

BIO 111: Biological Diversity and Evolution

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Research

Ecology and Evolution

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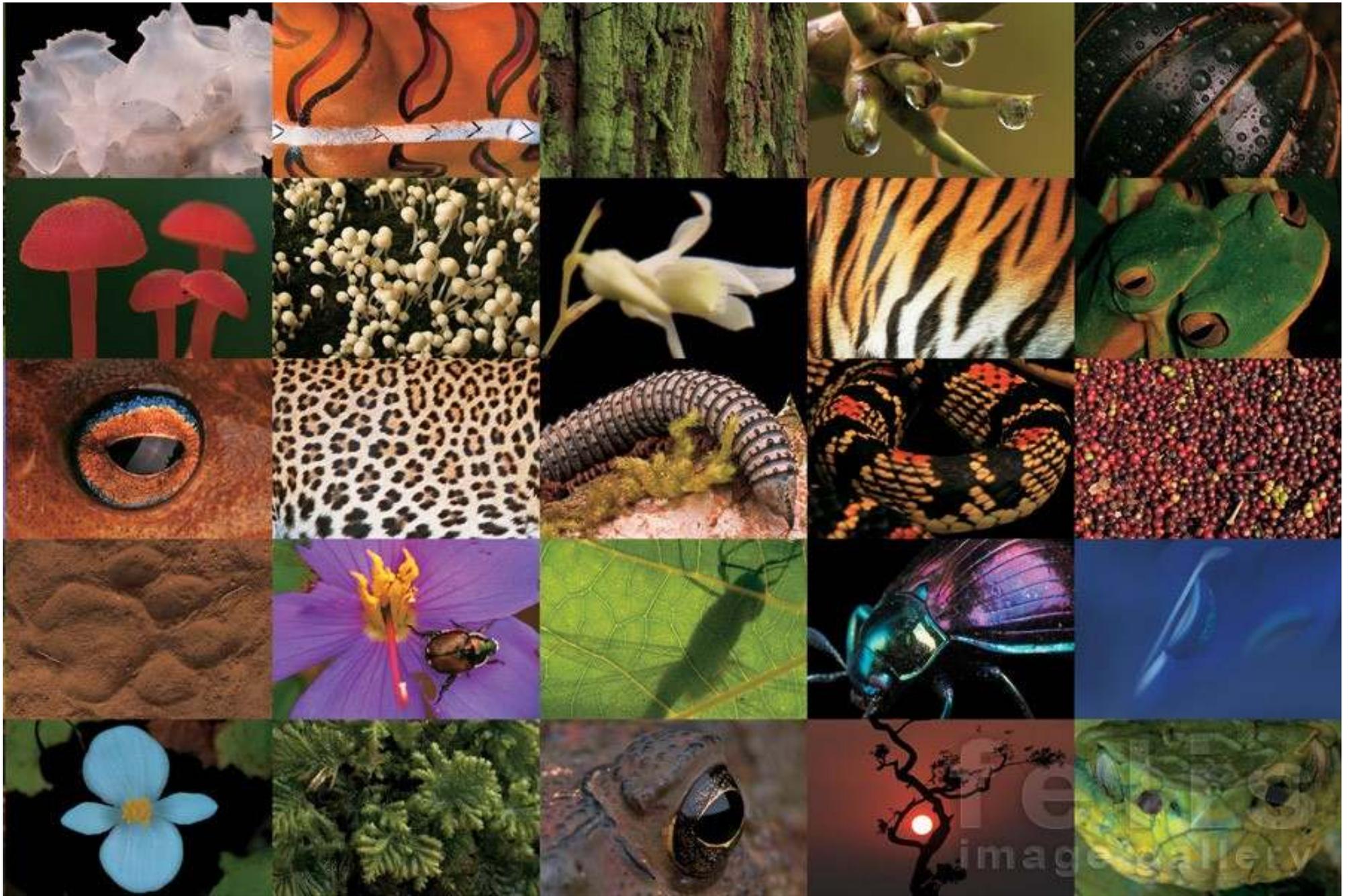
- Larvae of some butterflies are so highly specialized that they starve to death when given the 'wrong' plant. Some species are very general, i.e. feed on a large number of plants. One might expect generalization to be a big advantage, yet in many butterfly groups specialization is more common
- Why do people get cancer?
- Why do plants produce so many more flowers than they do seeds?

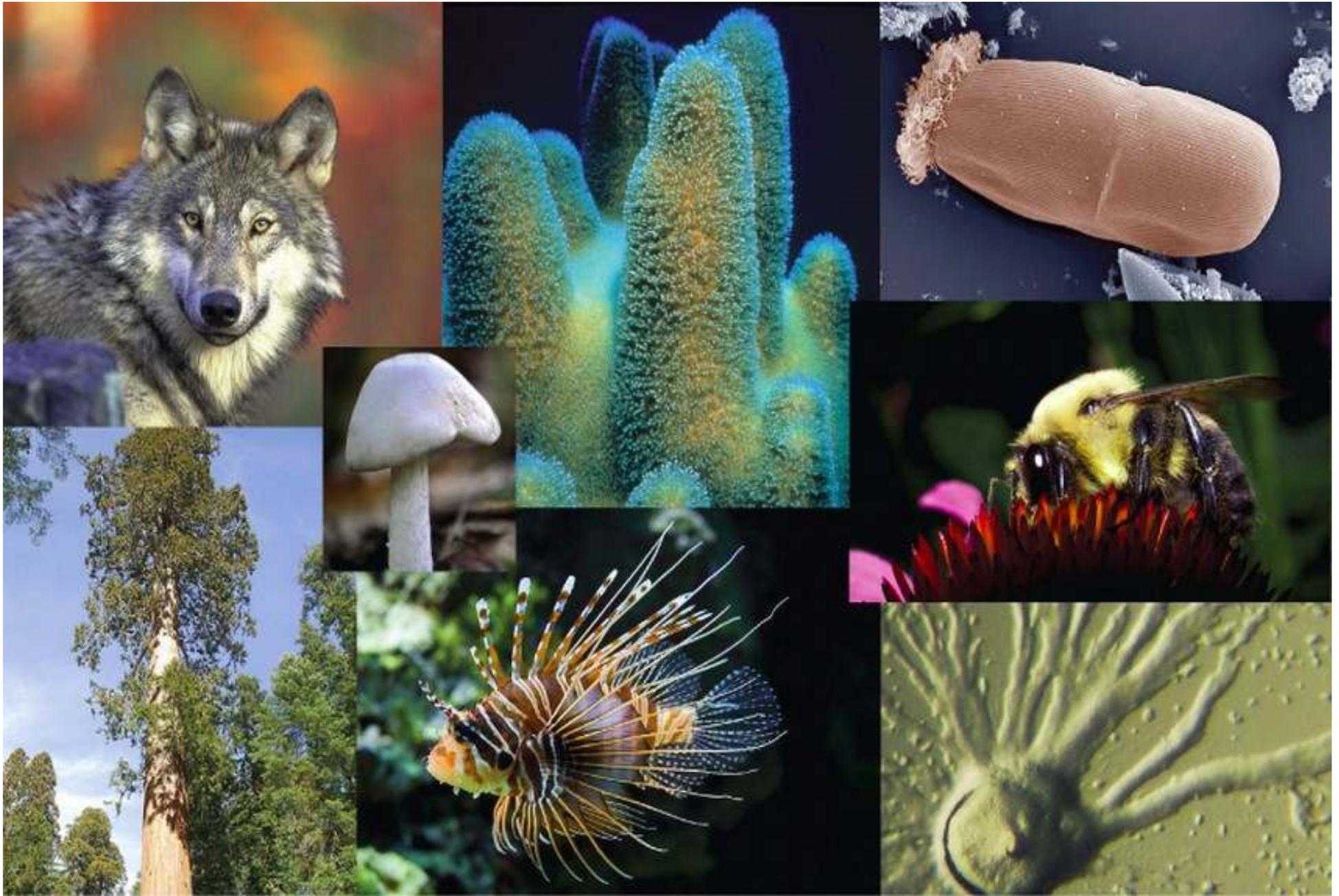
- Some microorganisms can survive in volcanoes and in the coldest regions of the earth, whereas humans can only survive in a small range of temperatures.
- In some turtles, temperature of incubation determines the sex of hatchlings. In most organisms, this is decided by the genetic make up of the offspring. What might be the advantage of the strategy used by turtles?

What is Biology?

Study of life, living things

What is life?





Life

- Difficult to define life
- *Assemblage* of molecules
- Life is a set of *processes*, not a thing or an event
- Can be described in terms of characteristics or features

‘Emergent’ properties: Whole is more than the sum of parts

e.g. 1) A car is made of parts. The way the parts are assembled is what makes a car function

2) Letters by themselves mean nothing, but can come together to start a revolution!

- Similarly molecules get assembled in various ways to give rise to living things

- Hierarchical

e.g. Molecules assemble make up parts of a cell, cells assemble into organs, organs assemble into an individual

Characteristics of life

~ Features or properties

I. Cellular organization

II. Metabolism

III. Homeostasis

IV. Response to stimuli

V. Growth and development

VI. Reproduction & Heredity

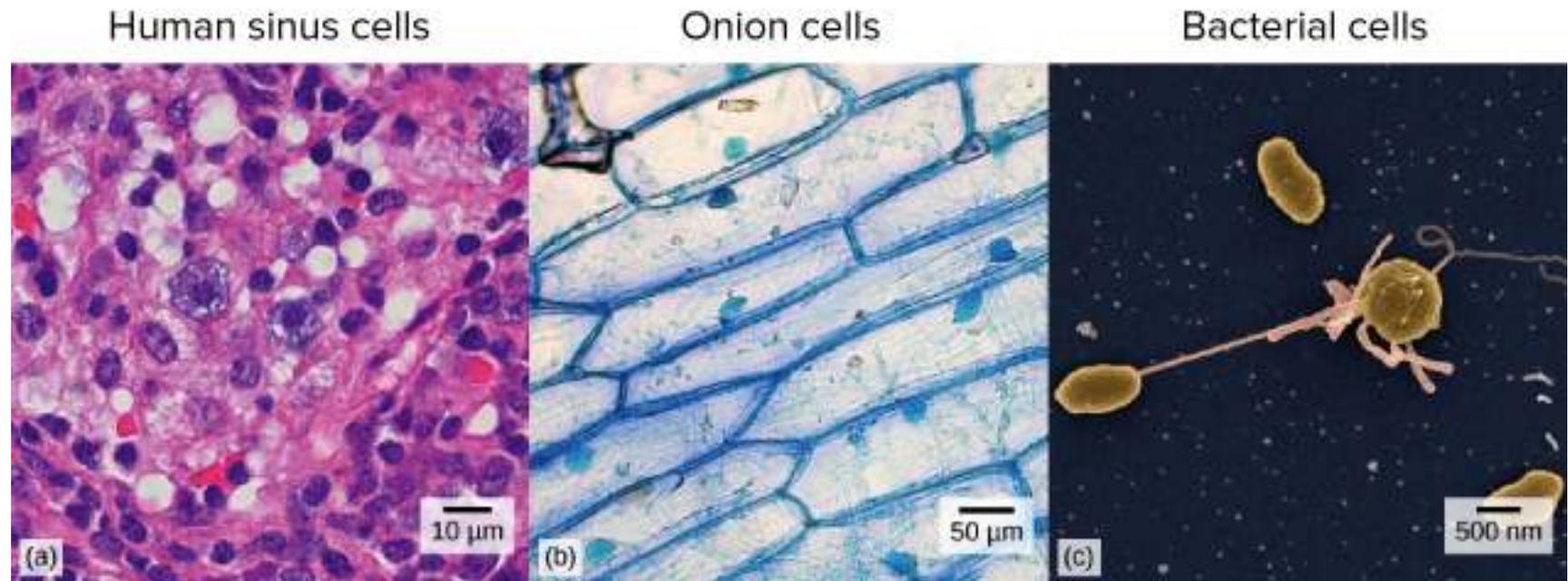
VII. Evolution

(Note: Not all biologists describe life using the above processes, some do it in slightly different ways)

I. Cellular organization

Cells – basic building blocks of all living organisms

- Smallest unit that can perform all the processes of life



I. Cellular organization

- **Unicellular (e.g. bacteria)** versus **Multicellular** (cell specialization)
e.g. Skin cells, Muscle cells
- Cells always small (size of organism related to cell number)
As size increases, volume increases much more rapidly than surface area, hence diffusion time increases

Cell

All cells have a **cell membrane** (also called **plasma membrane**), which is the border between the inside of the cell and the external environment

- Extremely important feature. *Why?*
- Cells contain molecules (proteins, carbohydrates, lipids, nucleic acids, water)

Cell

- Within the cell membrane, cells have various **organelles** and the **cytoplasm**
- Each organelles has a different function.
- For e.g *mitochondria* are the ‘power houses’ of cells where energy is produced from food

Photosynthesis

- Organisms capable of **photosynthesis** (plants, some algae) have chloroplasts, which are organelles that trap energy in sunlight to produce food
- Photosynthesis also releases **Oxygen** into the atmosphere

DNA and Genes

- The nucleus contains chromosomes, which have DNA.
- Genes are regions of the chromosome, and contain information for all of the processes of life
- The diversity of life is due variation in genes among organisms

II. Metabolism

Sum of all chemical processes in an organism

- Important purposes
- Obtain and use energy
 - for cellular processes
 - for making the building blocks of the cell
- Eliminate wastes

III. Homeostasis

Regulation - Keep internal conditions relatively constant under changing environmental conditions

In other words, maintenance of a stable body condition

Ex. body temperature, salt concentration

Metabolic processes are involved in these mechanisms.

IV. Response to stimulus

Respond to Changes in environment

A Stimulus → Response

- E.g Amoeba move away from light

Some animals hibernate when winter arrives

V. Growth and Development

- **Growth:** Result of cell division (formation of two cells from one) and cell enlargement (cells enlarge as they mature)
- **Development:** Maturation

*Single cell → Cell cluster → Differentiation
(specialization)*

VI. Reproduction & Heredity

- Reproduction, Replication
- **Asexual** reproduction: e.g. cell division in bacteria
- **Sexual** reproduction: Fusion of male and female gametes.
 - E.g. egg and sperm in animals
 - Pollen and ovule in plants

VI. Reproduction & Heredity

Heredity

Transfer of genetic information from parent to offspring during reproduction

i.e. transfer of *genes*

- In asexual reproduction, the offspring gets the exact copies of the parent

VI. Reproduction & Heredity

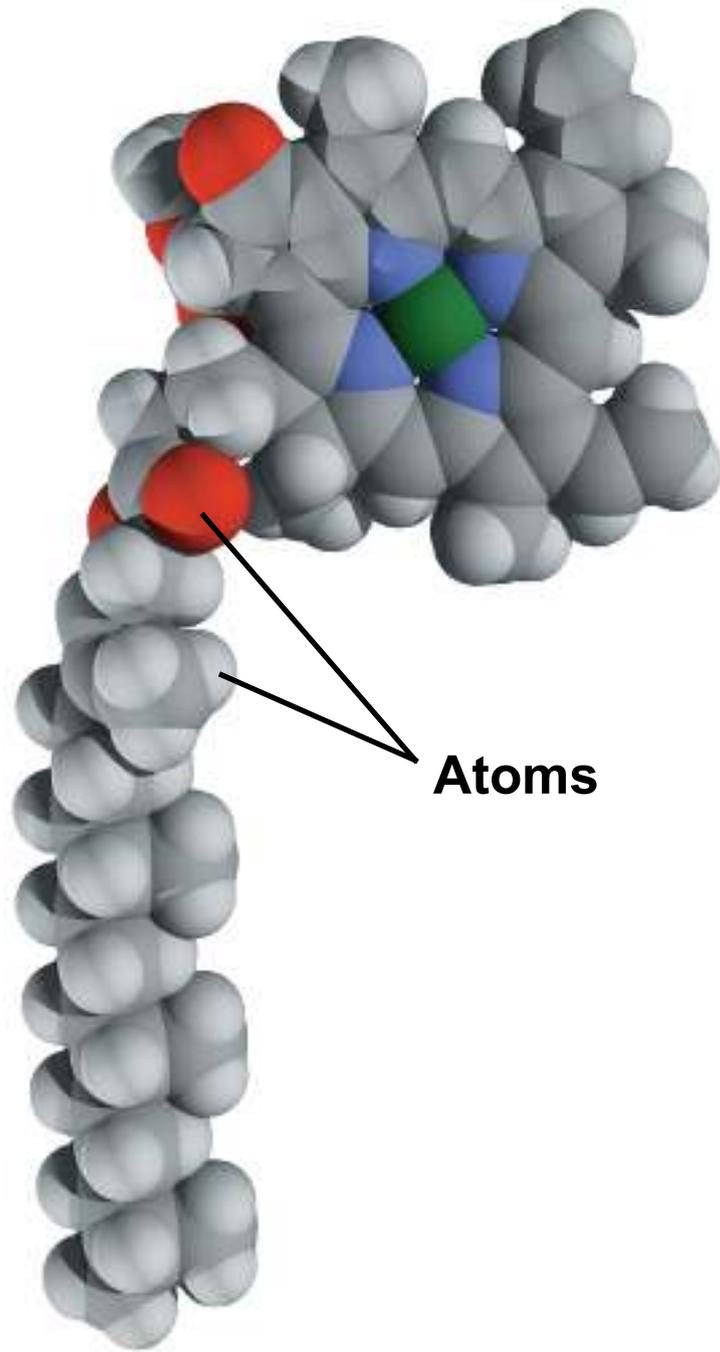
Some interesting reproductive strategies

- Female birds, rabbits, reptiles can store sperm for months
- Females of some mantises feed on the male immediately after mating
- Some fish can switch sex in minutes

VII. Evolution

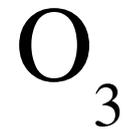
- Evolution ~ change
- *Biological evolution*, loosely speaking, is change in groups of organisms over the course of generations
- **Adaptations** are the result of evolution

Scales of biology



Atoms

Molecules



Organelles (subunits of Cells)

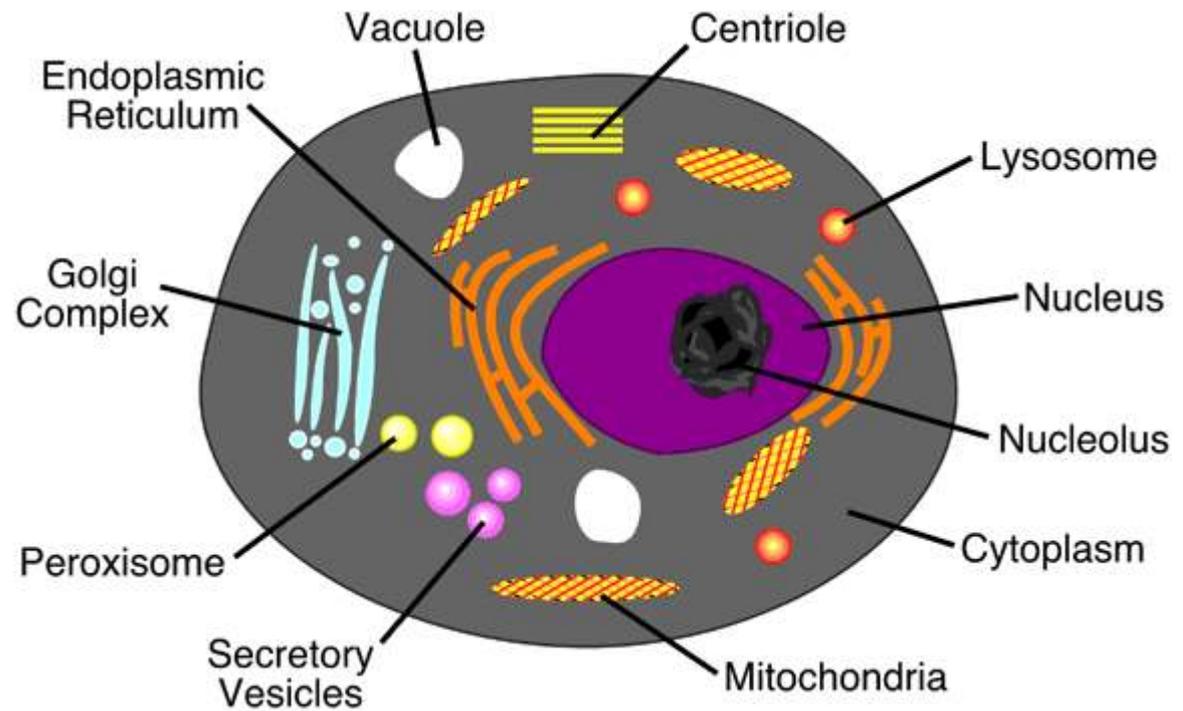
(e.g. Chloroplast - photosynthesis)



Figure 41-205 Micrograph of a chloroplast. Photo: Rip van Wafel

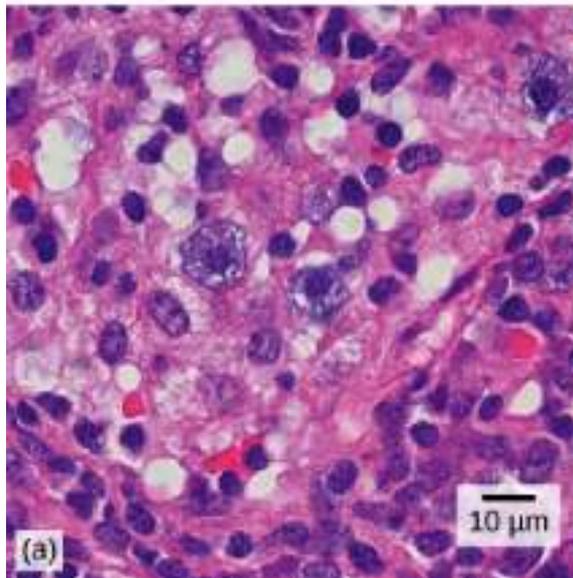
Cells

- basic building blocks of life

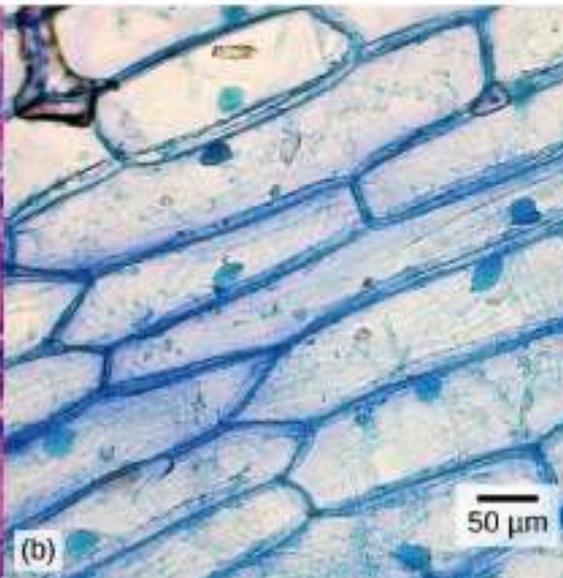


Source: <http://www.physicalgeography.net/fundamentals/6a.html>

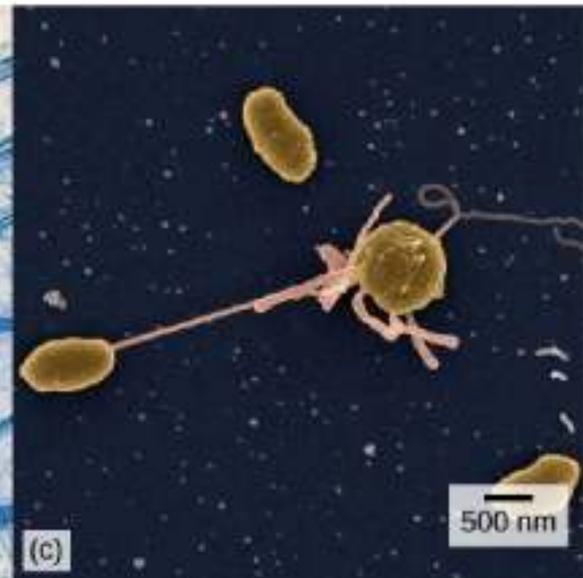
Human sinus cells



Onion cells

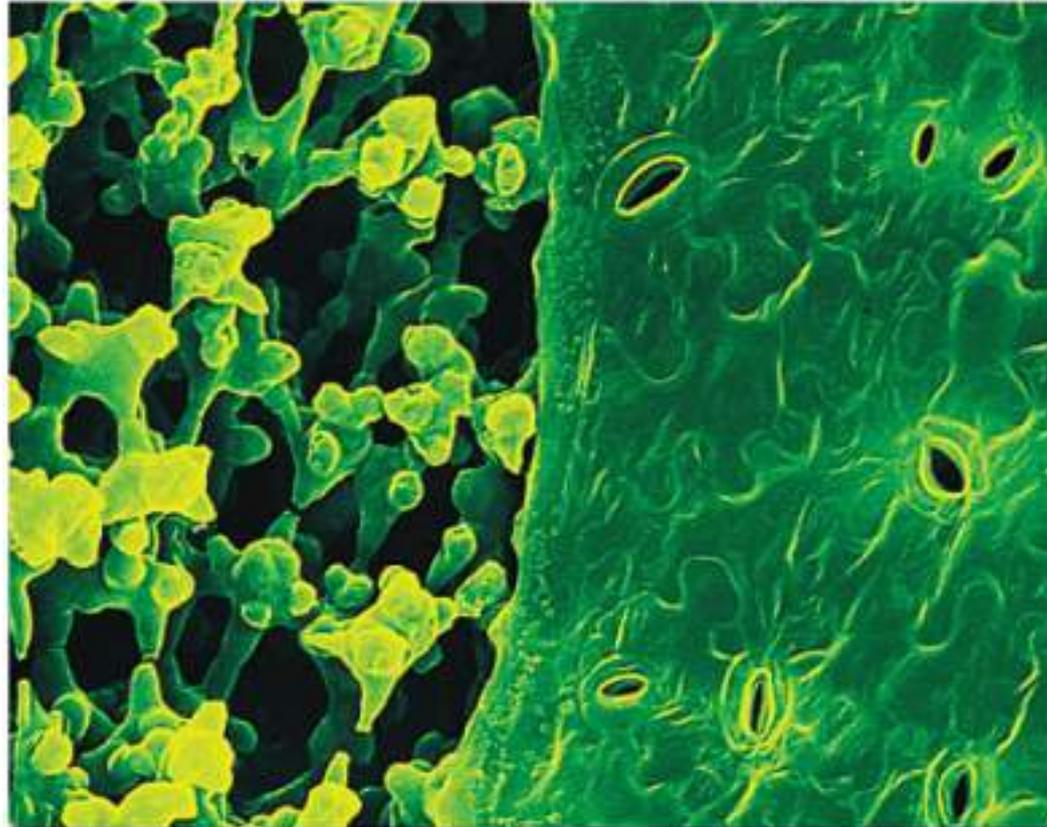


Bacterial cells



Source: <https://www.khanacademy.org/science/biology/structure-of-a-cell/introduction-to-cells/a/intro-to-cells>

Tissues (group of similar cells with a common function)



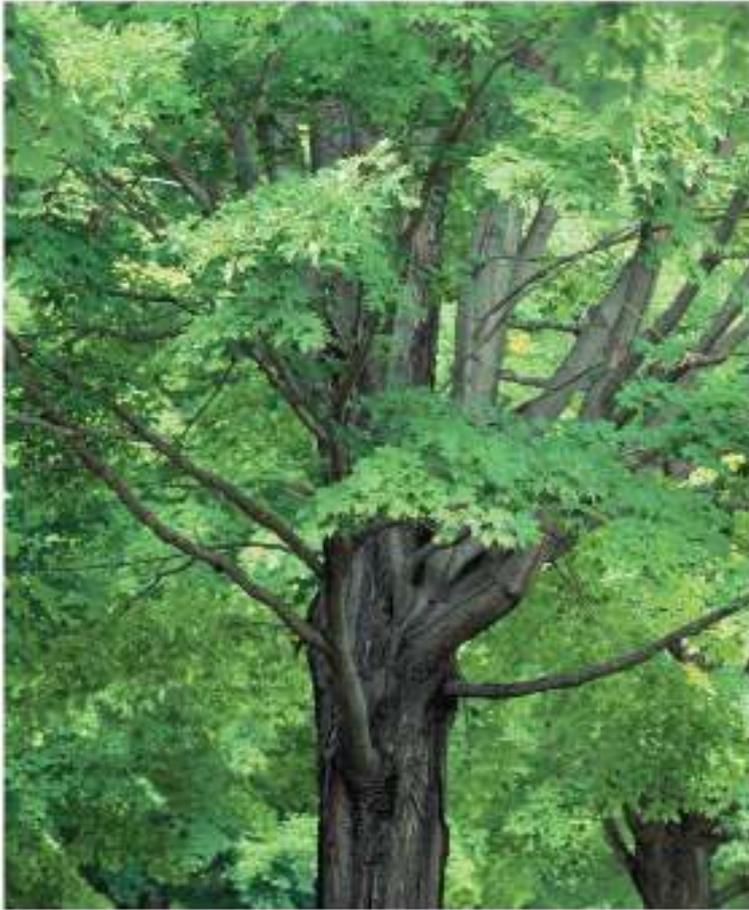
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50 μm

Organs



Organisms (Individuals)



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Populations (All individuals of a species living in an area)



Communities: Populations of all species in an area



Ecosystems: Community AND non-living environment



Environment

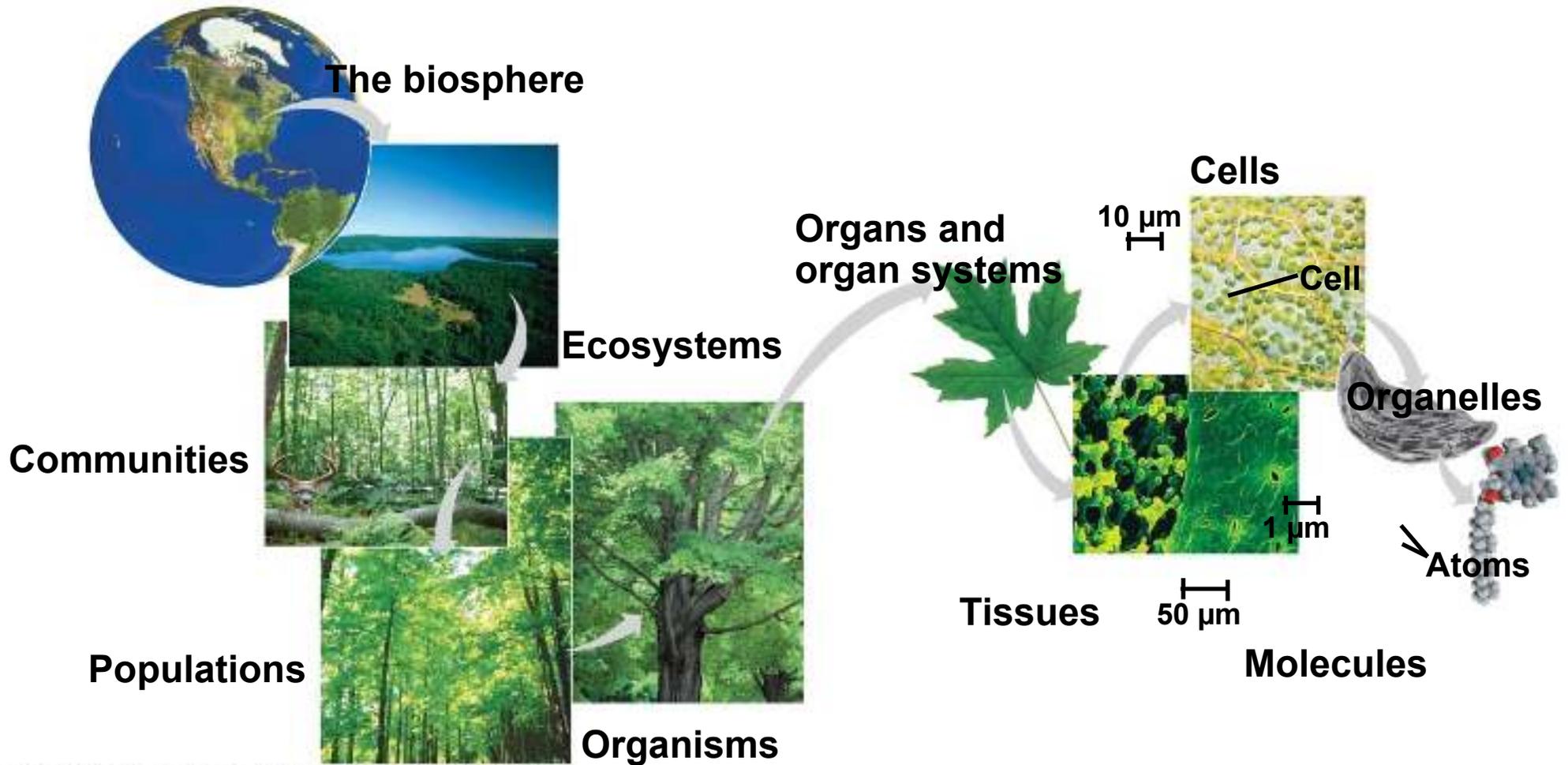
- Biotic – living things
- Abiotic – non-living matter

The biosphere

Zone of life on earth.
Sum of all ecosystems



Scales of Life



Ecology

- the scientific study of the interactions between organisms and the environment
- Remember that the environment includes both biotic and abiotic components

Subjects of ecological studies

- Molecules
 - Organelles and Cells
 - Tissues
 - Organs
- Whole organism (individual)
 - Population (of a Species)
 - Community
 - Ecosystem
 - Biosphere
 - Earth

Evolutionary biology

- Evolution ~ change

Biological evolution, loosely speaking, is change in groups of organisms over the course of generations

In its broadest sense, Ecology also includes Ethology (study of animal behaviour) and Evolutionary biology

- Behavioural ecology
- Evolutionary ecology

'Pure' ecology, Animal Behaviour and Evolution are all interrelated and it often impossible to assign a study strictly into one category.

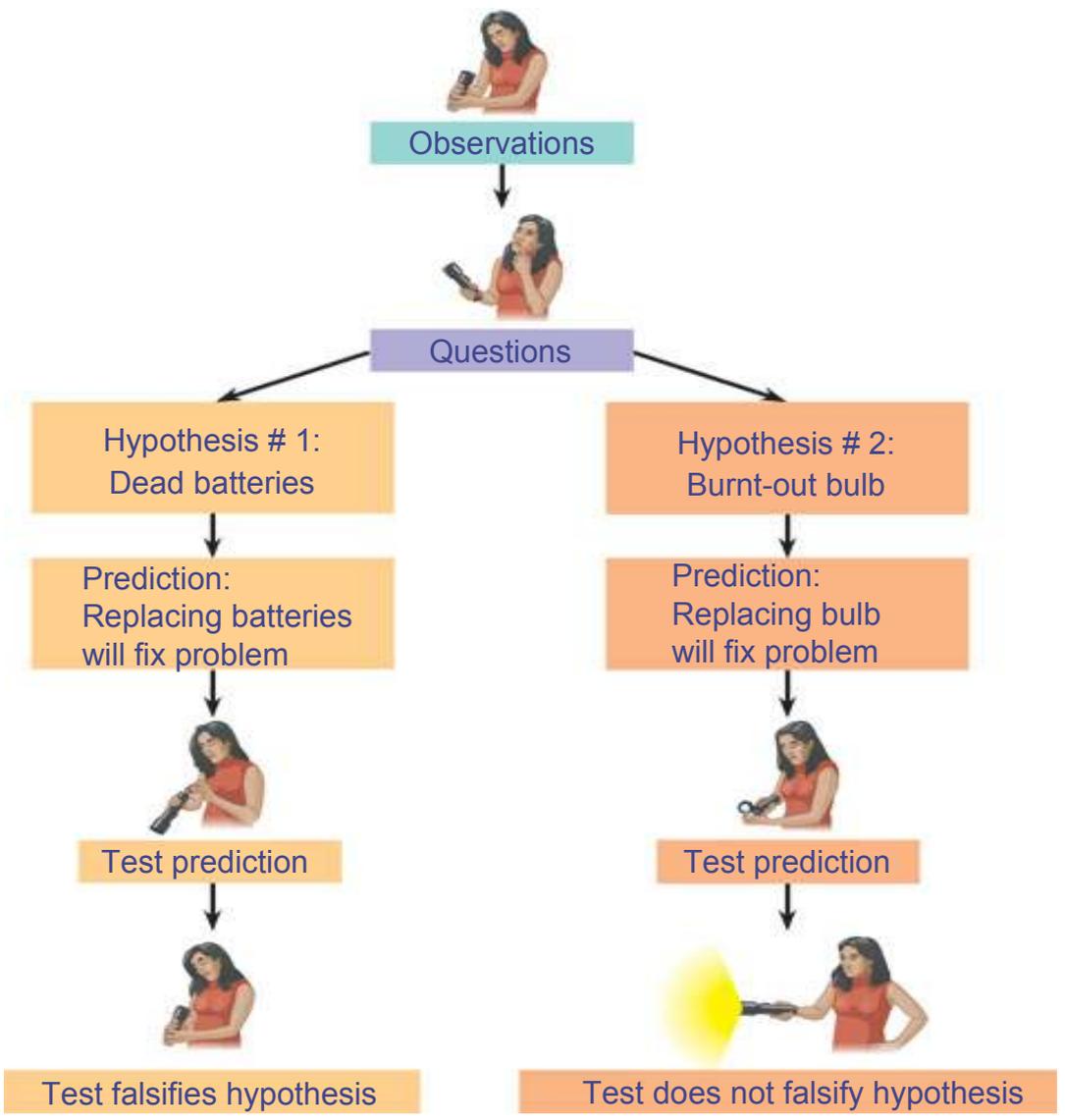
(division in this course is mainly for the sake of convenience of teaching)

Hypothesis testing

- Making Observations (think of a question)
- Formulate a Hypothesis
- Design & Conduct Controlled Experiment
- Analyze Data
- Make inferences
- Communicate results

Hypothesis

- Proposed scientific explanation for a set of observations
- Makes predictions that can be tested
- Generated using prior knowledge/observations
- Imagination, creativity



- A good scientific hypothesis should be
 - testable
 - falsifiable (i.e. should have the potential to be rejected)

Controlled Experiment

- Take two (or more) groups that are similar and manipulate a single variable. The groups are called '*treatments*'
- **Independent Variable:** the variable being manipulated
- **Dependent Variable:** the variable that changes as a response to the independent variable. This is the variable that is measured/observed, i.e. from which get *data*

Null hypothesis

- Hypotheses cannot be proved, can only be falsified or rejected
- Therefore, in practice, we formulate a null hypothesis, such that when the data reject the null hypothesis, there is support for the alternative hypothesis.
- The alternative hypothesis is the hypothesis of our interest

Statistical tests

Eg *Vanessa cardui* is a butterfly that is very widely distributed – in all continents except South American and Antarctica.

Telinga oculus (= *Heteropsis oculus*, *Mycalesis oculus*) is found only in higher altitudes of mountains in Southern India.

Vanessa cardui (Painted lady)



Heteropsis oculus (Red-disc Bushbrown)



Photo: Wikimedia commons, author: "Tbc"

Photo: Balakrishnan Valappil

Some potential ecological, evolutionary and behavioural factors/traits affecting their distributions

- Hostplants ~ genes
- Environmental conditions (temp, humidity, etc) ~ genes
- Time since origin of species
- Competition
- Behavioural traits (e.g. dispersal ability) ~ genes
- Human disturbances

Exercise: Can you try to formulate a specific hypotheses and design experiments to test them?