What to FOCUS on when reading Ch.18 *(Regulation of Gene Expression)* & to STUDY well in your slides

- **After studying, practice teaching the contents of your slides out loud to your imaginary classroom. Practice sketching all the components of eukaryotic vs prokaryotic genes, using proper terminology, defining terms, describing steps to activate gene expression in prokaryotes vs eukaryotes etc.**

- **Once you are done studying & teaching the material, check off those boxes next each of the topics below that you know you have fully mastered.**
  - **Restudy unchecked topics until you are able to check them ALL off !**

Bacterial Gene Expression Topics to Know

Concept 18.1: Bacteria often respond to environmental change by regulating transcription.

☐ Prokaryotes and eukaryotes can alter their pattern of gene expression in response to change in environmental conditions. Multicellular organisms also must control which genes are expressed in different tissues. State **the 2 levels at which metabolic control occurs.** Which is considered a **rapid response** and which a **slower more long-term response** to changes in the environment?

☐ Describe the structure and role of a **promoter.**

Most genes in a prokaryote are composed of a **promoter** *(where RNA polymerase docks on to the DNA*) followed downstream by a section containing **coding DNA** *(nucleotide sequences that encode instructions regarding the amino acid sequences of a polypeptide / protein)*, known as an open reading frame (ORF) or transcriptional unit since this is the part of the gene that will get transcribed into mRNA. However, **PROKARYOTES** have also evolved coordinate gene expression control systems called **operons**. For example, *E. coli* synthesizes the amino acid tryptophan in a multi-step pathway in which each step is catalyzed by a specific enzyme. The five (structural) genes that code for these enzymes are clustered together on the bacterial chromosome as part of an operon instead of found separately within the circular chromosome of the bacteria.

☐ List the **three components (structure) of an operon**. Explain the role of **each** one of these components..

☐ Describe the role / purpose of an **operon**. What is the benefit of organizing multiple structural genes' Open Reading Frames (transcriptional units / coding sequences) into one operon?

☐ Describe the **operator**. Where is it located?

☐ How does the operator's location within the promoter or between the promoter and structural protein-coding genes allow the **control of RNA polymerase access to the structural genes** *(the open reading frames or transcription units with coding sequences for building proteins within the operon)*?

☐ What is the role of the **repressor protein.** How does it do its job in general?

☐ What are **regulatory genes** (which are not found within operons) in general?

☐ In E. coli, **a SINGLE promoter serves all 5 genes** (all 5 Open Reading Frames) that code for the tryptophan synthesizing enzymes, which together constitute now one operon transcription unit. Transcription gives rise to one long mRNA molecule that codes for the five polypeptides making up the enzymes in the tryptophan pathway. What is a **major benefit of grouping genes with related function into one transcription unit within one operon?**

☐ Distinguish between **inducible operons** vs **repressible operons**.

NEGATIVE GENE REGULATION:
Operons are switched OFF by the active form of the repressor protein.

- The **trp operon is a repressible operon**, its transcription is always on but it can be inhibited (repressed) when a small molecule like tryptophan binds allosterically to a regulatory protein.

☐ **The trp operon in E. coli** allows cell to control the making of the enzymes needed in the amino acid tryptophan biosynthesis pathway based on changes in tryptophan availability in the environment. Can you **draw** a labeled trp operon? **Remember the trpR regulatory gene for the trp operon is NOT part of the top operon.**

☐ How exactly is the **operon switched off**?

☐ How does the bacterial cell make the **trp repressor**?

☐ Is the **trp repressor made it its active or inactive form**?

☐ How do we **activate and deactivate** the trp repressor protein? What is a **co-repressor**? What is acting as a corepressor when it comes to the trp operon?

☐ Can you draw a labeled **trp operon when it is being repressed** and transcription is off?

☐ Can you draw the steps that occur to express the **trp operon** (to turn transcription on)?

☐ What are the **final products of the genes that are a part of the trp operon**?

POSITIVE GENE REGULATION: Transcription is switched ON by a regulatory protein.

The **lac operon is an inducible operon**, usually off but stimulated (induced) by a small molecule interacting with a regulatory protein.

☐ The lac operon includes the genes (*lacZ, lacY, lacA*) that code for three enzymes involved in lactose utilization. Describe the **function of the product of the *LacZ* gene product β–galactosidase.**

☐ What is the purpose of the ***lacI* regulatory gene** and what is **the function of the protein it codes for**?

☐ Define the term **inducer**.

☐ Explain how **allolactose** *(an isomer that naturally forms from lactose)* functions as an **inducer of the lac operon**.

☐ Which sugar does *E. coli* prefers to use as its source of energy, breaking it down in glycolysis.

☐ What happens when a **repressor** is bound to the *lac* operon's operator?

☐ Would *E.coli* preferentially use glucose or lactose if **BOTH** glucose and lactose concentrations were high in the cells environment?

☐ What is an **activator**?

☐ What is **CAP**?

☐ How and when is **CAP activated** in *E. coli*? How does **CAP** work?

☐ Explain why **CAP binding** and stimulation of gene expression is **positive regulation**. Describe the effect of **CAP activation and inactivation** on *lac* operon transcription.

☐ Describe in your own words the **relationship between glucose supply, lactose supply, cAmp, and CAP**.

☐ **The *lac* operon is under both positive and negative control.** In negative control, when lactose (and so allolactose) is **not** present (but glucose is), the lac repressor binds to the operator when no lactose is present in the cell. The operon is thus **not** expressed. Why is this an advantage to the bacterial cell trying to survive?

☐ The lac repressor though is deactivated in the presence of allolactose (thus lactose). When glucose and lactose are present, the operon is transcribed but at very low levels (hardly at all). Why is this an advantage to the bacterial cell trying to survive?

☐ The lac repressor though is deactivated in the presence of allolactose (thus lactose). In positive control, when lactose alone is present and glucose is absent, the operon **is** expressed and so transcribed at **high levels**, because of the additional activation of CAP when AMP levels get high in the cell *(a result of low glucose and so low amount of cellular reparation).* Why is this an advantage to the bacterial cell trying to survive?

To review…

☐ Comment on the **transcription rate** of the *lac* operon when **glucose is present and lactose absent**.

☐ Comment on the **transcription rate** of the *lac* operon when **glucose is present and lactose is present**.

☐ Comment on the **transcription rate** of the *lac* operon when **glucose is absent and lactose is present**.

ONLY when lactose Is available AND glucose absent does E. coli use lactose as a main energy source.

FYI - *COMPARE means "to tell how they are similar" and CONTRAST means "to tell how they are different."*

☐ **Compare** the lac operon and the trp operon.

☐ **Contrast** the lac operon and the trp operon.