

Basics of Transcription and Translation

Overview: The Flow of Genetic Information

- The information content of DNA is in the form of specific sequences of nucleotides
- The DNA inherited by an organism leads to specific traits by dictating the synthesis of proteins
- Gene expression, the process by which DNA directs protein synthesis, includes two stages: **transcription** and **translation**
- The ribosome is part of the cellular machinery for translation, polypeptide synthesis

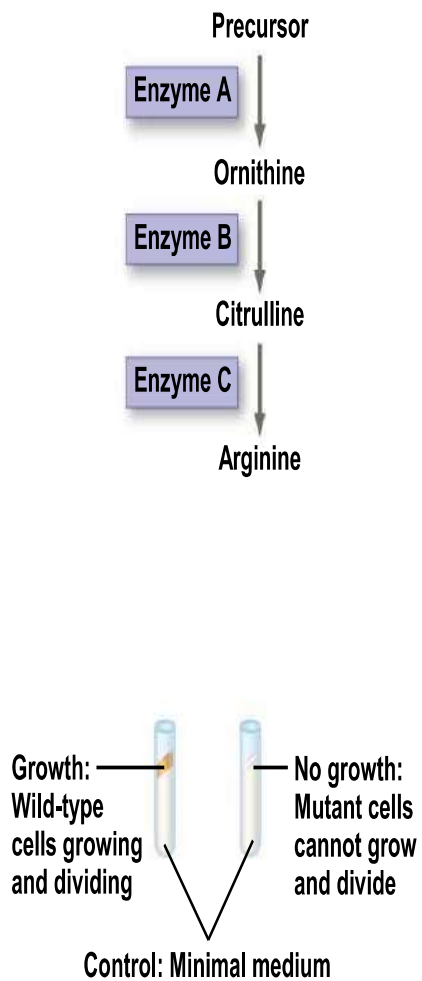
Evidence from the Study of Metabolic Defects

- In 1902, British physician Archibald Garrod first suggested that genes dictate phenotypes through enzymes that catalyze specific chemical reactions
- He thought symptoms of an inherited disease reflect an inability to synthesize a certain enzyme
- Linking genes to enzymes required understanding that cells synthesize and degrade molecules in a series of steps, a metabolic pathway

Nutritional Mutants in Neurospora:

Scientific Inquiry

- **Beadle and Tatum** exposed bread mold to X-rays, creating mutants that were unable to survive on minimal medium as a result of inability to synthesize certain molecules
- Using crosses, they identified three classes of arginine-deficient mutants, each lacking a different enzyme necessary for synthesizing arginine
- They developed a “**one gene–one enzyme**” hypothesis, which states that each gene dictates production of a specific enzyme



Results Table		Classes of <i>Neurospora crassa</i>			
Condition		Wild type	Class I mutants	Class II mutants	Class III mutants
	Minimal medium (MM) (control)				
	MM + ornithine				
	MM + citrulline				
	MM + arginine (control)				
	Summary of results	Can grow with or without any supplements	Can grow on ornithine, citrulline, or arginine	Can grow only on citrulline or arginine	Require arginine to grow

Gene (codes for enzyme)	Wild type	Class I mutants (mutation in gene A)	Class II mutants (mutation in gene B)	Class III mutants (mutation in gene C)
Gene A	Enzyme A	Enzyme A	Enzyme A	Enzyme A
Gene B	Enzyme B	Enzyme B	Enzyme B	Enzyme B
Gene C	Enzyme C	Enzyme C	Enzyme C	Enzyme C
	Precursor → Ornithine → Citrulline → Arginine	Precursor → Ornithine → Citrulline → Arginine	Precursor → Ornithine → Citrulline → Arginine	Precursor → Ornithine → Citrulline → Arginine

Figure 17.2

The Products of Gene Expression: A Developing Story

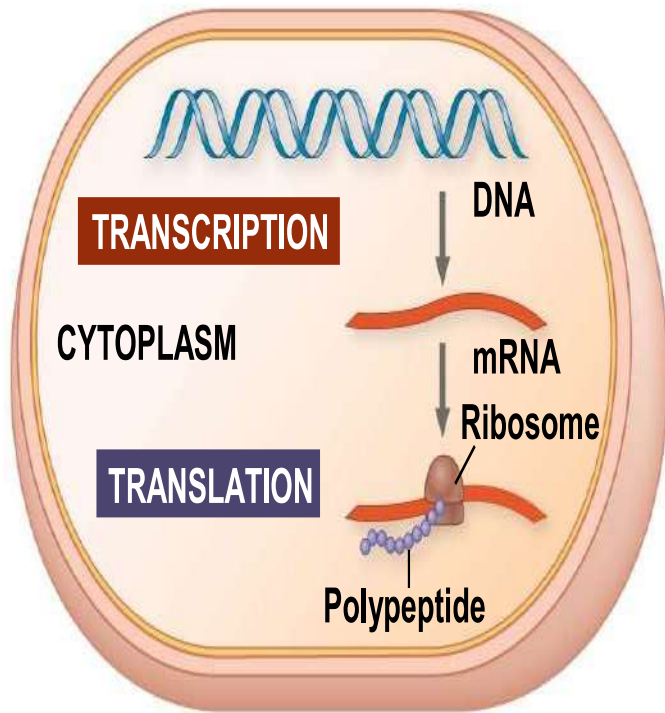
- Some proteins aren't enzymes, so researchers later revised the hypothesis: one gene—one protein
- Many proteins are composed of several polypeptides, each of which has its own gene
- Therefore, Beadle and Tatum's hypothesis is now restated as **one gene—one polypeptide**

Basic Principles of Transcription and Translation

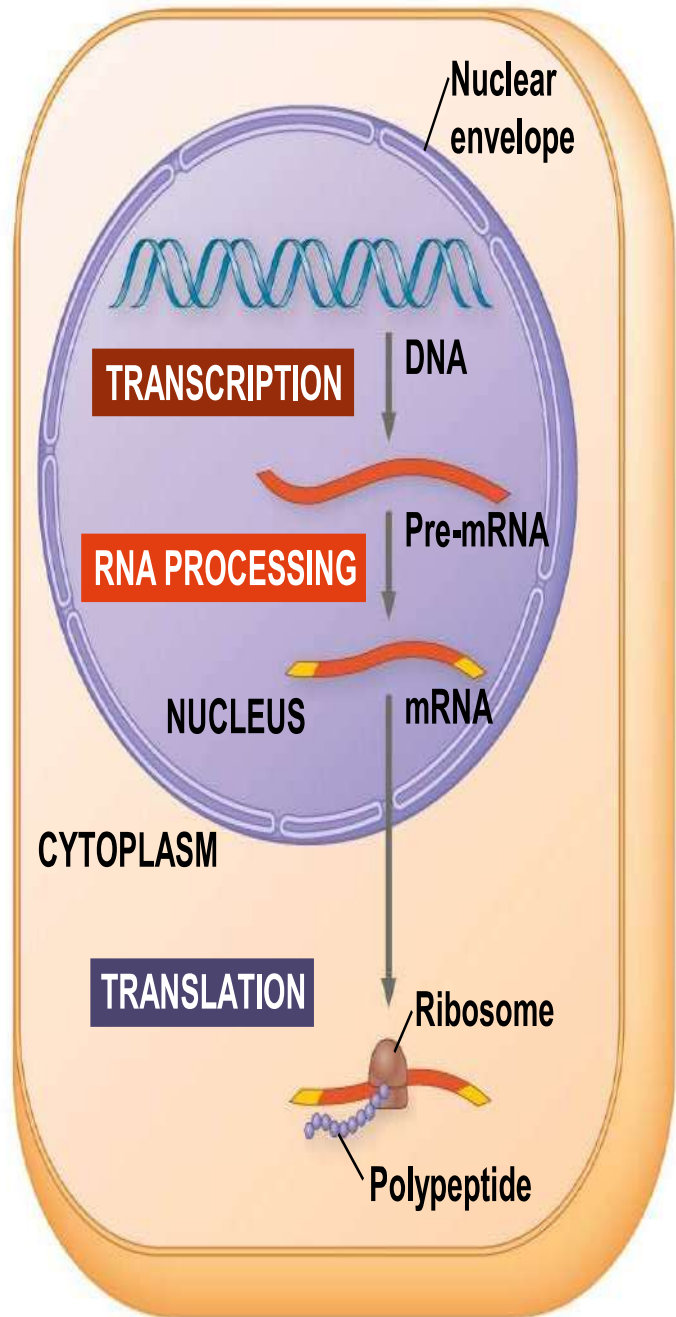
- Transcription is the synthesis of RNA under the direction of DNA
- **Transcription** produces messenger RNA (mRNA)
- **Translation** is the synthesis of a polypeptide, which occurs under the direction of mRNA
- **Ribosomes** are the sites of translation

- In **prokaryotes**, mRNA produced by transcription is immediately translated without more processing--**coupled**
- In a **eukaryotic cell**, the nuclear envelope **separates** transcription from translation
- Eukaryotic RNA transcripts are modified through RNA processing to yield finished mRNA
- Cells are governed by a cellular chain of command: DNA → RNA → protein

Figure 17.3



(a) Bacterial cell



(b) Eukaryotic cell

The Genetic Code

- How are the instructions for assembling amino acids into proteins encoded into DNA?
- There are 20 amino acids, but there are only four nucleotide bases in DNA
- So how many bases correspond to an amino acid?

Codons: Triplets of Bases

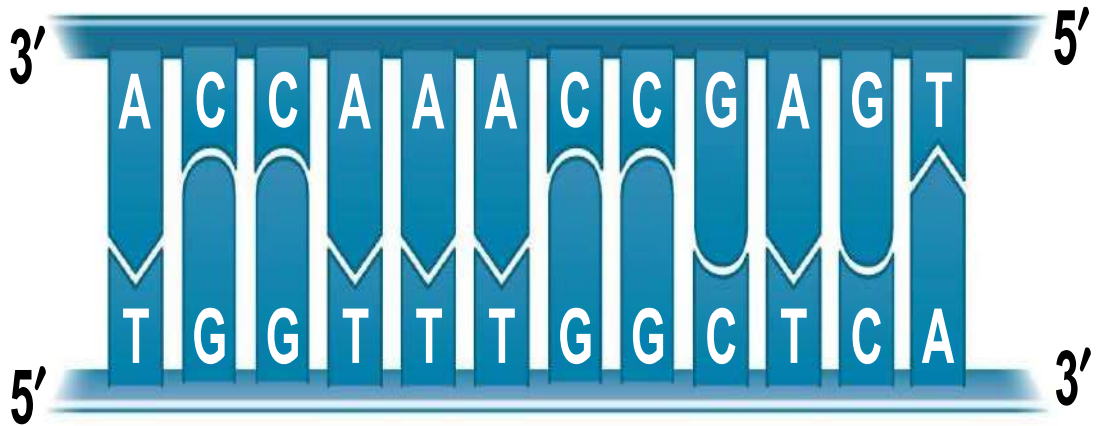
- The flow of information from gene to protein is based on a triplet code: a series of nonoverlapping, three-nucleotide words
- These triplets are the smallest units of uniform length that can code for all the amino acids
- Example: AGT at a particular position on a DNA strand results in the placement of the amino acid serine at the corresponding position of the polypeptide to be produced

- During transcription, a DNA strand called the template strand provides a template for ordering the sequence of nucleotides in an RNA transcript
- During translation, 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

Figure 17.4

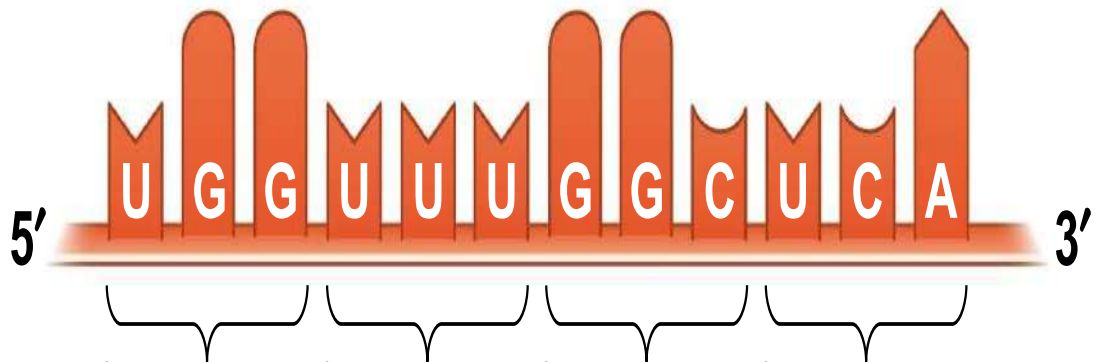
DNA

template
strand



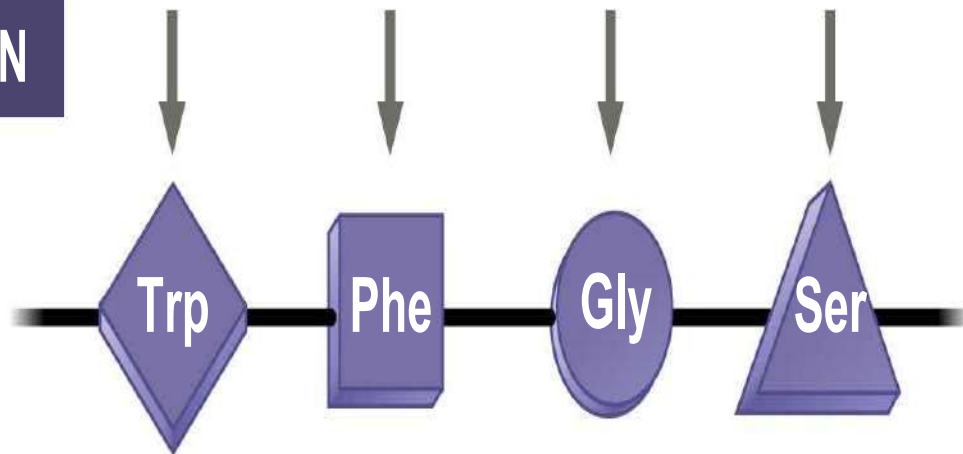
TRANSCRIPTION

mRNA



TRANSLATION

Protein



Amino acid

Cracking the Code

- All 64 codons were deciphered by the mid-1960s
- The genetic code is redundant but not ambiguous; no codon specifies more than one amino acid
- Codons must be read in the correct **reading frame** (correct groupings) in order for the specified polypeptide to be produced

Figure 17.5

		Second mRNA base					
		U	C	A	G		
First mRNA base (5' end of codon)	U	UUU] Phe	UCU]	UAU] Tyr	UGU] Cys	U	C
		UUC]	UCC] Ser	UAC]	UGC]		
		UUA] Leu	UCA]	UAA Stop	UGA Stop		
		UUG]	UCG]	UAG Stop	UGG Trp		
	C	CUU]	CCU]	CAU] His	CGU]	U	C
		CUC] Leu	CCC] Pro	CAC]	CGC] Arg		
		CUA]	CCA]	CAA] Gln	CGA]		
		CUG]	CCG]	CAG]	CGG]		
	A	AUU]	ACU]	AAU] Asn	AGU] Ser	U	C
		AUC] Ile	ACC] Thr	AAC]	AGC]		
		AUA]	ACA]	AAA] Lys	AGA] Arg		
		AUG Met or start	ACG]	AAG]	AGG]		
	G	GUU]	GCU]	GAU] Asp	GGU]	U	C
		GUC] Val	GCC] Ala	GAC]	GGC] Gly		
		GUA]	GCA]	GAA] Glu	GGA]		
		GUG]	GCG]	GAG]	GGG]		
						Third mRNA base (3' end of codon)	

Evolution of the Genetic Code

- The genetic code is **nearly universal**, shared by the simplest bacteria to the most complex animals
- Genes can be transcribed and translated after being transplanted from one species to another



(a) Tobacco plant
expressing
a firefly gene



(b) Pig expressing a
jellyfish
gene

Disclaimer: The above contents have been collected/ compiled from different sources of internet and may be protected under copyright. If anyone publish/ copy/ transmit with an intention to publish with some modifications in his/her name, then all the liability/ legal offences will be bear by such individual/ individual/ organization/ organization/ entity who have misused the content.

Shailendra Sharma