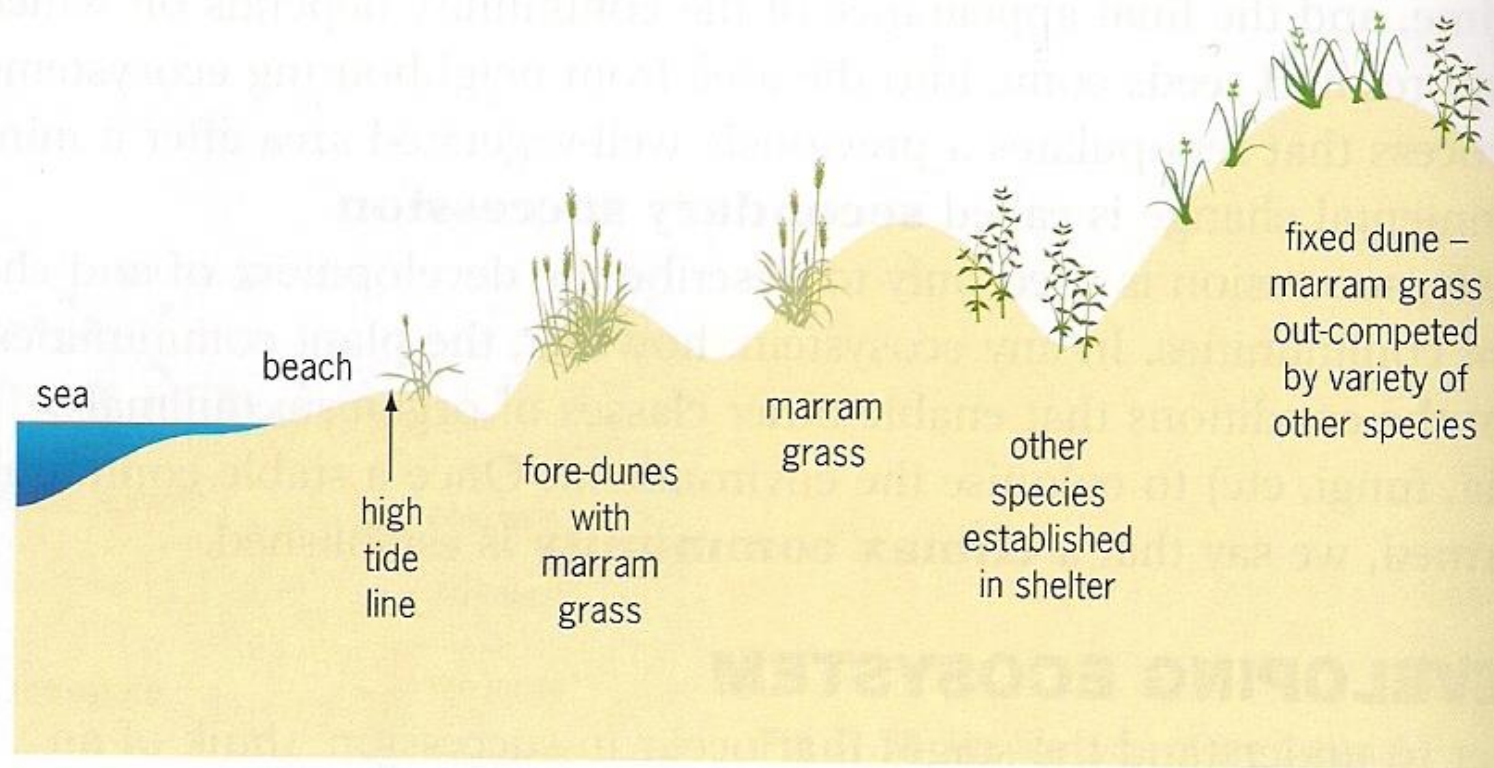


2 Studying a sand dune system

Sand dunes are useful areas to study because you can observe colonisation and succession without having to wait 50 years. You can see some of the changes associated with the development of ecosystems as you simply walk inland (Fig 37.21). Near the sea, the dunes are at their youngest and wind tends to pile up the sand. As a result, the profile changes from year to year. Sand is a very difficult medium for plants; water and nutrients drain straight through, and the constant shifting makes it very difficult for the roots to

anchor the plant. However some pioneer species, notably marram grass, have a dense root system that binds the sand together. This holds water and humus particles and makes the whole dune more permanent. Once the marram grass has made the environment less hostile, other plants such as ragwort, willow and grasses can take over. As you move inland the sand gets darker because the humus content increases, as does the species diversity.

Fig 37.21 Sand dune succession



***Practical work** - qualitative and quantitative techniques used to investigate the distribution and relative abundance of plants and animals in a habitat*

- Sampling procedures:
 - Random sampling
 - Line transect
 - Belt transect
- Sampling devices: quadrats, pitfall traps, sweep nets and pooters
- Estimation of species abundance, density and percentage cover
- Appreciate and measure abiotic and biotic factors which may influence the distribution of organisms

Sampling methods

Ecologists often need to estimate the abundance and distribution of animals and plants e.g. for conservation, to observe change, monitor pest or invasive species. It is not usually possible to count all the individuals present in a population, so samples are taken which will hopefully be representative of the entire population

When sampling always ensure to generate sample sites randomly and repeat (take replicates) to ensure reliable results

SAMPLING METHODS

Random sampling: Taking experimental samples in a way that avoids bias. E.g. using a random number generator or table to select placement of quadrats along a belt transect



Quadrat: Samples plants and slow moving animals. Usually split into 25 squares (0.25m² quadrat) where presence or absence will be decided (objective measurement) or percentage cover (subjective measurement)

Belt transect: A line marked out through an area. Can show how an environmental gradient affects organism distribution. Stations are placed along the belt and then random samples are taken at each station (along the width)



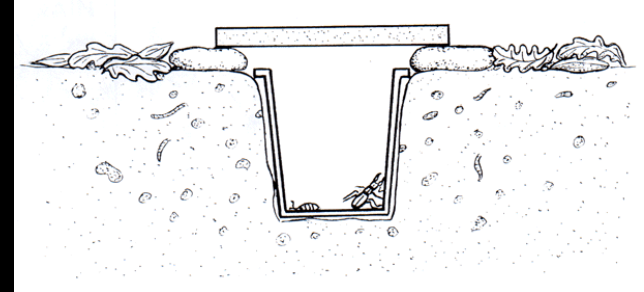
Line transect: Line through an area to show change i.e. an environmental gradient; whatever is touching the line gets recorded at interval along its length



Pooters: Used to live capture small invertebrates for study by sucking them up a tube

Sweep nets: Catches invertebrates in low growing vegetation. Tipped into a jar or tray for study

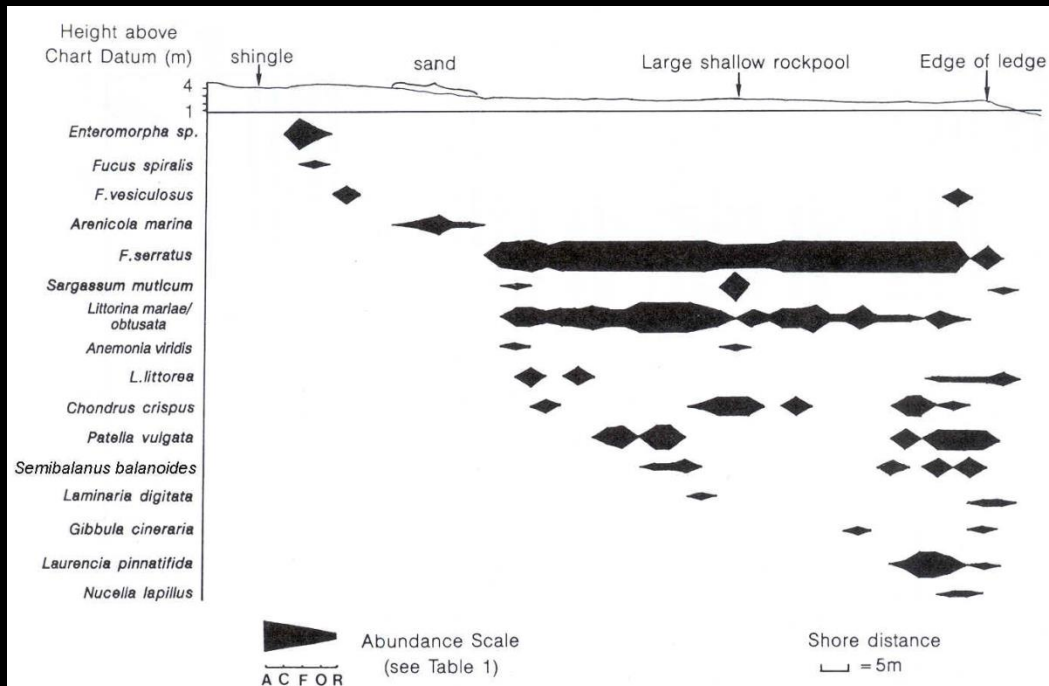
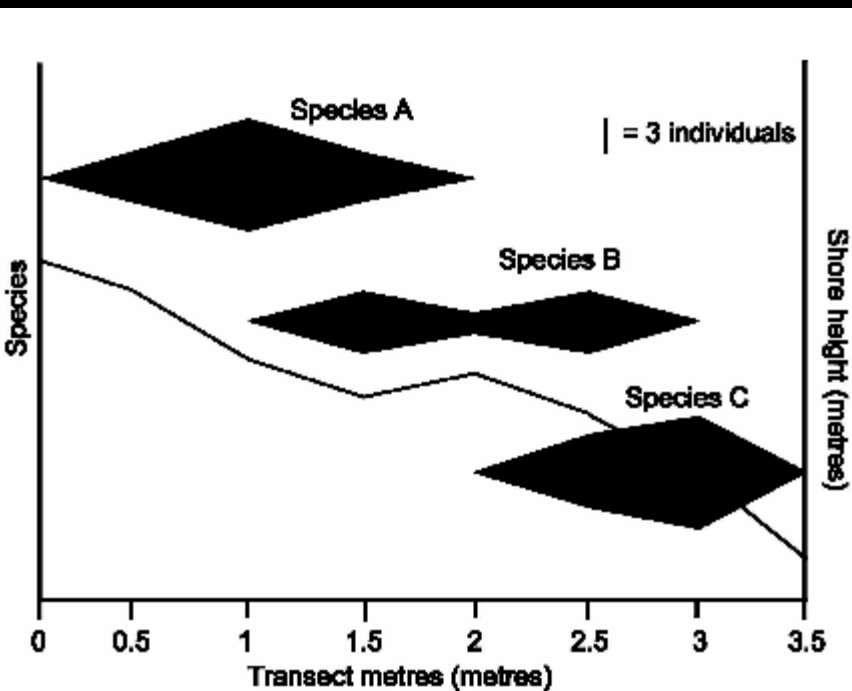
Pitfall traps: Collects invertebrates active on soil surface or leaf litter; they fall into the trap and a lid keeps rain out



- *Density can also be assessed: the mean number of individuals per unit area e.g. the average number within a quadrat or a sample area*
- *Species abundance: the number of individuals of a species within a defined area*

Using a belt transect through an area of changing environmental conditions we can observe how the distribution of organisms changes over that environmental gradient.

The kite diagram/chart is useful because we can see both the distribution and the gradient on the same graph e.g.:

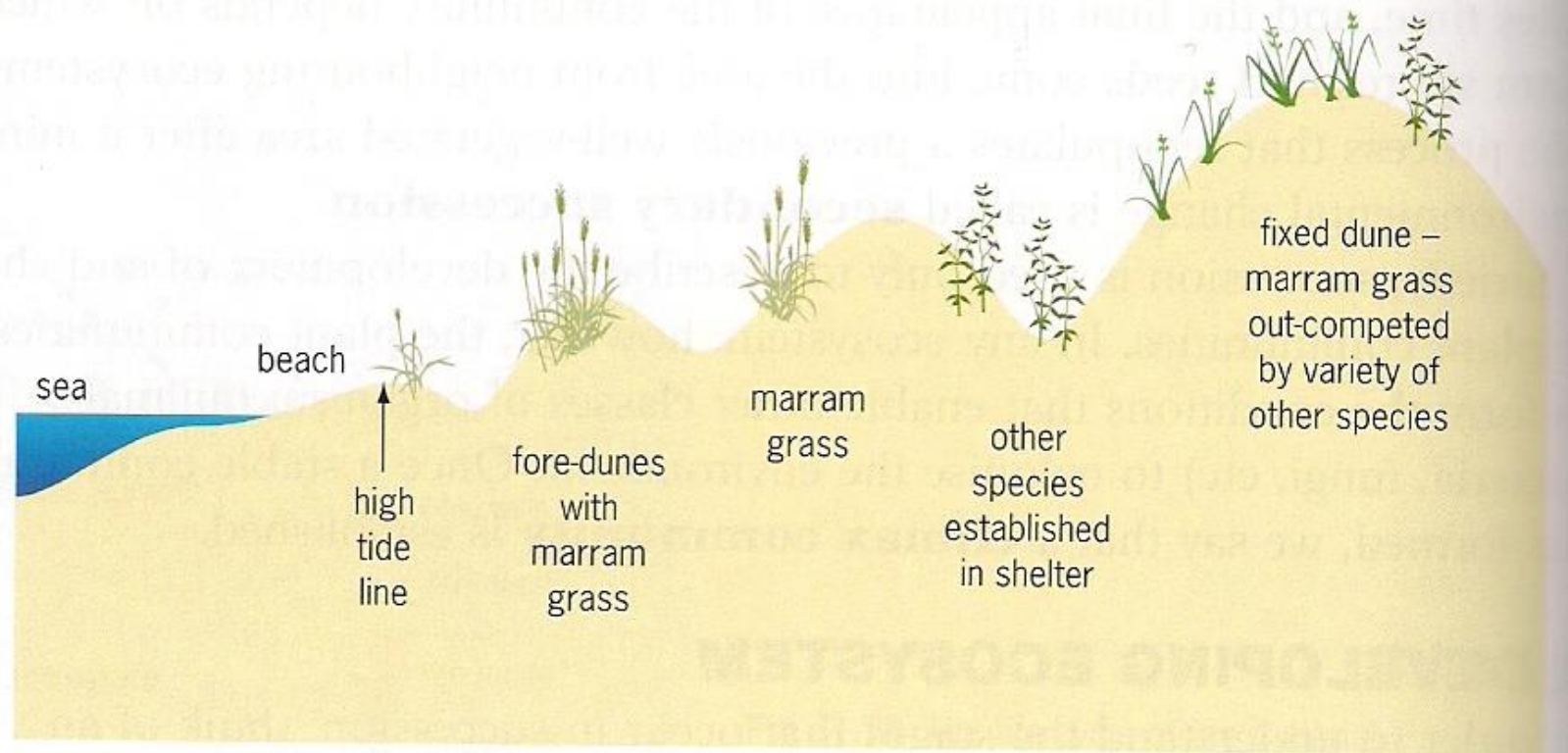


2 Studying a sand dune system

Sand dunes are useful areas to study because you can observe colonisation and succession without having to wait 50 years. You can see some of the changes associated with the development of ecosystems as you simply walk inland (Fig 37.21). Near the sea, the dunes are at their youngest and wind tends to pile up the sand. As a result, the profile changes from year to year. Sand is a very difficult medium for plants; water and nutrients drain straight through, and the constant shifting makes it very difficult for the roots to

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on to the plot. **Fig 37.21** Sand dune succession



Selection



SELECTION

Genetic variation allows populations of organisms to maintain their adaptiveness in their environment.

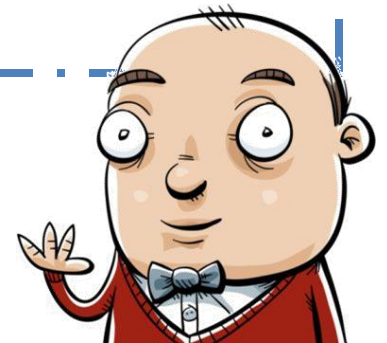
Natural selection acts on this variation and is seen as the driving force behind the theory of evolution;

there are two main types of selection:

- **STABILISING SELECTION** maintains the constancy of features in a non-changing environment
- **DIRECTIONAL SELECTION** brings about a change in frequency of a feature in a changing environment, and accounts for the diversity of organisms - leads to an evolutionary change

Handy hint:

Remember that within the members/**population** of the same species we see great physical **variation** due to the **genetic diversity**. In different environments/conditions, this genetic variation will allow some individuals to be better adapted and therefore will be more successful at surviving and reproducing. The alleles causing the differences are passed on to any offspring



Where does the genetic variation come from within individuals of the same population?

A small prize for the first person/team to name three sources!



WHERE DOES THE GENETIC VARIATION COME FROM?

There are processes in an organism's life cycle that generate this genetic variation and therefore introduce it into the population:

- **Meiosis** - through the events of Crossing over in prophase 1 and Independent assortment in metaphase 1, haploid cells are produced (i.e. gametes in animals), each of which is genetically different from any other
- **Cross-fertilisation** - brings a set of alleles from one parent into combination with a set of alleles from another parent (*Sexual reproduction*). The gametes that fuse are randomly selected.
- **Mutation** - new alleles may be introduced into a gamete/gamete producing cell by mutation in a gamete or gamete producing cell (a spontaneous change in the coding DNA) *e.g. by radiation or mutations arising through DNA replication*

BUT HOW DOES SELECTION WORK?

SELECTION - *the story...*

1. Fitness is a measure of those features which allow an organism to be adapted to its environment

These features are contained in each organism's genotype/genes (and shown through the phenotype). In terms of population we talk about the frequency of advantageous (fit) genes and the frequency of disadvantageous genes in the population

2. So selection maintains the fitness of a population of organisms

Selection maintains how a population is adapted to its environment, OR how the population responds to a change in the environment i.e. it maintains the genetic frequency which allows that population to survive

3. Those individuals with features best suited to their environment leave proportionally greater numbers of offspring
4. This differential **reproductive success** maintains the fitness of a population;

The organisms that are best adapted to the environment (have more fit/ advantageous genes), will therefore survive for longer, have more chance of mating and thus leaving more offspring - which carry on their genes and represent them in the whole population i.e. the frequency of those fit genes increases due to selection for them

5. Natural selection does not create useful adaptations but rather **edits genetically inheritable features** in a population, increasing the frequency of some while decreasing the frequency of others over time

Natural selection will act for or against certain genes e.g. selection for dark colour genes in peppered moth (*Biston betularia*) in polluted areas, and selection against the gene that causes light coloured moths

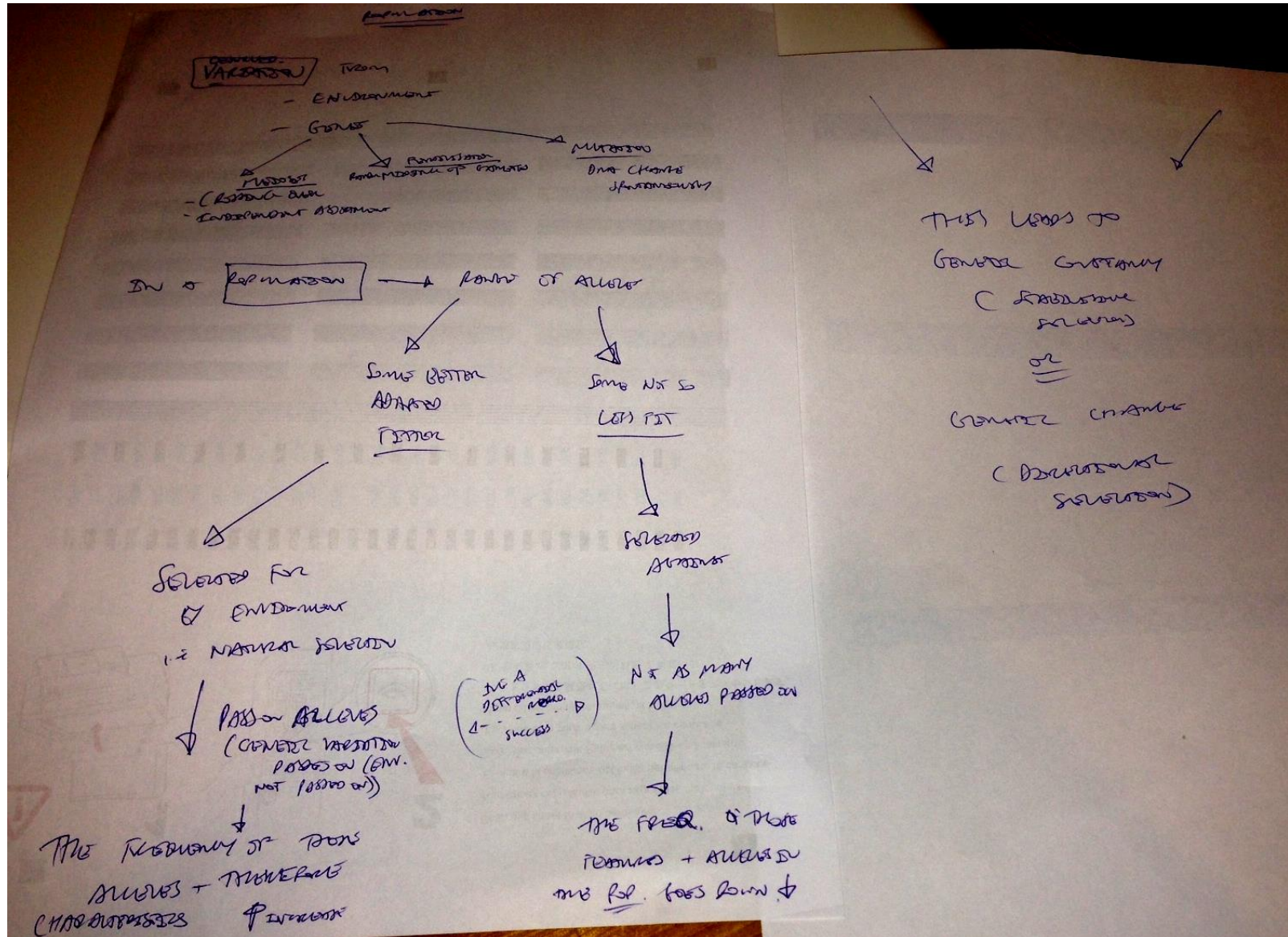


6. Selection acts on the phenotype which then in turn promotes certain genotypes within a population and acts against others

7. Selection is the process by which organisms adapt to survive in a changed environment
8. It allows populations of organisms to maintain their adaptiveness within a population

If the environment changes then due to the genetic variation among individuals of the same species, some will have advantageous characteristics and will survive and reproduce, thus ensuring the continuation of the species

Draw a flow chart summary of natural selection...



TEN MINUTE TASK

In groups, construct a short drama/skit/sketch explaining an aspect of natural selection, or just generally what it's all about!



1. STABILISING (OR NORMALISING) SELECTION

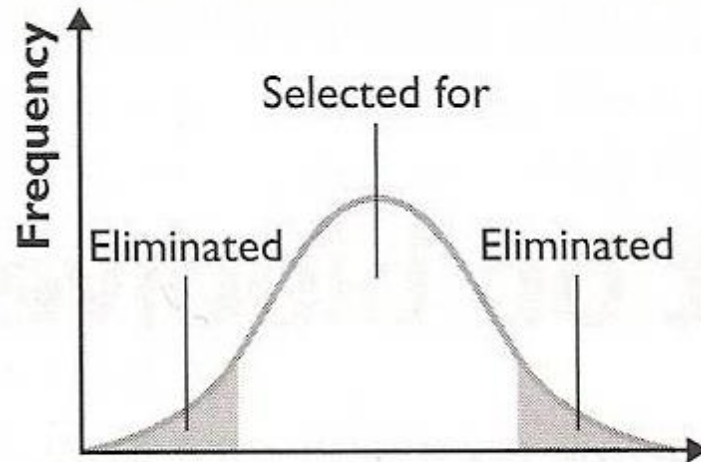
In a relatively stable environment i.e. one in which conditions are not changing over time, most variations from the average are selected against. Natural selection will act to maintain the most adapted/normal form of the species - the **average form**. We know that natural selection doesn't have to cause change, and if an environment doesn't change there is no pressure for a well-adapted species to change.

The organisms most likely to reproduce successfully are those with characteristics close to the norm/average for the population - (this is also known as the adaptive norm)

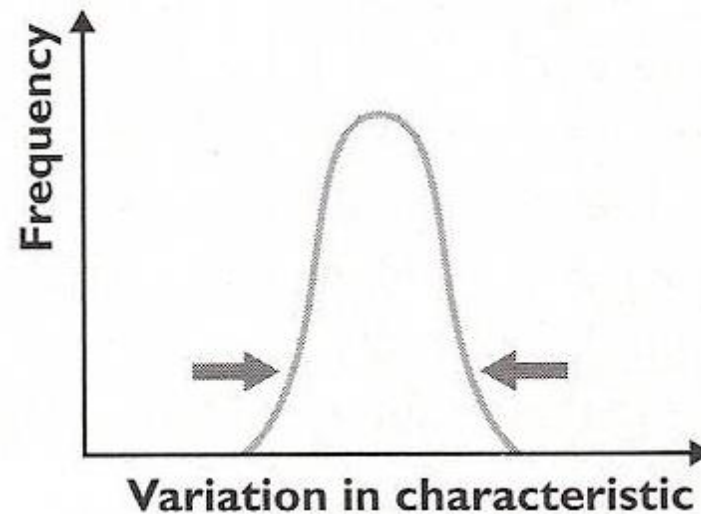
Add this to your notes:

(a) Stabilising selection

Before selection



After selection



Stabilising selection occurs when individuals near the mean are favoured/selected for and the extreme forms tend not to survive and pass those characteristics on

- Fossils suggest that many species remained unchanged for long periods of geological time e.g. **the coelocanth**:

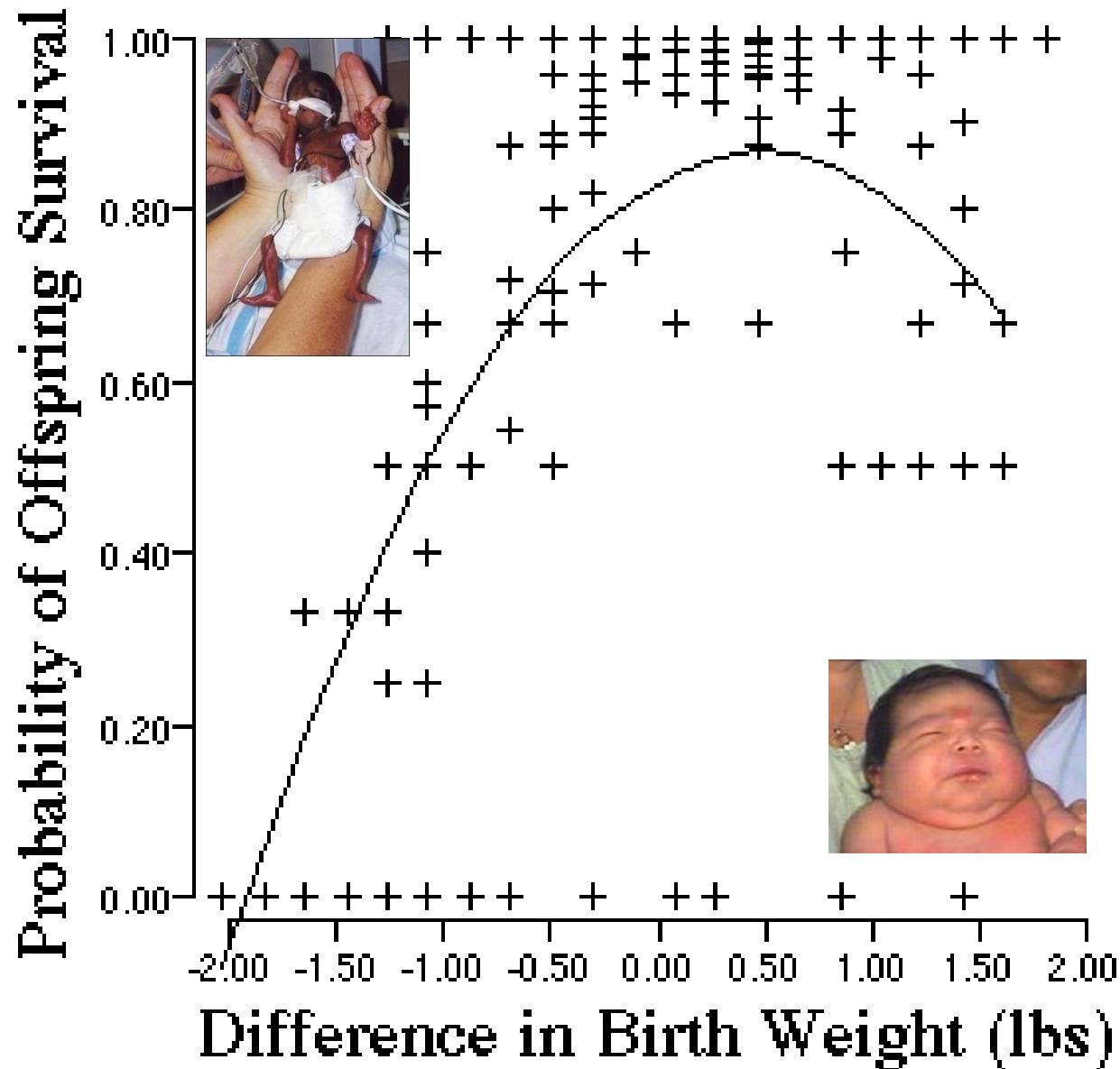
- This fish species was known only from ancient fossils and was assumed to have been extinct for 70 million years until a living specimen was found in a trawler net off South Africa in 1938

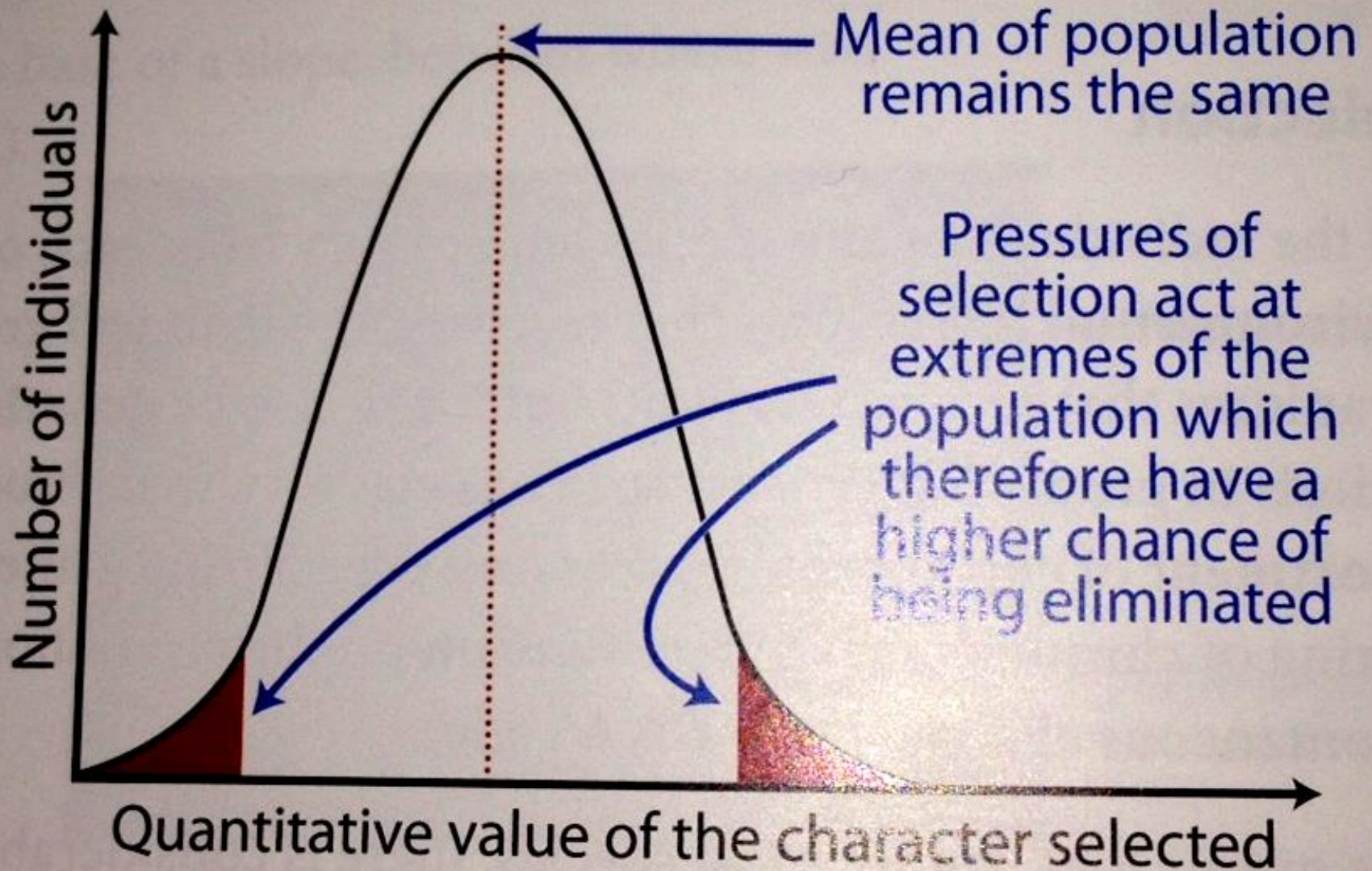


- So this species has not changed in all that time

- Another example of stabilising selection can be seen in the **birth weight of humans**
- The heaviest and lightest babies (much more and much less than the average birth weight) have the highest mortality (death rate)
- They are less likely to survive to reproduce and pass on their alleles; therefore the consistency of features are maintained in this non-changing environment
- The adaptive norm is for babies of weight in the middle of these two extremes

Human birth weight (example of stabilising selection)





STABILISING SELECTION

Homework for Wednesday:

- Complete questions 2 and 3 of PPQs
- Complete drawing task

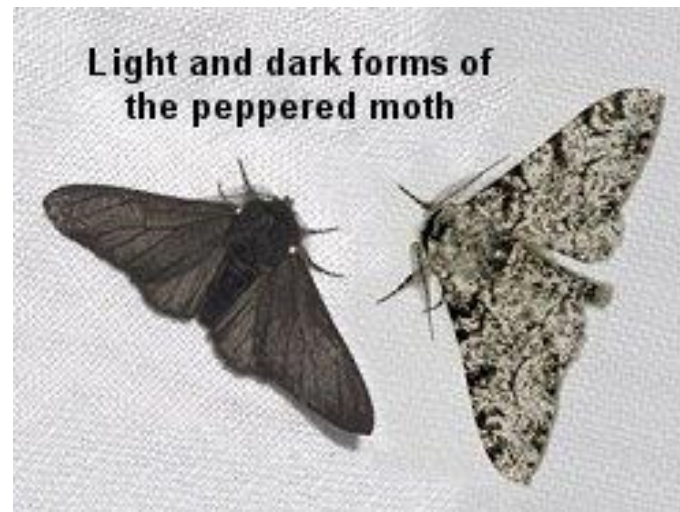
2. DIRECTIONAL SELECTION

If an environment changes gradually over time, the **mean** for the population (the adaptive norm) may no longer be the most adaptive form. There is **selective pressure** for the population to change in response to the environmental change. The variants towards one extreme of the population may now possess the "fitter" characteristics.

- *They are now more likely to survive and reproduce, thus passing on their genes to the next generation*
- *These genes will increase in frequency within the population*

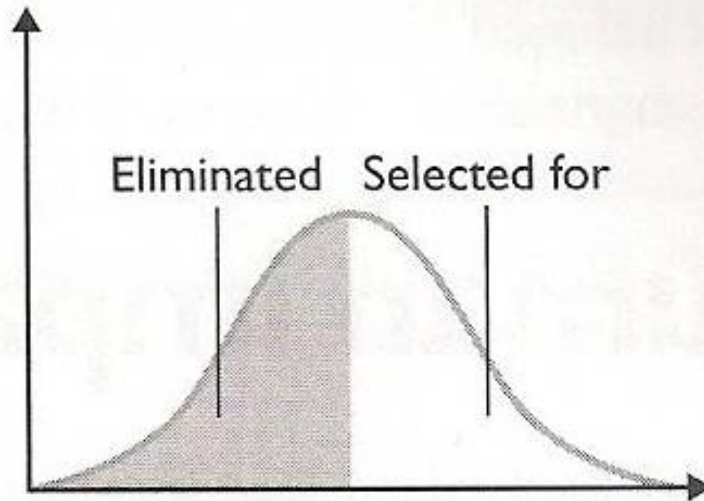
This is **directional selection**; there is a shift in the most favoured characteristic as different variants (variations of the same species) are selected for and **the mean frequency shifts towards the variant that is selected for by the selection pressure.**

It results in a change in the genetic composition of the population i.e. There is evolutionary change. **This allows the population to maintain diversity, respond to environmental change and remain adaptive**

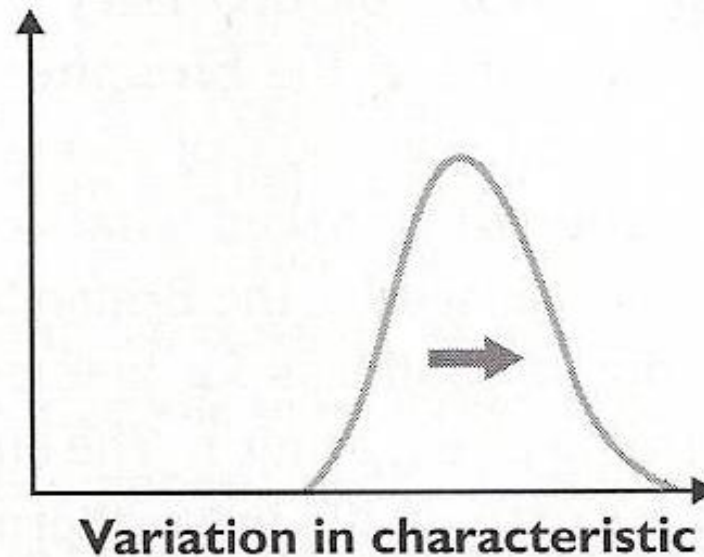


(b) Directional selection

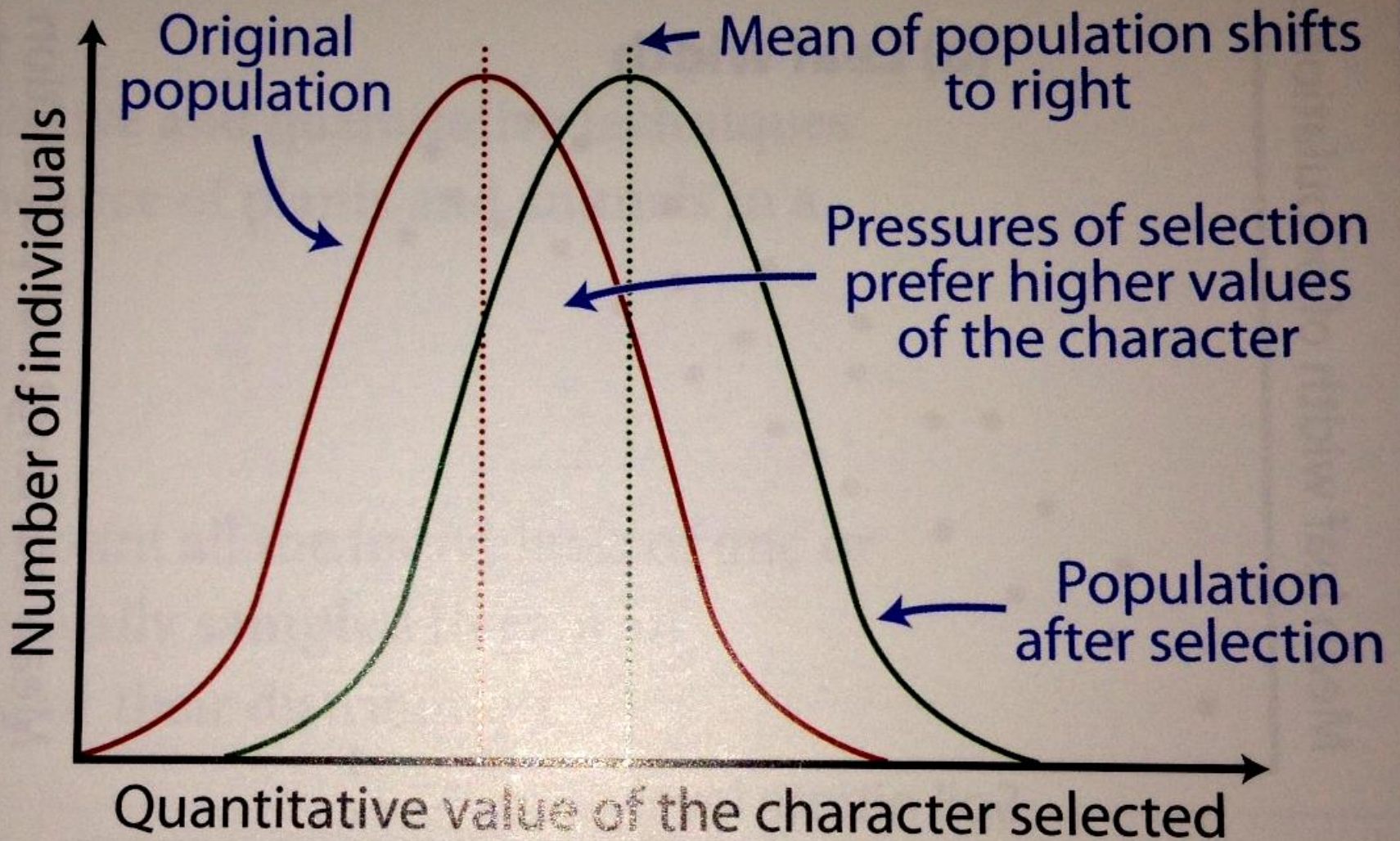
Before selection



After selection



Directional selection can result in evolutionary change as one of the forms (within the range for the characteristic) is selected for/is favoured and this leads to an increase in the frequency of those favoured individuals i.e. the mean shifts towards the favoured form



DIRECTIONAL SELECTION

- Remember that "environment" includes biotic as well as abiotic factors that can change; organisms evolve in response to each other. e.g. if predators run faster there is selective pressure for prey to run faster, or if one tree species grows taller, there is selective pressure for others to grow tall
- *This is often described as an "evolutionary arms race" (see Futurama clip)*
- Most environments do change **over time** e.g. due to migration of new species, or natural catastrophes, or climate change so directional selection is common



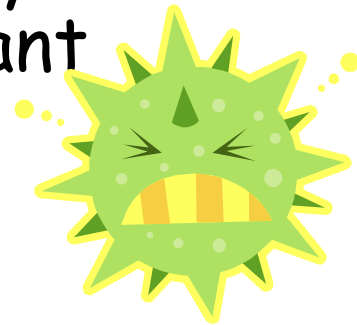
Read through the examples of directional selection:

- The Peppered moth
- Antibiotic resistance in bacteria
- Warfarin/rat poison resistance in rats



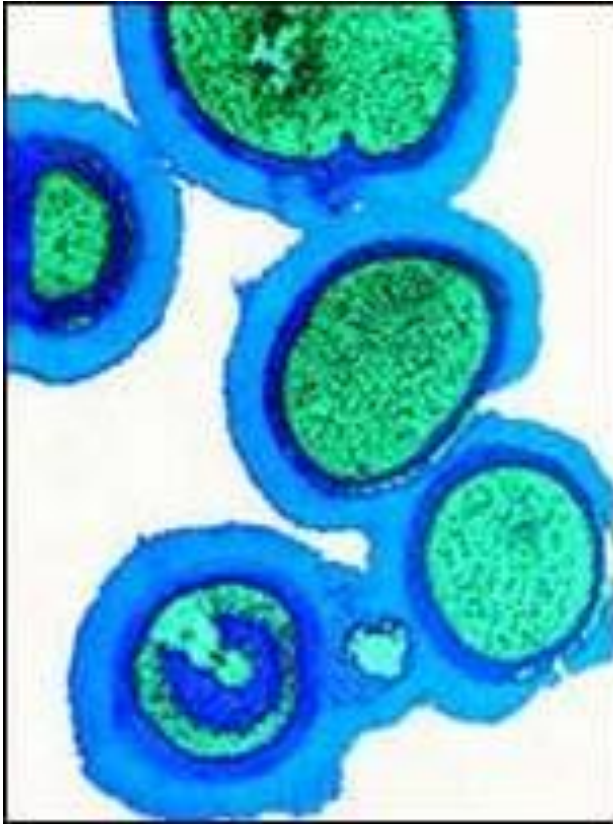
BACTERIAL RESISTANCE TO ANTIBIOTICS

- Antibiotics kill bacteria. Bacteria reproduce very rapidly and have a naturally high rate of genetic mutations. Occasionally a chance mutation appears that makes the bacterium resistant to that antibiotic
- In an environment where the antibiotic is often present, this mutant has an enormous selective advantage since all the normal bacteria are killed!
- The mutant cell is then free to reproduce and colonise the whole environment without any competition e.g. MRSA (methicillin resistant *Staphylococcus aureus*)



MRSA

(methicillin resistant *Staphylococcus aureus*)



PESTICIDE RESISTANCE

- Warfarin is a poison used to kill rats (it thins their blood and they bleed to death internally)
- Some rats have a chance mutation that gave them resistance to the poison
- Without warfarin, stabilising selection favours normal rats - resistant rats are selected against, because they need a lot of vitamin K in their diet (this thickens blood by promoting clotting agents)
- Warfarin was a new environmental factor that killed normal rats
- A few resistant rats survived, reproduced and passed on the resistance gene
- They produced a new population of resistant rats



THE PEPPERED MOTH

- There are two forms of this moth. Light coloured moths are well camouflaged from bird predators against the pale bark of birch trees, whereas dark moths are easily seen and eaten
- During the industrial revolution in the 19th century, woods near industrial centres became black with pollution
- The black moths had a selective advantage, camouflaged they were able to reproduce and pass on their genes to their offspring, becoming the most common colour
- Pale moths were easily predated and unable to pass on their genes their numbers were reduced

Directional selection was observed in peppered moths (*Biston betularia*) in Britain during the industrial revolution. Before the industrial revolution changed the environment, the light '*typica*' form was well adapted and the occasional dark '*carbonaria*' form (arising as a result of mutation) was selected against as it lacked camouflage on the lichen-covered trees. The environmental effects of the industrial revolution reversed these selective advantages, so that '*carbonaria*' became the favoured form with the result that its frequency increased in affected populations. Other examples of directional selection have been observed — for example, antibiotic resistance in bacteria, DDT resistance in mosquitoes and warfarin resistance in rats.



Some key points about natural selection:

- Natural selection is a process that acts on **populations** through its effect on **individuals**. Individuals survive or die depending on their degree of adaptation, but with directional selection the population will change over time, or evolve, as allele frequency changes.
- Fitness is **environmentally dependent**. For example, pesticide resistance is only an advantage if pesticides are used (it is a disadvantage if they are not used).
- Natural selection is effective **through differential reproductive success**. Differential reproduction is necessary to ensure that more favoured alleles get passed on to the next generation than less favoured alleles.
- Natural selection is an **ongoing process**. It is always taking place.

Homework for Friday:

- Read selection notes
- Complete PPQs 1 and 4
- Draw Heather block diagram

*Look at the selection extra info on
the back page of your handout...*

Some useful definitions...

The mode - is the value that occurs the most frequently in a data set **9**

The mean/average - the sum of the data divided by the number of separate values **8.17**

The standard deviation - describes the spread of the data (often with reference to the mean)

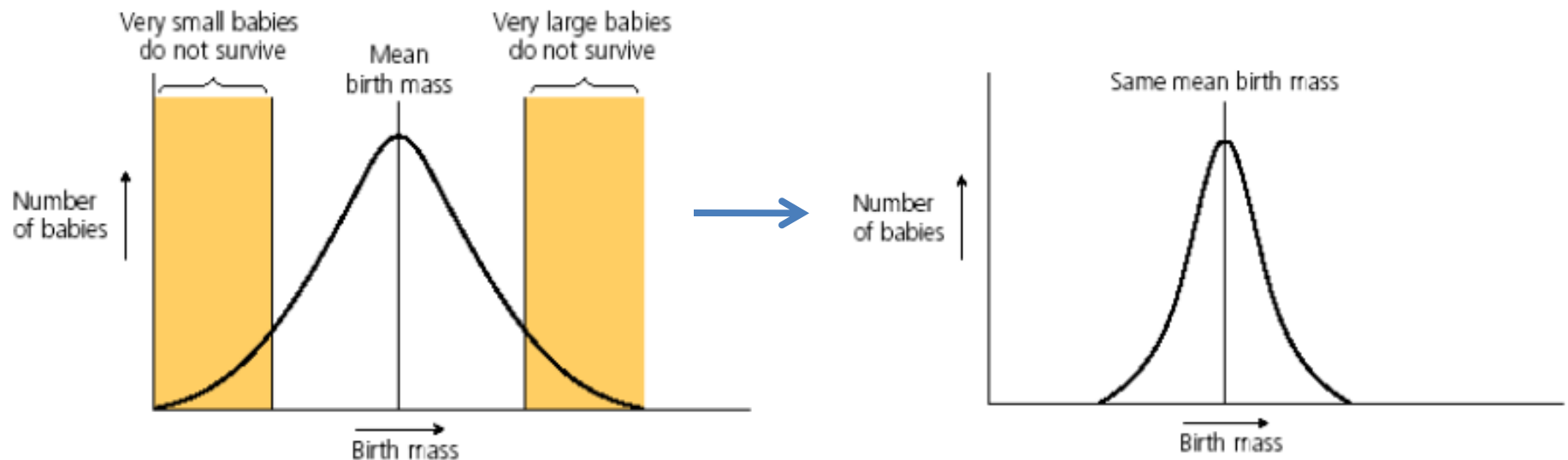
The median - is the middle value from the data set (the number that separates the top half from the bottom half of numbers) **9**

Dataset example: 5,6,7,9,9,8,9,9,10,9,7,9

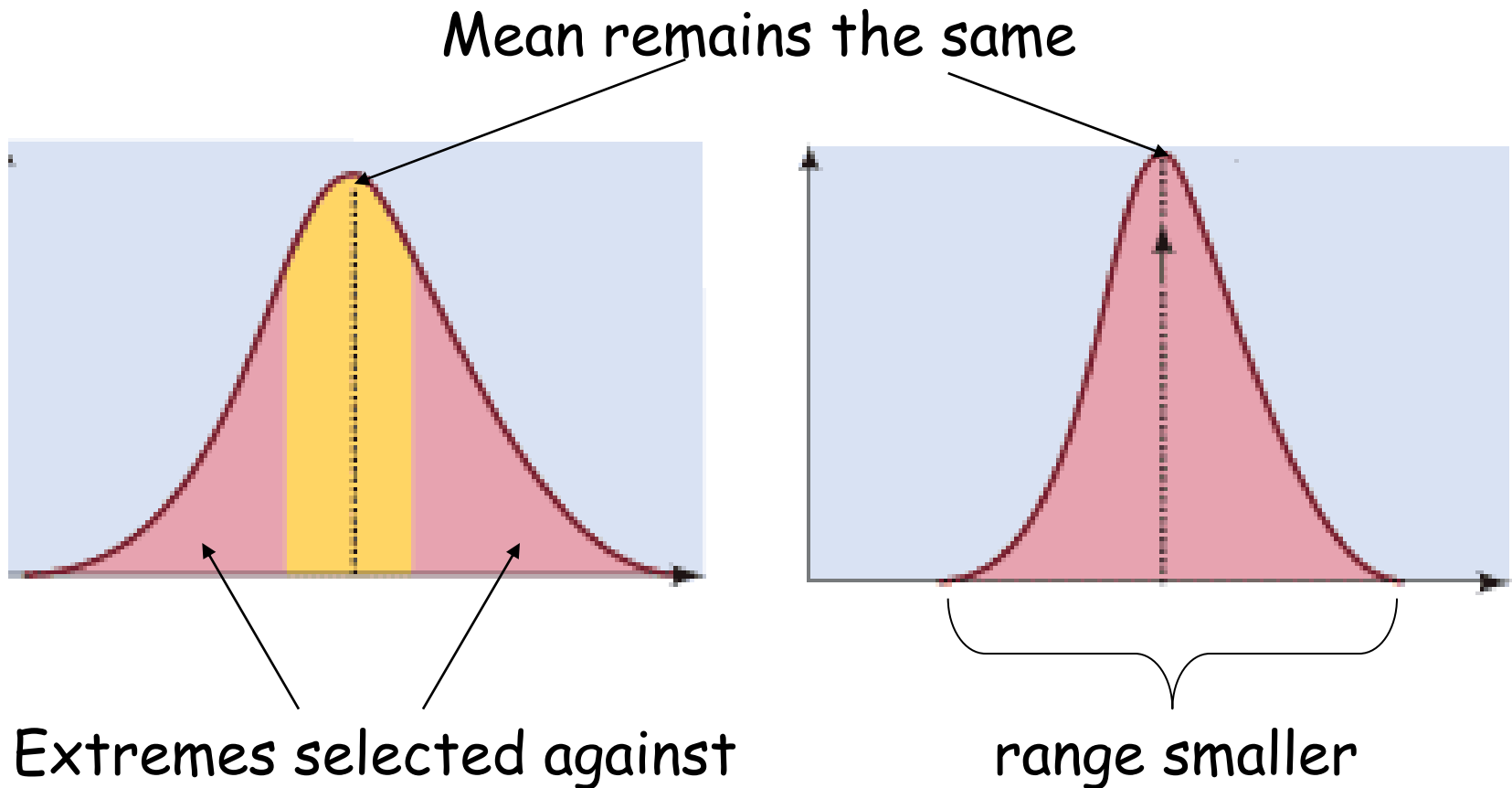
5,6,7,7,8,**9,9**,9,9,9,9,10

Stabilising selection:

This is **the most common**, and is a **response to a stable environment**. A good example is birth weight, since underweight babies are clearly less likely to survive, and overweight babies are likely to get stuck during birth, killing not only themselves, but also their mothers! The result is that **the mean stays the same, but the SD of the population falls**, i.e. the **population graph gets narrower and taller**, as **selection against mutations** takes place.



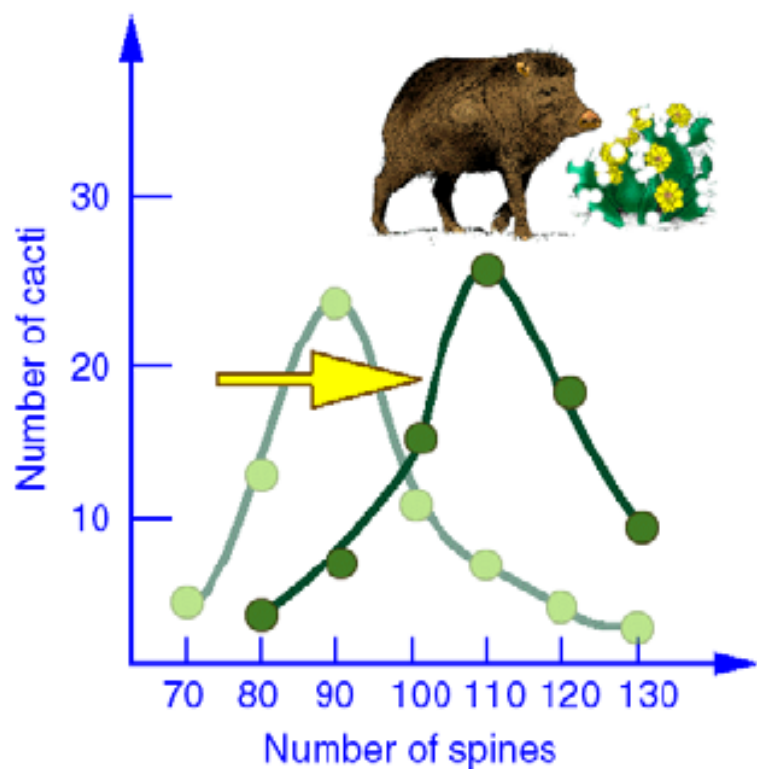
In stabilising selection the mean remains the same
but the range is smaller



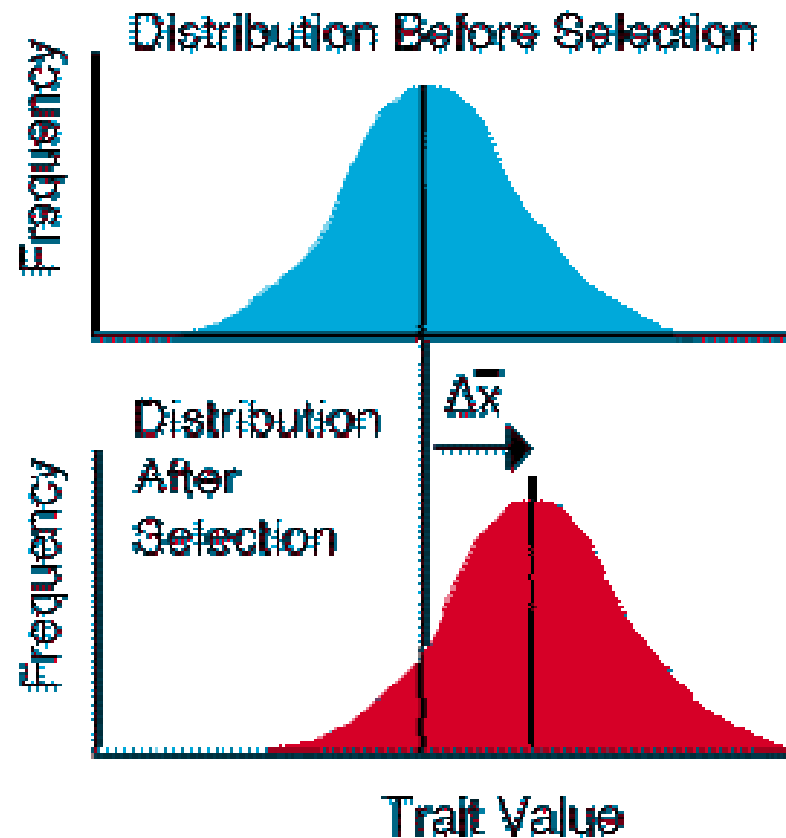
Directional selection:

This is the most common form of selection that results in a population with a new trait. It takes place **whenever change occurs in the environment**,

such as when a poison is used and resistant individuals begin to occur. These soon become the dominant type within the population. It does not matter if the example is Warfarin resistance in rats, DDT resistance in mosquitoes, or antibiotic resistance in bacteria. In Nature, such selection can also occur, as we saw, in spine selection in Holly, or when cacti are grazed (*see left*):



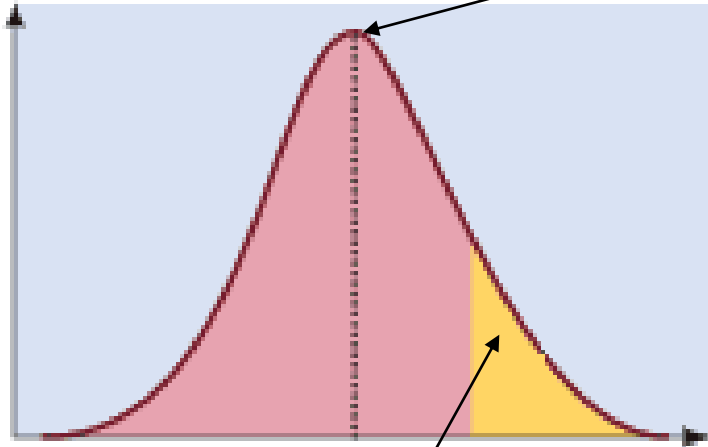
The mean has shifted as a result of this directional selection due to a change in the environment e.g. pollution:



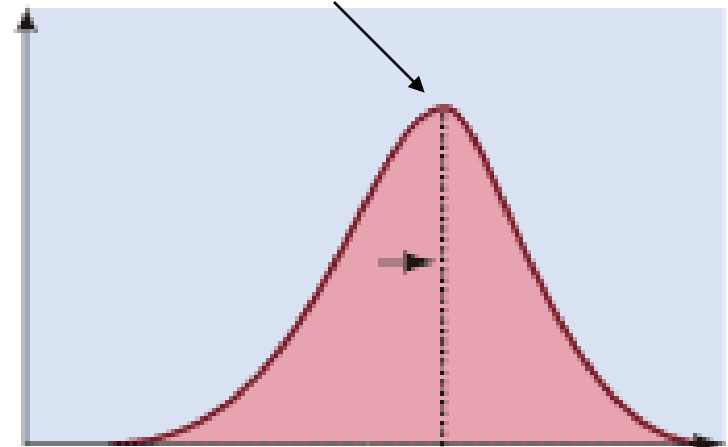
- In a normal distribution (bell shaped curve), the extremes were selected against but if the environment changes...
- In continuous features (e.g. size of bill) one extreme could become favourable and the mean then shifts either to the right or left
- In discontinuous features (e.g. resistance to poison or not) it causes one form to be favoured over another
- If two different environments exist which favour both extremes then the directional selection can act against the mean to create two dominant populations in the two different environments e.g. seen in the peppered moth

Directional selection

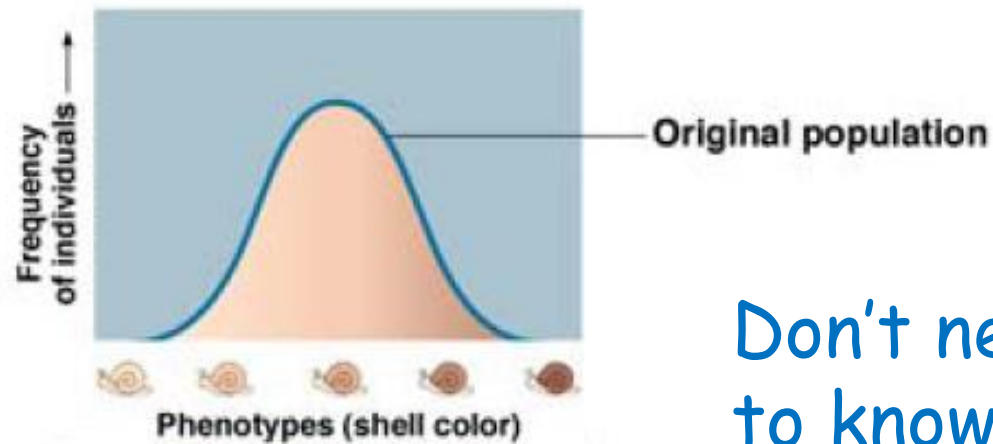
Mean moves to the right



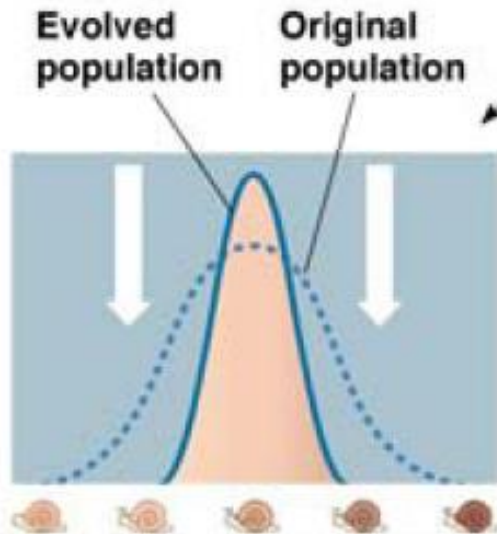
One extremes selected for



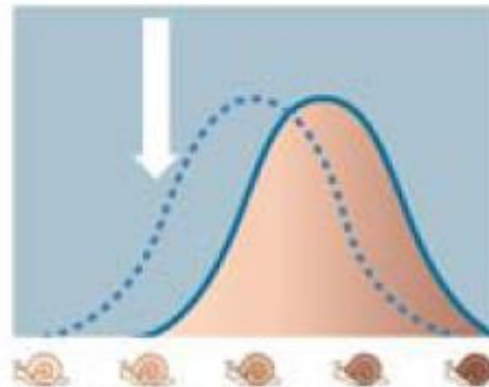
Summary:



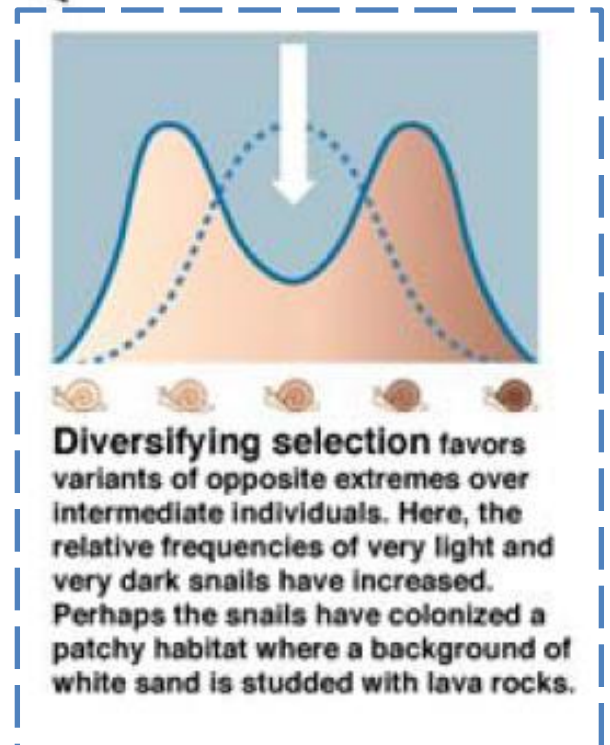
Don't need to know



Stabilizing selection culls extreme variants from the population, in this case eliminating individuals that are unusually light or dark. The trend is toward reduced phenotypic variation and maintenance of the status quo.



Directional selection shifts the overall makeup of the population by favoring variants of one extreme. In this case, the trend is toward darker color, perhaps because the landscape has been blackened by lava.

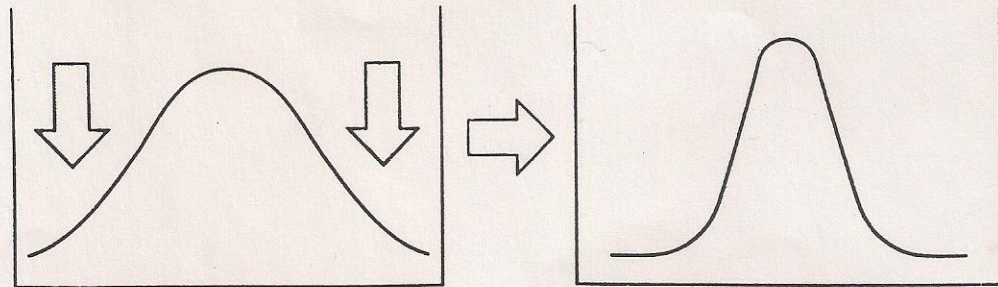


Diversifying selection favors variants of opposite extremes over intermediate individuals. Here, the relative frequencies of very light and very dark snails have increased. Perhaps the snails have colonized a patchy habitat where a background of white sand is studded with lava rocks.

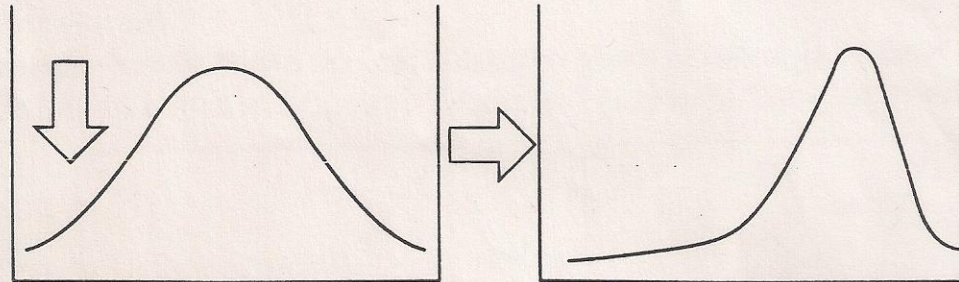
Stabilizing selection favours intermediate phenotypic classes and operates against extreme forms – there is thus a **decrease** in the frequency of alleles representing the extreme forms.

Stabilizing selection operates when the phenotype corresponds with optimal environmental conditions, and competition is not severe.

It is probable that this form of selection has favoured heterozygotes for **sickle cell anaemia** in an environment in which **malaria** is common, and also works against **extremes of birth weight** in humans.



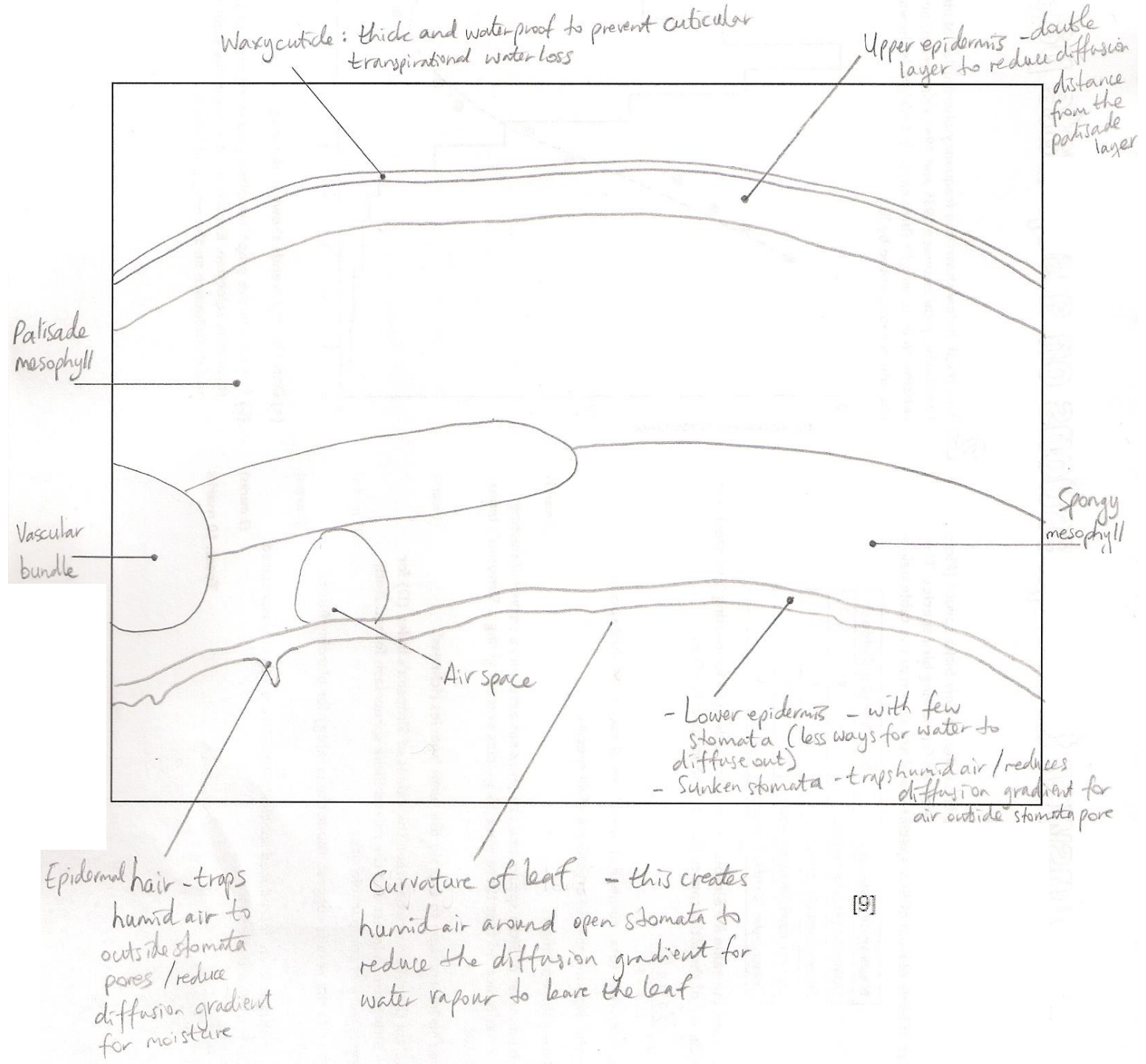
Directional selection favours one phenotype at one extreme of the range of variation. It moves the phenotype towards a new optimum environment; then stabilizing selection takes over. There is a change in the allele frequencies corresponding to the new phenotype.



Directional selection has occurred in the case of the peppered moth, *Biston betularia*, where the dark form was favoured in the sooty suburban environments of Britain during the industrial revolution: **industrial melanism**. Another significant example is the development of **antibiotic resistance** in populations of bacteria – mutant genes confer an advantage in the presence of an antibiotic.

Complete the selection question...





- 3 Drawing skills:
- block diagram showing tissue layers;
 - all tissue layers drawn (completeness of drawing to show the tissues obvious in the photograph);
 - accurate representation of the photograph, i.e. a drawing rather than a diagram;
 - accurate positioning and proportionality of the tissue layers;
 - quality of drawing (e.g. clear – smooth and continuous – lines drawn, not sketchy);

[5]

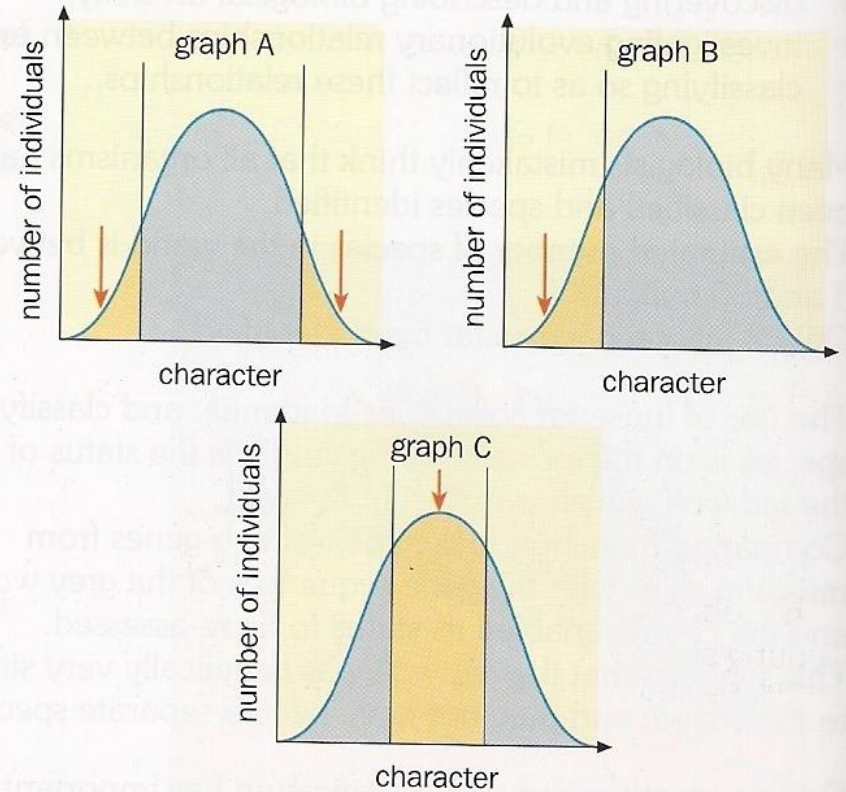
Annotations:

Any two from

1. Thick (waxy) cuticle on upper epidermis;
(increases) the waterproofing of the epidermis/reduces cuticular transpiration;
2. Double epidermal layer;
reduces loss of water from the palisade layer/increases diffusion distance;
3. Epidermal hairs on lower epidermis;
reduces movement of air/maintain humid air immediately outside stomata pores/reduce diffusion gradient for moisture;
4. Few stomata;
fewer ways in which water diffuses out;
5. Sunken stomata;
reduces movement of air/maintain humid air immediately outside stomata pores/reduce diffusion gradient for moisture;
6. Leaf curvature;
reduces movement of air/maintain humid air immediately outside stomata pores/reduce diffusion gradient for moisture;

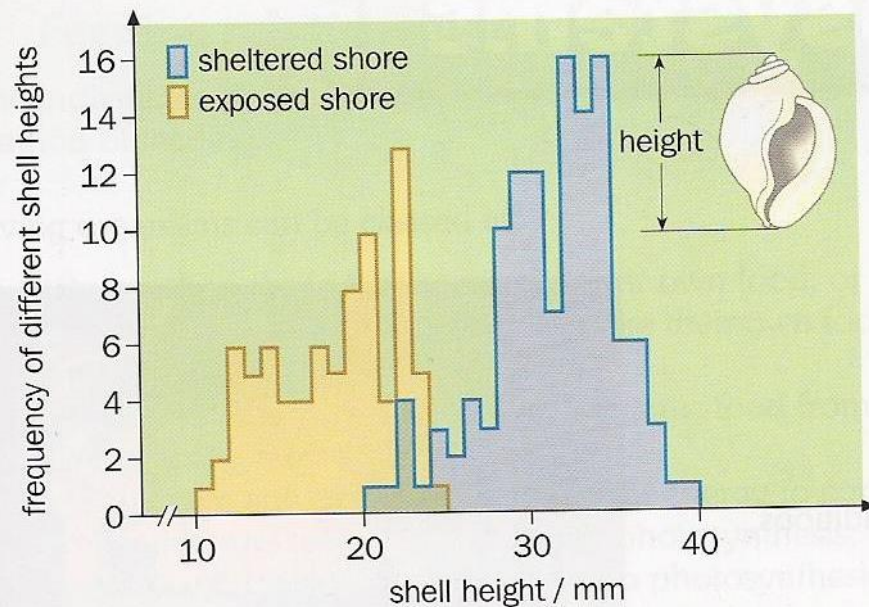
[4]

- 3 The graphs show three different types of selection. The shaded areas marked with arrows show the individuals in the population which are being selected against.



- What name is given to the type of selection shown in graph A?
- Describe one specific example of the type of selection shown in graph B. Be sure to name the organism and describe the character selected.
- What will happen to the modal class in subsequent generations as a result of the type of selection shown in:
 - graph B,
 - graph C?

- 4 The dog-whelk lives on rocky shores around Britain. The graphs show the variation in shell height in two different populations, one from a rocky shore exposed to strong wave action and the other from a sheltered rocky shore. Shell height was measured as shown in the diagram.



- What type of variation is shown in the graphs?
- Describe two differences shown in the graphs between dog-whelks from the exposed shore and dog-whelks from the sheltered shore.
- In a follow-up investigation, it was found that dog-whelks on the sheltered shore had much thicker shells than those on the exposed shore. On the sheltered shore, there were more crabs, which are predators of dog-whelks. Describe how natural selection could account for this difference in shell thickness.