

Chapter 17.

From Gene to Protein



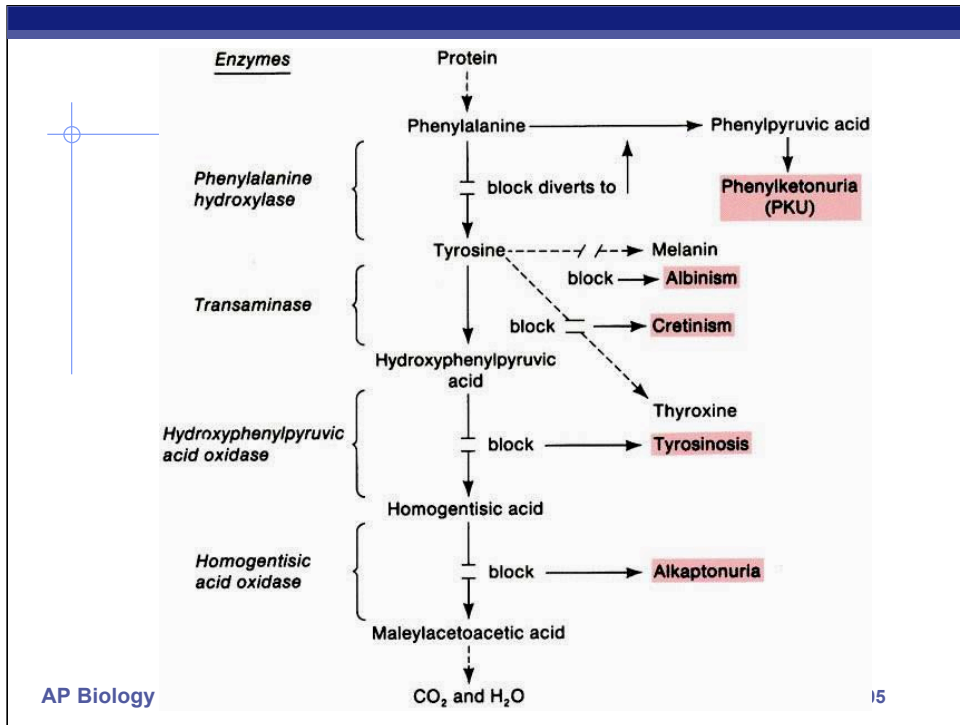
Metabolism teaches us about genes

- Metabolic defects

- ◆ non-functional enzyme



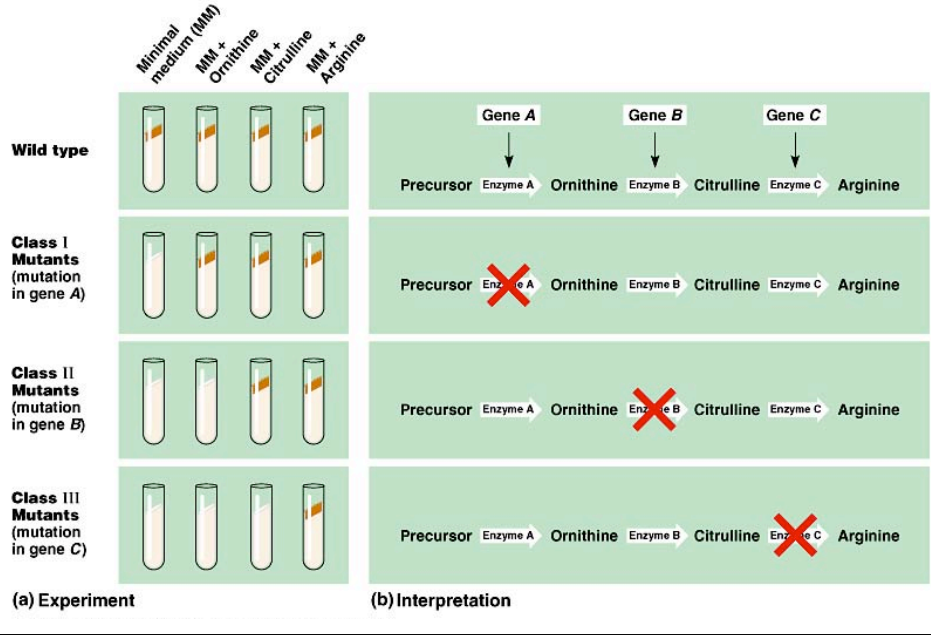
- ◆ studying metabolic diseases suggested that genes specified proteins
 - alkaptonuria (black urine from alkapton)
 - PKU (phenylketonuria)
- ◆ genes dictate phenotype



1 gene–1 enzyme hypothesis 1941|1958

- **Beadle & Tatum (1941)**
 - ◆ Compared different nutritional mutants of bread mold, *Neurospora*
 - created mutations by X-ray treatments
 - ◆ X-rays break DNA
 - wild type grows on “minimal” media (sugar)
 - mutants require different amino acids
 - each type of mutant lacks a certain enzyme needed to produce a certain amino acid
 - broken gene = non-functional enzyme

Beadle & Tatum's *Neurospora* experiment



One gene - one polypeptide

- **One gene - one enzyme**
 - ◆ but not all proteins are enzymes
 - ◆ those proteins are coded by genes too
- **One gene - one protein**
 - ◆ but many proteins are composed of several polypeptides, each of which has its own gene
- **One gene - one polypeptide**
- **Now???**

Defining a gene...

“Defining a gene is problematic because small genes can be difficult to detect, one gene can code for several protein products, some genes code only for RNA, two genes can overlap, and there are many other complications.”

— Elizabeth Pennisi, *Science* 2003

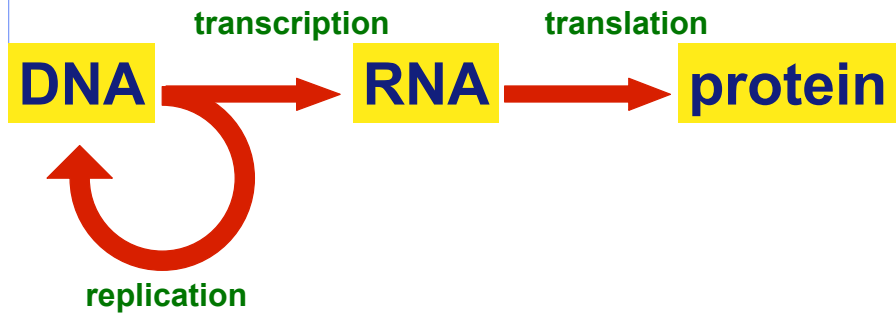


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2004-2005

The “Central Dogma”

- flow of genetic information within a cell



From nucleus to cytoplasm

- **Where are the genes?**
 - ◆ genes are on chromosomes in nucleus
- **Where are proteins synthesized?**
 - ◆ proteins made by ribosomes in cytoplasm
- **How does the information get from nucleus to cytoplasm?**
 - ◆ **messenger RNA**

RNA

- similar to DNA
- ribose sugar
- N-base: uracil instead of thymine
 - ◆ U : A
 - ◆ C : G
- single strand

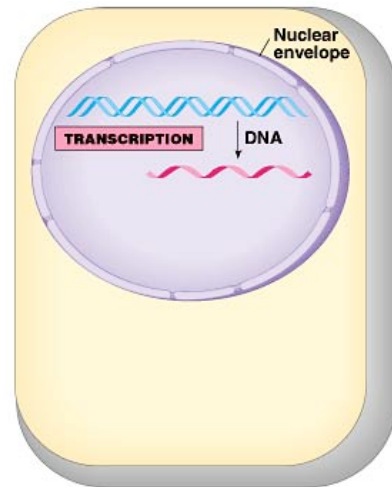


To get from the chemical language of DNA to the chemical language of proteins requires 2 major stages:

transcription and translation

Transcription

- 1 DNA strand is template strand
- Synthesis of complementary RNA strand
 - ◆ messenger RNA (mRNA)
- Enzyme
 - ◆ RNA polymerase



Transcription

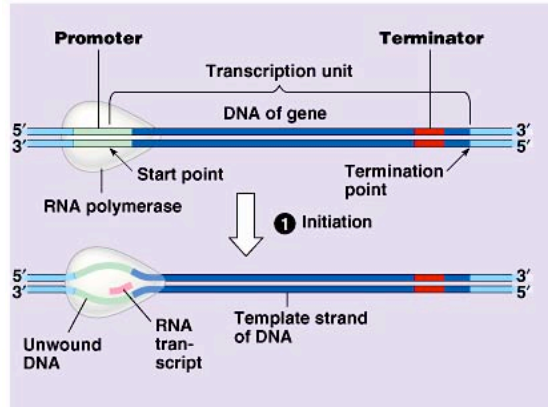
■ Initiation

- ◆ RNA polymerase binds to promoter sequence on DNA

Role of promoter

- Where to start reading = initiation site
- 2. Which strand to read = template strand
- 3. Direction on DNA = reads DNA 3'→5'

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Transcription

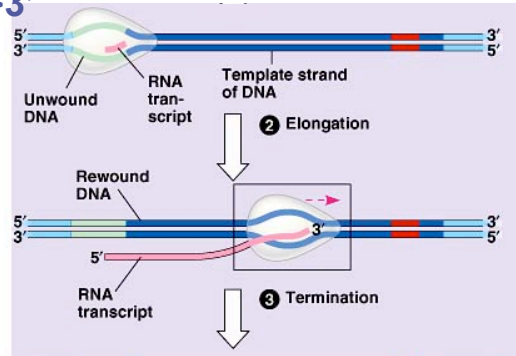
■ Elongation

- ◆ RNA polymerase unwinds DNA ~20 base pairs at a time
- ◆ reads DNA 3'→5'
- ◆ builds RNA 5'→3'

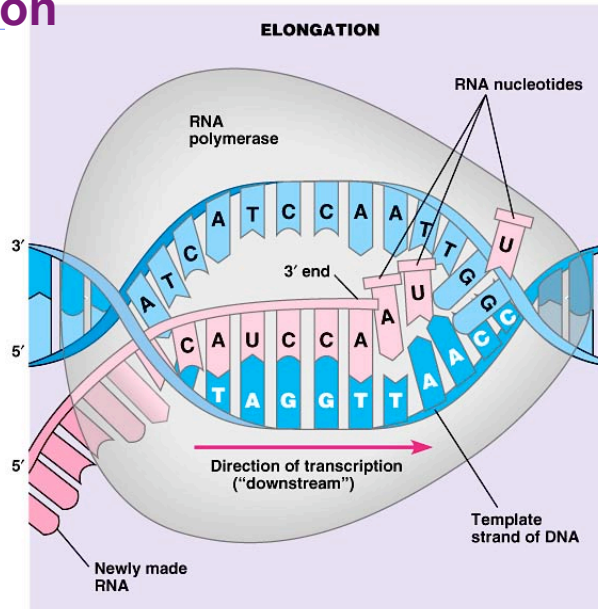
no proofreading

- 1 error/ 10^5 bases
- many copies
- short life
- no problem!

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Transcription

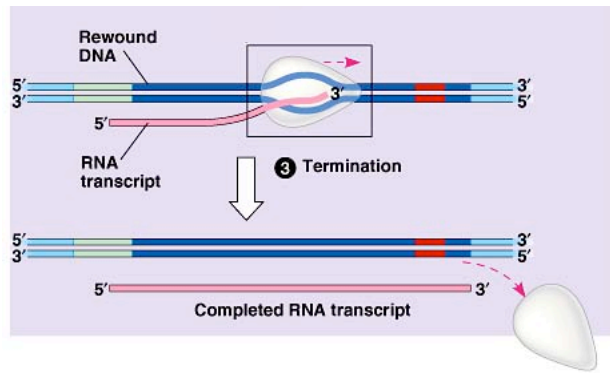


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Transcription

■ Termination

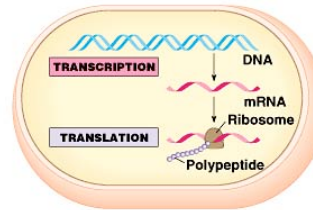
- ◆ RNA polymerase stops at termination sequence
- ◆ mRNA leaves nucleus through pores



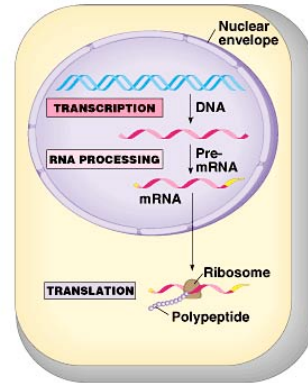
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Putting it together

- Transcription to translation
- Differences between prokaryotes & eukaryotes
 - ◆ time & physical separation between processes
 - ◆ RNA processing



(a) Prokaryotic cell



(b) Eukaryotic cell