13 Inheritance

126 Inheritance - key definitions

Inheritance is the **transmission** of **genetic information** from one generation to the next, leading to continuity of the species and variation within it.

Key definitions

Chromosome	A thread of DNA, made up of genes.
Allele	An alternative form of a gene. Pairs of alleles occupy the same relative positions on chromosome pairs.
Gene	A section of DNA, which codes for the formation of a protein controlling a specific characteristic of the organism.
Haploid nucleus	A nucleus containing a single set of unpaired chromosomes, e.g. in sperm and ova (eggs). In humans, the haploid number is 23.
Diploid nucleus	A nucleus containing pairs of chromosomes, e.g. in somatic (body) cells, In humans the diploid number is 46.
Genotype	The genetic make-up of an organism, e.g. Tt, where T and t are alleles of a gene.
Phenotype	The characteristics visible in an organism, controlled by the genotype, e.g. a tall plant or a dwarf plant.
Homozygous	Having a pair of identical alleles controlling the same characteristics, e.g. TT, where T=tall. The organism will be pure-breeding for that characteristics.
Heterozygous	Having a pair of dissimilar alleles for a characteristic, e.g. Tt.
Dominant	A gene, e.g. T, that always shows in the phenotype of an organism whether the organism is heterozygous (Tt) or homozygous (TT).
Recessive	A gene, e.g. t, that only has an effect on the phenotype when the organism is homozygous (tt)

Video: The Human Genome Project, 3D Animation
https://www.youtube.com/watch?v=VJycRYBNtwY

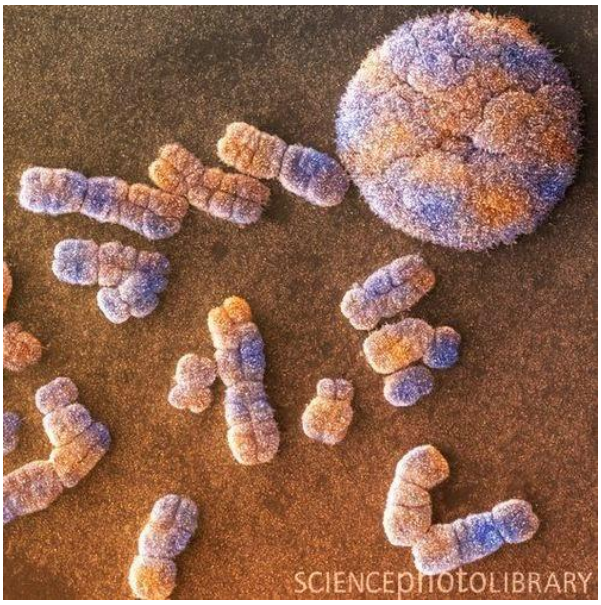
#127 Chromosomes, DNA, genes and alleles

In the nucleus of every cell there are a number of long threads called **chromosomes**.

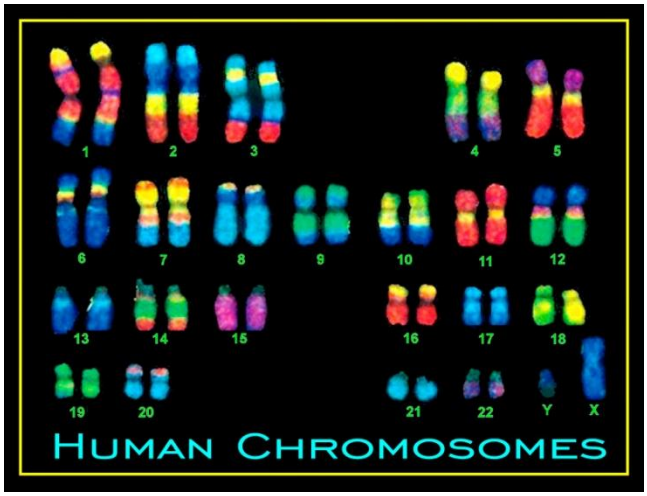
Chromosomes

Most of the time, the chromosomes are too thin to be seen except with an electron microscope. But when a cell is dividing, they get shorter and fatter so they can be seen with a light microscope.

Human chromosomes and nucleus. Chromosomes are a packaged form of DNA. The DNA normally exists in a non-condensed form in the cell nucleus (upper right). It condenses into chromosomes (centre and lower left) during cell replication.



Human cells contain 46 chromosomes, which are in pairs. Sex cells (sperm and ova) contain only 23 chromosomes. The 23 chromosomes comprise one from each pair.

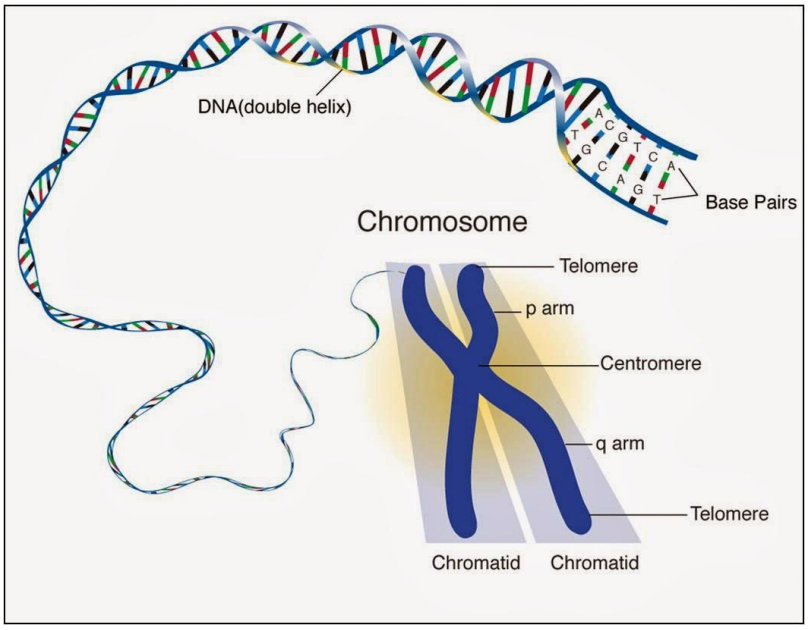


Inheritance of sex in humans

Of the 23 pairs of chromosomes present is each human cell, one pair is the sex chromosomes. These determine the sex of the individual. Male have XY, female have XX. So the presence of a Y chromosome results in male features developing.

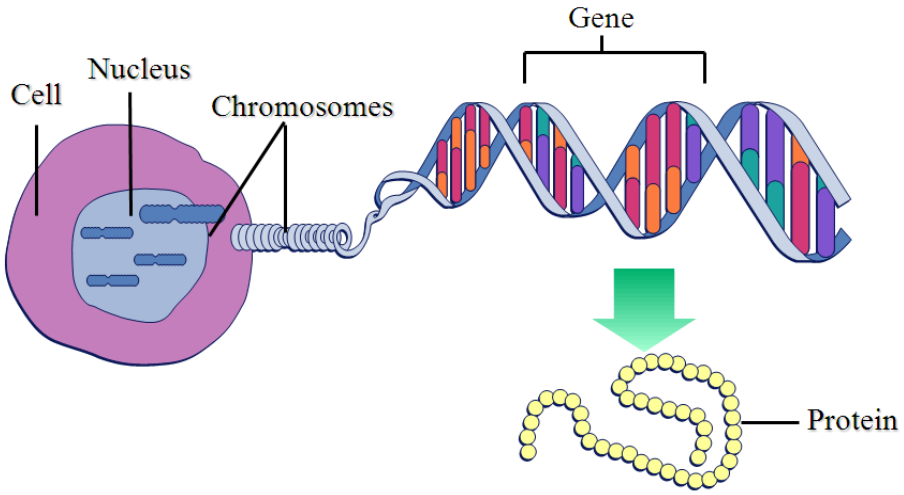
DNA

Each chromosome contains one very long molecule of DNA. The DNA molecule carries a code that instructs the cell about which kind of **proteins** it should make. Each chromosome carries instructions for making many different proteins.



Gene

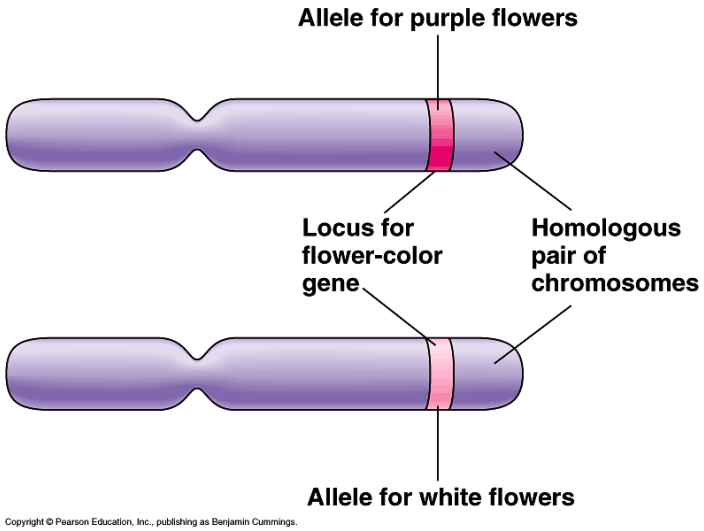
Each chromosome is made up of a large number of **genes** coding for the formation of different proteins which give us our characteristics. The gene responsible for a particular characteristic is always on the same relative position on the chromosome.

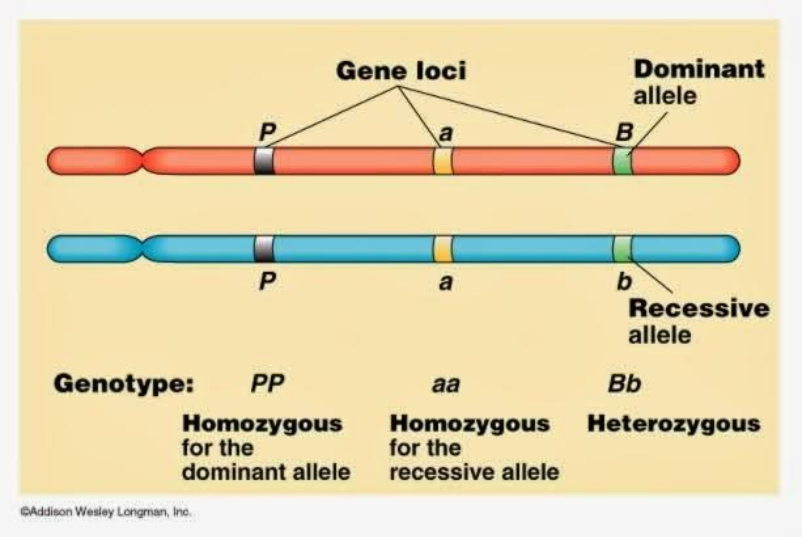


A part of a DNA molecule coding for one protein is called a gene.

Alleles

When the chromosomes are in pairs, there may be a different form (allele) of the gene on each chromosome.





Video: What is a Chromosome?

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

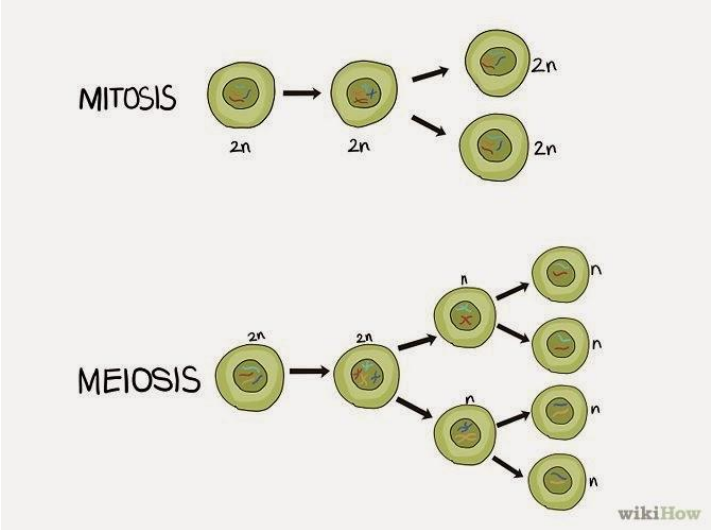
Video: What is DNA?

https://www.youtube.com/watch?v=zwibgNGe4aY

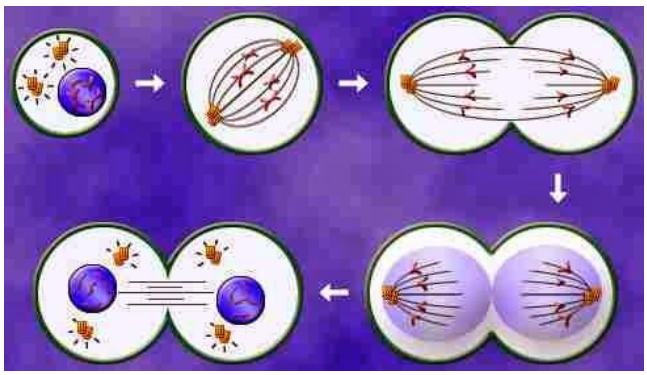
128 Cell division – Mitosis and Meiosis

Mitosis is a nuclear division giving rise to genetically **identical** cells in which the chromosome number is maintained by the exact duplication of chromosome.

Meiosis is a reduction division in which the chromosome number is **halved** from diploid to haploid.



Mitosis

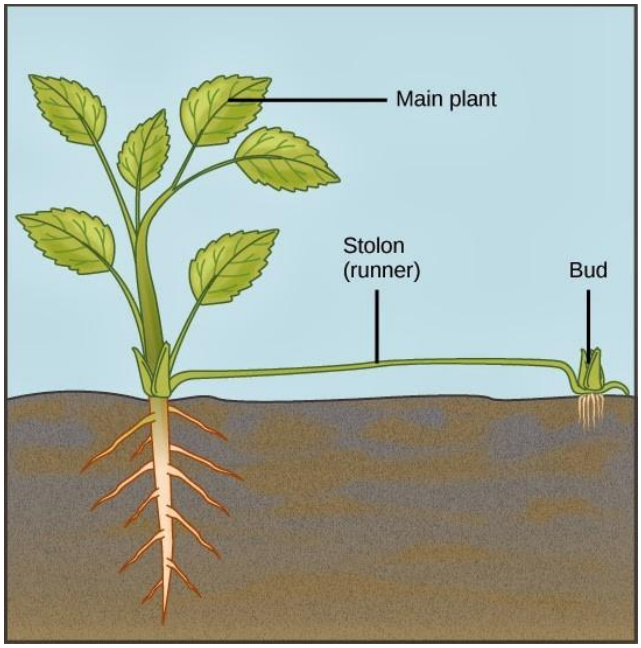


Mitosis is the way in which **any cell** (plant or animal) divides when an organism is:

- **growing**
- **repairing** a damaged part of its body
- **replacing** worn out cells

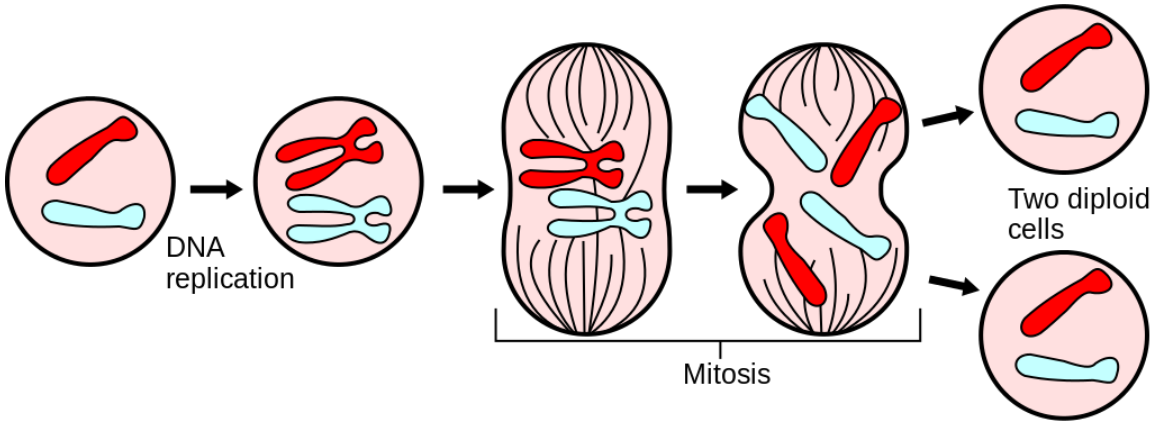
Growth means getting bigger. An individual cell can grow a certain amount, but not indefinitely. Once a cell gets to a certain size, it becomes difficult for all parts of the cell to obtain oxygen and nutrients by division. In order to grow any more, the cell divides to form two smaller cells, each of which can then grow and divide again.

Mitosis is also used in **asexual reproduction**. For example, sweet potato plant can reproduce by growing adventitious roots or runners which eventually produce new plants.



Process of mitosis

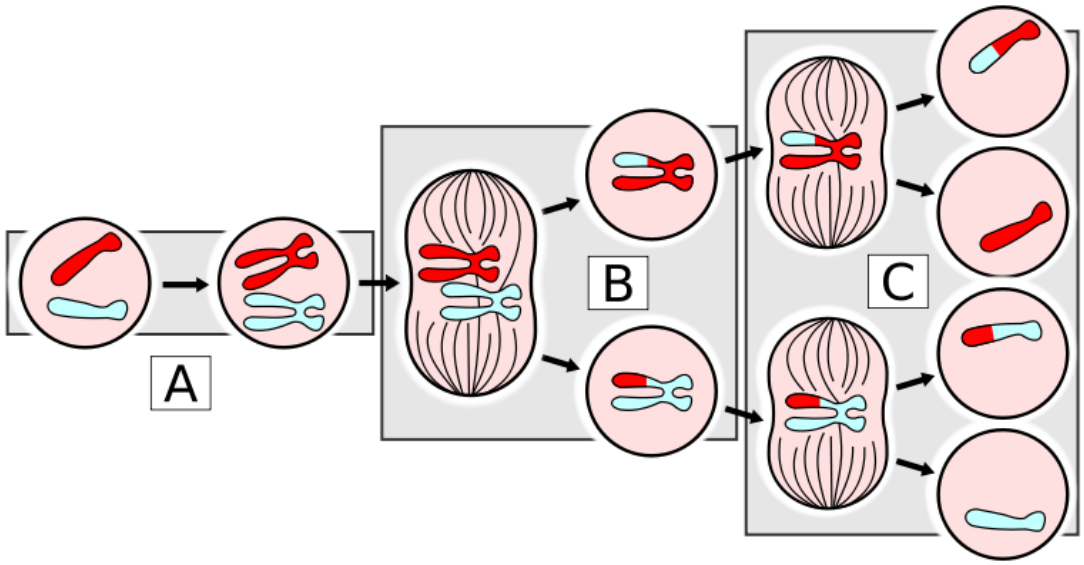
- During the process, all the **chromosomes** in the parent cell are **copied**.
- Each copy remains attached to the original one --> each chromosome is made up of 2 identical threads joined together.
- The parent cell (with 4 chromosomes) **split** to form 2 nuclei each with 2 chromosomes as the parent nucleus cell.
- At the end of a mitotic cell division, the number of cells is doubled and the **daughter cells** produced are genetically **identical** to the **parent.**



Meiosis

Meiosis is the way in which **gametes** (sex cells) are produced. Gametes have only **half** the number of chromosome of a normal body cell. They have 1 set of chromosome instead of 2. When they fuse together, the zygote formed has 2 sets.

- Human gametes are formed by the division of cells in the ovaries and testes
- The gametes produced are haploid, but they are formed from diploid cells, so meiosis involves **halving** the normal chromosome number - the pairs of chromosomes are separated.
- During meiosis, the new cells get a mixture of homologous chromosomes from father and mother --> A sperm cell could contain a chromosome 1 from father and a chromosome 2 from mother.
- There are all sorts of combinations --> gametes are **genetically different** form the parent cells. Meiosis produces genetic variation.
- When ova are formed in a woman, all the ova will carry an X chromosome. When sperm are formed in a man, half the sperm will carry an X chromosome, half will carry a Y chromosome.



Sample question

Complete the following passage, using only words form the list below.
diploid gametes haploid meiosis mitosis red blood cells

The transfer of inherited characteristics to new cells and new individuals depends on two types of cell division. During _____, the chromosomes are duplicated exactly and _____ cells are produced.

However, during _____, the chromosome sets are first duplicated and then halved, producing cells. These cells will become _____ . [4 marks]

Student's answer

During **meiotosis** û , the chromosomes are duplicated exactly and **identical** û cells are produced.

However, during **meiosis** ü, the chromosome sets are first duplicated and then halved, producing cells. These cells will become **gametes.** ü

Examiner's comments

The first answer is not clear – it mixes up the terms 'mitosis' and 'meiosis'. Sometimes candidates do this deliberately when they are not sure of the answer, hoping that the examiner will give them the benefit of the doubt. (We don't!). This candidate has not followed the rubric (instructions) in the question for the second answer: the term 'identical' does not appear in the word list. The correct answers are 'mitosis' and 'diploid'.

Try this

1) The nuclei of human liver cells contain 46 chromosomes. Complete the table below to show how many chromosomes would be present in the cells listed. [3 marks]

Type of cell	Number of chromosomes
Ciliated cell in windpipe	
Red blood cell	
Ovum	

2) Describe 2 differences, other than the number of chromosomes, between nuclei produced by mitosis and those produced by meiosis. [2 marks].

Answer:
1) Ciliated cell: 46
Red blood cell: 0 (this cell has no nucleus)
Ovum: 23

2) Two differences from:chromosomes in daughter mitotic cells will be identical to parental chromosomes (or there is no variation).

- genes in daughter mitotic cells will be identical to parental genes.
- chromosomes in daughter mitotic cells will be in homologous pairs, but they will be single in meiotic nuclei.

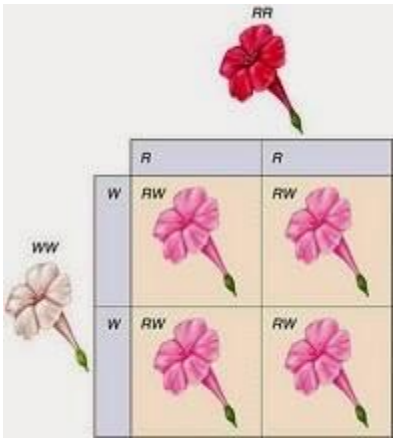
Video: Mitosis
https://www.youtube.com/watch?v=VlN7K1-9QB0

Video: Meiosis
https://www.youtube.com/watch?v=D1_-mQS_FZ0

Video: Difference between mitosis and meiosis
https://www.youtube.com/watch?v=Ba9LXKH2ztU

129 Monohybrid cross and the punnett square

A **monohybrid cross** involves the crossing of individuals and the examination of **one** (*mono*) **character** (flower colour, pod shape...) and **different** (*hybrid*) **traits** (red colour, white colour) in their offspring.

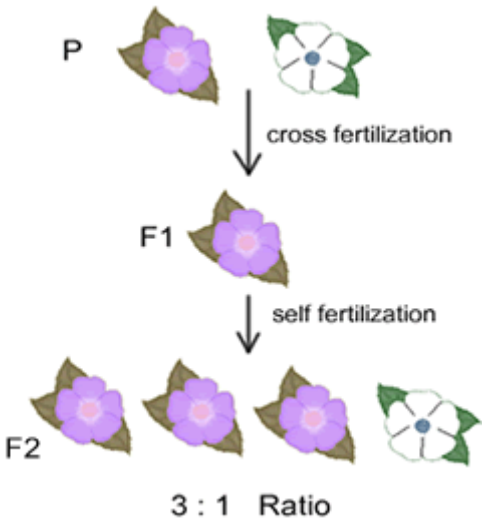


The **Punnett square** is a useful tool for predicting the genotypes and phenotypes of offspring in a genetic cross involving Mendelian traits.

Mendel crossed true-breeding plants that differed for a given character. Pollen from true-breeding pea plants with **purple** flowers (one trait) was placed on stigmas of true-breeding plants with **white** flowers (another trait).

The **F1** seeds were **all purple**; the white flower trait failed to appear at all. Because the purple flower trait completely masks the white flower trait when true-breeding plants are crossed, the purple flower trait is called **dominant**, and the white flower trait is called **recessive**.

The F1 plants were allowed to self-pollinate. This step was the monohybrid cross. (or the F1 cross). The progeny, called **F2**, were examined: roughly **1/4** were white, and **3/4** were purple.



All the genetic crosses shown below will involve examples using pea plants, which can be tall (T) of dwarf (t) – tall is dominant to dwarf.

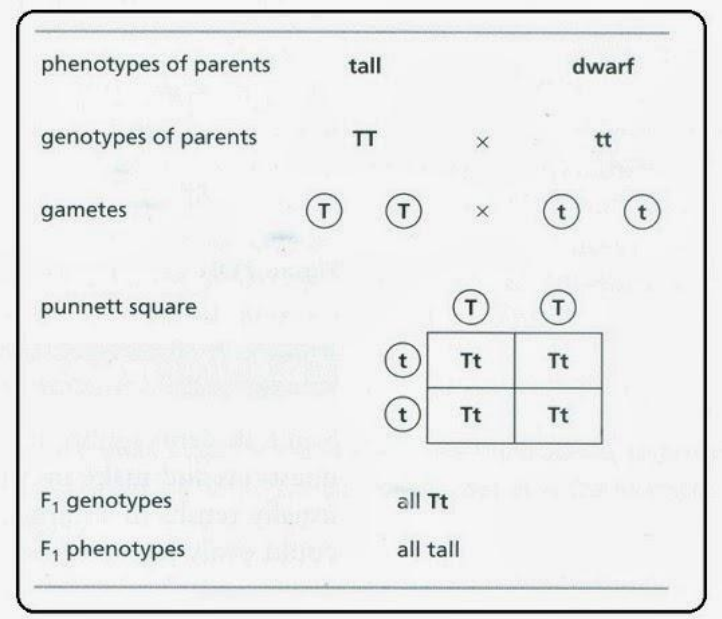
Examiner's tips

- *When you rite out a genetic cross, make sure you state what the symbols represents, e.g. T=tall, t=dwarf.*
- *Make sure you label each line in the cross (phenotype, genotype…).*
- *It's a good idea to circle gametes to show that meiosis has happened.*
- *Read the question really carefully – are you asked to state the outcome in terms of the genotype or the phenotype?*

Punnett square

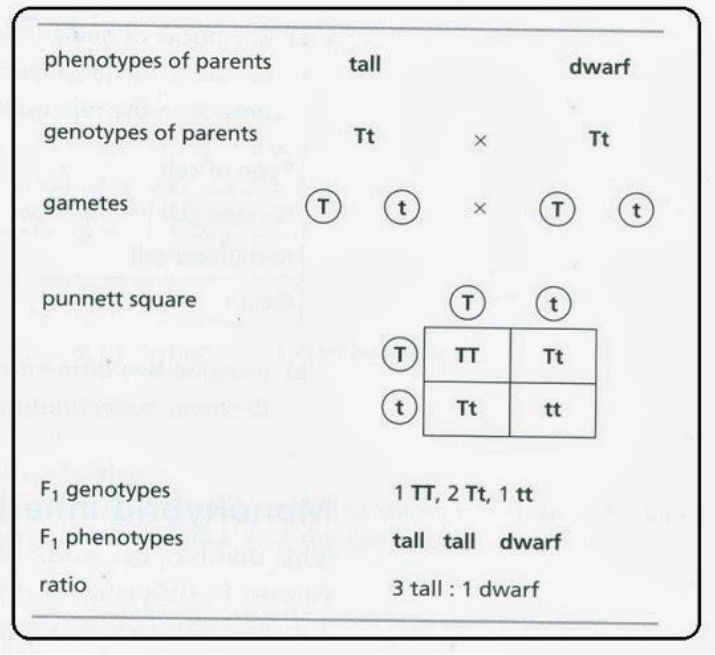
*1. A cross between a pure-breeding **tall** pea plant and a pure-breeding **dwarf** pea plant.*

As tall is dominant to dwarf, and both plants are pure-breeding, their genotypes must be **TT** and **tt**.



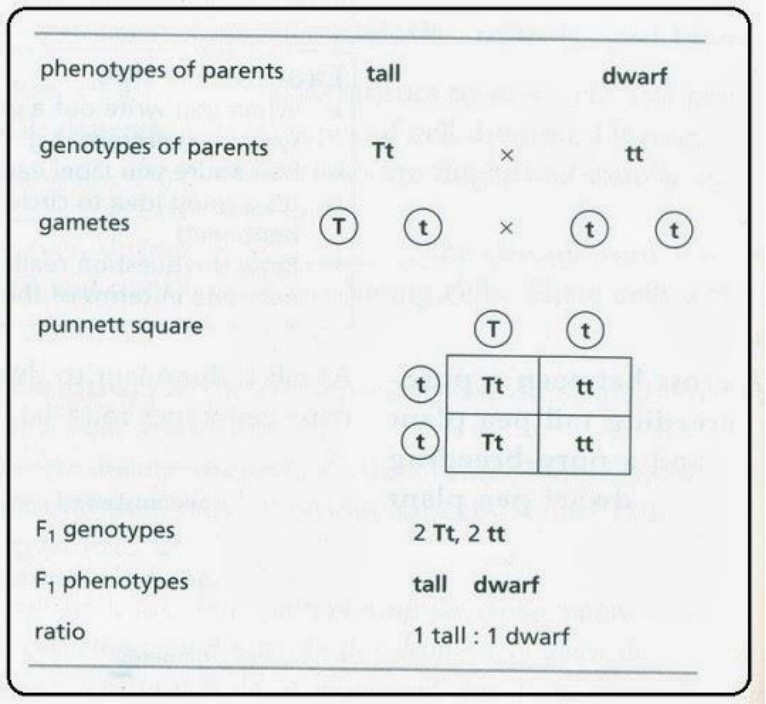
*2. A cross between two **heterozygous tall** pea plant.*

The genotype of both plants must be **Tt**.



*3. A cross between two **heterozygous tall** pea plant.*

The hetetozygous tall pea plants must be **Tt**.
The dwarf pea plants must be **tt**.



Common misconceptions

Some students ignore the letters for alleles given in genetic questions and make up their own, without stating a key. This usually results in a number of marks being lost through errors that could easily have been avoided.

Try this

1. In exam questions involving genetic crosses, you often need to predict the genotypes of the parents form descriptions of them. Work out the following genotypes, based on peas that can be round or wrinkled, with round being dominate to wrinkled. Remember that the dominant allele normally takes the capital letter or the characteristic is represents

a) A heterozygous round pea [1 mark]
b) A wrinkled pea [1 mark]
c) A pure-breeding round pea [1 mark]

Answer

a) Rr
b) rr
c) RR

2. Complete the passage by writing the most appropriate word from the list in each space.

chromosome diploid gene heterozygous meiosis mutation phenotype recessive dominant

Petal colour in pea plants is controlled by a single ___which has two forms, red and white. The pollen grains are produced by _____. After pollination, fertilization occurs and the gametes join to form a _____ zygote.

When two red-flowered pea plants were crossed with each other, some of the offspring were white-flowered. The _____ of the rest of the offspring was red-flowered. The white-flowered form is_____ to the red-flowered form and each of the parent plants was therefore_____. [6 marks]

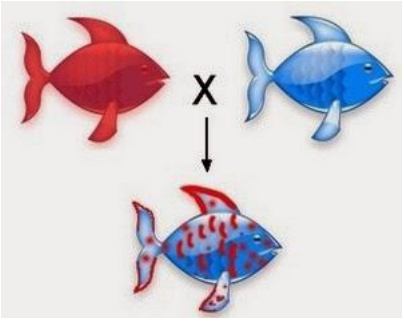
Answer

gene meiosis diploid phenotype recessive heterozygous

Video: Punnett squares

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

130 Codominance and inheritance of blood group



Sometimes, neither of a pair of **alleles** is completely dominant or completely recessive. Instead of one of them completely hiding the effect of the other in a heterozygote, they **both have an effect on the phenotype**. This is called **codominance.**

The result is that there can be three different phenotypes. When writing the genotypes of codominant alleles, the common convention is to use a capital letter to represent the gene involved, and a small raised letter for each phenotype.

Imagine a kind of flower which has two alleles for flower colour. The allele C^w produces white flowers, while the allele C^R produces red ones. If these alleles show codominance, then the genotypes and phenotypes are:

genotype	**phenotype**
$C^w C^w$	white flowers
$C^w C^R$	pink flowers
$C^R C^R$	red flowers

Common misconceptions

When factors are codominant, students often think this will result in different proportions of offspring having the parents' features. However, codominance results in the appearance of a new characteristic, which is intermediate to the parents features. For example, if the parents are pure-breeding for long fur and short fur, the offspring will all have medium-length fur.

Inheritance of A, B, AB and O blood group - an example of codominance

- In humans, there are 4 blood types (phenotypes): A, B, AB, and O
- Blood type is controlled by **3 alleles**: I^A, I^B, I^O (the base letter = I stands for immunoglobulin)
- I^O is **recessive**, two I^O alleles must be present for the person to have type O blood
- I^A and I^B are **codominant** but both are dominant to I^o. If a person receives an I^A allele and a I^B allele, their blood type is type AB, in which characteristics of both A and B antigens are expressed.

Because I^O is dominated by both I^A and I^B alleles, a person with blood group A could have the genotype $I^A I^O$ or $I^A I^A$. This has implication when having children because, if both parents carry the I^O allele, a child could be born with the genotype $I^O I^O$ (blood group O), even though neither of the parents have this phonotype.

Blood type	Genotype	
A	I^A, I^O I^A, I^A	AO AA
B	I^B, I^O I^B, I^B	BO BB
AB	I^A, I^B	AB
O	$I^O I^O$	OO

Video: Codominance and the inheritance of blood type

https://www.youtube.com/watch?v=nykVH9Z7Gw8

#131 Variation continuous and discontinous

Variation is all the **differences** which exist between members of the same species. It is caused by a combination f **genetic** and **environmental** factors.

There are two kinds of variation:
continuous and **discontinuous**.

Continuous variation

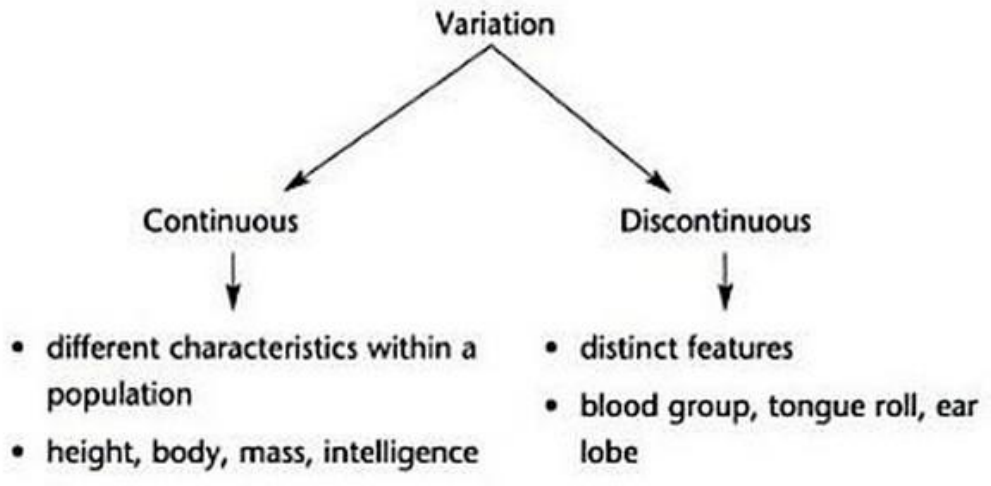
- shows a complete range of the characteristic within a population.

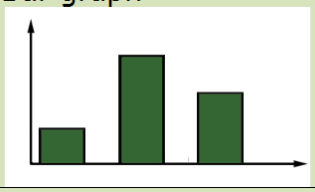
- caused both by both **gens** (often a number of different genes) and **environment**:

- Plants: availability of/competition for: nutrients, light, water; exposure to disease…
- Animals: availability of food/balanced diet; exposure to disease (or the availability of health serviced for humans).

Discontinuous variation

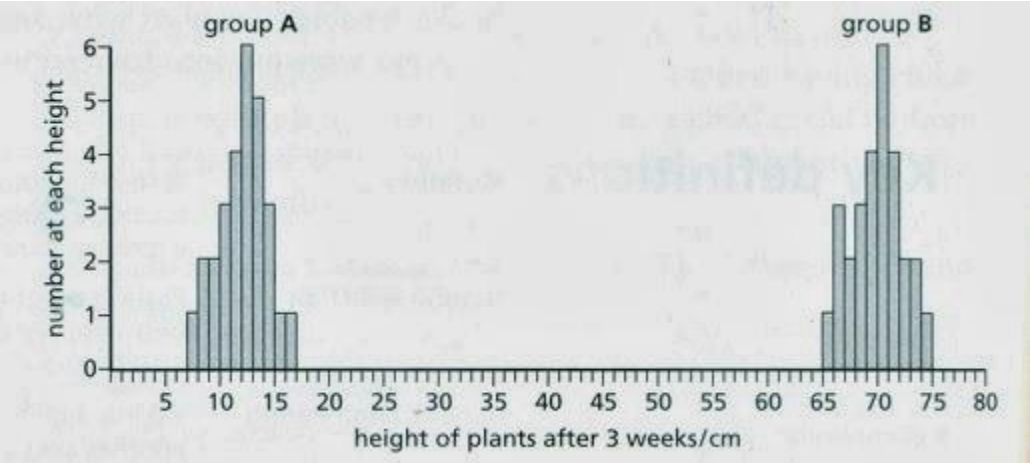
- seen where there are obvious, distinct categories for a feature.
- no intermediates between categories, the feature cannot usually change during life.
- caused by a single gen/a small number of **genes**, with **no environmental** influence.



	Continuous variation	Discontinuous variation
Properties	- No distinct categories - No limit on the value - Tends to be quantitative	- Distinct categories. - No in-between categories - Tends to be qualitative
Examples	• height • weight • heart rate • finger length • leaf length	• tongue rolling • finger prints • eye colour • blood groups
Representation	Line graph 	Bar graph 
Controlled by	A lot of Gene and environment → range of phenotypes between 2 extremes, e.g. height in humans.	A few genes → limited number of phenotypes with no intermediates e.g. A, B, AB and O blood groups in humans

Try this

Seventy seeds were collected from a cross between two plants of the same species. The seeds were sown at the same time and, after 3 weeks, the heights of the plants which grew were measured and found to fall in to two groups, A and B, as shown in figure below.



a) Calculate the percentage of seeds which germinated. Show your working. [2 marks]

b) i) Name the type of variation shown within each group [1 mark]

ii) State three factors which might have caused this variation. [3 marks]

Answer

a) 56/70x100=80%

b) i) continuous variation.

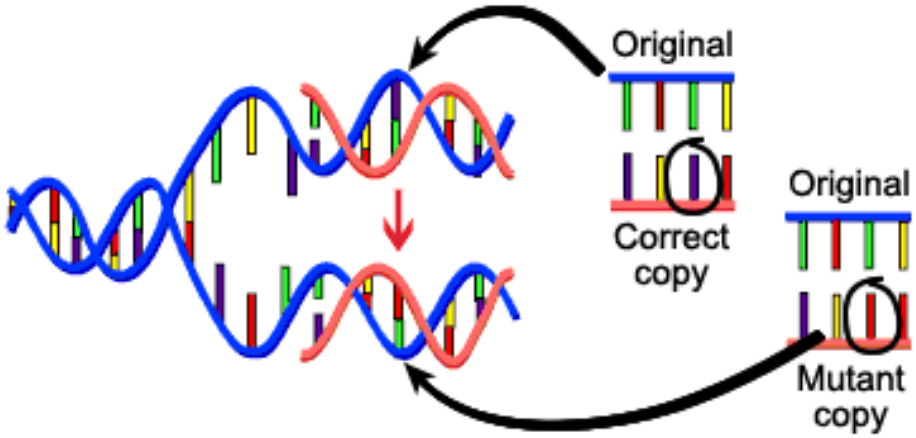
ii) Any 3 factors from: genes, temperature, disease, seed size, light, O_2, CO_2, H_2O, minerals, mutation, trampling by animals.

Video: What is meant by genetic difference?

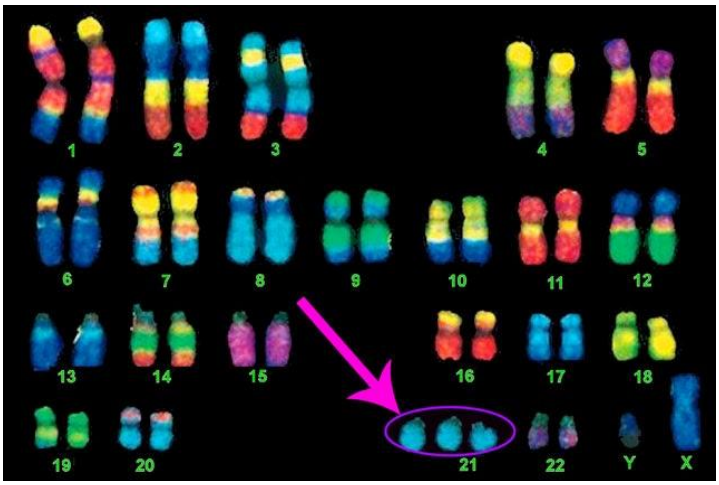
https://www.youtube.com/watch?v=a5yzRRvROpE

#132 Mutation, Down syndrome, effect of radiation

Mutation is a unpredictable **change** in the **genes** or **chromosome** number, as a result of fault copying when DNA is replicated, faulty separation of chromosomes during cell division, or exposure to radiation or some chemicals.



Down's syndrome is caused by a mutation. When ova are formed in the ovaries, the chromosome number is halve. During this division process (meiosis), one of the chromosome (number 23) sticks to its partner. This results in one ovum with 24 chromosomes and one with only 22, and the ovum with 24 chromosomes is still viable. If it is fertilized, the fetus formed will have 47 chromosomes instead of 46.



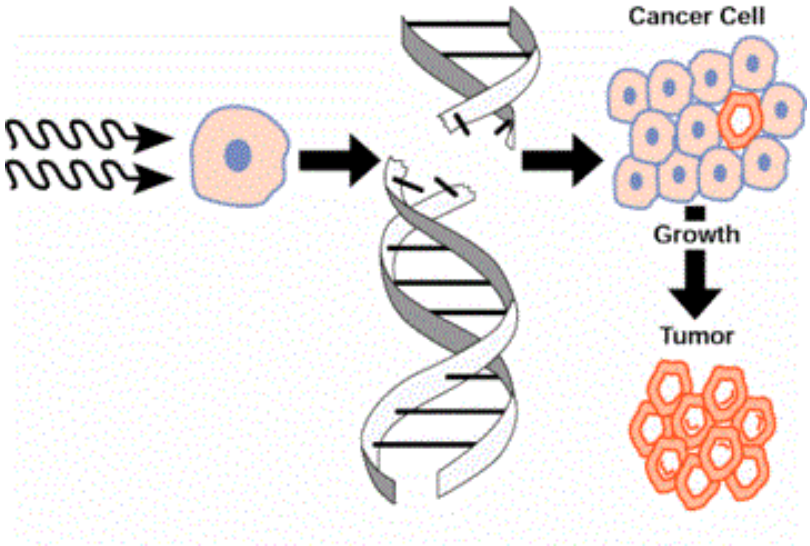
3 chromosome 21 in Down syndrome.

The presence of the extra chromosome causes unusual characteristics in the baby. These usually include lowered life expectancy, mental retardation (although some Down's children are very intelligent), early puberty, and a distinctive round face and short neck.

A child with Down syndrome.

Effects of ionising radiation and chemicals on the rate of mutation

- Mutation are normally very rare. However, exposure to radiation and some chemicals, such as tar in tobacco smoke, **increases** the **rate of mutation**.
- Exposure can cause uncontrolled cell division, leading to the formation of tumours (cancer).



The development of cancer from mutated cells.

- Exposure of gonads (testes and ovaries) to radiation can lead to sterility or to damage to genes in sex cells that can be passed on to children.
- Some scientists argue that there is a higher incidence of leukaemia (a form a white blood cells cancer) in the children of workers at nuclear power stations.

Video: DNA mutation, effect of radiation and chemicals on mutation

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

#133 Sickle cell anaemia and its incidence to that of malaria

Sickle cell anaemia is caused by a **mutation** in the blood pigment **haemoglobin**. When the faulty haemoglobin is present in a red blood cell, it causes the cell to deform and become **sickle-shaped**, especially when oxygen levels in the blood become low.

Normal and sickle red blood cells

In this state the sickled red blood cells are less efficient at transporting oxygen and more likely to become stuck in a capillary, preventing blood flow.

The faulty allele is dominated by the allele for normal haemoglobin, but still has some effect in a heterozygous genotype.

The possible genotypes are:

- H^NH^N normal haemoglobin, no anaemia
- H^NH^n some abnormal haemoglobin, sickle cells trait (not life-threatening)
- H^nH^n abnormal haemoglobin, sickle cells anaemia (life-threatening)

Malaria is a life-threatening disease caused by a parasite that invades red blood cells. The parasite is carried by some species of mosquito.

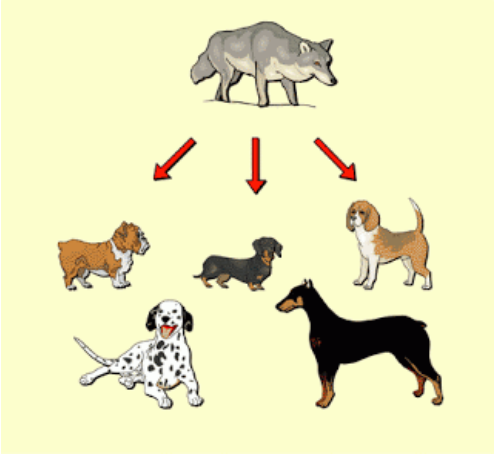
- A person who is heterozygous (H^NH^n) for sickle cell anaemia has **protection** from malaria, because the malaria parasite is unable to invade an reproduce in the sickle cells.
- A person who is homozygous for sickle cell anaemia (H^nH^n) also has **protection**, but is at high risk of dying form sickle cell anaemia.
- A person with normal haemoglobin (H^NH^N) in a malarial country is at **high risk** of contracting malaria.

When the distributions of malaria and sickle cell anaemia are shown on a map of the work, it is found that the two coincide in tropical areas because of the selective advantage of the H^n allele in providing protection against malaria.

Video: Sickle cell
disease https://www.youtube.com/watch?v=9AHFHleYwdU
Video: What is Sickle cell anaemia
https://www.youtube.com/watch?v=Qd0HrY2NlwY
Video: Evolution of sickle cell malaria
https://www.youtube.com/watch?v=1fN7rOwDyMQ

#134 Artificial and natural selection

Artificial selection is a method used by humans to produce varieties of animals and plants which have an increased economic importance. People use **selective breeding** to produce new varieties of a species, so that certain **desirable traits** are represented in successive generations.



A variety is a type of a particular species that is different in some clear way from other varieties of that species. The different breeds of domestic dogs and large ears of maize corn are products of artificial selection.

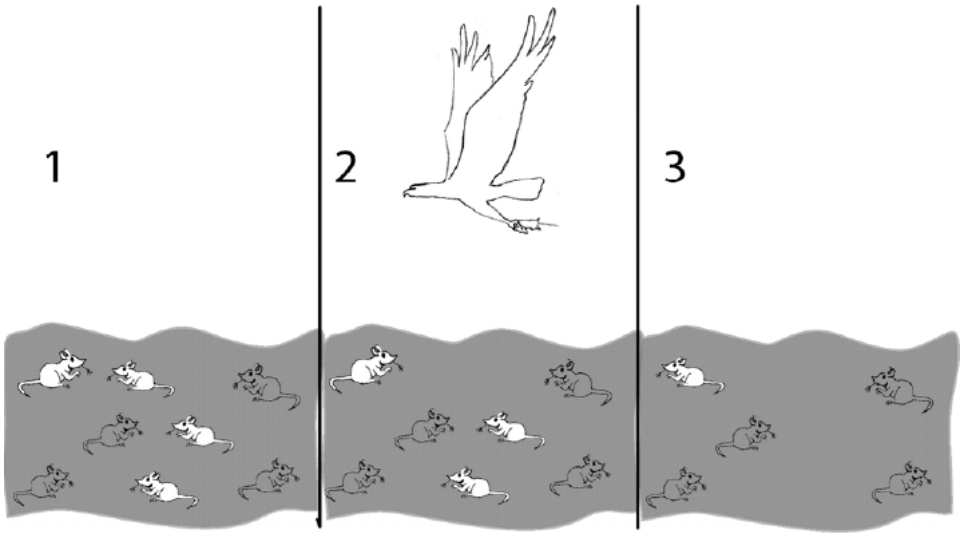
These common vegetables were cultivated from forms of wild mustard. This is evolution through artificial selection.

Selective breeding of cows

Suppose you wanted a variety of cow that produced a lot of milk. This is what you could do:

- choose or select the cows in your herd that produce the most milk
- let only these cows reproduce
- select the offspring that produce the most milk
- let only these offspring reproduce
- keep repeating the process of selection and breeding until you achieve your goal.

Natural selection is the process by which plants and animals that **can adapt** to changes in their environment are able to **survive** and reproduce while those that cannot adapt do not survive. It gives the greater chance of **passing** on of **genes** by the **best adapted organisms**.



Try this

Farmers have carried out artificial selection to improve the breeds of some animals. Some of the original breeds have become very rare and are in danger of becoming extinct.

a) Explain what is meant by artificial selection [2 marks]

b) i) Name one species which is in danger of extinction. [1 mark]
ii) Biologists are concerned that species of animals and plants should not become extinct. Why is it important to prevent the extinction of plant and animal species? [2 marks]

Answer

a) A method used by humans to produce varieties of animals and plants which have an increased economic importance.

b) i) Any endangered species, such as panda, tiger, elephant, named whales species, named tuna species.

ii) Two point from:

- to maintain the gene pool
- to provide chemicals that may be useful in development of medicines
- the species may be an important part of a food chain
- rare species may provide tourism to supply poor communities with money.

Additional source: **BBC Bitesize**

Video: What is Natural Selection?

https://www.youtube.com/watch?v=0SCjhI86grU&list=PLfHpBjIQ933u6AuVr6y78X5rd-AFr0aq8

SlideShow

http://learn.genetics.utah.edu/content/selection/artificial/

#135 Variation and antibiotic-resistance strains of bacteria

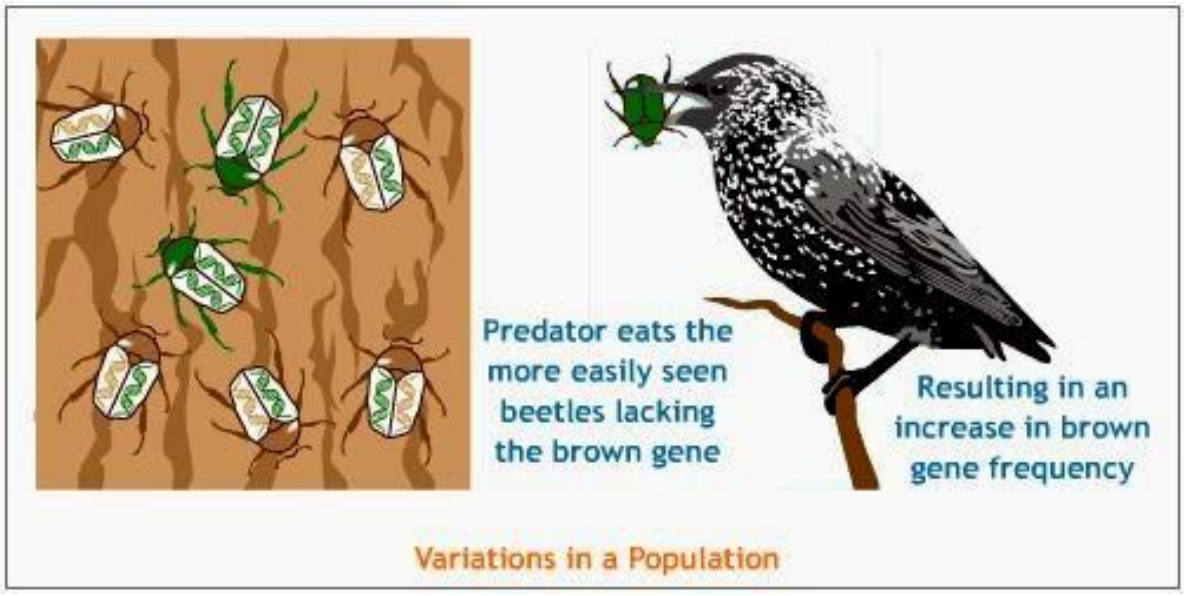
Variation is the slight individual **differences** within populations. All living things change and evolve from one generation to the next. As they do so, more variation is produced.

Some variations is **inherited** (passed on from parents) and some is **acquired** (developed during life).

Animals and plants produced by sexual reproduction will show variation from their parents, for example in the size of the muscles in the legs of lions.

When new organisms are produced, not all of them are likely to survive because of competition for resources such as food, water and shelter. The same is true for plants (they compete for resources such as nutrients, light, water and space).

The individuals with the most favourable characteristics are most likely to survive.



The process of natural selection follows a sequence, as listed below.

- Some of the variations within a population may give some individuals an advantage over others in the population. Bigger muscles in the legs of a lion would enable it to run more quickly and get food more successfully.
- In an environment where there is food shortage, the lion with the biggest leg muscles is most likely to survive to adulthood.

- The weaker individuals die before having the chance to breed, but the surviving adults breed and pass on the advantageous genes to their offspring.
- More of the next generation carry the advantageous genes, resulting in a stronger population, better adapted to a changing environment.

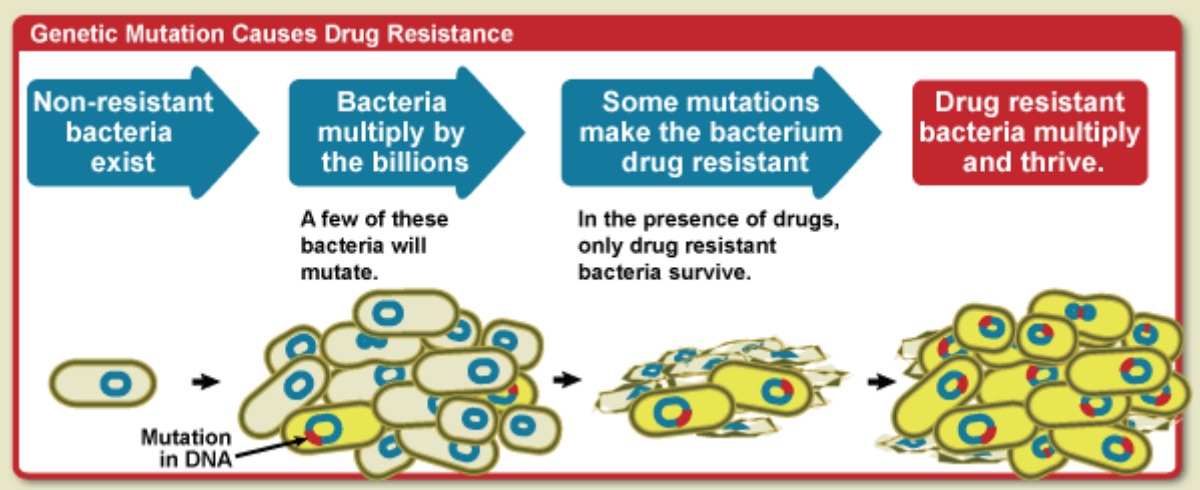
Slow changes in the environment results in adaptation in a population to cope with the change. Failure to adapt could result in the species becoming extinct. This gradual change in the species through natural selection over time, in response to changes in the environment, is a possible **mechanism for evolution.**

Examples: antibiotic-resistance strains of bacteria
Bacteria reproduced rapidly - a new generation can be produced every 20 minutes by binary fission. Antibiotics are used to treat bacterial infections: an antibiotic is a chemical that kills bacteria by preventing bacterial cell wall formation.

Mutations occur during reproduction, which produce some variation in the population of bacteria.

Individual bacteria with the most favourable features are most likely to survive and reproduce.

A mutation may occur that enables a bacterium to resist being killed by antibiotic treatment, while the rest of the populating is killed when treated. This bacterium would survive the treatment and breed, passing on the antibiotic - resistant gene to its offspring. Future treatment of this population of bacteria using the antibiotic would be ineffective.

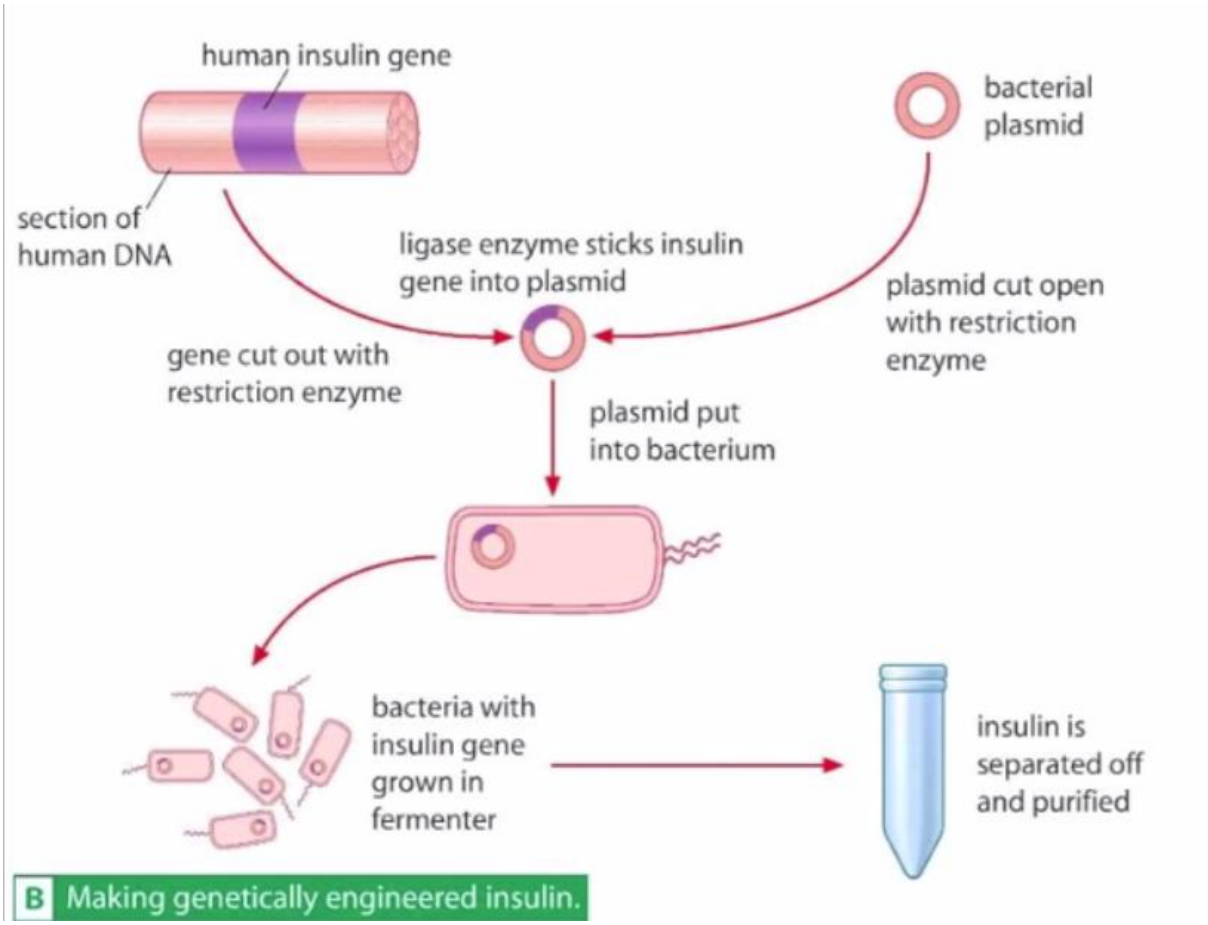


Video GCSE BBC Science Bitesize - Variation, Inheritance and Evolution: https://www.youtube.com/watch?v=1m_m18UaxUs

Video The Animation of Antimicrobial Resistance
https://www.youtube.com/watch?v=AYvX8tnCM9s

 # 136 Genetic engineering,
putting human insulin genes into bacteria

Genetic engineering is a process of **taking a gene** from one **species** and **putting** it into another species.



B Making genetically engineered insulin.

The control of all the normal activities of a bacterium depends upon its single **chromosome** and small rings of genes called **plasmids**. In genetic engineering pieces of chromosome from a different organism can be inserted into a plasmid. This allows the bacteria to make a new substance.

The ethics of genetic engineering

Benefits:

- cures for diseases, such as cystic fibrosis and cancer
- food which is healthier, stays fresh for longer periods and tastes better.

Risks:

- unknown effects of moving genes from one organism to the other
- new dangerous diseases being created
- against God and nature.

Using genetic engineering to put human insulin genes into bacteria

1. Human cells with genes for healthy insulin are selected.
2. A chromosome (a length of DNA) is removed from the cell.
3. The insulin gene is cut from the chromosome using restriction endonuclease enzyme.
4. A suitable bacterial cell is selected. Some of its DNA is in the form of circular plasmids.
5. All the plasmids are removed from the bacterial cell.
6. The plasmids are cut open using the same restriction endonuclease enzyme.
7. The human insulin gene is inserted into the plasmids using ligase enzyme.
8. The plasmid are returned to the bacterial cell (only one is shone in the diagram).
9. The bacterial cell is allowed to reproduce in a fermenter. All the cells produced contain plasmids with the human insulin gene.

The importance of this process

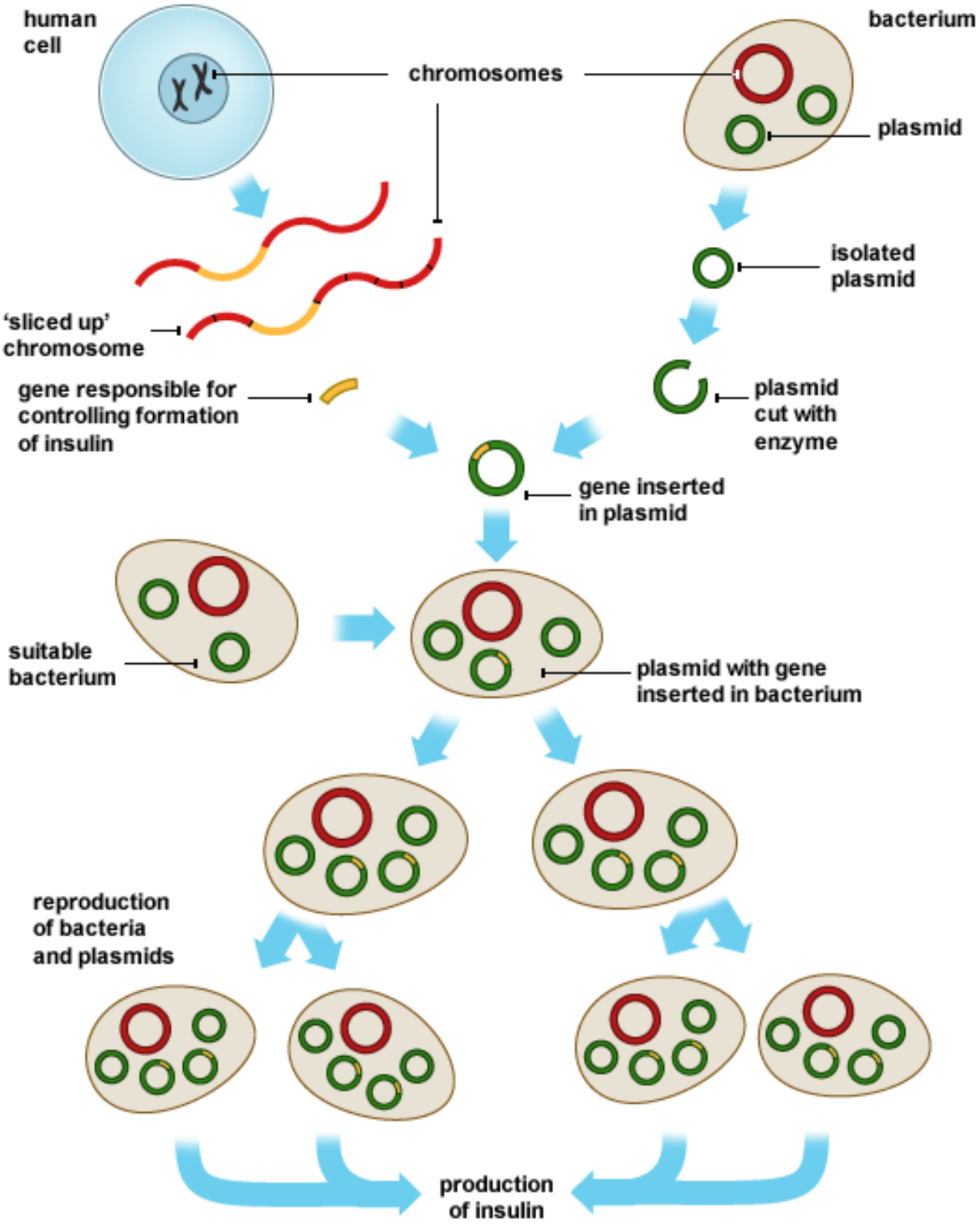
- Diabetics need a source of insulin to control their blood sugar level. In the past cow insulin has been used, but some people are allergic to it. Human insulin produced from genetically engineered bacteria will not trigger an allergic reaction.
- The insulin is acceptable to people with a range of religious belief who may not be allowed to use insulin form animals such as cows or pigs.
- The product is very pure.
- Human insulin can be made on a commercial scale, reducing costs.

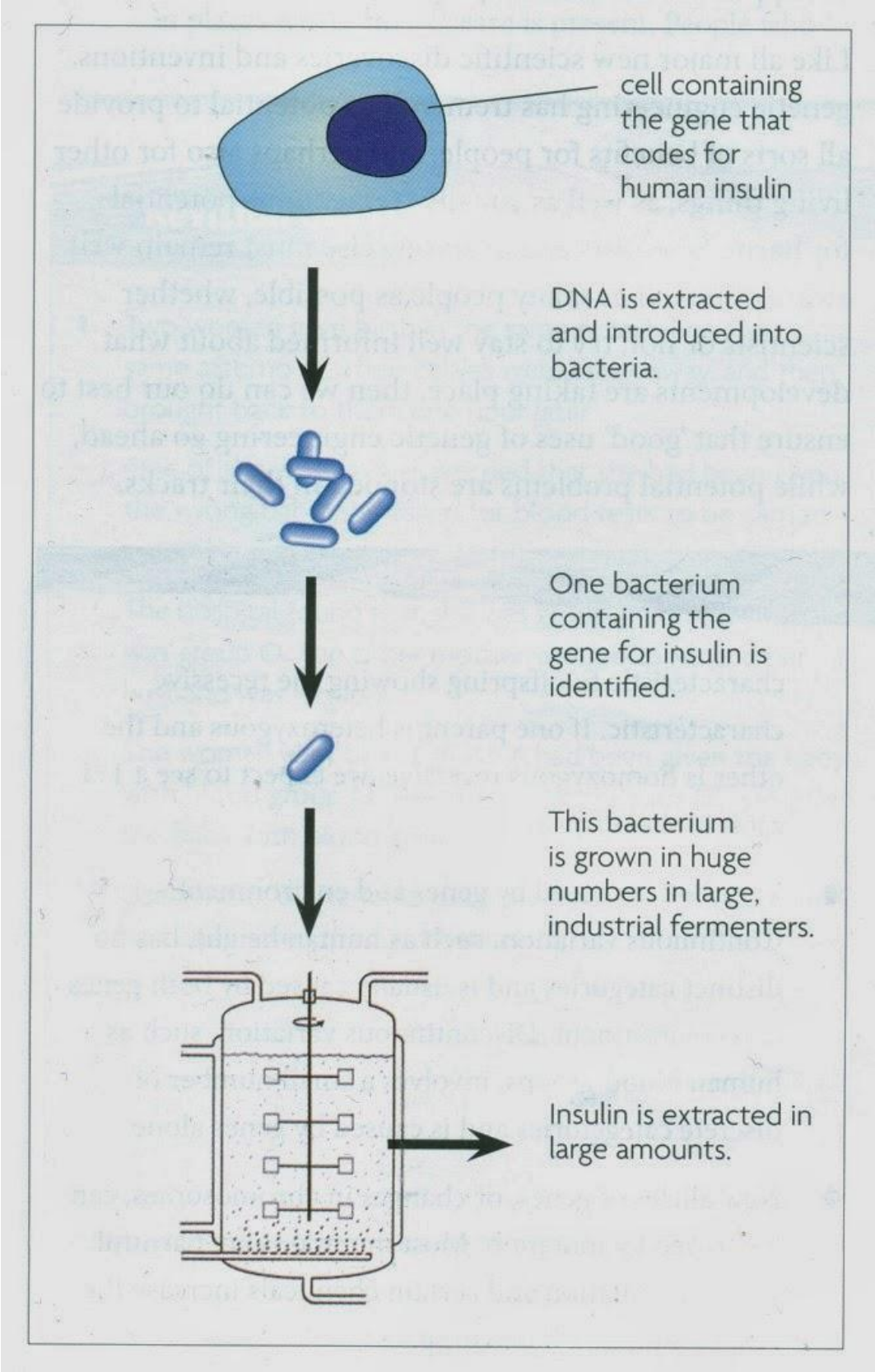
Video Genetic Engineering

https://www.youtube.com/watch?v=zlqD4UWCuws

Video Genetically Engineered Insulin

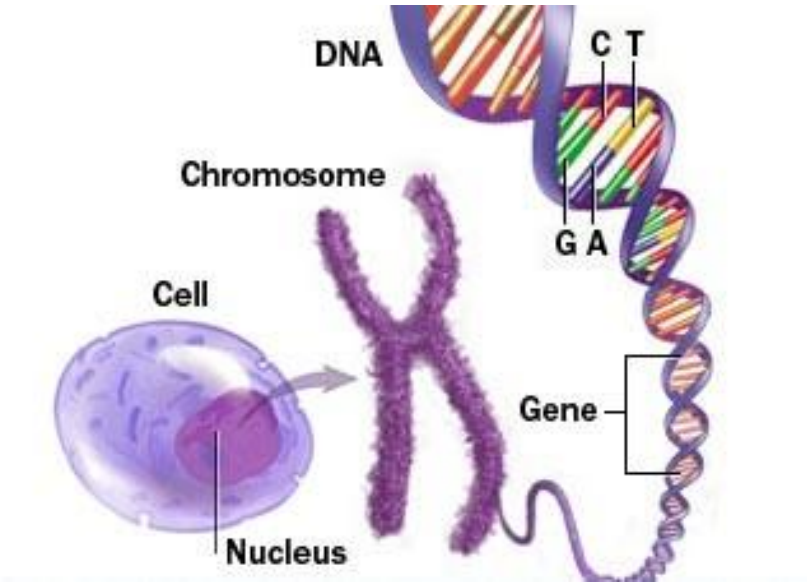
https://www.youtube.com/watch?v=MJ_6oXaLRj4


human cell
chromosomes
bacterium
plasmid
isolated plasmid
'sliced up' chromosome
gene responsible for controlling formation of insulin
plasmid cut with enzyme
gene inserted in plasmid
suitable bacterium
plasmid with gene inserted in bacterium
reproduction of bacteria and plasmids
production of insulin



Using genetic engineering to produce bacteria that make human insulin.

#137 Summary of inheritance



- **Chromosomes** are long thread of **DNA** made up of strings of **genes**. In a diploid cell, each of a pair of homologous chromosomes carries the same genes in the same position. A diploid cell therefore has 2 copies of each gene.

- **Gametes** have only one set of chromosomes , and so they have only one copy of each gene.

- Different forms of a particular gene are called **alleles**. They may be **dominant** of **recessive**. The genotype of an organism tells us the alleles of genes that it carries. If the 2 alleles of a gene are the same in the organism, then it is **homozygous**. If they are different, it is **heterozygous**.

- If **2 heterozygous** organisms breed together, we expect a **3:1 ratio** of offspring showing the dominant characteristic to offspring showing the recessive characteristic. If one parent is **heterozygous** and the other is **homozygous** recessive, we expect to see a **1:1 ratio** in the offspring.

- **Variations** is caused by genes and environment. **Continuous** variation, such as human height, has no distinct categories and is usually caused by both genes and environment. **Discontinuous** variation, such as human blood groups, involves a small number of discrete categories and is caused by genes alone.

- New alleles of genes, or changes in categories chromosomes, can be caused by **mutation**. Most mutations are harmful. Ionising radiation and certain chemicals increase the risk of mutation happening.

- In a population of organisms, those with the characteristics best adapted to the environment are most likely to survive and reproduce. This is called **natural selection**.

- It the environment changes, or if a new advantageous allele appears, natural selection can leas to change over many generations. This is called **evolution**.

- **Sickle cells anaemia** is caused by recessive allele of the gene for haemoglobin. People who are homozygous recessive often die before they can reproduce. People who are homozygous dominant have a greater chance of getting **malaria** if they live in places where this disease is present. People who are heterozygous have a selective advantage, because they are less likely to get malaria. Natural selection therefore maintains this allele in the population in parts of the world where people may be killed by malaria.

- Human select plants and animals with desirable characteristics and breed from them. Over many generations, this produces new strain of plants or animals with features that's we require. This is called **artificial selection**.

- **Genetic engineering** involves taking a **gene** from one species and inserting it into another. This has been done with the human insulin gene, to give bacteria that produce **insulin** for harvest an sale, for use by people with diabetes.