

## Chapter 11 - Control of Gene Expression

### Control of Gene Expression: The *Lac* Operon Model of Prokaryotes

The operon model was developed by Jacob and Monod

It explains how prokaryotes can regulate genes coding for the production of enzymes for lactose utilization (depending on whether lactose is available)

The bacterium *E. coli* uses 3 enzymes to utilize lactose and the genes coding for these enzymes (**structural genes**) are regulated as a unit

Adjacent to these genes are short sections of DNA:

- A **promoter**- a short sequence of DNA where RNA polymerase first attaches when a gene is to be transcribed
- The **operator** - a short sequence of DNA (the "on/off switch" of transcription) that determines whether RNA polymerase can attach to the promoter and start transcription. For example, when a repressor binds to it, RNA polymerase is prevented from attaching to the promoter

Collectively, the genes to be transcribed plus the promoter-operator sequence that precede them make up what's called the **operon**

*Q. What determines whether the switch is on or off?*

Transcription of the genes is turned off by a protein molecule called a **repressor**

It binds to the operator and in doing so prevents RNA polymerase from attaching to the promoter

There is a gene called a **regulator gene** that is located outside the operon that codes for the repressor protein molecule

The regulatory gene is expressed continually

But the presence of lactose interferes with the attachment of the *lac* repressor to the promoter by binding to the repressor and changing its shape

When its shape is changed, the repressor cannot bind to the operator

The operator switch remains on and RNA polymerase can bind to the promoter

## Cell Differentiation and Cloning of Eukaryotes

During growth and development among eukaryotes, individual cells undergo **differentiation** – they become specialized in structure and function  
And differentiation results from selective gene expression

*Q. Among the differentiated cells of eukaryotes, are all genes still present?  
And, if they are, do the differentiated cells retain the ability to express them?*

A nuclear transplantation experiment addressed these questions among animals  
In **nuclear transplantation**, the nucleus of an egg or zygote is replaced with the nucleus from a differentiated cell

*Q. Will the transplanted nucleus support the development of the embryo?*

In the 1950s, nuclear transplantation experiments were performed by Briggs and King using frogs

They destroyed the nuclei of frog egg cells using UV light and then transplanted nuclei removed from intestinal cells into the eggs  
Many of these transplanted egg cells began to develop, and a few developed into normal tadpoles (clones)

In 1997, Wilmut and his colleagues were successful in cloning a mammal, using the nucleus of a mammal cell

The cloning of Dolly and tadpoles is called **reproductive cloning**  
Another type of cloning is called **therapeutic cloning** – creation of an early embryo (i.e., a blastocyst stage of about 200 cells; a stage before implantation into the mother's uterus)  
These blastocysts are important because they contain **embryonic stem cells** – cells which eventually give rise to all the differentiated kinds of cells of the body

The harvested embryonic stem cells can be used to create specialized types of cells that are damaged

### **Control of Gene Expression Among Eukaryotes**

DNA is usually tightly wound and coiled so that its genes are not accessible

At the first level of packing we see **histones** attached to DNA

The DNA-histone complex is called a **nucleosome**

Nucleosomes may help control gene expression by limiting the access of the cell's transcription enzymes to the DNA (e.g. the DNA is inaccessible for transcription)

At the next level of DNA packing, the beaded string is wrapped around into a tight helical fiber

Then this fiber coils further into a thick supercoil

More looping and coiling can further compact the DNA

The roles of DNA packing in the control of gene expression are mostly unknown, except in a few cases

One such case is the **Barr body** found in the cells of female mammals

A barr body is a highly compacted X chromosome in which almost all of the genes are inactive – **X chromosome inactivation**