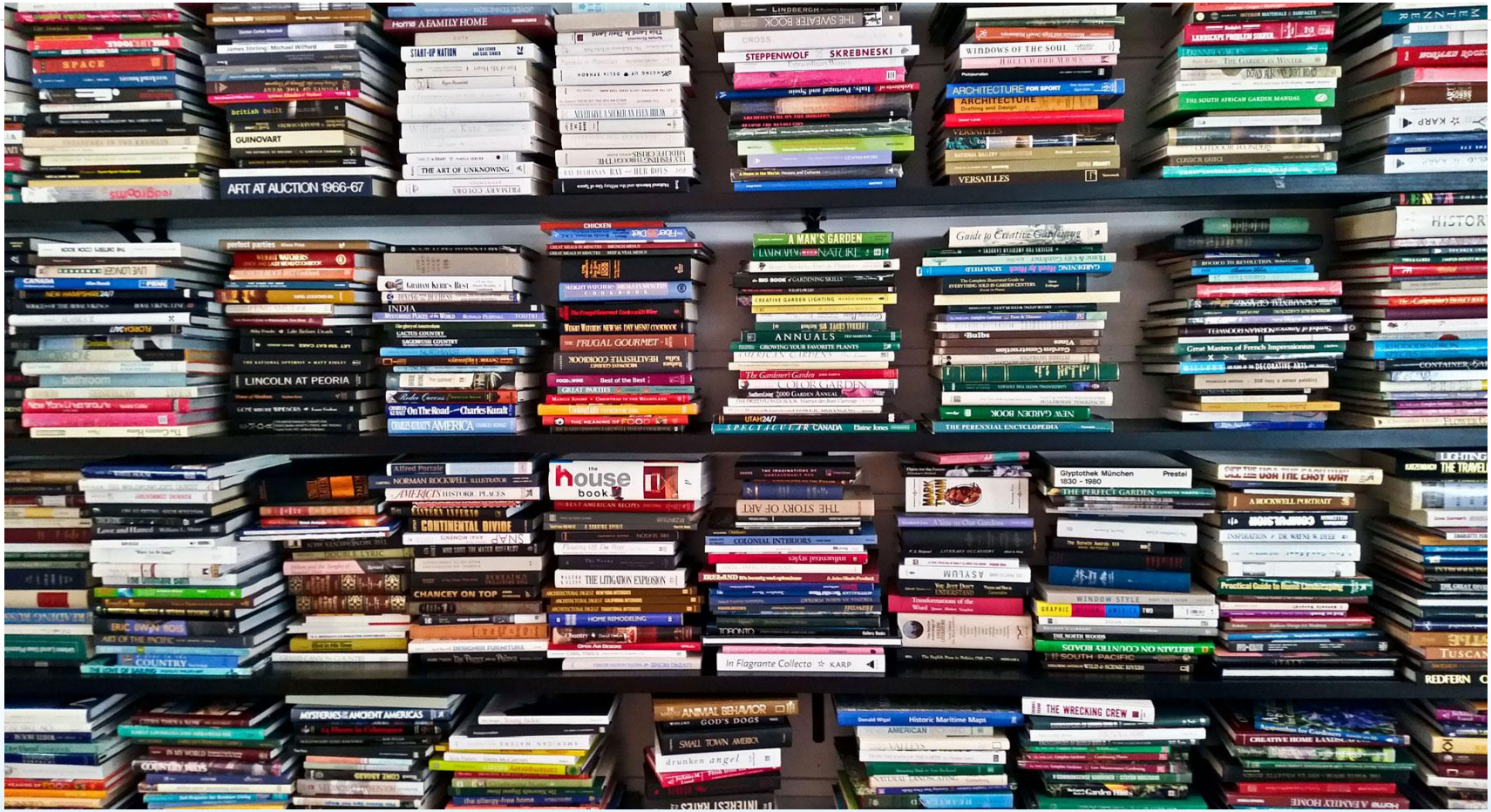
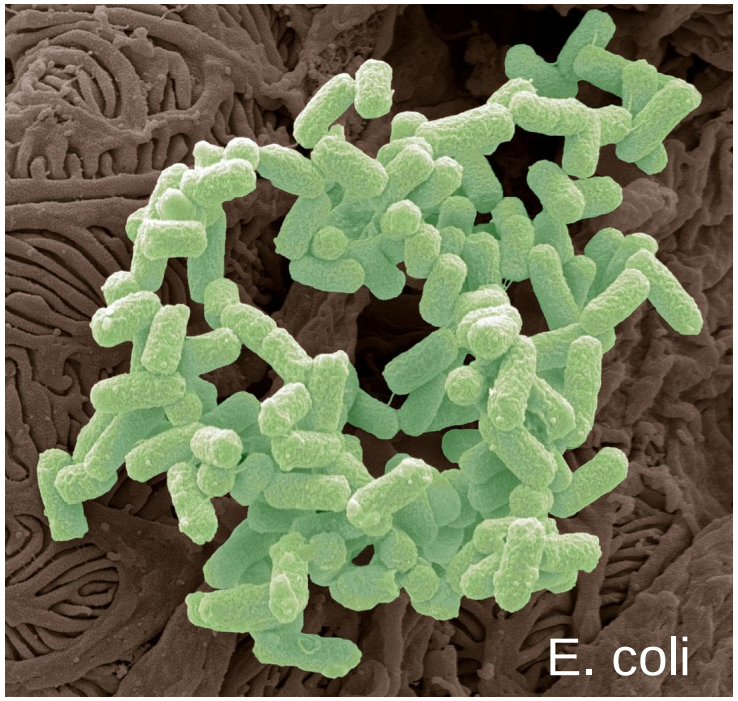
Gene Regulation and Expression



Prokaryotic Gene Regulation

- To conserve energy and resources, cells control which genes they express.
- By regulating gene expression, bacteria can respond to changes in their environment such as the presence or absence of nutrients.
- DNA-binding proteins in prokaryotes regulate genes by controlling transcription.

One of the keys to gene transcription in bacteria is the organization of genes into **operons:** a group of genes that are regulated together.



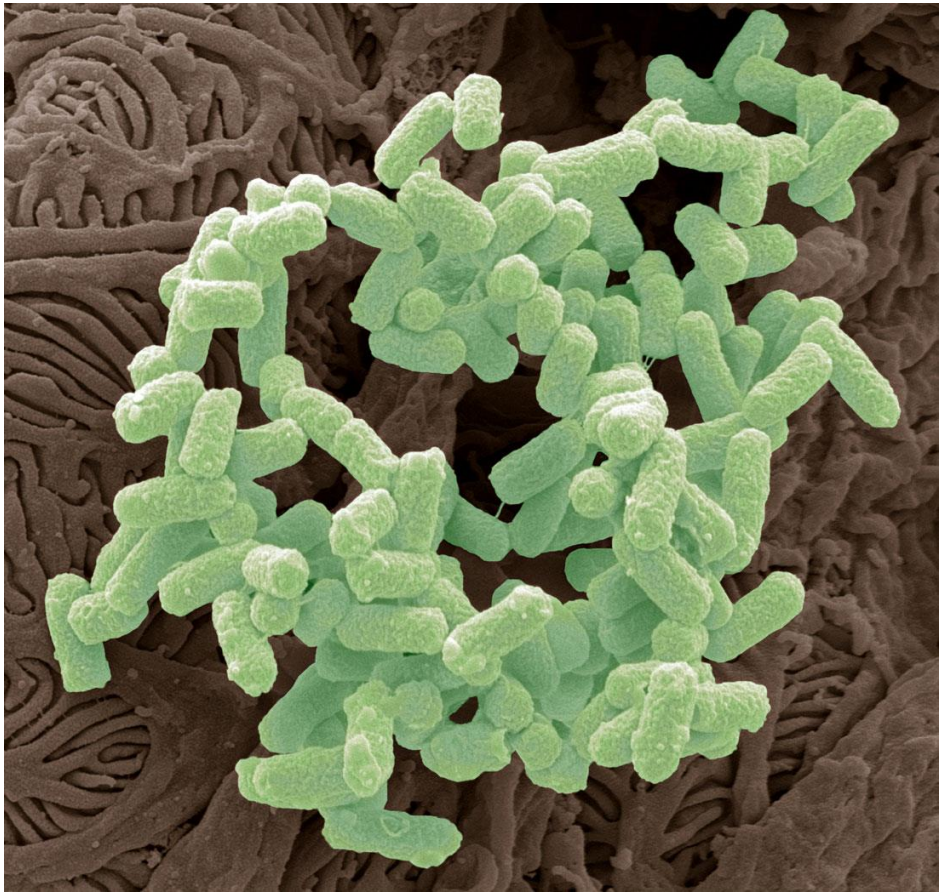
The *Lac* Operon

Lactose provides food for the bacterium.

When lactose is present, the genes must be transcribed to produce the proteins.

When lactose is not present, the *lac* genes are turned off by regulatory proteins that bind to DNA and block transcription.

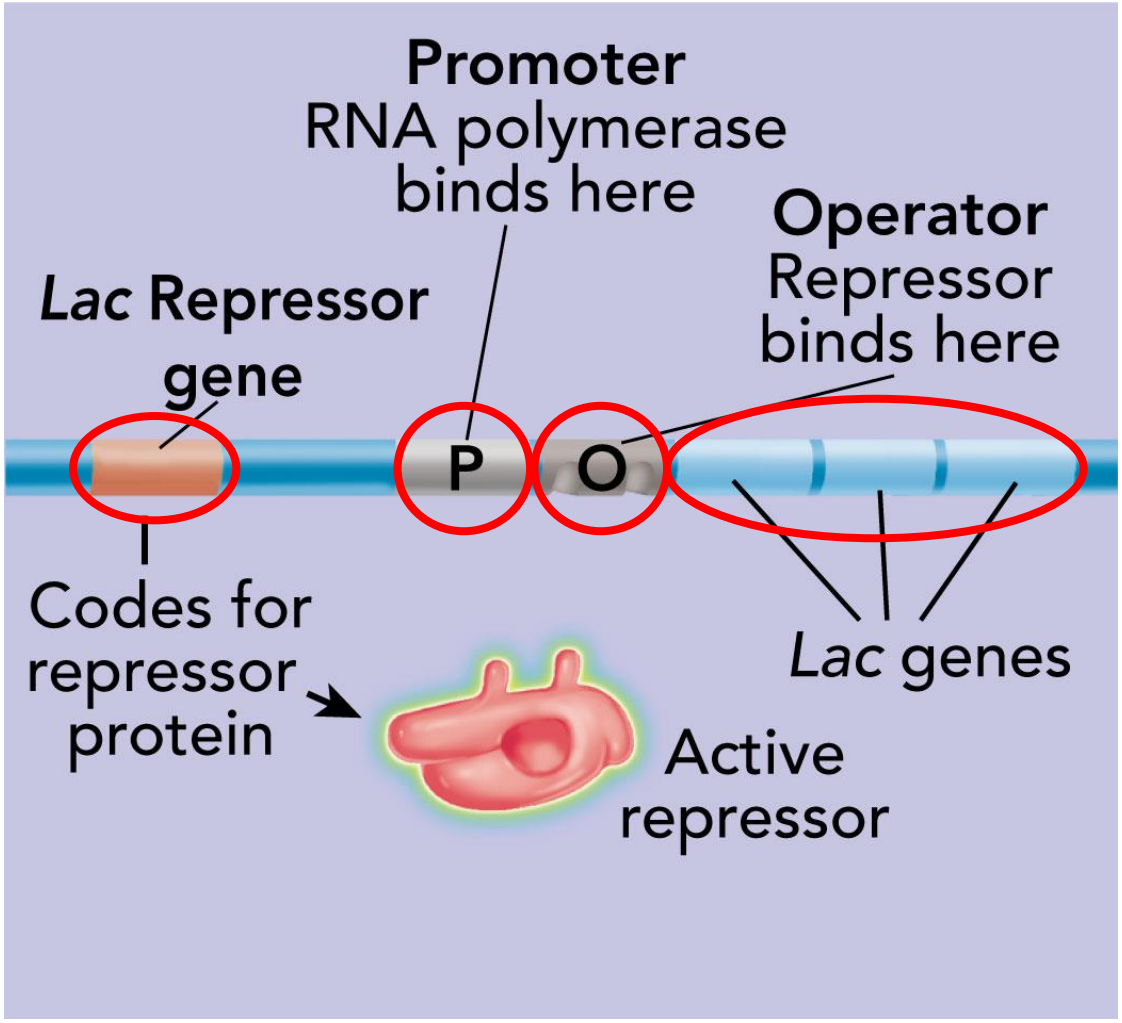
The bacterium “knows”.



Promoters and Operators

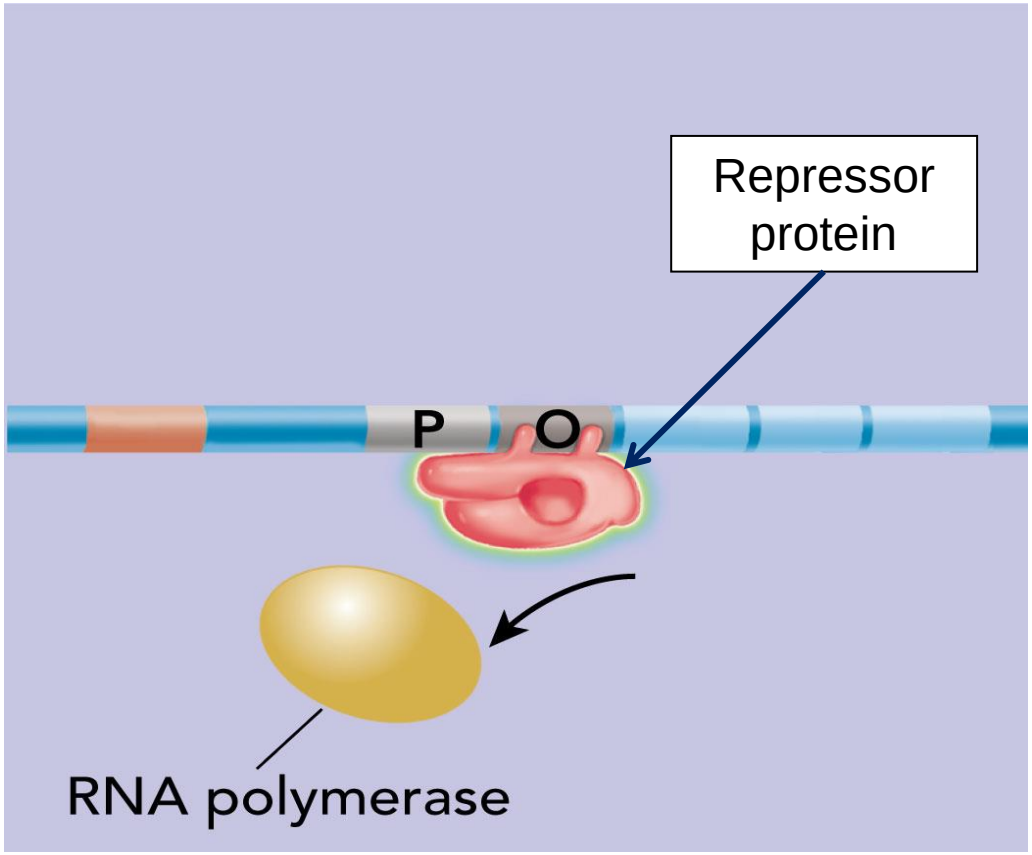
Located in front of the operon's three genes are two regulatory regions:

- A promoter (P): a site where RNA polymerase can bind to begin transcription
- An **operator** (O): site where a DNA-binding protein known as the *lac* repressor can bind to DNA



The *Lac* Repressor Blocks Transcription

When lactose is not present, the *lac* repressor binds to the operating region (O). This blocks RNA polymerase from transcribing the *lac* genes.



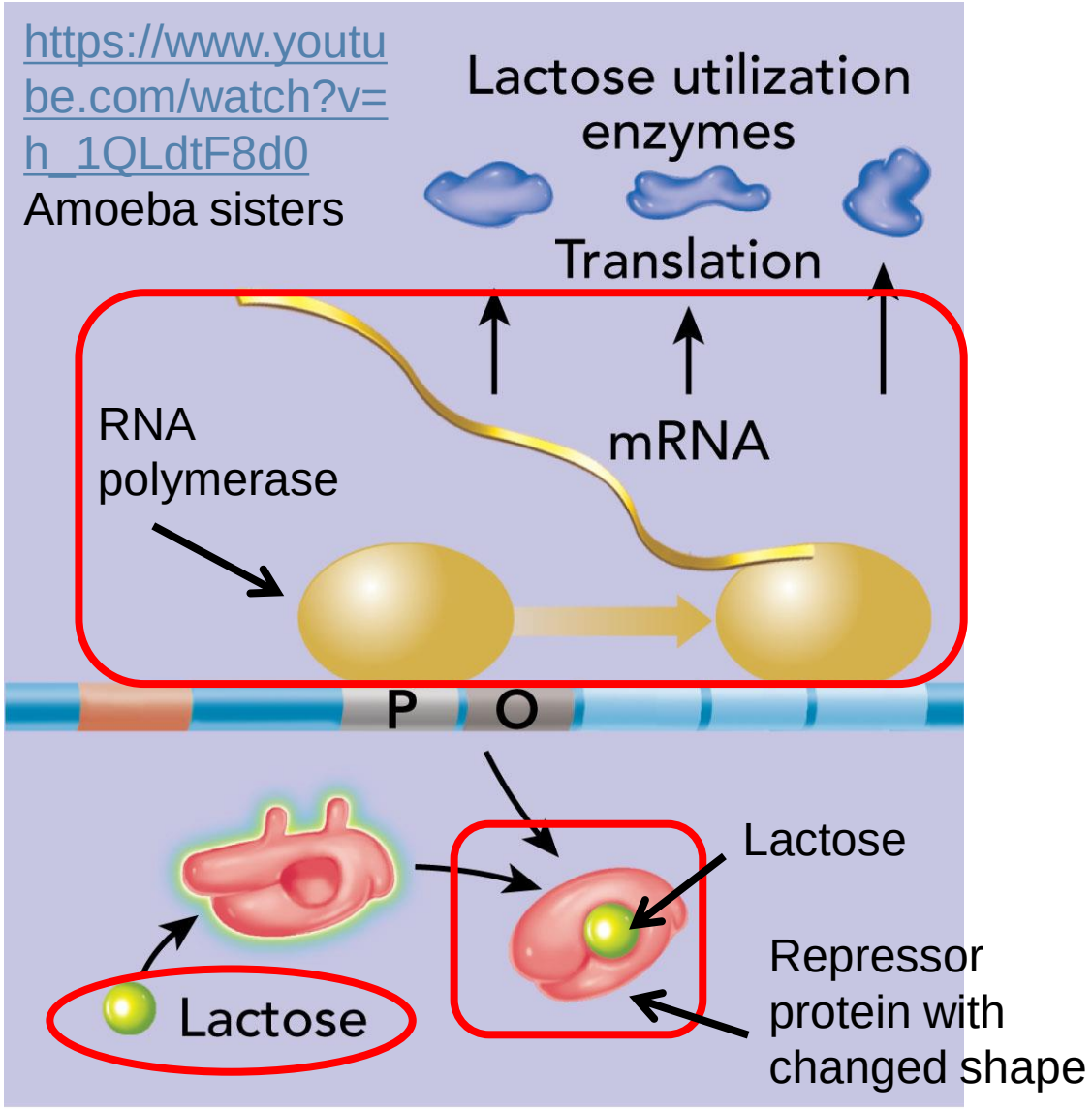
Lactose Turns On the Operon

When lactose is added to the medium, it diffuses into the cell and attaches to the *lac* repressor.

This causes the release of the repressor, which then moves away from the operating region.

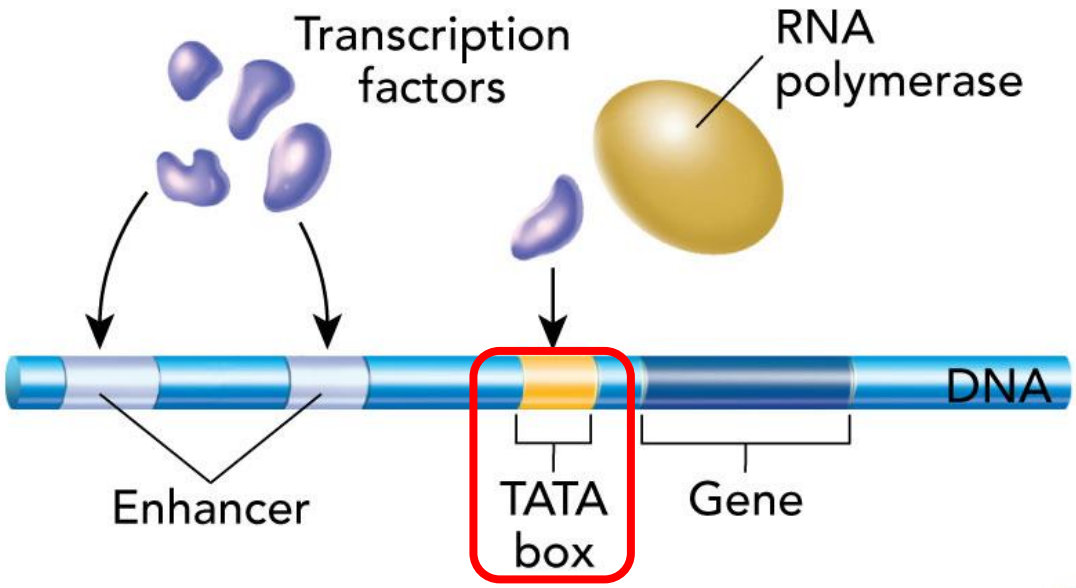
Transcription can now take place.

https://www.youtube.com/watch?v=h_1QLdtF8d0
Amoeba sisters



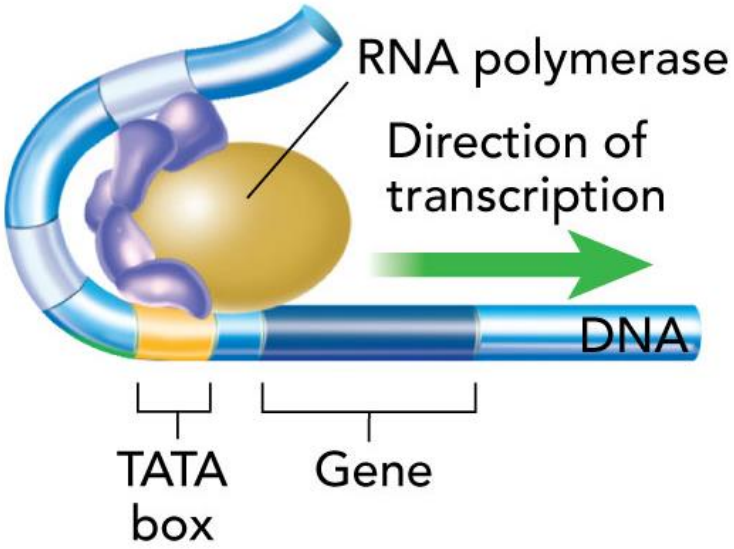
Eukaryotic Gene Regulation

A typical eukaryotic gene has a TATA box.



TATA box is a short region of DNA (25-30 base pairs before the start of a gene).

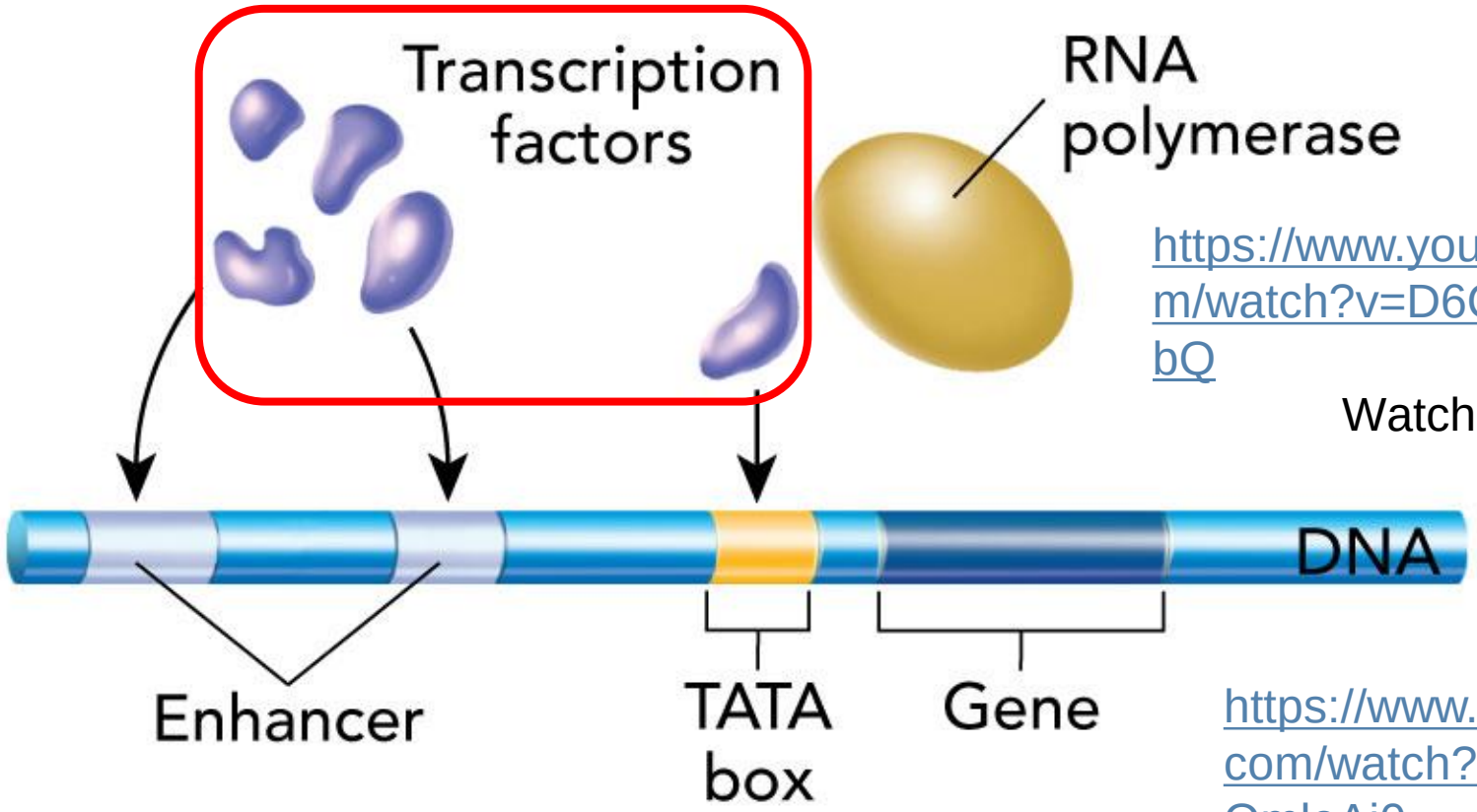
Binds a protein that helps position RNA polymerase by marking a point just before the beginning of the gene.



Transcription Factors

DNA-binding proteins known as *transcription factors* play an important part in regulating gene expression.

By binding DNA sequences in the regulatory regions of eukaryotic genes, transcription factors control the expression of those genes.



https://www.youtube.com/watch?v=D6CYI4HqabQ

Watch 1st

https://www.youtube.com/watch?v=3S3ZOmleAj0

Watch 2nd

Cell Specialization

The genes that code for liver enzymes are not expressed in nerve cells.

Cell differentiation requires genetic specialization, yet most of the cells in a multicellular organism carry the same DNA in their nucleus.

Complex gene regulation in eukaryotes is what makes differentiation and specialization possible.

Complex changes in gene expression allow the cell (for a new organism that begins as a single cell) to develop into a functioning multicellular organism.

Genetic Control of Development

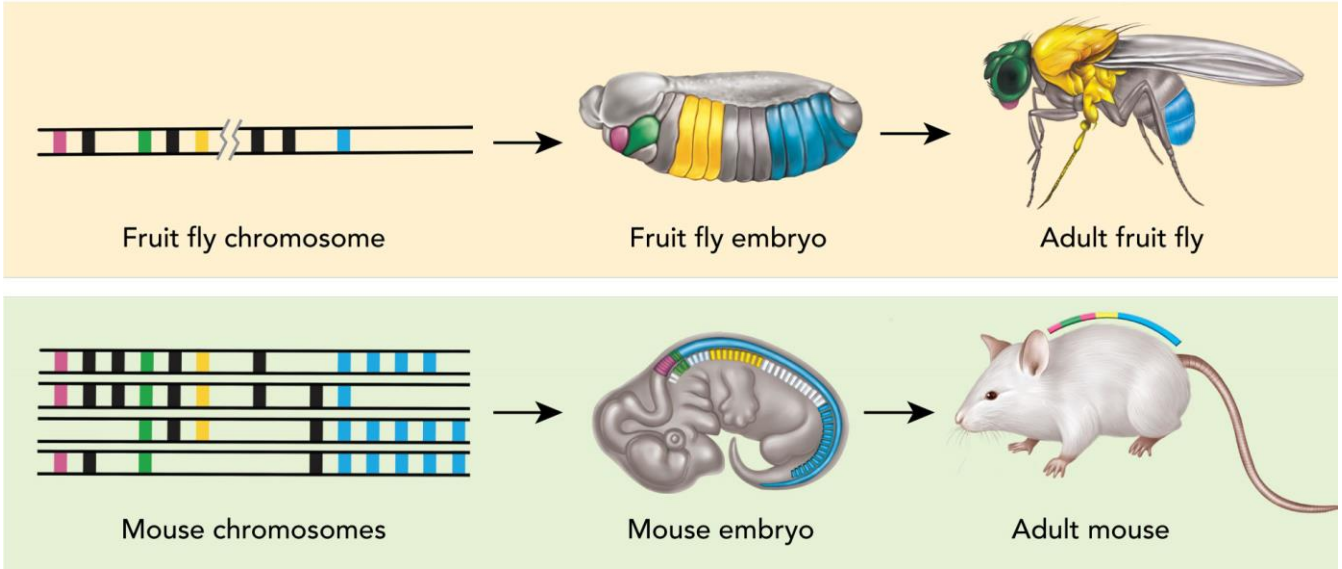
Regulating gene expression is important in shaping how a multicellular organism develops especially in the earliest stages of development.

Each of the specialized cell types found in the adult originates from the same fertilized egg cell.

Differentiation: a process that gives rise to specialized tissues and organs

Homeotic, Homeobox, and Hox Genes

- **Homeotic genes:** regulate organ development; these are the master control genes
- **Homeobox genes:** code for transcription factors that activate other genes that are important for cell development and differentiation.
- **Hox genes:** determine the identities of each body segment.



Clusters of Hox genes exist in humans as well. They tell the cells of the body how to differentiate as the body grows. This means that nearly all animals share the same basic tools for building the different parts of the body.

Epigenetics

- Epigenetic mechanisms control which genes are on and which are off during each stage of an insect's life cycle.
- Large numbers of methyl groups (-CH_3) will cause chromatin to condense shutting down gene expression.
- The attachment of acetyl groups (-COCH3) will open chromatin up for transcription and gene expression.

https://www.youtube.com/watch?v=_aAhcNjmvhc
https://www.youtube.com/watch?v=MD3Fc0XOjWk

Environmental Influences

In prokaryotes and eukaryotes, environmental factors such as temperature, salinity, and nutrient availability can regulate gene expression.

The environment can influence how and when epigenetic marks are attached. Examples include children born after WWII. They had higher rates of obesity, diabetes, and cardiovascular disease from malnourished mothers.

Environmental factors can affect gene regulation.

Raised at temperatures below 25°C

Raised at temperatures above 30°C