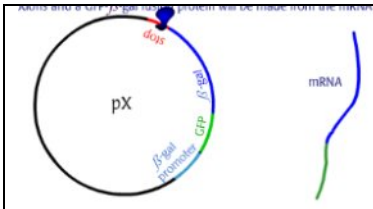
MODULE 3: MOLECULAR BIOLOGY

Model Organisms:

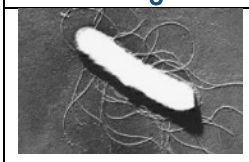
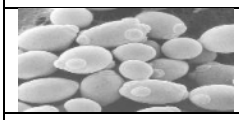
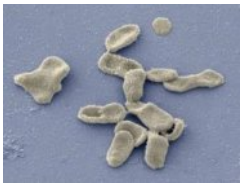
A ***model organism*** is a non-human species that is extensively studied to understand particular biological phenomena, with the expectation that discoveries made in the ***organism model*** will provide insight into the workings of other ***organisms***.

- used to research human disease when human experimentation would be unfeasible or unethical.
- usually meet a determined taxonomic equivalency to humans, so as to react to disease or its treatment in a way that resembles human physiology.

	GFP causes *Aequorea Victoria* jellyfish to glow. The GFP gene is inserted downstream of the promoter of the gene of interest in an organism. RNA Polymerase binds to the promoter region to initiate transcription through the end of the gene of interest. If GFP gene is correctly inserted, there will be no stop codon in between the two genes and a fusion protein will be made from the mRNA.

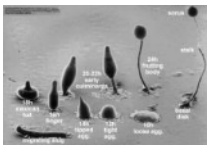
1.) Attaching the GFP gene to the native promoter can make the whole cytoplasm glow.
2.) Making a rDNA (recombinant) with GFP gene and gene of interest causes only particular sites with that protein to glow (helps visualise cell differentiation).

Model sub-cellular processes (w/o multicellularity)

Model Organism	Notes
	*Escherichia coli* • Model prokaryotic organism • Easily obtained, cultured and manipulated • Glycolysis, Citric acid cycle
	*Saccharomyces cerevisiae* • Model Eukaryotic organism
	*Mycoplasma genetalium* • Prokaryote with smallest known genome- **Minimal Organism.** • First artificial organism • Lost most of its genome since it can only survive in one environment only • Contains names of researchers from Craig Venter Institute, a quote from James Joyce “To live, to err, to fall, to recreate life out of life”, contains executable HTML code.

Model cellular interactions (w/o tissues)

Model Organism	Notes
	*Chlamydomonas reinhardtii* • Models photosynthesis • Alga with uni and first multi cellular stage (jelly holding many cells) • Motile (flagella), follows signals to communicate between cells through ECM, and can solve problems.

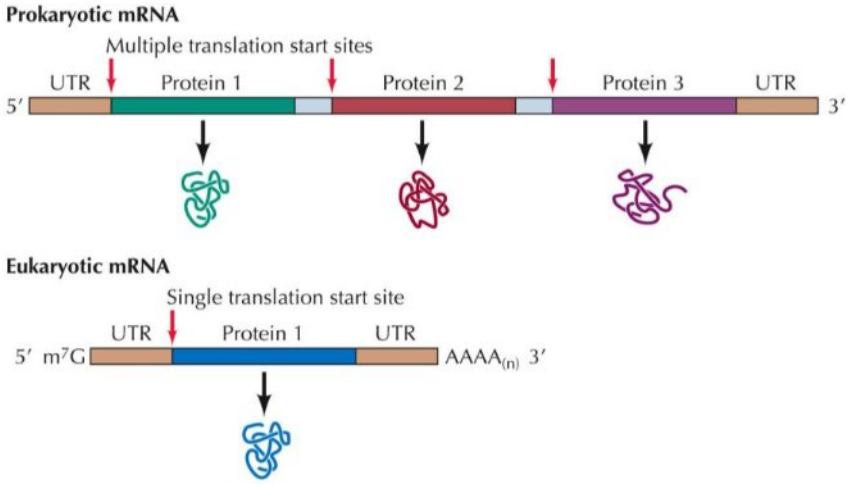


Dictyostelium discoideum

- Slime mold (X) with uni- and multi-cellular life stages
- Single-celled stage looks like an amoeba and engulfs bacteria
- Lives on moist substrate, no flagella – very slow
- Once it eats all the bacteria on the substrate, it starts starving and individual cells send signals to aggregate into **migrating slug**. Has a head to look around and detect signals. It can move faster as a slug and fins food to feed faster. Once eaten a lot, it stops.
- Models Apoptosis- cell sacrifice of stalk cells

TRANSCRIPTIONAL REGULATION

It is the means by which a cell regulates the conversion of DNA to RNA (transcription), thereby orchestrating gene activity by transcription factors and other proteins working in concert to finely tune the amount of RNA being produced through a variety of mechanisms.



Polycistronic mRNA refers to a messenger RNA which encodes two or more proteins, and participate in the translation process of prokaryotes.

Operon: a transcriptional unit made up of multiple linked genes controlled by the one promoter/ which is thought to regulate other genes responsible for protein synthesis.

-These details were worked out by mutant analysis.

- **Inducible Operon** (turned on): usually switched off but can be stimulated/ activated when **glucose** is low and **lactose** is present. **Inducible enzymes** are usually catabolic, their synthesis is induced.

- Repressible: usually switched on but can be inhibited when a specific molecule binds allosterically to a regulatory protein. **Repressible enzymes** are usually anabolic that synthesize an end product from raw material.

- **Non-inducible mutants-** lac operon was never expressed because repressor always binds to the operator due to:

- mutant repressor
  - weak dipole-dipole/ H-bonding between allolactose and repressor,
  - even if allolactose attaches to inhibitory repressor protein, it does not detach- structural mutation
  - active site of protein is blocked
- mutant operator

-Constitutive mutants- lac operon always expressed because the repressor was unable to bind to the operator due to:

- unavailability of repressor
- presence of mutant repressor (mutation in lacI gene)
- mutant operator (mutation in the non-coding DNA regions that have an effect on protein phenotype)

MODULE 1b: BIOCHEMISTRY

(Alberts et al. readings)

- Folding of protein macromolecules occurs via a large set of weak interactions produced by non-covalent bonds between atoms- ionic, hydrogen, van der waal's and interactions between non-polar groups caused by hydrophilic expulsion from water.
- In accordance with the second law of thermodynamic laws, universe is an isolated system that tends towards greater degree of disorder (random motion of molecules measured by entropy). To create order, living things perform various catabolic and anabolic chemical reactions involving small organic molecules of amino acids, sugars, nucleotides and lipids. A Living cell is not an isolated system, it takes in energy from the environment (as food, photons) and uses it to create order within itself. A part of this energy is released as heat which is discharged into the environment and creates more disorder. Hence, the total entropy (cell + surroundings) increases. This is also compatible with the first law of thermodynamics- energy cannot be created or destroyed but can be converted from one form to another. The conversion of chemical energy to heat energy is essential if the reactions inside a cell are to cause the whole universe to become more disordered.
- Spontaneous process: Generation of a greater degree of disorder without intentional effort.
- Cell metabolism is organised by enzymes. They exert a level of control and accelerate/ catalyse one of the many reactions a single molecule can possibly undergo. Long linear reaction pathways form a maze of interconnected reactions.
- Catabolic pathways: break down macromolecules for utilization and generate energy
- Anabolic pathways: synthesis of molecules
- Photosynthetic organism use sunlight to synthesise organic molecules. Thus the energy obtained from sunlight as electromagnetic energy is converted to chemical bond energy (stored as chemical bonds).
- Two stages of photosynthesis:
  - Sunlight energy is captured and transiently stored as chemical bond energy in small molecules that act as energy carriers (eg: ATP). Molecular oxygen (O_2) is released as a waste product.
  - These energy carriers are used to drive CARBON FIXATION process in which sugars are manufactured from CO_2 and water.
    Light energy + CO2 + H20 → sugars + O2 + heat energy
- These activated carriers store the energy in an easily exchangeable form
  - Readily transferable chemical group
  - High energy electrons