

BIO 111 - Principles of Life I: Biomolecules, Genetics and Evolution

(Varsha 2023)

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Research

Evolutionary ecology

www.vanasiri.in





Photo: Kris Kelley



Photo: Vivek Cyriac





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Research Focus

Developmental processes impact behavioural tendencies later in life. We analyse different behaviours across the lifespan of zebrafish, which undergo external fertilization and development and offer access to recording complex behaviours from early stages of life. We combine the study of behaviour with understanding the molecular basis of these behaviours. Currently, we are interested in understanding the role of immune factors in stress-responsive behaviour.

Education & Experience

Publications

Awards and Professional Recognition

Contact

Developmental defects can result in conditions like epileptic seizures. Though epilepsy is a neurodevelopmental disorder, it has been mostly studied using adult mammals. Zebrafish are emerging as a useful model to study neurodevelopmental disorders like epilepsy, since they are vertebrates with >75% genetic similarity to humans. Further, they undergo external fertilization and development allowing in-depth analysis of neurodevelopmental processes. Currently, we are interested in understanding how mutations in epigenetic factors result in epilepsies.

BIO 111 (and generally, courses at IISER TVM)

- Reference material
- Memorization *versus* Understanding
- Exams/Grading
- Emphasis on understanding 'research'

Some questions in ecology and evolution

- 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?
- Why are there more species in the tropics?
- Why do plants produce so many more flowers than they do seeds?

- Why do bees prefer flowers with particular colours?
- 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?
- How is climate change affecting species?

Some research questions in School of Biology

- Why do people get cancer?
- What molecular mechanisms control cell division?
- Understand mechanisms of host switching in viruses
- What leads to mutations?

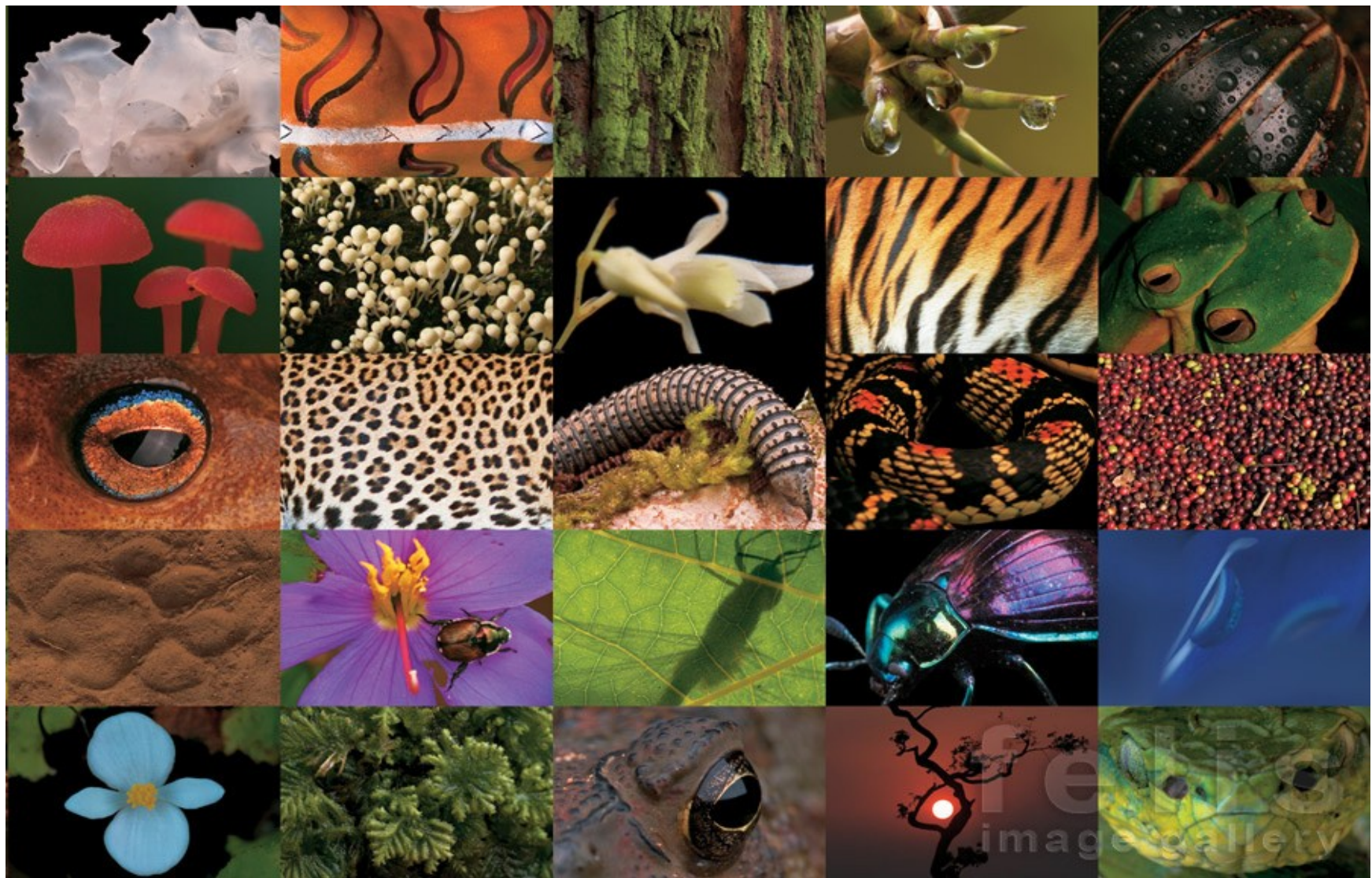
MODULE: OVERVIEW OF BIOLOGY

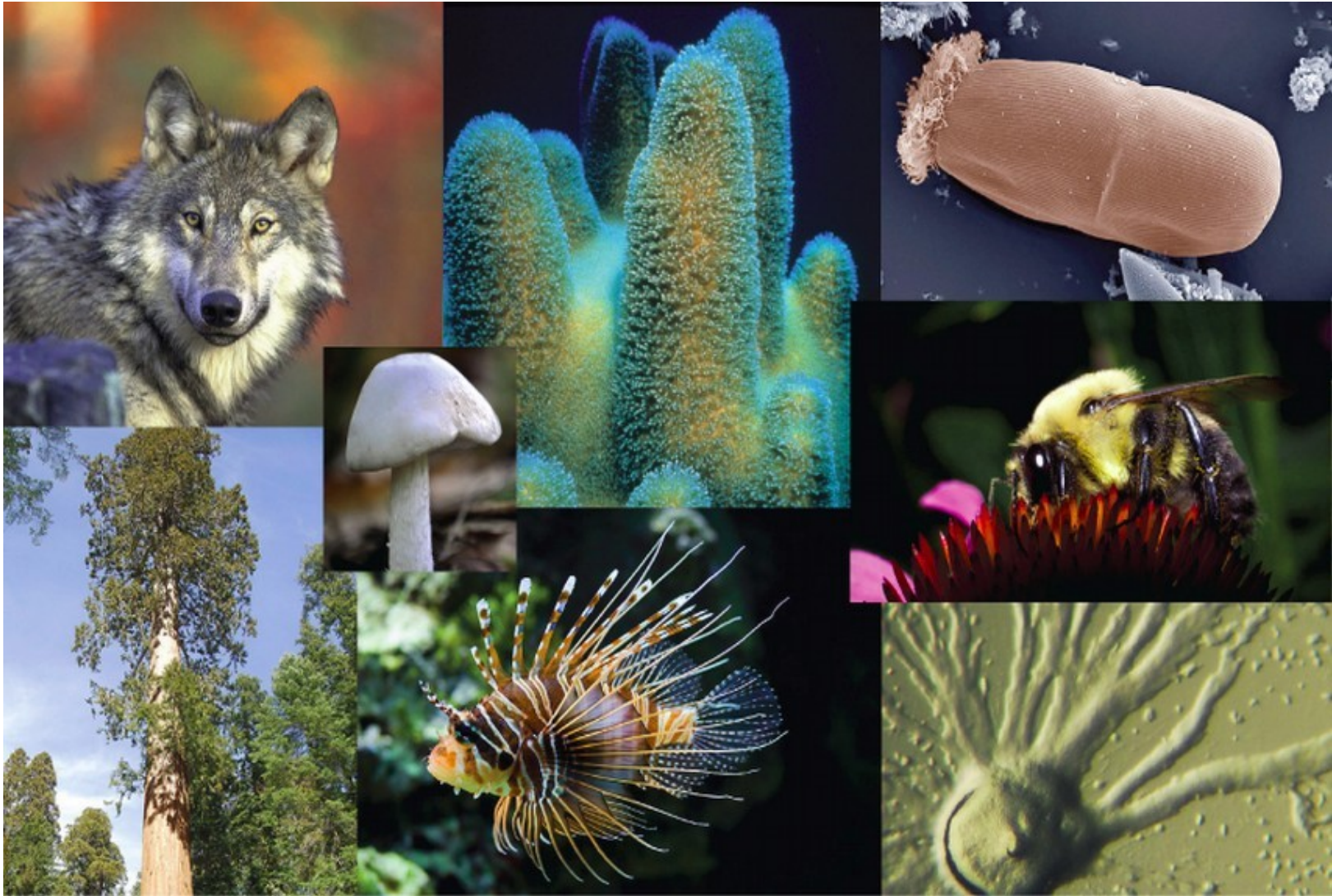
Part I – Introduction to Biology

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

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 to 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

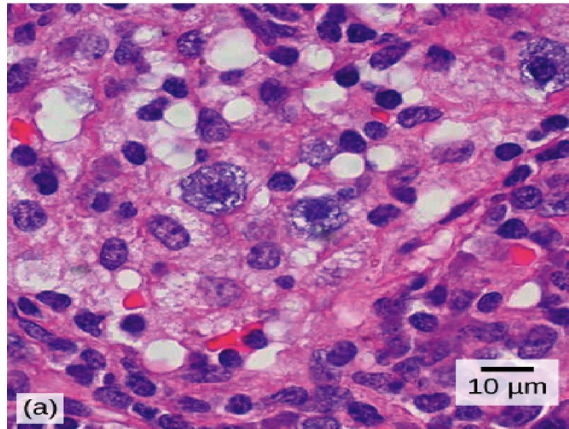
(Note: Not all biologists describe life using the above processes, some do it in slightly different ways)

I. Cellular organization

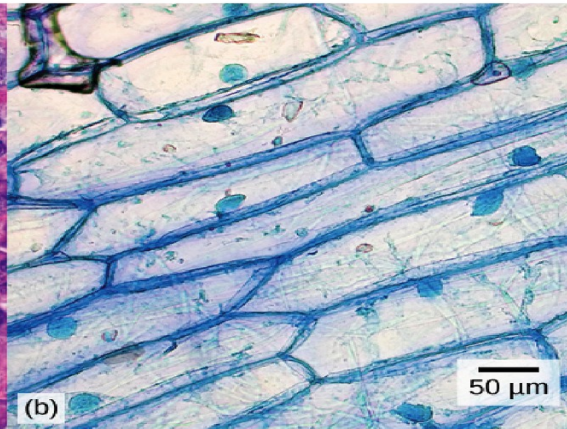
Cells – basic building blocks of all living organisms

- Contained space that isolates reactions from the surrounding environment
- Smallest unit that can perform all the processes of life

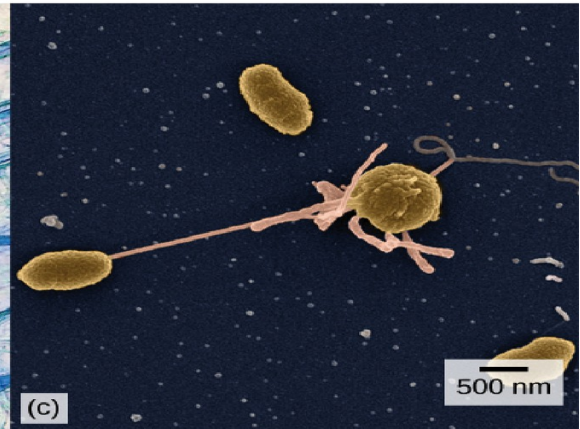
Human sinus cells



Onion cells



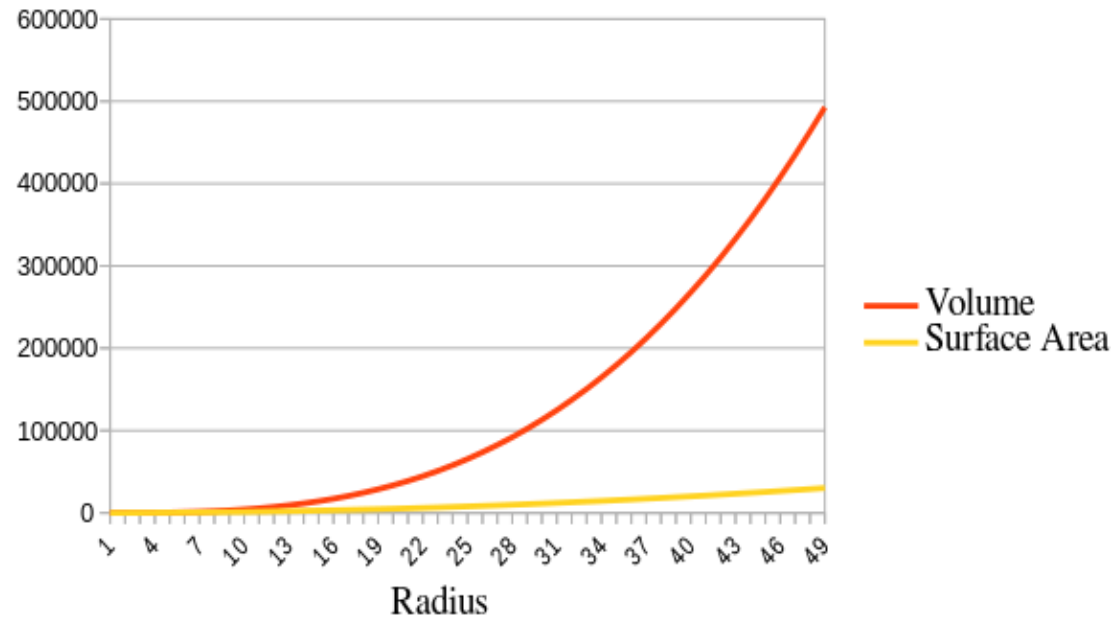
Bacterial cells



- **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

**rare exceptions*

Volume and surface area for a sphere



(Reading) Exercise

- Rarely, cells are so large that they can even be seen with the naked eye. *Which are the largest cells found in nature?*

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)

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

DNA and Genes

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

II. Metabolism

Sum of all chemical processes in an organism

- Obtain and use energy
 - for cellular processes
 - for making the building blocks of the cell
- Eliminate waste

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

- E.g. Amoeba moving away from light
 - Some animals hibernating 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

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

Some interesting reproductive strategies

- Many female birds, rabbits and reptiles can store sperm for months
- Females of many species, including some mantises and spiders, feed on the male immediately after mating
- Some fish can switch sex in days



Photo: Nick Hobgood/Wikimedia

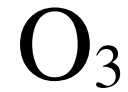
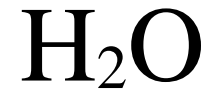
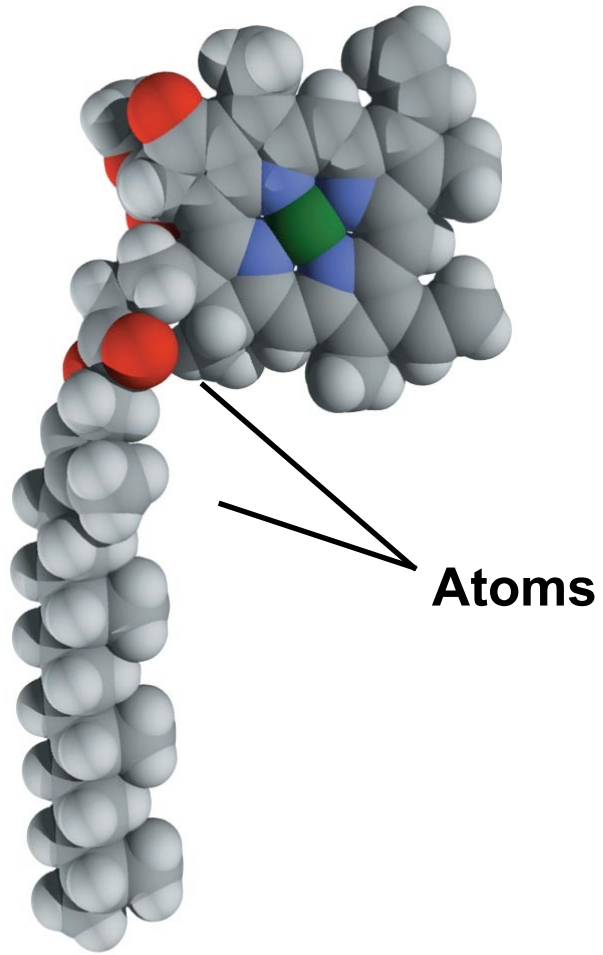


Photo: Oliver Koemmerling/Wikimedia

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



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Molecules

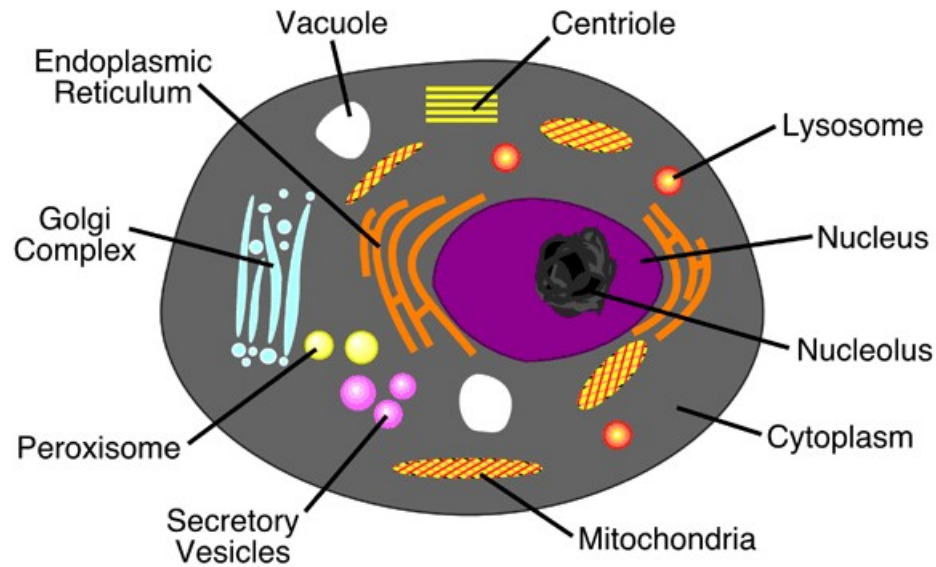
Organelles (subunits of Cells)

(e.g. Chloroplast - photosynthesis)



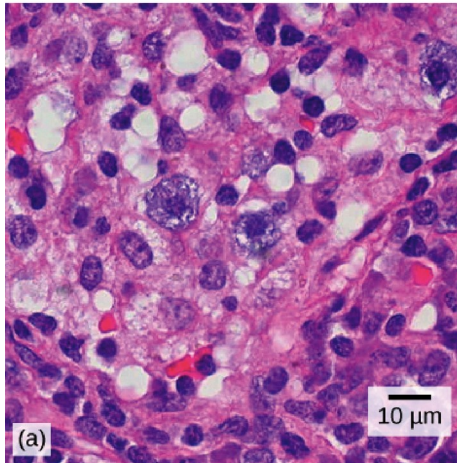
Cells

- basic
building
blocks of
life

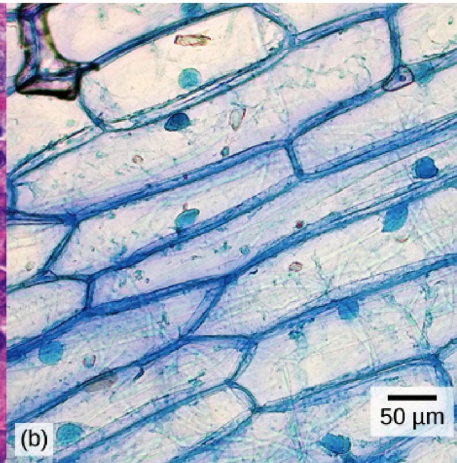


Source: <http://www.physicalgeography.net/fundamentals/6a.html>

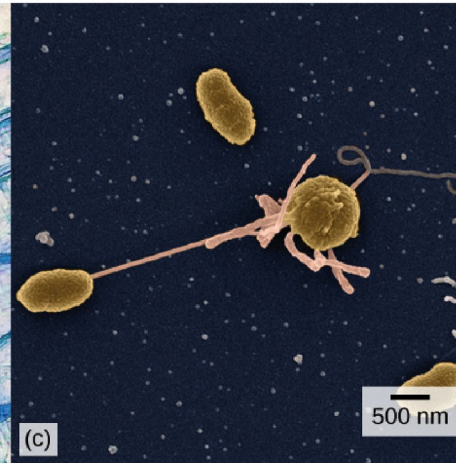
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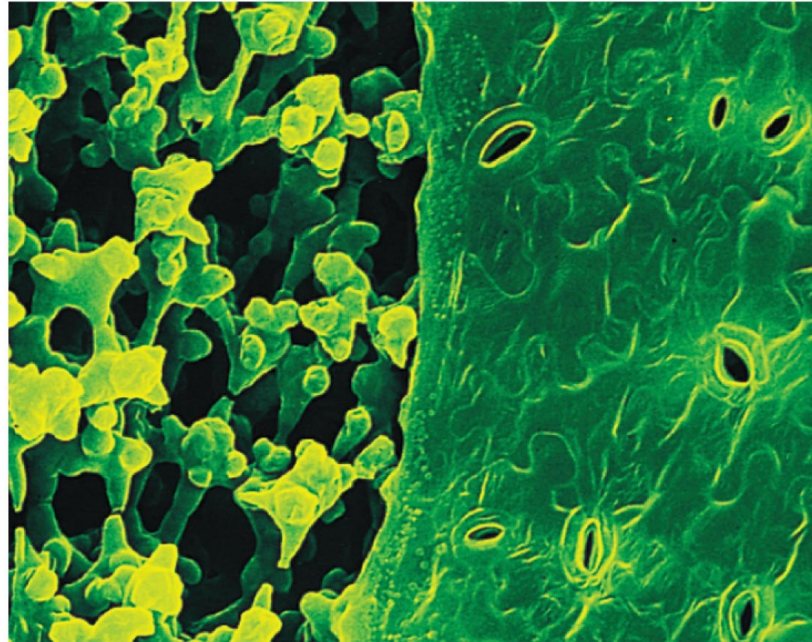


Bacterial cells



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

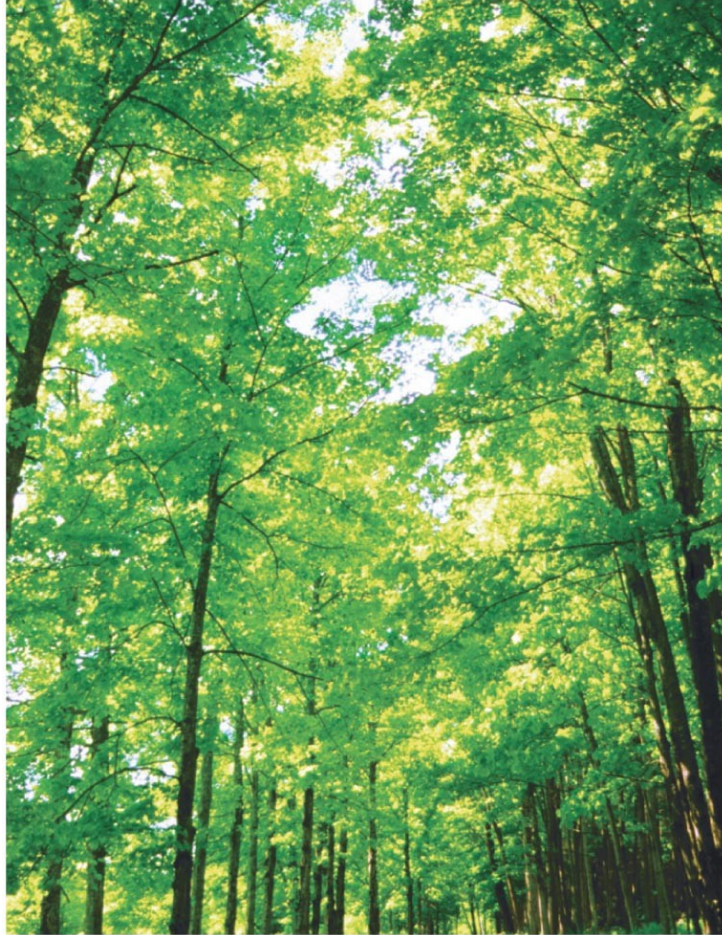
Organs



Organisms (Individuals)



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



Community - Populations of all species in an area



Ecosystems - Community AND non-living environment



Environment

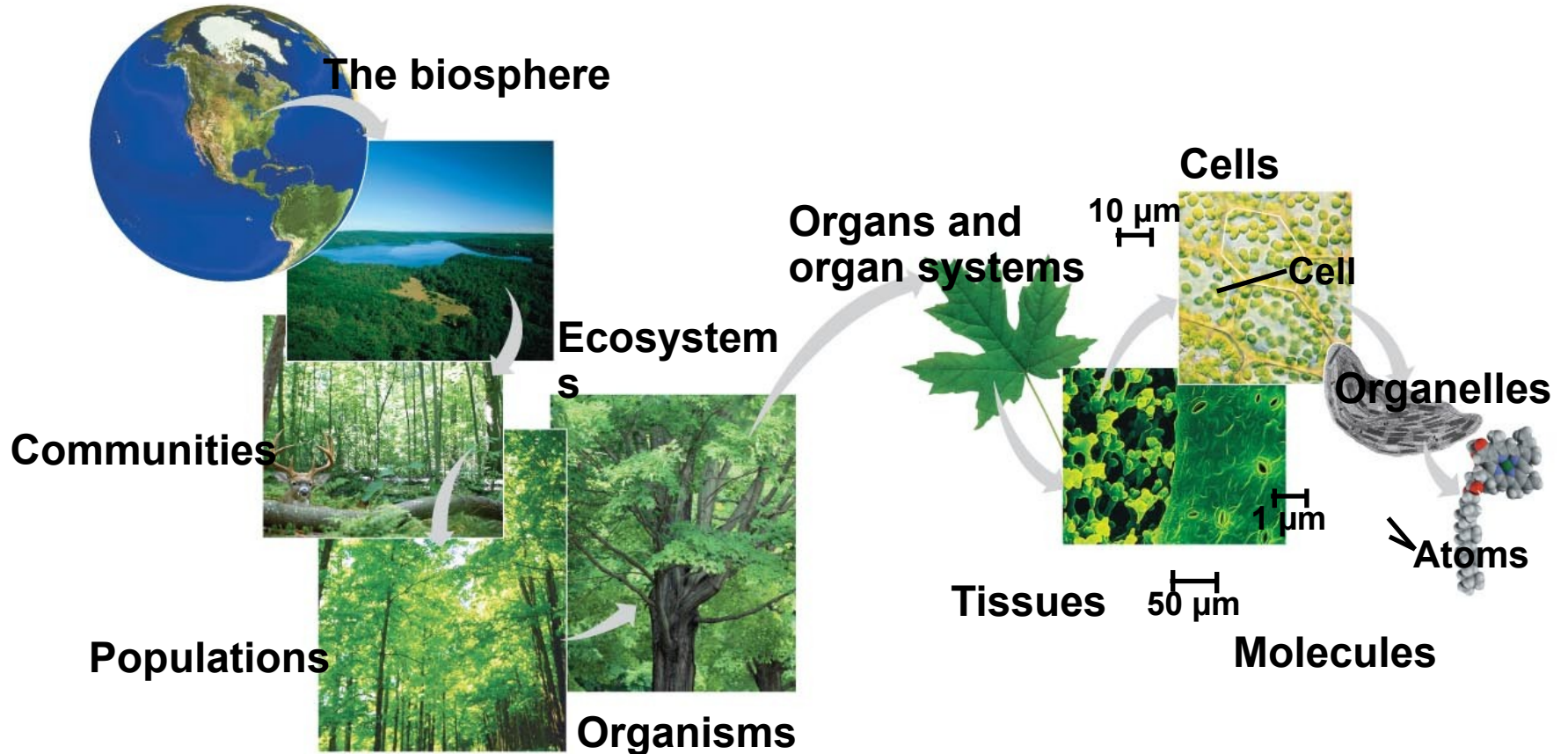
- Biotic – living things
- Abiotic – non-living matter

The biosphere

Zone of life on earth.
Sum of all ecosystems



Scales of Life



Ecology

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

Subjects of typical ecological studies

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

In its broadest sense, Ecology also includes

Ethology/Behavioural Ecology (study of animal behaviour), and

Evolutionary Biology/Evolutionary Ecology

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