

# BIOLOGY

LEAVING CERTIFICATE  
HIGHER LEVEL

GENETICS/EVOLUTION



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# Genetics & Genetic Crosses

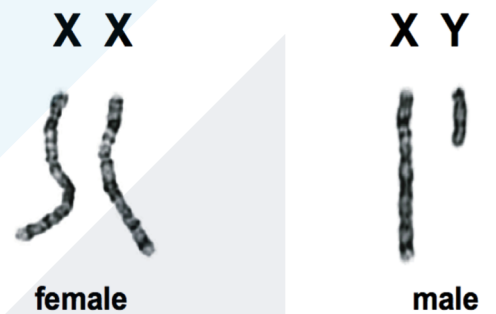


Genetic Terms	
<i>(Not only could these be asked by the examiner, but the understanding of the following terms will dramatically reduce the difficulty of genetic cross questions)</i>	
1.	<p>Genetics: Study of variation and heredity</p> <p>Gene: Specific section of DNA</p> <p>Heredity: Transmission of genetically controlled characteristics</p> <p>Somatic Cells: All body cells except the reproductive ones (<math>2n=46</math>)</p> <p>Gametes: Haploid sex cells capable of fusion</p>
2.	<p>Variation: Differences between living organisms</p> <p>Species: Populations capable of interbreeding and producing viable offspring</p>
3.	<p>Allele: Alternative form of the same gene. Can be <u>dominant</u> or <u>recessive</u> e.g. (B) – blue eyes (b) green eyes</p> <p>Locus: Position of a gene on a chromosome</p>
4.	<p>Genotype: Genetic makeup of organism e.g. Bb/BB/bb</p> <p>Phenotype: Physical makeup of an organism e.g. Bb = Blue eyes BB = Blue eyes</p>
5.	<p>Dominant: Allele that is fully expressed. Denoted by capital letter.</p> <p>Recessive: Allele prevented from being expressed by dominant. Denoted by lower case letter.</p> <p>Incomplete Dominance: Neither is dominant and a mix is formed e.g. red and yellow snapdragons make a pink flower</p>

6.	Homozygous: Alleles are identical e.g. BB/bb Heterozygous: Alleles are different e.g. Bb
7.	Monohybrid Cross: Study of the inheritance of one gene (bb X Bb) Dihybrid Cross: Study of the inheritance of two genes (bbRr X BbRR)

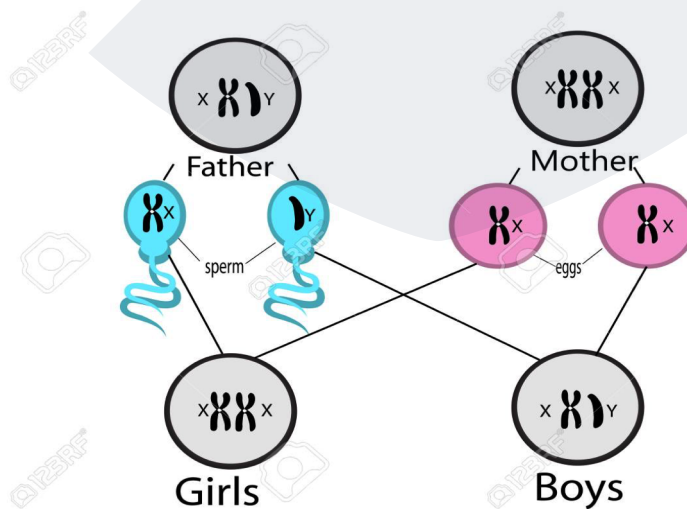
## Sex Linkage and Determination

Somatic cells in humans have 46 chromosomes (23 pairs). In males and females, the first 22 are identical. (these are known as *autosomes*). The 23<sup>rd</sup> pair are referred to as the sex chromosomes.



Female:	two long chromosomes	XX
Male:	one long and one short chromosome	XY

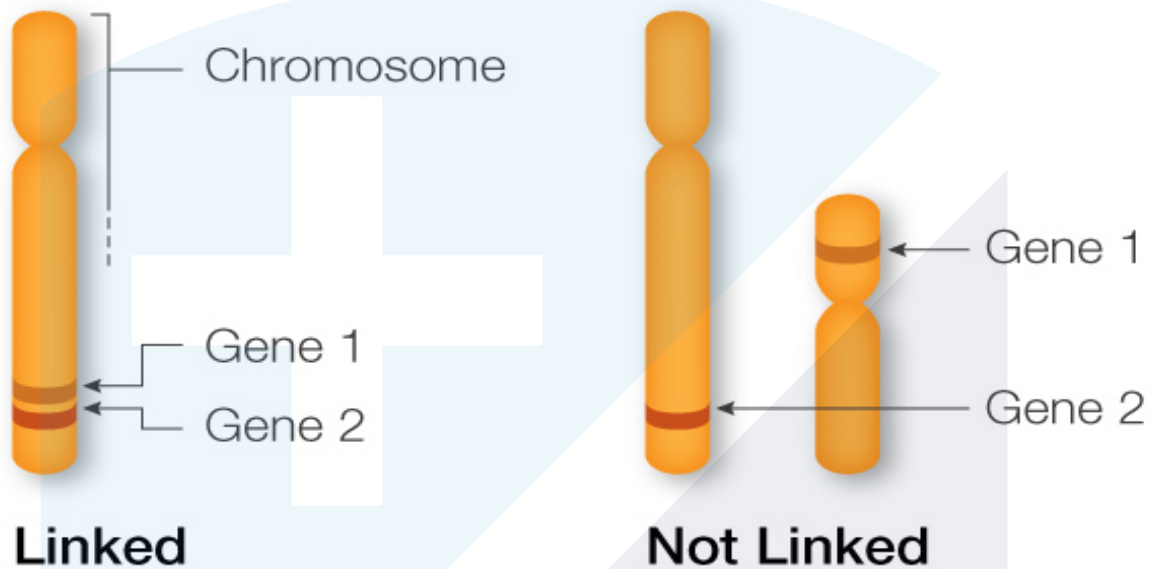
- All female gametes carry X chromosome
- Half of male gametes carry X chromosome and half carry Y chromosome
- Sex of child is determined by the father\*



*Exceptions:*  
Birds, butterflies and moths.  
XY= female  
XX= male

## **Linkage:**

- The genes are located on the same chromosome.
- They do not show independent assortment and are thus in contradiction with Mendel's Second Law.



## **Disadvantages:**

- less variation
- do not assort independently, contradicts Mendel's 2<sup>nd</sup> law

### **Definition**

**Punnett square:** a grid to show the ratio of the genotypes of the progeny in a genetic cross.

## Definition

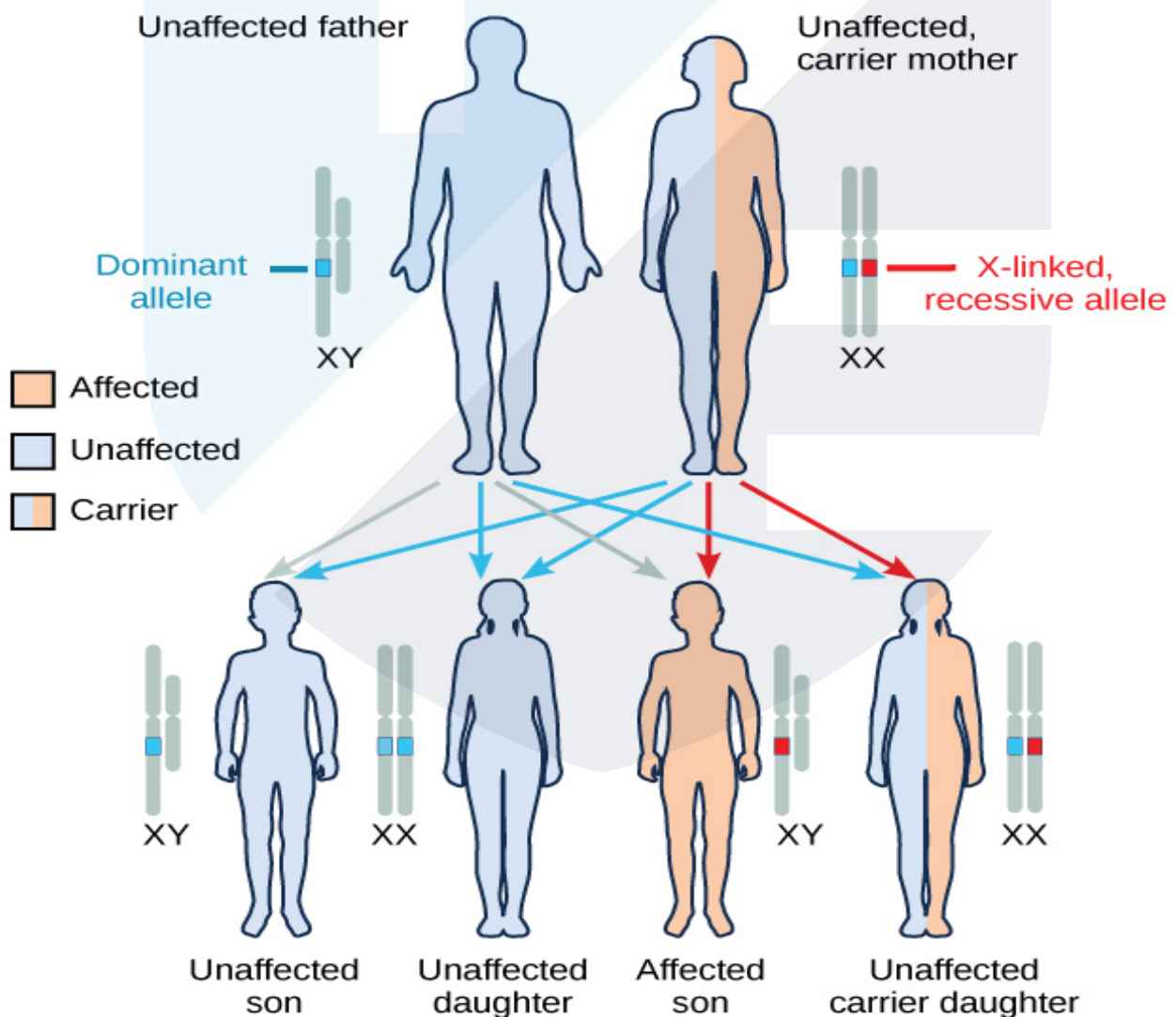
**Sex Linkage:** traits that are on the X chromosome but not on the Y and as a result traits that are expressed more often in males than females.

- The X chromosome is longer than the Y chromosome. Some genes located on the X chromosome don't have a corresponding allele on the Y chromosome

## Example

1) **Blood clotting:** (N) Normal clotting is dominant, (n) haemophilia is recessive.

2) **Colour Vision:** (N) Normal vision is dominant, (n) colour blindness is recessive.



## Gregor Mendel (Mendelian Genetics)

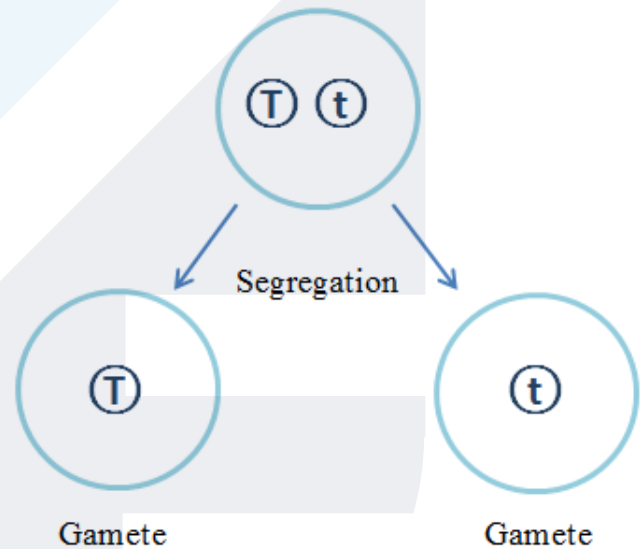
- Gregor Mendel interbred pea plants and studied the inheritance of seven characteristics (e.g. height, seed shape) in their offspring.
- The characteristics were specifically chosen as they only had two contrasting qualities e.g. height = tall or small.
- Mendel kept strict record of the crosses and from these he developed simple inheritance ratios and his two laws of genetics.



### *Mendel's First Law: The Law of Segregation*

- Characteristics are controlled by a pair of genes.
- These genes separate from each other at gamete formation.
- Each gamete receives only one of each pair of factors.
- At fertilisation a pair is re-established for each characteristic.

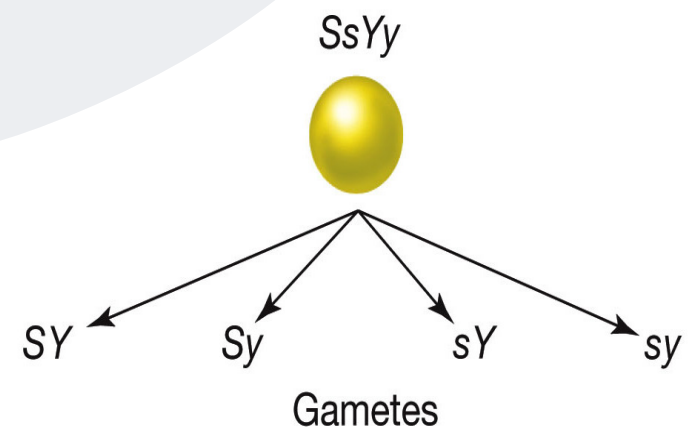
*\*(gametes 1<sup>st</sup>)*



### *Mendel's Second Law: The Law of Independent Assortment*

- During formation of gametes either of the pairs of factors controlling a trait have an equally chance of entering gamete.
- This is uninfluenced by any other pair of factors.

*\*gamete may only have one member of each pair of factors*





### Question 1

In Dalmation dogs the allele for brown spots is recessive to the allele for black spots. The two parents were heterozygous in respect of spot colour. What is the % chance of obtaining offspring with black spots?

### Question 2

Red hair in humans is recessive to all other hair colours. A red haired woman and a black haired man, whose own father was red haired, started a family. What is the % chance of obtaining offspring with red hair?

## Incomplete Dominance

- Incomplete dominance in plants:

Flower colour in snapdragons shows incomplete dominance (heterozygous condition Rr is pink).

If **two pink flowered plants are crossed**, what are the offspring genotypes:

RR = Red flower, Rr = pink flower, rr = white flower

Parents genotypes Rr x Rr

Gametes		R	r
	R	RR	Rr
	r	Rr	rr

Offspring genotype RR, Rr, Rr, rr

Offspring phenotypes 1 red flower: 2 pink flowers: 1 white flower

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<i>Phenotype</i>	Red	Pink	White
<i>Genotype</i>	RR	Rr	rr

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- Incomplete dominance in cattle:

Shorthorn cattle have incomplete dominance when dealing with coat colour.

RR= Red

rr = white

Rr = roan

Parent phenotypes: Red male x white female

Parent genotypes:

RR x rr

Gametes

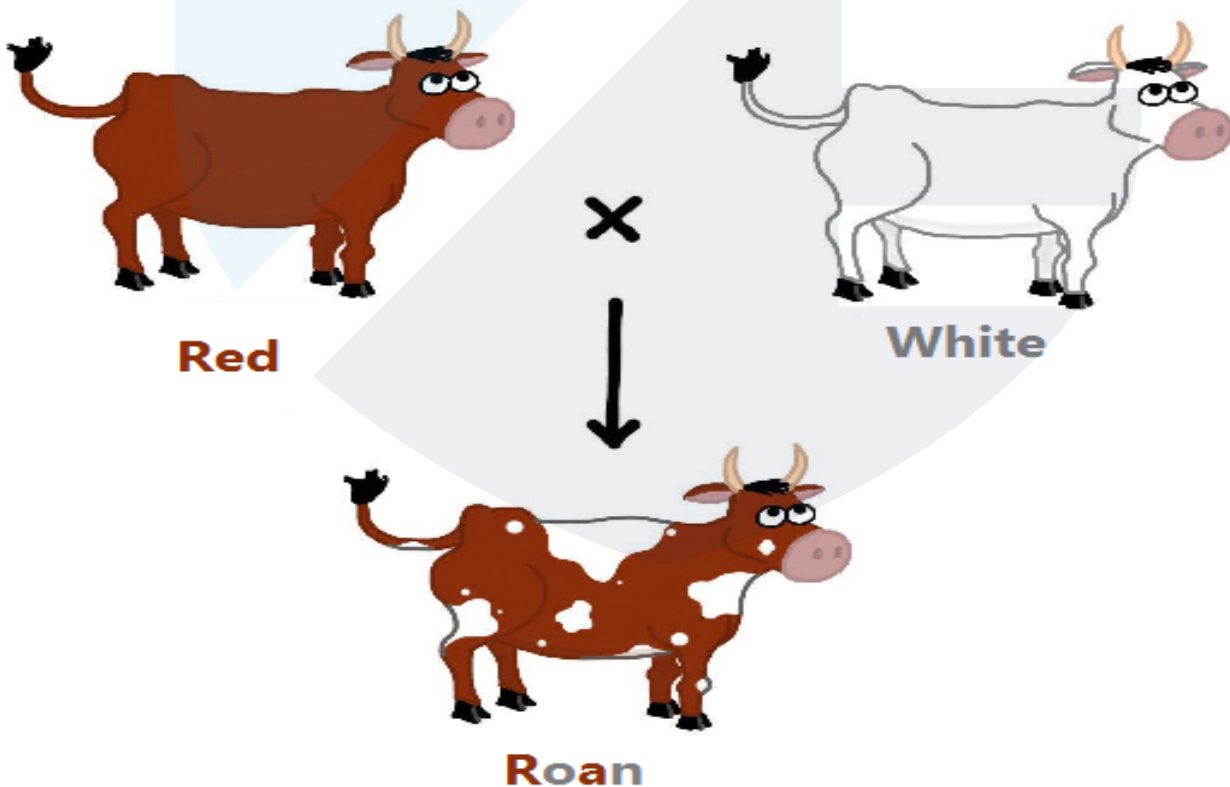
R x r

Offspring phenotypes

Rr

Offspring genotypes

All roan cattle



## Dihybrid Crosses

1) Question:

In dogs, black coat (B) is dominant to white coat (b). Also short hair (S) is dominant to long hair (s).

Show the genotypes and phenotypes of the F1 progeny for a cross involving a black coated, short haired dog (heterozygous for both traits) and a white coated, long haired animal.

Answer:

B = black coat   b = white coat   S = short hair   s = long hair

Parent Genotype: BbSs   x   bbss

Gametes:

	bs	bs
BS	BbSs	BbSs
Bs	Bbss	Bbss
bS	bbSs	bbSs
bs	bbss	bbss

Offspring Genotype: BbSs   Bbss   bbSs   bbss

Offspring Phenotype:

Black coat, Short hair

Black coat, Long hair

White coat, Short hair

White coat, Long hair

2) Question:

Purple flower is dominant over red flower. Short stemmed plants are dominant over long stemmed plants.

Give the expected genotype and phenotype of the F1 progeny if a purple flowered, short stemmed plant (heterozygous) is self-pollinated.

Answer:

P = purple p = red S = short s = long

Parent Genotype: PpSs x PpSs

Gametes:

	PS	P <sub>s</sub>	pS	ps
PS	PPSS	PPSs	PpSS	PpSs
P <sub>s</sub>	PPSs	PPss	PpSs	Ppss
pS	PpSS	PpSs	ppSS	ppSs
ps	PpSs	Ppss	ppSs	ppss

Offspring Genotype:

Offspring Phenotype:

Purple flowered, Short stemmed x 9  
Purple flowered, Long stemmed x 3  
Red flowered, Short stemmed x 3  
Red Flowered, Long stemmed x 1

3) Question:

In pea plants the characteristic for being tall (T) is dominant over the characteristic for being small (t). The purple flower (P) of this plant is also dominant over white flowers (p). Linkage occurs between the allele for tall (T) and purple (P) and the allele for small (t) and white (p).

What are the possible offspring if one parent plant is tall and purple (heterozygous for both) and the other is short and white?

Answer:

T = tall t = small P = purple p = white

Parent Genotype: TPtp x tptp

Gametes:

	tp	tp
TP	TPtp	TPtp
tp	tptp	tptp

Offspring Genotype: TPtp TPtp tptp tptp

Offspring Phenotype:

Tall plant, Purple flower  
Tall plant, Purple flower  
Short plant, White flower  
Short plant, White flower

4) Question:

Haemophilia in humans is governed by a sex linked allele. The allele for normal blood clotting (N) is dominant to the allele for haemophilia (n):

Determine the possible genotypes and phenotypes of the progeny of the following cross:

haemophilic male x heterozygous normal female

Answer:

X = female chromosome Y = male chromosome N = normal n = haemophilia

Parent Genotype:  $X^nY^-$  x  $XX^Nn$

Gametes:

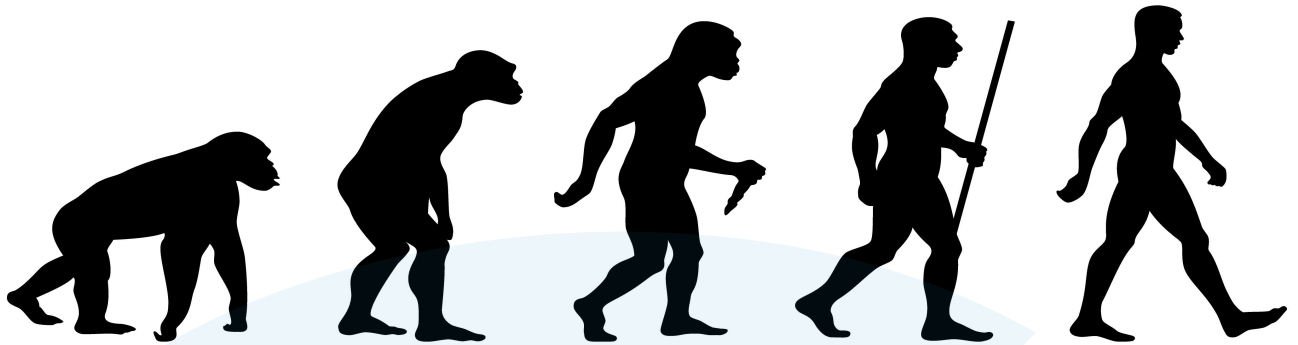
	$X^N$	$X^n$
$X^n$	$XX^Nn$	$X^nX^n$
$Y^-$	$X^NY^-$	$X^nY^-$

Offspring Genotype:  $XX^Nn$   $X^nX^n$   $X^NY^-$   $X^nY^-$

Offspring Phenotype:

- Female, Normal clotting (carrier)
- Female, Haemophilia
- Male, Normal clotting
- Male, Haemophilia

## Evolution and Heredity



### Definitions

**Evolution:** The change in characteristics of a population from generation to generation and is the process that produces new species.

**Classification:** placing objects into groups based on their similar characteristics.

**Species:** a group of individuals who can interbreed and produce fertile offspring.

**Variation:** the difference between individuals of the same species. They can be due to *environmental* or *genetic* causes.

**Inherited variations:** differences within a species that are controlled by *genes*.

**Acquired variations:** differences within a species that are *learned/developed* through an organism's life

### Causes of genetic variation:

- Mutations
- Meiosis: different combination of genes in an individual's gametes.
- Sexual reproductions: one set of information from each parent. Offspring different genetic combination to parent.



## Natural Selection

Proposed by Alfred Russel Wallace and Charles Darwin.

### Observation

- Within a population there is great variation (genotype and phenotype).
- Usually there is overbreeding and the number of offspring far outweighs the number of parents.
- Population numbers remain constant.

### Result

- Competition for limited resources leaves a struggle for survival.
- Those with adaptive usually genetic characteristics survive (others are deselected ☹)
- Survivors reproduce and have more offspring than those less adapted.

### Conclusion

- Next generation contains more of the successful genes. ('best of the best')
- Populations become better adapted to their environment with each generation.

**Mutation:** *change in the amount or sequence of DNA (changing protein produced)*

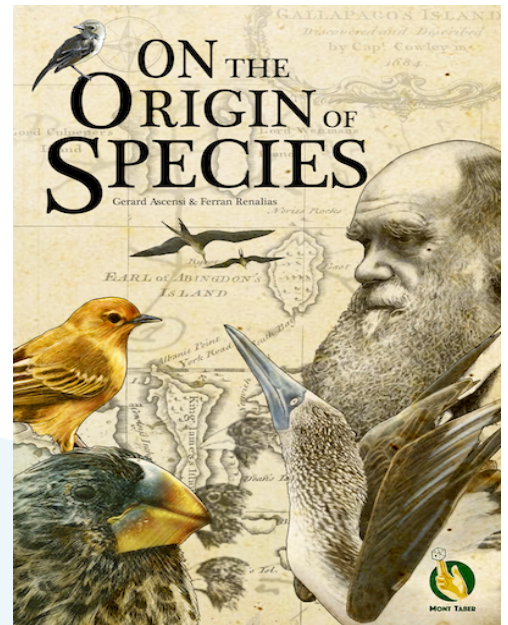
- Most affect the recessive allele and so have no overall change on the organism
- Most are harmful but some can be beneficial (cystic fibrosis, lactose tolerance)
- Caused by mutagens e.g. X-rays

1) *Gene mutation* – changes in a single gene that results in a protein being incorrectly made or not made at all. E.g. cystic fibrosis, Haemophilia

2) *Chromosome mutation* – large changes in the structure or number of chromosomes in an organism. E.g. Down Syndrome.

- Down syndrome is a result of 3 copies of chromosome 21 in the human genome. Usually happens due to homologous chromosomes not splitting during meiosis in formation of eggs (female).

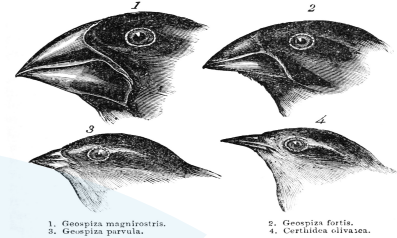
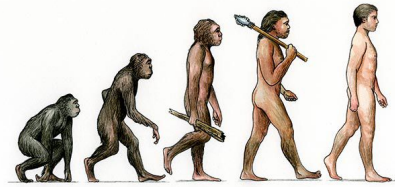
A mutation can be caused by a spontaneous change resulting from a mistake in DNA replication. These changes are rare although possible.



## Evolution

Evidence:

- fossils (may be aged and compared)
- anatomically similar organisms
- vestigial structures



1. *Geospiza magnirostris*,  
3. *Geospiza parvula*,  
2. *Geospiza fortis*,  
4. *Certhidea olivacea*.

**Fossils:** remains of organisms that lived a long time ago.

**Speciation:** production of a new species because of evolution.

