TOPIC 4: ECOLOGY and EVOLUTION

4.1 Species, Communities and Ecosystems

Definitions:

- **Species:** A group of organisms that can interbreed and produce fertile offspring. Members of a species may be reproductively isolated in separate populations
- **Habitat:** The environment in which a species normally lives or the location of a living organism.
- **Population:** A group of organisms of the same species who live in the same area at the same time.
- **Community:** A group of populations living and interacting with each other in an area.
- **Ecosystem:** A community and its abiotic environment (eg. water, light). They have the potential of being sustainable over long periods of time.
- **Ecology:** The study of relationships between living organisms and between organisms and their environment.

Autotroph: An organism (plants) that synthesizes its organic molecules from simple inorganic substances. They obtain nutrients from the abiotic environment.

Heterotroph: An organism that obtains organic molecules from other organisms.

Consumers: An organism that ingests/feeds on other organic matter that is living or recently killed

DECOMPOSERS:

Detritivore: An organism that internally ingest non-living organic matter (vulture, jackal, hyenas)

Saprotroph: An organism (bacteria, microorganisms) that lives on or in non-living organic matter, externally secreting digestive enzymes into it and absorbing the products of digestion.

4.2 FOOD CHAINS

Producer → Primary consumer → Secondary consumer → Tertiary consumer

a) Passion flower→ Helliconius butterly→ Tegu lizard→ Jaguar

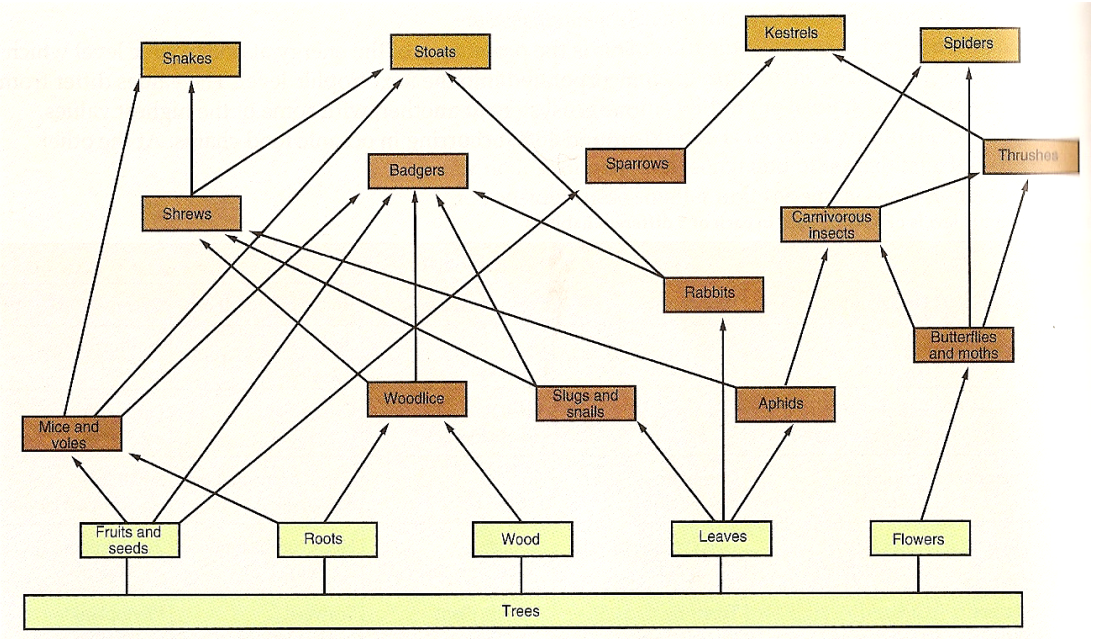
b) Sea lettuce→ marine Inguana→ Galapagos snake→ Galapagos hawk

c) Carrot plant→ Carrot fly→ Flycatcher→ Sparrowhawk

Note: the arrows indicate the **energy flow** between different trophic levels in the food chain.

FOOD WEBS

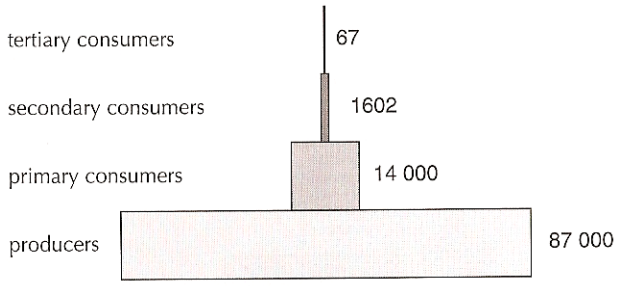
A food web is an interconnection of food chains thus a more realistic approach of an ecosystem.
Food webs are comprised of several trophic levels such as producers, primary, secondary and tertiary consumers.



Please **label** the organisms of the food web according to the trophic level they belong to and **construct** your own including at least ten organisms.

ENERGY FLOW and pyramids of energy

- Light is the initial source of energy (KJ/m^2/yr) for almost all communities!!!



Approximately 10% to 20% of the energy is transferred to the next trophic level since energy can be lost through:

- cell respiration as heat (energy losses)
- excretion (urine)
- egestion (feces)
- materials not consumed (teeth, bones, nails etc.)

Therefore, energy losses between trophic levels restrict the length of food chains and the biomass of higher trophic levels.

RECYCLING OF NUTRIENTS

Energy is always supplied to ecosystems, but what happens with the nutrients that unfortunately are not re-supplied and cannot be lost either??

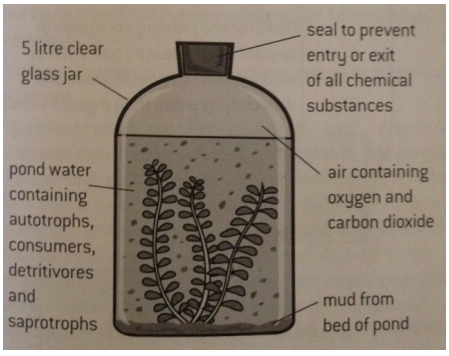
Saprotrophs and fungi (decomposers) are responsible for the recycling of nutrients. They secrete digestive enzymes onto dead organic matter thus breaking complex organic compounds into simpler inorganic elements. These can be re-absorbed by autotrophs and be transferred to the rest of the trophic levels (organisms).

4.3 Mesocosms

As mentioned before, ecosystems have the potential to be sustainable over long periods of time.

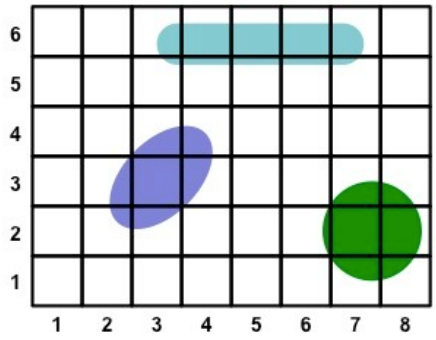
As long as nutrients are recycled, ecosystems only require a supply of energy (light), to continue indefinitely. This can be demonstrated by using mesocosms.

→ A **mesocosm** is a small experimental area set up in an ecological research program. They can be set up in open tanks, but sealed glass vessels are preferable because entry and exit of matter can be prevented but light can enter and heat can leave. Aquatic systems are likely to be more successful than terrestrial ones.



4.4 Quadrat sampling

A quadrat (1 m^2 x 1 m^2) is a square sample area used in ecological research.



Quadrat Sampling

- Define a sampling region
- Select random areas – e.g. (1,2)
- Count individuals in area
- Determine population density

The quadrat must be thrown/placed randomly to cover the area. This can be done by using a calculator to generate two random numbers to use as coordinates OR thrown randomly as many times as possible.

The population size of a species in an area can then be calculated as follows:

$$\text{Population size} = \frac{\text{Mean number per quadrat} \times \text{total area}}{\text{Area of each quadrat}}$$

The use of chi – square (x^2) test

When an analyst attempts to fit a statistical model to observed data, he or she may wonder how well the model actually reflects the data. How "close" are the observed values to those, which would be expected under the fitted model? One statistical test that addresses this issue is the chi-square test.

Example:

If the presence or absence of two species is recorded in a large number of quadrats, a chi-square test for association between the species can be performed.

→ The presence or absence of two seaweeds was recorded in 50 x 1 m^2 quadrats on a rocky sea shore.

Table 1: The contingency table shows the results

		Fucus vesiculosus	
		Present	Absent
Fucus serratus	Present	6 (10.9)	15 (10.1)
	Absent	20 (15.1)	9 (13.9)

To find the expected frequencies, we assume independence of the rows and columns. To get the FIRST expected frequency, we look at row total and column total, multiply them, and then divide by the overall total. So the expected frequency is:

$$\text{Expected frequency} = \frac{\text{Row total (21) x column total (26)}}{\text{Grand total (50)}} = 10.9$$

To calculate the chi-squared the following equation is used:

$$X^2 = \sum \frac{(\text{observed - expected})^2}{\text{expected}}$$

Hence:

$X^2 = 2.20 + 2.37 + 1.59 + 1.73 =$ **7.89**

From the table below we need to select the “degrees of freedom” (number of columns -1) x (number of rows - 1) = 1

The critical value for biology is found in the 0.05 column (significance level 5%)

If calculated x^2 > critical x^2 then there is a SIGNIFICANT DIFFERENCE! The algae tend NOT to occur in the same place/quadrats.

Critical Values of the χ^2 Distribution

df \ p	0.995	0.975	0.9	0.5	0.1	0.05	0.025	0.01	0.005	df
1	.000	.000	0.016	0.455	2.706	3.841	5.024	6.635	7.879	1
2	0.010	0.051	0.211	1.386	4.605	5.991	7.378	9.210	10.597	2
3	0.072	0.216	0.584	2.366	6.251	7.815	9.348	11.345	12.838	3
4	0.207	0.484	1.064	3.357	7.779	9.488	11.143	13.277	14.860	4
5	0.412	0.831	1.610	4.351	9.236	11.070	12.832	15.086	16.750	5
6	0.676	1.237	2.204	5.348	10.645	12.592	14.449	16.812	18.548	6
7	0.989	1.690	2.833	6.346	12.017	14.067	16.013	18.475	20.278	7
8	1.344	2.180	3.490	7.344	13.362	15.507	17.535	20.090	21.955	8
9	1.735	2.700	4.168	8.343	14.684	16.919	19.023	21.666	23.589	9
10	2.156	3.247	4.865	9.342	15.987	18.307	20.483	23.209	25.188	10
11	2.603	3.816	5.578	10.341	17.275	19.675	21.920	24.725	26.757	11
12	3.074	4.404	6.304	11.340	18.549	21.026	23.337	26.217	28.300	12
13	3.565	5.009	7.042	12.340	19.812	22.362	24.736	27.688	29.819	13
14	4.075	5.629	7.790	13.339	21.064	23.685	26.119	29.141	31.319	14
15	4.601	6.262	8.547	14.339	22.307	24.996	27.488	30.578	32.801	15