GENETICS

PART 1

TOPIC OVERVIEW

- What is Genetics?
- Importance of Genetics
- History of Genetics
- The Father of Genetics
- Mendelian Genetics
- Non-Mendelian Genetics
- Genetic Engineering

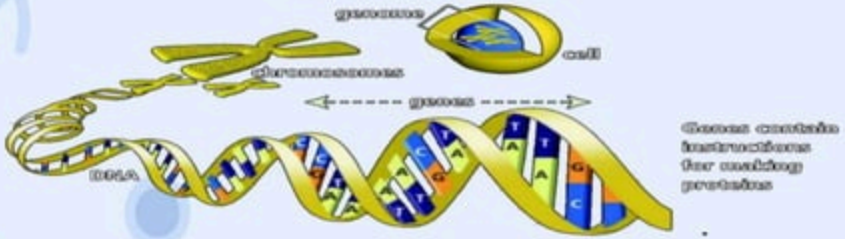
GENETICS

Genetics is the branch of biology concerned with the **study of inheritance**, including the interplay of genes, DNA variation and their interactions with environmental factors.

IMPORTANCE OF GENETICS

Understanding and studying genetics is important in learning about development, maintenance, and reproduction of organisms.

GENETICS EXPLAINS



What makes you unique, or one of a kind.

GENETICS

Why family members look alike

GENETICS

Why some diseases like diabetes or cancer run in families.

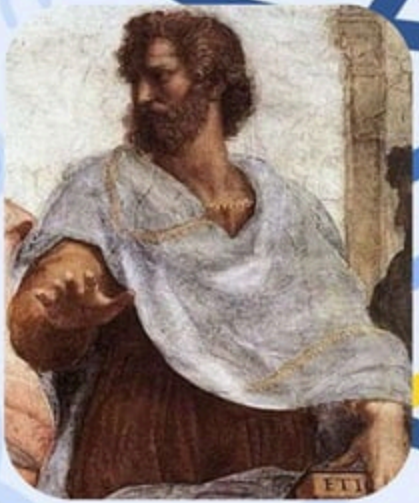
HISTORY OF GENETICS

16TH CENTURY

Before Mendel's experiment and ideas, Genetics was **poorly understood**. Some theories were made in attempt to explain the field but concluded to be inaccurate due to lack of foundation on their observations.

ARISTOTLE

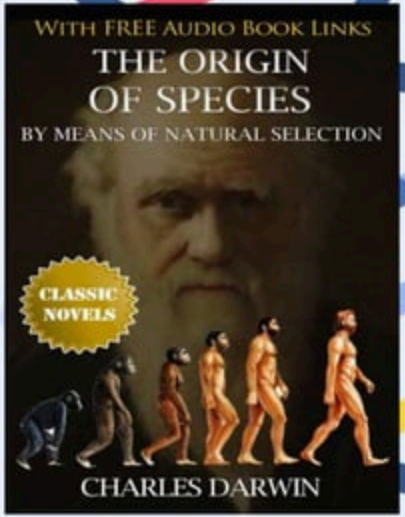
He believed that inheritance was conveyed via the **blood**. This is the reason why people still refer to "*blood relatives*" "*blood lines*" and offspring as products of their own "*flesh and blood*".



CHARLES DARWIN

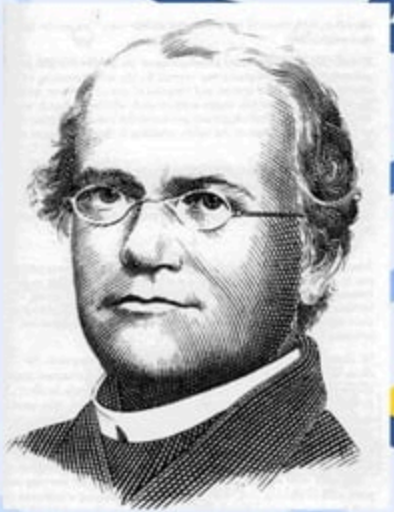
He developed the **theory of natural selection**—the idea that members of a population who are better adapted to their environment will be the ones most likely to survive and pass their traits on to the next generation.

On the Origin of Species by Means of Natural Selection (1859)



GREGOR MENDEL

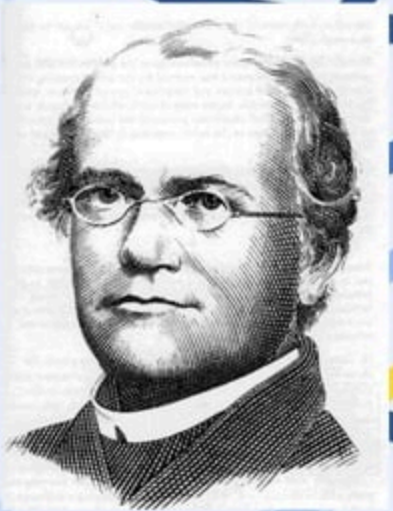
Developed the understanding genetics by experimenting garden peas (*Pisum sativum*).



MENDELIAN GENETICS

GREGOR MENDEL

- ***Father of Modern Genetics***
- Austrian biologist and meteorologist
  - He illustrated the basic patterns of inheritance of characters from parent to offspring wherein he showed that "**factors of inheritance**" are transferred from parents to offspring.



MENDEL'S EXPERIMENT

In between 1856 and 1863, Mendel conducted carefully designed experiments with nearly 30,000 pea plants (*Pisum sativum*) he cultivated in the monastery garden.

WHY PEAS?

The success of Mendel's experiments to explain the basic pattern of inheritance may be attributes to his good choice of experimental organism (*Pisum sativum*) because they are easy to grow, easy to artificially hybridize (self-pollinating plants, has a short life cycle, with a large number of offspring in a single cross, and the presence of contrasting traits (alleles), and his use of pure breeds (homozygous pure lines).

WHY PEAS?

Seed form	Seed color	Pod form	Pod color	Flower color	Flower position	Stem length
 Round	 Yellow	 Inflated	 Green	 Purple	 Axial	 Tall
 Wrinkled	 Green	 Constricted	 Yellow	 White	 Terminal	 Short

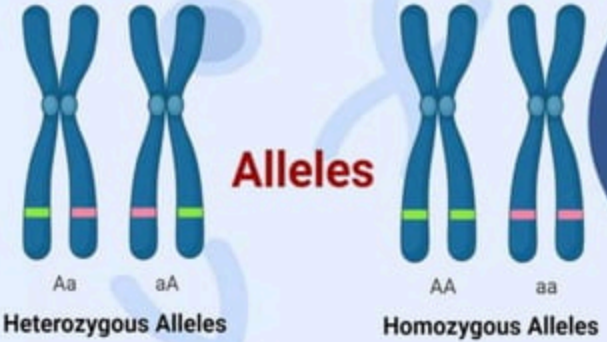
MENDEL'S IDEAS

- According to Mendel, genetic material of organisms exist in pairs (**alleles**) and segregate during gamete formation.
- The genetic materials (**genotype**) of organisms are responsible for observable characteristics (**phenotype**) as result of fertilization.

GENETIC LANGUAGE

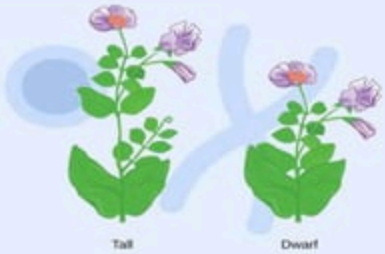
ALLELES

One of two or more versions of a genetic sequence at a particular region on a chromosome (*genes*). An individual inherits two alleles for each gene, one from each parent.



GENETIC TERMS

TT



GENOTYPE

The genotype is the set of genes in our DNA which is responsible for a particular trait.

PHENOTYPE

The phenotype is the physical expression, or characteristics, of that trait.

EXAMPLES

PP/pp

GENOTYPE

PP and pp are alleles of the pea plant flower color.

PHENOTYPE

PP is for purple flowers, pp is for white flowers.

GENETIC TERMS

TT/tt

HOMOZYGOUS

An organism that has the **same two copies of a gene** is considered homozygous for that trait.

Tt

HETEROZYGOUS

An organism that has **different copies of a gene** for a particular trait is considered heterozygous for that trait.

GENETIC TERMS

TT/Tt

DOMINANT

The allele that is expressed and overrules the recessive gene. Denoted by using capital letters.

tt

RECESSIVE

Recessive traits are expressed only if both the connected alleles are recessive. Denoted by using lower case letter.

EXAMPLES

DOMINANT TRAITS

- ✓ Dark hair
- ✓ Curly hair
- ✓ Baldness
- ✓ Widow's peak
- ✓ Freckles
- ✓ Right handedness

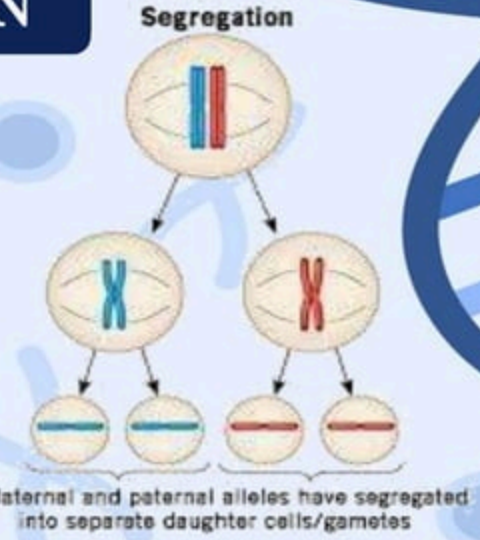
RECESSIVE TRAITS

- ✓ Blonde or red hair
- ✓ Straight hair
- ✓ Straight hairline
- ✓ Round eyes
- ✓ Left handedness
- ✓ Blue eyes

MENDEL'S LAW OF INHERITANCE

LAW OF SEGREGATION

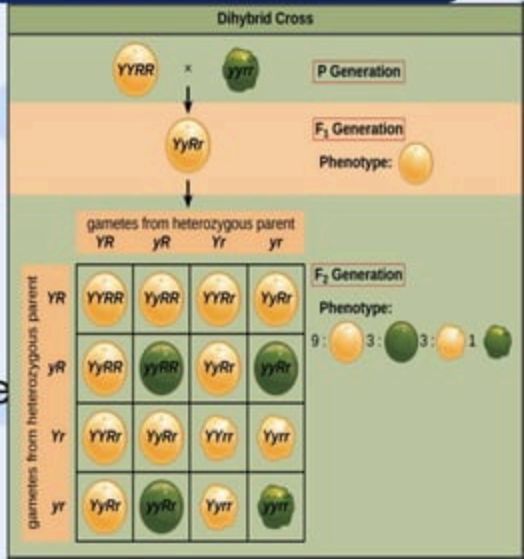
- States that each pair of alleles segregates, or separates, during **meiosis**.
- During formation of gametes, the paired unit factors segregate randomly to ensure that each parent's offspring attains one factor.



LAW OF SEGREGATION

LAW OF INDEPENDENT ASSORTMENT

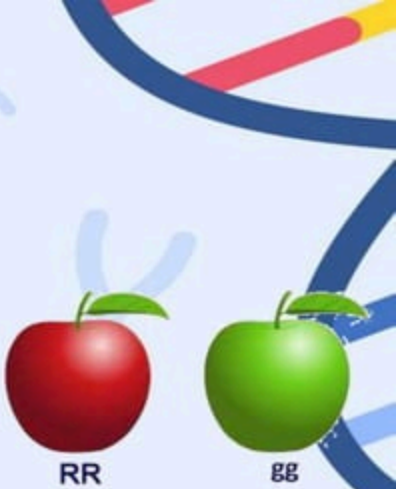
- The alleles of two (or more) different genes get sorted into gametes **independently** of one another.
- The allele a gamete receives for one gene **does not influence** the allele received for another gene.



LAW OF DOMINANCE

- *"When parents with pure, contrasting traits are crossed together, only one form of trait appears in the next generation. The hybrid offsprings will exhibit only the dominant trait in the phenotype."*

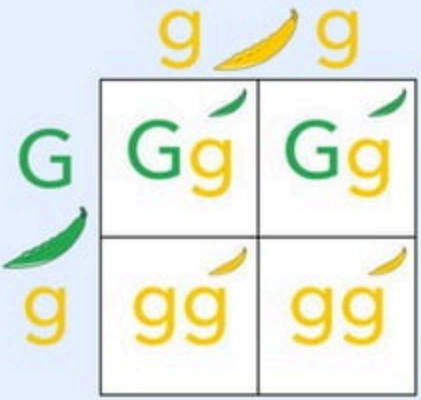
- An allele that always controls a trait is called **dominant** allele. An allele that is hidden when paired with a dominant allele is called a **recessive** allele.



LAW OF DOMINANCE

	Seed shape	Seed colour	Pod Shape	Pod colour	Flower colour	Stem Height	Flower position
Dominant Trait							
	Round	Yellow	inflated	Green	Purple	Tall	Axial
Recessive trait							
	Wrinkled	Green	Constricted	Yellow	White	Short	Terminal

PUNNETT SQUARE



The Punnett square is a tabular **summary of possible combinations** of maternal alleles with paternal alleles. These tables can be used to examine the **genotypical** outcome probabilities of the offspring of a single trait (allele), or when crossing multiple traits from the parents.

MONOHYBRID VS DIHYBRID CROSS

MONOHYBRID

A monohybrid cross is defined as the cross happening in the F1 generation offspring of parents differing in **one trait only.**

DIHYBRID CROSS

A dihybrid cross is a cross happens F1 generation offspring of differing in **two traits.** A dihybrid cross is a breeding experiment between two organisms which are identical hybrids for two traits.

MONOHYBRID CROSS

True Breeding Yellow Pod

	g	g
G	Gg	Gg
G	Gg	Gg

True Breeding Green Pod

Cross of F_1 Generation

round, yellow 

round, yellow 

	RY	Ry	rY	ry
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

DIHYBRID CROSS

DIHYBRID CROSSES

SEED SHAPE	SEED COLOR
R = round	Y = yellow
r = wrinkled	y = green

RRYY x rryy

FOIL

First Out Inside Last

D = Dominant traits (R & Y)
R = recessive traits (r & y)

1	:	0	:	0	:	0
D - D		D - R		R - D		R - R

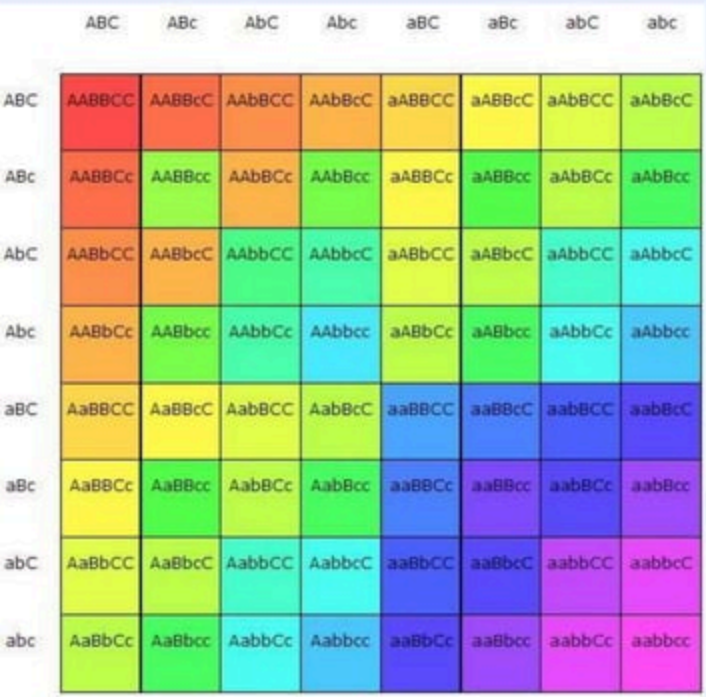
RRYY	rryy
RY	ry
RY	ry
RY	ry
RY	ry

GET RID OF REPETITIONS!

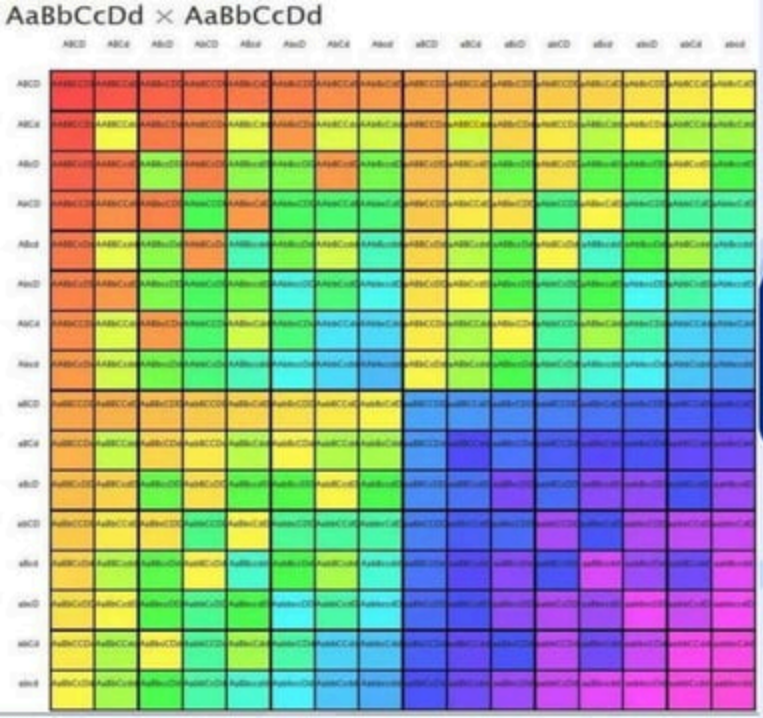
RY

ry

RrYy
round with yellow seeds



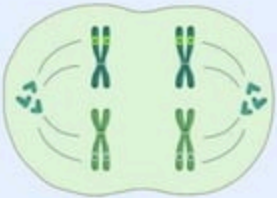
TETRAHYBRI DCROSS



TETRAHYBRIDCROSS

MENDEL'S LAWS

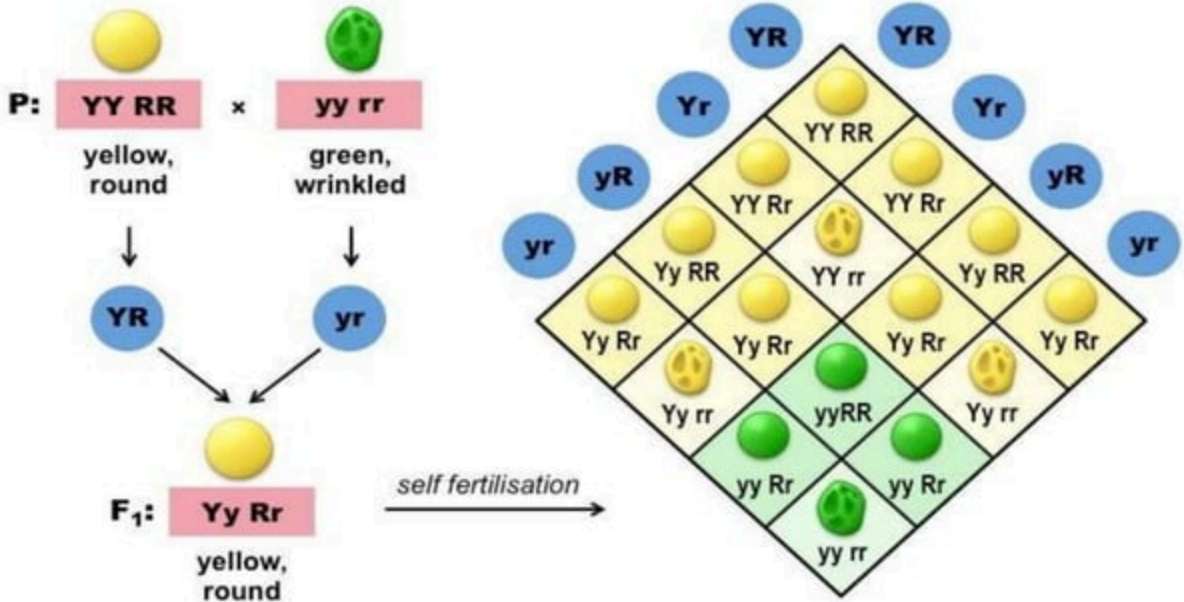
LAW OF INDEPENDENT ASSORTMENT



LAW OF SEGREGATION

TT/Tt

LAW OF DOMINANCE


P:
YY RR
yellow, round
×
yy rr
green, wrinkled
YR
yr
F1:
Yy Rr
yellow, round
self fertilisation
YR
YR
Yr
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yR
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Yy Rr
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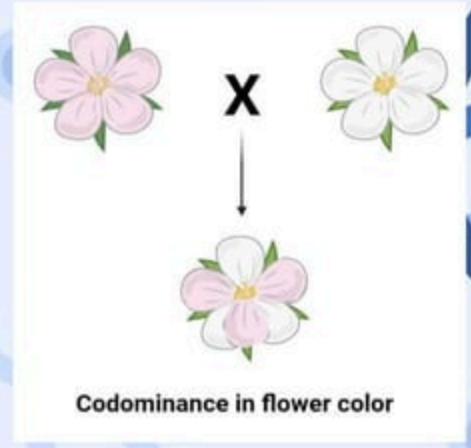
Yy rr
yyRR
Yy rr
yy Rr
yy Rr
yy rr

NON-MENDELIAN PATTERNS OF INHERITANCE

CODOMINANCE

- Two dominant alleles are present and **combined**.
- As a result, traits associated with each allele are displayed simultaneously.
- Heterozygotes exhibit the mixture of the phenotypic characters of both homozygotes instead of a single intermediate expression.

Ex. People with AB blood type



Codominance in flower color

INCOMPLETE DOMINANCE

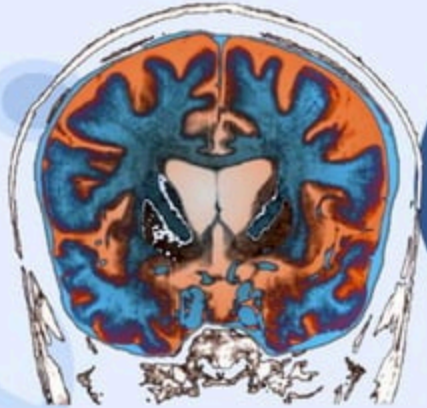
- aka *Partial Dominance*
- In incomplete dominance, a **mixture** of the alleles in the genotype is seen in the phenotype.

Ex. Pink flowers of 4'o clock plant

LETHAL GENES

Lethals or lethal genes or lethal alleles are **alleles causing the end of an entity which carries it**. Basically, lethal genes are lethal to the organism carrying it, lethal meaning (here) death.

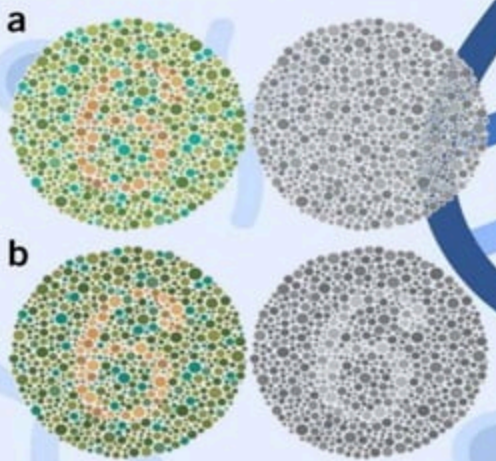
Ex. Huntington's disease



SEX LINKED INHERITANCE

Sex-linked inheritance is a biological process which involves the transmission of traits or characters from parents to the offspring through sex chromosomes.

Ex. *X-linked*: hemophilia, red-green color blindness, and congenital night blindness, *Y-linked*: Hypertrichosis



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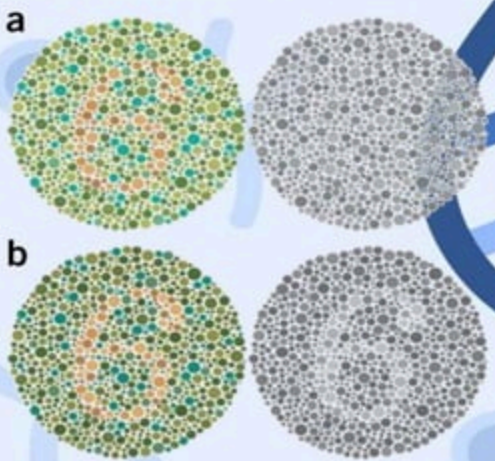


MULTIPLE ALLELES

An excellent example of multiple allele inheritance is human blood type. Blood type exists as four possible phenotypes: A, B, AB, & O. There are 3 alleles for the gene that determines blood type.

Blood Type	Genotype	
A	$I^A I$ $I^A I^A$	AA AO
B	$I^B I$ $I^B I^B$	BB BO
AB	$I^A I^B$	AB
O	ii	OO

POLYGENIC TRAITS

- Traits that are controlled by two or more genes.
- ***Polygenes***: Genes involved in polygenic inheritance.
- Ex. skin color, height, IQ, and eye color

GENETIC ENGINEERING

GENETIC ENGINEERING TERMINOLOGIES

- **Genetically Modified Organism (GMO)** – an organism that is a product of genetic engineering.
- **Transgenic** – Any organism that has the genetic material from some other organism.
- **Vector** – vehicle for transferring the recombinant DNA (altered genetic material) into the organism of interest. Ex. Plasmid and Viruses
- **Plasmid** – a circular DNA usually found in bacteria and yeast, commonly used for genetic engineering.

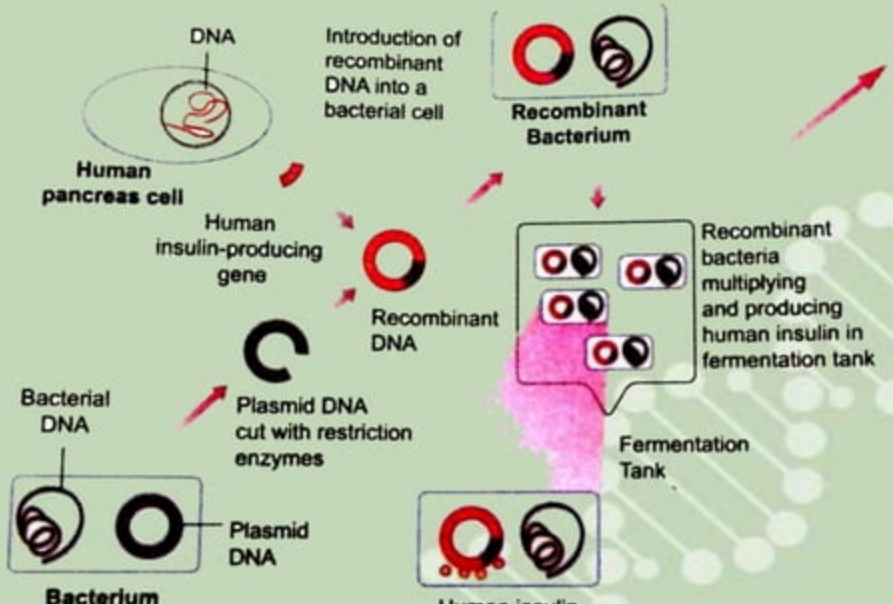
GENETIC ENGINEERING

- Genetic engineering, sometimes called **genetic modification**, is the process of **altering** the DNA in an organism's genome using biotechnology tools or techniques.

- *In some cases, genetic engineering means extracting DNA from another organism's genome and combining it with the DNA of that individual.*

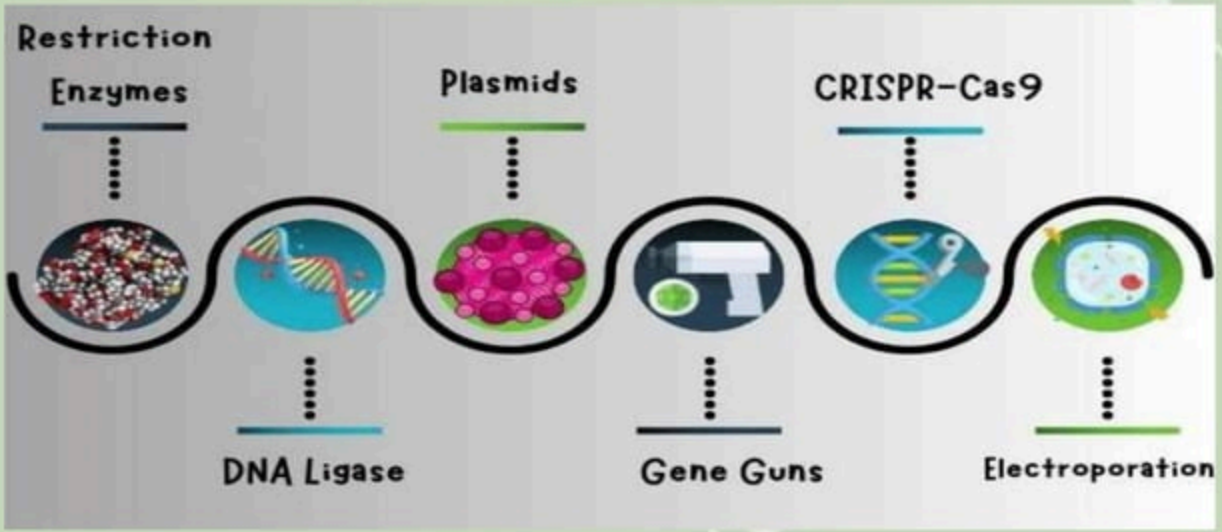
INSULIN PRODUCTION

- Synthetic insulin used for treatment for patients with Type 1 diabetes were produced via genetic engineering.
- Human gene that encodes for insulin production were inserted to a bacterial ***plasmid*** (circular DNA) using enzymes to form the **recombinant DNA**.



Human Insulin Production

GENETIC ENGINEERING TOOLS

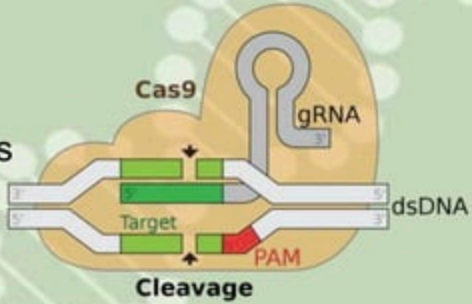


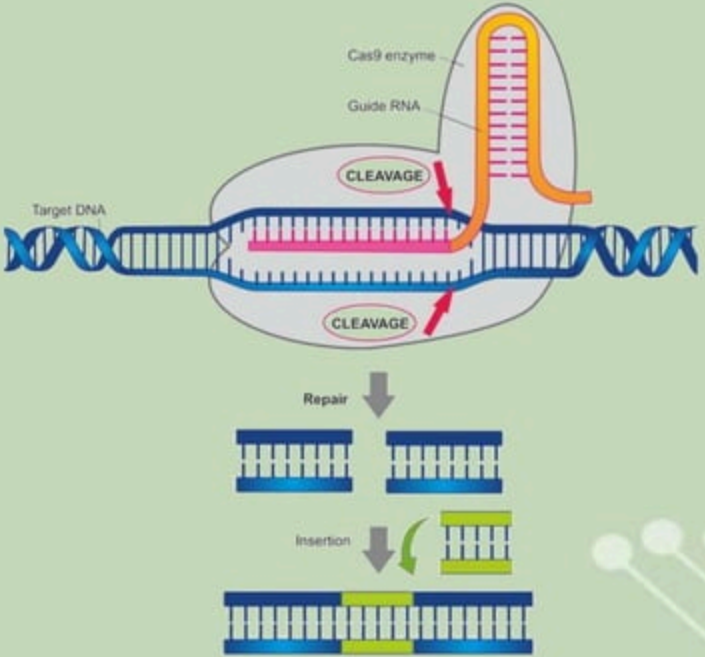
CRISPR-CAS9 TECHNOLOGY

- ***"Clustered Regularly Interspaced Short Palindromic Repeats"***

- **"CRISPR-Cas9"** is a gene-editing technology that **targets specific** stretches of genetic code and edit DNA at precise locations.

- **Cas9** is guided with specific guide RNA to cut at points around specific target where new gene can be inserted.





CRISPR-CAS9 TECHNOLOGY

GENETIC ENGINEERING APPLICATIONS

MEDICINE

AGRICULTURE

RESEARCH

GENETICALLY MODIFIED ORGANISMS

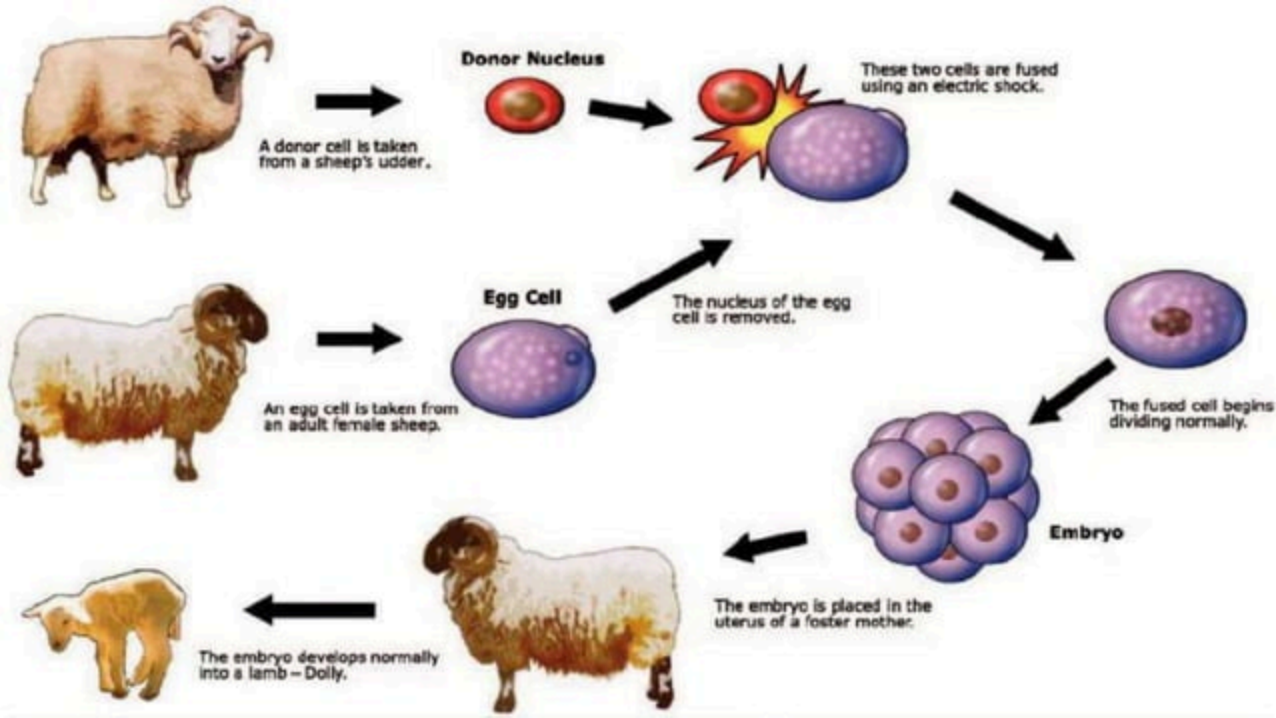
- **Golden Rice** is a new type of rice that contains beta ***carotene*** (provitamin A, a plant pigment that the body converts into vitamin A as needed).
- This compound is what gives this grain its yellow-orange or golden color, hence its name.

GOLDEN RICE

GENETICALLY MODIFIED ORGANISMS

- **Dolly the sheep** is the first **cloned** sheep using nuclear transfer, by transferring the nucleus from an adult mammary gland cell into an unfertilized premature egg.
- Dolly is named after the country singer, *Dolly Parton*.
- Dolly the sheep died at the age of 6.

DOLLY THE SHEEP


Donor Nucleus
A donor cell is taken from a sheep's udder.
These two cells are fused using an electric shock.
Egg Cell
The nucleus of the egg cell is removed.
An egg cell is taken from an adult female sheep.
The fused cell begins dividing normally.
Embryo
The embryo is placed in the uterus of a foster mother.
The embryo develops normally into a lamb – Dolly.