HISTORY OF **BIOLOGY**

- and **GENETICS** from very earliest to the latest concepts

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The History of Earliest Concepts of Biology

In the prehistoric era Humans observed heritable traits in plants and animals through selective breeding, laying the foundation for the concept of genetics.

The first man to came up with a structural way of classification of biological (living) things is **Aristotle** . He divided living things on the basis of their morphological characters.
He decided **plants into trees, shrubs and herbs**. He also divided animals into two groups, **those which had red blood and those that did not**.

He was a student of Plato, going on to found his own school of philosophy, whose principles were widely spread by his most famous student, Alexander the Great. His knowledge and philosophies were carried by word of mouth and the writing of other people.

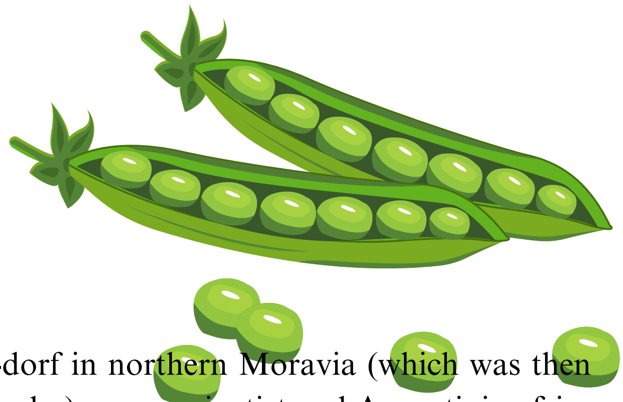
Hippocrates earlier postulated "**pangenesis**," a hypothesis similar to Charles Darwin's, that each component of the body creates "gemmules" that are collected in germ cells and passed on to children. Aristotle disagreed and noted that people occasionally resemble distant relatives more than their parents. He also discovered that offspring can inherit hair colour and gait, but not mutilations or body part loss.

Aristotle identified actual and mythical animals and hypothesised that some, like the giraffe, were hybrids. Later authorities ignored Aristotle's restrictions and created unsupported hybrids.

Aristotle and others observed that the Smyrna fig and date palm had male and female trees. Nehemiah Grew in 1676 and Camerarius in the late 17th century invented plant sexual reproduction.

Kölreuter made many crosses and researched pollination in the mid-18th century to examine plant hybrids. **Darwin** tested plant hybrids and gathered data from breeders and hybridizers. He noticed hybrids as intermediate between their parents and recognised continuous and discontinuous changes. "Pangenesis," Darwin's theory of heredity, was not widely recognised but impacted later views by Weismann and de Vries, which led to the recognition of Gregor Mendel's work.

*In the late Middle Ages , though publicly demonstrated dissection have been done, the Renaissance (1300s-1500s) represents a rebirth of old knowledge.



Mendel

Gregor Johann Mendel, born in 1822 in the village of Heinzen-dorf in northern Moravia (which was then part of Austria and is now in Czechoslovakia near the Polish border), was a scientist and Augustinian friar known for his groundbreaking work in the field of genetics. He came from a peasant background and had to overcome various obstacles to pursue his education.

Mendel joined the Augustinian monastery in Brünn (now Brno) in 1843 and became a priest in 1847. He initially faced difficulties in his academic pursuits and failed an examination for a teaching certificate in natural science in 1850. To improve his knowledge and qualifications, Mendel attended the University of Vienna between 1851 and 1853, where he studied various subjects including physics, chemistry, mathematics, zoology, entomology, botany, and paleontology. During his time in Vienna, he was exposed to influential scientists and researchers who likely influenced his later work.
Upon his return to Brünn, Mendel conducted a series of experiments on pea plants, which ultimately led to his groundbreaking discoveries in heredity. He studied the transmission of traits from one generation to another and formulated the laws of inheritance that came to be known as Mendelian genetics. Mendel presented his findings in a paper titled **"Experiments on Plant Hybridization"** which he read to the Brünn Society for Natural History in 1865 and was published in 1866.

Despite the significance of his work, Mendel's discoveries initially went unnoticed by the scientific community. His paper was met with little attention, and it was only later, in the early 20th century, that his work was rediscovered and recognized as a foundation for the field of genetics. Mendel's experiments and principles laid the groundwork for our understanding of genetic inheritance and formed the basis for modern genetics.

Apart from his work in genetics, Mendel had other interests as well. ***He was involved in beekeeping and attempted to crossbreed different strains of bees.*** He also had an interest in meteorology and made extensive meteorological and horticultural observations throughout his life.
Mendel's scientific work gradually came to an end after he was elected abbot of the Brünn monastery in 1868. Administrative duties and a controversy with the government over taxation of monastery property occupied much of his time. Mendel's scientific contributions largely went unrecognized during his lifetime, and he passed away on January 6, 1884.

Overall, Mendel's contributions to the field of genetics and his pioneering experiments with pea plants have had a profound and lasting impact on our understanding of heredity and the principles of inheritance.

1866 TO 1900

The period between the publication of Mendel's paper and its recognition in 1900 was marked by the development of the theory of evolution and its implications.

During this time, several advances helped make Mendel's results more acceptable, including the **germ-plasm theory**, the challenge to the inheritance of acquired characters, increased knowledge of cytological details of fertilization and cell division, and the emphasis on the importance of discontinuous variation.
August Weismann, a prominent figure of the time, proposed the germ-plasm theory, which emphasized the effects of germinal material on the body. **He conducted experiments that challenged the inheritance of acquired characters and provided evidence against it**.

The observation of the role of the nucleus in fertilization and cell division, particularly through the work of **O. Hertwig and Fol**, solidified the importance of the nucleus in heredity.

A period of rapid development in the understanding of chromosome behavior in mitosis and meiosis occurred from about 1882 to 1885. Researchers such as **Flemming, Strasburger, and van Beneden** made key observations about the **behavior of chromosomes during cell division**.

Weismann and Roux proposed theories of heredity and development based on the role of chromosomes. Weismann's theory emphasized competition between chromosomes, while Roux emphasized the equal distribution of chromosomal material to daughter cells.
Hugo de Vries developed a theory of heredity called Intracellular Pangenesis, which introduced the idea of "pangens" as units responsible for individual characteristics. De Vries' theory aligned with the principles of Mendelian inheritance.

Dissatisfaction with the view that natural selection was the sole explanation for evolution led to an increased interest in "sports" or sharply separable variations. This interest was expressed by scientists like Bateson, who emphasized the importance of discontinuous variations.

Francis Galton made significant contributions to the quantitative study of heredity, including the development of correlation analysis and the concept of ancestral inheritance. His work focused on measuring various traits and examining their inheritance patterns.
While it is uncertain if any biologist would have fully appreciated Mendel's work before 1900, **Galton** is considered a likely candidate due to his interest in discontinuous variation, mathematical mindset, and acceptance of Weismann's ideas about germ cells.

The period also saw debates and controversies surrounding various theories, including Weismann's ideas, the effectiveness of natural selection, and the interpretation of **Galton's Law of Ancestral Inheritance**

The Re-discovery!

At the end of the 19th century, both Bateson and de Vries believed that studying variation would lead to an understanding of heredity. However, they soon realized that **understanding the nature of segregation and recombination was essential before analyzing the origin of variability.**
In 1899, Bateson published an analysis emphasizing the need to examine offspring statistically and separately for each characteristic when parents differ in multiple traits. This demonstrated his readiness to appreciate Mendel's approach.
Mendel's original paper, titled "**Experiments on Plant Hybridization**," had limited initial recognition. Mendel sent copies of his paper to various botanists, including Nägeli and Kerner, but their responses did not indicate a deep understanding of the work. Only four references to Mendel's paper before 1900 are known.

Hugo de Vries, a Dutch scientist, published three papers on Mendelism in 1900. Although his first French paper did not mention Mendel, his later papers recognized Mendel's work and its significance. De Vries claimed to have worked out the Mendelian scheme himself but later discovered Mendel's paper through a reference by L. H. Bailey or a reprint from Beijerinck.

Carl Correns, a student of Nägeli and Pfeffer, independently arrived at the Mendelian interpretation through his work on xenia (the influence of pollen on endosperm development). He mentioned Mendel's name in his paper, providing the first printed indication of someone understanding Mendel's work.
Erich von Tschermak, **a *grandson of Fenzl (Mendel's teacher)***, conducted studies on crossing and inbreeding in plants. He observed the 3:1 ratios and backcrossing results similar to Mendel's findings. Tschermak published two papers on the subject in 1900, with the second one showing a clearer understanding after reading the papers by de Vries and Correns.

William Bateson, influenced by **W. K. Brooks**, became a strong advocate of Mendel's work. He read a paper in May 1900 describing Mendel's work and its confirmation by de Vries. Bateson played a crucial role in promoting Mendelian genetics and establishing a group of researchers at Cambridge.
Overall, the passage highlights the sequence of events leading to the rediscovery of Mendel's laws of heredity and the recognition of their significance by prominent scientists in the early 20th century.

Mendel usually used the word Merkmal for what we now term gene, and this was translated as character, often appearing as unit character; **Bateson usually used the word factor**. It was somewhat later (1909) that **Johannsen introduced the word gene**.

GENES AND CHROMOSOMES

Understanding chromosomes and inheritance improved in the early 20th century. Wilson's "The Cell in Development and Inheritance" served as a seminal study for decades.Its 1900 second edition summarised Mendel's chromosomal understanding.

At that period, the number of chromosomes in a species was stable and usually even, with equal contributions from egg and sperm. It was discovered that each chromosome divides longitudinally during somatic cell divisions, with visible granules splitting evenly. The last two divisions before mature gametes in mammals or gametophytes in plants reduced chromosomal number. Chromosomes were thought to contain vital genetic material.

During this time, many essential biological principles were unknown. The theory that chromosomes reemerged as a single thread or spireme, breaking into the species' particular number, proved unproven. **Rabl and Boveri** hypothesised that *chromosomes kept their identity during nucleus resting*, although this was not widely recognised. Meiotic chromosomal decrease was unknown since meiotic prophase chromosome pairing was not recognised. The concept of chromosomal pairs and cell-specific chromosomes remained unknown.

Cytologists eventually resolved these uncertainties. Montgomery postulated chromosomal pairs in 1901. In 1902, **Sutton** demonstrated *in a grasshopper that each pair has one maternal and one paternal chromosome*. In the same year, **Winiwarter's** rabbit ovary studies revealed that side-by-side chromosome pairing forms *bivalents* in the first meiotic division. More cytologists confirmed this hypothesis, which was vital to later gene and chromosome investigations.

Boveri studied *polyspermy sea urchin egg fertilisation in 1902*. He showed that numerous sperm in one egg caused mosaic embryos with damaged organs. Boveri found that embryo development required at least one complete haploid pair. This called into question Weismann's interpretation of chromosomal reduction during meiosis and the notion that an individual's chromosomes were comparable.

In 1900, **Correns** asked where Mendelian segregation occurred and produced several papers, including his 1902 full analysis. His maize hybrid tests proved that seed embryos and endosperms were identical. He concluded that the anther must segregate before the last division that creates two sperm nuclei in a pollen grain and before the megaspore. Late segregation prevents offspring multiplication differences, Correns said. He observed that sporophyte meiotic divisions create haploid nuclei and segregate.

Chromosome and inheritance research advanced in the early 20th century. Wilson's study established chromosomal knowledge, and following investigations discovered chromosome pairs, the mechanism of chromosome reduction during meiosis, and the importance of entire haploid chromosome sets in development. These discoveries opened the door to genetics and chromosomal biology.

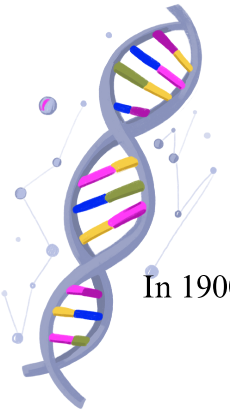
Linkage , Drosophila Work

Genetics breakthroughs occurred in the early 1900s. **Sutton and de Vries** hypothesised gene swapping during meiosis to explain independent assortment because there were more genes than chromosomes. **Correns** and others found connectivity in inheritance patterns, challenging independent assortment. **Bateson and Punnett** developed incomplete linkage and the reduplication idea, which was disproven. **McClung and Stevens** **discovered sex-determining chromosomes**. **Doncaster, Morgan**, and others found sex-linked inheritance. **Janssens' chiasmatype theory** explained meiotic division and genetic exchange. Genetic research of Drosophila melanogaster, the fruit fly, led to advances in gene linkage and recombination. **Morgan's** Drosophila research verified the chromosomal basis of heredity and introduced crossing over. These findings advanced genetics.

Early Drosophila studies had trouble attaining Mendelian ratios due to high larval and pupal mortality. Bridges' handling techniques—better equipment, temperature control, and standardised culture media—have improved the material's survivability. Bridges also identified novel mutants, which are still useful decades later.
Gene symbol systems evolved from Mendel's random letters and Cuénot's misinterpreted method. Johannsen emphasised standardisation, whereas Bateson introduced mnemonic symbols. Cuénot's mouse colour and gene determinant research improved knowledge. Morgan's unexpected correlations between agouti, black, and yellow in Drosophila disproved the presence-and-absence idea and led to the multiple allele concept.
Cuénot's yellow gene in mice and **Baur's** results in snapdragons were examined as lethal genes. Morgan discovered Drosophila's first sex-linked lethal gene, emphasising recessive lethals' importance in mutation studies. Crossing over and interference illuminated genetic recombination. Bridges and others examined female age, temperature, and crossing over frequency.

Crossing geometrical relations was illuminated by Drosophila attached-X strains. Anderson's investigations on attached-X strains with numerous pairs of genes improved knowledge, while Sturtevant's four-strand crossing over was confirmed. Stern showed that crossing over can occur during mitotic divisions, leading to twin spots as a tool for analysing recessive genes.

Chromosome changes such as inversions affected crossing over and segregation. Inversions preserved sterile or semisterile genes and solved phylogenetic difficulties. They were fundamental to Muller's mutation studies.
Improved Drosophila handling techniques have solved early problems. Genetics developed gene symbol systems and multiple allele concepts. Lethal genes, crossing over, and chromosome modifications have illuminated genetic pathways and aided mutation investigations.



Genetics, Immunology & Biochemical Genetics

In 1900, **Landsteiner** discovered the ABO blood type system, advancing gene action research. Genetics and immunology helped researchers examine chemical effects and build gene expression techniques.

Landsteiner discovered three blood types and red cell and serum agglutinins and agglutinogens. Decastello and Sturli found the fourth blood type, establishing the ABO blood-group system.

During World War I, L and **H. Hirszfeld found that blood types were not inherited independently.**

Bernstein's triple allele system better described the proportions.

Landsteiner and **Levine** used injectable antibodies and absorption methods to explore induced antibodies to human blood cells. The Rh system, including Rh positive and Rh negative blood types, was discovered through immunological study.

Antigen specificity indicated no gene product interaction in most situations, even in hybrid species. Grafted tissues showed genetic parameters affecting transplantation effectiveness.

Cow red-cell antigens showed placental transfer of foreign erythropoietic cells between twins. This discovery illuminated immune specificity and foreign tissue tolerance.

Genetics and immunology improved gene action and blood group system comprehension.

Biochemical investigations of gene substitutions and direct chemical attacks on genetic material have contributed to genetics. It took a long time to create these procedures, which was discouraging. *Garrod's 1902 study on alkaptonuria*, a condition caused by an alternative metabolic pathway that excretes homogentisic acid instead of urea, was important. Gene biochemistry and enzymes' function in genetic characteristics were illuminated by Garrod's studies.

Over the years, **Bateson, Cuénot, Gortner, Scott-Moncrieff, and Wright investigated the relationship between genes and enzymes**, notably in the context of biochemical abnormalities in humans and gene activation. Direct gene activity was also found in red blood cell antigen studies.

In 1919, ***Morgan and Bridges*** found that sex-linked genes impact specific body parts without affecting others in Drosophila gynandromorphs. Gene activation and its effects were further studied after this discovery. Tissue-to-tissue transfers and metabolic pathway effects of gene alterations were shown in Ephestia, Drosophila, and other organisms.

20-21th Century

Beadle and Tatum's 1940s work with Neurospora, a fungus, proved to be crucial in understanding metabolic pathways and gene activity. Their investigations showed that mutants unable to synthesise particular compounds may be found and examined by giving the missing ingredients in a controlled media.

The discovery of nucleic acids by Miescher, the clarification of DNA and RNA structures by **Ascoli, Levene, Chargaff, Watson, and Crick**, and the deciphering of the genetic code by **Nirenberg, Ochoa**, and others increased genetics. These discoveries helped us comprehend heredity and gene expression.

This summary provides a brief overview of biochemical genetics' historical progress, but recent discoveries like genome editing techniques like CRISPR-Cas9 have opened new avenues for studying and manipulating genetic material.

2017: single-cell RNA sequencing
2016: first synthetic genome of a living organism,Mycoplasma genitalium

2013: CRISPR-Cas9 system's ability to edit genes in human cells

2012: CRISPR-Cas9 gene editing system
2007: Induced pluripotent stem cells (iPSCs)

2003: Completion of the Human Genome Project
1977: Frederick Sanger

James Watson and Francis Crick(1953)
Gregor Mendel (1822-1884)

Charles Darwin (1809-1882)
Carl Linnaeus (1707-1778)

Anton van Leeuwenhoek (1632-1723)
William Harvey (1578-1657)

Andreas Vesalius
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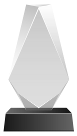

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This project has provided me with a unique chance to learn more about the intriguing background of biology and genetics, and how evolutionary milestones and achievements have moulded our understanding of life. I want to express my deep appreciation to everyone who has helped make this project a reality.

I appreciate it.

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