Topic 7 Molecular Biology

Topic 7.2 Transcription and Gene Expression

Essential idea: Information stored as a code in DNA is copied onto mRNA.

Understandings:

- 7.2.U1 Transcription occurs in a 5' to 3' direction.
- 7.2.U2 Nucleosomes help to regulate transcription in eukaryotes.
- 7.2.U3 Eukaryotic cells modify mRNA after transcription.
- 7.2.U4 Splicing of mRNA increases the number of different proteins an organism can produce.
- 7.2.U5 Gene expression is regulated by proteins that bind to specific base sequences in DNA.
- 7.2.U6 The environment of a cell and of an organism has an impact on gene expression.

Applications and Skills:

- 7.2.A1 The promoter as an example of non-coding DNA with a function.
- 7.2.S1 Analysis of changes in the DNA methylation patterns.

Review: 7.1.U6 Some regions of DNA do not code for proteins but have other important functions.

Between genes exist non-coding regions of DNA. Although such DNA does not code for polypeptides it can affect transcription of mRNA.

Promoters sequences are attachment points for RNA polymerase adjacent to the gene

Some other regions act as binding sites for particular proteins, which in turn affect transcription of the nearby gene: Enhancers are sequences that increase the rate of transcription (when a protein is bound to it)

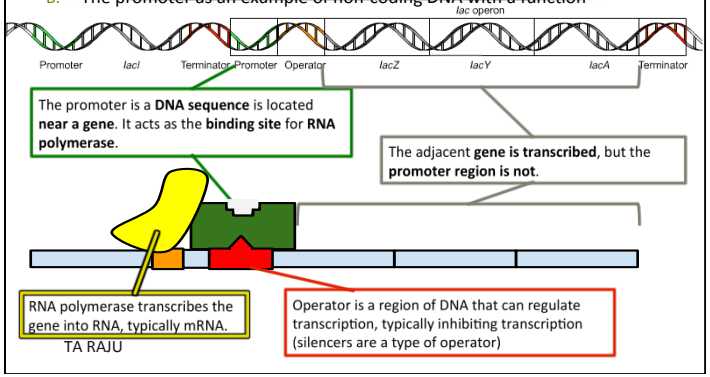
Silencers inhibit transcription (when a protein is bound to it)

National Human Genome Research Institute

I. Regulation of Gene Expression by Proteins

A. Gene expression is regulated by proteins that bind to specific base sequences in DNA-

B. The promoter as an example of non-coding DNA with a function-



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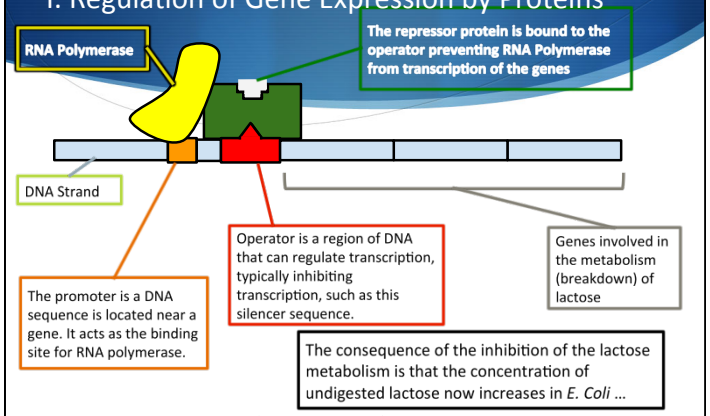
I. Regulation of Gene Expression by Proteins



One well known example of the regulation of gene expression by proteins is the metabolism of lactose in *E. Coli* bacterium. The diagram illustrates this example.

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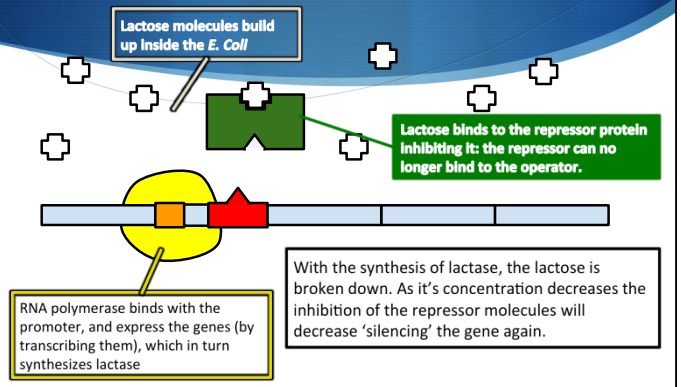
I. Regulation of Gene Expression by Proteins



I. Regulation of Gene Expression by Proteins

B. Summary of common types of regulating proteins and associated sequences found in eukaryotes.

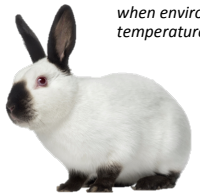
DNA Sequence	Binding protein	Function
Enhancers	Activator	Activator proteins bind to enhancer sequences of DNA to greatly increase the rate of transcription of a gene.
Silencers	Repressor	Repressor proteins bind to non-coding regions of DNA to either block or reduce the transcription of a gene.
Promoter	RNA Polymerase	A region of DNA located close to a specific gene. Once bound to the sequence RNA polymerase transcribes the gene.

Bioknowledgy.com

II. The Impact of the Environment on Gene Expression

A. The environment of a cell and of an organism has an impact on gene expression-

1. The environment of an organism impacts gene expression.
   a. *Pigments in the fur of Himalayan rabbits (Oryctolagus cuniculus) are regulated by temperature.*
   b. *Gene C controls fur pigmentation in Himalayan rabbits. The gene is active when environmental temperatures are between 15 and 25°C. At higher temperatures the gene is inactive.*



In low temperatures Gene C becomes active in the rabbit's colder extremities (ears, nose, and feet) and produces a black pigment.

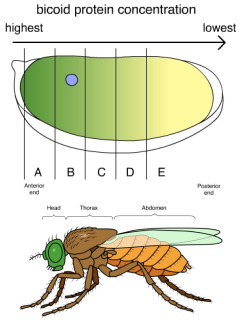
In the warm weather no pigment is produced and the fur is white

Ck12.org; Pet Guide

II. The Impact of the Environment on Gene Expression

B. The environment of a cell can also impact gene expression. This is a complex area of genetics, but can be outlined as follows:

1. Only a small number of genes are involved in determining body patterns during embryonic development.
2. The expression of these genes is regulated by a group of molecules referred to as morphogens.
   a. Morphogens regulate the production of a transcription factors in a cell.
3. Morphogens diffuse across the surfaces of cells from a concentrated source. Therefore different embryonic cells get different concentrations of morphogens.
   a. This results in the activation and inhibition of different genes in different cells.



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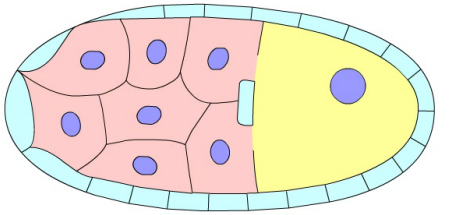
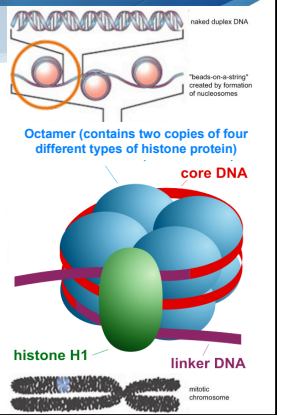


III. Nucleosomes Regulate Transcription

A. Nucleosomes help to regulate transcription in eukaryotes-

Review:

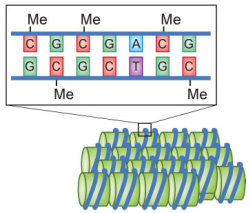
1. *Eukaryotic DNA supercoiling is organized by nucleosomes.*
2. *Nucleosomes both protect DNA and allow it to be packaged, this in turn allows DNA to be supercoiled.*
3. *Nucleosomes are formed by wrapping DNA around histone proteins*



Beyond the Dish

III. Nucleosomes Regulate Transcription

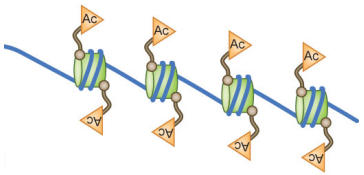
2. Methylation is the addition of methyl groups to DNA
   a. Methylation of DNA inhibits transcription
   b. Processes that inhibit transcription bind the DNA more tightly to the histone making it less accessible to transcription factors (forming heterochromatin).



Nature

III. Nucleosomes Regulate Transcription

3. Acetylation is the addition of acetyl groups to histones
   a. Acetylation promotes transcription
   b. Processes that promote transcription bind the DNA more loosely to the histone making it more accessible to transcription factors (forming euchromatin).

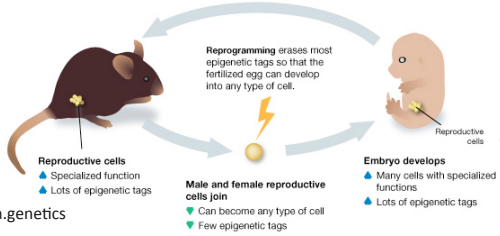


Nature

III. Nucleosomes Regulate Transcription

A. Changes in the environment affect the cell metabolism, this in turn can directly or indirectly affect processes such as acetylation and methylation.
   1. *Methylation and acetylation mark the DNA to affect transcription. These these markers are known as epigenetic tags (The branch of genetics concerned with heritable changes not caused by DNA is called Epigenetics)*

Reprogramming scours the genome and erases the epigenetic tags to return the cells to a genetic "blank slate".

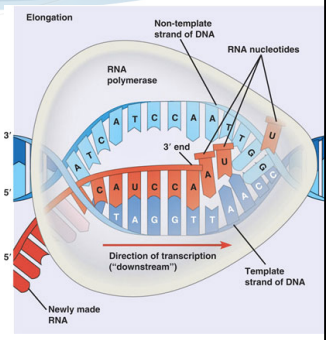


For a new organism to grow it needs unmarked DNA that can develop into lots of different specialized cell types.

Learn.genetics

IV. The Direction of Transcription

A. Transcription occurs in a 5' to 3' direction.
   1. Three stages of transcription
      a. Initiation – RNA polymerase binds to a promoter on DNA
      b. Elongation – RNA polymerase unwinds DNA and synthesizes an RNA copy (using base pairing rules: T – A, A – U, C – G, G – C) from 5' to 3' on DNA.
      c. Termination – RNA polymerase and the new pre-mRNA strand detach from DNA and the double helix reforms

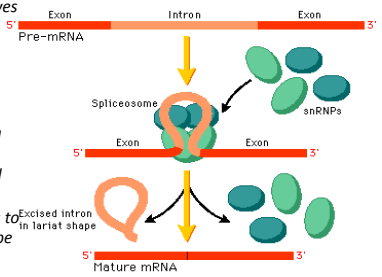


Benjamin Cummings

V. Post-Transcriptional Modification

A. Eukaryotic cells modify mRNA after transcription-
   1. Eukaryotic genes (unlike prokaryote) contain base sequences that are not translated into polypeptides

a. Mature mRNA contains only exons leaves the nucleus to be translated into polypeptides.
b. Exons are coding sections of the gene.
c. Introns are non-coding sections of the gene
d. Introns are removed then broken down back into nucleotides ready for use
e. The spliceosome (a complex assembled from small nuclear RNA (snRNA) and proteins) forms and causes the introns to form loops which allows the exons to be joined



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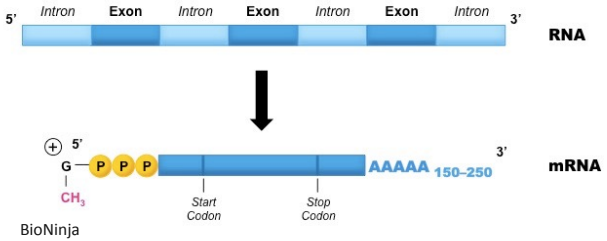
V. Post-Transcriptional Modification

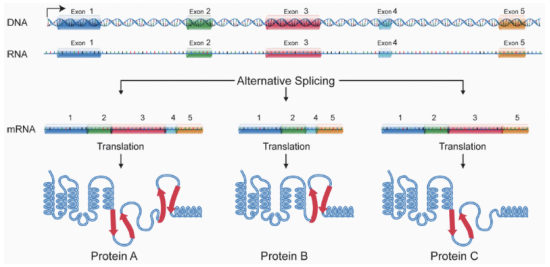
2. Post-transcriptional modification also includes the addition of a 5’ cap and poly-A tail.
   a. Both are hypothesized to reduce degradation of the mRNA, and assist in translation



BioNinja

VI. mRNA Splicing

A. Splicing of mRNA increases the number of different proteins an organism can produce-
   1. The splicing process can happen in different ways to the same gene. particular exons (of a gene) may be included within or excluded from mature mRNA, resulting in multiple proteins produced by a single gene



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