Unit 1

DNA and the Genome

Key Area 3

- Gene Expression

Gene Expression

- Vocabulary 1:
  - Transcription
  - Translation
  - Phenotype
  - RNA (mRNA, tRNA, rRNA)
  - Codon
  - Anticodon
  - Ribosome
  - RNA polymerase
  - RNA splicing
  - Introns
  - Extrons

Gene Expression

- Vocabulary 2:

➢ Peptide bonds

➢ Polypeptide chain

➢ Protein

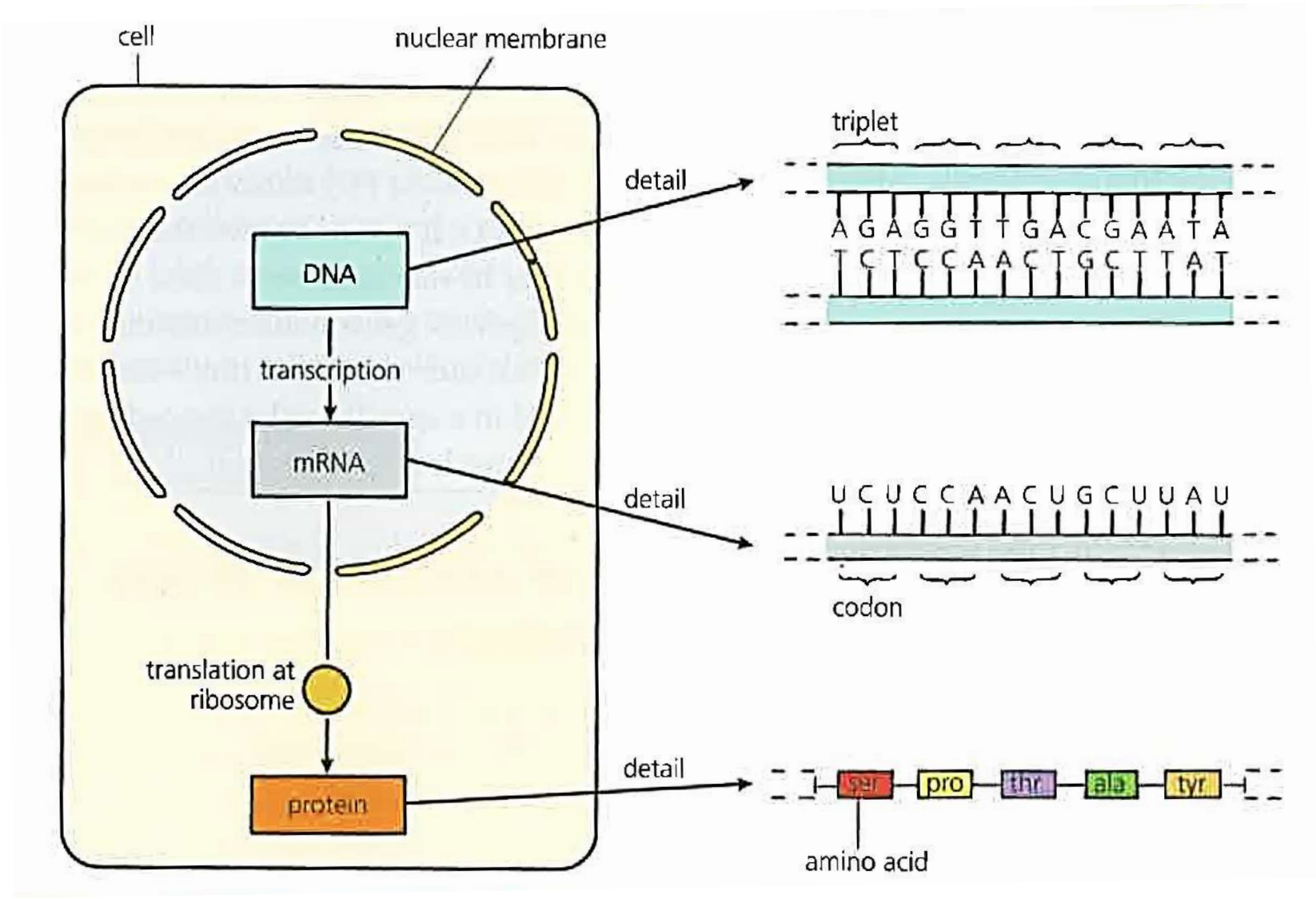
Gene Expression

- Process involving **transcription** and **translation** where DNA sequences are used to direct the **production of proteins**

- Otherwise known as protein synthesis

- An organisms **phenotype** is determined by the proteins produced as a result of gene expression

Fig 2.11 Overview of gene expression

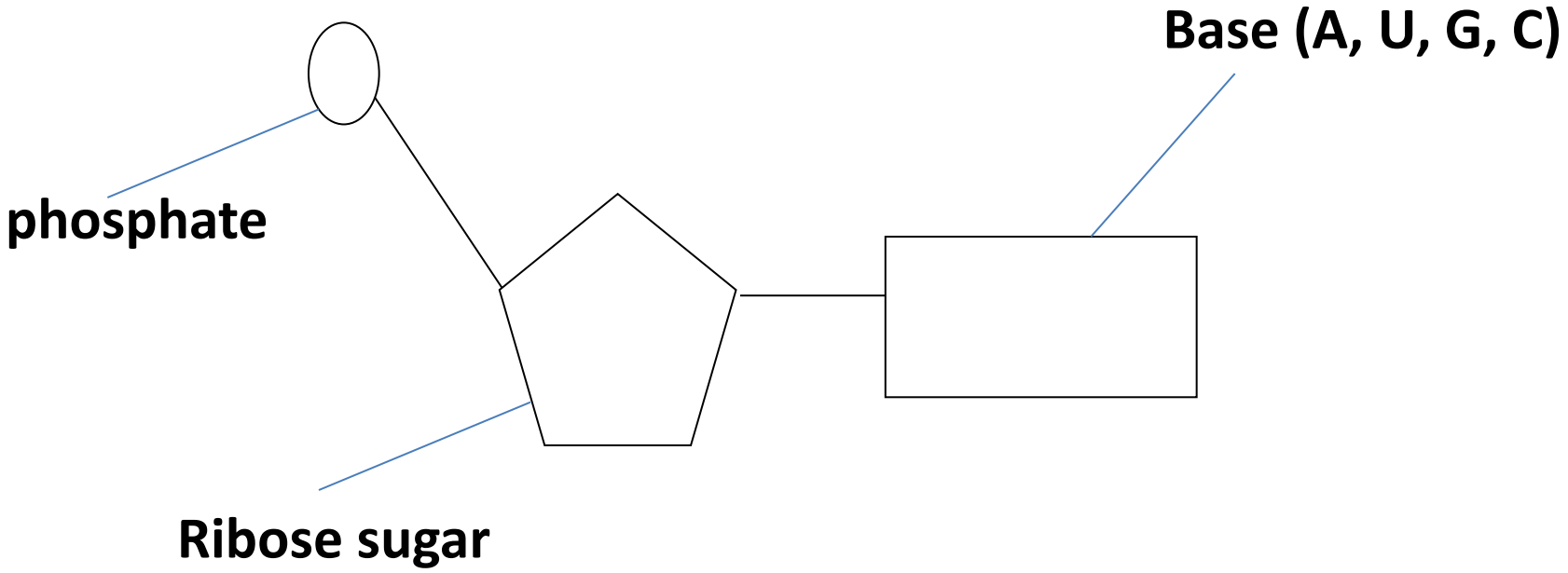


Structure and function of RNA

RNA =

ribonucleic acid

Draw an RNA nucleotide



Differences between DNA and RNA

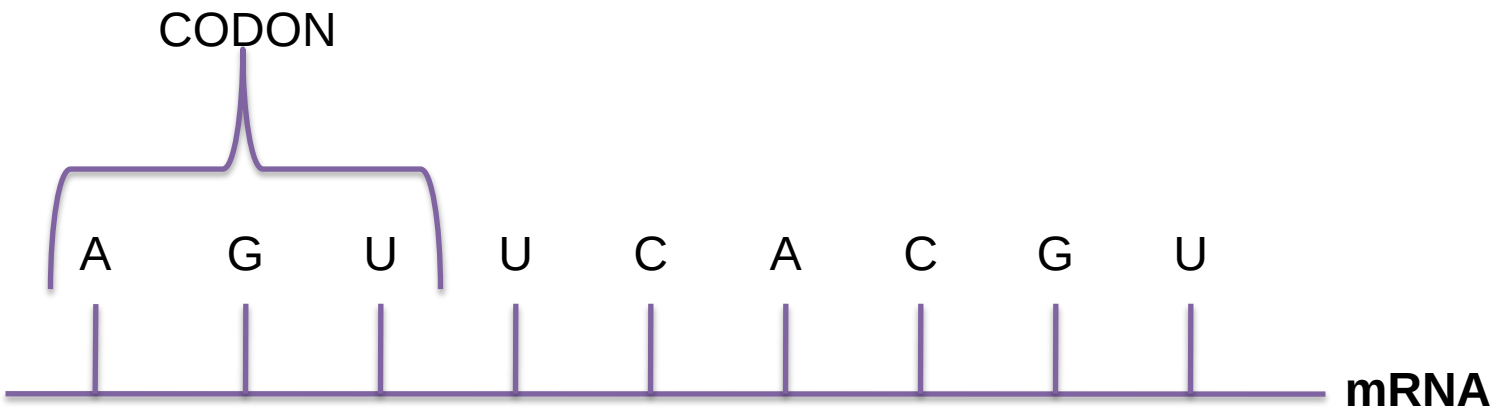
	DNA	RNA
Found in		
Strands		
Sugar		
Bases		

Forms and functions of RNA

1. Messenger RNA (mRNA)

Carries a **copy** of the specific DNA code from the Nucleus to a ribosome that is either attached to the RER or free floating in the cytoplasm.

It has a linear form and groups of 3 bases called codons

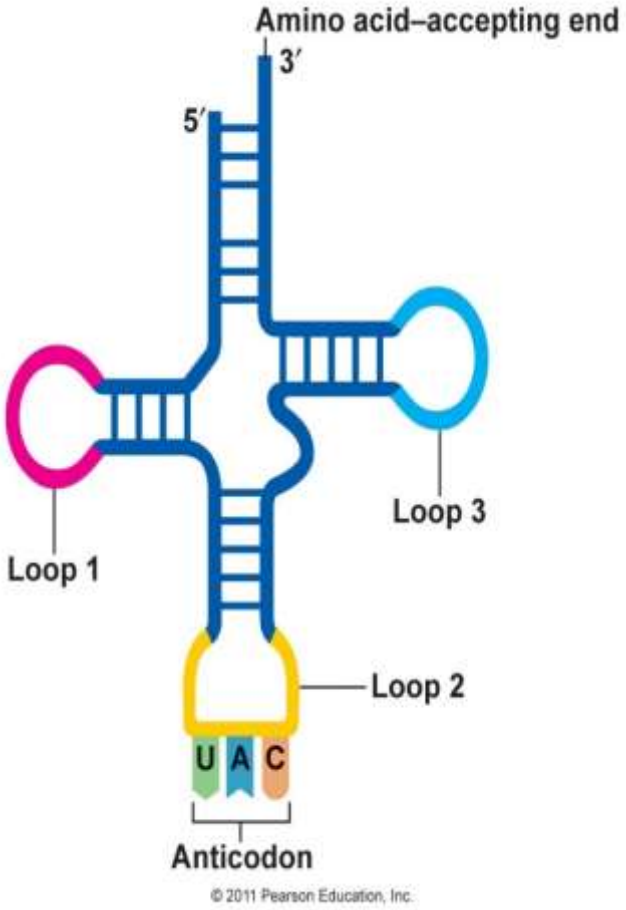


Forms and functions of RNA

2. Transfer/Transport RNA (tRNA)

Each molecule of tRNA carries a specific amino acid.

It has a folded shape and groups of 3 bases called anticodons.



Forms and functions of RNA

3. Ribosomal RNA (rRNA)

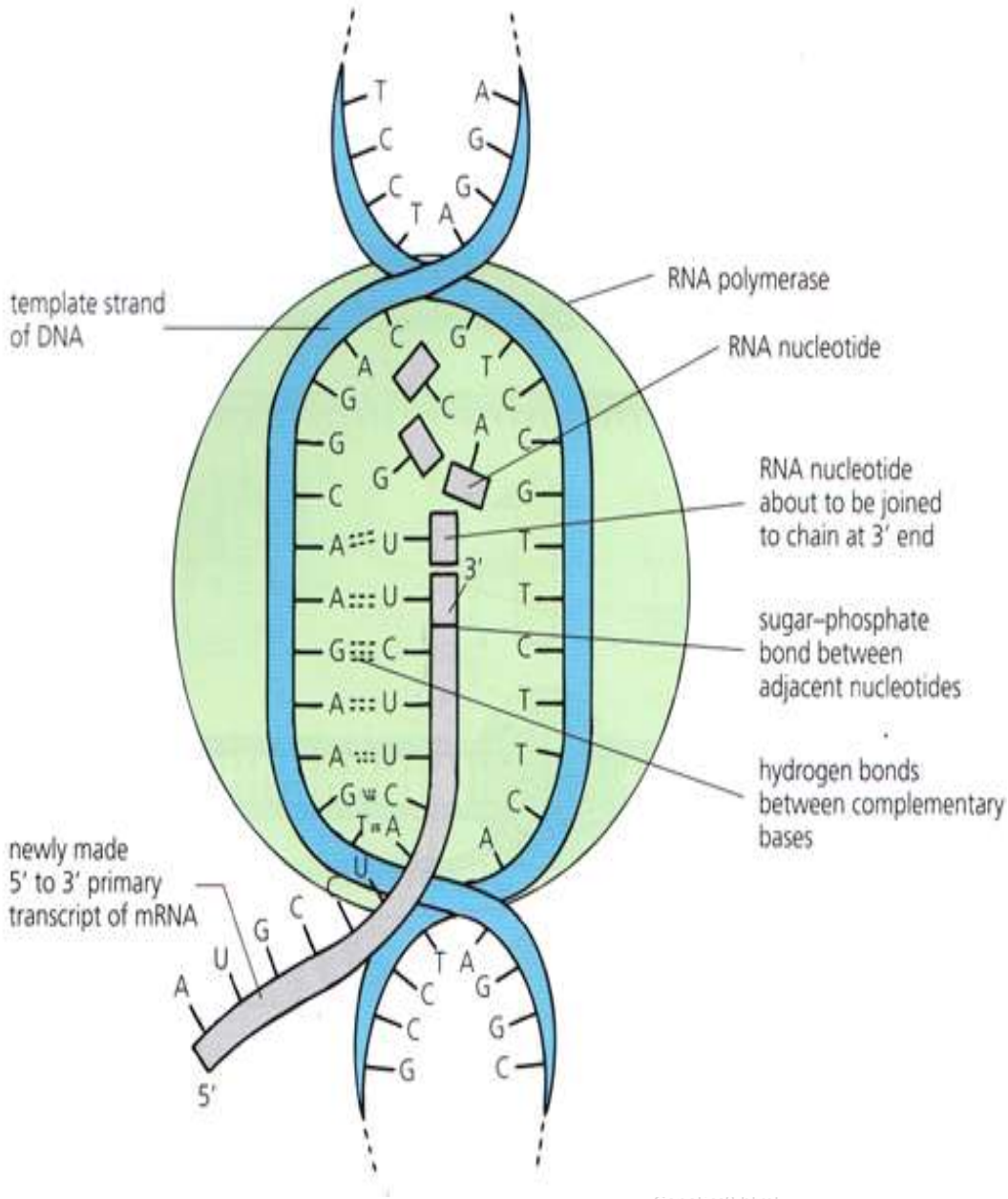
Along with ribosomal protein, rRNA forms the protein-synthesising organelles Ribosomes

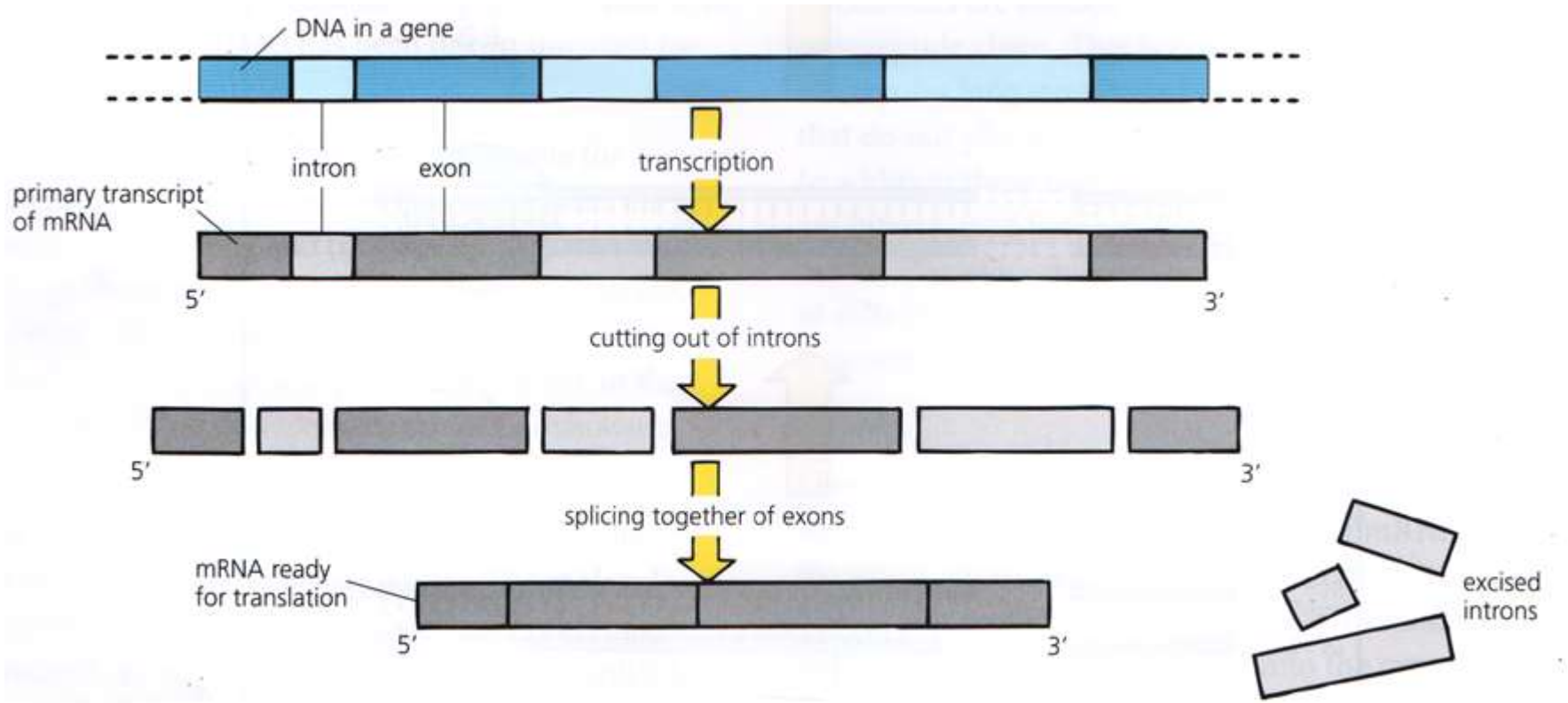
Protien Synthesis

- Stages

1. Transcription
(takes place in the nucleus)

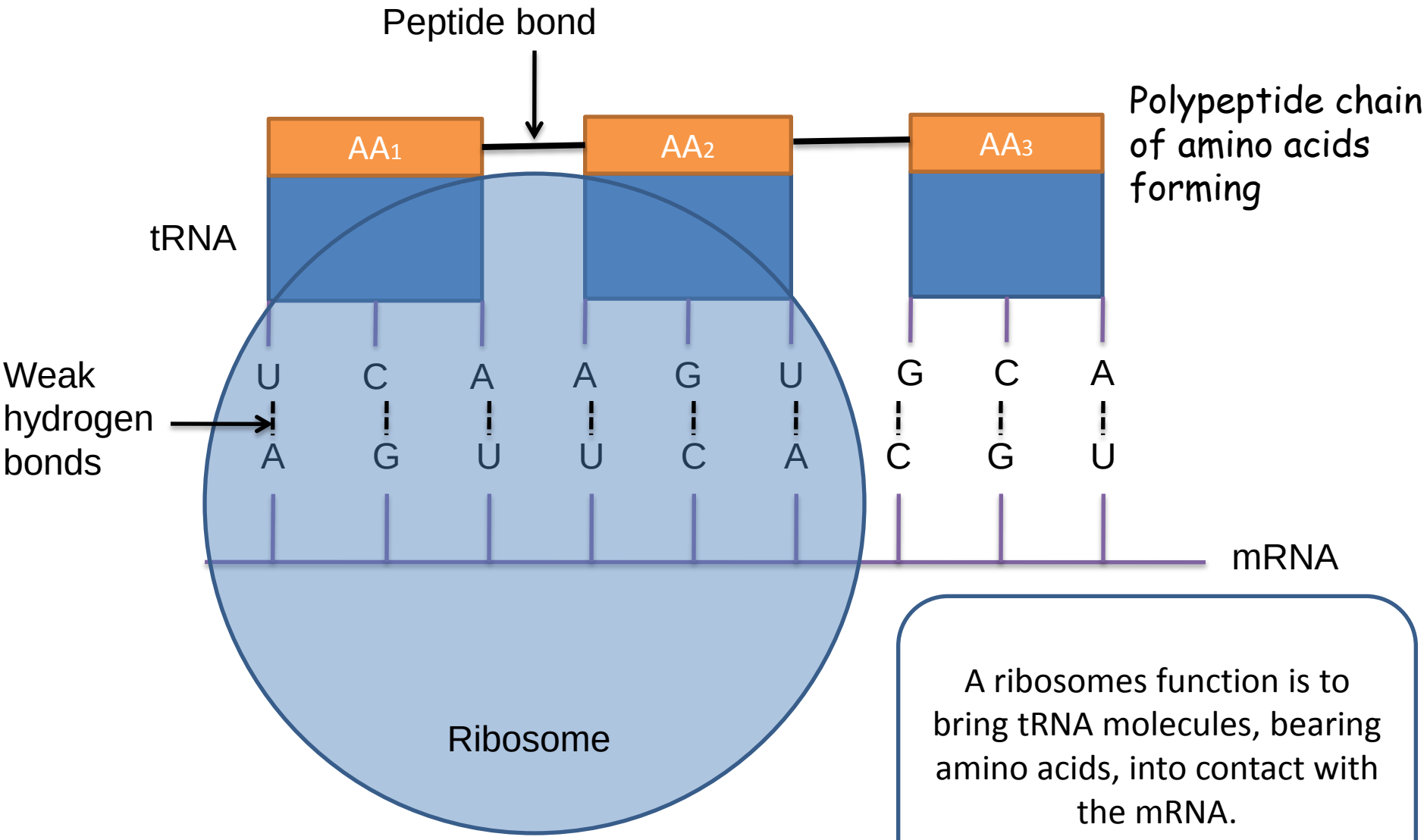
- DNA is “unzipped” and unwound by <u>RNA polymerase</u>.
- RNA polymerase joins together **RNA nucleotides**, which are complementary to the DNA, to create primary messenger RNA (mRNA).





- This is a primary transcript of mRNA, it contains both introns (non-coding regions) and exons (coding regions).
- To create a mature mRNA transcript, from which a protein can be assembled, the introns must be removed and exons joined together.
- This process is called RNA splicing.
- The mRNA then passes out through a nuclear pore into the cytoplasm.

2. Translation
(takes place in the cytoplasm on ribosomes)



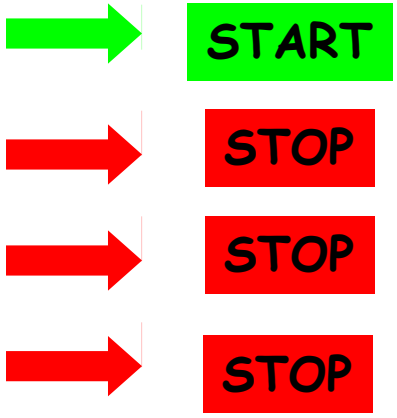
A ribosomes function is to bring tRNA molecules, bearing amino acids, into contact with the mRNA.

- Is the synthesis of a protein in the form of a polypeptide chain.
- Before translation can start a ribosome must bind to the 5’ end of the mRNA template.

Start and Stop Codons

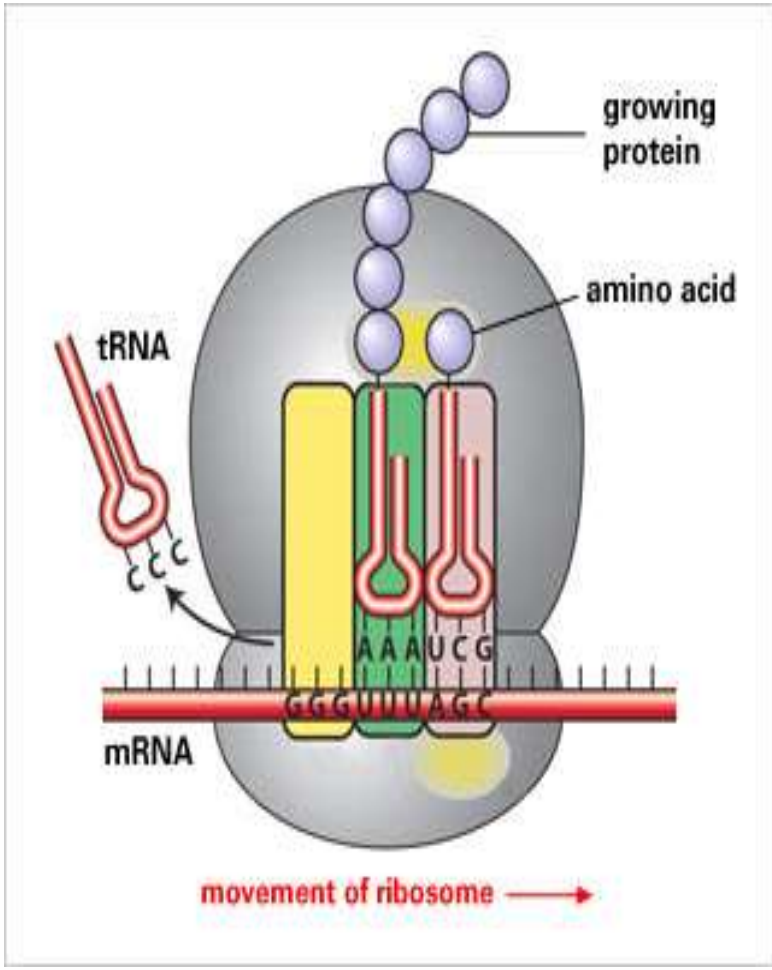
- Some codons have important roles at the beginning and end of the translation process. They are known as "start" and "stop" codons.

mRNA codon	tRNA anticodon	Amino acid
AUG	UAC	Methionine
UAA	AUU	NONE
UAG	AUC	NONE
UGA	ACU	NONE

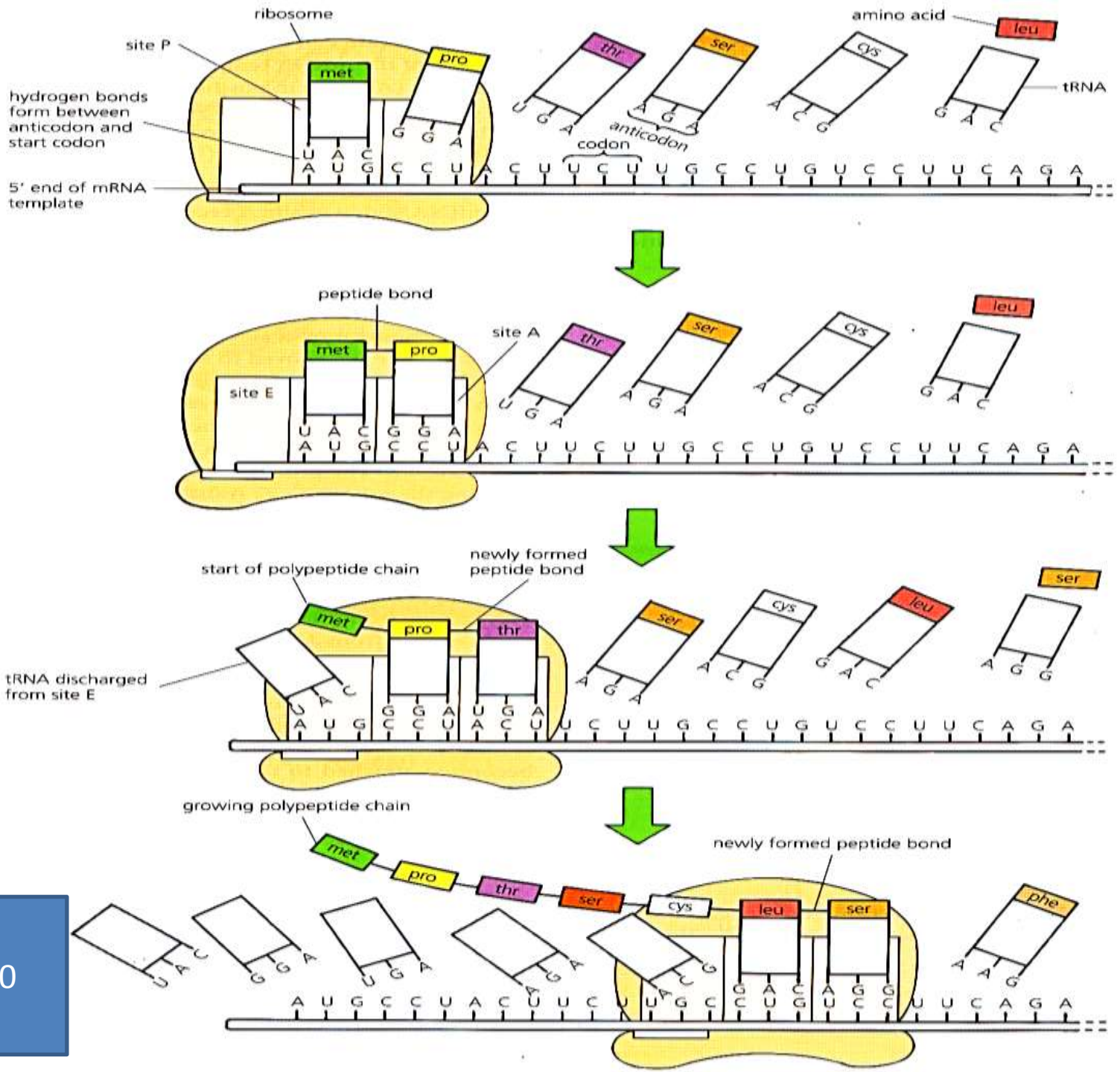


Translation

- As the mRNA moves through the ribosome an mRNA codon is read.
- A tRNA, with an anticodon **complementary** to the mRNA codon, brings the **specific** amino acid.
- **Peptide bonds** form between the amino acids and the tRNA leaves the ribosome free to collect another specific amino acid.



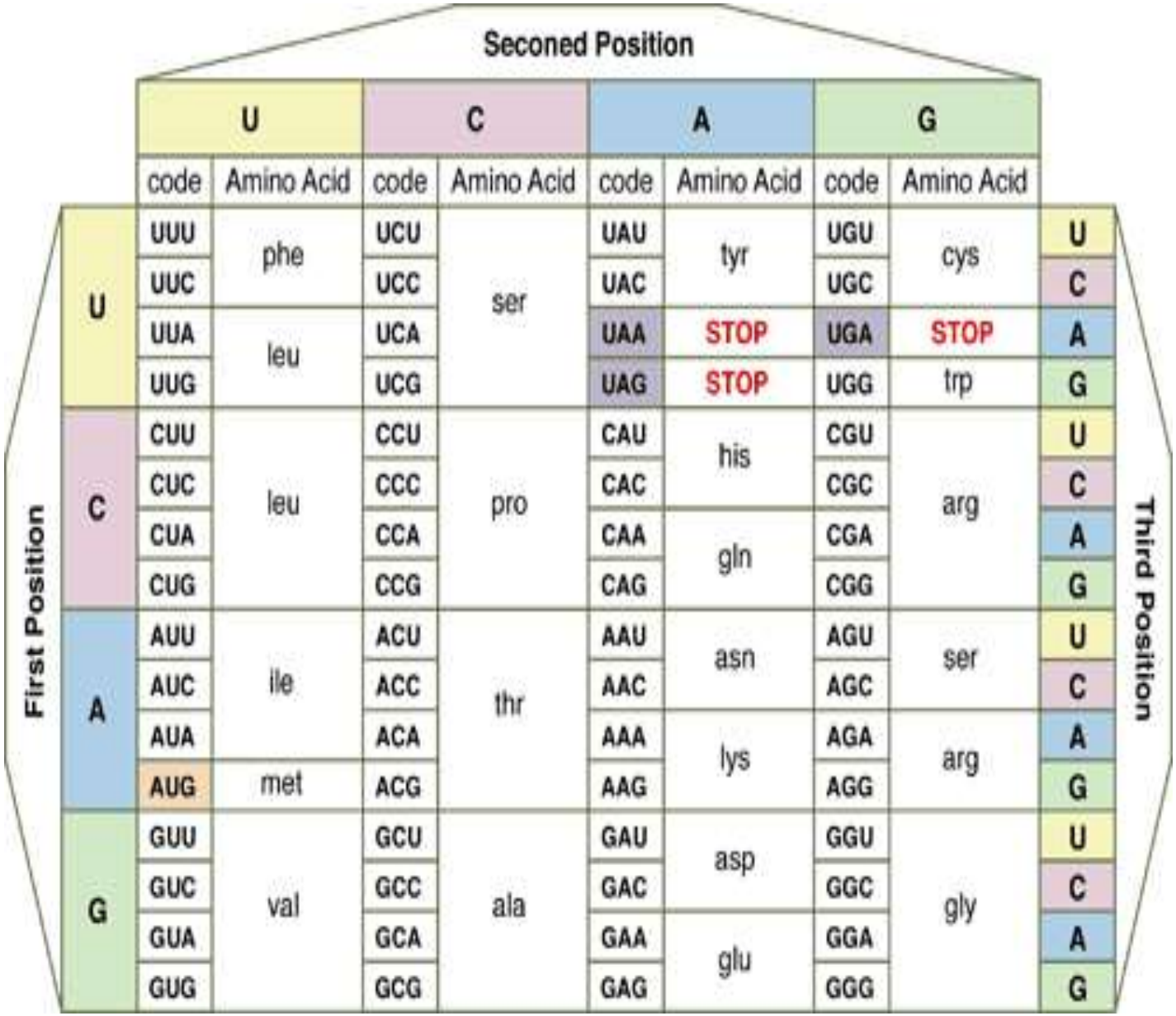
http://www.proteinsynthesis.org/w
is-protein-synthesis/


ribosome
site P
met
pro
thr
ser
cys
leu
amino acid
tRNA
hydrogen bonds form between anticodon and start codon
anticodon
codon
5' end of mRNA template
peptide bond
site A
site E
start of polypeptide chain
newly formed peptide bond
tRNA discharged from site E
growing polypeptide chain
phe

Importance of Protein Synthesis (gene expression)

- Allows **specific** proteins to be made

Codons



First Position	U		C		A		G		Third Position
	code	Amino Acid	code	Amino Acid	code	Amino Acid	code	Amino Acid	
U	UUU	phe	UCU	ser	UAU	tyr	UGU	cys	U
	UUC		UCC		UAC		UGC		C
	UUA	leu	UCA		UAA	STOP	UGA	STOP	A
	UUG		UCG		UAG	STOP	UGG	trp	G
C	CUU	leu	CCU	pro	CAU	his	CGU	arg	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	gln	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	ile	ACU	thr	AAU	asn	AGU	ser	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	lys	AGA	arg	A
	AUG	met	ACG		AAG		AGG		G
G	GUU	val	GCU	ala	GAU	asp	GGU	gly	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	glu	GGA		A
	GUG		GCG		GAG		GGG		G

http://www.biologycorner.com/worksheets/codon-bingo.html

Codon Bingo

- Draw a grid which is 4x4.
- There are 20 different amino acids, fill your grid with 16 of these.
- Codons will then be read out, if it codes for an amino acid on your card highlight it.

ALA – alanine	ARG – arginine	ASN – asparagine	ASP – aspartic acid
CYS – cysteine	GLU – glutamic acid	GIN – glutamine	GLY – glycine
HIS – histidine	ILE – isoleucine	LEU – leucine	LYS – lysine
MET – methionine	PHE – phenylalanine	PRO – proline	SER – serine
THR – threonine	TRP – tryptophan	TYR – tyrosine	VAL - valine

is-protein-synthesis/

Transcribe and Translate a Gene

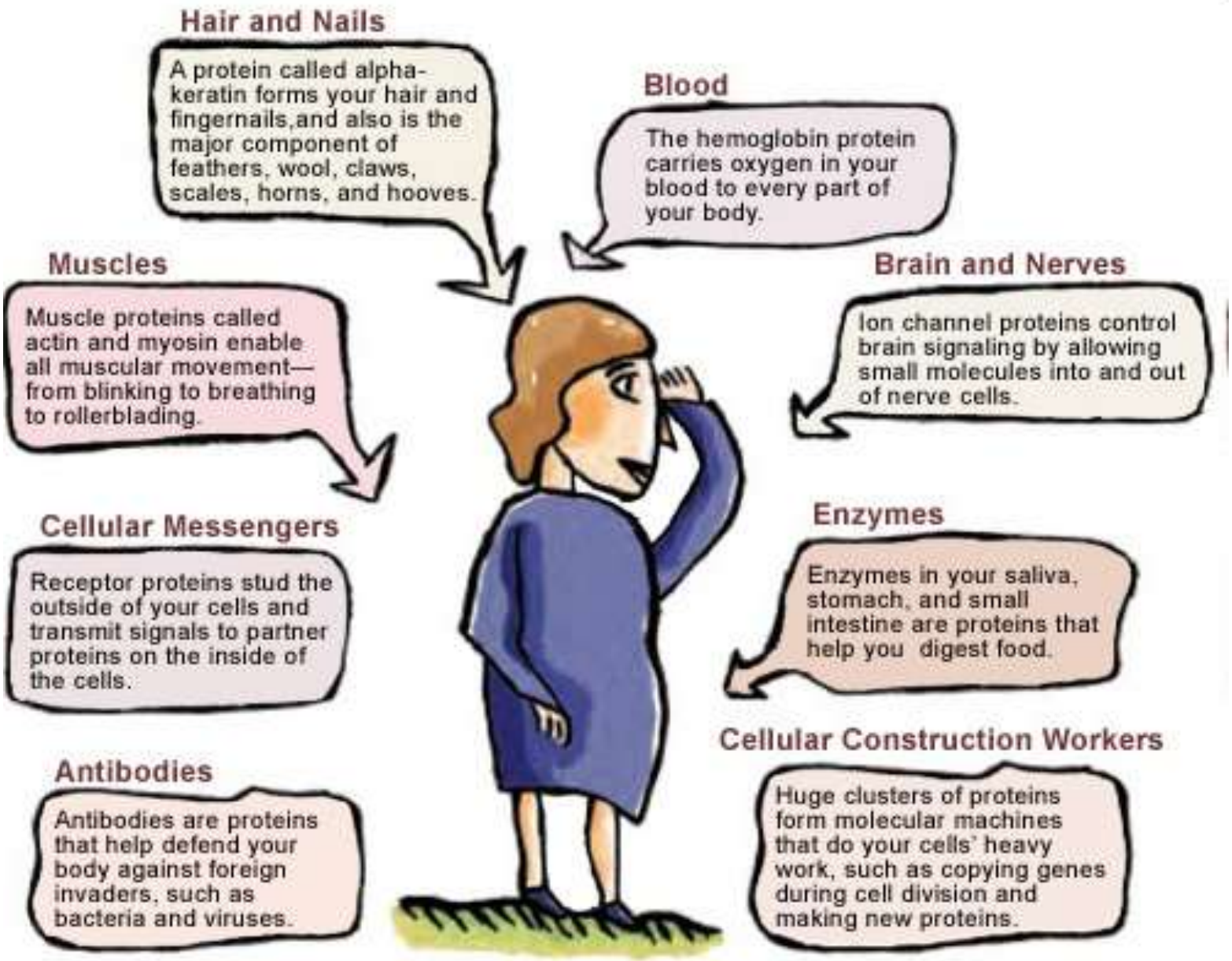
http://learn.genetics.utah.edu/content/molecules/transcribe/

Structure and Function of Proteins

- Here is a list of all the things composed of protein:

1. Hormones (Oestrogen, Progesterone, Testosterone, ADH, Growth hormone…)
2. Cell Membranes- important in making new cells and repairing damaged cells
3. Enzymes – control all chemical reactions
4. Antibodies – to fight infection
5. Hemoglobin in red blood cells
6. Cytochrome carriers

Proteins are the body's worker molecules



Amazing Biology Fact

- A human being possess 10 000 different types of protein !!!!!!!!!!!!!!!!!!!

- PROTEINS ARE IMPORTANT MAN !!!!!!!!

Structure of Proteins

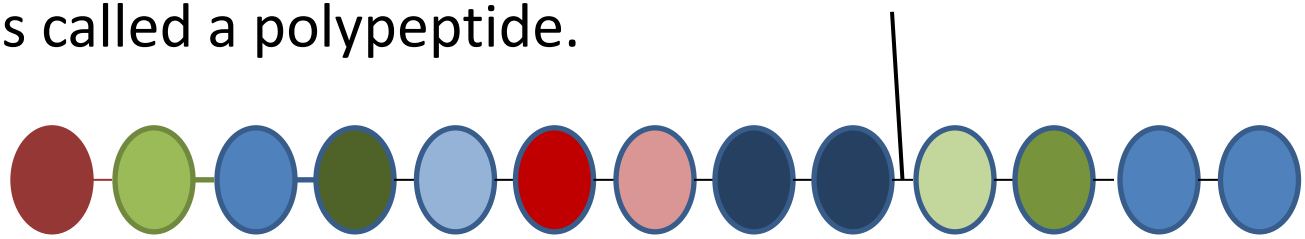
- Proteins contain carbon (C), hydrogen (H), oxygen (O) and nitrogen (N). They can also contain sulphur (S).

- Each protein is made of subunits called amino acids and there can be thousands of these long or just a few e.g. insulin only contains 51 amino acids.

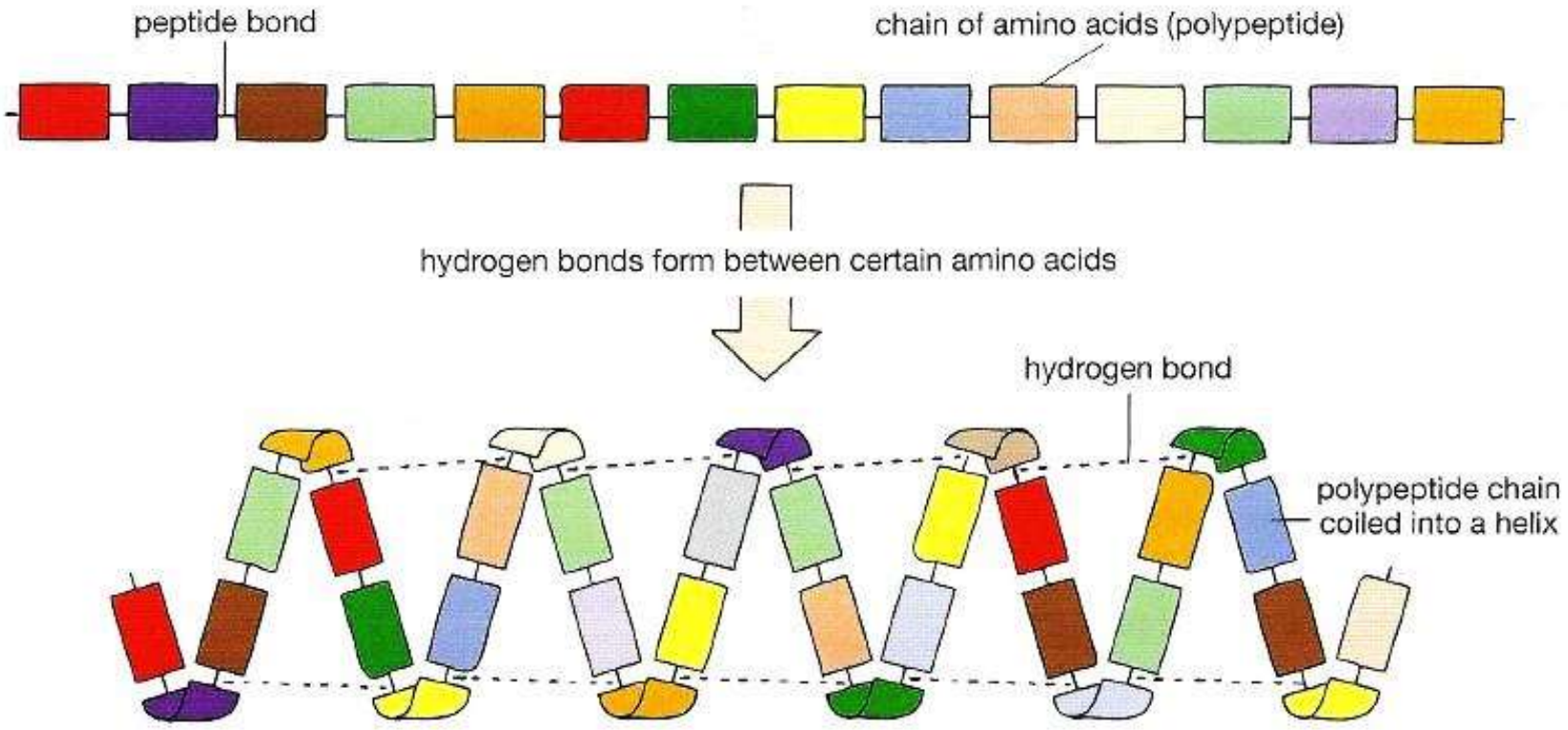
- In total, there are 20 different amino acids.

Polypeptides

- The order of amino acids in a protein is determined by the order of bases in the DNA.
- The final shape and function is determined by the sequence of amino acids.
- Amino acids are joined together by peptide bonds, each chain is called a polypeptide.



Hydrogen bonds form between certain amino acids in a polypeptide chain causing the chain to become coiled/folded.



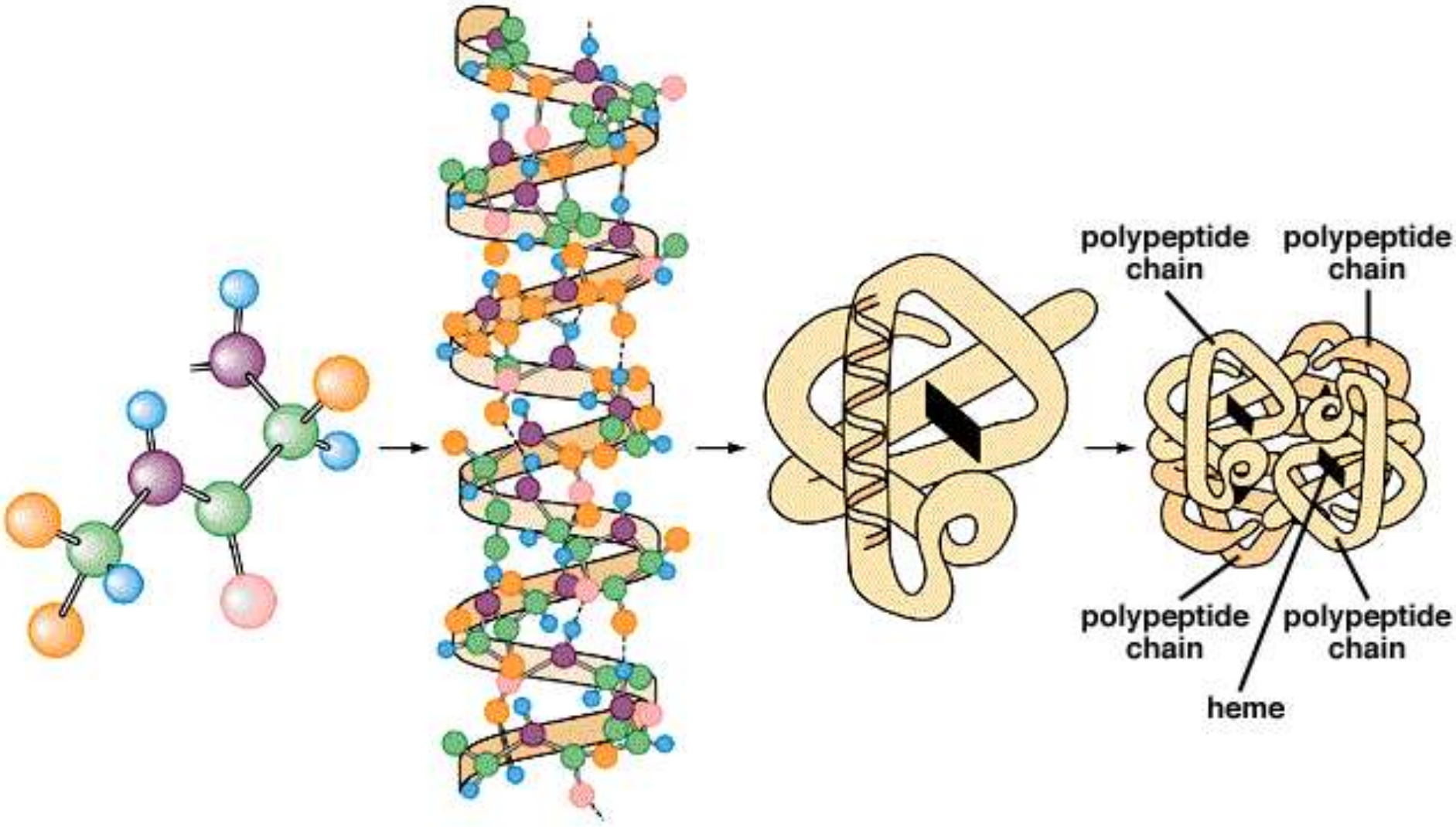
- As the protein folds, interactions between other amino acids can occur, more hydrogen bonds are formed as are sulphur bridges.

- These bonds are important as they cause the protein to adopt the 3D shape needed to perform its function.

- A polypeptide may also need to be cut to become active or be combined with another polypeptide.

- Non-protein components can also be required ,such as carbohydrate or a phosphate group.

The Four Levels of Protein Structure



Summary of the four levels of protein structure, using hemoglobin as an example.

Shapes of proteins

Primary structure (1°)

Consists of the initial amino acid sequence, linked by strong **covalent** bonds.

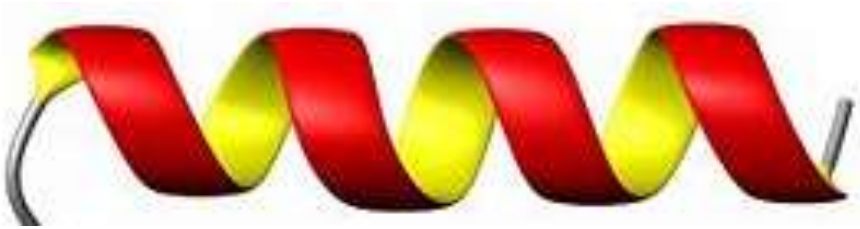
Crosslinks can be by **covalent** disulphide bridges and **ionic** interactions between charged amino acids.

There are also weaker **hydrogen** bonds and **other London dispersion** forces.

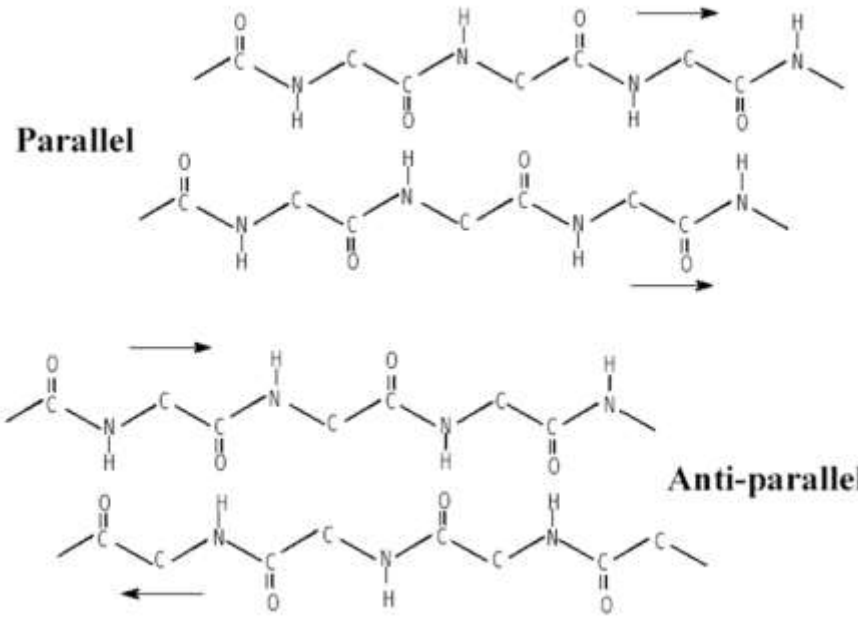
Secondary structure (2º)

There are two main secondary structures stabilised by **hydrogen** bonds.

Alpha helix



Beta pleated sheet

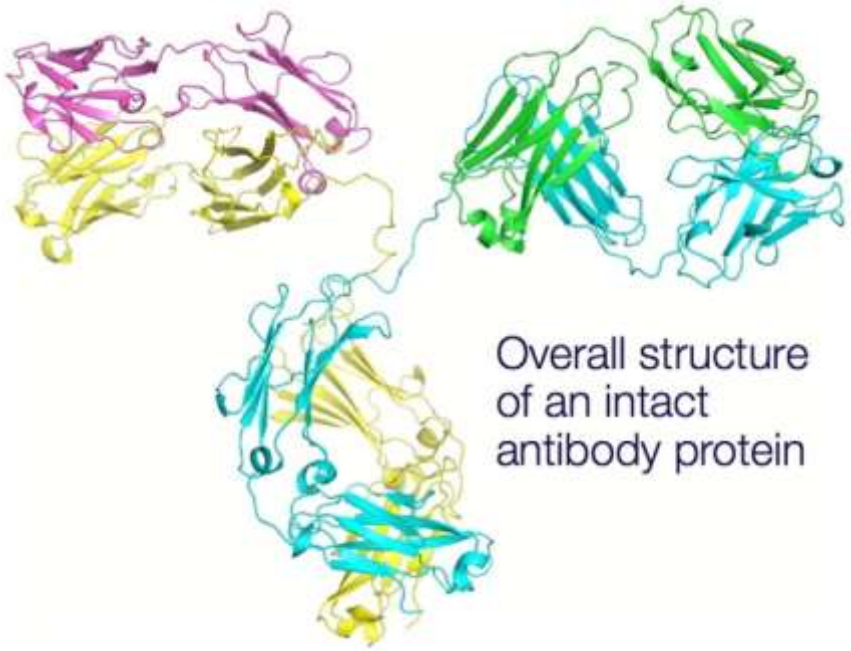


Tertiary structure (3^o)

The final folded shape of the polypeptide is the tertiary structure.

Quaternary structure (4°)

Polypeptides are linked together (each chain forms a d**omain**) and sometimes other non-protein elements are added.



Overall structure of an intact antibody protein

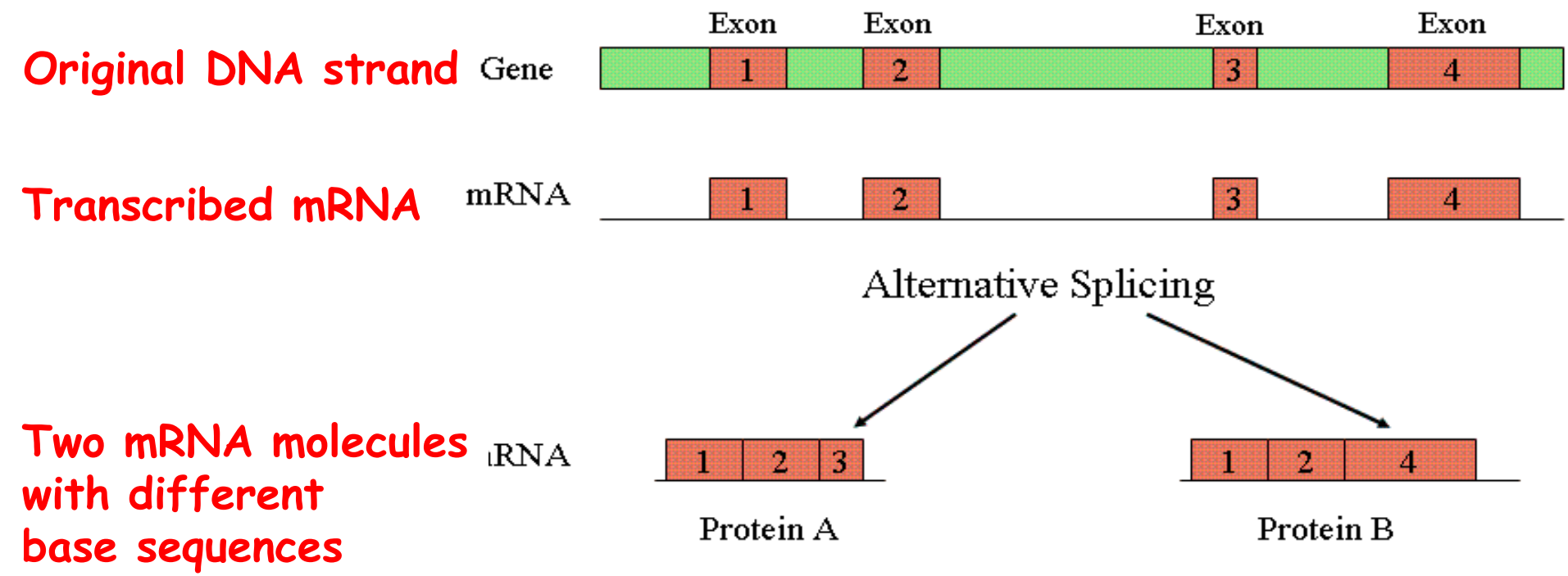
One Gene, Many Proteins

- The number of genes coded for in DNA is less than the number of different proteins you find in organisms.

- There are 2 main mechanisms for giving multiple proteins from a single gene.

http://bioinfo.cs.ccu.edu.tw/wiki/doku.php?id=splicing

Alternative RNA Splicing (see fig 2.14)

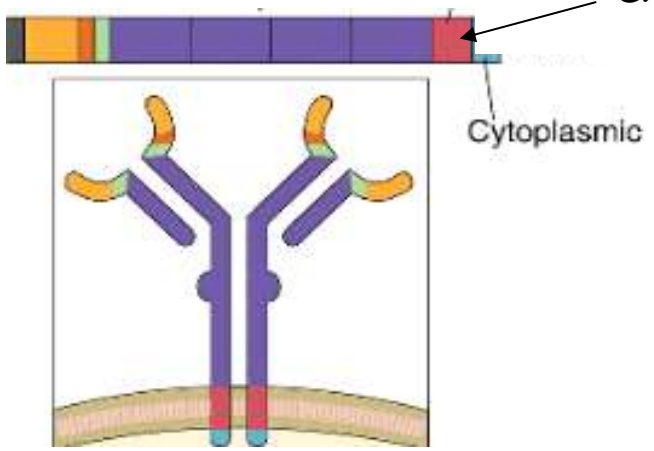


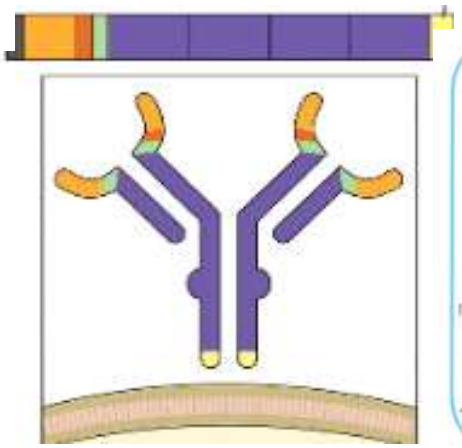
Alternative segments of mRNA can be treated as exons and introns.

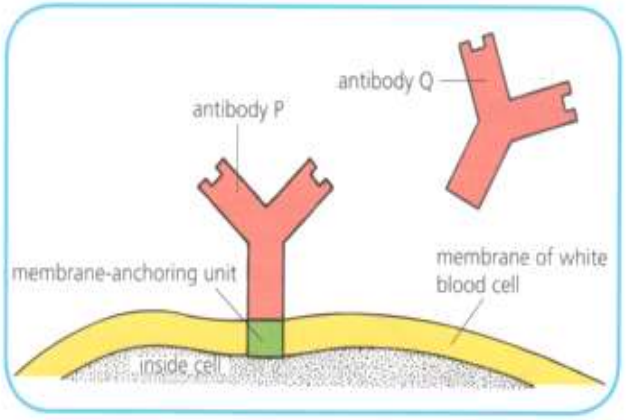
As a result, the original, transcribed mRNA can produce several mRNA molecules.

One gene can, therefore, code for several different proteins

One gene –Two Antibodies an example of alternative splicing







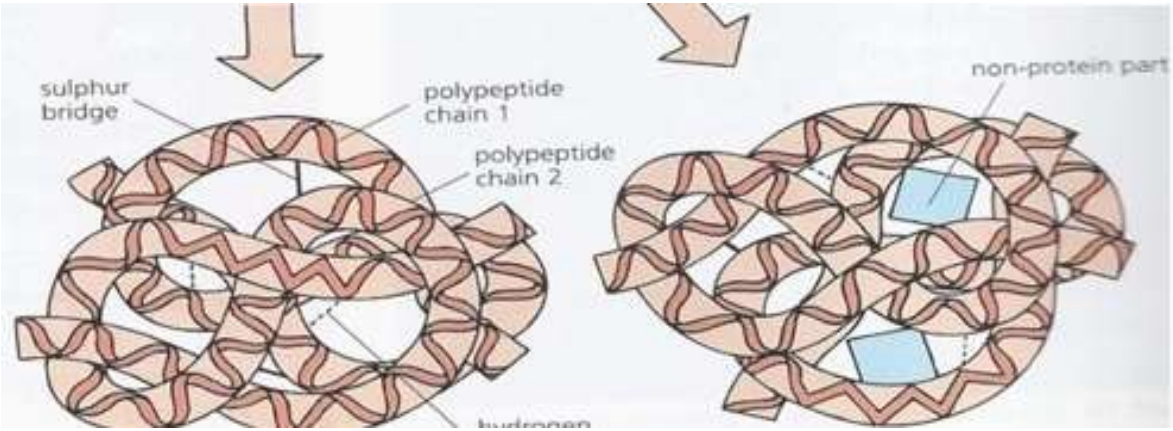
Antibody P
Membrane-anchored antibody

Antibody Q
Operates freely in the bloodstream

An antibody may have an extra exon coding for a structure which allows it to attach to cell membranes.
Another may lack the structure so cannot attach to membranes.

Post-translational Modification

- Once translation is complete ,further modification (in addition to the folding and coiling) may be required to enable a protein to perform its specific function



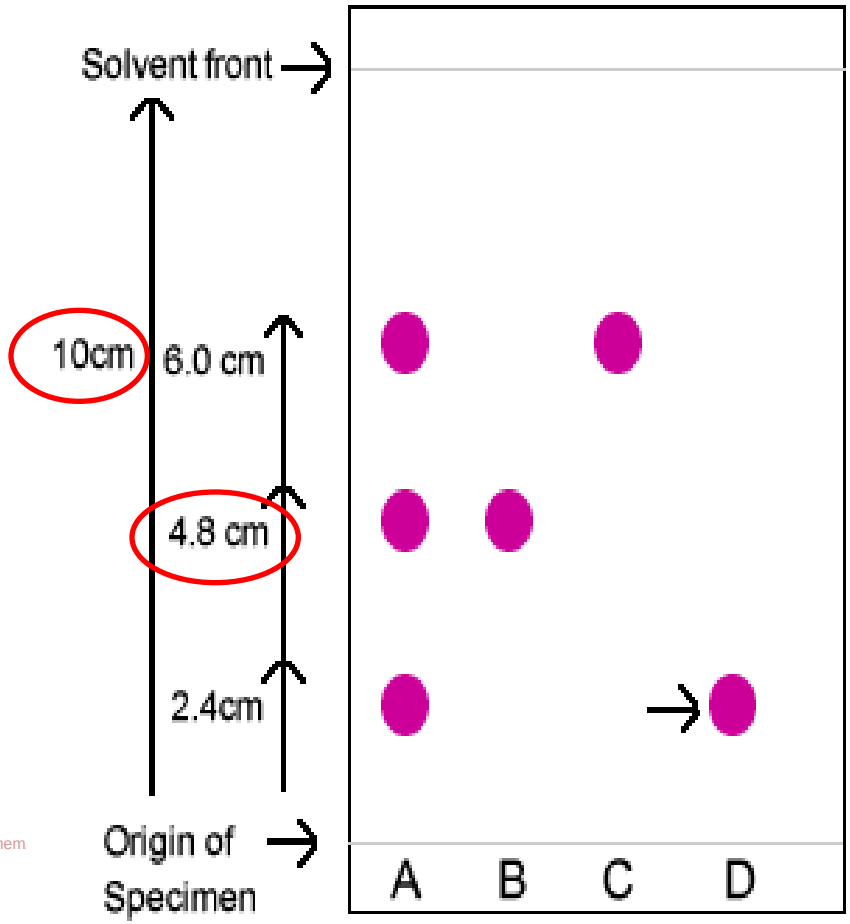
Separation and identification of amino acids using paper chromatography *(you will be given formula)*

- Rf (relevant front) value can be used to identify amino acids.

$$Rf = \frac{distance\ travelled\ by\ amino\ acids's\ front\ from\ origin}{distance\ travelled\ by\ solvent\ from\ origin}$$

- Amino acid b, $Rf = \frac{4.8}{10}$, = 0.48.

- This can then be compared to a table of known Rf values in the same solvent and the amino acid can be identified.



http://webcls.utmb.edu/samplecourses/chemu2-l3.asp?page=2352