Today’s objective

Get familiar with some (molecular / cell) biology terms…

gene
gene expression
geno

DNA

transcription

translation

translation factors

protein

procaryote
eucaryote

RNA

ribosome

cell

chromosome

promoter

procaryote
eucaryote

mitochondrion

transcription factors
There’s a long way from *cells* to complex organisms, but *cells* are the building blocks of more complicated beings and therefore are worth studying.

Besides, *cells* are difficult to understand already. And they can be very complex as well!

What do cells do?

- **grow and divide**
- **store information**
- **form part of bigger organisms**
- **move around**
- **interact with the environment**
- and so on…
What’s in a cell?

4 basic types of small organic molecules

- ? sugars — energy sources, food
- ? fatty acids — membranes
- ? nucleotides — subunits of nucleic acids (DNA, RNA); can also act as energy carriers (ATP)
- ? amino acids — subunits of proteins, the “workhorses” of the cells

And also ions (Ca$^{2+}$, Mg$^{2+}$, Cl$^{-}$, K$^{+}$, etc), lots of water, some other organic molecules, and structures that arise by combining these basic constituents.

Two classes of cells

- Bacteria and cyanobacteria
- 1 to 10 $\mu$m
- anaerobic or aerobic
- few or none organelles
- circular DNA in cytoplasm
- RNA and protein synthesis in same compartment
- no cytoskeleton
- chromosomes pulled apart by attachments to plasma membrane
- mainly unicellular

**procaryotes**

- protists, fungi, plants and animals
- 5 to 100 $\mu$m
- aerobic
- many organelles
- long linear DNA bounded by nucleus
- RNA synthesis in nucleus, protein synthesis in the cytoplasm
- cytoskeleton
- chromosomes pulled apart by spindle apparatus
- mainly multicellular

**eucaryotes**

[adapted from Alberts et al, Molecular Biology of the Cell]
**Cell structure**

- **In procaryotes** it is a circular chain that floats around in the cytoplasm.
- **In eucaryotes** it consists of several long linear chains called *chromosomes*, with specialized structures that guarantee a faithful duplication (centromere, telomeres); everything heavily packed inside the nucleus.
- The collection of all the DNA in one cell is referred to as its *genome*.
- Composed of A, T, C, G bases
- Double helix structure, but it can also fold in several ways.
- Negatively charged
- Human: 24 chromosomes, each with $10^7 - 10^8$ base pairs.

**DNA**

DNA encodes information. It defines the *genotype* of a cell.

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The central dogma

A portion of DNA, called a gene, is transcribed into RNA. RNA is translated into proteins.

Details of the process are different in eucaryotes / procaryotes.

Expression might depend on the gene.

More details...

The genetic code

From DNA to proteins in an eucaryotic cell.

Introns and exons

126 580
143 222 224

Rabbit β-globin

tRNA and ribosomes
Proteins

- The function of a protein is basically given by its geometric shape.
- After translation a protein has to be folded properly for rendering it functional.
- Predicting the shape of a protein given its sequence it's a huge open problem!

Regulation of gene expression

Regulation can take place all along the protein synthesis process.

To start transcription, RNA polymerase has to bind to a portion of DNA right before the gene to be translated. That region is known as the gene **promoter**.

“Activity” of promoters is regulated by the binding / unbinding of transcription factors to some “neighboring” pieces of DNA.

Being able to predict where a transcription factor will bind to and what its effect will be it is also a huge open problem.
Regulation of gene expression

Two examples

Gene expression

Lactose consumption regulation in *E. Coli.*

Galactose signaling network in *S. Cerevisiae.*

The amount of proteins produced is a dynamic process. It is not entirely determined by the genotype, it will also depend on the environment and the cell history. Cells can use this fact to store information in the amounts of proteins that they hold; different patterns of protein concentrations can lead to macroscopic changes in cell behavior. Any information encoded in this way is referred to as the *phenotype* of a cell.