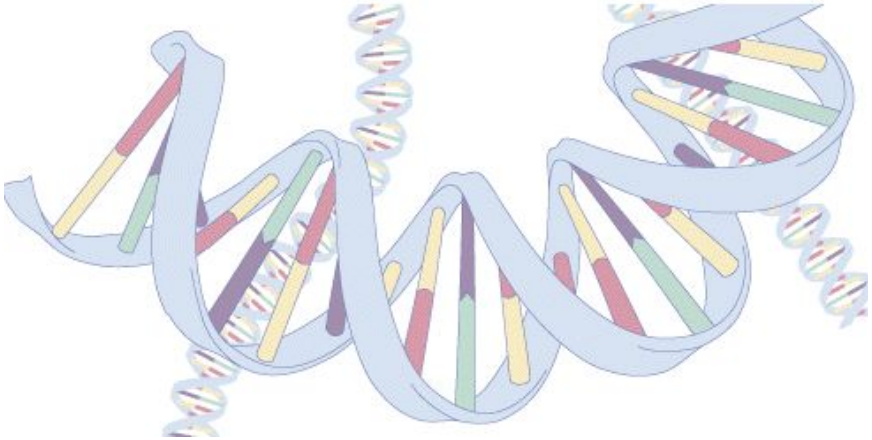
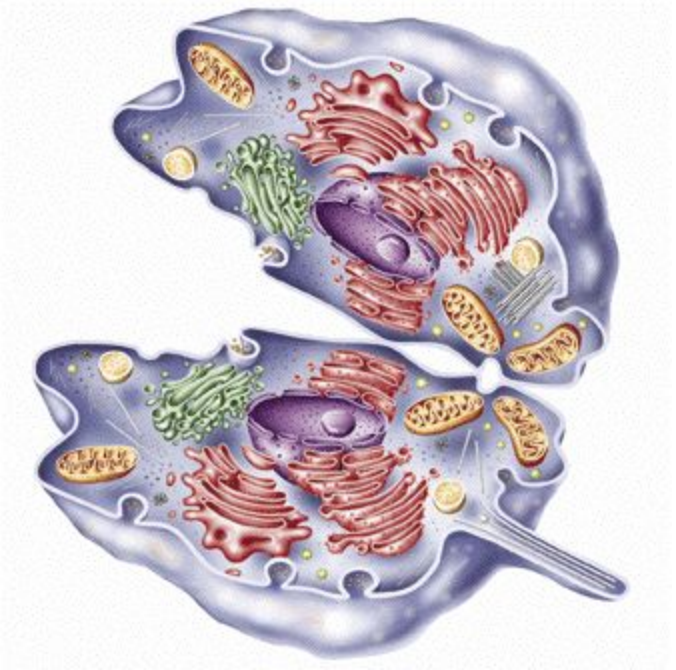


DNA, Genes and Genetics

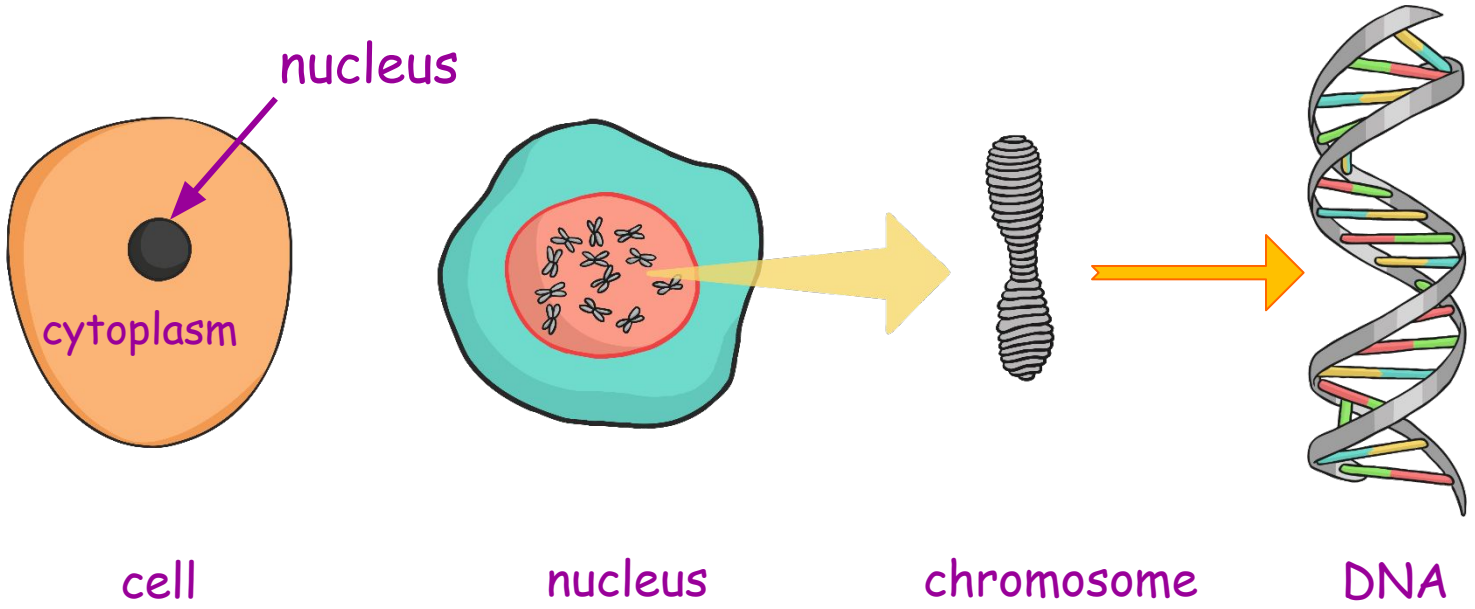
John Strouboulis
King's College London
john.strouboulis@kcl.ac.uk

The Cell

- Basic component of life
- All cells share basic organisation and structure, e.g. nucleus, mitochondria etc.
- They are highly specialised depending on the tissue they're in and functions they execute

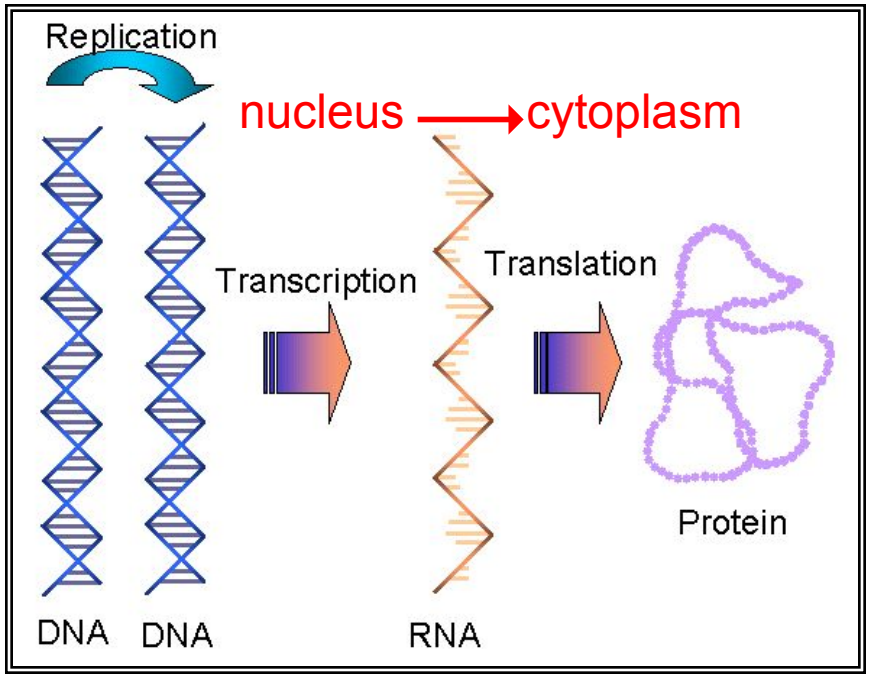


- Genetic material is located in nucleus
- The genetic information is stored in Deoxyribonucleic acid, DNA
- DNA contains the information needed to build an individual



What is DNA needed for?

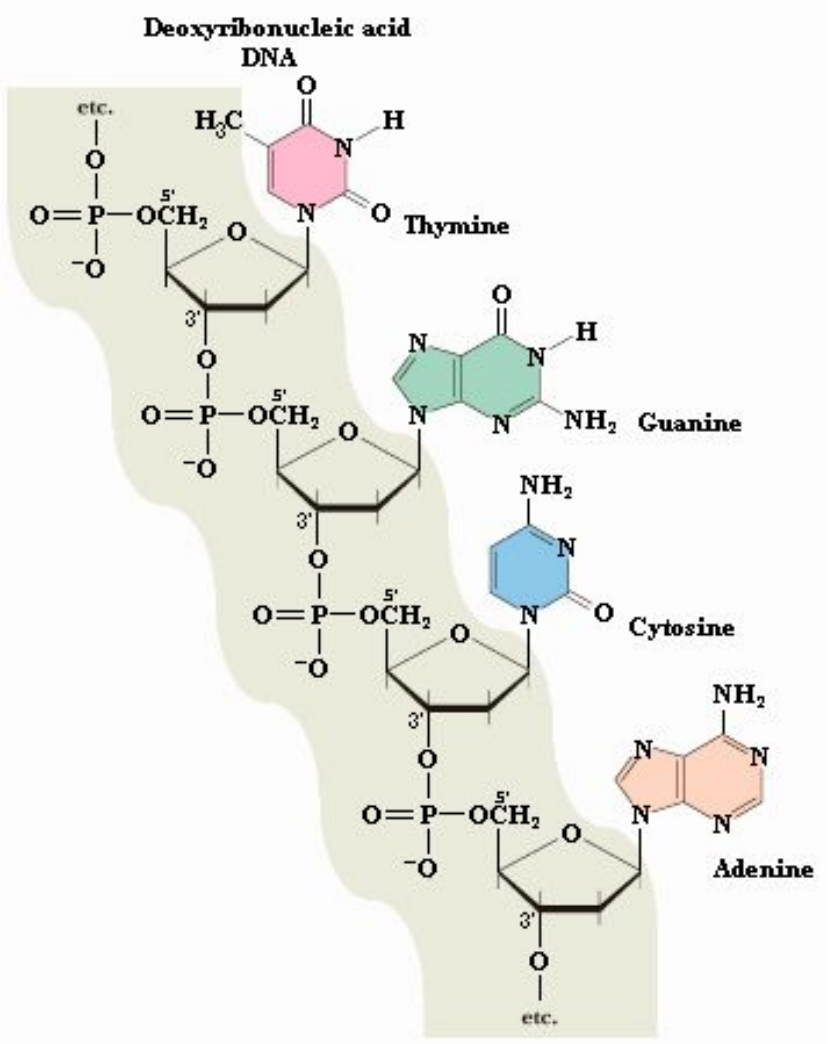
- Genetic information stored in the DNA is copied and converted to protein
- RNA molecules work as messengers
- Proteins are the biological workers



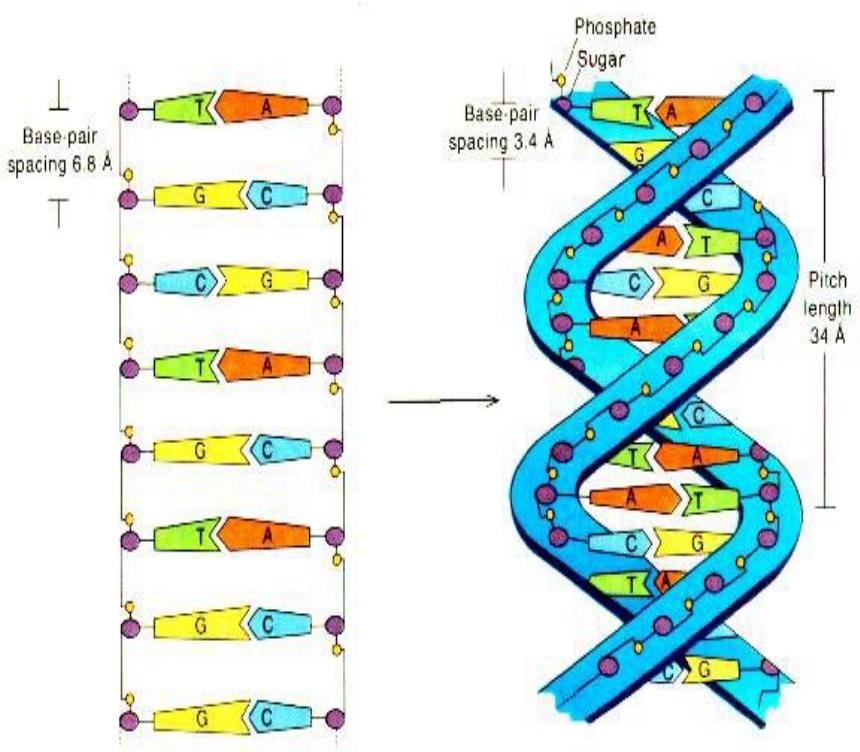
What is DNA?

- DNA is made up of 4 building blocks called nucleotides:
  - Adenine (A)
  - Cytosine (C)
  - Guanine (G)
  - Thymine (T)

- They join up to form VERY long chains



The DNA double helix



"ladder" Double helix

- Two chains are joined and twisted to form the double helix!
- The pairing up of the building blocks (nucleotides) in the double helix is specific:
  - *A always pairs up with T*
  - *C always pairs with G*

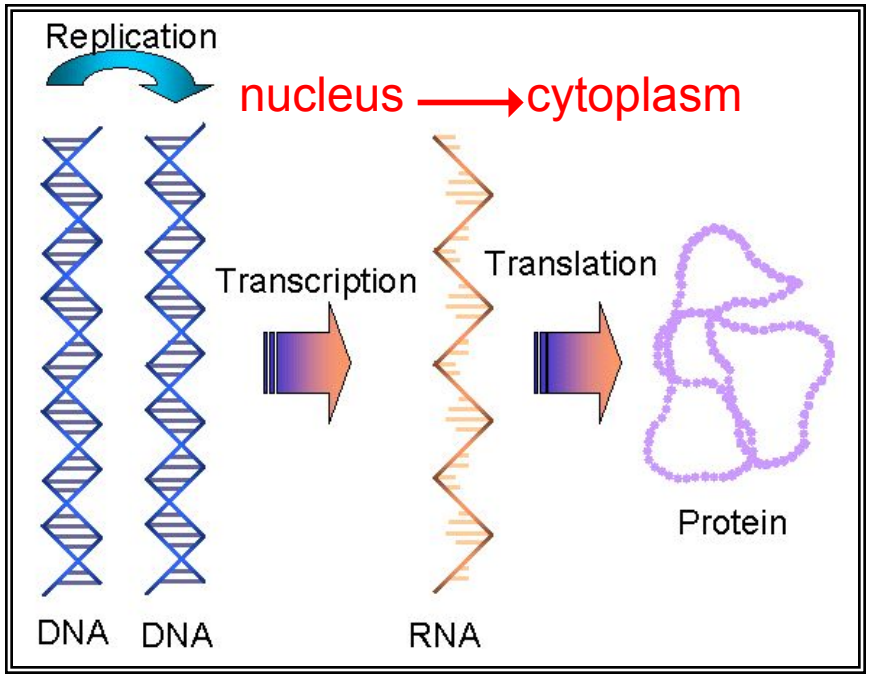
  EASY TO COPY!
- Sequence of nucleotides in the chains varies **genetic information coding!**

- Genetic information stored in the DNA is copied to an RNA molecule in a process called **transcription**

- RNA directs the protein synthesis by a process called **translation**

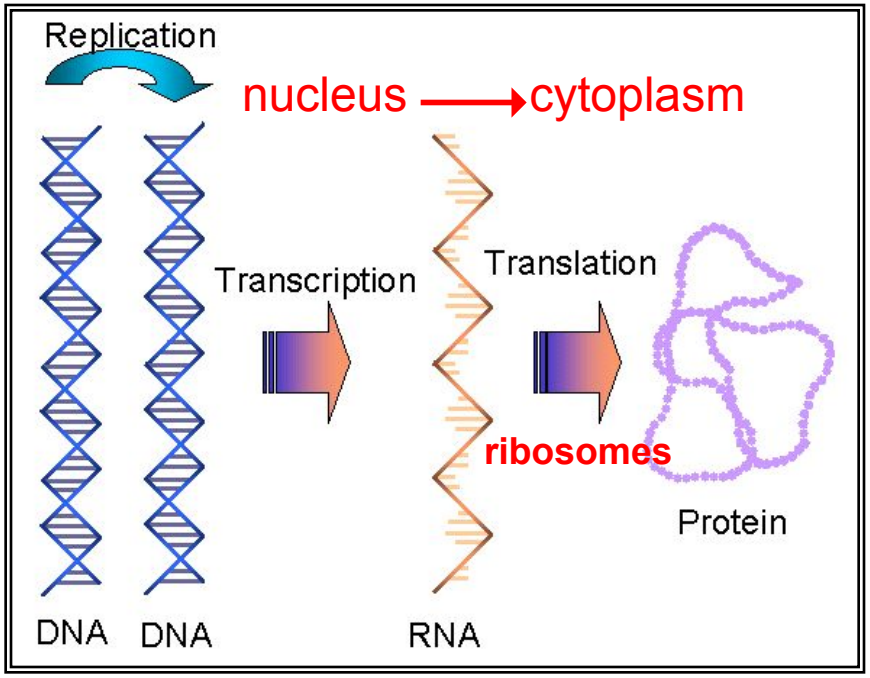
- Translation takes place in ribosomes

- The protein's structure, (dictated by the DNA that was copied) determines it's function



The Genetic Code

- Every three DNA building blocks (nucleotides) correspond to one protein building block: they are called codons!
- Codons are faithfully copied into RNA (the "messenger") which moves out of the nucleus
- The codons copied by the RNA are faithfully translated into proteins by ribosomes (in the cytoplasm)
- Each codon corresponds to one protein building block (amino acid)



The genetic code: letters that make words!

Codon	Alphabet Letter (amino acid)
GCT	D
GCA	E
TCG	K
ATC	N
AAT	W

DNA building blocks: A, T, C, G

AAT GCA GCA TCG GCA ATC GCT

W E E K E N D word (protein)

AAT GCA GCT TCG GCA ATC GCT

W E D K E N D nonsense

GCA AAT GCT TCG GCA GCA ATC

E W D K E E N nonsense

It is the order (sequence) of codons that produces meaningful words (functional proteins)!!

The Genetic Code

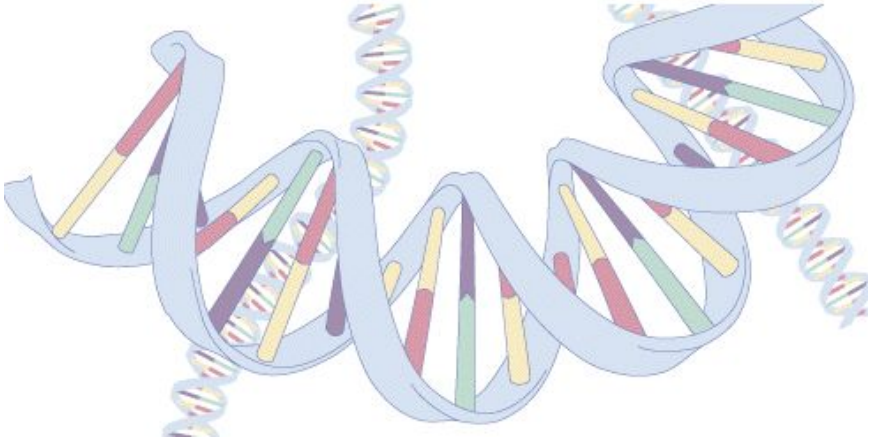
- 26 letters in the alphabet can make for volumes of text!
- 20 amino acids are found in nature
- 4 nucleotides (building blocks) in DNA, hence 64 combinations of unique triplets (codons)!
- More than enough to code for all 20 amino acids!!

1st	2nd position T	2nd position C	2nd position A	2nd position G	3rd
T	Phe	Ser	Tyr	Cys	T
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	STOP	STOP	A
	Leu	Ser	STOP	Trp	G
C	Leu	Pro	His	Arg	T
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	T
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	T
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

The Genetic Code

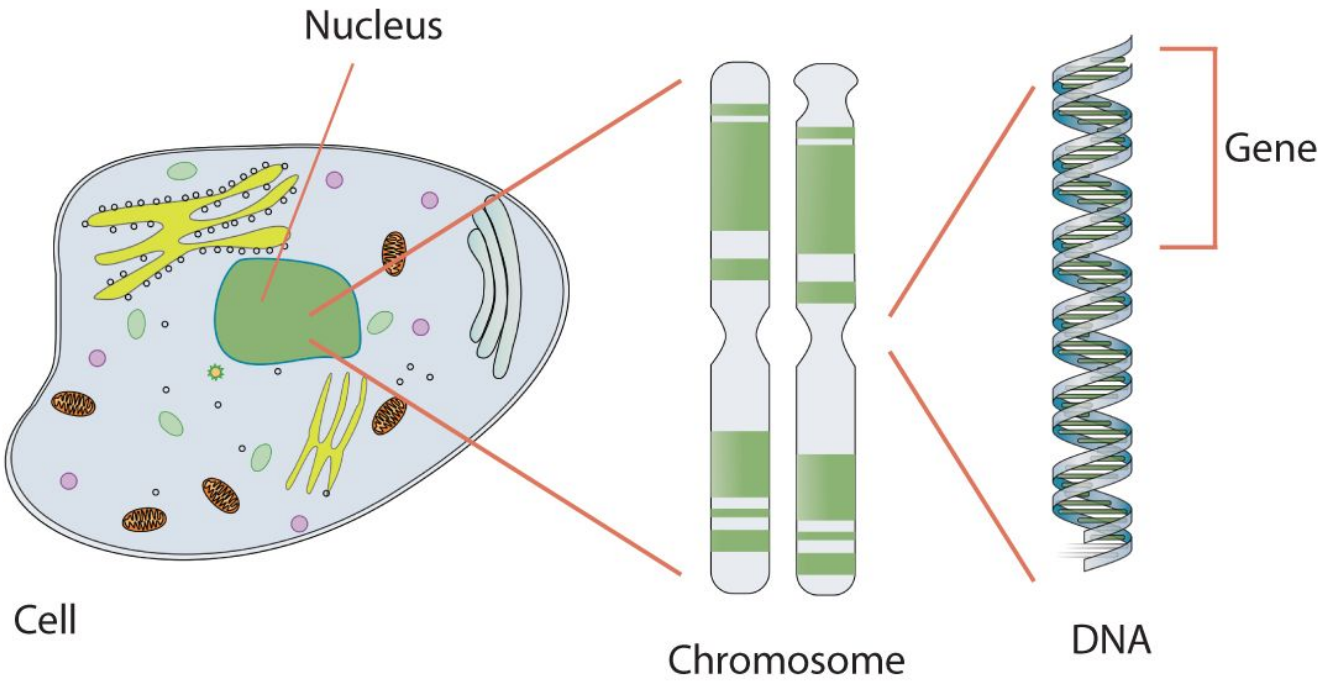
Amino acids

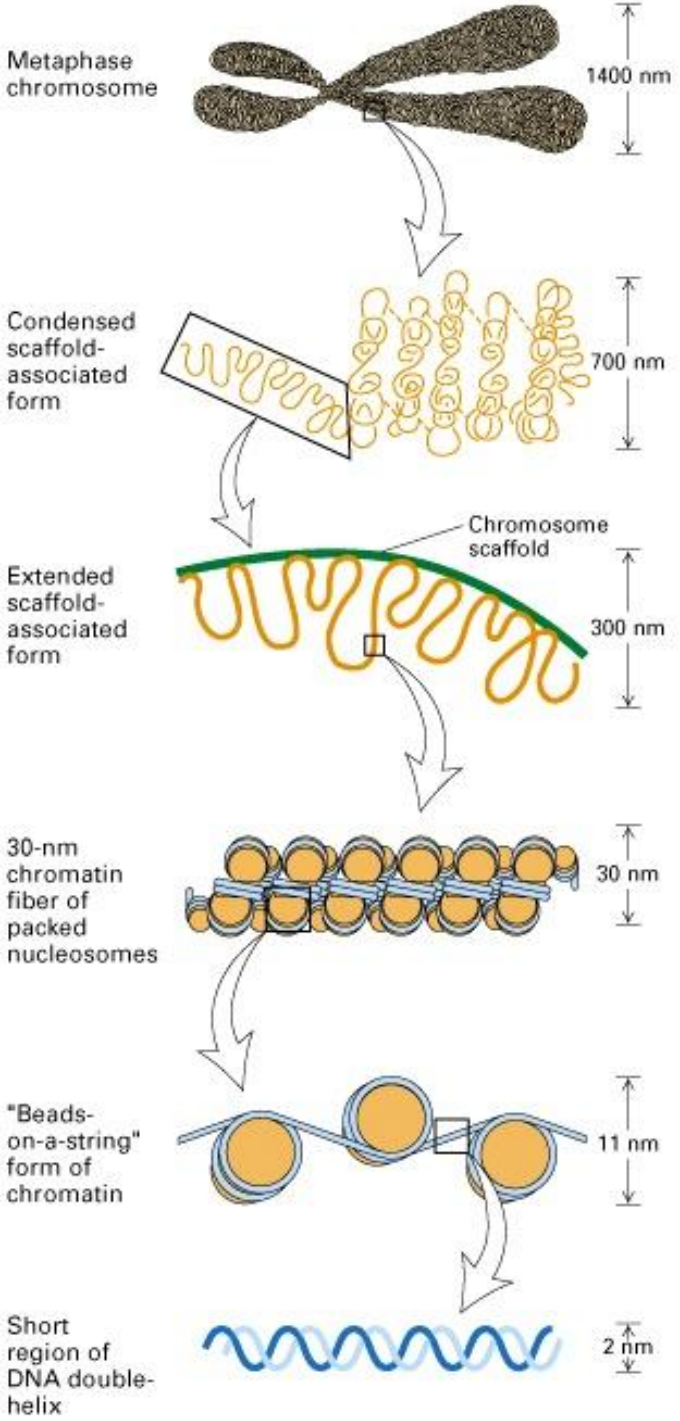
ala - alanine
arg - arginine
asn - asparagine
asp - aspartic acid
cys - cysteine
gln - glutamine
glu - glutamic acid
gly - glycine
his - histidine
ile - isoleucine
leu - leucine
lys - lysine
met - methionine
phe - phenylalanine
pro - proline
ser - serine
tthr - threonine
trp - tryptophan
tyr - tyrosine
val - valine



Genes, Chromosomes and Genetics

DNA and chromosomes





Chromosome

Condenced scaffold

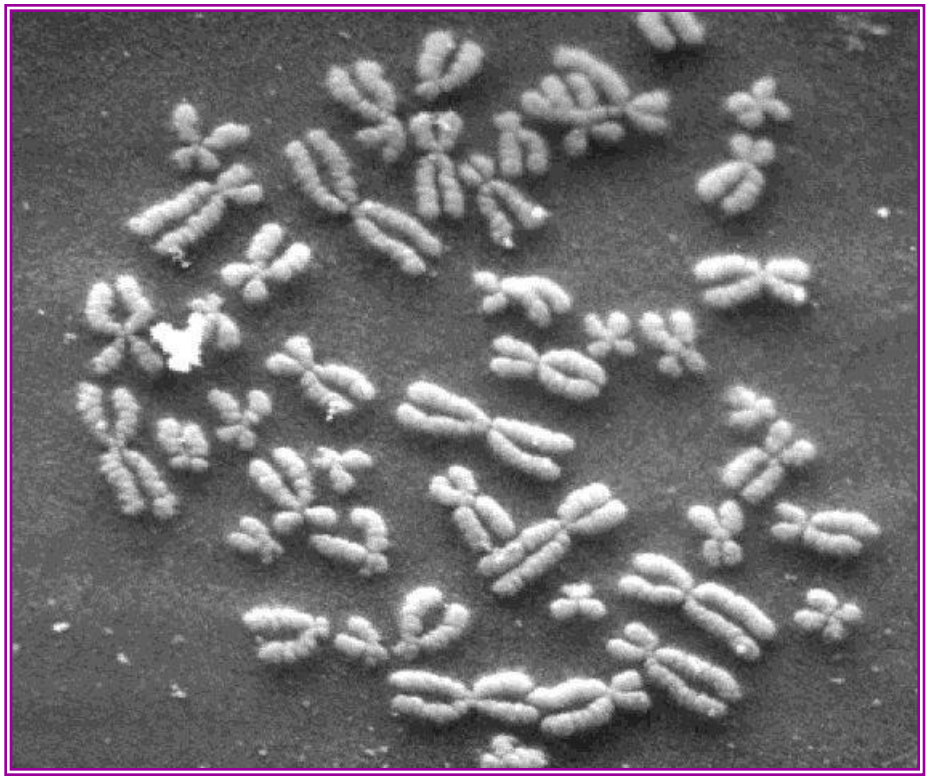
fibers connected to chromosome scaffold

chromatin fibers

chromatin

DNA

Chromosomes



- Humans have 23 pairs of chromosomes, i.e. **total of 46 chromosomes**

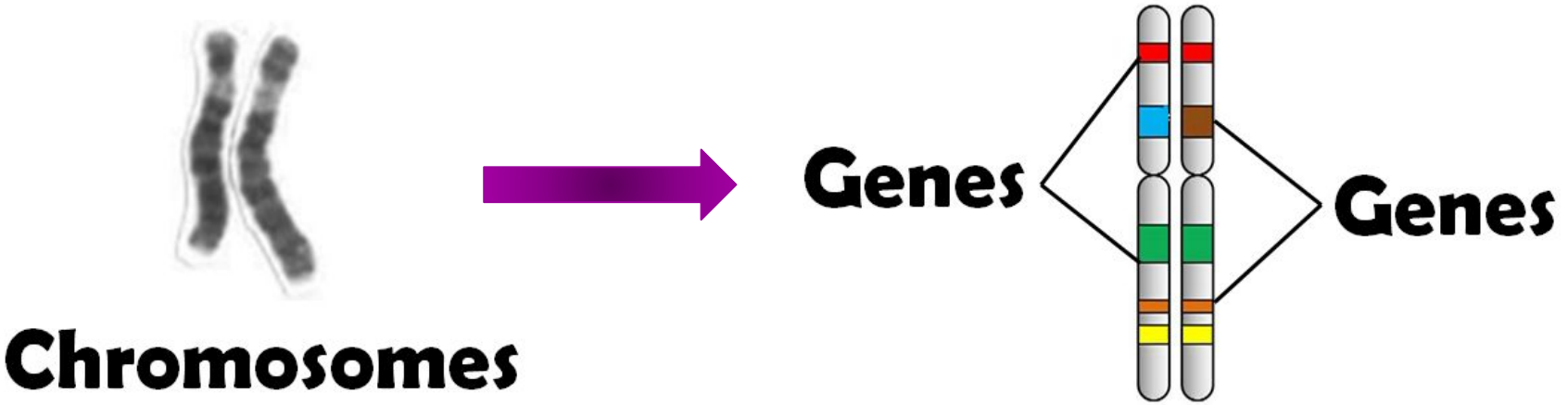
- 23 chromosomes from mom
- 23 chromosomes from dad

- 2 sex chromosomes: X and Y -chromosomes

- XX female

- XY Male

Chromosomes and genes

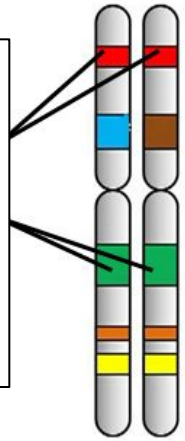


A gene: a segment of DNA that codes for the amino acids that make up a specific protein

Chromosomes and genes

Chromosomes

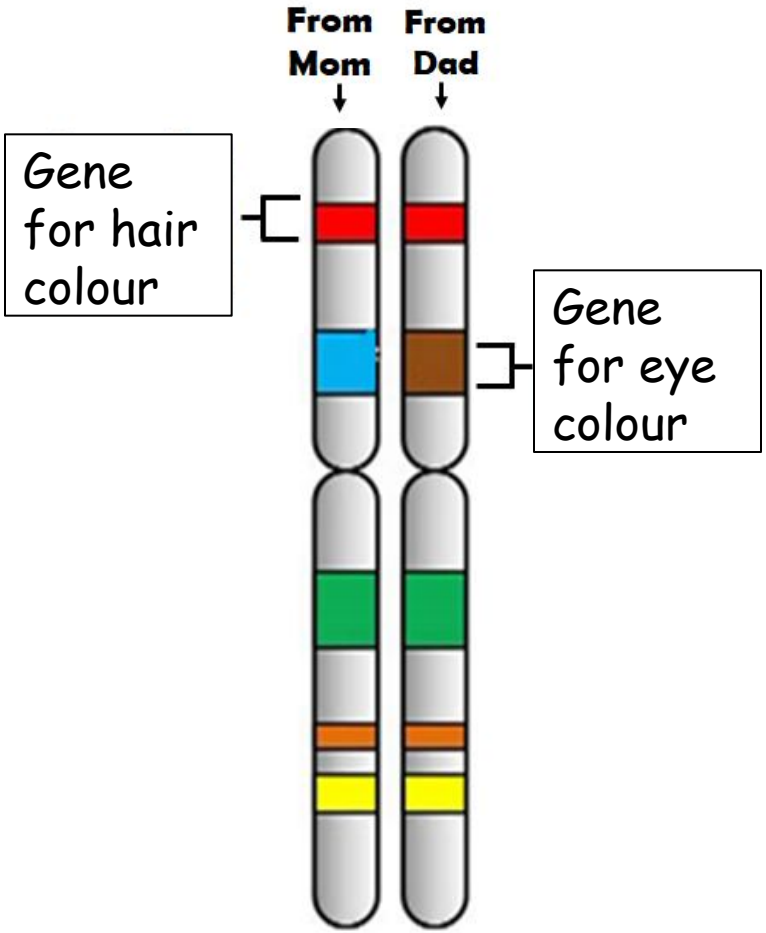
Each set of genes codes for a different protein



A gene: a piece of DNA that codes for the amino acids that make up a specific protein

Each chromosome contains many genes...

Inheritance of traits



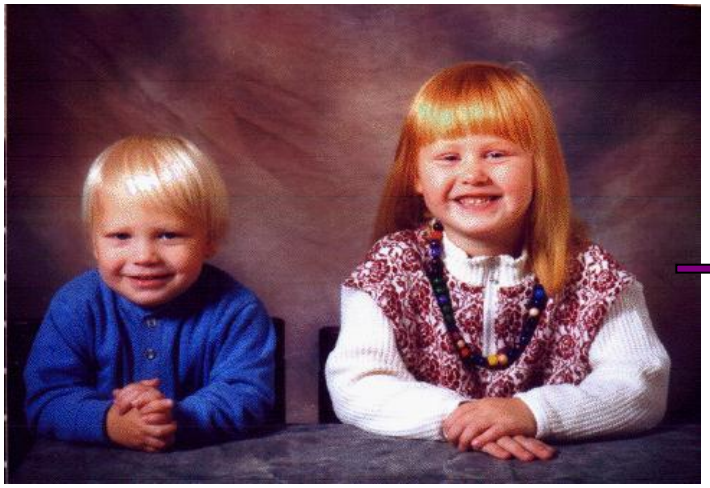
- One copy of every gene inherited from Mom
- Second copy every gene inheritied from Dad
- Each copy is called an allele
- Specific inherited characteristics of an individual (e.g. eye colour, hair colour etc.) that are coded by individual genes are called traits.
- Traits are *genetically* determined by genes inherited from each parent

Two important terms…

Phenotype: An observable trait in an individual, e.g. hair colour

Genotype: The genetic information that corresponds to this observable trait

Phenotypes



Genotype

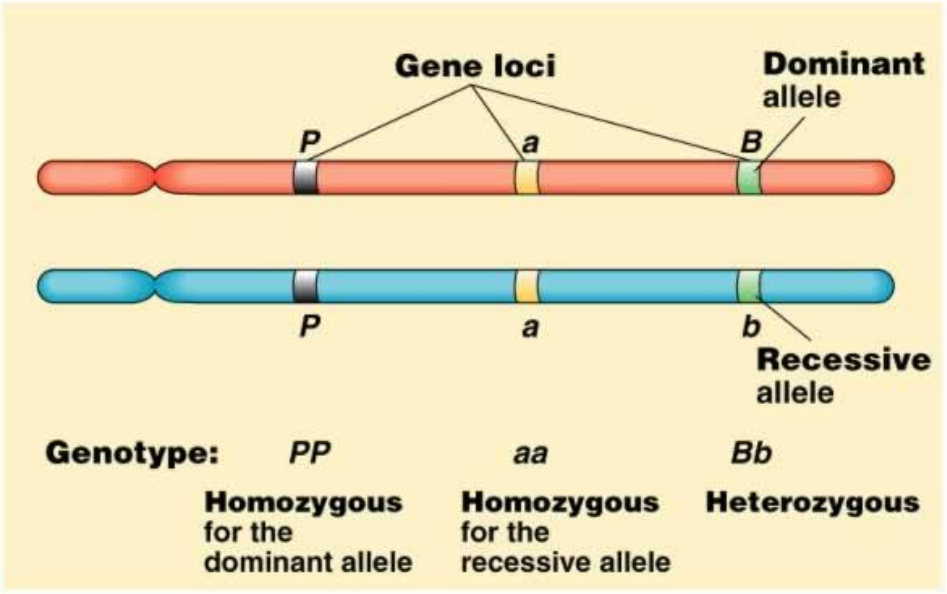
GCCAAGAATGGCTCCCACCT
GGCTCTCAGACATTCCCCTGG
TCCAACCCCCAGGCCATCAAG
ATGTCTCAGAGAGGCGGCTAG
ACACCCAGAGACCTCAAGTGA
CCATGTGGGAACGGGATGTTT
CCAGTGACAGGCA

Genotype

ATGTTTCCACCTTCAGGTTCC
ACTGGGCTGATTCCCCCCTCC
CACTTTCAAGCTCGGCCCCTT
TCAACTCAGAGAGGCGGCTA
GACACCCAGAGACCTCAAGT
GACCATGTGGGAACGGGATG
TTTCCAGTGACAGGCAG

- **Dominant** character: only one allele needed to cause the phenotype (heterozygous)

- **Recessive** character: both allels needed to cause the phenotype (homozygous)



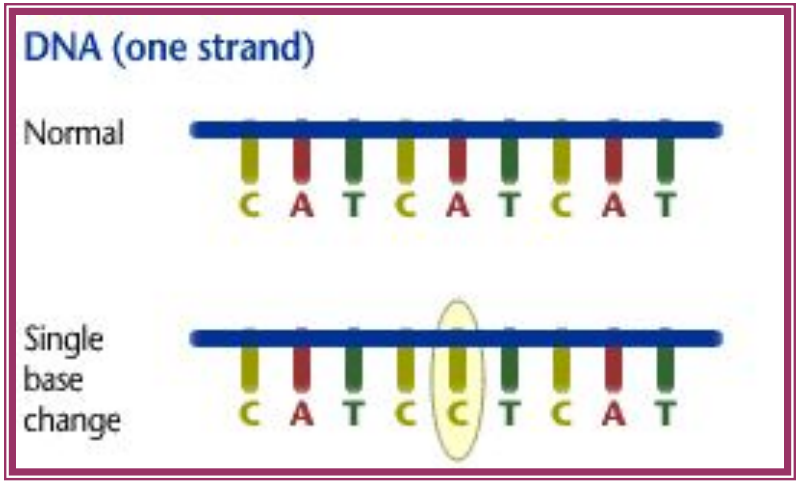
Some facts about DNA and genes

- About 22 000 genes in man
- Only 2 % of the total DNA in the nucleus (the genome) encode proteins (i.e. they are genes)
- Genes vary a lot in size:
  Humans: average 3000 nucleotides
  largest 2.4 million nucleotides
- 50 % of DNA in chromosomes is repetitive DNA ("junk DNA")

Mutations

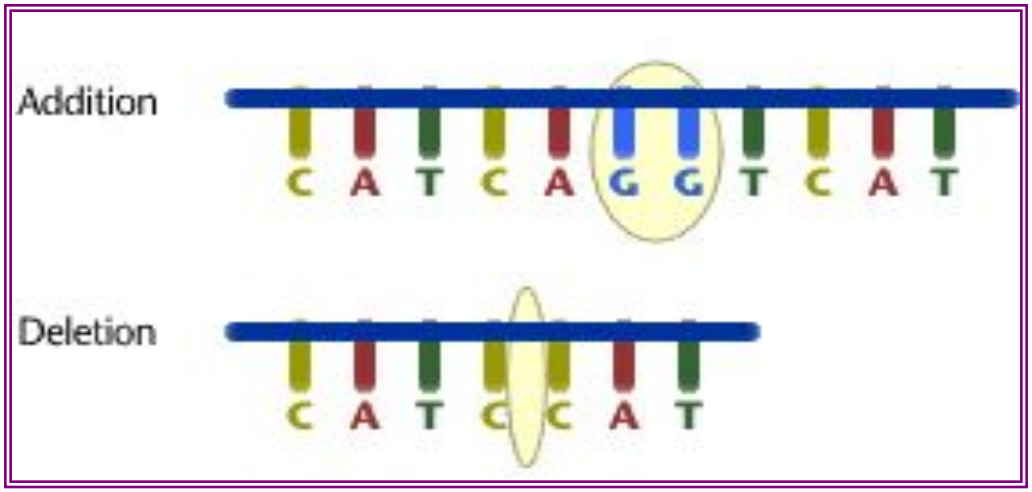
- Alterations in DNA sequence
- Caused by chemical and physiological agents and errors in DNA replication (i.e. when cell divide)
- Cells can repair some mistakes
- If not repaired, changes in DNA sequence are made permanent by DNA replication
- A mutation can have no effect (majority of cases), or it can have a deleterious effect (e.g. damage a gene)

Point mutations:



Single nucleotide mutations:

1. Missense mutation: leads to an amino acid change
2. Silent mutation: does not change the amino acid
3. Nonsense mutation: causes premature stop-codon



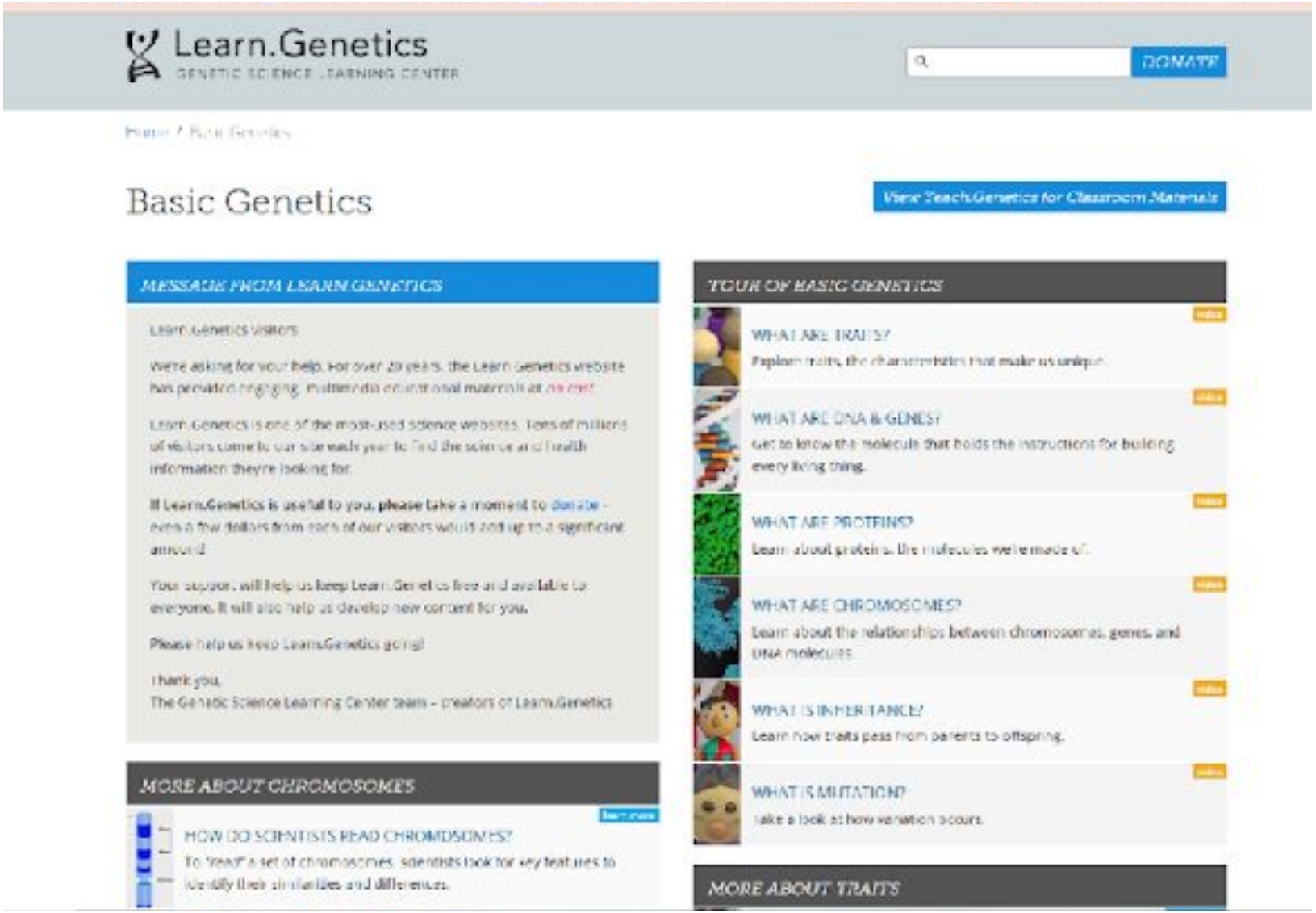
- **Frameshift mutations**:
  insertion/deletion
  dublication
  translocation

  - Change the oder of the codons, hence the identity of the translated protein
  - Severe impacts on protein structure

Inherited diseases

- DNA mutations are significant in development of diseases
- Inherited diseases are caused by mutations passed from a parent to a offspring
- **Monogenic diseases**: disease is caused by one mutation in one gene
- **Multifactiorial diseases**: disease is caused by interaction of different mutations and environmental factors

Questions? Contact me: john.strouboulis@kcl.ac.uk



Excellent website for understanding basic genetics:
https://learn.genetics.utah.edu/content/basics/