What is Gene Regulation in Eukaryotes?

Worksheet

Gene regulation in eukaryotes is the multi-level control of gene expression - chromatin structure, transcription factors and enhancers, RNA processing, mRNA stability, and translation/post-translational modification - that determines which proteins a cell actually makes.

Questions

1. Which of these is unique to eukaryotic (not prokaryotic) gene regulation?

A) Transcription factors exist
B) Alternative splicing of pre-mRNA
C) Genes can be turned on or off
D) Promoters exist

2. What does DNA methylation typically do to a gene?

A) Increases transcription
B) Usually silences/represses transcription
C) Has no effect
D) Deletes the gene

3. How can a microRNA reduce a protein's abundance?

A) By mutating the gene's DNA
B) By binding target mRNA and blocking translation or triggering degradation
C) By removing the gene's promoter
D) By editing the amino acid sequence

4. Why can a liver cell and a skin cell have very different proteins despite identical DNA?

A) They have different genomes
B) Different genes are accessible and transcribed due to differential regulation
C) Only liver cells have DNA
D) Skin cells lack RNA polymerase

5. A liver cell and a neuron have the same genome. Explain why they make different proteins.

6. One pre-mRNA transcript produces two different proteins in different tissues. How?

7. A microRNA (miRNA) is highly expressed in a cell. What happens to its target mRNA?

8. Define: Where does eukaryotic gene regulation happen?

9. Define: What is an enhancer?

10. Define: What is alternative splicing?

Answer Key

1. B) Alternative splicing of pre-mRNA - Prokaryotic mRNA isn't spliced; alternative splicing of introns/exons is a eukaryotic RNA-processing mechanism.

2. B) Usually silences/represses transcription - Methylation of promoter regions is usually associated with condensed chromatin and gene silencing.

3. B) By binding target mRNA and blocking translation or triggering degradation - miRNAs act post-transcriptionally on mRNA, not on the DNA itself.

4. B) Different genes are accessible and transcribed due to differential regulation - Differential gene regulation - not different DNA - creates cell-type-specific protein profiles.

5. Each cell type has a different set of active transcription factors binding its enhancers Different chromatin regions are open (euchromatin) or closed (heterochromatin) in each cell type Only the genes with accessible chromatin and the right transcription factors get transcribed into mRNA and translated into protein

6. The primary transcript contains multiple exons and introns Spliceosomes include or exclude different exons depending on the tissue (alternative splicing) The resulting mature mRNAs differ, so translation produces two distinct protein isoforms from one gene

7. The miRNA base-pairs with a complementary sequence in the target mRNA's 3' UTR This recruits proteins that either block translation or degrade the mRNA Less protein is made from that gene even though the gene was transcribed normally

8. At multiple levels: chromatin structure, transcription, RNA processing, mRNA transport/stability, and translation/post-translation.

9. A DNA sequence, often far from the gene, that transcription factors bind to increase transcription; it works even at a distance via DNA looping.

10. Including or excluding different exons from the same pre-mRNA to make different protein isoforms.