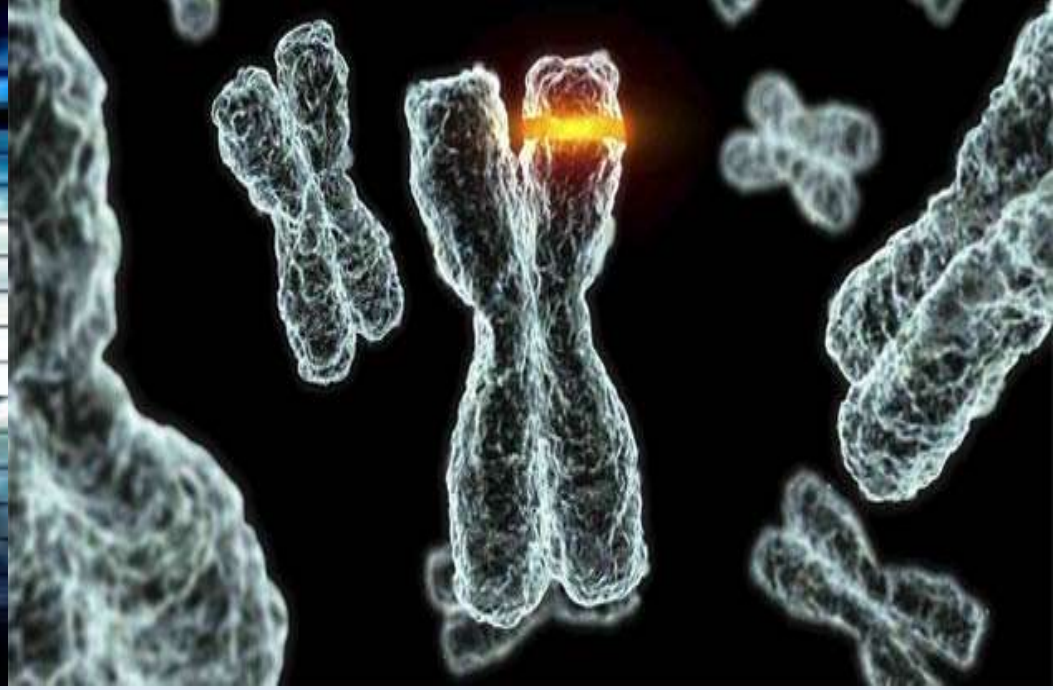
Starter

Watch the programme on 'Mutations'
(50 mins long)

(if link does not work, search for Pure Nature Mutations)

https://www.youtube.com/watch?v=qVmusHZtQms



Unit 1: DNA & the Genome

Topic 6: Mutations

Learning Outcomes

- State that mutations are changes in the genome that can result in no protein being produced or an altered protein being expressed.
- A single gene mutation involves the alteration of a DNA nucleotide sequence
- Gene mutations include Substitution, Insertion and Deletion of nucleotides.
- State that Insertion and Deletion of nucleotides are *frame - shift* mutations.

Mutations

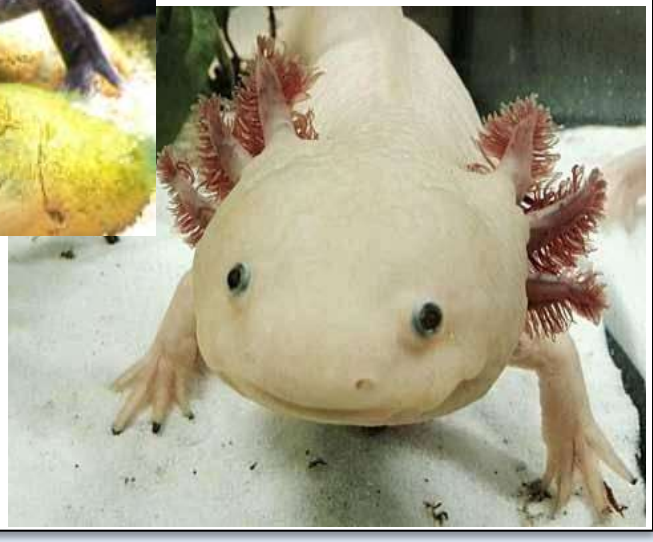
Mutations are a change in the structure or amount of an organism's DNA.

Mutations arise **spontaneously** and at **random**.

Leucism in axolotls is an example of mutation.

Leucistic animals do not have **any** skin pigmentation.

(different to albinos because they only lack melanin)



Frequency of Mutations

Mutations are rare.

In humans it is estimated that there is 1 mutation per 15-30 million base pairs.

Mutation rates differ in different genes and different organisms.

Types of Mutation

1. Single gene mutations
2. Chromosome structure mutations
3. Polyploidy

1. Single Gene Mutations

These mutations involve a change in one of the base pairs in the DNA sequence of a single gene. Also known as **point mutations**.

These may occur in the protein-coding sequence or the regulatory sequences which control expression of the gene.

There are 3 types of point mutations:

- deletion
- insertion
- substitution

Deletion

this nucleotide base is deleted

mRNA

Protein

Met	Gln	Thr	Ser	STOP

mRNA

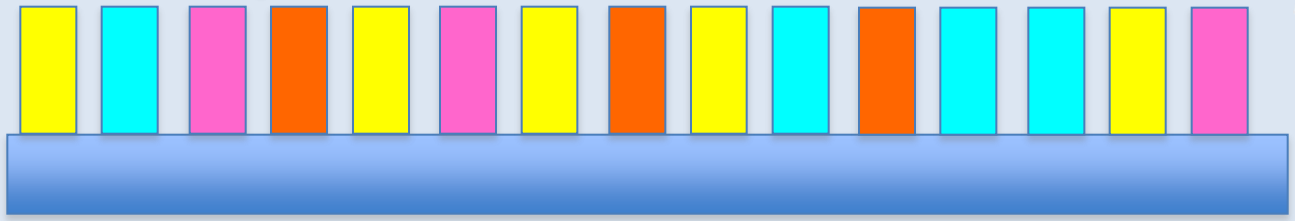
Protein

Met	Gln		His	Leu	

all the amino acids after this point are altered so that the protein made is not longer functional (this is known as a frameshift mutation)

Insertion

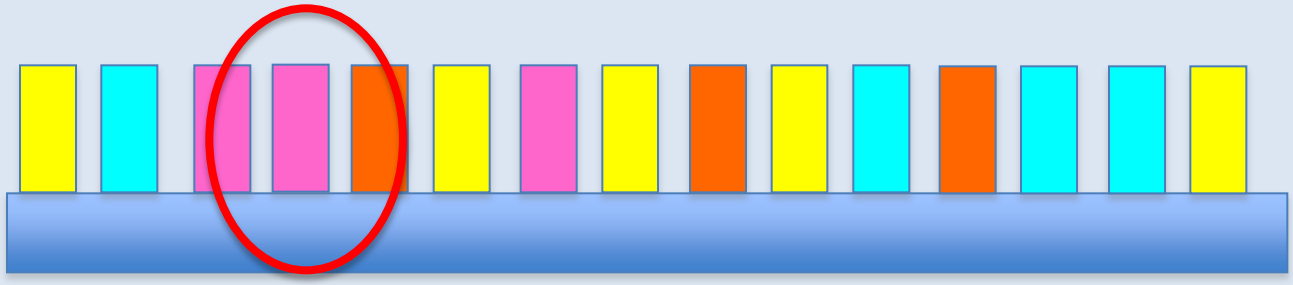
an extra nucleotide base is inserted



mRNA

Protein

Met	Gln	Thr	Ser	STOP



mRNA

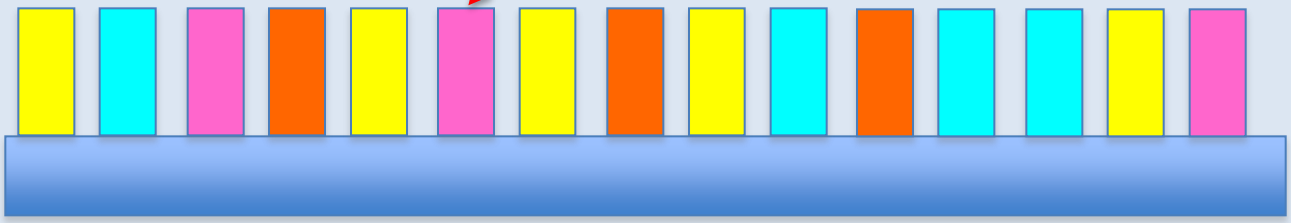
Protein

Met	Ala	Asp	Ile	Leu

all the amino acids after this point are altered so that the protein made is not longer functional (this is also a frameshift mutation)

Substitution

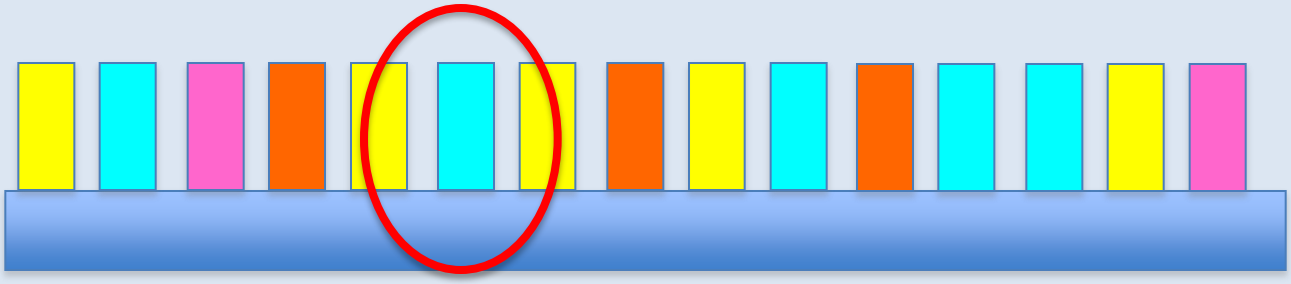
this nucleotide base is substituted with a different nucleotide base



mRNA

Protein

Met	Gln	Thr	Ser	STOP



mRNA

Protein

Met	Pro	Thr	Ser	STOP

At most, only one amino acid will be affected. Sometimes there is no change to the amino acid sequence. The protein function may be slightly altered or, as in the case of sickle cell anaemia, the protein may have a major defect if the substitution occurs at a critical point (this is a point mutation).

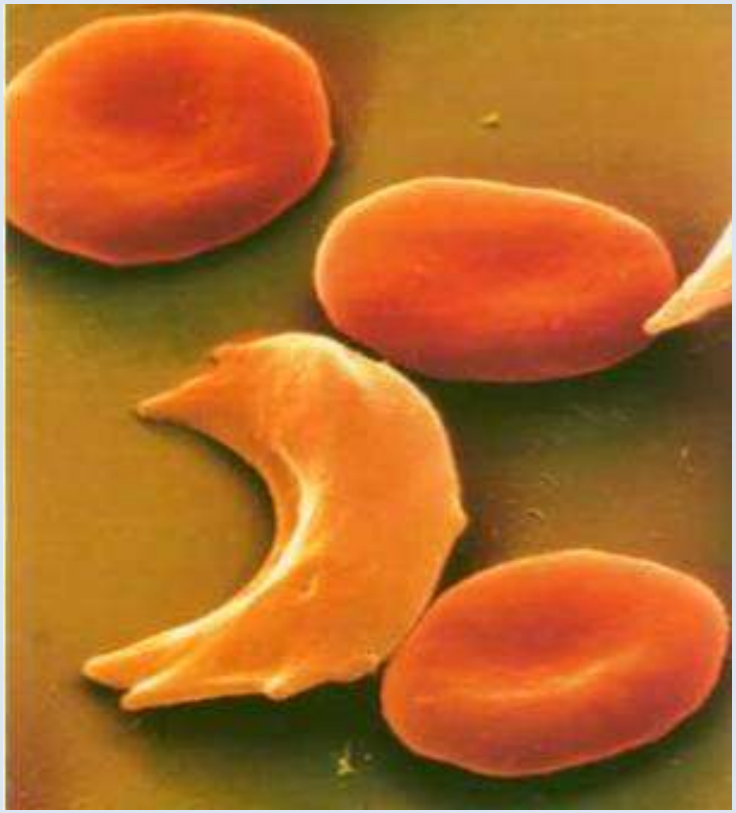
DIGS

3 types of **gene** mutation :

- Deletion
- Insertion
- Substitution

- DIGS

Problems Caused by Substitution



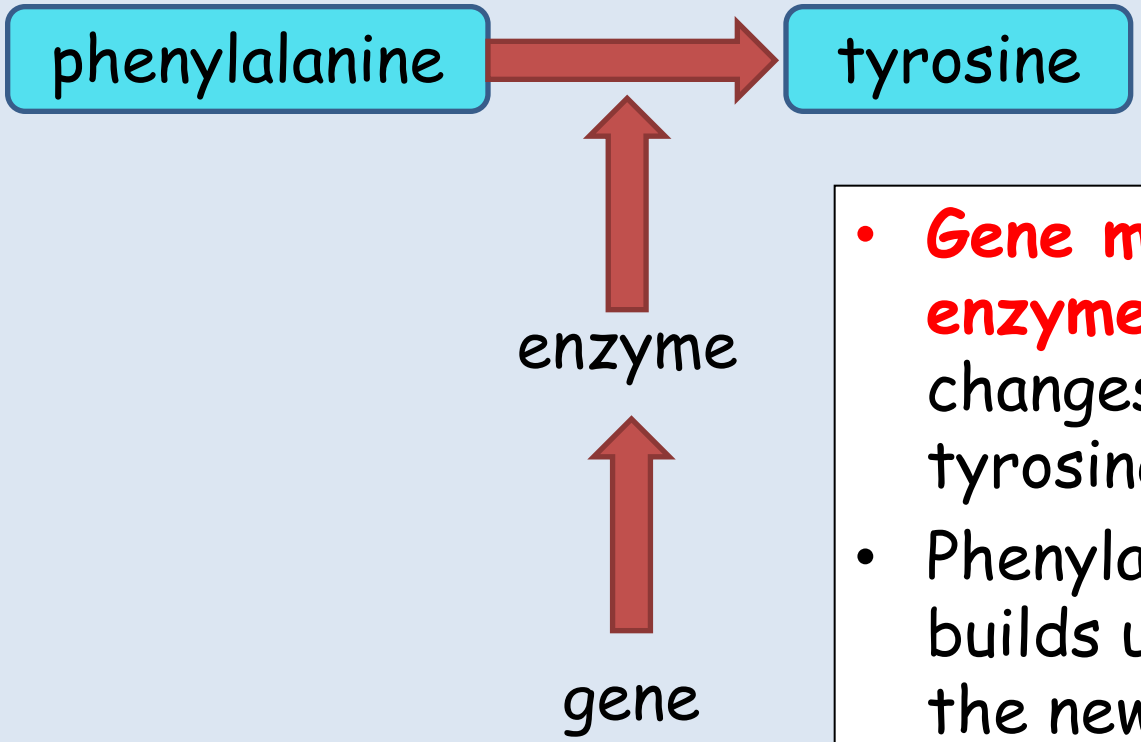
Sickle Cell Anaemia

- genetically transmitted disease
- caused by abnormal haemoglobin (protein)
- known as a point mutation (substitution)

Problems Caused by Insertion and Deletion

- Brings about a **major change** in the protein which is made since a large section of DNA is affected.
- Many amino acids are altered which results in a non-functional protein (known as a lethal gene).
- This is known as a frameshift mutation.
- Sometimes a metabolic pathway enzyme is affected and the pathway is disrupted e.g. phenylketonuria.

Phenylketonuria



- **Gene mutation** results in **enzyme not produced** that changes phenylalanine to tyrosine.
- Phenylalanine concentration builds up within the body of the newborn baby.
- Phenylalanine is converted into **toxic substances.**
- The toxic substances cause **irreversible damage to the developing brain.**

Screening for PKU at birth
Guthrie Test for PKU

The Impact of Point Mutations

Research and produce a A3 poster on what is meant by:

- Silent mutations
- Neutral mutations
- Missense mutations
- Nonsense mutations
- Frameshift mutations

Use diagrams to demonstrate the effects of each mutation on the resulting protein sequence.

Splice-Site Mutation and Evolutionary Importance of Mutation

Learning Outcomes

- Describe the consequences of a splice – site mutations

- Describe the evolutionary importance of gene duplication

Splice Site Mutations

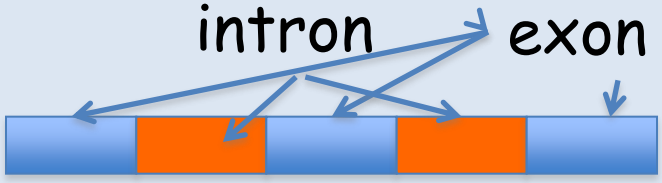
RNA splicing is important in creating the mature mRNA transcript before it is translated into a protein.

Mutations in the area that marks the start or end of an intron, may lead to one or more introns not being removed.

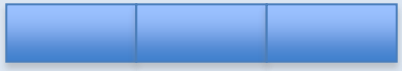
This will lead to a creation of a protein that does not function properly.

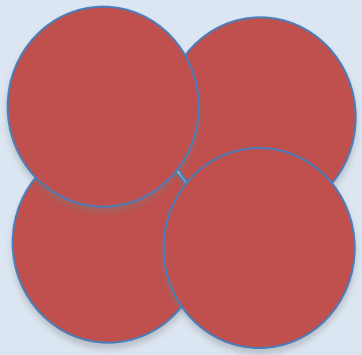
Thalassemia is a type of anaemia (similar to Sickle Cell) where a splice site mutation has caused a defect in the synthesis of haemoglobin.

Thalassemia, a disease caused by a defect in haemoglobin synthesis, is caused by a splice site mutation.



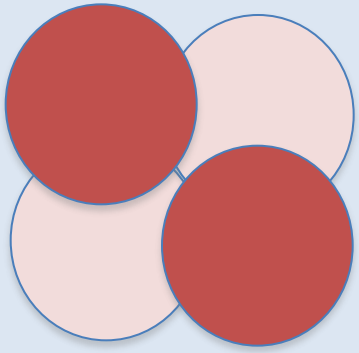
normal splicing





Normal functional haemoglobin with 4 oxygen carrying subunits.

abnormal splicing



Haemoglobin with only 2 oxygen carrying subunits.

2. Chromosome Structure Mutations

Can be a change to either:

chromosome structure (order of genes)

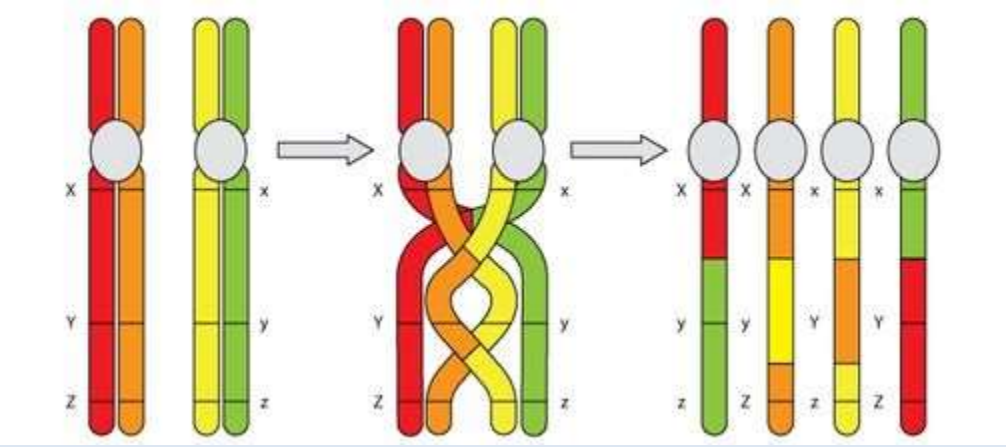
OR

chromosome number (polyploidy)

Change in Chromosome Structure

- There is a change in **number or sequence** of genes on a chromosome.

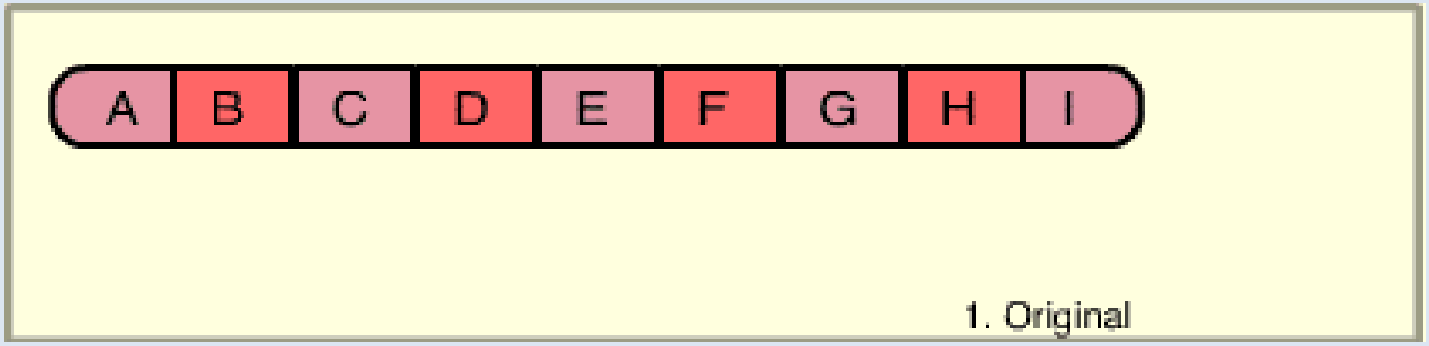
- Often happens during crossing over at chiasmata during meiosis.



Types of Chromosome Structure Mutation

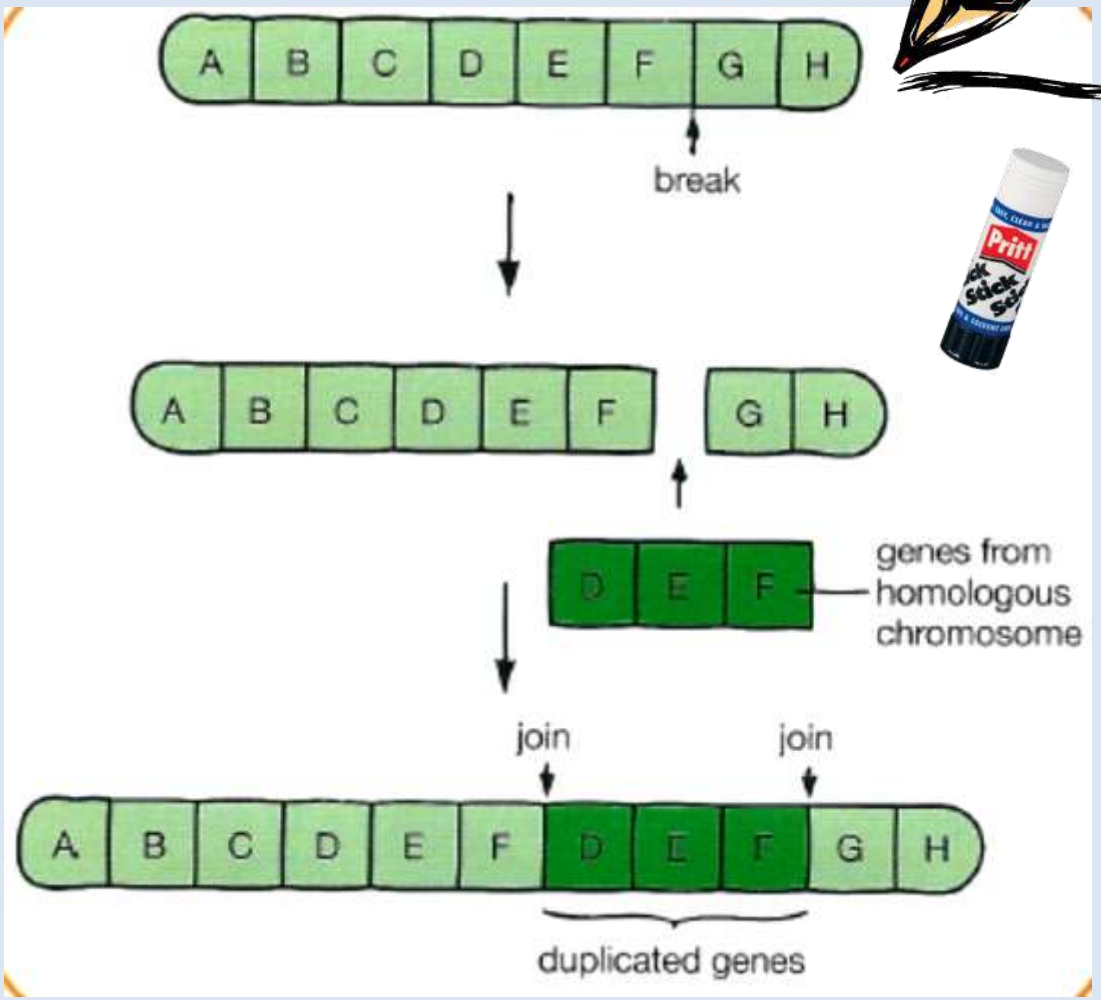
- **D**uplication
- **I**nversion
- **T**ranslocation
- **D**eletion

Make up a rhyme!



Duplication (genes repeated)

- Duplicated genes may undergo mutation
- This can introduce a new characteristic that may or may not be advantageous
- Duplication of a gene produces a second copy of the gene which is free from selection pressure (it can become altered with out affecting the original gene's function).



Evolutionary Importance of Duplicated Genes

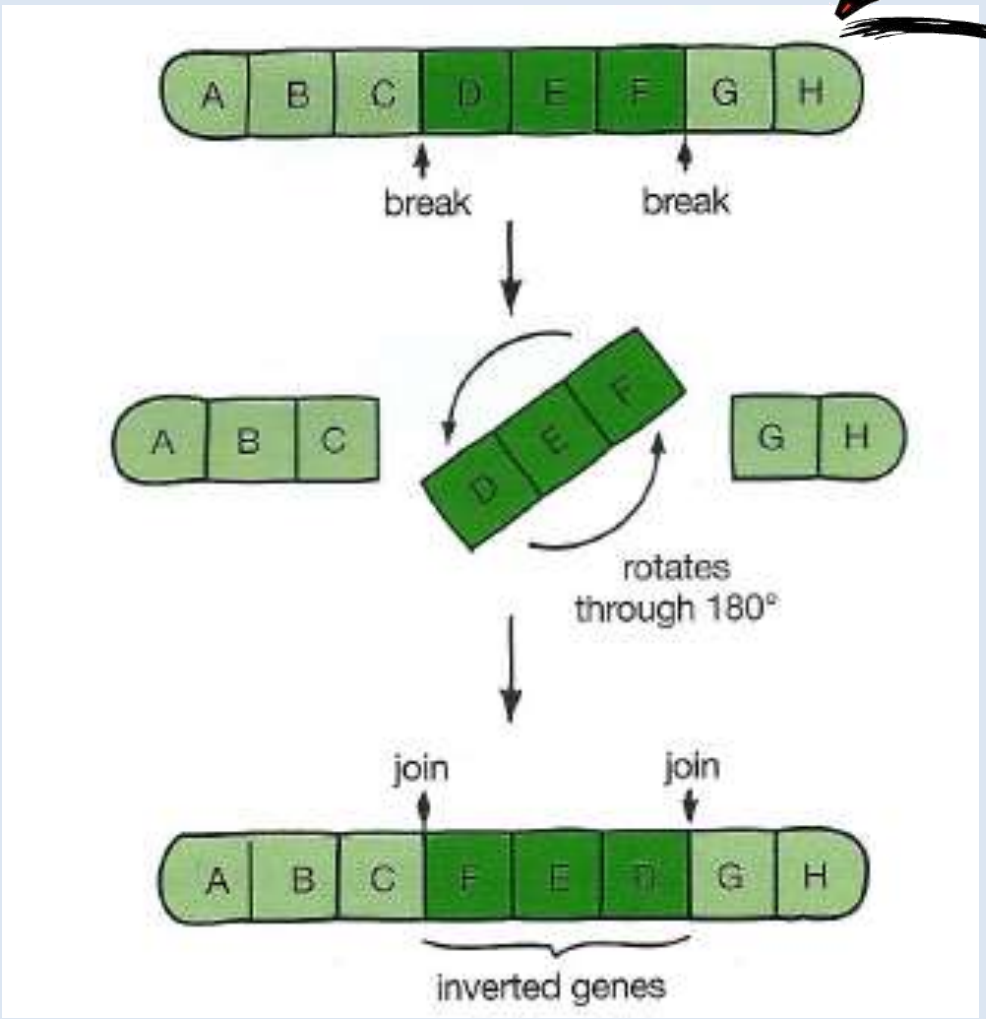
Duplication of a gene produces a second copy of the gene which is free from selection pressure.

This means that it can become altered without affecting the original gene's function.

Therefore it can mutate to produce new DNA sequences. This may confer advantages to the organism and possibly increase its fitness and chances of survival.

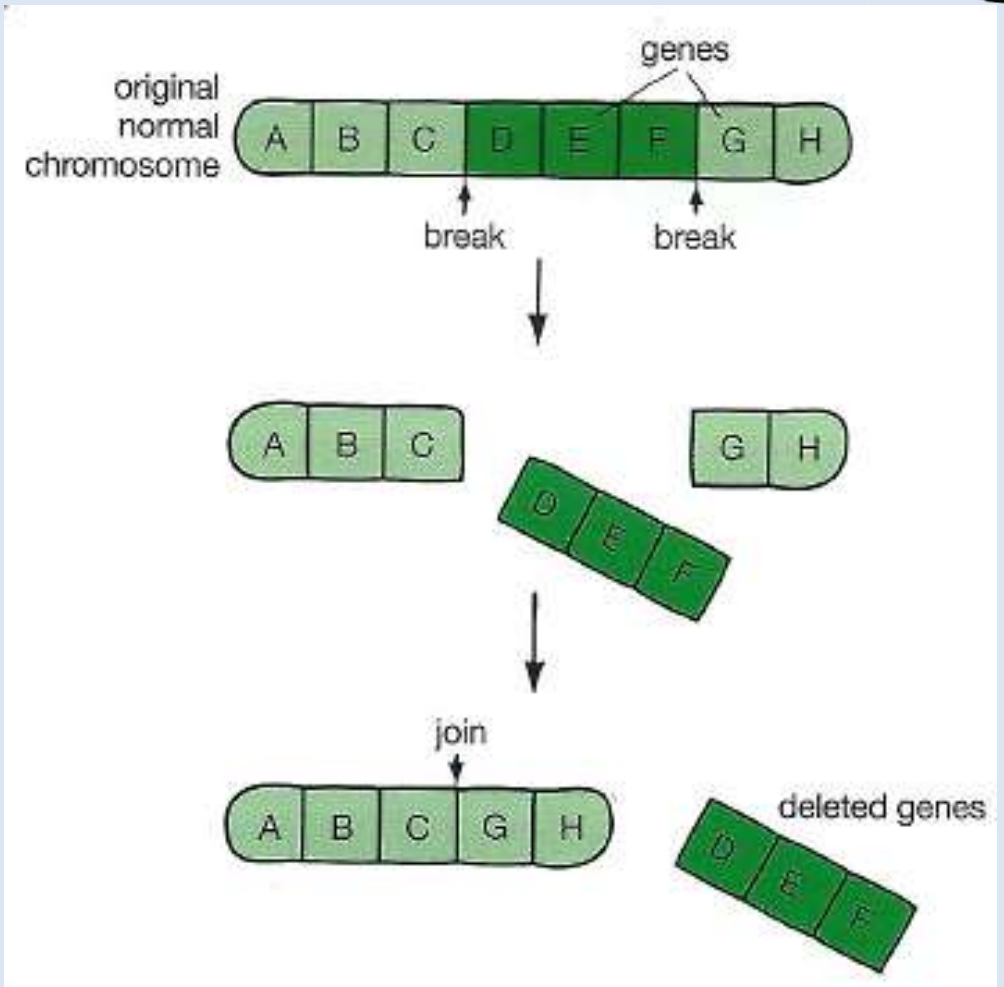
Inversion (swapping around of genes)

- Reversal of sequence.
- Problems with pairing and crossing over in meiosis.
- Often non-viable gametes.



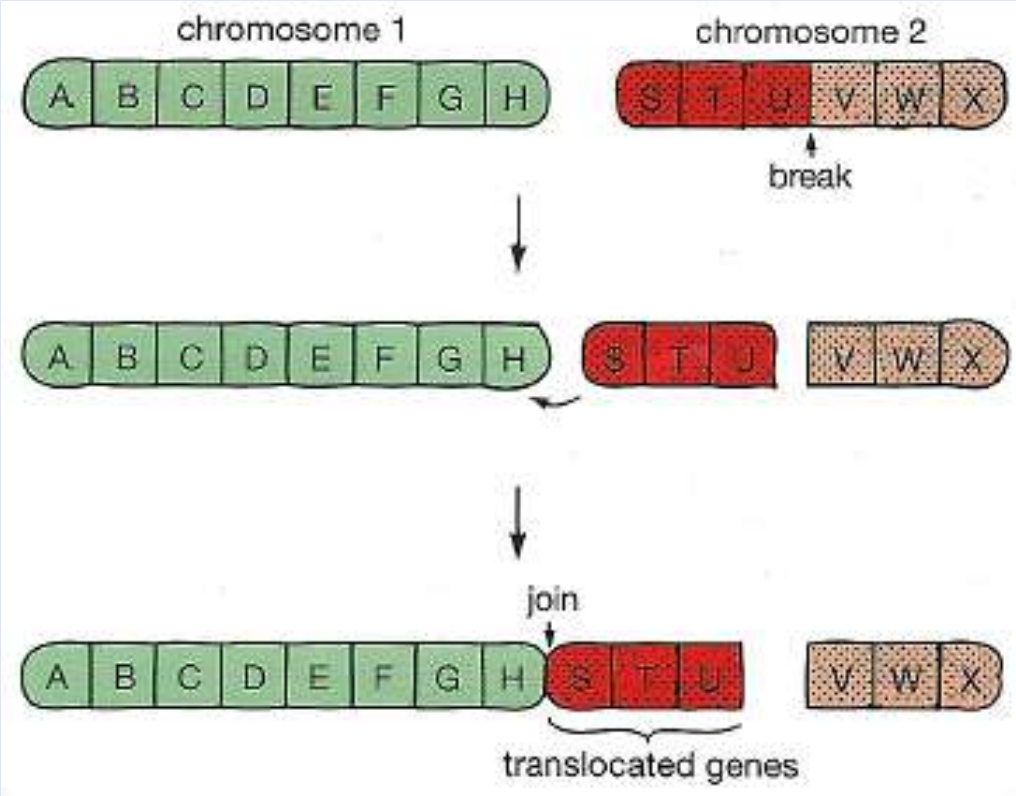
Deletion (removal of genes)

- Drastic effect
- Humans – cri du chat
  - mental retardation

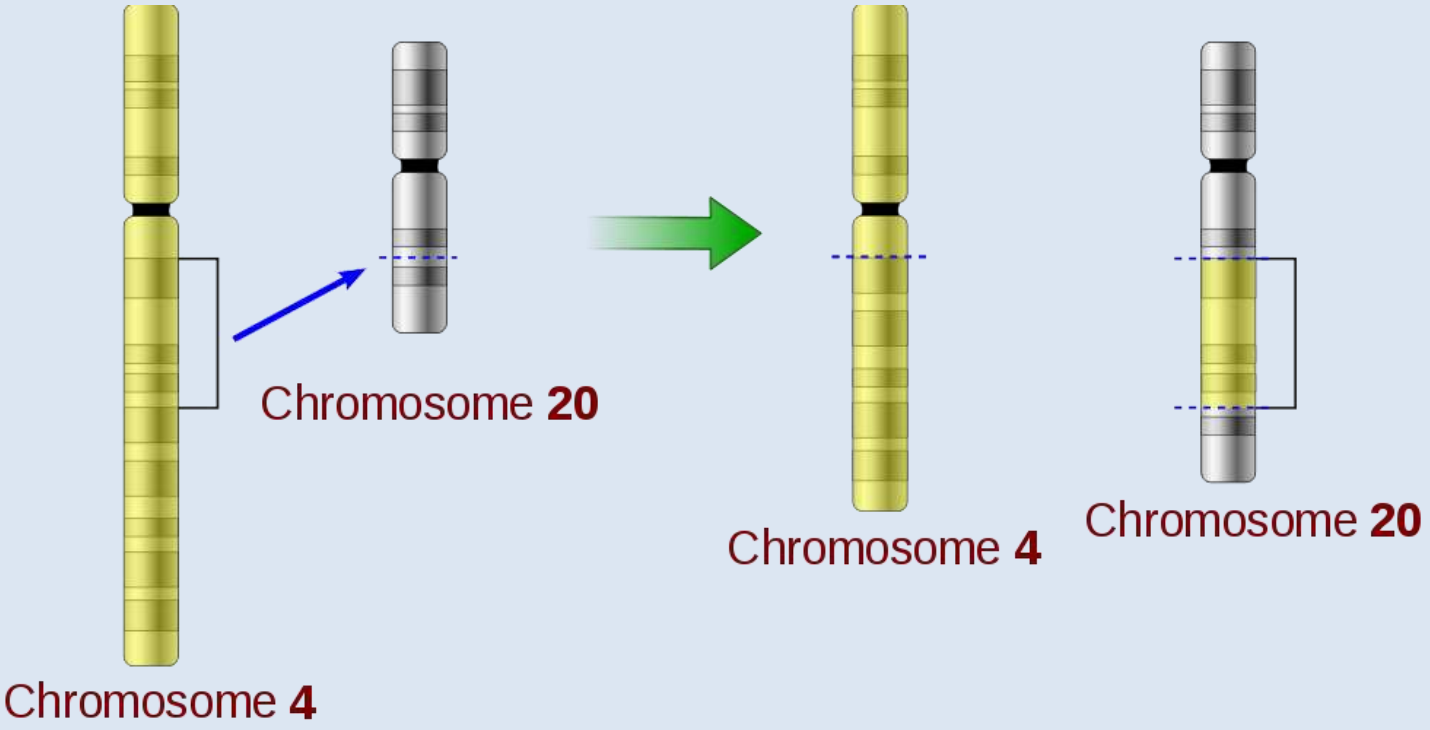


Translocation (genes added on)

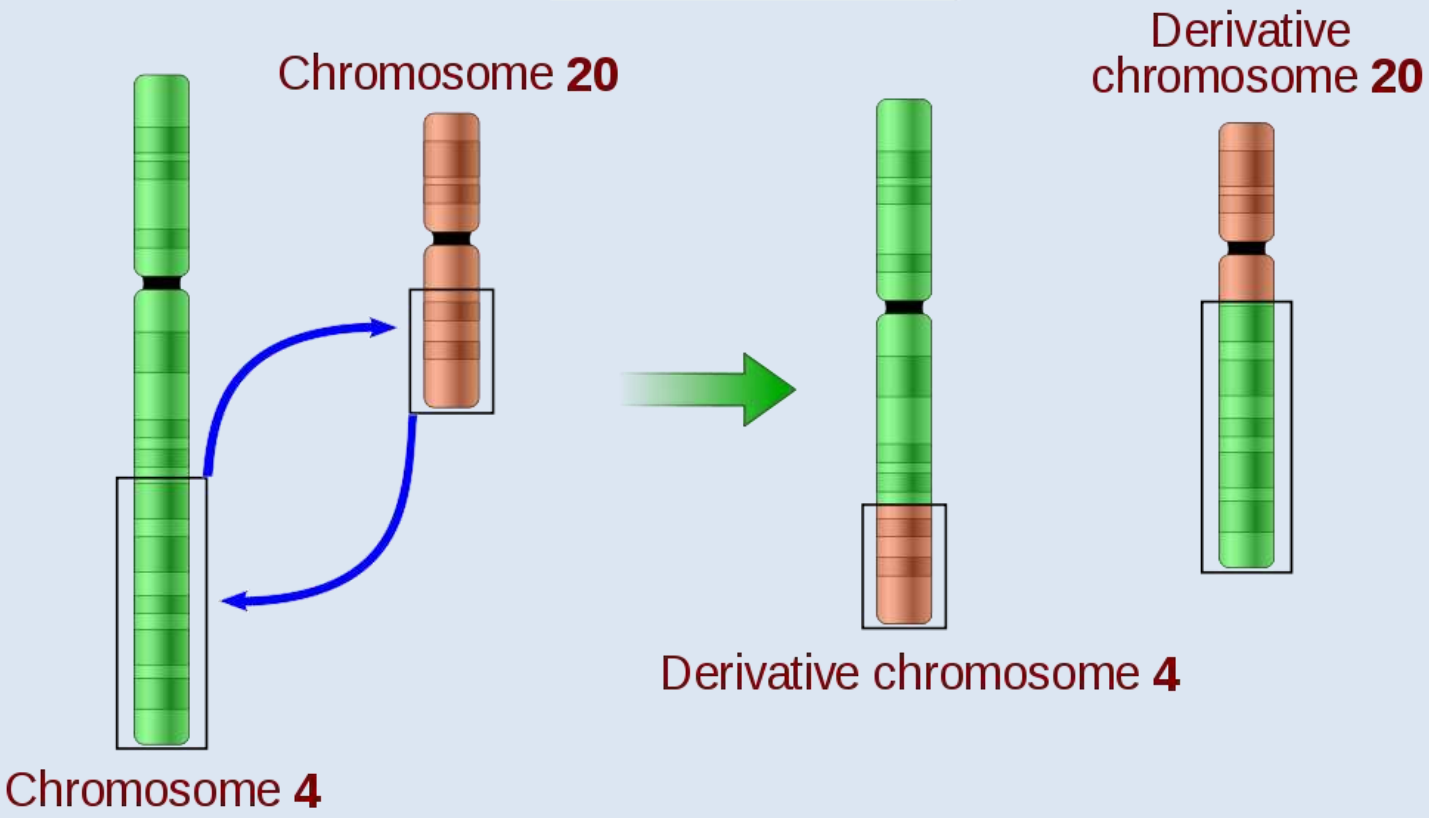
- Sections attaching to non-homologous partners.
- Problems with pairing in meiosis.
- Translocation involves transfer of genes from one chromosome to another.
- This results in problems pairing chromosomes during gamete formation and leads to non-viable gametes.



Non-Reciprocal Translocation



Reciprocal Translocation



Learning Outcomes

- Explain the meaning of polyploidy
- Give a reason as to why polyploid plants are important in human food crops

3. Polyploidy

Polyploidy is duplication of all the chromosomes resulting in extra sets of chromosomes.

It is the result of an error during gamete formation.

Duplicated genes may undergo single gene mutations without affecting the functioning of the original copy of the gene.

This could result in a new gene appearing which may have a selective advantage but the original gene would still function as normal.

Polyploidy in Plants

Roughly 50% of plant species are polyploid.

Polyploid plants are normally larger, and have increased seed and fruit size. This is of economic importance.

Hybrid plants (mixing of genes from two different breeds) have a selective advantage over non-polyploid plants.

Polyploid plants (hybrids) with an uneven number of sets of chromosomes are sterile.

This allows the production of **seedless** fruits.
e.g. bananas

Polyploidy in Animals

It is thought that polyploidy contributed to the evolution of vertebrate animals.

However, mammals which are polyploid fail to survive.

The plains viscacha rat lives in Argentina.

It is one of the few vertebrates to show polyploidy.