**Mutation and Operons Notes 2019**

**Concept: Mutations of one or a few nucleotides can affect protein structure and function**

Universal Code:

Code is redundant

several codons for each amino acid

“wobble” in the tRNA

“wobble” in the aminoacyl-tRNA synthetase enzyme that loads the tRNA

Mutagen:

-Mutagens are substances of forces that interact with DNA in ways that cause mutations. X-rays and other forms of radiation are known mutagens, as are certain chemicals.

Mutations:

-Point mutations

-\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ base change

-base-pair substitution

-silent mutation

-no amino acid change

-redundancy in code

-missense

-change amino acid

-nonsense

-change to stop codon

-Frameshift mutations

-\_\_\_\_\_\_\_\_\_\_\_\_\_ in the reading frame

-changes everything “downstream”

-insertions: adding base(s)

-deletions: losing base(s)

**Concept: Bacteria often respond to environmental change by regulating transcription**

Regulation of Gene Expression:

-Bacteria respond to their environment by regulating their gene expression

-Bacteria require \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to survive

-If there is not enough tryptophan in the environment, the bacterium responds by activating a metabolic pathway that makes tryptophan from another compound

-If, later, however, there is enough tryptophan in the environment, the bacterium switches “off” that metabolic pathway to conserve resources

-Light switch analogy

Metabolic control:

-Cells can adjust the activity of enzymes already present. This is a fairly rapid response, which relies on the sensitivity of many enzymes to chemical cues that increase or decrease their catalytic activity. The activity of the first enzyme in the tryptophan synthesis pathway is inhibited by tryptophan the pathways end product. Thus, if tryptophan accumulates in the cell, it shuts down the synthesis of more tryptophan by inhibiting enzyme activity. This is called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ inhibition, typical of anabolic pathways.

-Cells can also regulate the amount of transcription occurring for the production of an enzyme.

Prokaryote Operons:

-In bacteria, genes are often clustered into units called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, which allow the expression of several related genes to be controlled as a unit.

-An operon consists of 3 parts:

-An operator that controls the access of RNA polymerase to the genes. The operator is found within the promoter site or between the promoter and the protein coding genes of the operon.

-The promoter, which is where RNA polymerase attaches.

-The genes of the operon. This is the entire stretch of DNA required for all the enzymes produced by the operon.

- In E. coli, all 5 genes that code for the production of the enzymes that make tryptophan (when necessary) are all located together

-Benefit:

-A single “on/off” switch can control the whole group of genes

-This on/off switch, which is part of the DNA, is known as an operator

-The operator controls the access of RNA polymerase to the promoter, and therefore controls whether or not transcription occurs

Domains:

Modular architecture of many proteins

-separate functional & structural regions

-coded by different exons in same “gene”

Regulatory genes:

-Located some distance from the operon is a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ gene. Regulatory genes produce repressor proteins that may bind to the operator site. When a regulatory protein occupies the operator site, RNA polymerase is blocked from the genes of the operon.

-A \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ binds to the operator and blocks the attachment of RNA polymerase to the promoter. A repressor protein is specific for the operator of a particular operon.

Operon Types:

-A \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ operon is normally on but can be inhibited. This type of operon is normally anabolic, building an essential organic molecule.

-The repressor protein produced by the regulatory gene is inactive. If the organic molecule being produced by the operon is provided to the cell, the molecule can act as a corepressor and bind to the repressor protein, activating it.

-The activated repressor protein binds to the operator site, shutting down the operon. This type of repressible operon show the corepressor turning off the operon.

-An \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ operon is normally off but can be activated. This type of operon is normally catabolic, breaking down food molecules for energy. The repressor protein produced by the regulatory gene is active. To turn an inducible operon on, a specific small molecule, called an inducer, binds to and inactivates the repressor protein. With the repressor out of the operator site, RNA polymerase can access the genes on the operon. The lac operon is an example of an inducible operon.

-The lac operon differs from the trp operon because it is an inducible operon

-It is usually off but can be turned on

-The enzyme B-galactosidase is necessary to break down lactose (disaccharide) into glucose and galactose

-If there isn’t much lactose, there aren’t many enzymes

-In the normal state, the lac repressor is bound to the operator, causing the gene to be “off”

-When lactose is added to the environment, however, an inducer inactivates the repressor, turning the gene “on”

**Concept: Eukaryotic gene expression is regulated at many stages**

Expression of Genes:

-The expression of eukaryotic genes can be turned off and on at any point along the pathway from gene to functional protein. Further, the differences between cell types are not caused by different genes being present but by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ gene expression, the expression of different genes by cells with the same genome.

-Recall that the fundamental packaging unit of DNA, the nucleosome, consists of DNA bound to small proteins termed histones. The more tightly bound DNA is to its histones, the less accessible is for transcription. The relationship is governed by two chemical interactions:

-DNA methylation is the addition of methyl groups to DNA. It causes the DNA to be more tightly packaged, thus reducing gene expression.

-In histone acetylation, acetyl groups are added to amino acids of histone proteins, thus making the chromatin less tightly packed and encouraging transcription.

-Notice that methylation occurs primarily on DNA and reduces gene expression, whereas acetylation occurs on histones and increases gene expression.

-\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ inheritance is the inheritance of traits transmitted by mechanisms not directly involving the nucleotide sequence. The DNA sequence is not changed, just its expression.

-Transcription initiation is another important control point in gene expression. At this stage, DNA control elements that bind transcription factors are involved in regulation.

-The transcription initiation complex greatly enhances gene expression. DNA sequences far from the gene, termed enhancer regions, are bound to the promoter region by proteins termed activators.

-The control of gene expression may also occur after transcription and just after translation, when proteins are processed.

-Coordinately controlled genes, such as the genes coding for the enzymes of a metabolic pathway, are expressed together. This is possible even though the genes in a given pathway may be scattered on different chromosomes. All of the genes that code of the enzymes of the pathway share the same control elements. In general, eukaryotes do not have operons.

Noncoding RNA:

Recent research has indicated that large, diverse populations of RNA molecules in the cell play crucial roles in regulating gene expression. Small molecules of single-stranded RNA can complex with proteins and influence gene expression.

Two types of RNA, micro RNAs (miRNA) and small interfering RNAs (siRNAs), can bind to mRNA and degrade the mRNA or bind to mRNA and block its translation. The blocking of gene expression in this manner is called RNA \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (RNAi).

Expression of Genes:

The zygote undergoes transformation through three interrelated processes:

Cell division: The series of mitotic divisions that increase the number of cells

Cell differentiation: is the process by which cells become specialized in structure and \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Morphogenesis: gives an organism its shape.

What controls differentiation and morphogenesis?

1. Cytoplasmic determinants are maternal substances in the egg that influence the course of early development. These are distributed unevenly in the early cells of the embryo and result in different effects.

2. Cell-cell signals result from molecules, such as growth factors, produced by one cell influencing neighboring cells, a process called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, which causes cells to differentiate.

-Determination is the series of events that lead to observable differentiation of a cell. Differentiation is caused by cell-cell signals and is irreversible.

-Pattern formation sets up the body plan and is a result of cytoplasmic determinants and inductive signals. This is what determines head and tail, left and right, back and front. Uneven distribution of substances called morphogens plays a role in establishing these axes.

-Homeotic genes are master control genes that control pattern formation.