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Gene Expression



Which of the following is the best example of gene expression? Why?

- a. A frog adapts to variation in its environmental temperature.
- b. Mouse fur color results from pigment formed by geneencoded enzymes.
- c. DNA is replicated during the S phase of the cell cycle.
- d. The percent of A versus a alleles (alleles are variations in genes) in a population is altered by natural selection.
- e. Mutation alters the sequence of a region of DNA.

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The Products of Gene Expression: A Developing Story

Much of what we know about the relationship between genes and proteins came from the study of metabolic disorders.

The following hypotheses were proposed:

True or False, and why?:

- One gene one enzyme hypothesis
- One gene—one protein hypothesis
- One gene-one polypeptide hypothesis

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Slide 4 DNA inherited by organisms lead to specific traits Which of the following illustrate genotype? Phenotype? Nucleotide #17 - Adenine (A) is replaced by Thymine (T), resulting in a Val for Glu substitution at amino acid #6. A BRCA1 mutation Slide 5 Overview: The Flow of Genetic Information Proteins are the link between genotype and phenotype The information content of DNA is in the form of specific sequences of nucleotides called genes, which "code for" RNA and proteins. • Gene expression, the process by which DNA directs protein synthesis, includes two stages: 1. Transcription 2. Translation - The central dogma is the concept that cells are governed by a cellular chain of command: DNA \to RNA \to Protein Slide 6 **Basic Principles of Transcription and Translation** • Transcription is the synthesis of RNA under the direction of DNA. RNA is the intermediate between genes and the proteins for which they code. A **primary transcript** is the initial RNA transcript from any gene Processing of the primary transcript produces messenger RNA (mRNA) • Translation is the synthesis of a polypeptide, which occurs under the direction of mRNA

• In prokaryotes, mRNA produced by transcription is immediately translated without more processing. Is it the same for eukaryotes?

TRANSCRIPTION

DNA

MRNA

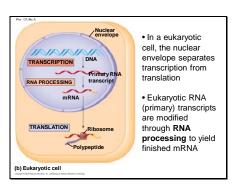
Ribosome

TRANSLATION

Polypeptide

(a) Bacterial cell

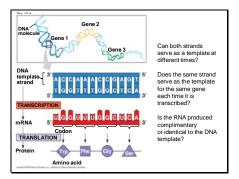
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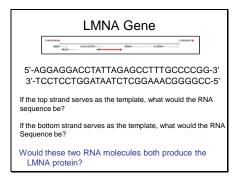
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- <u>During transcription</u>, only one of the two DNA strands, called the **template strand**, provides a template for producing the RNA transcript
- <u>During translation</u>, the mRNA base triplets, called **codons**, are read in the 5' to 3' direction
- Each codon specifies the amino acid to be placed at the corresponding position along a polypeptide

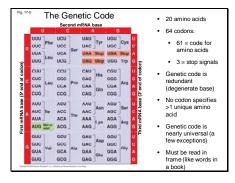
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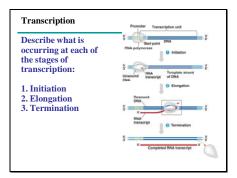


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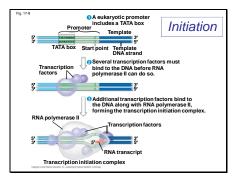


These examples demonstrate the ability of genes from one species to be expressed in a different species. This is possible because of which property of the genetic code?

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RNA Polymerase Binding and Initiation of Transcription

- Promoter RNA sequence that signal the initiation of RNA synthesis - A promoter called a TATA box is crucial in forming the initiation complex in eukaryotes
- Transcription factors mediate the binding of RNA polymerase II and the initiation of transcription in eukaryotes
- The completed assembly of transcription factors and RNA polymerase II bound to a promoter is called a transcription initiation complex

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Elongation of the RNA Strand

- As RNA polymerase moves along the DNA, the double helix is untwisted, 10 to 20 bases at a time, and RNA pol II adds ribonucleotides in the 5' to 3' direction.
- Transcription progresses at a rate of 40 nucleotides per second in eukaryotes, but a gene can be transcribed simultaneously by several RNA polymerases (increasing the amount of RNA transcribed)



Roger Kornberg Nobel Prize, 2006

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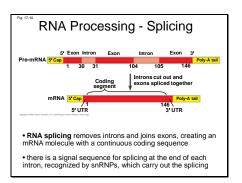
Termination of Transcription

- The mechanisms of termination are different in bacteria and eukaryotes
- In bacteria, the polymerase stops transcription at the end of the terminator sequence. RNA pol detaches and the mRNA is released
- In eukaryotes, the polymerase continues transcription after the pre-mRNA is cleaved from the growing RNA chain; the polymerase eventually falls off the DNA

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Processing - Modifications Enzymes in the eukaryotic nucleus modify pre-mRNA (primary transcript) before the genetic messages are dispatched to the cytoplasm. Protein-coding segment Polyadenylation signal Protein-coding segment Polyadenylation signal 3' UTR Poly-A tail During RNA processing, both ends of the primary transcript are usually altered with the addition of a: 1.5' cap - modified quanine is added after 20-40 nts are transcribed 2 poly-A tail - 50 to 250 adenines are added to the 3' end (at a polyadenylation signal, AAUAAA) What are the functions of these modifications?

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The Functional and Evolutionary Importance of Introns

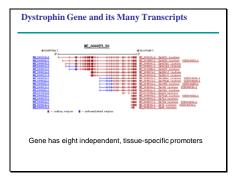
Some genes can encode more than one kind of polypeptide

Such variations result from alternative RNA splicing

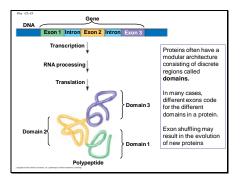
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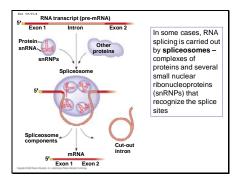
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Ribozymes

- Ribozymes are catalytic RNA molecules that function as enzymes and can splice RNA (molecular scissors) self-splicing and trans-splicing
- The discovery of ribozymes rendered obsolete the belief that all biological catalysts were proteins

