I. Genes and Chromosomes

Chromosomes	Are long chains of genes that are contained in the nucleus of the cell. They are made of DNA (Deoxyribonucleic Acid).
Genes	A segment of DNA that controls a hereditary trait.
Traits	The characteristics that an organism has.

Two alleles must be present for a trait to show up in the offspring. One must come from the mother and the other from the father. When fertilization occurs, the new offspring will have two alleles for every trait.

II. The Contributions of Mendel

Gregor Mendel	Known as the "Father of Genetics". He discovered the 3 Laws of Genetics that would forever change biology. He conducted a series of experiments in a quiet monastery garden. Mendel spent 14 years growing and experimenting with the pea plants grown in his garden.
Laws of Genetics	Law of Dominance and Recessive, the Law of Segregation, and the Law of Independent Assortment.
Parts of the Flower	Pistil and Stamen
Stamen	The male part of the flower. It produces pollen/sperm.
Pistil	The female part of the flower. It produces eggs.
Fertilization	Happens when pollen is driven to the pistil, and sperm travels to the egg. It produces a tiny embryo which is enclosed in an egg.

Mendel's great contribution was to demonstrate that inherited characteristics are carried by genes.

Mendel chose pea plants because they were readily available, easy to grow, grow rapidly, and because the sexual structure of the flower is completely enclosed within the petals so that there would be no accidental cross-pollination between plants.

Mendel's Use of Pea Plants for Genetic Experiments

Pea plants are normally self-pollinating. Since the male and female reproductive structures are relatively enclosed inside the flower, the sperm will fertilize the egg of the same flower. The resulting embryos will have the same characteristics as the parent plant. Even though sexual reproduction happens, there is only one parent. Mendel knew that these pea plants we "true-breeding". This means that if they are allowed to self-pollinate, they would produce "true-breeding" offspring.
For example: if allowed to self-pollinate, tall plants would always produce tall plants. Plants with yellow seeds would always produce offspring with yellow seeds. These true-breeding plants were the cornerstone of Mendel's experiments.
Mendel wanted to produce seeds by joining the egg and sperm from two different plants. To do this, he had to prevent the possibility of self-pollination. Mendel cut away the stamens and then dusted the remaining pistils with pollen from a different plant. This is known as cross-pollination and produces offspring from two different parents.

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III. Mendel's Experiments

Terms to know	P Generation, F1 Generation, F2 Generation, and Hybrids.
P Generation	Parental Generation.
F1 Generation	First Generation.
F2 Generation	Second Generation.
Hybrids	Offspring with different traits.
Mendel crossed true-breeding tall plants with true-b-reeding dwarf plants	Tall x Dwarf = Tall
1.	F1 Hybrids are all tall
2.	All of the offspring had the appearance of only one of the parents.
3.	The trait of the other parent seemed to disappear. Mendel though the dwarf trait is lost
Mendel's Two Conclusions	Biological inheritance is determined by "factors" that are passed from one generation to the next. Today, we know these factors to be genes. Each of the traits that Mendel observed in the pea plants was controlled by one gene that occurred in two contrasting forms. For example: the height of pea plants occurs in a tall form and a dwarf form. The different forms are called alleles.
Mendel realised that some alleles are dominant over the other alleles.	Law of Dominance and Recessiveness
Dominant Allele	If a dominant allele is present in an offspring, the dominant trait will show.
Recessive Allele	This trait will only show up if the dominant allele is not present.

F = Filial

Filial = denoting the generation or generations after the parental generation.

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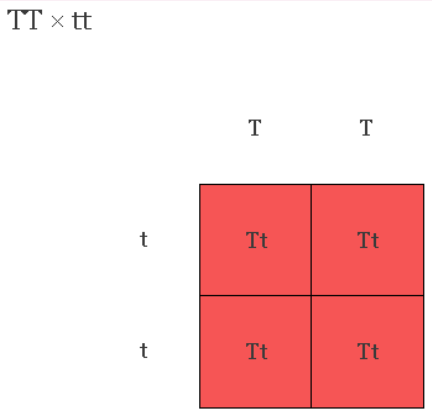
IV. Law of Segregation

Mendel had another question: Had the dwarf trait disappeared, or was it still present in the F1 offspring?
Mendel allowed the hybrid tall F1 generation to self-pollinate. F1 Tall x F1 Tall = $^{3/4}$ Tall and $^{1/4}$ Dwarf. The F1 "tall" offspring must have been carrying the dwarf trait but it had been hidden. The dwarf trait had been passed down to the offspring and it reappeared in the F2 generation.
Why did the recessive allele seem to disappear in the F1 generation and then reappear in the F2 generation?
Mendel realised that organisms have two alleles for every trait. These two alleles are inherited, one from each parent. If the offspring receives a dominant allele from one parent, that dominant trait will appear in the offspring. Recessive traits only show up in the offspring if it receive recessive alleles from each parent.
If a parent has two alleles for a trait, how does the parent pass only one allele to the offspring? Meiosis.
Gametes are the reproductive cells of an animal or plant. During meiosis, the DNA is replicated and separated into 4 gametes. This way, a parent passes one allele for each gene to their offspring (will include diagram).
Mendel's Law of Segregation says that every individual carries 2 alleles for each trait. These two alleles segregate during the formation of the egg or sperm.
An offspring will inherit two alleles for a trait, one from each parent. The combination of alleles received by the offspring may be either homozygous or heterozygous.
Homozygous means that two of the same alleles are present, either dominant or recessive. Heterozygous means that both alleles are present, dominant and recessive.
Genotypes and Phenotypes. Genotypes are the genetic makeup. Phenotypes are the physical characteristics.
For example: *T* is dominant and *t* is recessive. In Mendel's pea plants, the tall allele was dominant over the dwarf allele.
TT = Tall
Tt = Tall
tt = Dwarf

V. Punnett Squares

A Punnett Square is a diagram showing the allele combinations that might result from a genetic cross between two parents.
Practice Problem (will show diagrams):
Mendel began his experiments using true-breeding parents. He soon discovered that the tall trait was dominant over the dwarf trait.
The genotype of the tall is *TT* and the genotype of the dwarf is *tt*. It does not matter which letters are used, as long as it's the same letters.
Place the alleles of the first parent and the top of the square and the alleles of the second parent on the left of the square. Fill in the square with all the possible combinations of the alleles that the offspring might inherit.

Punnett Square Example



All offspring are tall because the dominant allele is present in all of them.

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VI. Law of Independent Assortment

Mendel designed a second set of experiments to follow different genes as they passed from parent to offspring. This is known as two-factor cross or dihybrid cross.

One parent had peas that were round and yellow and the other had peas that were wrinkled and green. Round and yellow were dominant.

Round, yellow (*RRYY*) x Wrinkled, green (*rryy*) = Round, yellow (*RrYy*)

F1 generation was allowed to self-pollinate (*RrYy* x *RrYy*), it resulted in 556 seeds.

315 round, yellow (*RRYY, RRYy, RrYy, RrYY*).

105 round, green (*RRyy, Rryy*)

104 wrinkled, yellow (*rrYY, rrYy*)

32 wrinkled, green (*rryy*)

This meant that the alleles for seed shape had segregated independently of the alleles for seed colour. The alleles of one gene had no effect on the alleles of another trait. This is known as indepented assortment.

Law of Independent Assortment states that when gametes are formed, the alleles of a gene for one trait segregate independently from the alleles of a gene for another trait.

VII. Punnett Squares for Dihybrid Crosses.

RRYY × rryy

	RY	RY	RY	RY
ry	RrYy	RrYy	RrYy	RrYy
ry	RrYy	RrYy	RrYy	RrYy
ry	RrYy	RrYy	RrYy	RrYy
ry	RrYy	RrYy	RrYy	RrYy

When two traits are being considered, the Punnett square will need 16 squares. Each parent will pass one allele of each gene pair to the offspring.

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VIII. Summary of the Laws

Inheritance of traits is determined by individual units known as genes. Each gene has two or more forms called alleles. Some alleles are dominant, others are recessive.
Each parent has two alleles for a particular trait that they inherited. They will pass one allele to their offspring when the alleles segregate into gametes.
Alleles for one trait segregate independently of the alleles for another trait.
Not all genes show a pattern of simple dominance. For some genes, there are more than two alleles. Many times, traits are controlled by more than one gene.

IX. Genes and the Environment

Gene expression is always the result of the interaction of genes and the environment. The presence of a gene is not all that is required for the expression of a trait. The gene product must be present along with proper environmental conditions. The phenotype of any organism is the result of interaction between its genotype and the environment.

Examples: Primrose plants that are red-flowered at room temperature are white when raised at hotter temperatures. Himalayan rabbits are white ate high temperatures and brown at low temperatures.

X. Incomplete Dominance

Some genes appear to blend together. For example: in some flowers, a homozygous red flower crossed with a homozygous white flower yields a heterozygous pink flower. This is incomplete dominance or nondominance.

Incomplete Dominance Example

RR × RW

	R	R
R	RR	RR
W	RW	RW

XI. Codominance

Humans have four blood types: A, B, AB, and O.
Three alleles determine blood type: I^A, I^B, i. *Alleles* I^A *and* I^B *are codominant and* i* is recessive. Codominance is when both alleles are apparent in the phenotype of the heterozygous alleles.
$I^A I^A$ = A
I^A i* = A
$I^A I^B$ = AB
$I^B i$ = B
$I^B I^B$ = B
$i i$ = O

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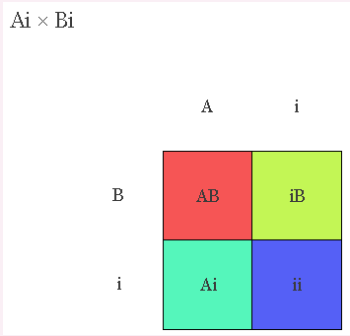
Codominance Example



B is supposed to be in front of *i* but I use an online generator so it is messed up.

XII. Multiple Alleles

Many genes have two or more alleles and are said to have multiple alleles. The best example is rabbit coats. Coat colour in rabbits are determined by a single gene that has at least four different alleles. The four alleles demonstrate a dominance hierarchy in which some alleles are dominant over others.

The alleles are ordered in hierarchy. C (full colour), c^{ch} (light grey, c^{h} (albino with black), c (albino).

Full colour: CC, Cc^{ch}, Cc^{h}, Cc

Chinchilla: c^{chc}, c^{ch}, $c^{ch}c^{ch}$, $c^{ch}c$

Himalayan: $c^{h}c^{h}$, $c^{h}c$

Albino: cc

XIII. Polygenic Inheritance

In polygenic inheritance, the determination of a given characteristic is the result of the interaction of multiple genes. Some traits, such as size, height, shape, weight, colour, metabolism, and behaviour are determined by many pairs of genes.

A trait affected by a number of genes does not show a clear difference between groups of individuals. Instead, it shows a graduation of small differences.

XIV. Chromosomes

Human calls contain 23 pairs of chromosomes. There are 22 pairs of autosomes, and one pair of sex chromosomes. All pairs of chromosomes are the same except one pair. The pairs are called autosomes. Autosomes are all of the chromosomes within a cell except for sex chromosomes.

Females have 2 copies of the X chromosome. Males have one X and one Y chromosome.

There are many genes found on the X chromosome. The Y chromosome appears to contain only a few genes. Since the X and Y chromosomes determine the sex of an individual, all genes found on these chromosomes are sex-linked. Sex-linked traits include colour blindness, haemophilia, and muscular dystrophy. These are caused by recessive alleles.

Since males only have one X chromosome, they will have the disorder if they inherit just one copy of the allele. Females must inherit two copies of the allele in order for the trait to show up.

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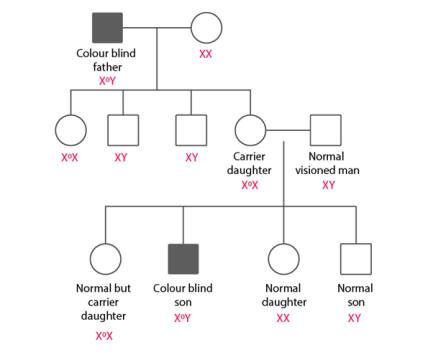
XV. Pedigree Charts



A pedigree chart shows relationships within a family. Squares represent males and circles represent females. A shaded circle or square indicates that a person has a trait.

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