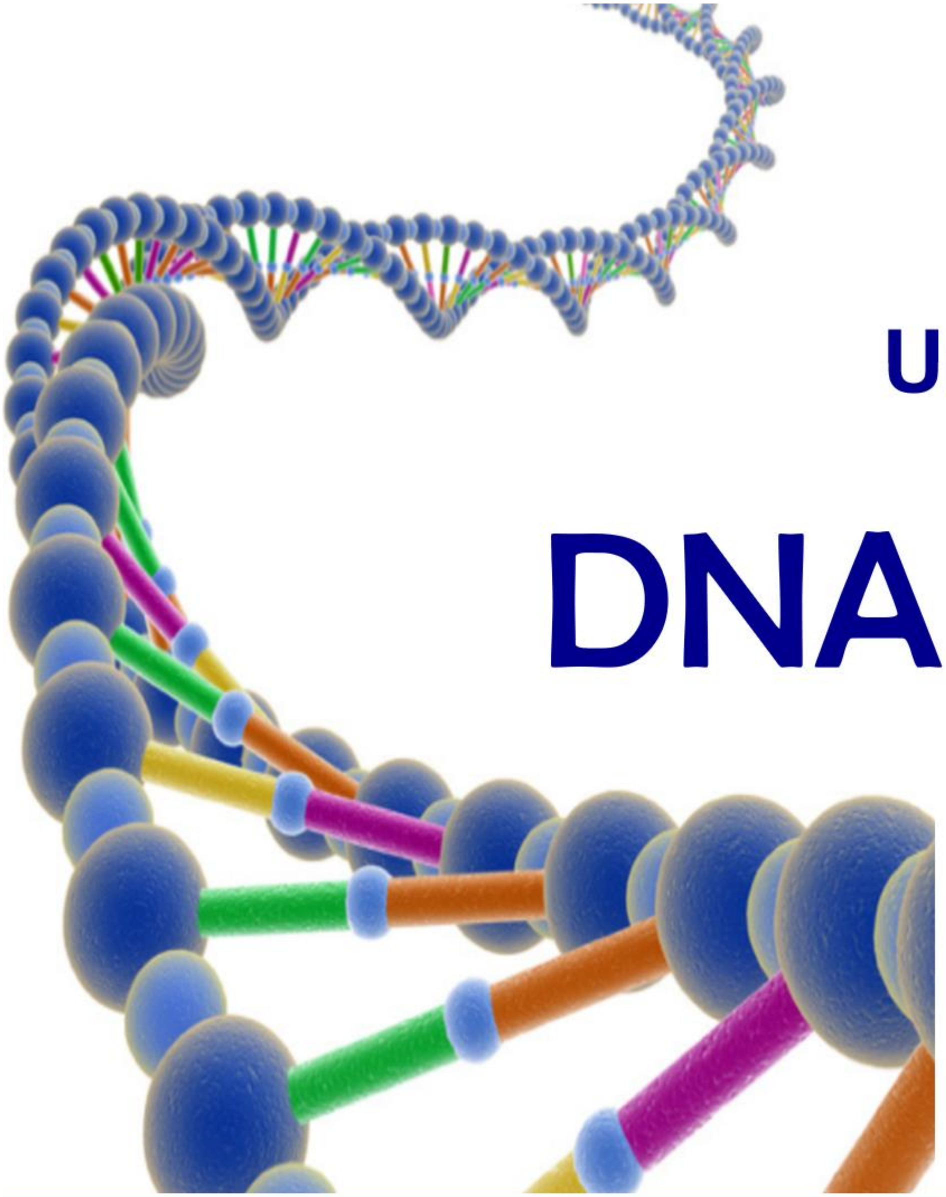
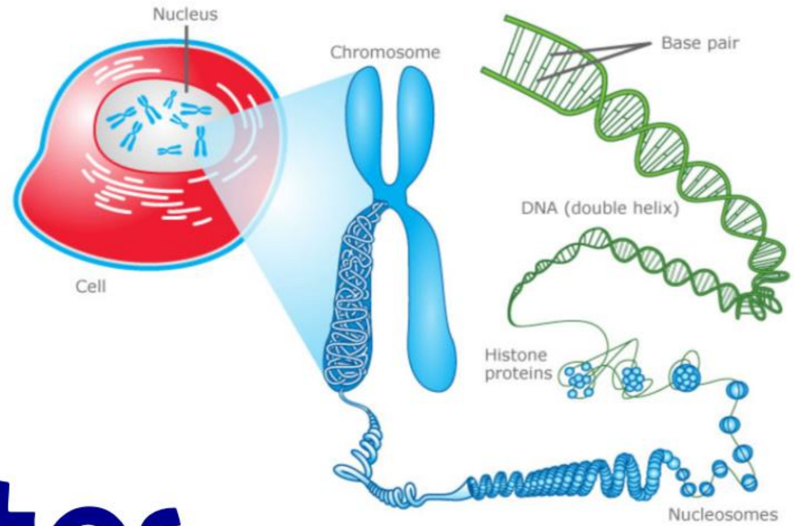


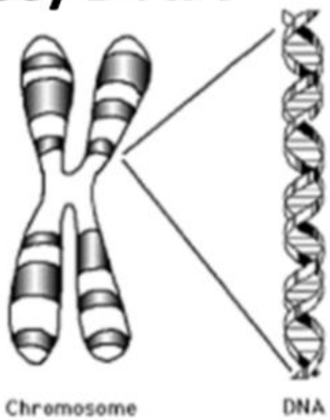
Unit 5

DNA Notes



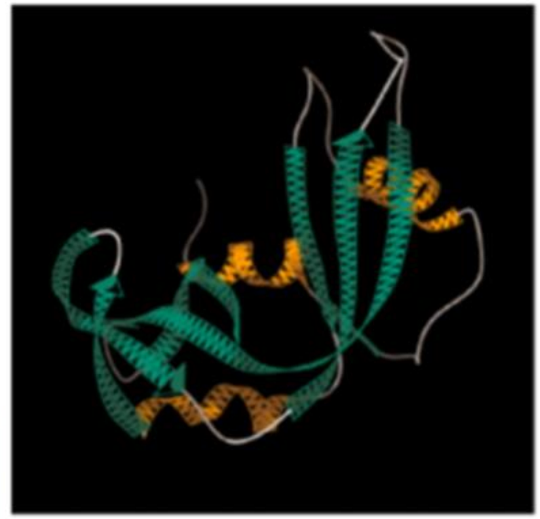
Why study gene expression

Genes/DNA



DNA

Gene Expression →



Proteins

People

Genetic information determines how we are build, how we look, how we function

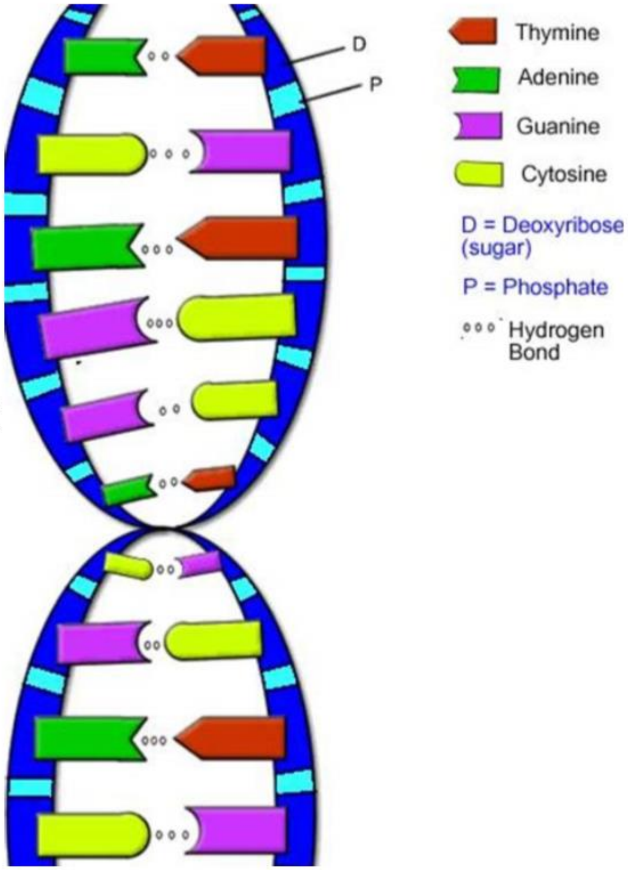
What is DNA?

DNA stands for Deoxyribonucleic Acid

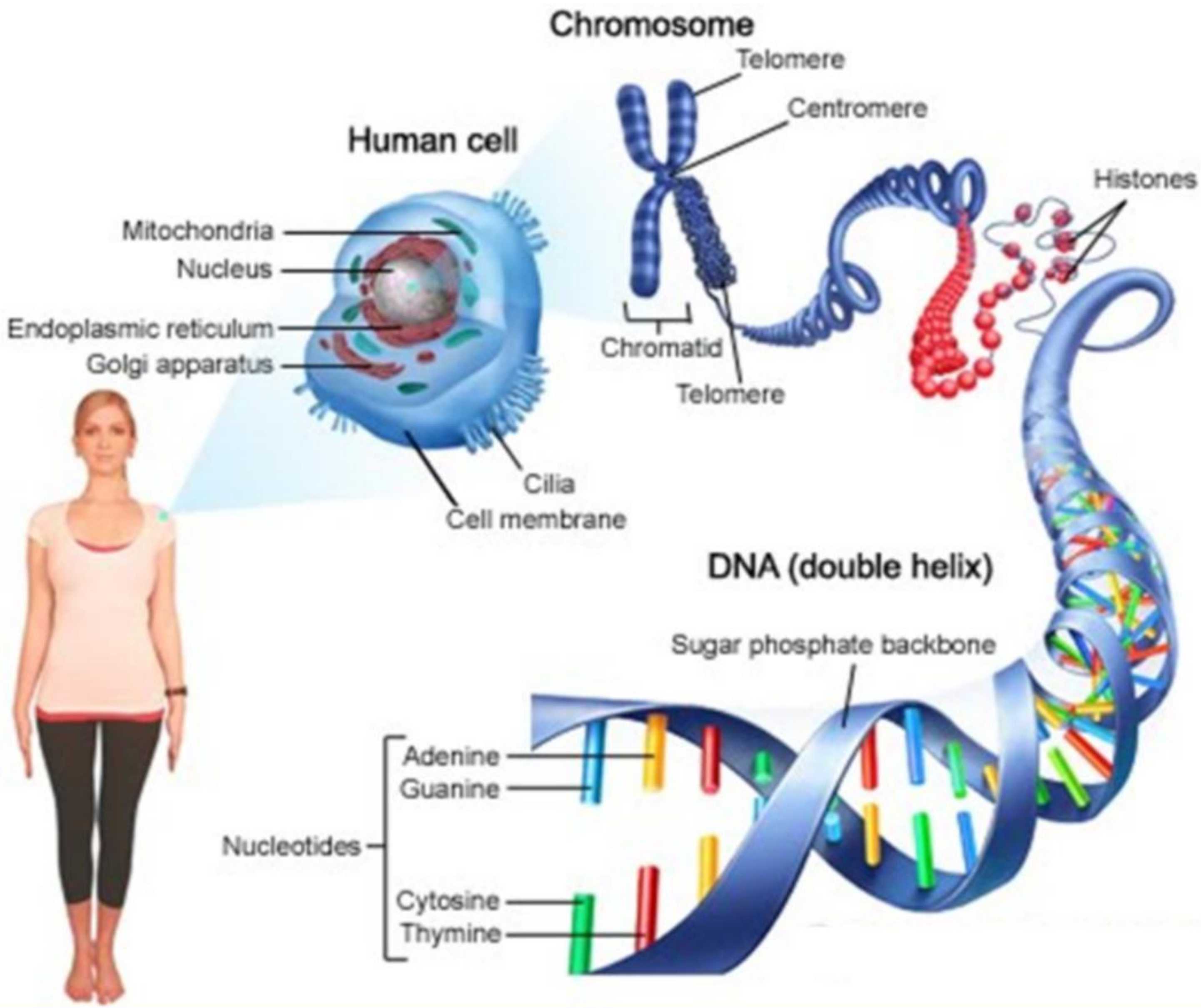
* Also known as the "twisted ladder" or double helix

DNA is a nucleic acid that stores and transmits genetic information from one generation of an organism to another.

All living things have DNA in their cells



Where is our DNA located?



What does DNA look like?

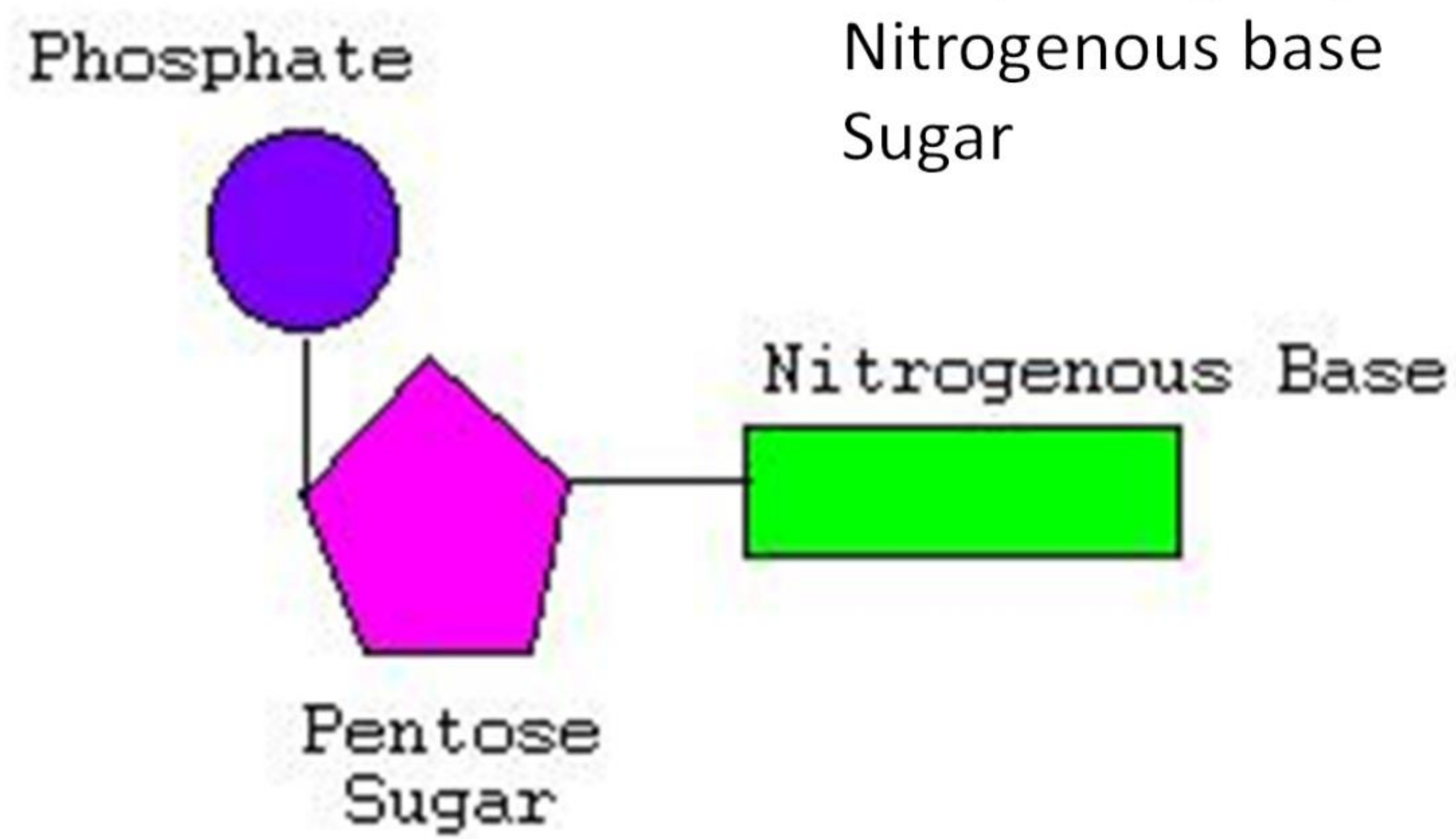
- DNA is made up of a chain of nucleotides

Nucleotides have three parts

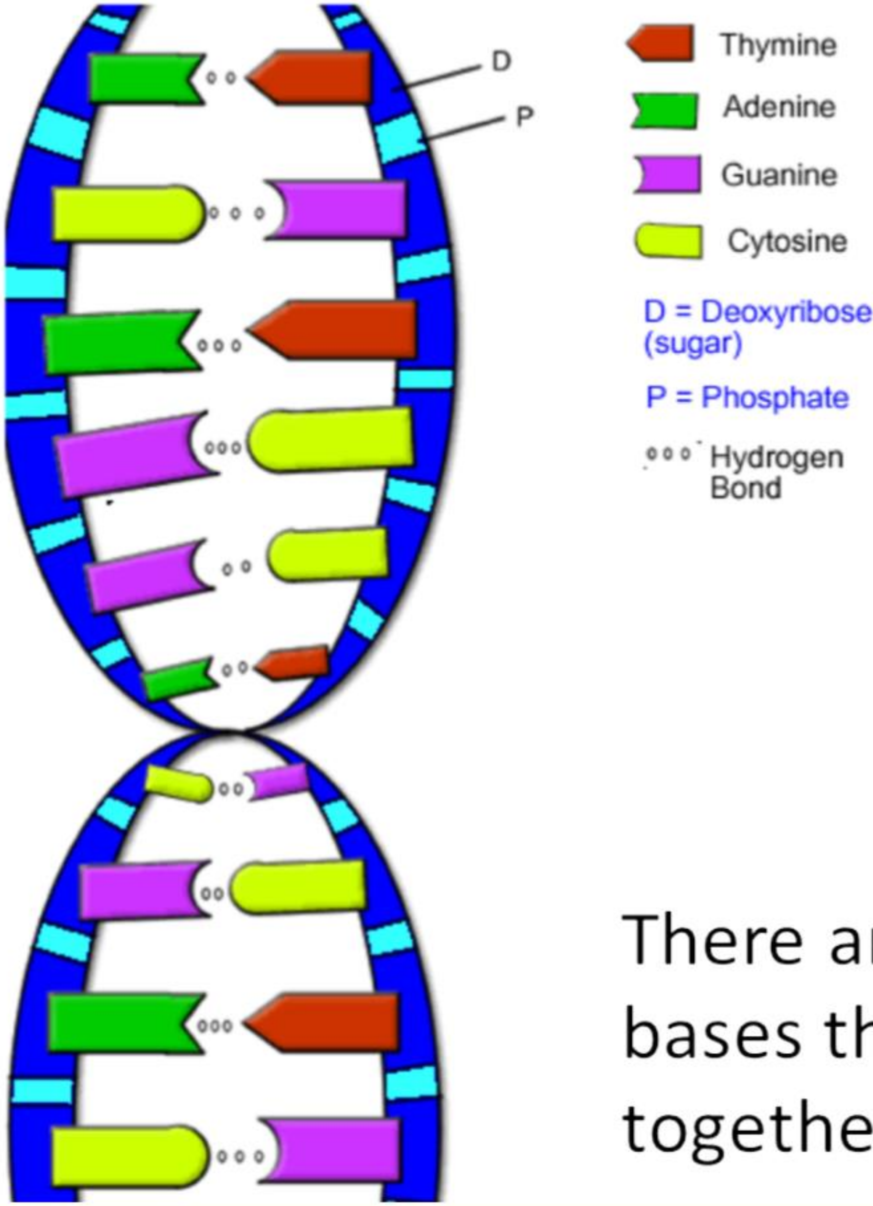
Phosphate group

Nitrogenous base

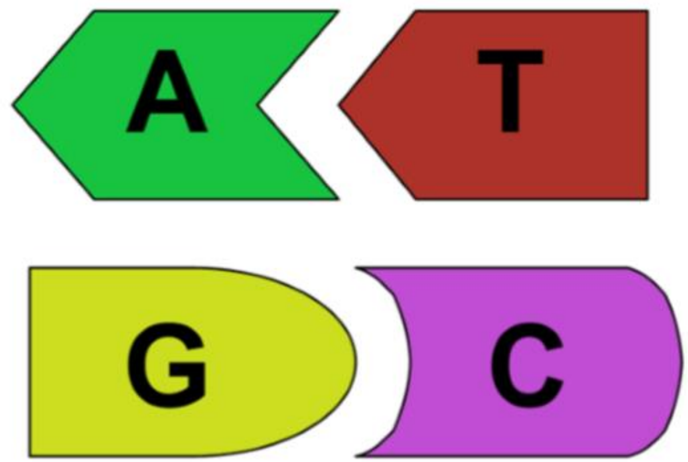
Sugar



What Does DNA Look Like?



Sugar (dark blue and phosphate (light blue) of the nucleotide make up the sugar phosphate backbone and support the DNA



There are four types of nitrogenous bases that hold the center of the DNA together using hydrogen bonds

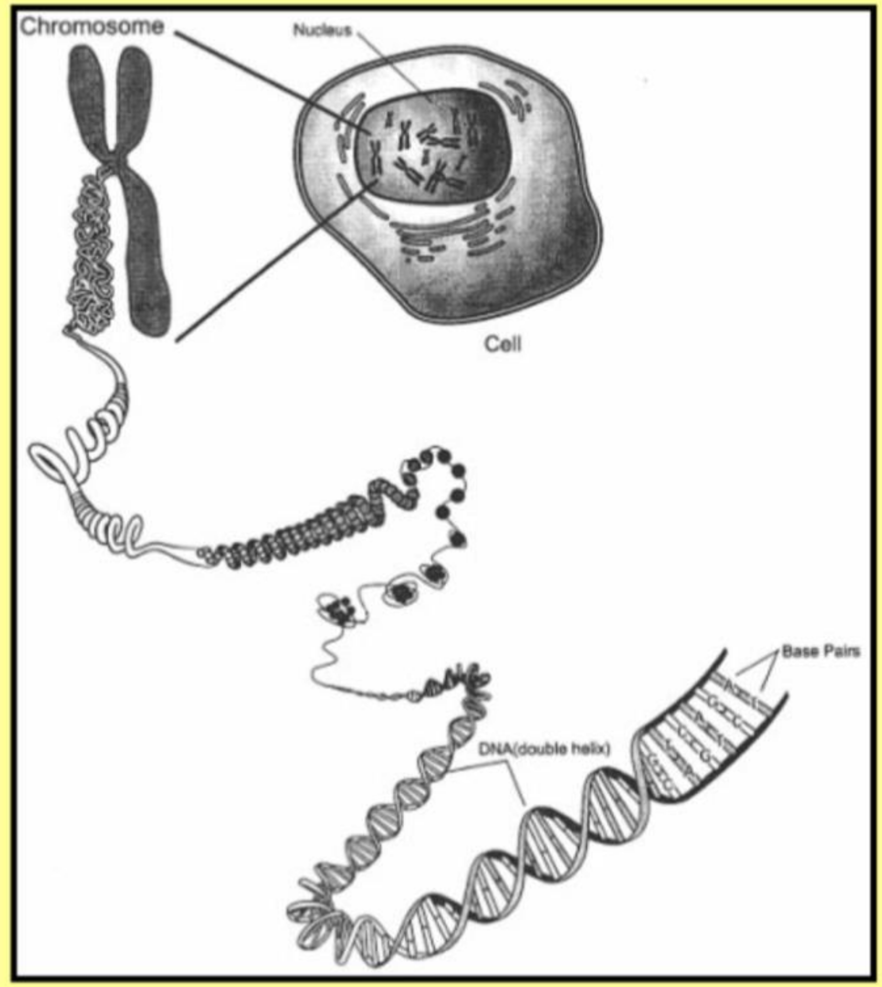
How much DNA is in one cell?

Genome = 46 chromosomes

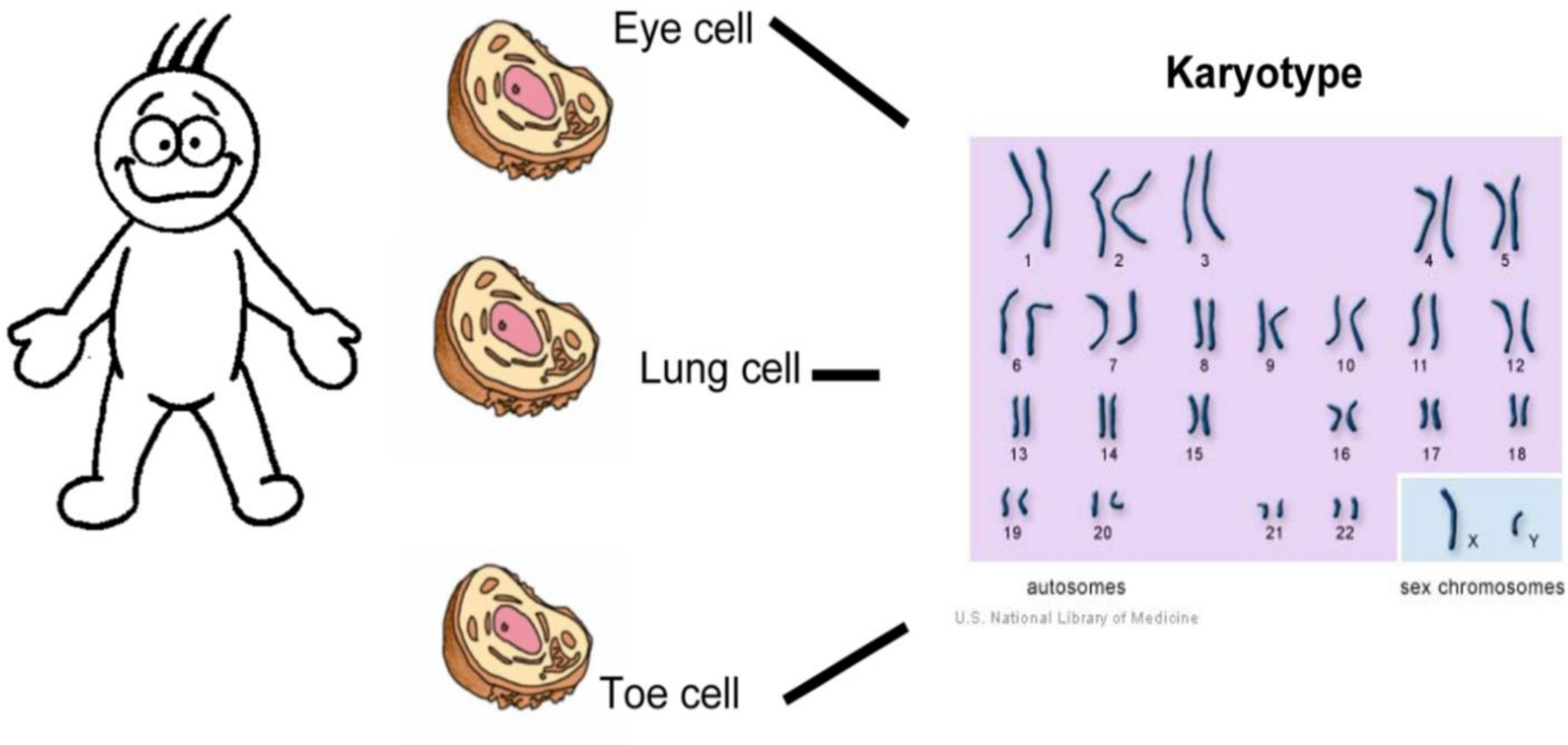
Genome = approx. 3 billion base pairs

One base pair is 0.00000000034 meters

DNA sequence in any two people is 99.9% identical – only 0.1% is unique!



Every cell in our body has the same DNA….

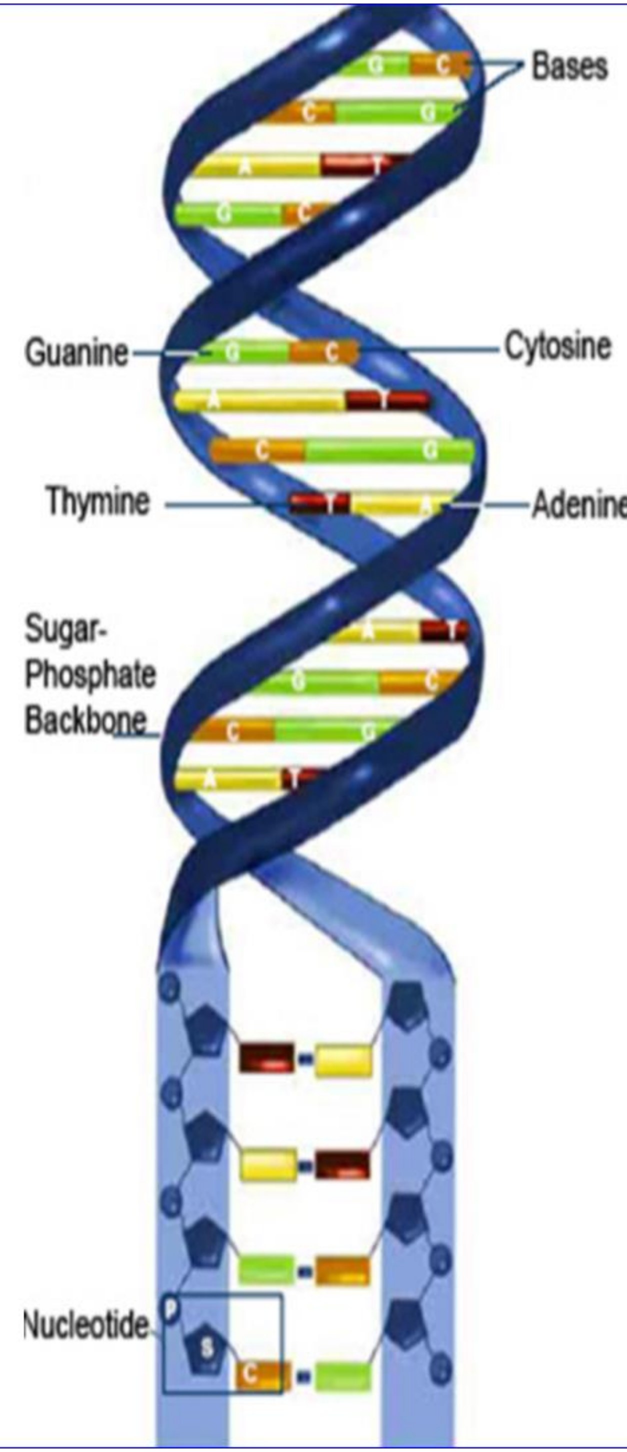


DNA Structure

Sugar and phosphate of the nucleotide link one nucleotide to another – making the chain

Nitrogenous bases link two chains together to form a twisted ladder or a double helix

The Bases are on the inside of the helix

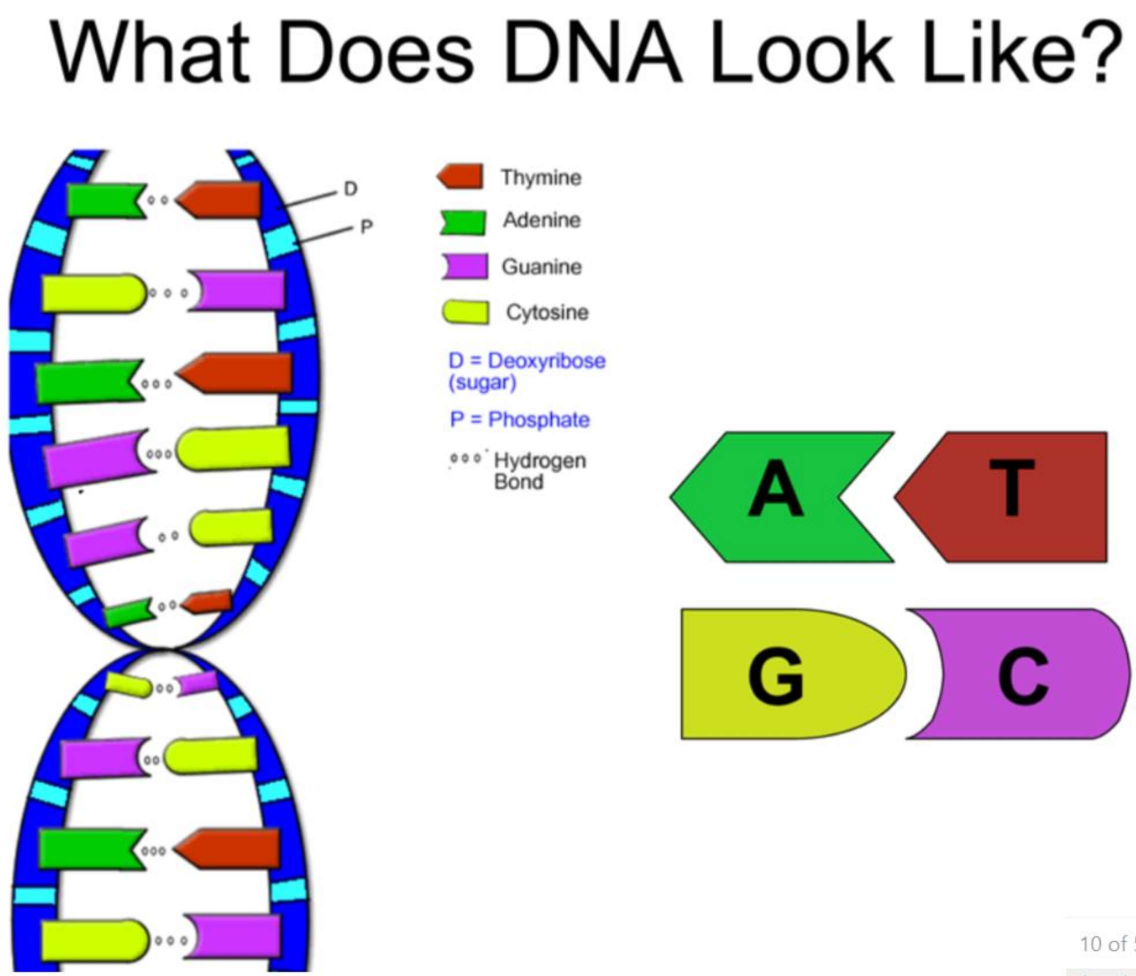


The Base-Pair Rule

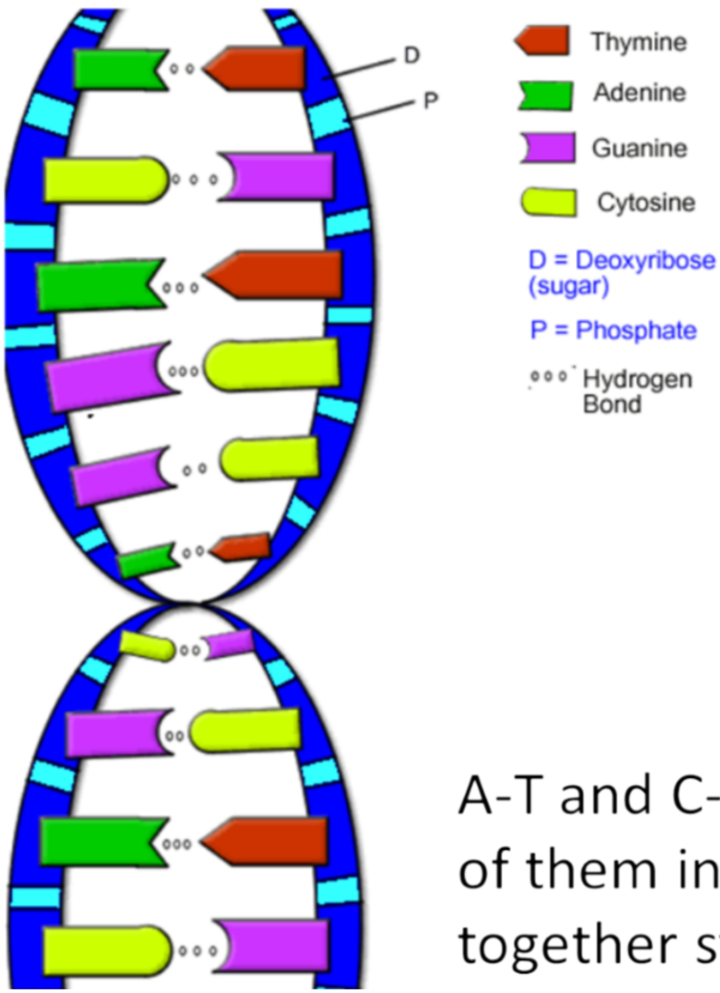
Nitrogenous bases:
A,G, C, T

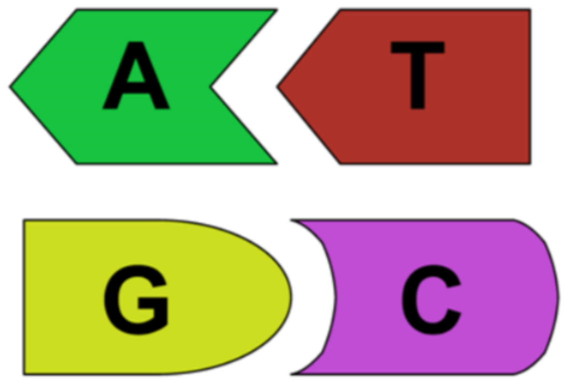
Adenine always pairs with thymine
A-T – using 2 bonds

Cytosine always pairs with Guanine
C-G – using 3 bonds



What Does DNA Look Like?





A-T and C-G bonds are weak, but since there are 1000s of them in one DNA molecule – the two chains are held together strongly

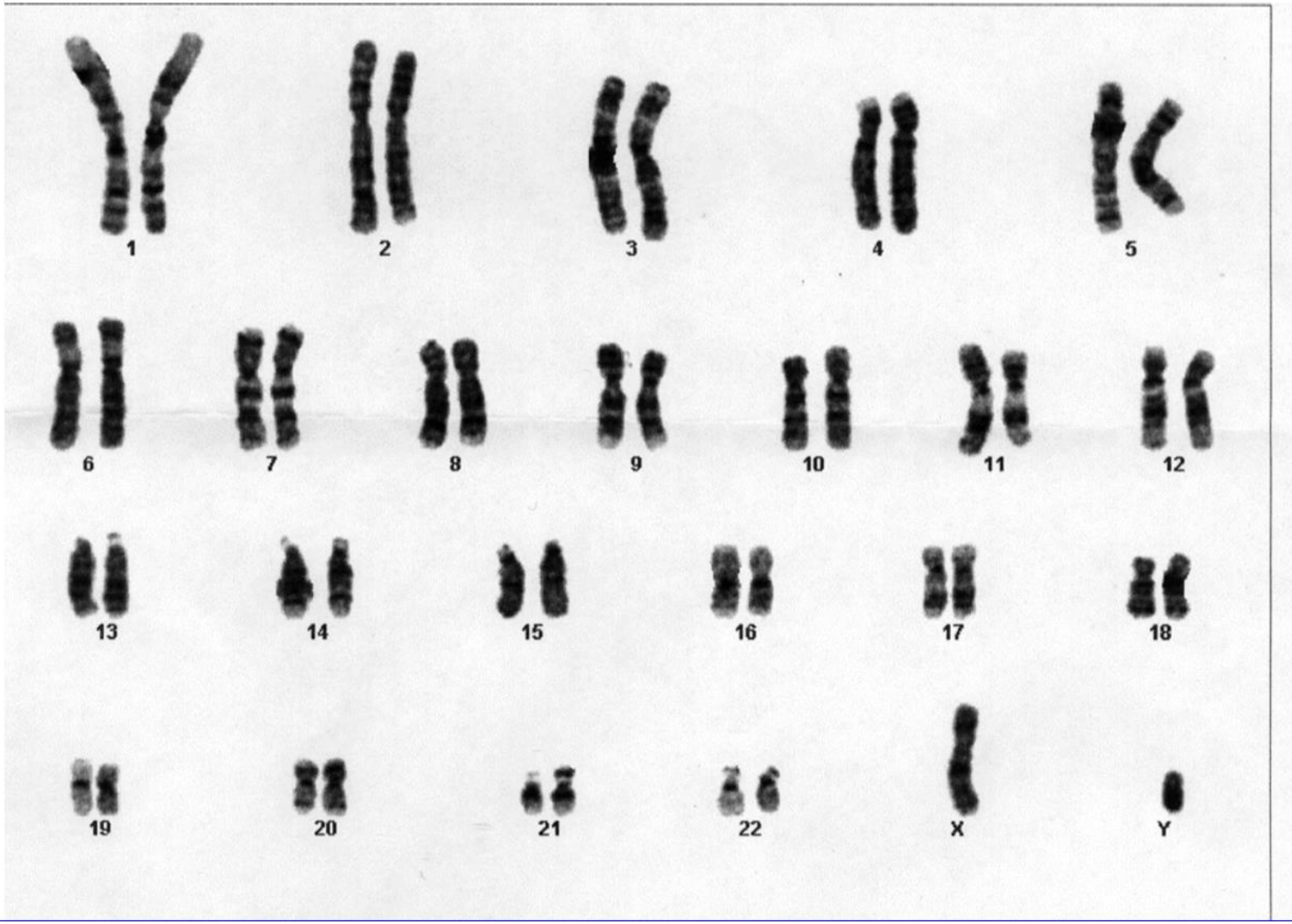
Vocabulary

- DNA – Deoxyribonucleic acid, a large molecule made up of many repeating units – nucleotides; carries our genetic information

- Gene – a segment of/a small portion of a DNA molecule; carries instructions how to build a living organism, determines the traits/ characteristics you inherit , e.g. eye color, nose shape, etc.

- Chromosome – 1 very large molecule of DNA, coiled and twisted, packaged tightly with the help of proteins – we have 46 chromosomes, fruit flies have 3 chromosomes

A Real picture of human Chromosomes



What makes Me different from You?

- What makes an individual different/unique is the sequence of DNA letters (A,G,C,T)

- Different sequence = different instruction how to build a protein, a cell, an organism

- We have mostly the same sequence of letters – it is the small differences that count

- By knowing the whole sequence of letters in our DNA we can: understand disease better; predict who may get sick; find cures for diseases, improve life quality, etc.

From 1 Cell to Billions of cells

- How we grow and develop: 1 cell makes 2 new ones; 2 cells make 4; 4 cells make 8 and so on
- We all started from a single cell – the fertilized egg – now we have trillions of cells in our bodies
- Cells divide to make more cells – this is how we grow and develop
- When cells divide the DNA has to be duplicated, doubled, copied to make 2 cells from 1 cell

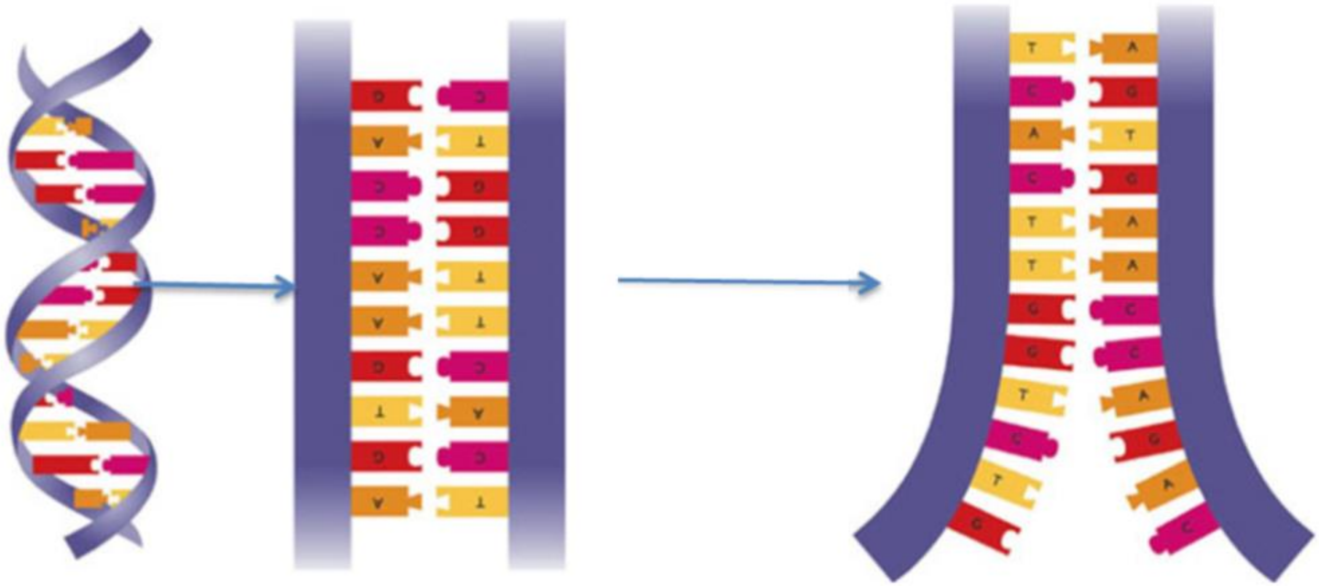
DNA Replication

DNA Replication is the process by which DNA duplicates, copies itself before a cell divides

Replication – comes from the word replica means an accurate, exact copy of the original

All the DNA in your body is a knockoff – it is a replica of the original DNA in the fertilized egg

Steps of DNA Replication



DNA is a twisted double helix – two chains held together and twisted – first it un-twists then it un-zips

Steps of DNA Replication

The 2 un-zipped DNA chains are used as a template to make new DNA chains using the base pairing rule

Enzymes add free, unattached nucleotides as follows: where in the 'old' chain there is an A – the new chain would have a T (T-A; G-C, C-G), the nucleotides are linked together to form a new chain

Base-Pairing allows for making accurate copies of DNA

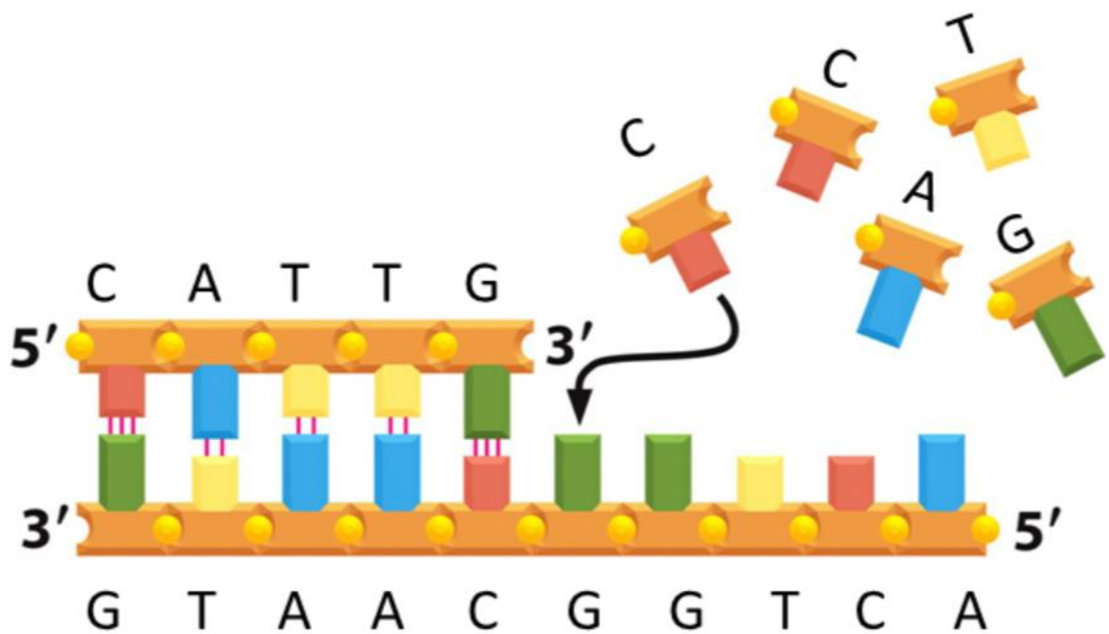
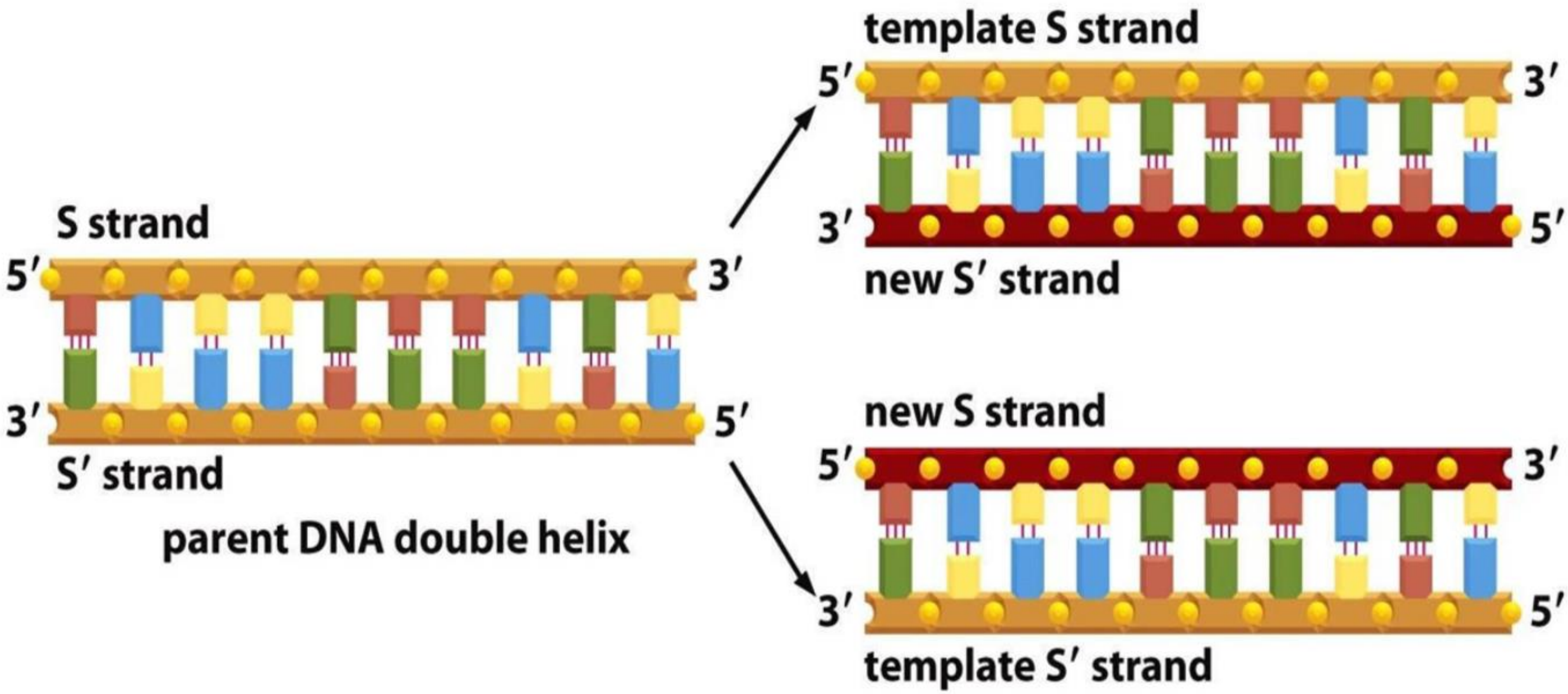
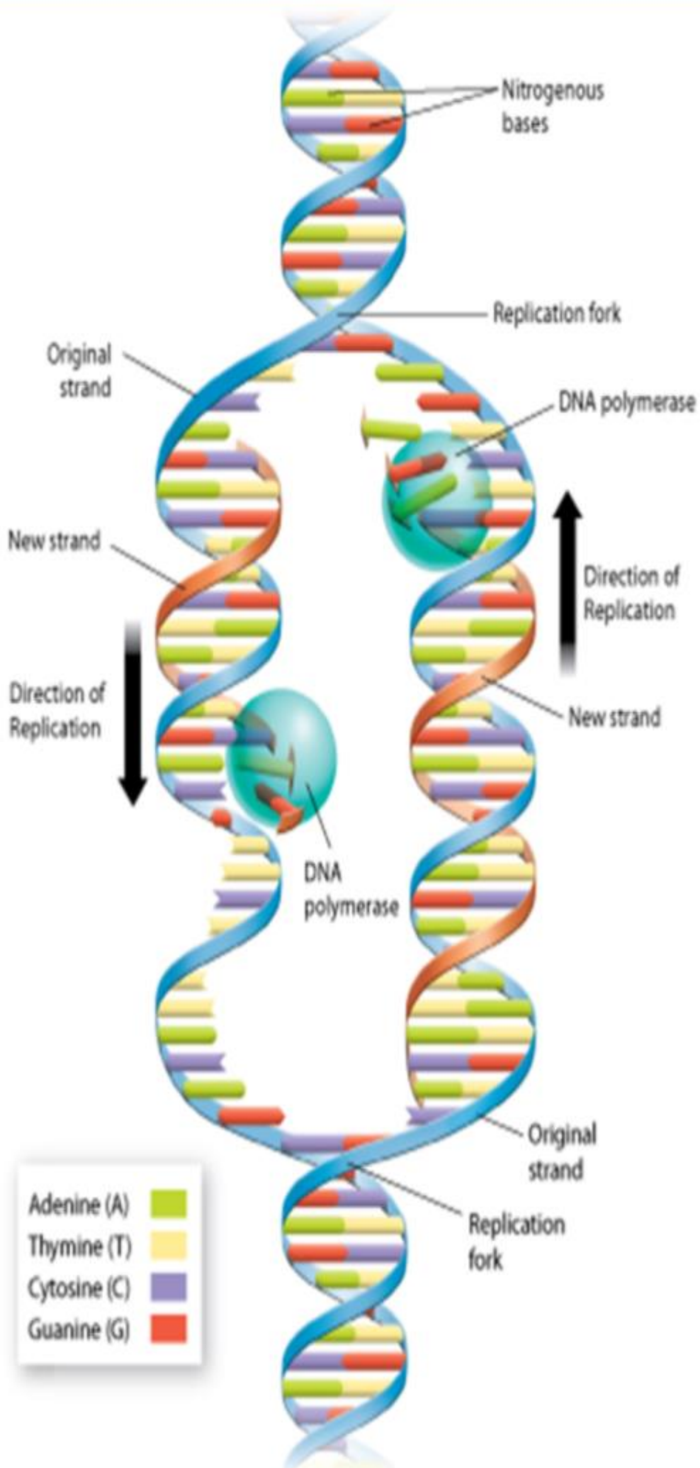


Figure 6-2 *Essential Cell Biology* (© Garland Science 2010)

The 2 copies of DNA are made up of 1 old and 1 new chain

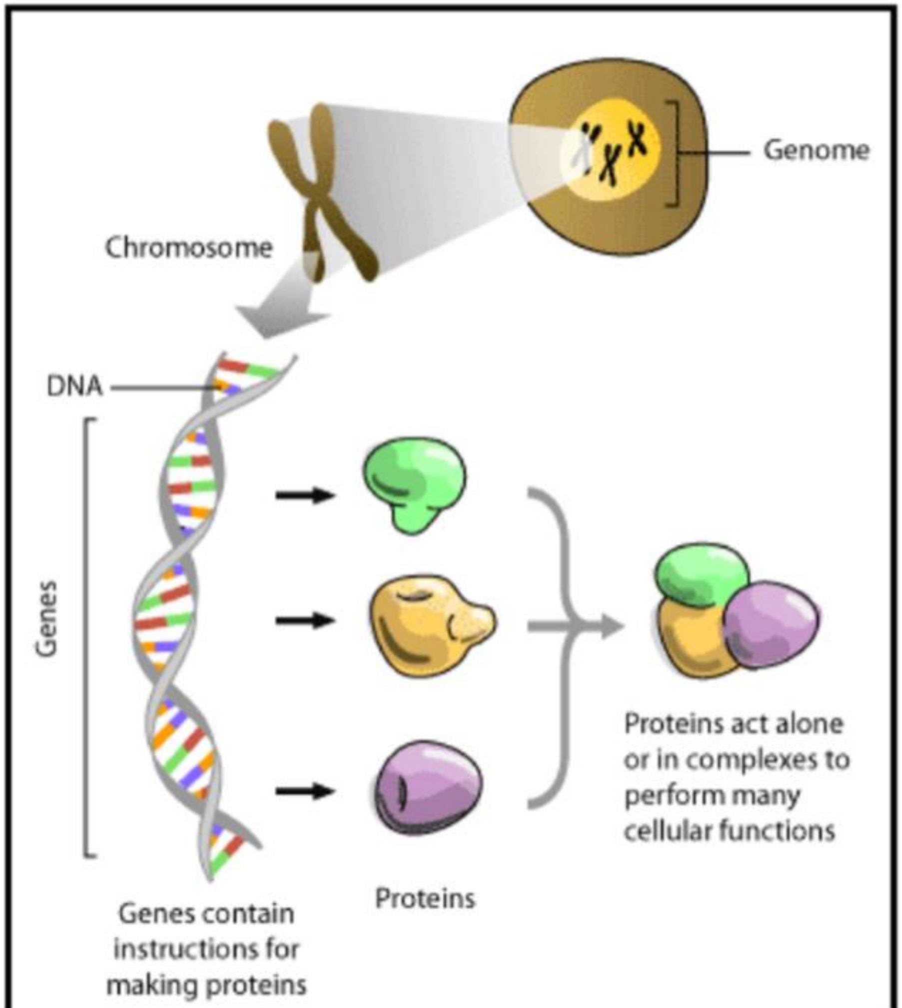


strand=chain



Nitrogenous bases
Replication fork
Original strand
DNA polymerase
New strand
Direction of Replication
Direction of Replication
New strand
DNA polymerase
Original strand
Replication fork
Adenine (A)
Thymine (T)
Cytosine (C)
Guanine (G)

What makes one cell different from another?



DNA = "the life instructions of the cell"

Gene = segment of DNA that tells the cell how to make a certain protein.

Allele = one of two or more different versions of a gene

The Flow of Information in All Living Things

replication

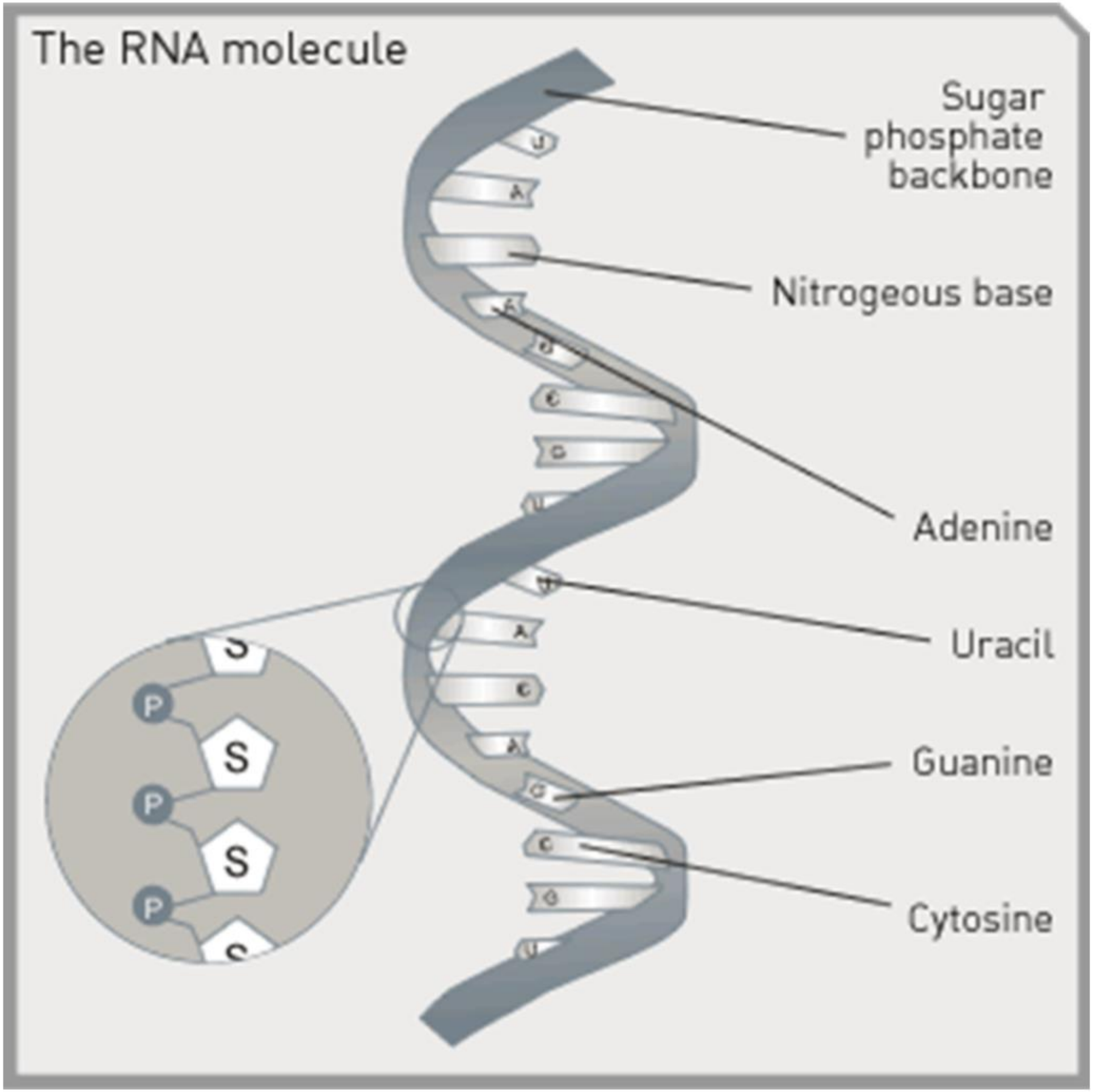
DNA transcription RNA translation Proteins

do all the work:

structure
regulation
enzymes
signaling
communication
transport

RNA – Ribonucleic Acid

- RNA – another type of nucleic acid
- Very similar to DNA, but not exactly the same
- Only one chain of nucleotides – one strand
- Made of nucleotides that have A, C, G and U as nitrogenous bases
  - U replaces T
  - C pairs with G, A with U
- Carries the coded message of DNA from the nucleus to the ribosomes (cytoplasm) – where this message is used to make proteins


The RNA molecule
Sugar phosphate backbone
Nitrogeous base
Adenine
Uracil
Guanine
Cytosine
P
S

Three major types of RNA

- mRNA – messenger RNA – carries DNA's message to ribosomes

- tRNA – transfer RNA – brings amino acids to the ribosome (recall: Amino acids bind together to make proteins)

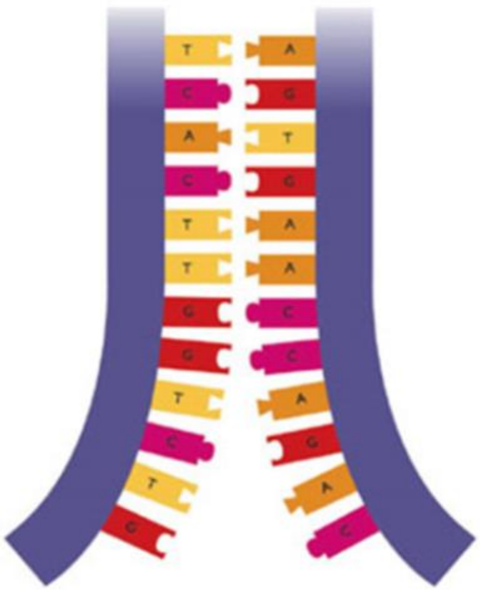
- rRNA – ribosomal RNA – is part of the ribosomes

Transcription – from DNA to RNA

- The genetic information of DNA is copied onto a strand of RNA – mRNA – will carry it into the cytoplasm to the ribosomes
- Highly regulated – if the cell wants a lot of protein X, gene X will make lots of mRNA; if the cell does not need protein X, gene X will not make mRNA

Steps of Transcription

Note: instead of a T we insert an U



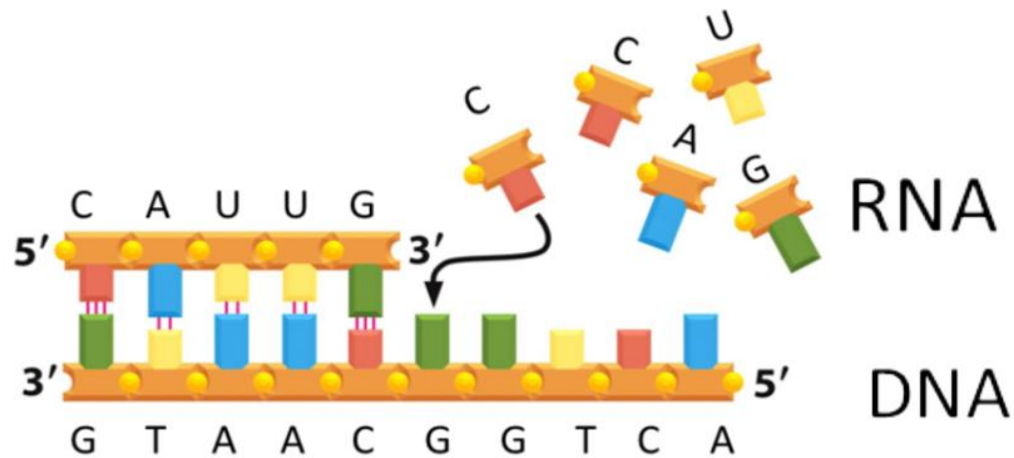


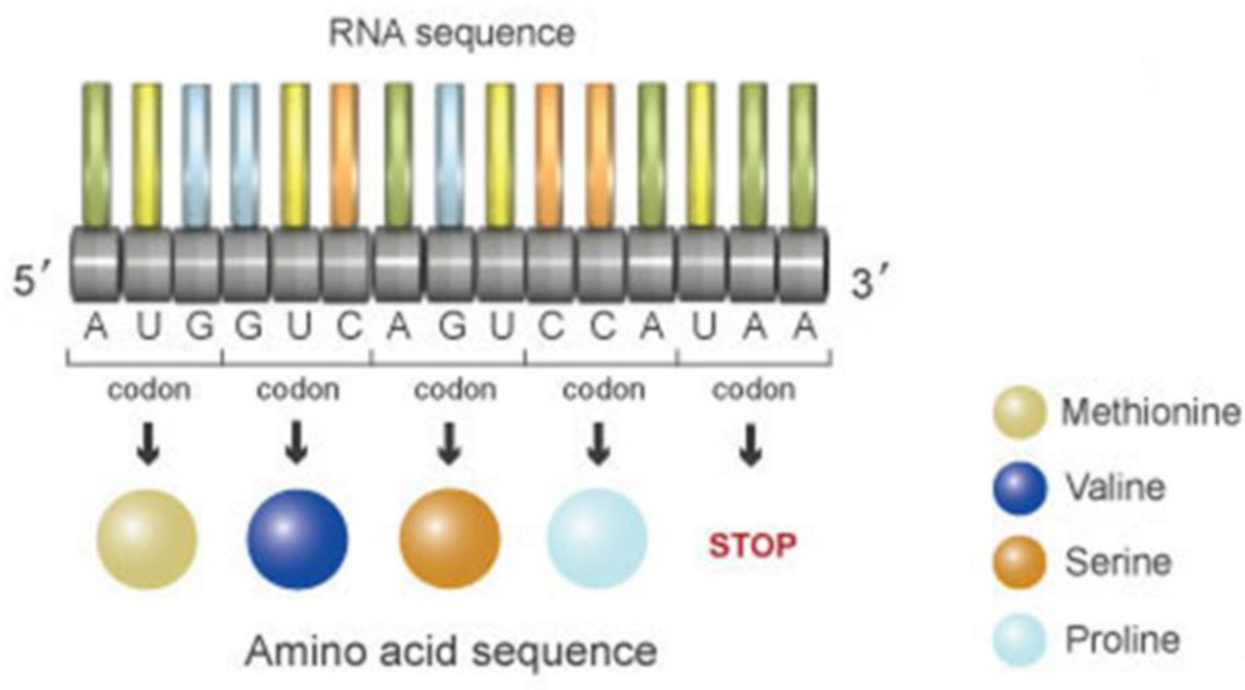
Figure 6-2 *Essential Cell Biology* (© Garland Science 2010)

1. Unzip DNA in a specific region – in front of gene X
2. Start adding nucleotides at the proper place – start point
3. Stop adding nucleotides – termination

Translation

- The language of Nucleic Acids (nucleotides) is translated into the language of proteins (amino acids)
- The sequence (order) of amino acids in a protein is determined by the sequence of nucleotides in mRNA
- mRNA is written in a 4 letter alphabet – A, U, C and G
- Proteins are written in a 20-letter alphabet – there are 20 different amino acids

- A gene (DNA) **carries the directions to make a protein (polypeptide)**
- **<u>Codon</u>**-3 base triplet on mRNA that codes for an amino acid (20 different)



The Codons – a Code

3 letter words translated into a 1 symbol

English	**Japanese**
M A N	男
E Y E	目

Are there more or less Japanese symbols than English letters?

The Codons – a Code

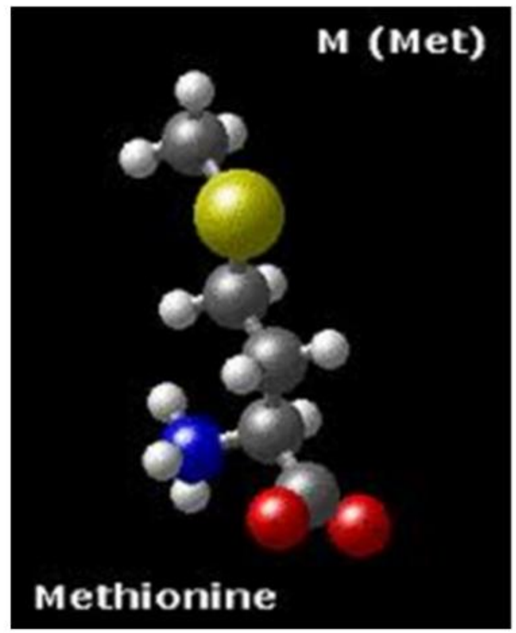
3 letter words translated into a 1 symbol

RNA

Protein

A U G

a 3 letter combination = codon



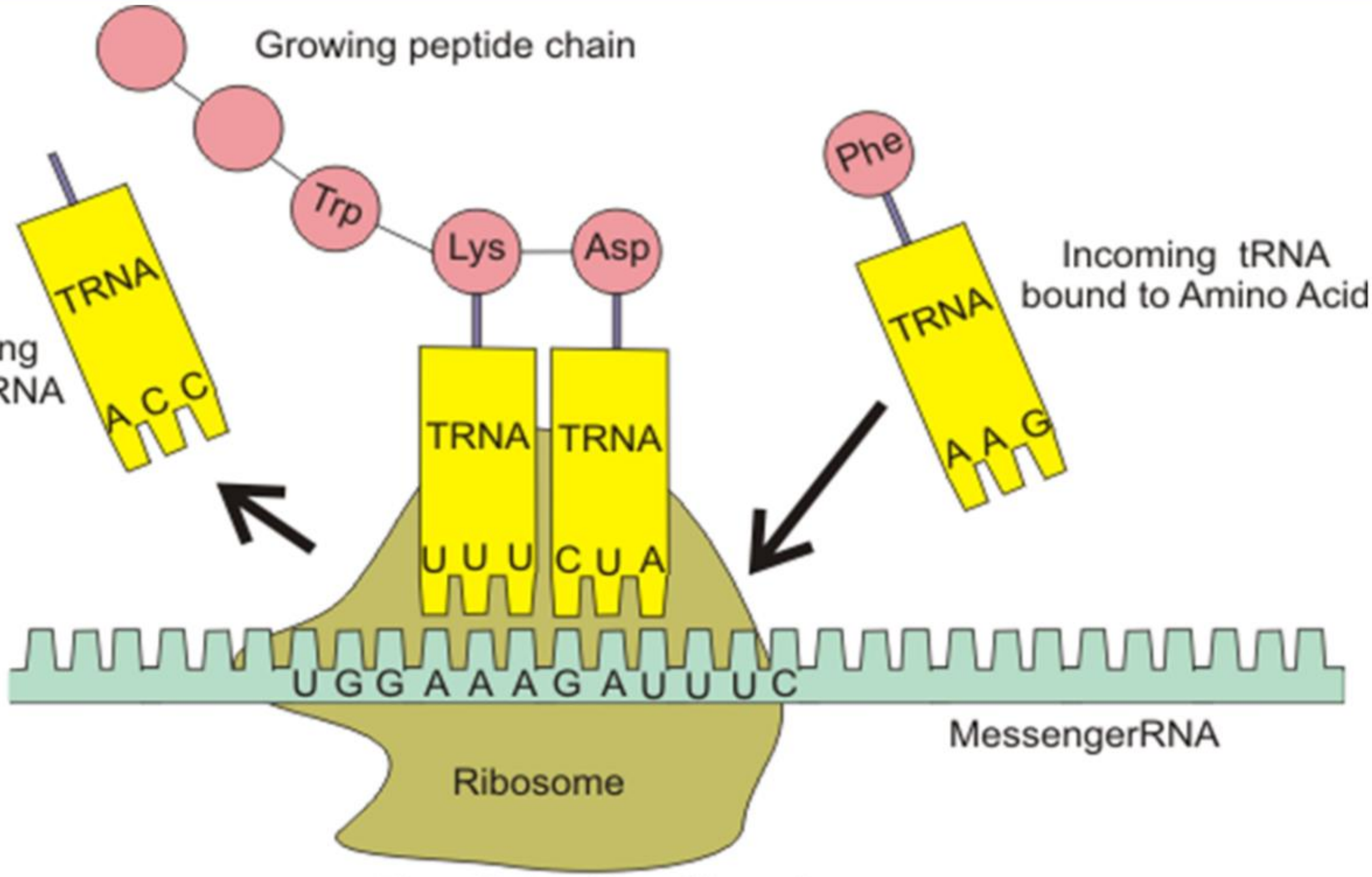
amino acid called Methionine

Second base of codon

First base of codon	U		C		A		G		Third base of codon
U	UUU	Phenylalanine phe	UCU	Serine ser	UAU	Tyrosine tyr	UGU	Cysteine cys	U
	UUC		UCC		UAC		UGC		C
	UUA	Leucine leu	UCA		UAA	STOP codon	UGA	STOP codon	A
	UUG		UCG		UAG		UGG	Tryptonphan trp	G
C	CUU	Leucine leu	CCU	Proline pro	CAU	Histidine his	CGU	Arginine arg	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	Glutamine gln	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	Isoleucine ile	ACU	Threonine thr	AAU	Asparagine asn	AGU	Serine ser	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	Lysine lys	AGA	Arginine arg	A
	AUG	Methionine met (start codon)	ACG		AAG		AGG		G
G	GUU	Valine val	GCU	Alanine ala	GAU	Aspartic acid asp	GGU	Glycine gly	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	Glutamic acid glu	GGA		A
	GUG		GCG		GAG		GGG		G

Special Codons

- **AUG-** start codon- methionine
- **UAA**
- **UAG** Stop codons
- **UGA**



Peptide Synthesis

One end of the tRNA will recognize and base-pair with the codon on the mRNA
The other end of the tRNA carries the amino acid

What makes Me different from You?

- What makes an individual different/unique is the sequence of DNA letters (A,G,C,T)

- Different sequence = different instruction how to build a protein, a cell, an organism – e.g. different sequence – different nose shape, different eye color etc.

- Changes in DNA sequence can alter the instructions (but not you eye color or nose shape):

    * changes can be harmful, even deadly
    * changes can be good

Changes in DNA sequence

- Mutations are changes in the DNA sequence that affect a gene or a gene control region (Note: not all of our DNA is genes, lots of 'filler' DNA)
- Mutations can occur spontaneously (very rare) or can be caused by exposure to certain agents (UV rays, radiation, chemicals)
- Different types of mutations: insertions, deletions, substitutions.

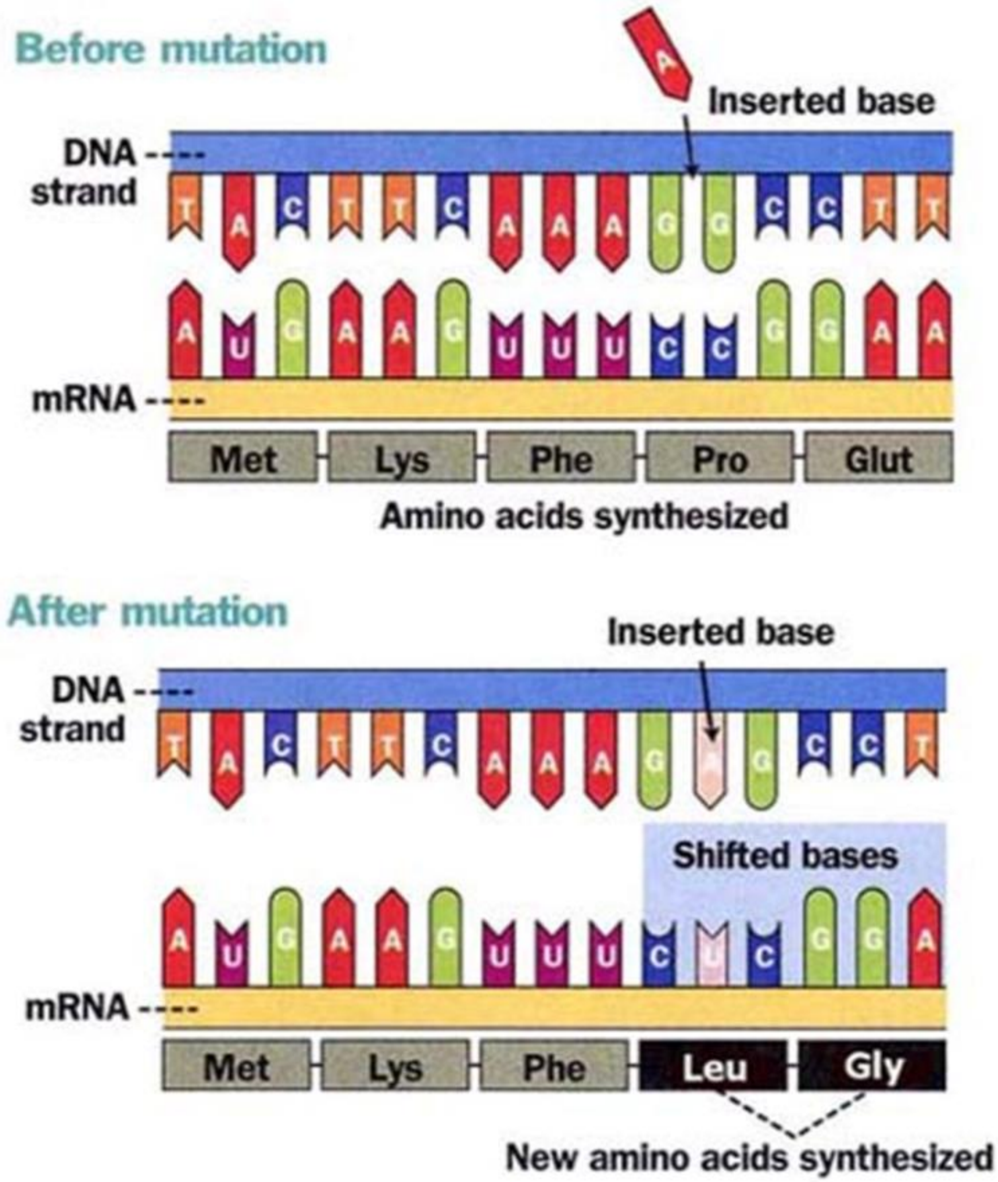
Insertions

- Extra nucleotides (from 1 to many) that don't belong are placed into the strand
- Now the DNA strand will not be read correctly when making proteins

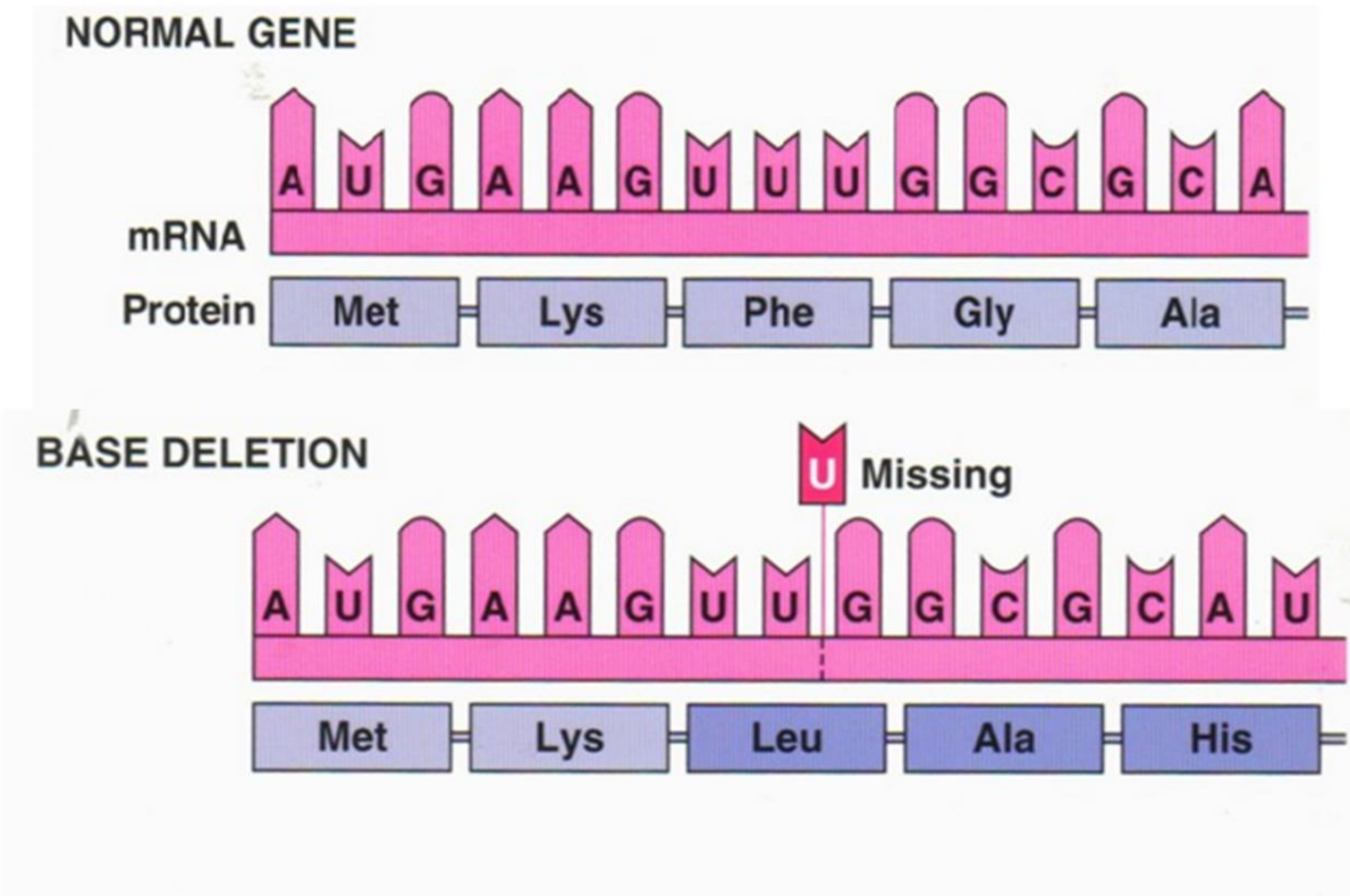
Deletions

- One ore more nucleotides are missing
- Some of the information is missing and the DNA strand will not be read correctly when making proteins

Insertion-base added



Deletion-base deleted

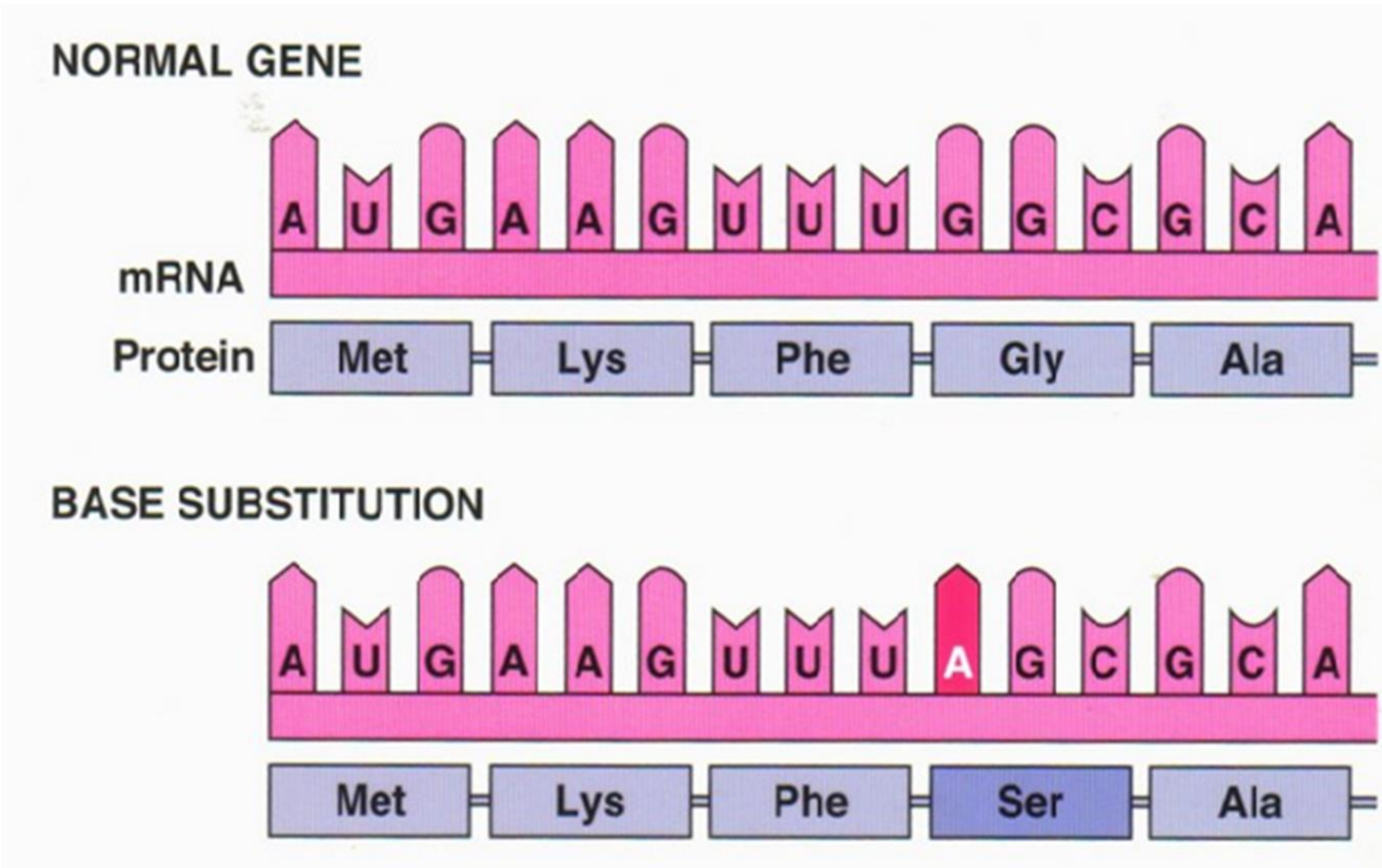


Substitutions

- One base is substituted for another
- Results in the wrong base pair sequence
- Can cause serious damage – wrong amino acid – protein non functional
- Can be silent – no change in amino acid, no change in protein:

  - UUU changed to UUC – both are codons for the same amino acid Phenylalanine

Substitution-one base replaced by another



- Insertion and deletion mutations **may** cause **frameshift mutations**-shift the “reading frame” of the genetic message
- Every **amino acid** after the point of mutation changes.

Mutagens- chemical or physical agents in the environment that cause mutations

Effects of Mutations:

1. Little to no effect
2. Beneficial
3. Harmful

DNA Mutations and Human Disease

- Cancer – accumulations of many mutations over time
- Sickle cell anemia; Cystic Fibrosis; Tay-Sachs disease; Color blindness – all cause by single nucleotide substitution
- Large insertions and deletions cause many types of cancer; Huntington's disease and other serious illnesses

HBB Sequence in Normal Adult Hemoglobin (Hb A):

Nucleotide	CTG	ACT	CCT	GAG	GAG	AAG	TCT
Amino Acid	Leu	Thr	Pro	Glu	Glu	Lys	Ser
	3			6			9

HBB Sequence in Mutant Adult Hemoglobin (Hb S):

Nucleotide	CTG	ACT	CCT	GTG	GAG	AAG	TCT
Amino Acid	Leu	Thr	Pro	Val	Glu	Lys	Ser
	3			6			9

A single nucleotide change – a single amino acid substitution - altered protein (hemoglobin) – altered red blood cell - disease