

From DNA to Trait

Composed By

Dr. ERNEST DAVID, Ph.D.

Prof. & Head

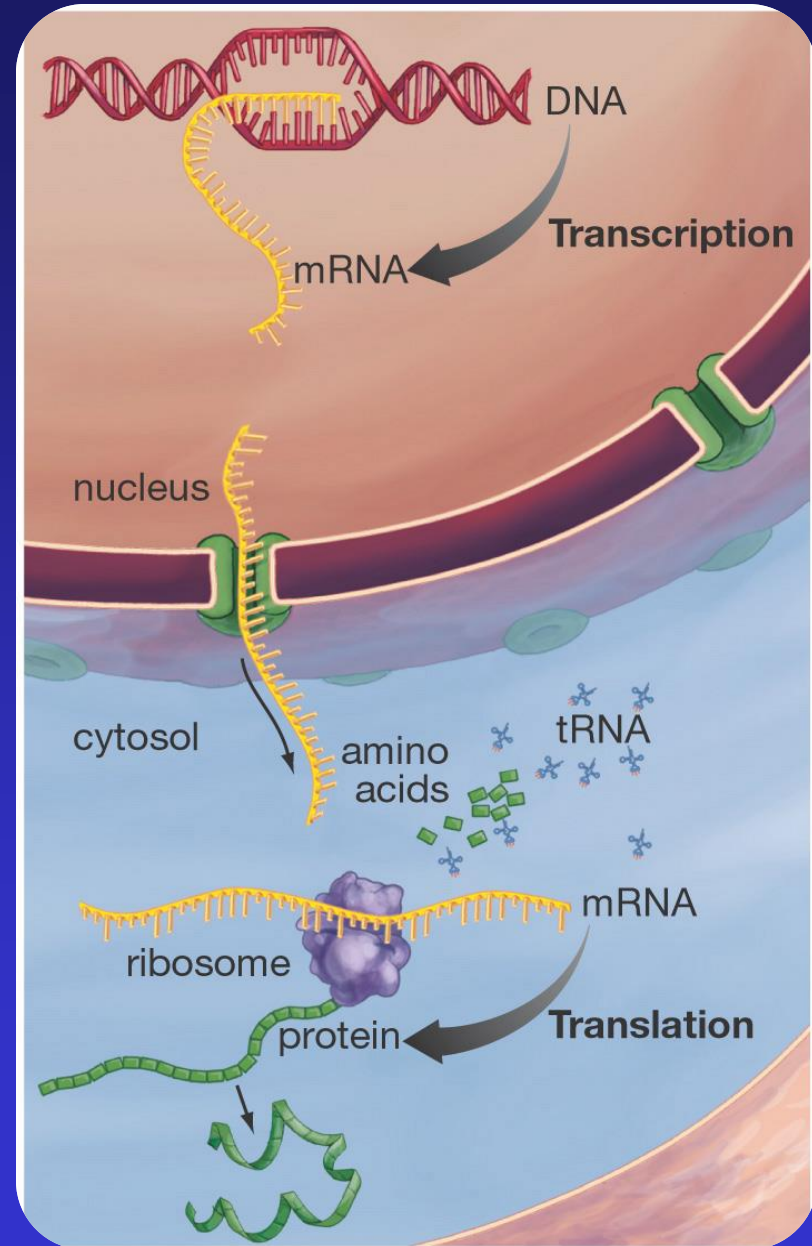
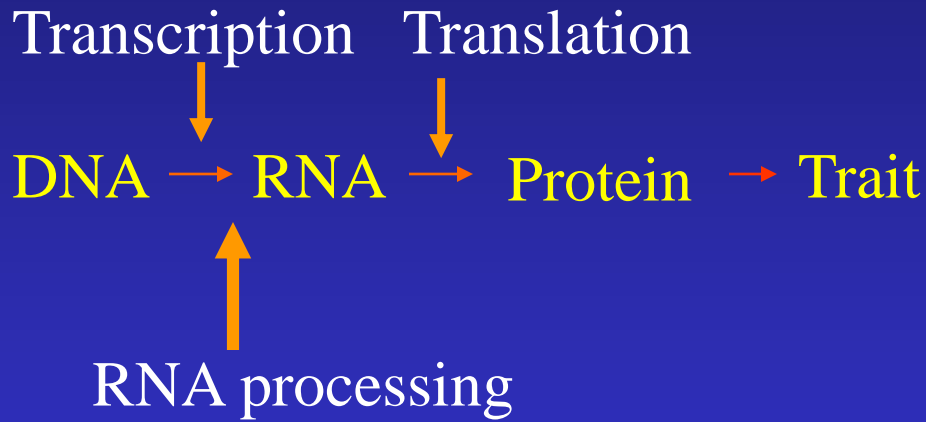
Dept. of Biotechnology

Thiruvalluvar University

Vellore-632115

Molecular Genetics - From DNA to Trait

The Central Dogma



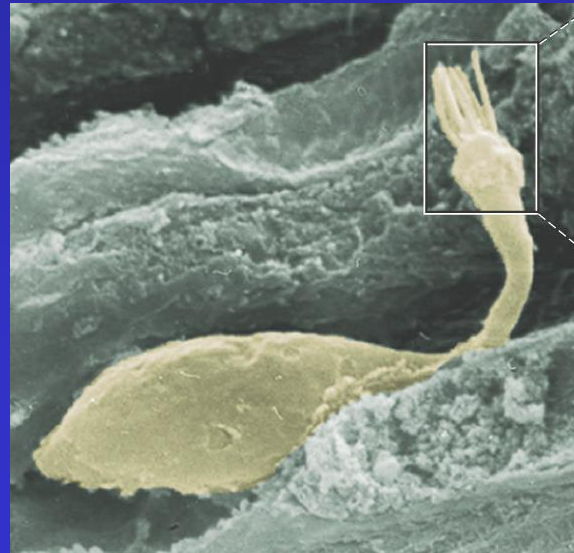
How Are Different Types of Cells Created and Maintained?

By differential gene expression.

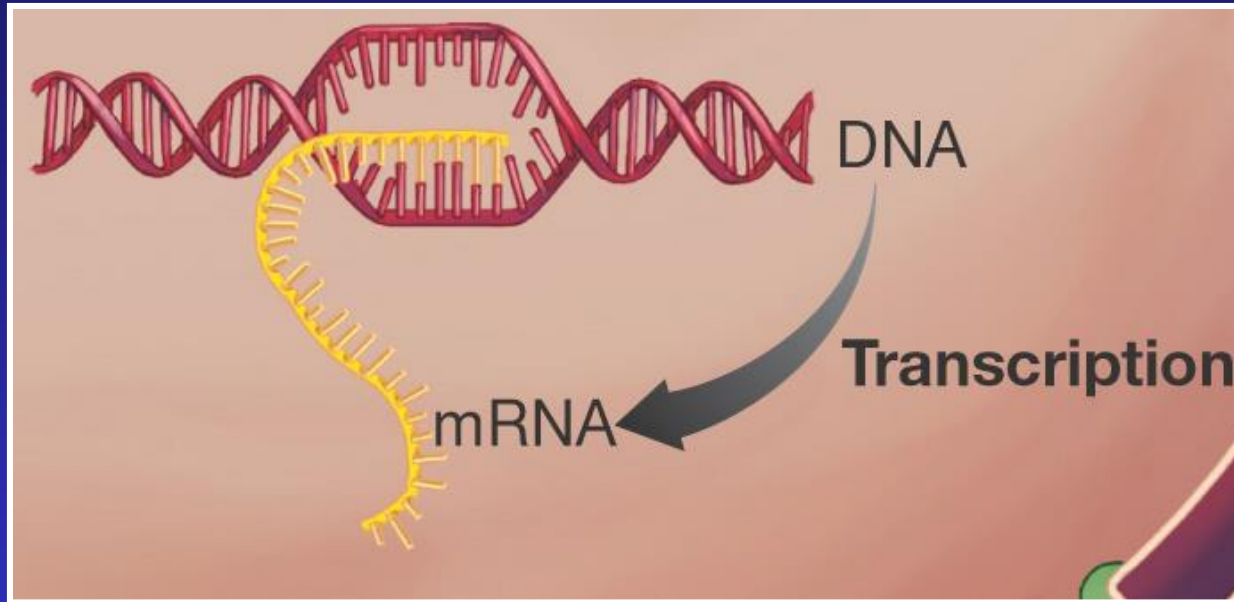
The same genetic information is in all 100 trillion cells of any one person. Different cells use the same blueprint in different ways.

How?

In essence, the control of gene expression occurs by regulating the flow of information from DNA to protein.



Transcription is a Key Step in Gene Expression

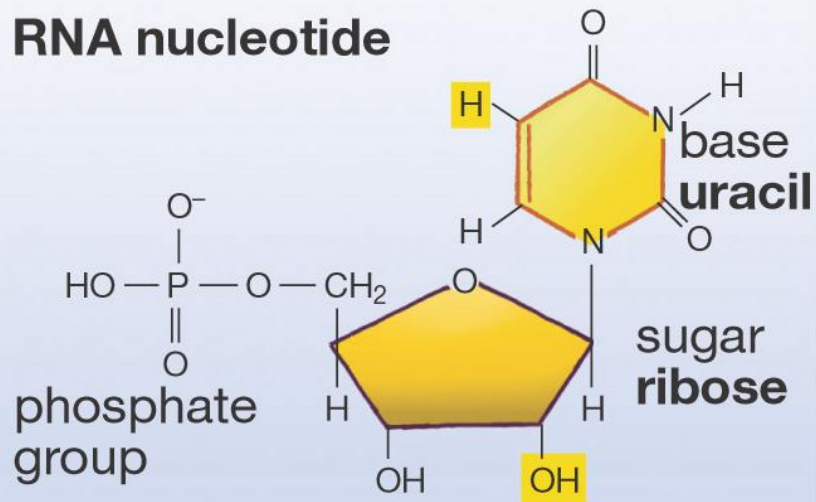


Transcription makes an RNA copy of DNA.

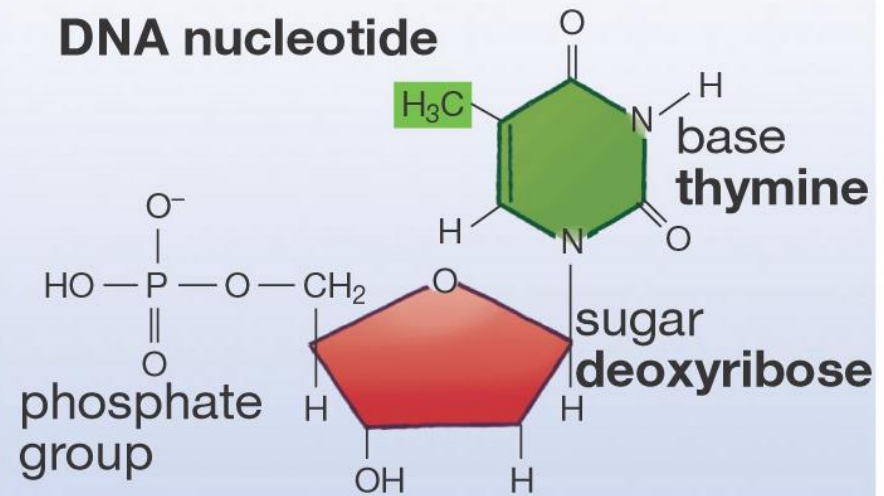
RNA

(a) Comparison of RNA and DNA nucleotides

RNA nucleotide



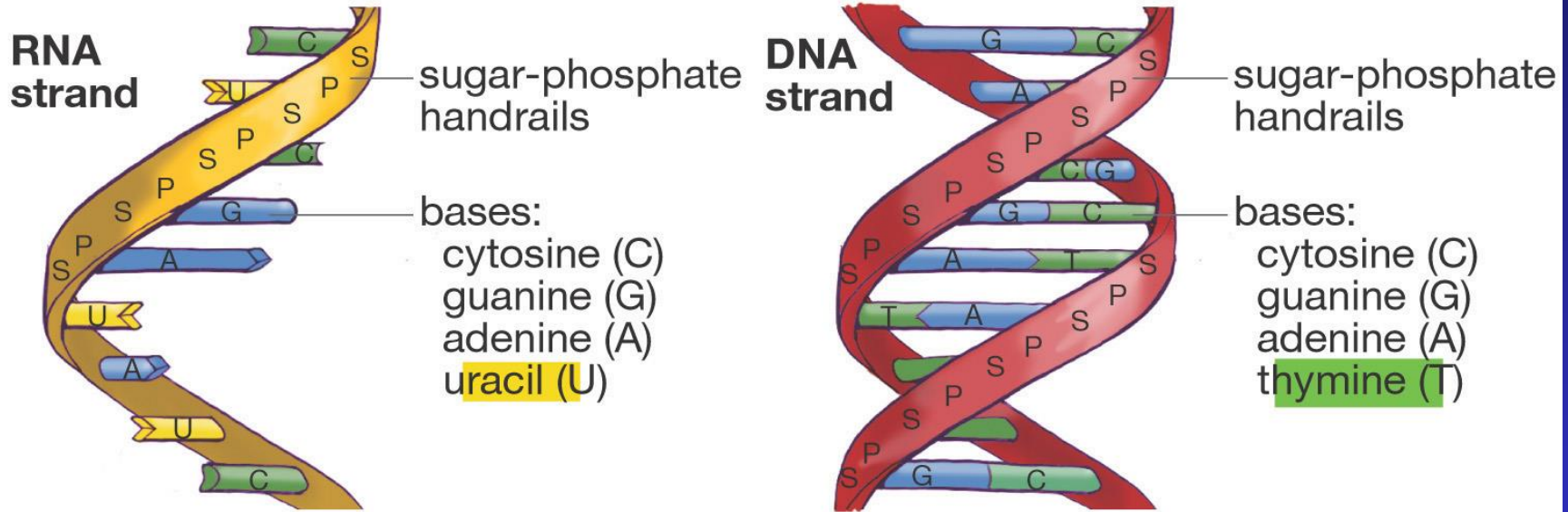
DNA nucleotide



RNA is a nucleic acid polymer that uses a slightly different sugar than DNA and the base uracil (U) in place of thymine (T).




RNA Is Largely Single-Stranded

(b) Comparison of RNA and DNA three-dimensional structure



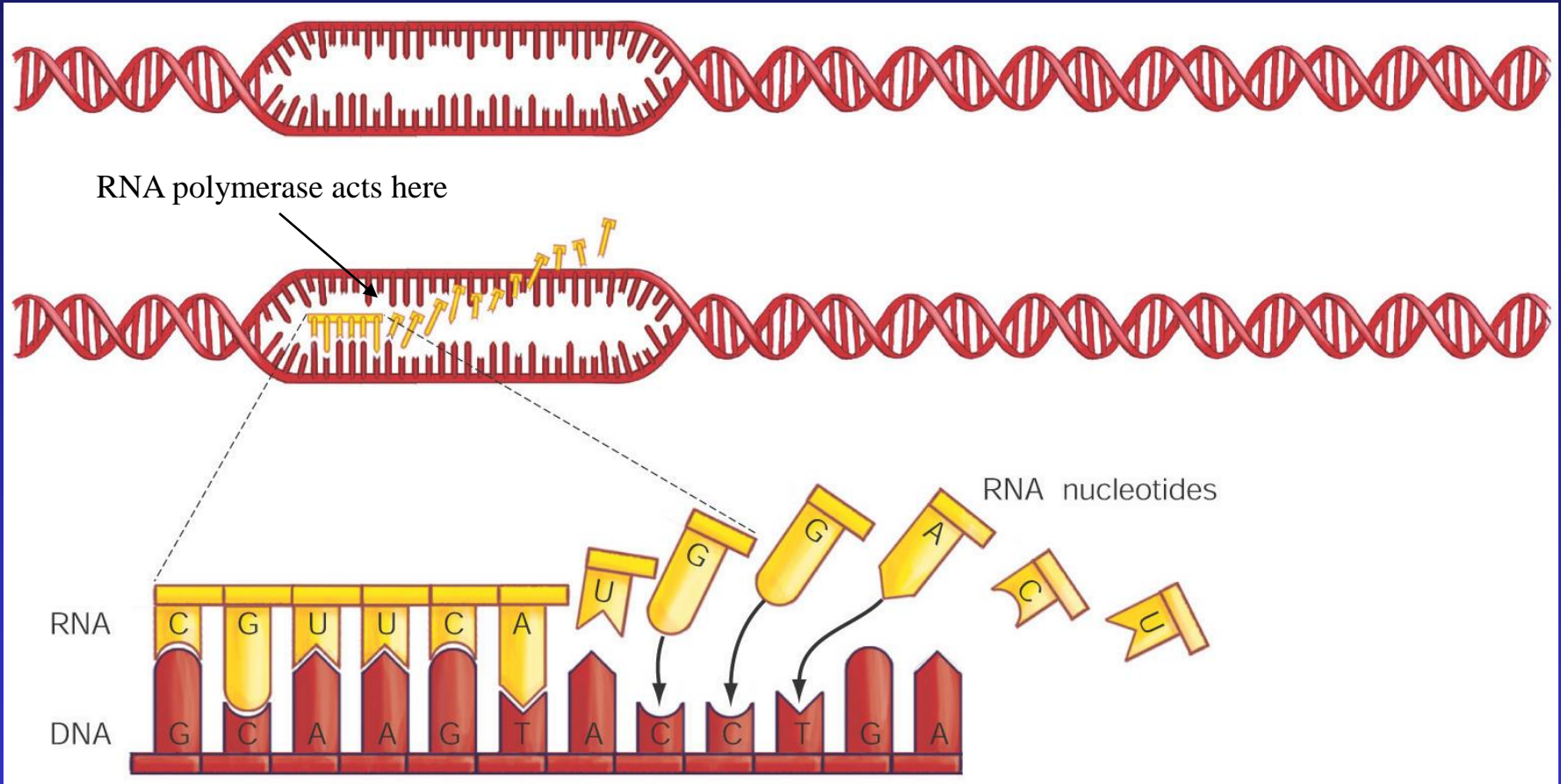
This is a bit of a simplification as RNA forms base pairs within a single strand, but RNA is not double helical over the entire molecule.

There are Different RNAs with Distinct Functions

Type of RNA	Functions in	Function
Messenger RNA (mRNA) 	Nucleus, migrates to ribosomes in cytoplasm	Carries DNA sequence information to ribosomes
Transfer RNA (tRNA) 	Cytoplasm	Provides linkage between mRNA and amino acids; transfers amino acids to ribosomes
Ribosomal RNA (rRNA) 	Cytoplasm	Structural component of ribosomes

Recently, a new class of RNA, microRNA, has been shown to regulate gene expression.

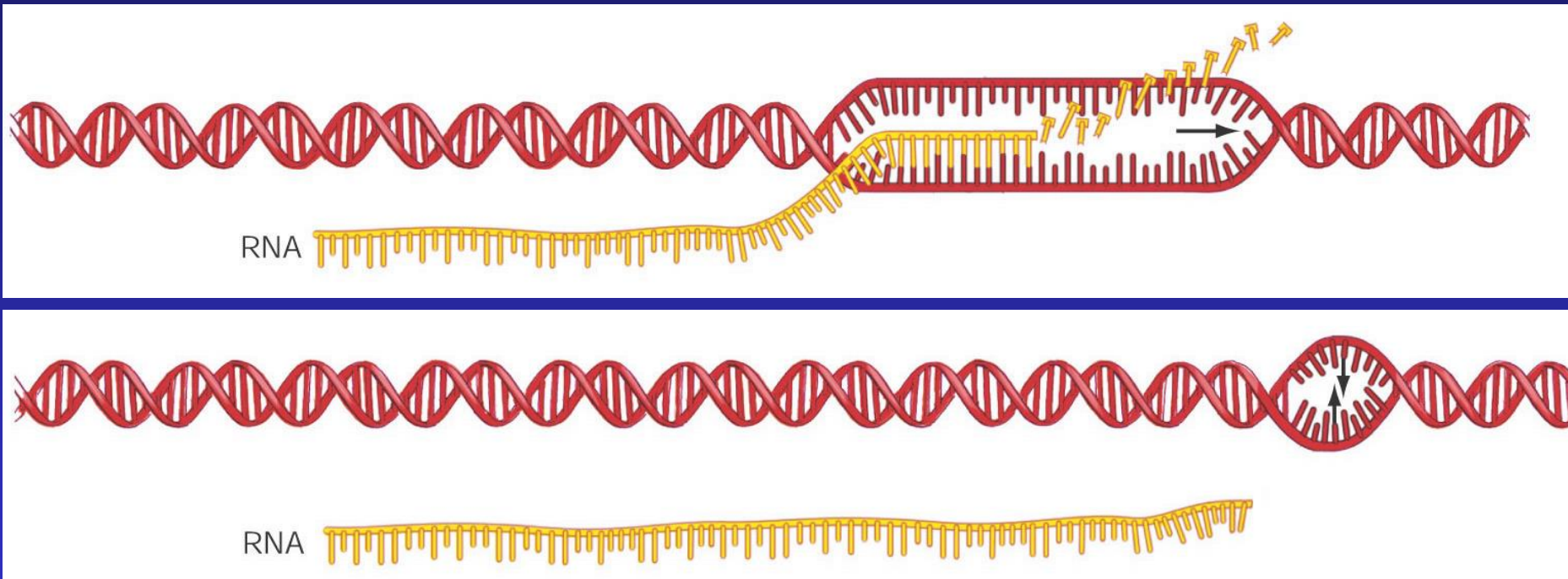
Transcription



The enzyme RNA polymerase opens the DNA strands and synthesizes an RNA complementary to only one of the DNA strands.

Transcription

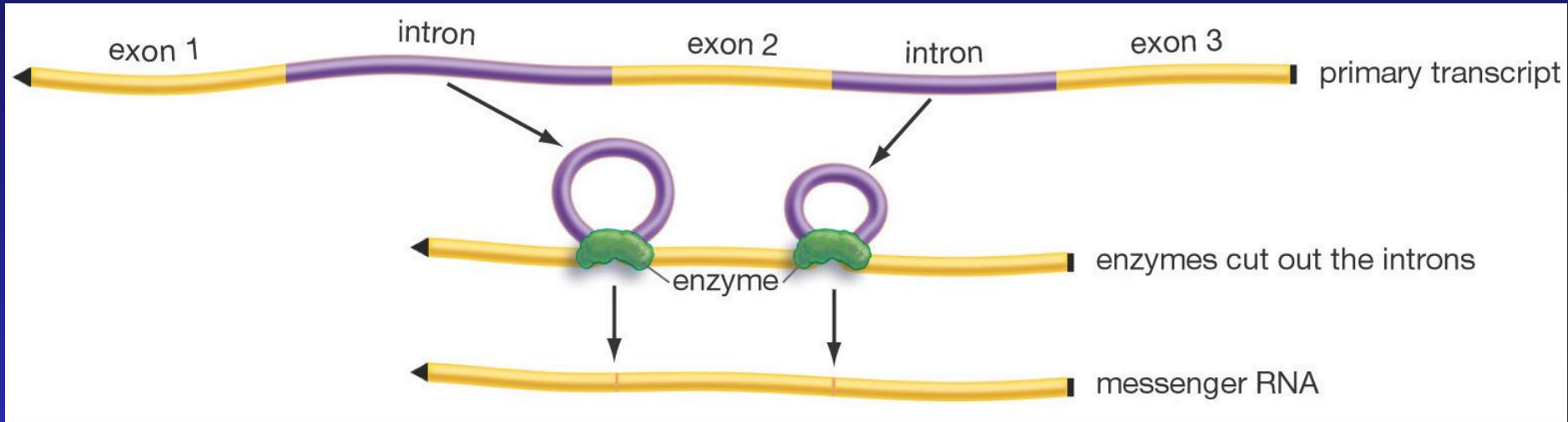
A gene



The decision to transcribe a gene is the most important step in the control of gene expression.

Transcription starts and stops at distinct sites at the ends of a gene.

Eukaryotic Genes are Segmented

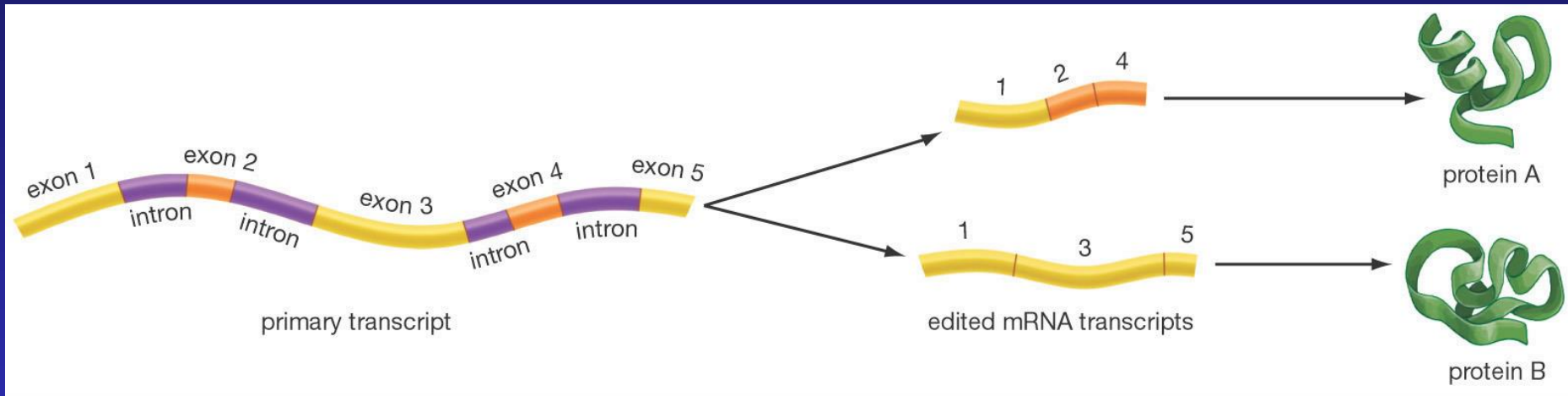


Genes are made of parts represented in the mRNA (exons) and parts that are transcribed but not present in the mRNA (introns).

Introns are removed from the primary transcript and exons are spliced together to make mRNA.

In some genes more than 90% of the pre-mRNA is destroyed, never to appear in the mRNA.

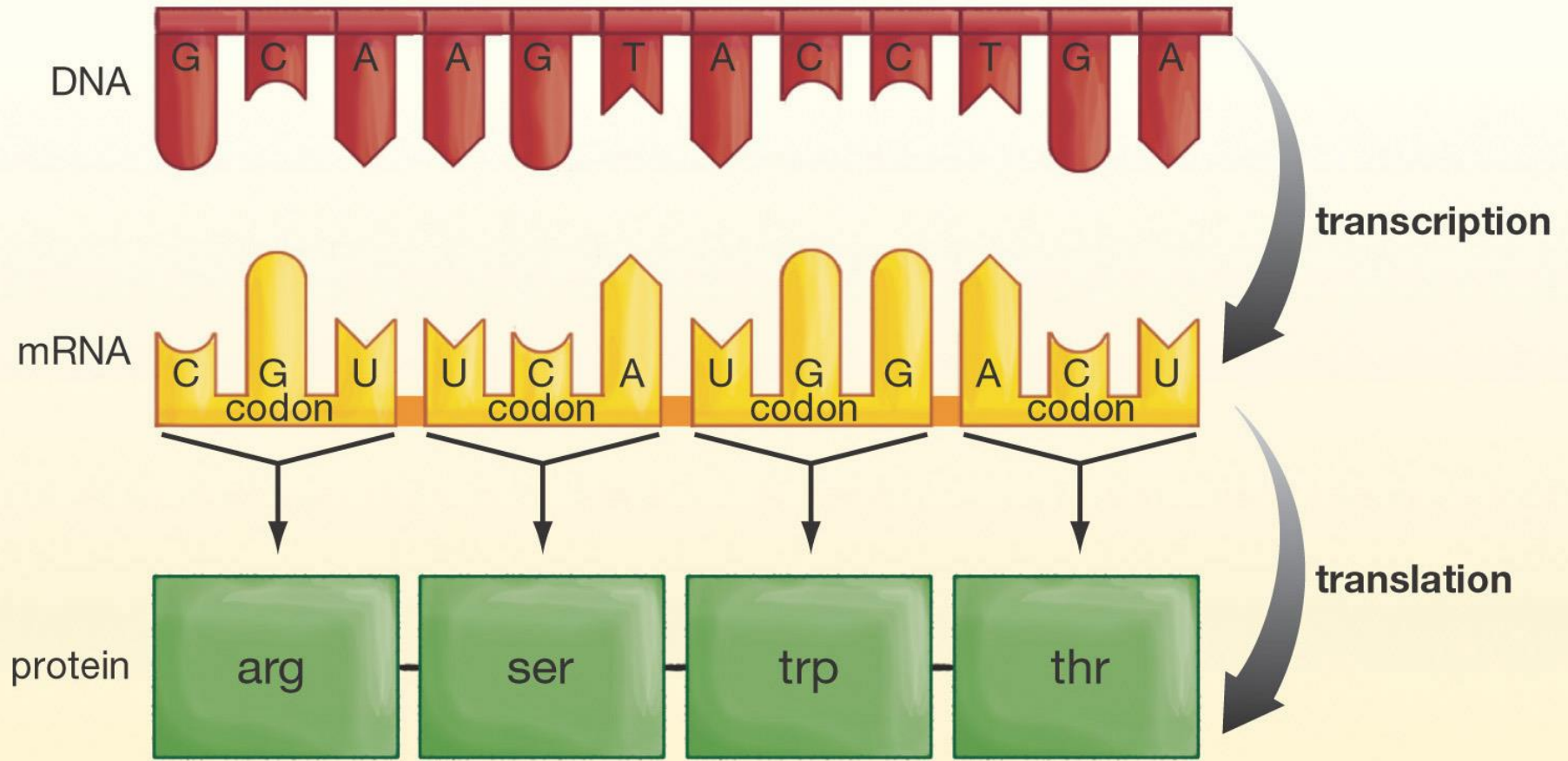
Alternative Splicing – More Bang for the Buck



This has the consequence that the count of our genes (~20,000) seriously underestimates the count of our different proteins.

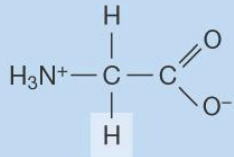
The Genetic Language Uses 4 Letters Written Into 3-Letter Words

The Triplet Code

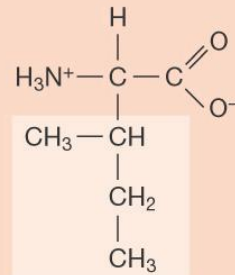


Amino Acids – What the Genetic Code Specifies

glycine (**gly**)



isoleucine (**ile**)



Two examples

There are 20 different amino acids

Table 14.1 Amino Acids

Amino Acid	Abbreviation
Alanine	ala
Arginine	arg
Asparagine	asn
Aspartic acid	asp
Cysteine	cys
Glutamine	gln
Glutamic acid	glu
Glycine	gly
Histidine	his
Isoleucine	ile
Leucine	leu
Lysine	lys
Methionine	met
Phenylalanine	phe
Proline	pro
Serine	ser
Threonine	thr
Tryptophan	trp
Tyrosine	tyr
Valine	val

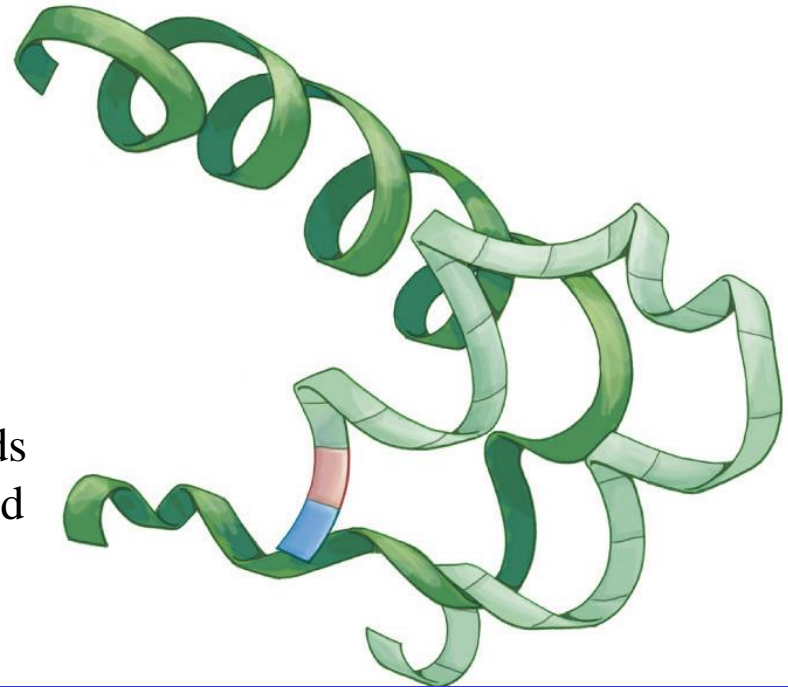
What Translation Accomplishes



Polypeptide chain

Protein

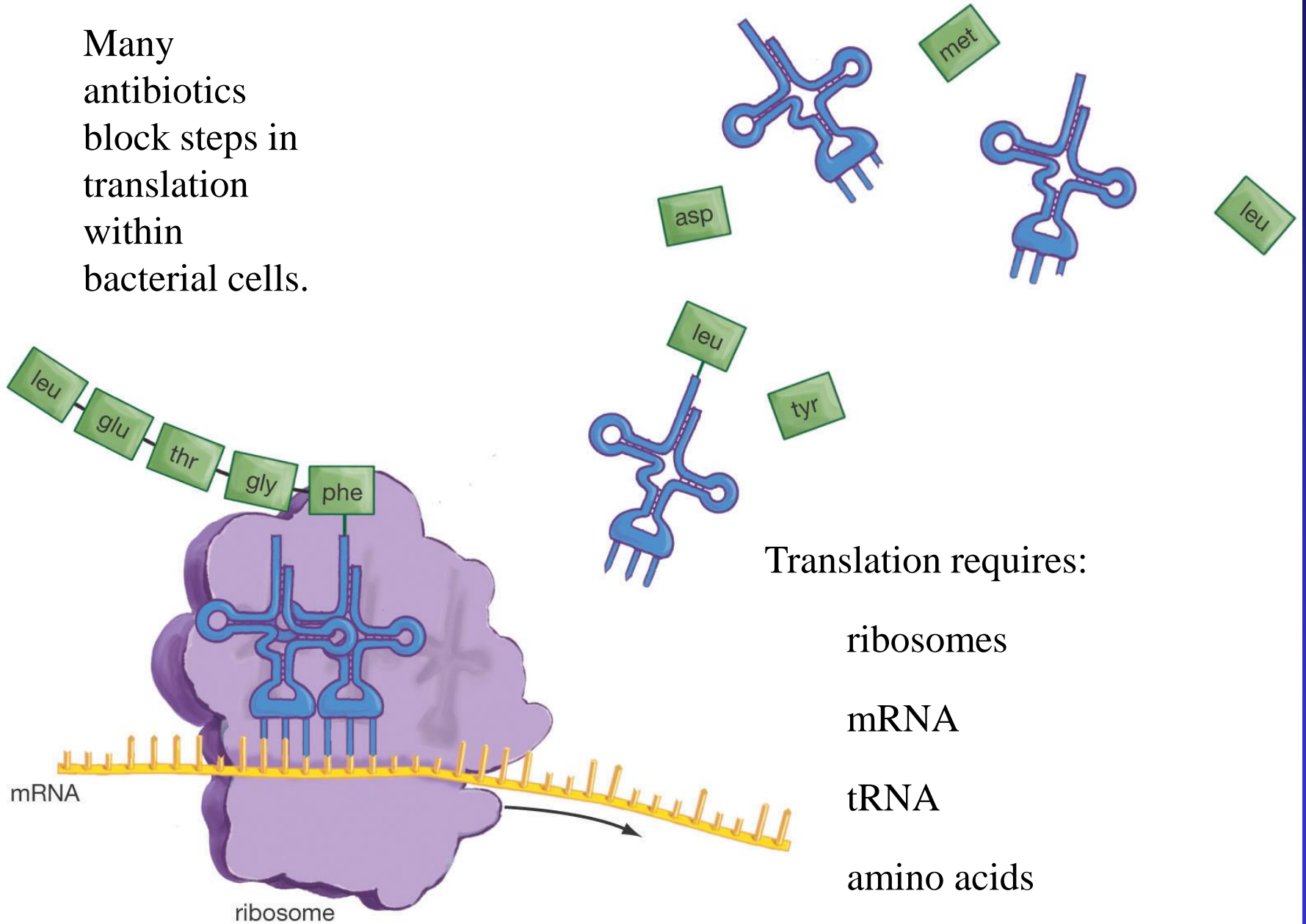
The sequence of amino acids determines the structure, and therefore the function, of a protein.



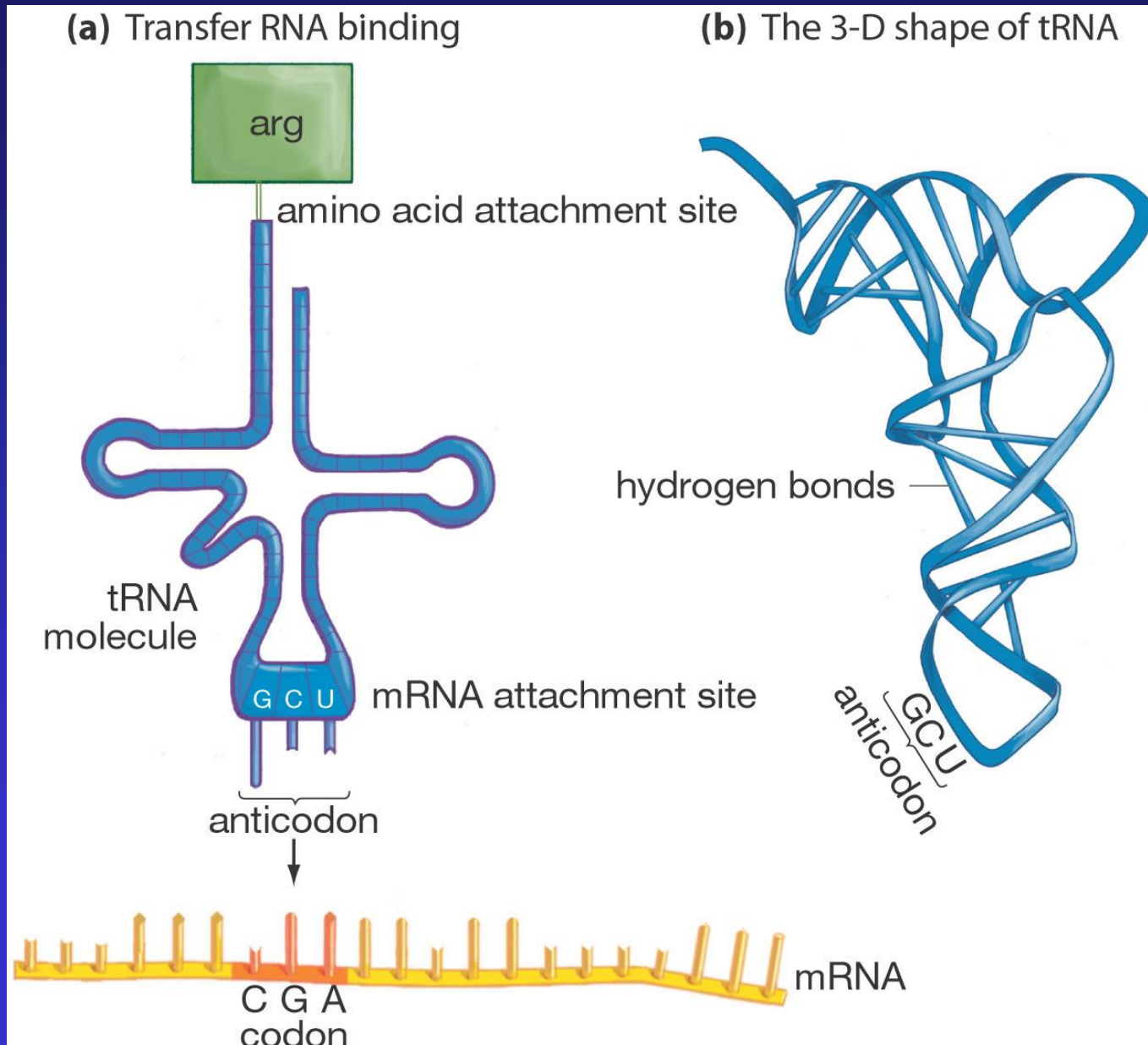
In translation, information present in the mRNA is read by the ribosome to synthesize a polypeptide.

Translation Is Complicated

Many antibiotics block steps in translation within bacterial cells.



tRNA Is An Adaptor That Couples Codons and Amino Acids



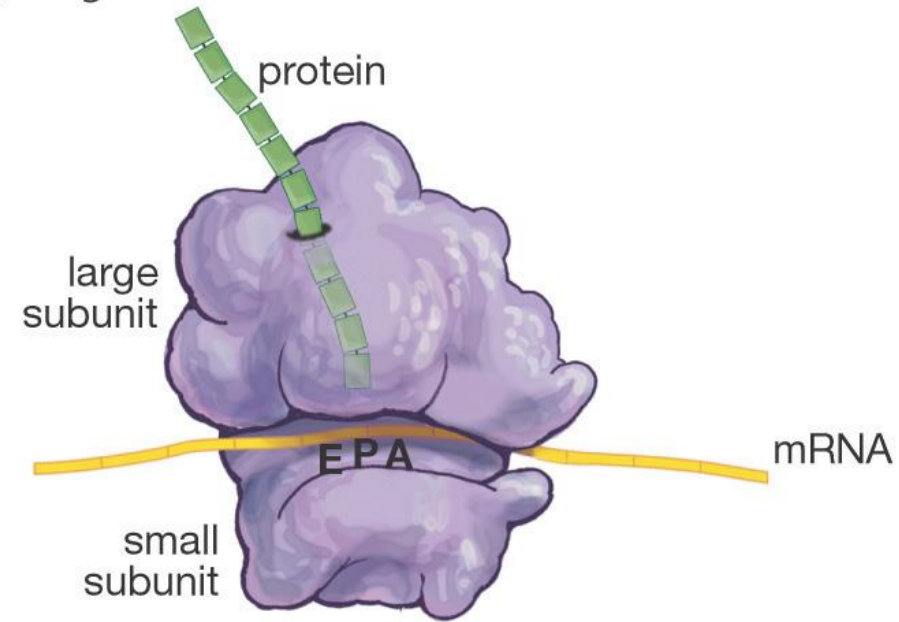
The Genetic Code is Biology's Rosetta Stone

		second base						
		U	C	A	G			
U	UUU	phe	UCU	tyr	UGU	cys	U	
	UUC							ser
	UUA	leu		UAA	UGA	A		
	UUG							UCG
C	CUU	leu	CCU	his	CGU	arg	U	
	CUC							pro
	CUA	CAG		CAA	CGA	A		
	CUG							CCG
A	AUU	ile	ACU	asn	AGU	ser	U	
	AUC							thr
	AUA	met (start)		ACA	AAA	AGA		
	AUG							ACG
G	GUU	val	GCU	asp	GGU	gly	U	
	GUC							ala
	GUA	GCG		GAA	GGA	A		
	GUG							GAG

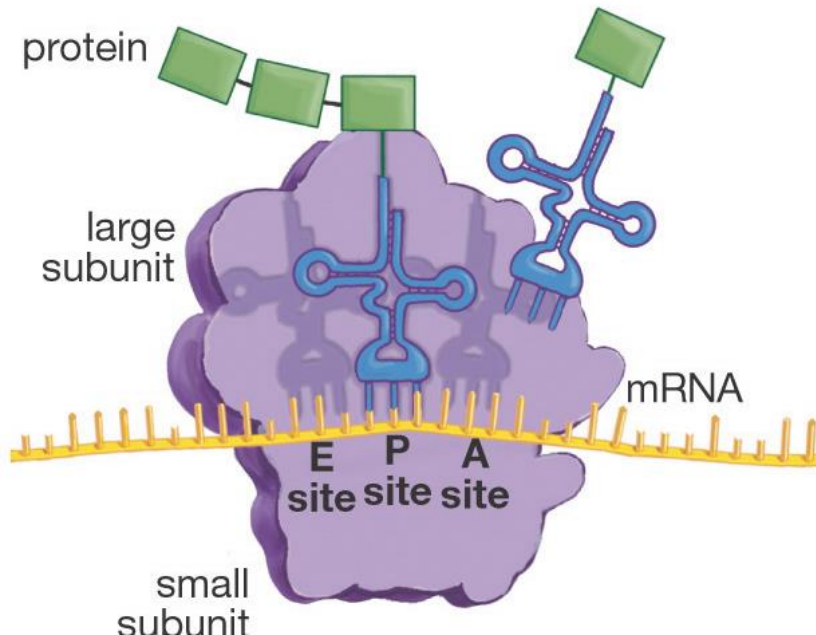
These are the words of the genetic language.

Ribosomes are Complicated Protein Synthesizing Machines

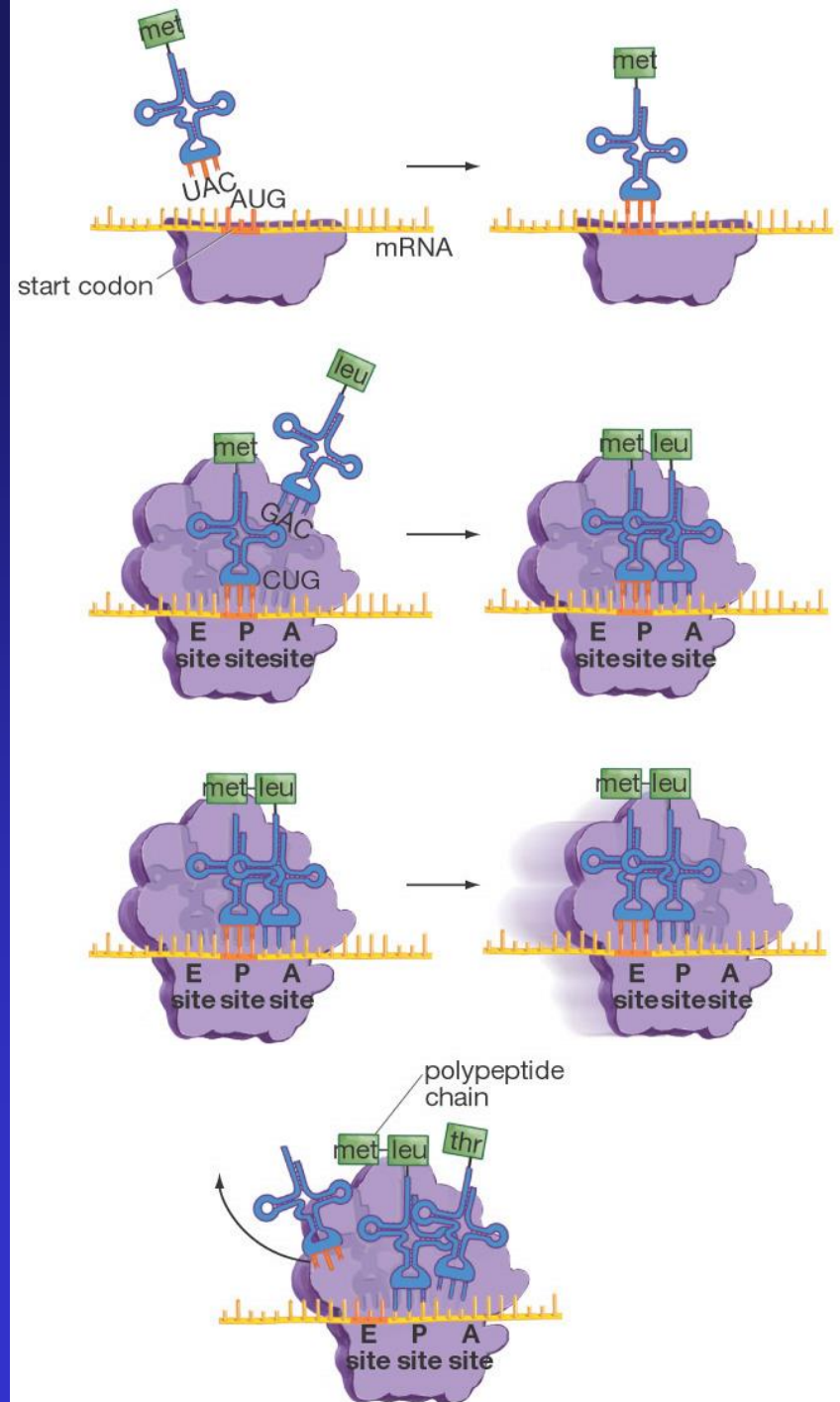
(a) Large and small ribosomal units



(b) Binding sites in the ribosome



Translation Is a Cyclic, Multistep Process

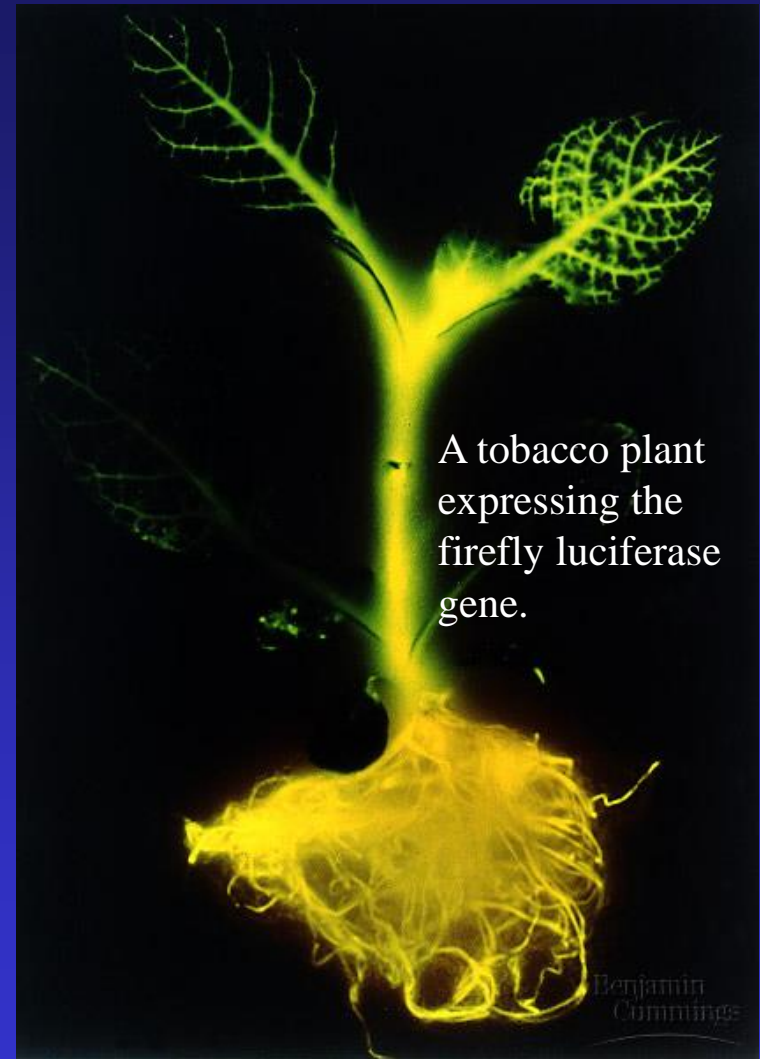


Basic Genetic Mechanisms are Universal

The storage of genetic information in DNA, the use of an RNA intermediate that is read in three letter words, and the mechanism of protein synthesis are essentially the same in all organisms.

Among other things, this means cancer can be studied productively in flies or yeast.

It also means that human genes can be expressed in a plant or mouse genes in a yeast.



A tobacco plant expressing the firefly luciferase gene.

Putting It All Together

The fundamental question of genetics -

What is the relationship between genes and traits?

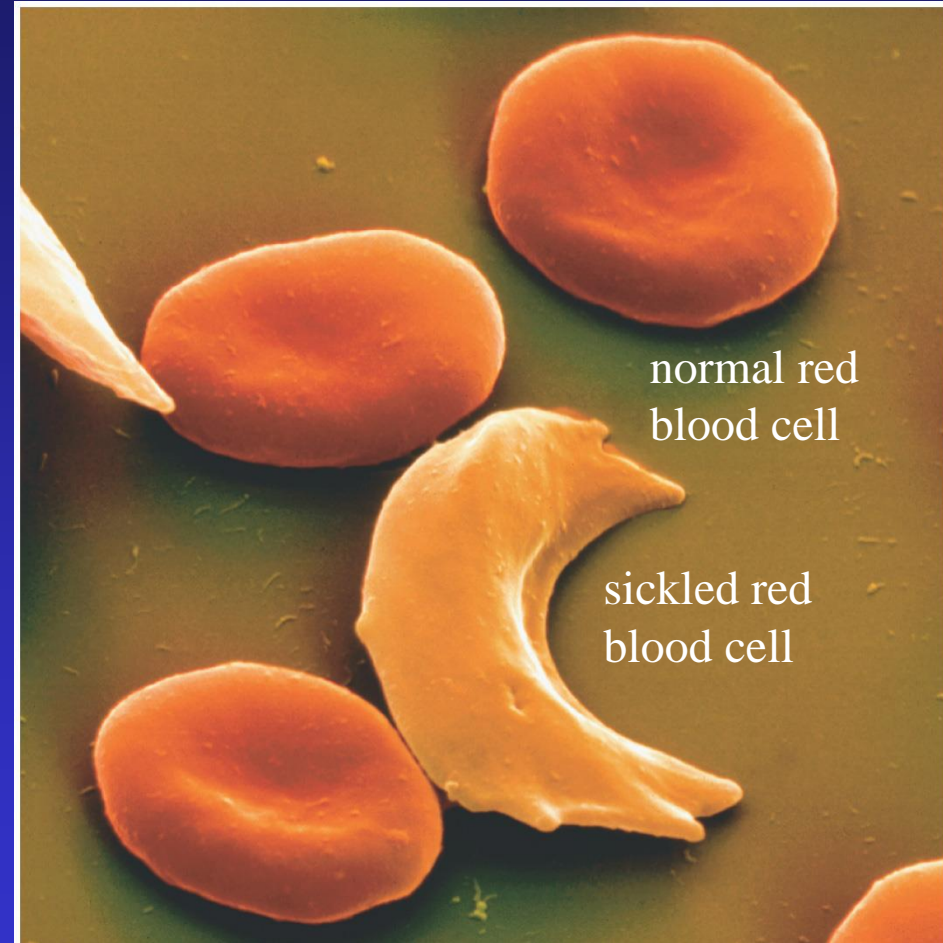
The answer -

Genes → Protein → Traits

Putting It All Together

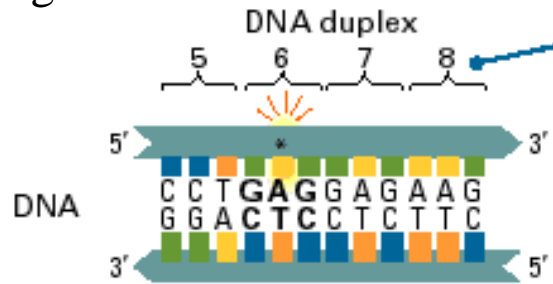
Once again, sickle cell anemia illustrates the gene – protein - biological character connection.

A single base (DNA “letter”) change in the gene for the protein β -globin changes one amino acid for another in this greater than 300 amino acid protein.



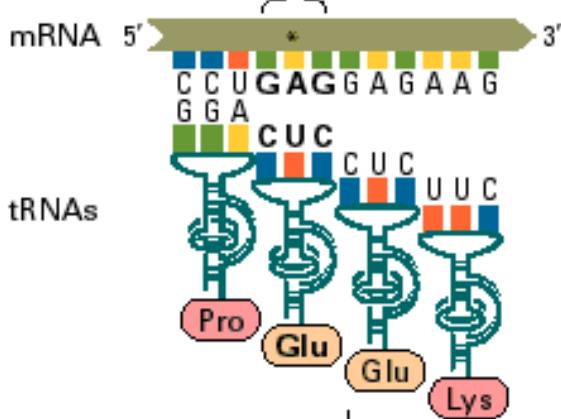
Normal β -globin

(A) Normal β -globin

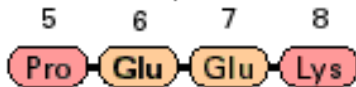


Normal codon is GAG,
codes for amino acid Glu

Transcription



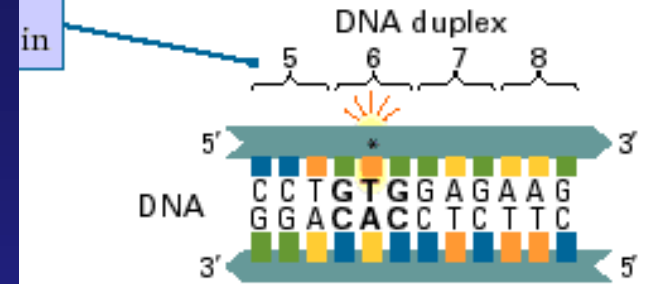
Translation



Glutamic acid is
normal at position 6

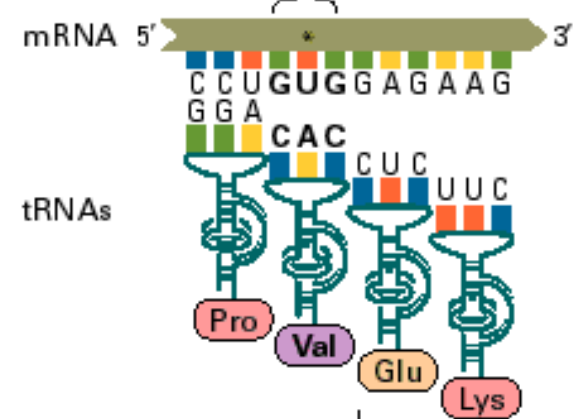
Putting It Together – Sickle Cell Anemia

Sickle cell form of β -globin



mutant codon is GUG,
for amino acid Val

Transcription



Translation



Valine present at position
6 instead of glutamic acid

Best of Luck