



Cambridge Assessment
International Education

A2 LEVEL

Chapter 18

Biodiversity, Classification & Conservation

Chapter Outline

3 Parts!

1. Classification
2. Biodiversity
3. Conservation



Chapter Outline

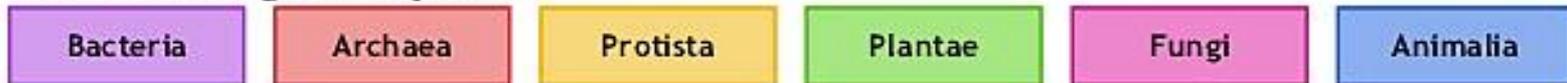
Part I: Classification

- Taxonomic hierarchy (DKPCOFGS)
- 3 Domains = Archaea vs Bacteria vs Eukarya
- 4 Kingdoms of Eukarya = Protocista, Fungi, Plantae, Animalia
- Viruses

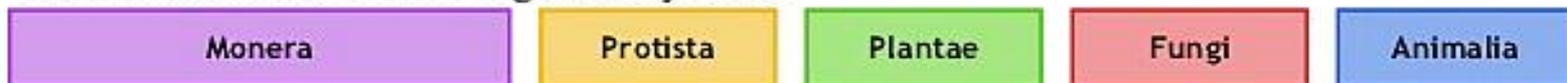
The three-domain system



The six-kingdom system



The traditional five-kingdom system



Chapter Outline

Part II: Biodiversity

- Define species, ecosystem and niche
 - Biodiversity – 3 Levels:
 - variation in ecosystems or habitats
 - the number of species and their relative abundance
 - genetic variation within each species
1. How to **calculate the biodiversity** of a habitat?
 - **P5:** Simpson's Index of Diversity (D)
 2. How to assess the **distribution and abundance of organisms** in a local area?
 - **P5:** Random sampling using frame quadrats
 - **P5:** Systematic sampling using line transects / belt transects
 - **P5:** Mark-release-recapture
 3. How to see the **effect of abiotic and biotic factors**....on the distribution and abundance of species?
 - **P5:** Spearman's rank correlation
 - **P5:** Pearson's linear correlation

Chapter Outline

Part III: Conservation

- The need to maintain biodiversity

1. The role of **NGOs** in conservation

- IUCN
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

2. What are the **threats** to biodiversity of aquatic and terrestrial ecosystems?

3. How to **protect** endangered species?

- Zoos and Captive Breeding
- Assisted Reproduction (IVF, Embryo transfer, Surrogacy)
- Botanic gardens
- Conserved areas (national parks and marine parks)
- Frozen zoos
- Seed banks
- Control alien species

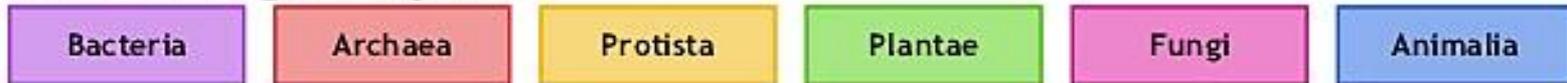


Part I: Classification

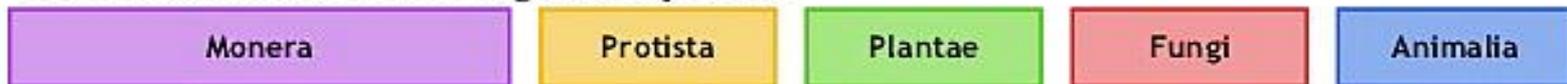
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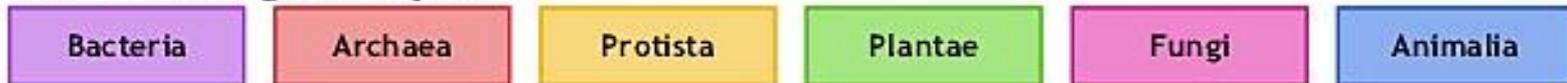
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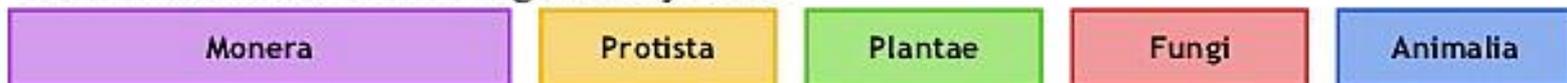
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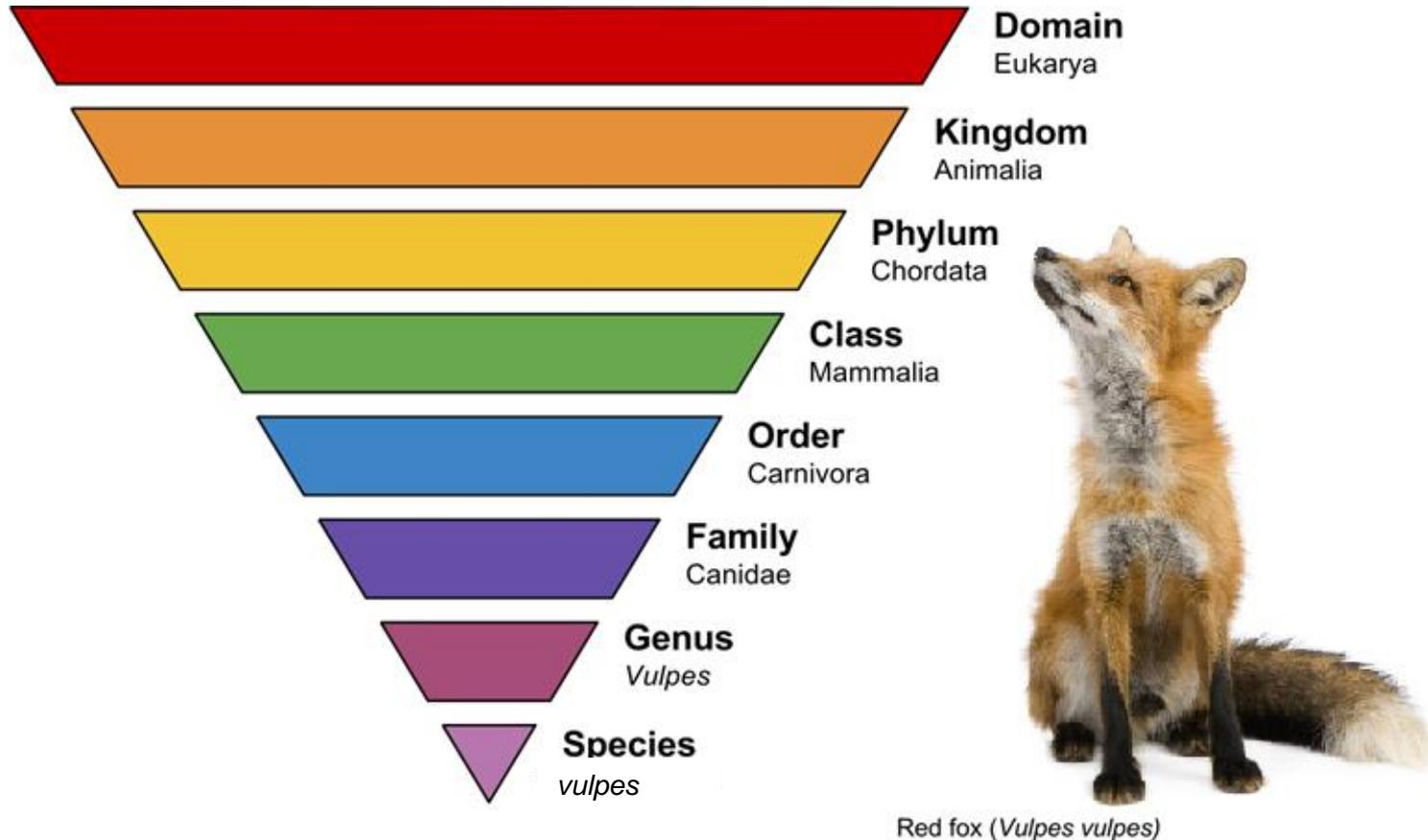


The traditional five-kingdom system



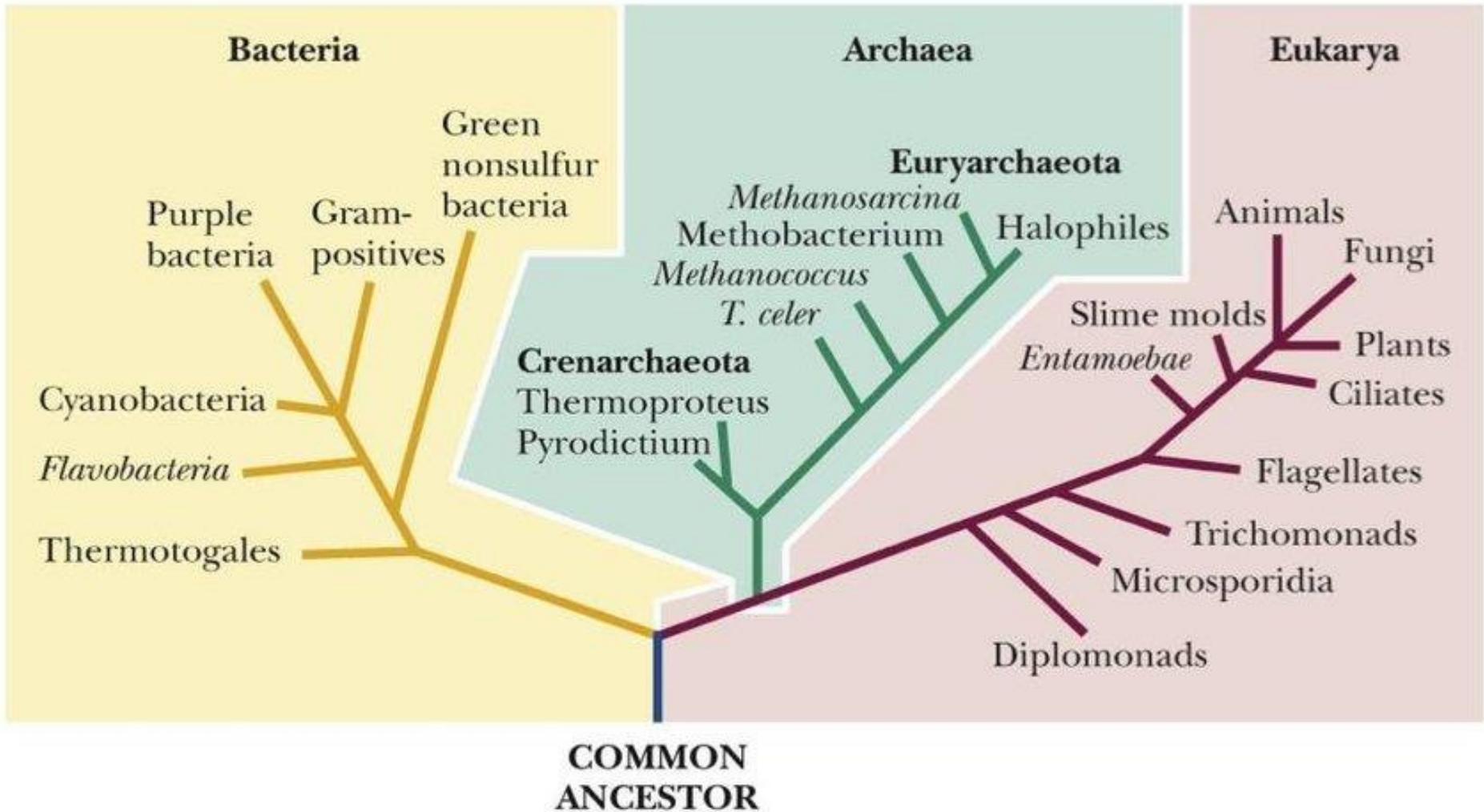
The Taxonomic Hierarchy (DKPCOFGS)

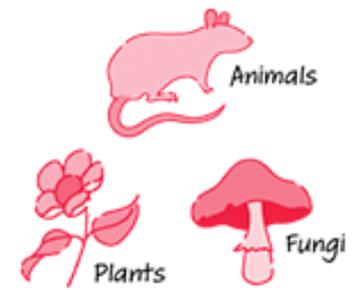
- Each rank/group is called a taxon



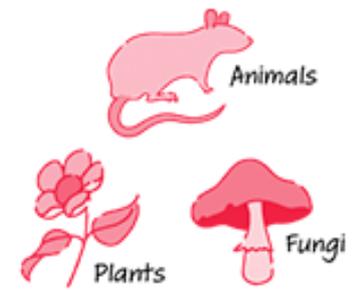
Dumb Kids Prefer Cheese Over Fried Green Spinach

3 Domains

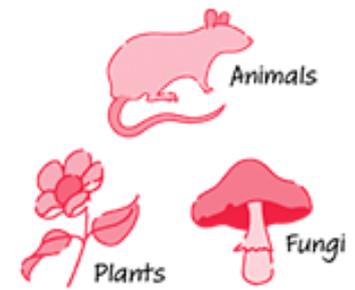




Feature	Bacteria	Archaea	Eukarya
Cell type	Prokaryotic	Prokaryotic	Eukaryotic
Size	0.5-5um	0.5-5um (similar to bacteria)	10-100um
DNA	<ul style="list-style-type: none"> • Circular • Not associated with histones • Plasmids may be present 	<ul style="list-style-type: none"> • Circular • Some associated with histones • Plasmids may be present 	<ul style="list-style-type: none"> • Linear • Associated with histones • But DNA in chloroplast and mitochondria is circular • Plasmid absent
Nucleus	<ul style="list-style-type: none"> • Absent • DNA is at nucleoid region / lies free in cytoplasm 	<ul style="list-style-type: none"> • Absent 	<ul style="list-style-type: none"> • Present



Feature	Bacteria	Archaea	Eukarya
Organelles	No membrane-bound organelles	No membrane-bound organelles	Has membrane-bound organelles Refer AS Chap 1
Ribosomes	70S	70S (same size as bacteria but rRNA sequence is closer to eukaryotes than bacteria)	80S (but chloroplasts and mitochondria have 70S)
Cell wall	Made of peptidoglycan	Present, but does not contain peptidoglycans	<ul style="list-style-type: none"> • Kingdom plantae = cellulose • Kingdom fungi = chitin

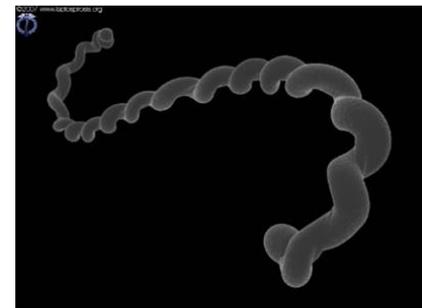
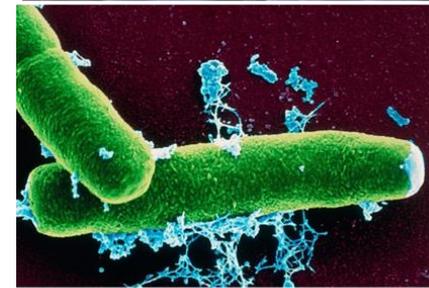


Feature	Bacteria	Archaea	Eukarya
Method of cell division	Binary fission	Binary fission	Mitosis, reproduction can be asexual and sexual
Cell organisation	<ul style="list-style-type: none"> • Unicellular • Spherical / rod / spiral / comma shape • May form pairs / tetrads / strings / filaments / clusters / palisades 	<ul style="list-style-type: none"> • Unicellular 	<ul style="list-style-type: none"> • Unicellular or multicellular • Colonial
AVP	May have flagella, pili, capsule, slime layer etc.	<p>Some are extremophiles</p> <p>Cell membrane composition different from bacteria / eukarya</p>	Refer AS Chap 1

Bacteria

- **Vary greatly in shape**
- Bacteria is classified using shapes

Shape	Name	Example
Spherical	Coccus (plural: cocci)	<i>Streptococcus pneumoniae</i> (causes pneumonia)
Rod-shaped	Bacillus (plural: bacilli)	<i>Bacillus anthracis</i> (causes anthrax in sheep and cattle)
Spiral	Spirillum (plural: spirilli/spirilla)	<i>Leptospira</i> (causes leptospirosis)
Comma-shaped	Vibrio	<i>Vibrio cholerae</i> (causes cholera)



Bacteria

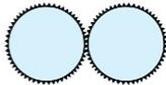
- Bacteria may form pairs / tetrads / strings / filaments / clusters / palisades
- Still unicellular but are arranged together in different ways

Arrangements of Cocci

coccus

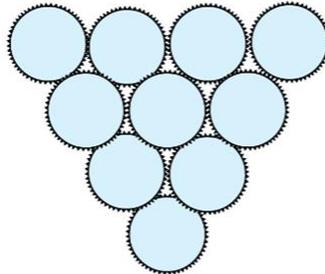


diplococci



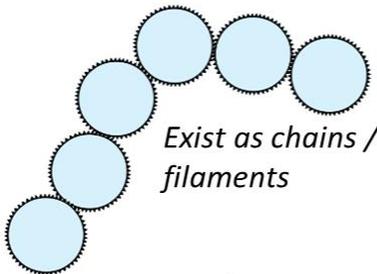
Spherical bacteria that occur in pairs

Staphylococci



Occur in clusters

Exist as chains / filaments



streptococci

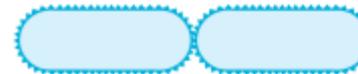
Arrangements of Bacilli



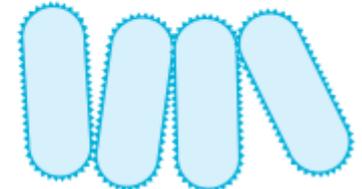
coccobacillus.



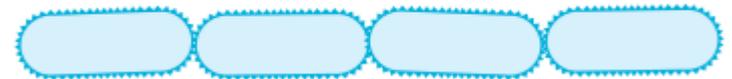
bacilli



diplobacilli



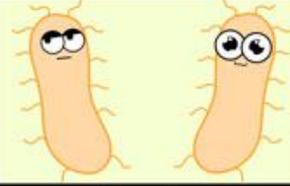
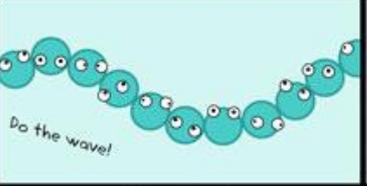
palisades.



Streptobacilli

The 4 Kingdoms of Eukarya

1. Protoctista
2. Fungi
3. Plantae
4. Animalia

Archaea Prokaryote 	Eubacteria Prokaryote 	Protista Eukaryote 
Fungi Eukaryote 	Plantae Eukaryote 	Animalia Eukaryote 

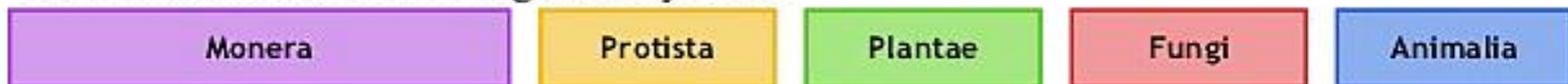
The three-domain system

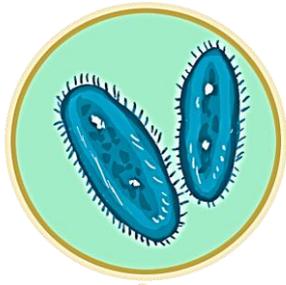


The six-kingdom system



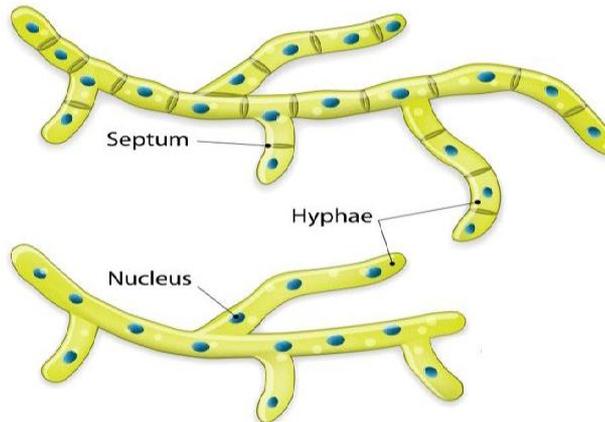
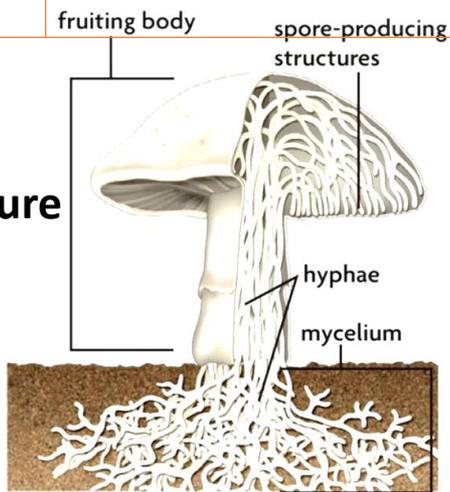
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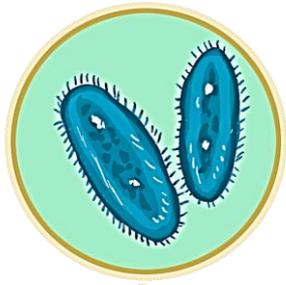


Feature	Protocista	Fungi	Plantae	Animalia
Examples	<i>Plasmodium falciparum</i> , algae, amoeba, <i>Paramecium</i>	Yeasts, mushrooms, <i>Penicillium</i>	Ferns, mosses, flowering plants, conifers	Vertebrates, insects, corals!, worms, jelly fish
Cell organisation	Unicellular, some colonial	Mostly multicellular, some unicellular	Multicellular, with differentiated cells	Multicellular, with many types of differentiated cells
Hetero/ autotrophic	Some hetero (animal-like = protozoa) Some autotrophic (plant-like = algae, have chloroplast)	Heterotrophic (saprophytes / parasites)	Autotrophic, can carry out photosynthesis	Heterotrophic

Feature	Protoctista	Fungi	Plantae	Animalia
Cell wall	Cellulose cell wall present in some	Made of chitin	Made of cellulose	Absent
Vacuole	Present in some	-	Large, central, permanent vacuole	Small, temporary
Special organelles/ structures	-	<p>Mycelium composed of thread-like hyphae</p> <p>May or may not have cross walls</p> <p>Reproduce by spores</p>	<p>Have chloroplasts</p> <p>Have vascular tissue e.g. xylem and phloem</p> <p>Have meristems</p>	<p>Cells differentiated to form tissues and organs</p> <p>Have nervous coordination and can respond to stimuli quickly</p>



Fungi structure



Feature

Protocista

Fungi

Plantae

Animalia

Motility

Some have flagella/cilia and are motile

Not motile, never have cilia/flagella

Not motile, only mosses and ferns have motile gametes

Motile, cell sometimes have cilia or flagella

Storage of carbohydrates

-

Glycogen

Starch

Glycogen

Viruses

Chap 1 Recap

- **Non-cellular** structure
- ~50 times smaller than bacteria (20-300nm)
- Much simpler
- No plasma membrane, cytoplasm, ribosomes

• Only:

1. **DNA or RNA**

2. Protein coat = **capsid**

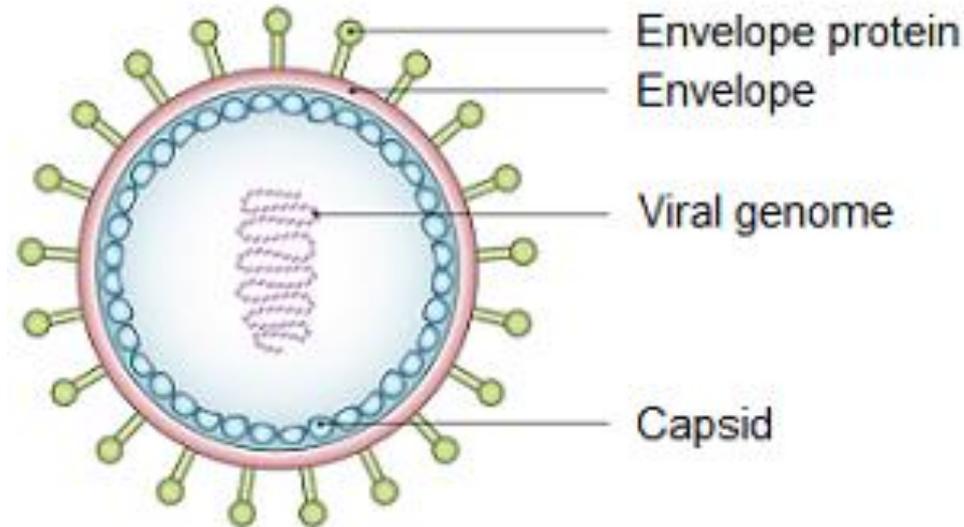
- Protective coat

- May have one or two coats

3. Many viruses also have a **lipid envelope**

4. Some proteins may be present

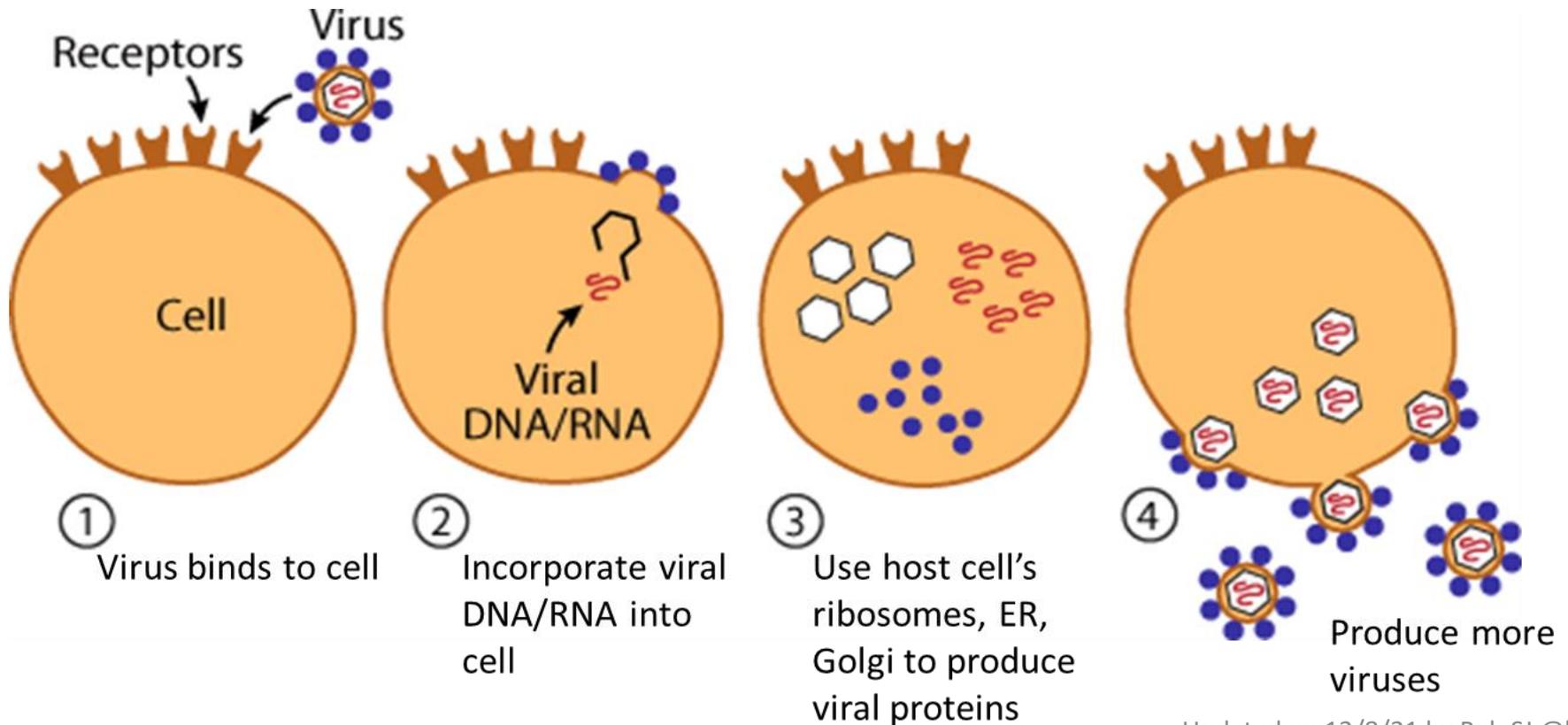
- e.g. haemagglutinin, neuraminidase



Viruses

Chap 1 Recap

- All **parasitic**
- Can only reproduce by **infecting** living cells
- **Uses protein synthesising machinery** of host cell to replicate

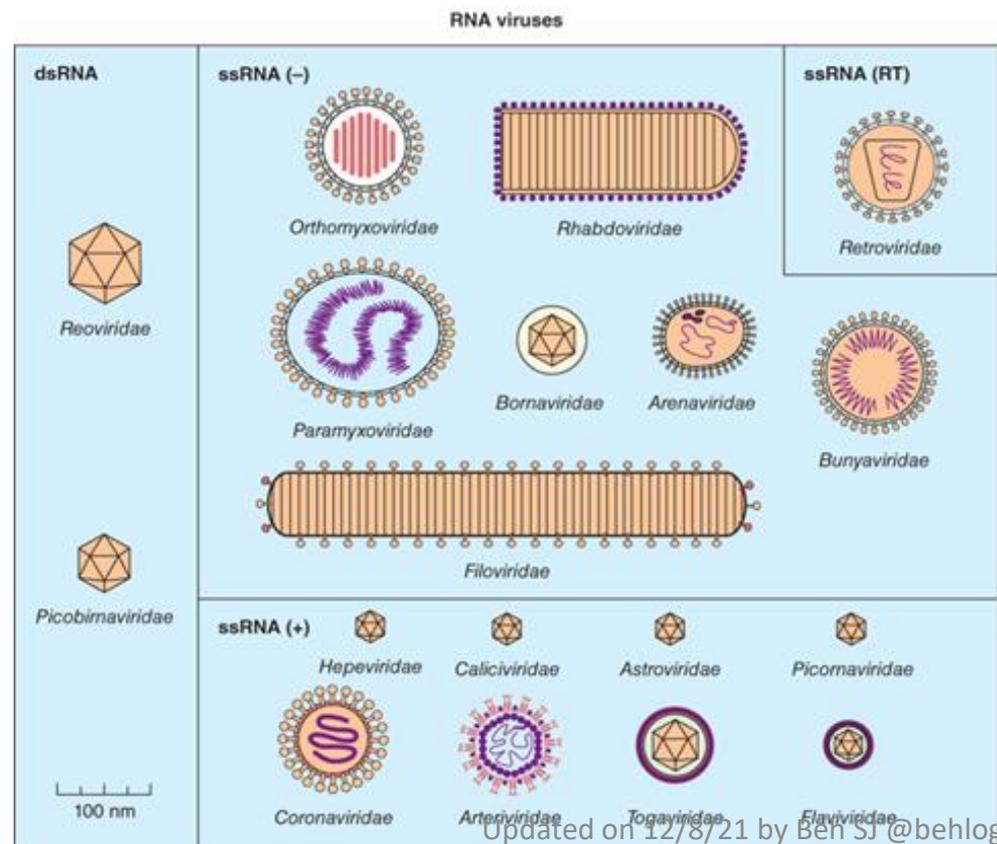
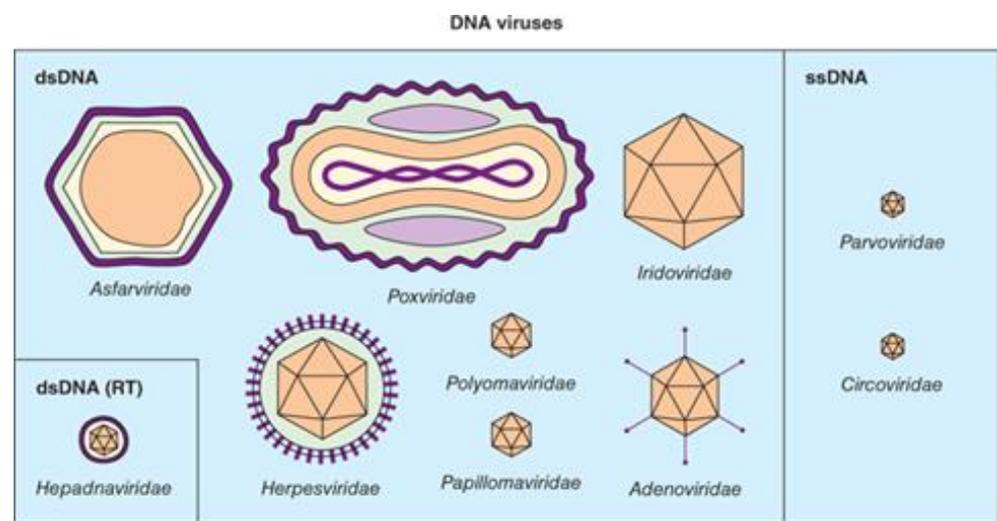


Viruses

Can be classified by:

- Type of nucleic acid they contain (DNA or RNA)
- Single-stranded or double-stranded
- Appearance

...and more



Chapter Outline

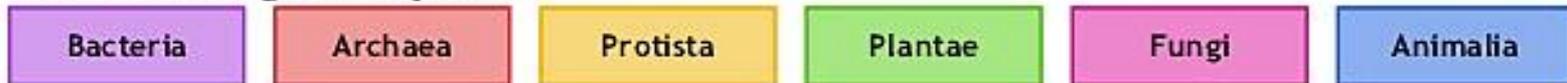
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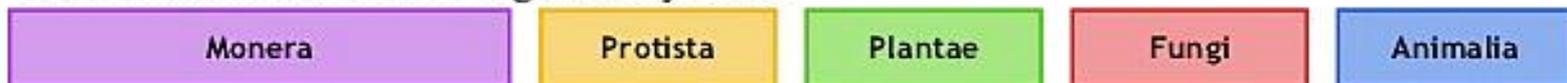
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UNIVERSITY of CAMBRIDGE
International Examinations

Excellence in education

A2 LEVEL

Chapter 18

Part II: Biodiversity

Chapter Outline

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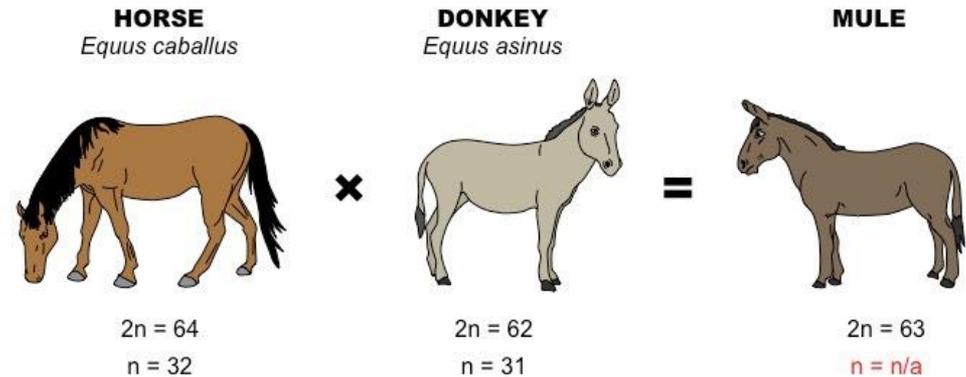
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 3. How to see the **effect of abiotic and biotic factors....**on the distribution and abundance of species?
 - **P5:** Spearman's rank correlation
 - **P5:** Pearson's linear correlation

Species

Chap 17 Recap

Species: Group of similar organisms with the **same**

- morphological,
- physiological,
- behavioural,
- biochemical features,



- which can **interbreed** to produce **fertile offspring**
- i.e. **NOT reproductively isolated** from each other

- Members of one species are **reproductively isolated** from another species

Species



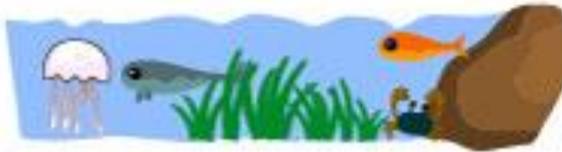
Population



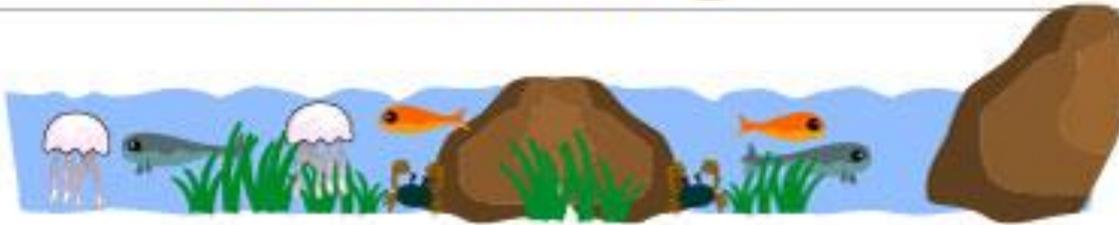
Community



Ecosystem



Biome

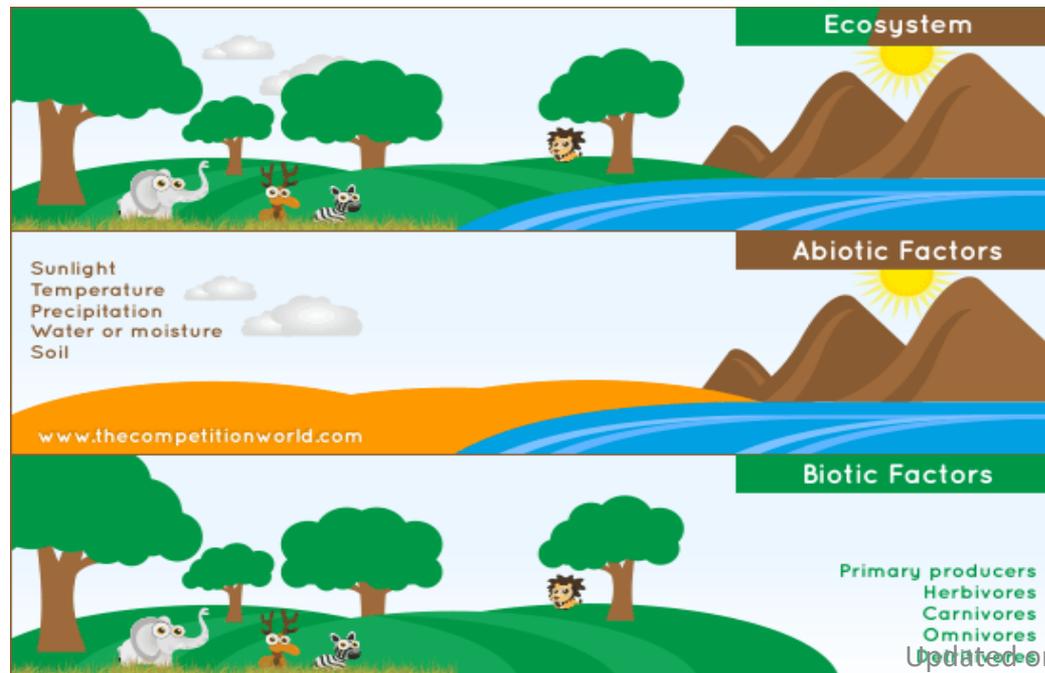


Biosphere



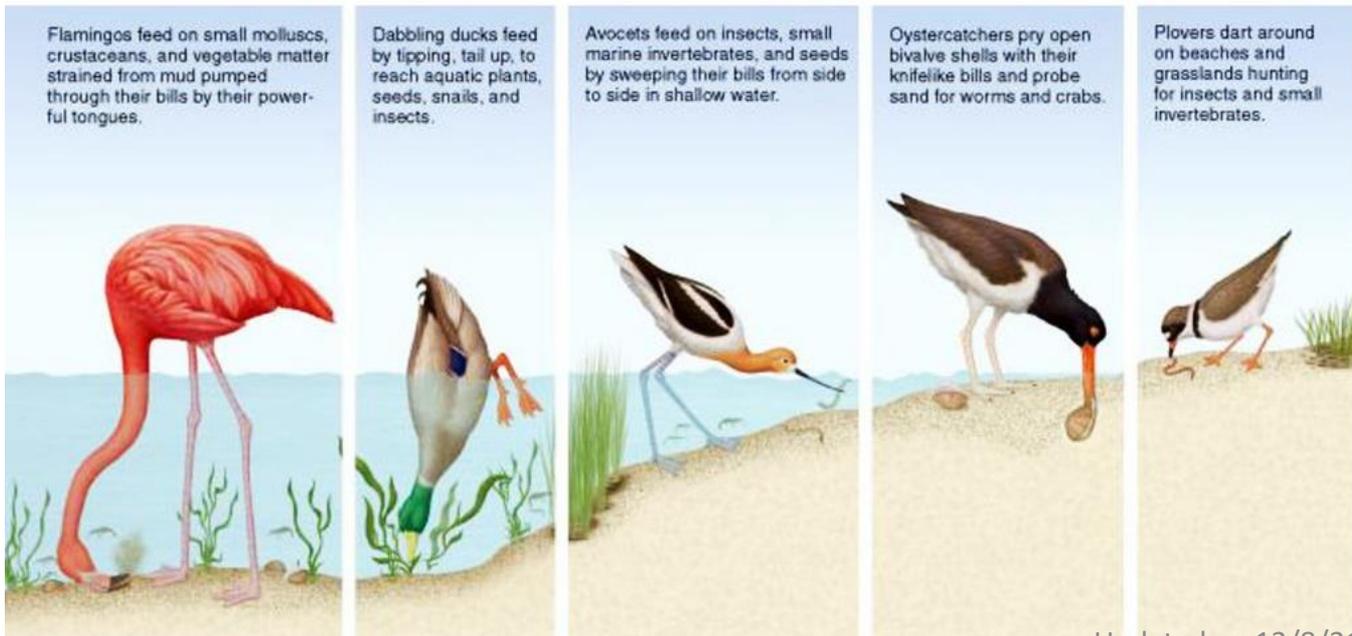
Ecosystem

- It is a **self-sustaining** unit
- It is a **self-contained** / defined area
- It is a **community of organisms** (i.e. includes all populations of diff species)
- Many interactions occur between **biotic and abiotic factors**
- All is linked by **food webs, energy flow** in system, nutrient cycling
- There is interdependence between organism and environment



Niche

- **Role of organism** or how it fits in **in an ecosystem**
- Including:
 - **where it lives**
 - **how it obtains its energy**
- Members of the same species occupy same niche
- Diff species alter their use of the niche to avoid competition by dividing resources (resource partitioning)



Biodiversity

3 levels of biodiversity to consider:

1. Variation in **ecosystems** or habitats
2. The number of diff **species** and their relative abundance
3. **Genetic variation** within each species



1 Genetic diversity

2 Species diversity

3 Ecological diversity

1) How to calculate the biodiversity of a habitat?

Use **Simpson's Index of Diversity, D**

You must remember this formula!

$$D = 1 - \left(\sum \left(\frac{n}{N} \right)^2 \right)$$

where

n = number of individuals of each species present in the sample

N = the total number of all individuals of all species

The higher the index is (nearer to 1), the higher the diversity

Example #1

E.g. A study was carried out to investigate the biodiversity of two fields, **A** and **B**. Field **A** had **not** been used for growing crops for 10 years. Field **B** had been used for growing crops until one year before the study. Random sampling was carried out for small flowering plants.

- i. The table shows the results of the sampling of field **A**. Calculate Simpson's Index of Diversity (D) for field A.

species	number of individuals (n)
<i>Scabiosa columbaria</i>	13
<i>Centaurea centaurium</i>	15
<i>Primula veris</i>	26
<i>Trifolium pratense</i>	36
<i>Leucanthemum vulgare</i>	11
<i>Silybum marianum</i>	5
<i>Anacamptis morio</i>	8
total number of individuals (N)	114

$$D = 1 - \left(\sum \left(\frac{n}{N} \right)^2 \right) \quad D = 0.802$$



Example #1

ii. The value of D for field B was 0.45.

Describe what both the figures for Simpson's Index of Diversity show about the effect of growing crops on small flowering plants.

D for Field A = 0.802

D for Field B = 0.45

- Field A has a higher value of D than field B.
- D for field A is closer to one.
- Field A has a higher diversity in species of small flowering plants.
- Growing crops lowers the biodiversity of small flowering plants.

Example #2



E.g. Soil from under bracken and under brambles was collected and placed in two funnels. A bright light was placed over each funnel so that small invertebrate animals moved down the funnels and were collected in two collecting vessels.

The main groups of invertebrates present were identified and counted.

invertebrate group	number present in soil under bracken	number present in soil under brambles
pseudoscorpion	49	21
wireworm	22	12
gamasid mite	18	7
springtail	10	1
total	99	41



i. State the null hypothesis for a statistical test comparing the data from the two types of site.

Example #2

ii. Simpson's Index of Diversity for invertebrates from the soil under bracken was calculated as 0.663 using the formula:

$$D = 1 - \left(\sum \left(\frac{n}{N} \right)^2 \right)$$

Calculate Simpson's Index of Diversity for the invertebrates from the soil under brambles. Complete the table and use the space provided to show your working. Show all working to three decimal places.

invertebrate group	number present in soil under brambles	$\frac{n}{N}$	$\left(\frac{n}{N}\right)^2$
pseudoscorpion	21		
wireworm	12		
gamasid mite	7		
springtail	1		
total	41	--	

Example #2

- iii. Describe what the results table and the calculated figures for Simpson's Index of Diversity show about the effect of bracken and bramble vegetation cover on the diversity and abundance of soil invertebrates in the woodland.
- Soil organisms more abundant under bracken
 - Bracken and bramble have similar Simpson's Index of Diversity (D) numbers
 - Bracken and bramble vegetation cover has little effect on soil organism diversity

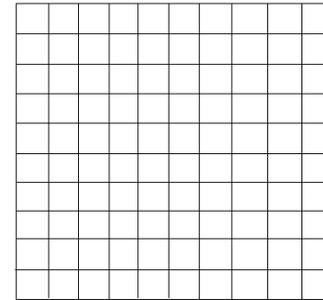


2) How to assess the distribution and abundance of organisms in a local area?

Method 1: Random Sampling using Frame Quadrats

For plants or small, slow moving animals

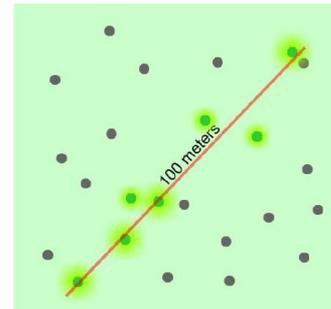
1 m² quadrat, scale 1 cm = 10 cm



Method 2: Systematic Sampling along Line Transects / Belt Transects

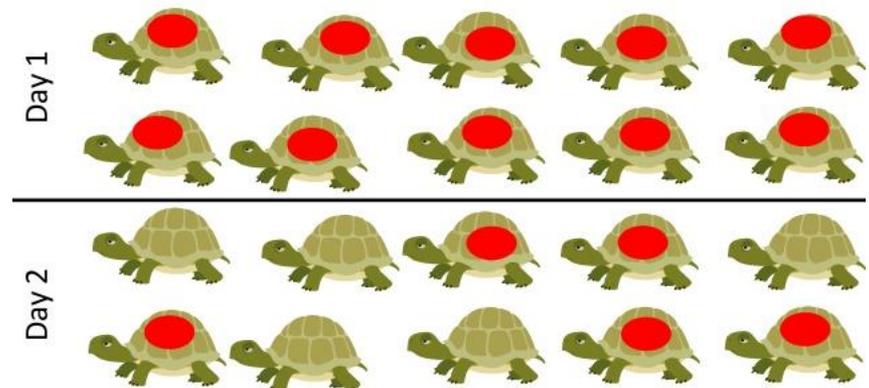
For plants or small, slow moving animals

Find distribution across an area



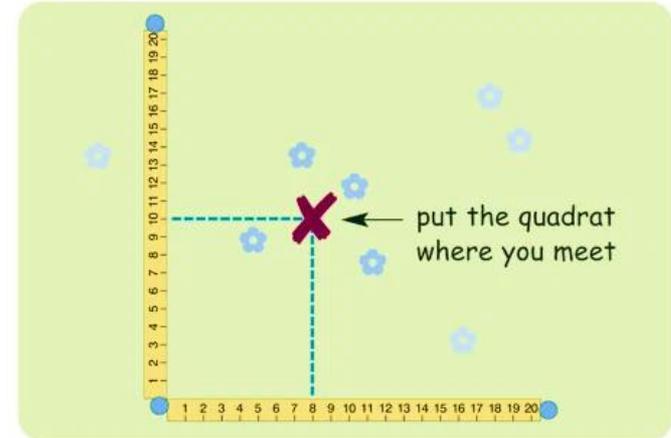
Method 3: Mark-Release-Recapture

For small, mobile animals



Method 1: Random Sampling Using Frame Quadrats

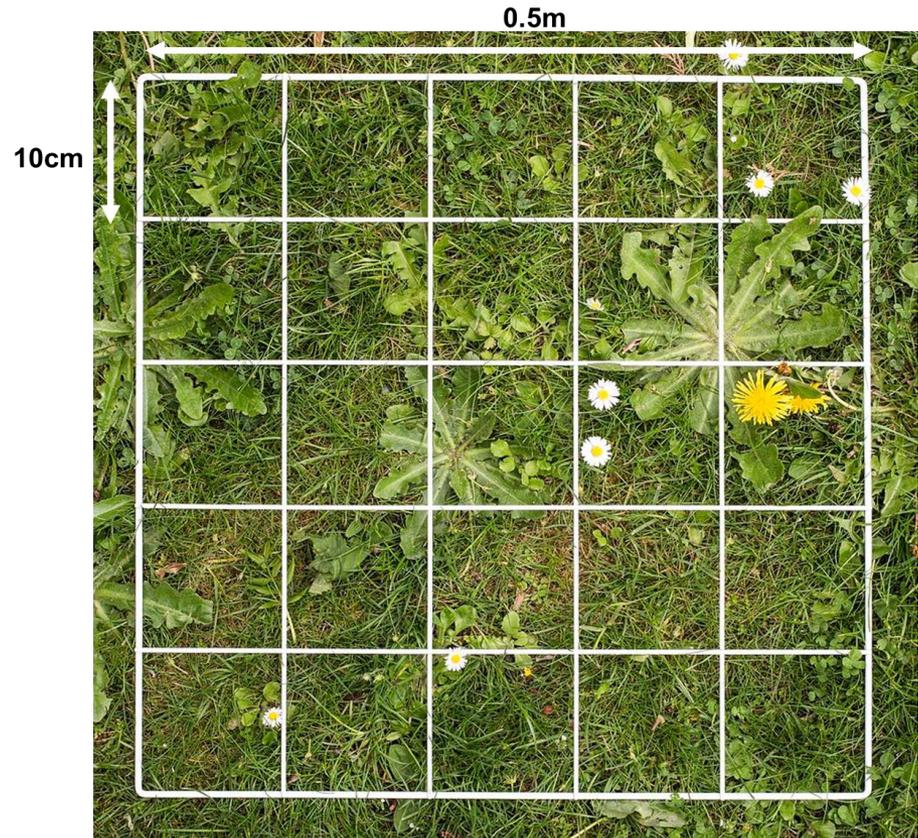
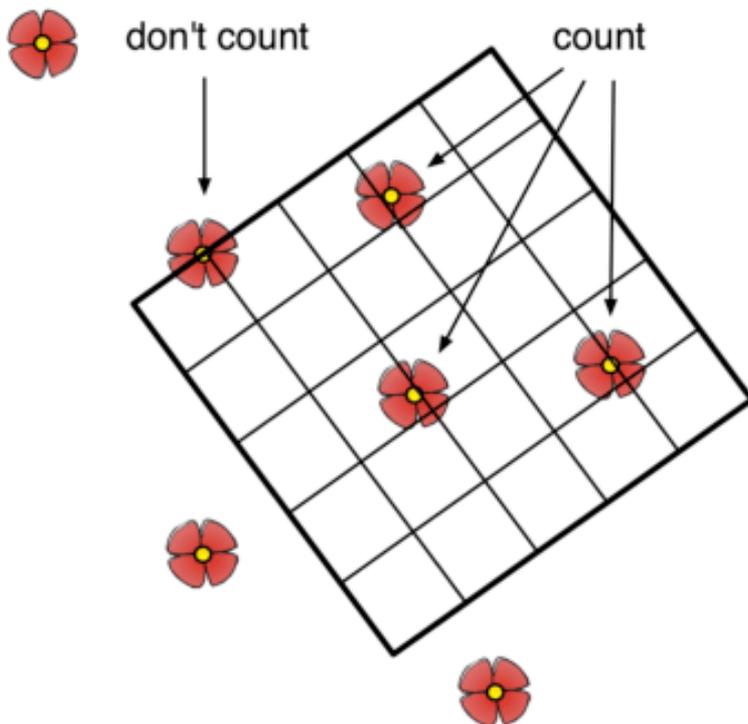
1. Mark out area to be sampled using string and marker pole
2. Use **random number generator** to obtain coordinates
3. Place **quadrat** on ground at random coordinates
 - Use same quadrat size of **1m²**
 - Small squares are 10x10cm usually
4. Identify species within quadrat using key / nature guide



Method 1: Random Sampling Using Frame Quadrats

5. Estimate species abundance – 3 ways

1) **Counting no. of individuals** / unit area
= species density



Method 1: Random Sampling Using Frame Quadrats

When it's difficult to isolate individuals / small species / plants...

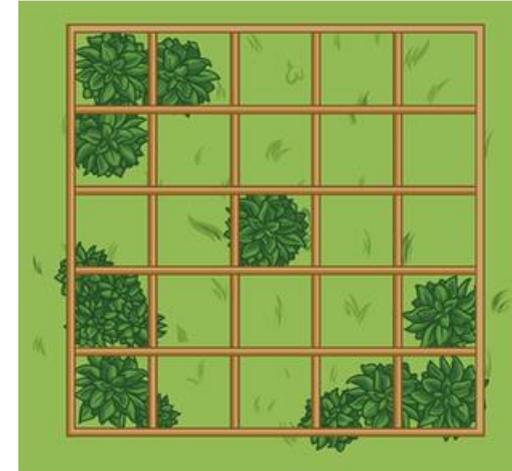
2) Estimating **percentage cover**

E.g. $100\% / 25\text{squares} = 4\%$

9 squares = $4\% \times 9 = 36\%$

3) Using a named **abundance scale**

E.g. ACFOR scale, Braun-Blanquet cover-abundance scale



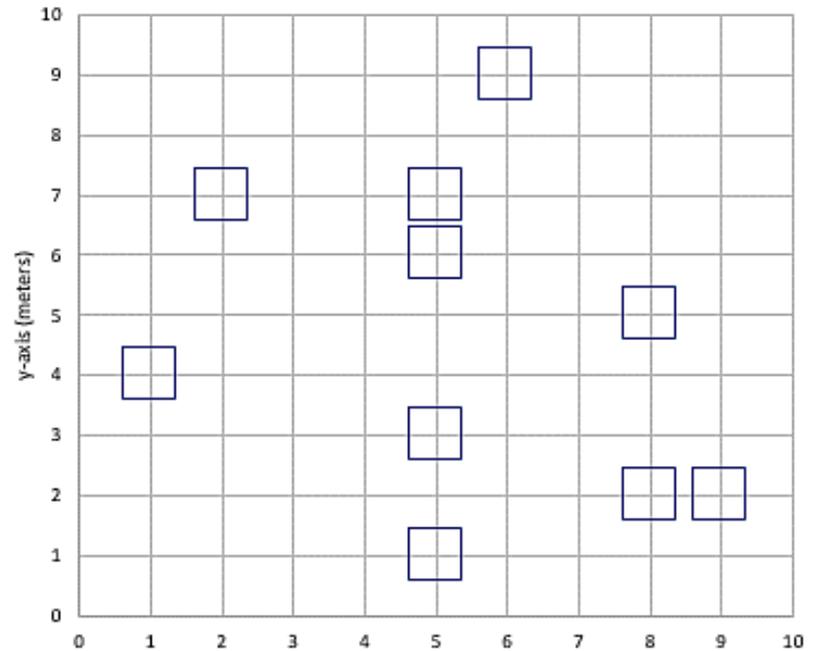
Abundant	80-100%
Common	60-80%
Frequent	40-60%
Occasional	20-40%
Rare	0-20%

Braun-Blanquet Score	Range of Cover (%)
5	75–100
4	50–75
3	25–50
2	5–25
1	<5; numerous individuals
+	<5; few individuals

Method 1: Random Sampling Using Frame Quadrats

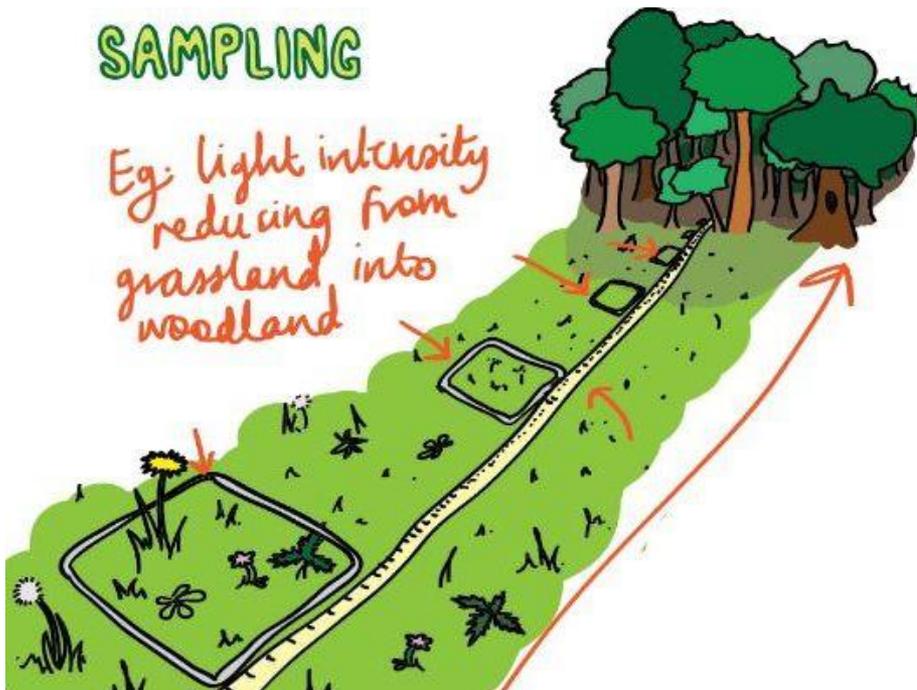
6. **Repeat many times** to ensure reliable results and obtain mean abundance
 - Not just 3 times!
 - Repeat sampling at diff times of year or seasons

7. Safety
 - Allergy to pollen – wear mask
 - Allergy to plants – wear gloves and protective clothing



Method 2: Systematic Sampling along Line Transects / Belt Transects

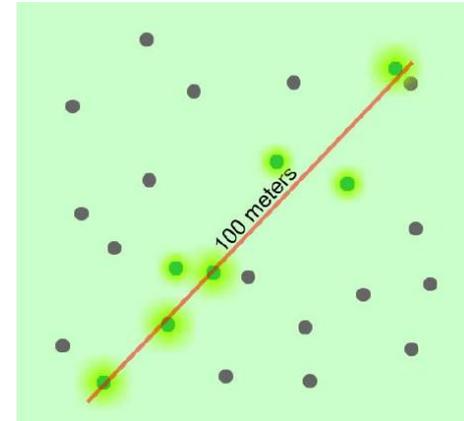
- Useful for non-uniform distribution
- Shows how communities change / distribution of diff species **across an area**
- Sample / measure species abundance at set distances along transect or line



Method 2: Systematic Sampling along Line Transects / Belt Transects

Types of systematic sampling:

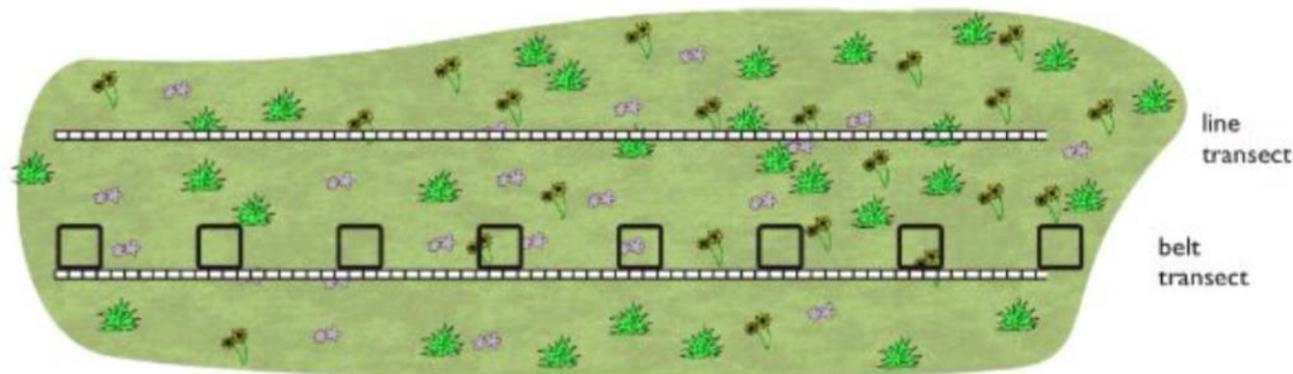
1. **Line transect** = Record what is touching the line / string
2. **Belt transect** = Use quadrats along transect
 - **Continuous belt transect**
= turn each quadrat over, end-to-end
 - **Interrupted belt transect**
= use regular intervals



Method 2: Systematic Sampling along Line Transects / Belt Transects

1. Lay out a **line/tape** running across a certain area
 - Measure using measuring tape (min 10m)
2. **Line Transect**: Count species that touches the line
OR
Continuous Belt Transect: Turn each quadrat over, end-to-end
Interrupted Belt Transect: Place quadrats along line in regular intervals
 - Use same quadrat size of 1m^2

3. Use key / nature guide to identify diff species

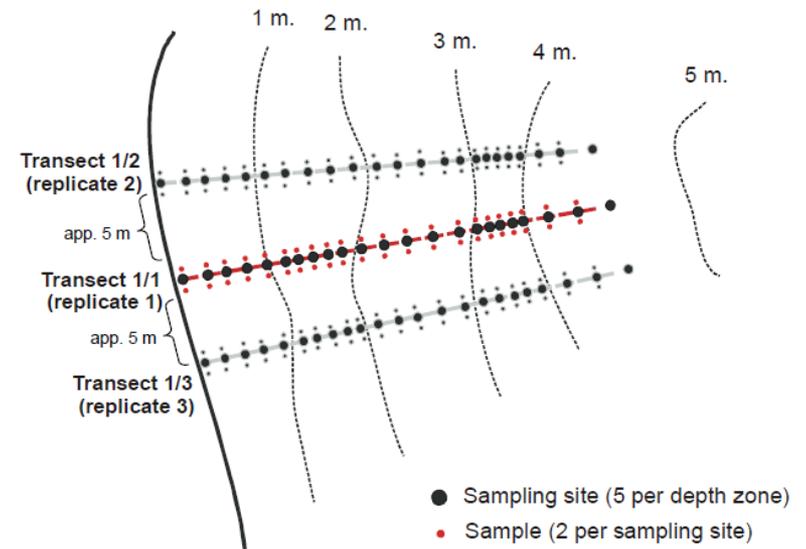


Method 2: Systematic Sampling along Line Transects / Belt Transects

4. Estimate species abundance – 3 ways
 - 1) **Count no. of individuals** / unit area = species density
 - 2) Estimate **percentage cover**
 - 3) Use ACFOR / Braun Blanquet cover-**abundance scale**

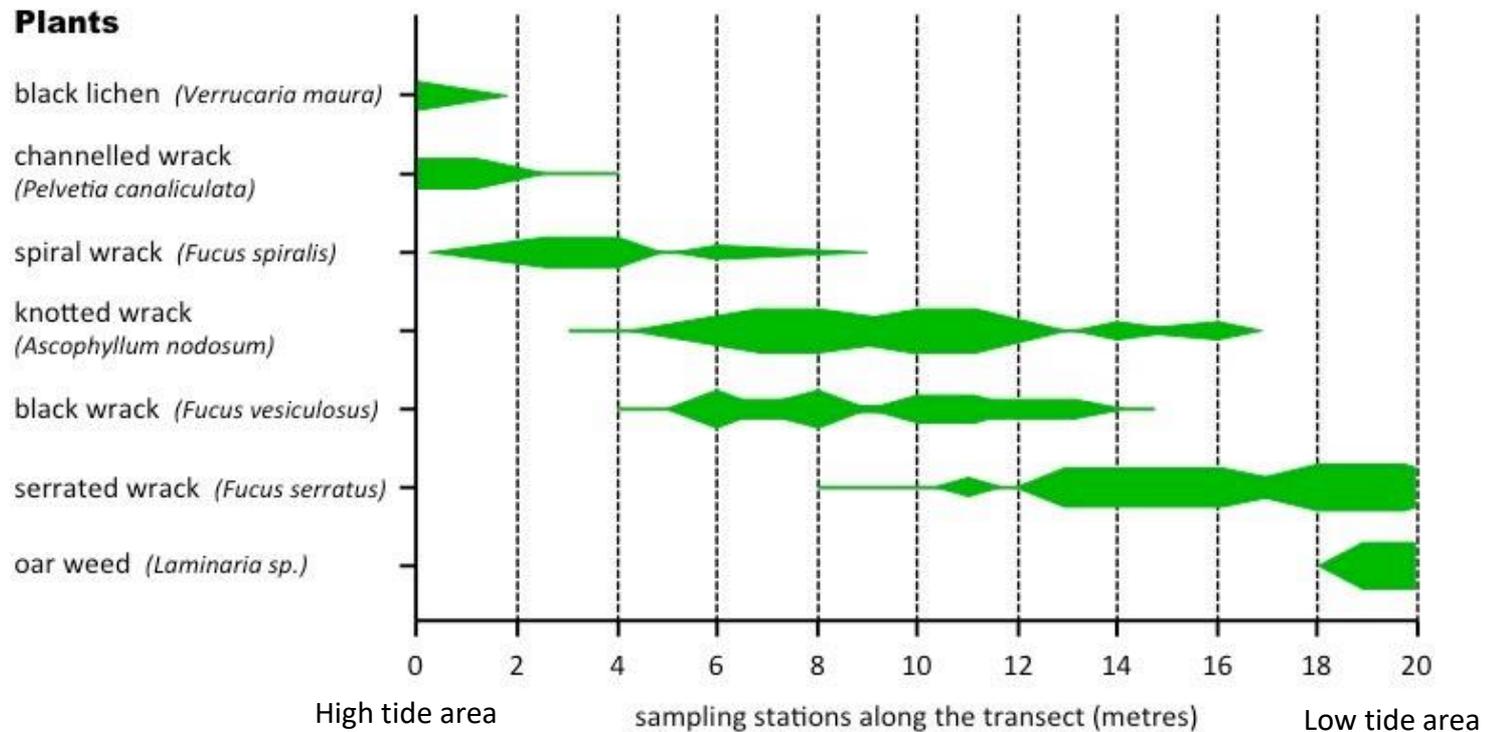
5. **Repeat** sampling
 - Repeat transect at a diff start point
 - At diff times of year and seasons

6. Safety
 - Allergy to pollen – wear mask
 - Allergy to plants – wear gloves and protective clothing



Method 2: Systematic Sampling along Line Transects / Belt Transects

E.g. Distribution of plants along a rocky shore from a high tide area to a low tide area. Represented as a kite diagram.



Key: — rare ■ occasional ■ frequent ■ abundant

Method 3: Mark-Release-Recapture

1. Capture animals using trap with food as bait
2. **Mark** animals
 - E.g. paint, clip fur
 - Ensure it does not have adverse effects / make them more visible to predators
3. **Release** animals to habitat
4. Allow some **time** for random mixing to occur, but not too long after as migration may occur
5. **Recapture** animals a 2nd time

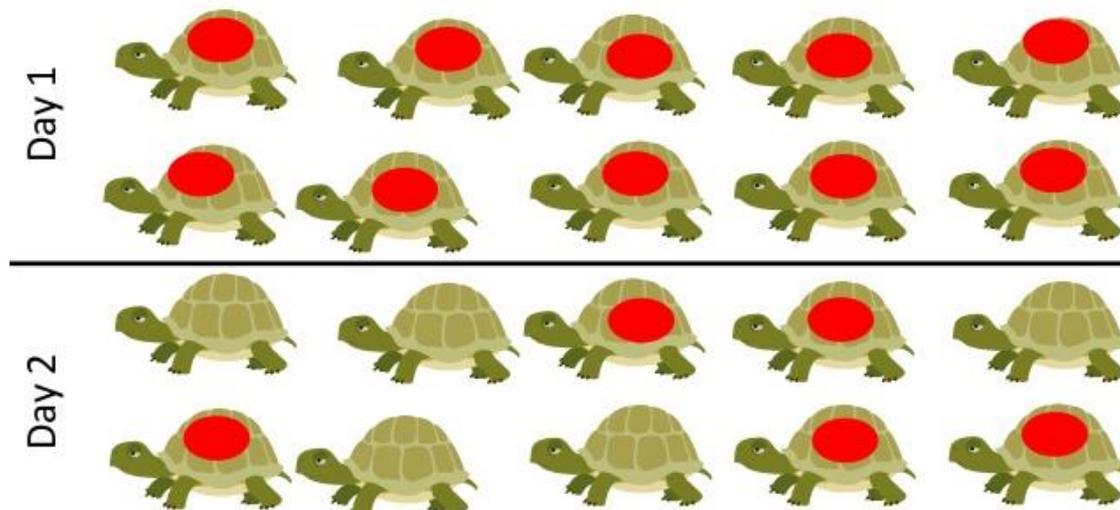


Method 3: Mark-Release-Recapture

6. Calculate no. of marked individuals

7. Use Petersen index / Lincoln index to estimate population size

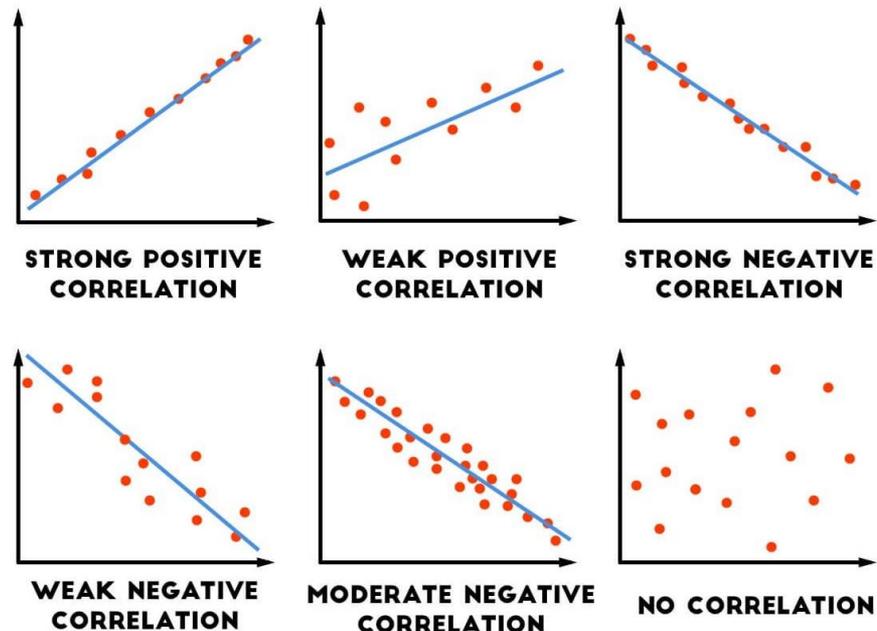
$$\text{Estimated population size} = \frac{\text{no. marked time 1} \times \text{no. capture time 2}}{\text{no. of marked individuals recaptured time 2}}$$



Equation is based on assumption that proportion of marked:unmarked on Day 2 is same as overall population

3) How to see the effect of abiotic and biotic factors.... on the distribution and abundance of species?

1. Plot a **scatter graph** of our data to assess the relationship between 2 **paired** sets of data.
 - E.g. % cover of plant species A and % organic matter in soil (abiotic factor), age vs glucose levels
 - Look whether the scatter graph is linear or skewed



3) How to see the effect of abiotic and biotic factors.... on the distribution and abundance of species?

2. Find correlation coefficient using statistical tests!

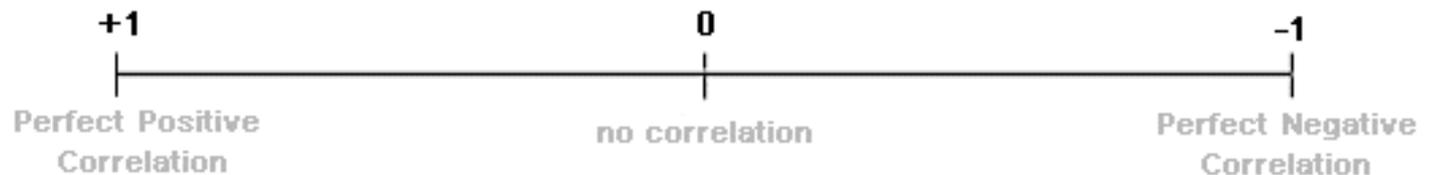
- **Method 1: Pearson's linear correlation**
- **Method 2: Spearman's rank correlation**

Correlation coefficient of...

+1 indicates perfect **positive** correlation

-1 indicates perfect **negative** correlation

0 indicates no correlation / points are scattered at **random**



Note: correlation does not equal causation!!!

P5: Pearson's Linear Correlation

Method 1: Pearson's Linear Correlation

- Test for correlation between 2 **paired** sets of data
- Null hypothesis = There is no significant **relationship/correlation** between..... and

Requirements:

- **Continuous** / interval data
- Both sets of data is **normally distributed**
- Scatter graph indicates a linear / skewed relationship with no obvious outliers
- There are **5 or more pairs** of data
- Pearson's correlation coefficient = r

$$r = \frac{\sum xy - n\bar{x}\bar{y}}{ns_x s_y}$$

where

x and y = readings of each sample

n = the number of readings

\bar{x} and \bar{y} = mean

s = standard deviation

Example #1

E.g. A student wanted to know if the number of galls on a leaf was correlated with the surface area of the leaf.



- i. State the null hypothesis.
- ii. Plot a scatter graph.
- iii. Calculate Pearson's correlation coefficient and determine the strength of the correlation.

$$r = \frac{\sum xy - n\bar{x}\bar{y}}{nS_xS_y}$$

Example #1

$$r = \frac{\sum xy - n\bar{x}\bar{y}}{nS_xS_y}$$

Leaf	Surface Area / cm ²	Number of galls	xy
1	101	180	
2	143	139	
3	53	119	
4	61	98	
5	111	120	
6	92	131	
7	149	151	
8	123	105	
9	47	88	
10	63	107	
11	120	149	
12	62	134	
13	141	156	
14	83	101	
15	76	137	
mean			-
std dev			-
		sum of xy	

Determining significance in Pearson's

1) Calculate **r value** using formula

$$r = \frac{\sum xy - n\bar{x}\bar{y}}{nS_xS_y}$$

2) Calculate total degrees of freedom

→ **v** = number of pairs - 2 = **n - 2**

→ In this case, $v = 15 - 2 = 13$

→ **Either n or df can be shown in table!**
So read table headings carefully!

3) Check critical value at **p = 0.05**

4) Check if **critical value** in r table is lower/higher compared to r value calculated
(Ignore positive or negative sign)

Pearson's correlation coefficient r critical value table

$r = 0.606$

df	$\alpha = .10$	$\alpha = .05$	$\alpha = .025$	$\alpha = .01$
1	0.988	0.997	0.999	1
2	0.900	0.950	0.975	0.990
3	0.805	0.878	0.924	0.959
4	0.729	0.811	0.868	0.917
5	0.669	0.754	0.817	0.875
6	0.621	0.707	0.771	0.834
7	0.582	0.666	0.732	0.798
8	0.549	0.632	0.697	0.765
9	0.521	0.602	0.667	0.735
10	0.497	0.576	0.640	0.708
11	0.476	0.553	0.616	0.684
12	0.458	0.532	0.594	0.661
13	0.441	0.514	0.575	0.641
14	0.426	0.497	0.557	0.623
15	0.412	0.482	0.541	0.606

Making Conclusions in Pearson's

1) If r value calculated is **higher** than value in table:

→ The two data sets are **significantly correlated**

→ **Reject** null hypothesis

→ Relationship is NOT due to random error/chance

2) If r value calculated is **lower** than value in table:

→ The two data sets are **not significantly correlated**

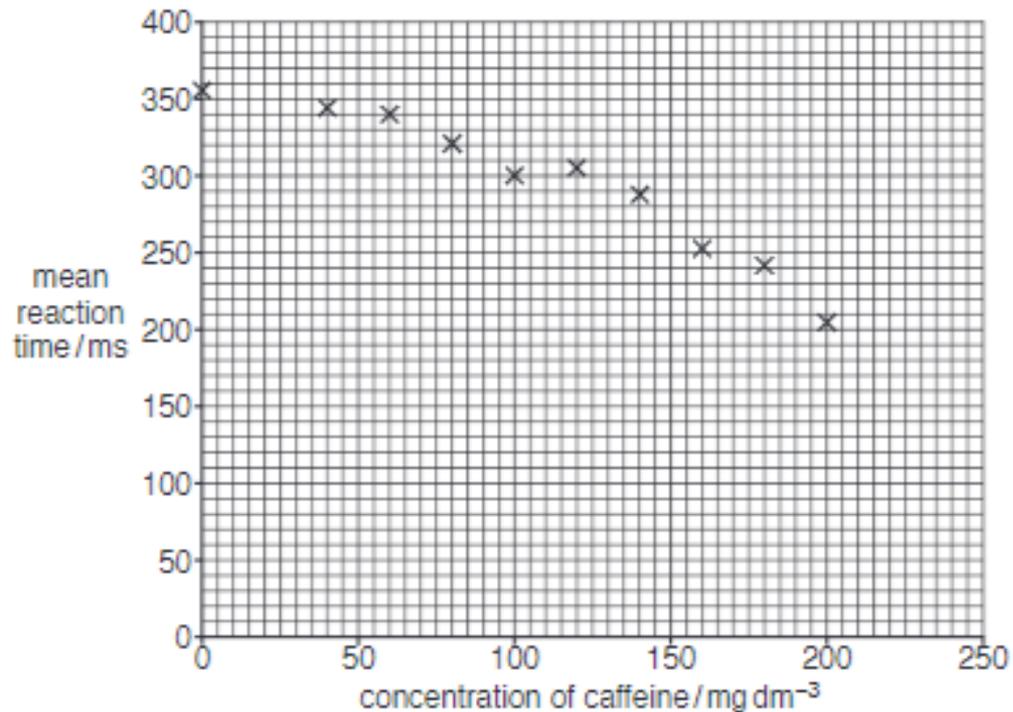
→ **Accept** null hypothesis

→ Relationship is due to chance/random error

Example #2

E.g. In an experiment, 10 subjects were each given a different concentration of caffeine. The reaction time was measuring 5 times for each subject and a mean calculated.

subject	1	2	3	4	5	6	7	8	9	10
concentration of caffeine / mg dm^{-3}	0	40	60	80	100	120	140	160	180	200
mean reaction time / ms	355	343	340	321	300	305	288	252	242	204



Example #2

Based on this graph the student decided to use a statistical test to find the strength of the correlation between the concentration of caffeine and the mean reaction time.

- i. State why Pearson's linear correlation test is suitable for the data.
- ii. The results of the statistical test gave Pearson's linear correlation, $r = -0.722$.

State what this value indicates about the relationship between the concentration of caffeine and the mean reaction time.

- iii. Describe how the student calculated the degrees of freedom.
- iv. Describe how the student used the probability table to find out if the value for $r = 0.722$ is significant.

Example #2

$r = -0.722$

<i>df</i>	$\alpha = .10$	$\alpha = .05$	$\alpha = .025$	$\alpha = .01$
1	0.988	0.997	0.999	1
2	0.900	0.950	0.975	0.990
3	0.805	0.878	0.924	0.959
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13	0.441	0.514	0.575	0.641
14	0.426	0.497	0.557	0.623
15	0.412	0.482	0.541	0.606

P5: Spearman's Rank Correlation

Method 2: Spearman's rank correlation

- Test for correlation between 2 paired sets of data

Requirements:

- Data is ordinal / **discrete**
- Data is not normally distributed
- Scatter graph shows that there is a relationship (not necessarily linear / skewed)
- There are **5 or more pairs** of data
- Data points within samples are independent
- All individuals must be selected at random from a population

- Spearman's correlation coefficient = r_s

$$r_s = 1 - \left(\frac{6 \times \sum D^2}{n^3 - n} \right)$$

where D = difference in rank

Example #1

We have measured the numbers of species R and species S in ten different 1m² quadrats.

i. State the null hypothesis.

ii. Plot a scatter graph.

iii. Calculate Spearman's rank correlation and determine the strength of the correlation.

Quadrat	Number of species R	Number of species S
1	38	24
2	2	5
3	20	8
4	50	31
5	28	27
6	8	4
7	42	36
8	13	6
9	20	11
10	43	30

Ranking in Spearman's

1. Do this for both sets of data.
2. Rank within the same set of data.
3. Start by ranking the smallest value as 1.
4. If same value, share same two ranks
5. Find difference in rank of the pair

$$r_s = 1 - \left(\frac{6 \times \sum D^2}{n^3 - n} \right)$$

where D = difference in rank

Quadrat	Number of species R	Rank for species R	Number of species S	Rank for species S	Difference in rank, D	D ²
1	38	7	24			
2	2	1	5			
3	20	4.5	8			
4	50	10	31			
5	28	6	27			
6	8	2	4			
7	42	8	36			
8	13	3	6			
9	20	4.5	11			
10	43	9	30			
					sum of D ² =	

Determining significance in Spearman's

1) Calculate **r_s value** using formula

$$r_s = 1 - \left(\frac{6 \times \sum D^2}{n^3 - n} \right)$$

where D = difference in rank

2) Calculate total degrees of freedom

→ **v** = number of pairs - 2 = **$n - 2$**

→ In this case, $v = 10 - 2 = 8$

→ **Either n or df can be shown in table!**
So read table headings carefully!

3) Check critical value at **$p = 0.05$**

4) Check if **critical value** in r_s table is lower/higher compared to r_s value calculated (Ignore positive or negative sign)

Spearman's correlation coefficient r critical value table

$$r_s = 0.936$$

**Note that n is shown
in table, not df !**

n	r_s	
	$P = 0.05$	$P = 0.01$
5	1.000	—
6	0.886	1.000
7	0.786	0.929
8	0.738	0.881
9	0.700	0.833
10	0.648	0.794
11	0.618	0.755
12	0.587	0.727
13	0.560	0.703
14	0.538	0.679
15	0.521	0.654
16	0.503	0.635
17	0.488	0.618

Making Conclusions in Spearman's

1) If r_s value calculated is **higher** than value in table:

→ The two data sets are **significantly correlated**

→ **Reject** null hypothesis

→ Relationship is NOT due to random error/chance

2) If r_s value calculated is **lower** than value in table:

→ The two data sets are **not significantly correlated**

→ **Accept** null hypothesis

→ Relationship is due to chance/random error

Example #2

E.g. The students collected samples of soil at different distances from the pond edge and estimated the water content.

The students wanted to find out if the water content of the soil at the different distances sampled was related to the number of different plant species found at the same distances. To do this, a Spearman's rank correlation (r_s) was carried out using the data in the table below.

sample	water content /arbitrary units	rank	number of species	rank	rank difference (D)	D^2
1	28	1	3	10	-9	81.00
2	26	2	4	9	-7	49.00
3	21	3	5	8	-5	25.00
4	18	4	6	7	-3	9.00
5	15	5.5	8	6	-0.5	0.25
6	14	7.5	9	4.5	3	9.00
7	15	5.5	10	3	2.5	6.25
8	14	7.5	9	4.5	3	9.00
9	13	9.5	11	2	7.5	56.25
10	13	9.5	12	1	8.5	72.25
$\Sigma D^2 =$						

$$r_s = 1 - \left(\frac{6 \times \Sigma D^2}{n^3 - n} \right)$$

where D = difference in rank

Note that the largest value is ranked as 1 here!
As long as you rank both sets of data in the same way, the resulting r_s value will be the same.

Example #2

- i. State what the value for r_s shows about the relationship between soil water content and the number of species present.

- ii. Explain whether the correlation is statistically significant.

n (number of pairs)	8	9	10	11	12
significance level 5%	0.738	0.700	0.648	0.618	0.618
significance level 1%	0.881	0.883	0.794	0.755	0.727

Chapter Outline

Part II: Biodiversity

- Define species, ecosystem and niche
 - Biodiversity – 3 Levels:
 - variation in ecosystems or habitats
 - the number of species and their relative abundance
 - genetic variation within each species
1. How to **calculate the biodiversity** of a habitat?
 - **P5:** Simpson's Index of Diversity (D)
 2. How to assess the **distribution and abundance of organisms** in a local area?
 - **P5:** Random sampling using frame quadrats
 - **P5:** Systematic sampling using line transects / belt transects
 - **P5:** Mark-release-recapture
 3. How to see the **effect of abiotic and biotic factors**....on the distribution and abundance of species?
 - **P5:** Spearman's rank correlation
 - **P5:** Pearson's linear correlation



Part III: Conservation



The last male Sumatran Rhino in Malaysia died on 27 May 2019

Chapter Outline

Part III: Conservation

- The need to maintain biodiversity

1. The role of **NGOs** in conservation

- IUCN
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

2. What are the **threats** to biodiversity of aquatic and terrestrial ecosystems?

3. How to **protect** endangered species?

- Zoos and Captive Breeding
- Assisted Reproduction (IVF, Embryo transfer, Surrogacy)
- Botanic gardens
- Conserved areas (national parks and marine parks)
- Frozen zoos
- Seed banks
- Control alien species

The Need to Maintain Biodiversity

Why maintain biodiversity?

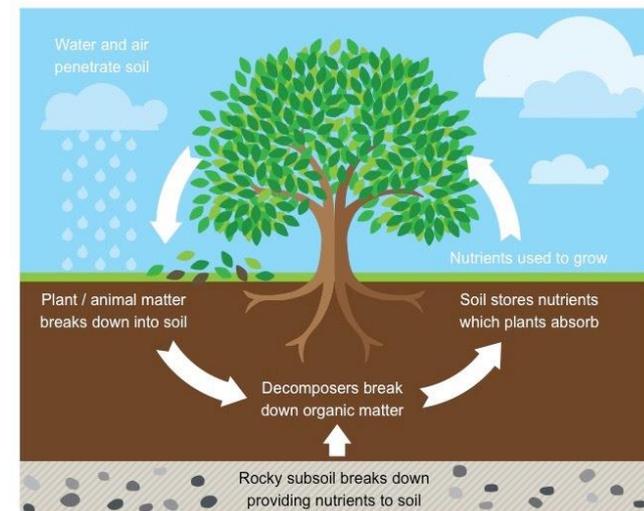
1. **Ecological reasons**
2. **Economic benefits**
3. **Moral/ethical reasons**
4. **Cultural and aesthetic reasons**



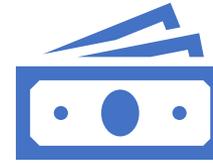
1. Ecological reasons



- **Maintains genetic variation** and large gene pool
 - High genetic diversity is important
 - Avoid inbreeding depression / promote hybrid vigour
 - So there is decrease in homozygosity / increase in heterozygosity
 - Less chance harmful recessive alleles may be expressed
 - Increases ability of population to adapt to changing environment
 - Increases chances of survival when exposed to pathogen / disease
- **Maintains food webs** / food chains in ecosystem
- **Nutrient cycling**
- **Protection against soil erosion**
- **Water and mineral retention**
- **Climate stability / prevent natural disasters**



2. Economic benefits



- **Resource material**

- E.g. wood for building, fibres for clothes, food for humans, herbs for medicine



- **Ecotourism**



- **Scientific research**

- Resource/species may have use in future
- E.g. medical use
- E.g. wild strains possess gene pool to further improve crops



3. Moral/ethical reasons



- Allow **indigenous population** to preserve its own cultural values
- Humans have **responsibility to conserve beauty** for its aesthetic value
- Humans have **responsibility to prevent extinction**
- Humans have no right to cause organisms to cease to exist



The Need for Conservation



- Need to especially protect **keystone species**! Removal of any keystone species will cause significant impact on the ecosystem.
 - E.g. The honeybee, *Apis mellifera* is an important pollinator for many plants, vegetables and crops.
- BUT it is not just individual species that need conserving, but **whole ecosystems**!
- Conserving biodiversity is thus a difficult task...
But is achieved by individuals, local groups, national and international organisations.
- At all levels – local, national and global levels.

The Role of NGOs in Conservation

In general, NGOs play a role to:

- **Conserve** species and biodiversity and **prevent extinction**
- Promote coexistence of wildlife and people
- **Educate** people and raise awareness through publicity campaigns
- **Raise funds / donations**
- Hold protests OR take direct action to prevent development or exploitation
- Influence governments and businesses
- Ban / reduce...hunting / polluting / oil drilling / mining / deforestation

E.g. worldwide fund for nature (WWF), Greenpeace, Oceana etc.



Especially Important International NGOs!

1. IUCN

- Global authority on the status of the environment and conservation
- **Monitor and categorise threatened and endangered species**
→ IUCN Red List <https://www.iucnredlist.org/>
- Vigorous **research and reporting**

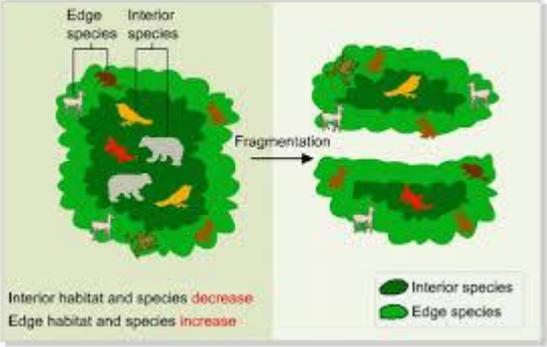


2. Convention on international trade in endangered species of wild fauna and flora (CITES) <https://cites.org/>

- Trade agreements law between governments
- Regulate / legislate for trade in wild species
- **To prevent international trade of endangered species** or certain animal products
- IUCN informs key decisions at the CITES Conferences



2. What are the threats to biodiversity of aquatic and terrestrial ecosystems?

Threat	Cause	Effect
Lack of human education	Ignorance lol	Stupidity lol
<p>Habitat loss and habitat fragmentation</p> 	<p>Deforestation Clear land for agriculture / housing / industry E.g. palm oil plantations in SEA</p> <p>Trawling destroys sea beds Reclaimed land Clearing of river banks</p>	<p>Loss of breeding sites Increased distance to find food</p> 
<p>Overexploitation of resources (Hunting, poaching, fishing, removal of plants)</p>	<p>For food, sport, medicine, decoration Trade in animal parts Selling of rare plants Grazing by cattle destroys plants</p>	<p>Decrease in numbers</p>

2. What are the threats to biodiversity of aquatic and terrestrial ecosystems?

Threat	Cause	Effect
<p>Climate change</p>	<p>Emissions of greenhouse gases E.g. CO₂ , methane, nitrous oxide, chlorofluorocarbons (CFC)</p> <p>Combustion of fossil fuels Manure of domestic livestock</p>	<p>Greenhouse effect + global warming Destruction of ozone layer Rising sea levels</p> <p>Decrease in area of ice sheets Change in sea temperature / decrease in oxygen concentration of sea Climate becoming more unpredictable and extreme</p>
<p>Increase in pollution / waste</p>	<p>Oil spill E.g. Oil rig explosion at Gulf of Mexico in 2010 – 4.9 million barrels of crude oil spilled</p> <p>Increase used of pesticides / insecticides / fertilisers Mining Plastic is hard to break down</p>	<p>Habitat loss / habitat fragmentation Decrease in numbers</p>  <p>Soil acidification due to fertilisers Pollution of water, soil, air Soil erosion due to mining</p>

2. What are the threats to biodiversity of aquatic and terrestrial ecosystems?

Threat	Cause	Effect
<p>Humans often introduce invasive alien species that outcompete native ones</p>	<p>Increased competition Decreased food, shelter and breeding sites in remaining natural habitats</p> <p>Increase in predators / grazers / spread of disease</p> <p>E.g. Grey squirrels from US brought to Europe are not affected by squirrelpox virus but spread it to red squirrels. They are also larger and outcompete red squirrels for food!</p>	<p>Decrease in numbers Inbreeding due to small population</p> <ul style="list-style-type: none">• Leads to inbreeding depression• So there is increase in homozygosity• Higher chance harmful recessive alleles may be expressed 

How to protect endangered species?

What is an **endangered species**?

- Species is **threatened with extinction**
- **Numbers reduced** to critical level / population too small
- Such low numbers that **reproduction is affected**
- **IUCN Red List of Threatened Species** provides info about the conservation status of species
- Vertebrates are usually higher profile bcs they are more visible, can detect easily when numbers decrease

How to protect endangered species?

1. Zoos and Captive Breeding
2. Assisted Reproduction (IVF, Embryo transfer, Surrogacy)
3. Botanic gardens
4. Conserved areas (national parks and marine parks)
5. Frozen zoos
6. Seed banks
7. Restoring degraded habitats

1. Zoos and Captive Breeding

- Zoos often have captive breeding programmes
- Goal of captive breeding = increase number of endangered species and release to wild

Advantages	Disadvantages
<ul style="list-style-type: none"> • Provide adequate food, healthcare • Protection from predators and disease • Provide as natural environment as possible 	<ul style="list-style-type: none"> • Stress in captivity • Behavioural changes ← Unnatural environment
<p>Reproduction</p> <ul style="list-style-type: none"> • Can monitor health of mother • Can monitor development of foetus 	<p>Reproduction</p> <ul style="list-style-type: none"> • Reproductive cycles disrupted
<ul style="list-style-type: none"> • Can use assisted reproduction (IVF, AI) • Store sperm / eggs / gametes • Can incubate fertilised eggs artificially / embryo transfer into surrogate mother 	<p>← May reject selected mate but...</p>
<ul style="list-style-type: none"> • Can have international cooperation to transfer breeding partners btwn zoos 	<p>← Inbreeding due to small gene pool but...</p>

1. Zoos and Captive Breeding

Advantages	Disadvantages
<p>Release after captive breeding</p> <ul style="list-style-type: none">• Increase number of endangered species• Can reintroduce to wild• Can prevent extinction	<p>Release after captive breeding</p> <ul style="list-style-type: none">• Difficulty in finding food• Lack of survival skills• Lack fear of humans / predators• May not integrate into other groups• More susceptible to disease in wild• Very little natural habitat left to release animals into
<p>Research and Education</p> <ul style="list-style-type: none">• Easier to research on behaviour, habitat requirements• Genetic records kept• Educate people	<p>N/A</p>

E.g. Captive-bred Lions: <https://www.youtube.com/watch?v=2xOzKO4u8k>

E.g. Raising Cute Pandas: <https://www.youtube.com/watch?v=cpPMjE0vU&feature=youtu.be>

2. Assisted reproduction

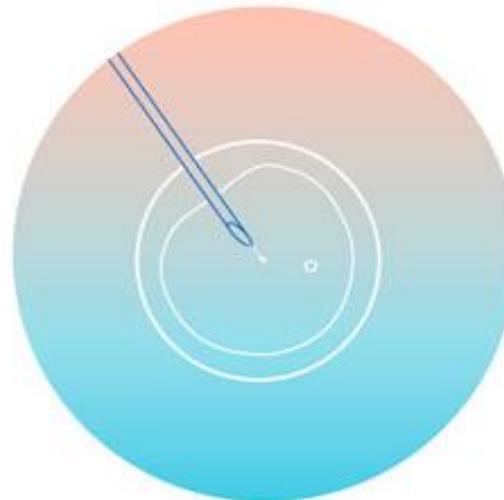
- Usually used in captive breeding!
- Useful for species where reproduction is difficult
- Maintains / increase genetic diversity
- Avoid inbreeding

Types:

a) In vitro fertilisation (IVF)

b) Artificial Insemination (AI)

etc...



IVF



AI

a) In vitro fertilisation (IVF)

1. **Hormone** treatment used to induce **superovulation**

2. Many oocytes harvested from female

3. Obtain fresh / frozen sperm

4. **Oocytes mixed with sperm**

- Ideally genetically different

5. Conduct genetic test and select embryos that are most likely to survive



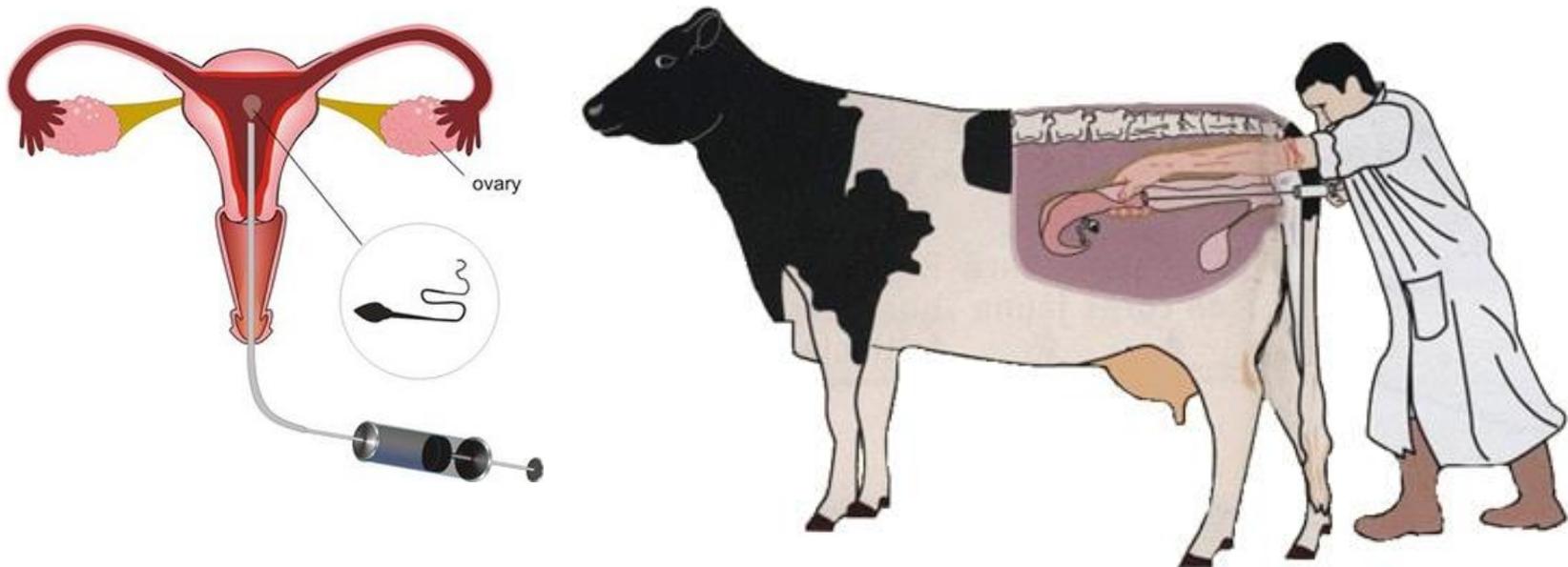
6. **Embryo transfer!**

- Embryo implanted in uterus of **donor female**
- OR may use similar species / non-rare breed as **surrogate mother**
- OR **freeze embryos** and store for long time in frozen zoo

E.g. IVF + Frozen Zoos: <https://www.youtube.com/watch?v=0UsoDqECYb8>

b) Artificial Insemination (AI)

1. **Collect semen**
2. **Screen** semen to select sperms
 - Sperm is ideally genetically different, fertile and disease-free
3. Sperm is artificially introduced into female



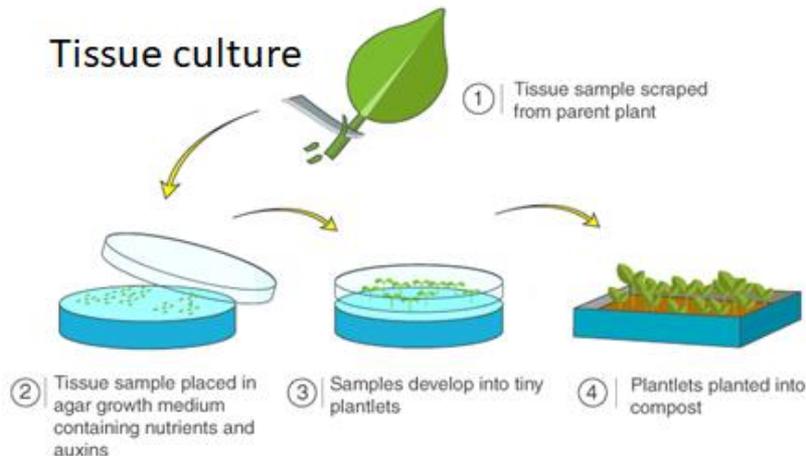
E.g. Semen Collection from Bull: <https://www.youtube.com/watch?v=HWS-61ZI8g4>

How to do AI in Cattle: https://www.youtube.com/watch?v=R6fYyxs_IDE

3. Botanic Gardens

Functions:

- Cooperate with governments / charities / universities for **research**
- To **conserve** habitats
OR **restore** habitats
- To **reintroduce species to wild**
- **Educate** public and raise awareness
- **Raise funds**



1. **Collect plants seeds** from the wild
 - From many countries,
 - Specially from areas at risk from climate change
2. **Plant seeds** and grow plants in botanic gardens
3. **Increase plant number and seed number** by tissue culture / cloning
4. Store seeds in **seed bank**
 - To **maintain /measure genetic diversity**
 - Seed bank acts as **gene bank**

4. Conserved Areas (National Parks and Marine Parks)

- **Protect habitat and breeding sites**
- **Prevent pollution**
- **Restrict human access and activity**
 - E.g. hunting, diving, fishing, control agriculture and industry
- **Rangers** patrol parks
- **Education** through visitor centres
- **Ecotourism**



[Rangers at Virunga National Park, Congo](#)

5. Frozen Zoos

E.g. [The Frozen Ark Project](http://news.bbc.co.uk/2/hi/science/nature/3928411.stm) <http://news.bbc.co.uk/2/hi/science/nature/3928411.stm>

- **Freeze sperm / eggs / embryos** of many different species of animals

→ Cryopreservation

- Acts as **gene bank**

→ Increases number of breeding stock / potential mates

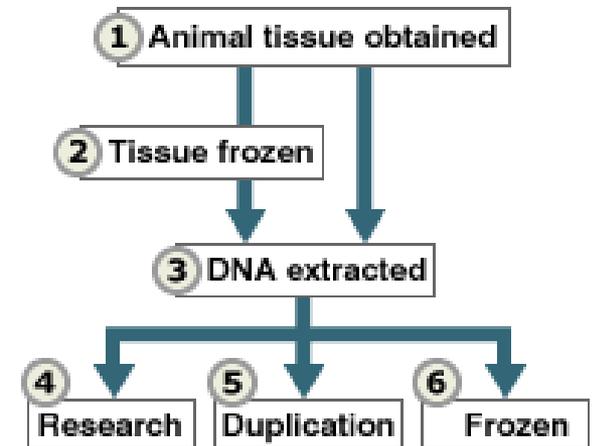
→ Can maintain or **increase genetic variation**

Advantages:

- Sperm **easily transported** to other zoos
 - Causing less stress to animal
- **Genetic material of endangered species** stored
 - For **conservation** and **research**
- Less **space** and **maintenance** to store than actual zoos



THE FROZEN ARK



SOURCE: Natural History Museum

6. Seed Banks

E.g. The Millennium Seed bank at Kew Gardens, UK and [Svalbard Global Seed Vault, Norway](#)

- **Variety / collection of seeds** in long-term storage
- **Frozen**, stored at temperatures below $-13\text{ }^{\circ}\text{C}$ or **dried**
 - Prevent germination / **maintain dormancy** of seeds
 - Seeds regularly tested for viability
 - Seeds re-stocked regularly
- Acts as **gene bank**
 - To **maintain genetic diversity** / preserve genetic material
 - Can be used after environmental disaster / new diseases... to **increase numbers**
- **Research** and **education**

Advantages:

- Seeds takes up **less space and maintenance**, is **cheaper** to store than growing plants
- Seeds are **less prone to disease** and being eaten
- Seeds can be **stored anywhere** in the world



7. Control alien species

- **Alien species** are non-native species introduced into new areas
- New area has **no natural predators or grazers** to control population
- So alien species population expand rapidly

Why the need to control?

- **Outcompete** native species
- **Spread disease**
- **Alter food webs** due to predation
- Reduce other organisms' abundance / **reduce biodiversity**
- May change habitat
- May be toxic to humans

INVASIVE SPECIES IN TEXAS

HELLO ZEBRA MUSSELS. GOODBYE TEXAS LAKES.

Zebra mussels are a destructive invasive species that can spread across Texas by hitching a ride on boats and trailers.

Boats are the primary carrier of zebra mussels.
Zebra mussels can easily attach to a boat's hard surfaces and boaters travel frequently between water basins. Surveyed boaters planned to visit more than 50 Texas lakes in the next 30 days.

8 Texas Lakes Infested IN ONLY 6 YEARS:

- Texoma
- Lavon
- Ray Roberts
- Waco
- Lewisville
- Belton
- Bridgeport
- Dean Gilbert

Zebra mussels size range from microscopic (larvae) up to 1.5 inches long (adults).

1,000,000 Zebra mussel eggs spawned every year by ONE female.

RECREATIONAL IMPACT
Attached zebra mussels can decrease boat fuel efficiency, damage a boat's finish and clog water pumps.

DAMAGE TO THE ECOSYSTEM
Algal bloom
Zebra mussels caused an algal bloom that led to a "do not drink" order for half a million Lake Erie residents.

FINANCIAL IMPACT
Cost to taxpayers
Zebra mussels can completely clog an entire municipal pipeline up to 12 inches wide.

452 per square inch
Zebra mussels can reach densities of 452 per square inch, covering beaches with sharp shells.

70% reduction
Zooplankton have been reduced by 70% in other infested lakes, impacting filter feeding fish, important prey for bass and other sportfish.

Decreased property value
Up to 19% in some areas infested with aquatic invasive species.

FOR SALE

Stop the spread! 1 Clean 2 Drain 3 Dry

texasinvasives.org/zebramussels

TEXAS PARKS & RECREATION

Chapter Outline

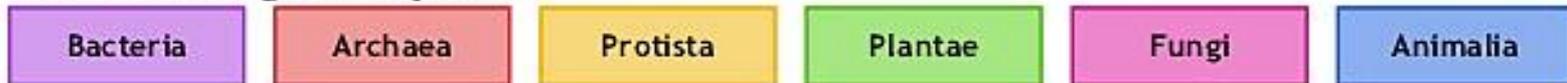
Part I: Classification

- Taxonomic hierarchy (DKPCOFGS)
- 3 Domains = Archaea vs Bacteria vs Eukarya
- 4 Kingdoms of Eukarya = Protocista, Fungi, Plantae, Animalia
- Viruses

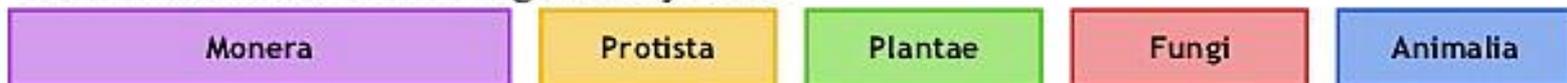
The three-domain system



The six-kingdom system



The traditional five-kingdom system



Chapter Outline

Part II: Biodiversity

- Define species, ecosystem and niche
 - Biodiversity – 3 Levels:
 - variation in ecosystems or habitats
 - the number of species and their relative abundance
 - genetic variation within each species
1. How to **calculate the biodiversity** of a habitat?
 - **P5:** Simpson's Index of Diversity (D)
 2. How to assess the **distribution and abundance of organisms** in a local area?
 - **P5:** Random sampling using frame quadrats
 - **P5:** Systematic sampling using line transects / belt transects
 - **P5:** Mark-release-recapture
 3. How to see the **effect of abiotic and biotic factors**....on the distribution and abundance of species?
 - **P5:** Spearman's rank correlation
 - **P5:** Pearson's linear correlation

Chapter Outline

Part III: Conservation

- The need to maintain biodiversity

1. The role of **NGOs** in conservation

- IUCN
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

2. What are the **threats** to biodiversity of aquatic and terrestrial ecosystems?

3. How to **protect** endangered species?

- Zoos and Captive Breeding
- Assisted Reproduction (IVF, Embryo transfer, Surrogacy)
- Botanic gardens
- Conserved areas (national parks and marine parks)
- Frozen zoos
- Seed banks
- Control alien species