**TIMELINE OF DNA**

**1865**: Gregor Mendel discovers through breeding experiments with peas that traits are inherited based on specific laws (later to be termed “Mendel's laws”).

**1866**: Ernst Haeckel proposes that the nucleus contains the factors responsible for the transmission of hereditary traits.

**1869**: Friedrich Miescher isolates DNA for the first time.

**1871**: The first publications describing DNA (“nuclein”) by Friedrich Miescher, Felix Hoppe-Seyler, and P. Plósz are printed.

**1882**: Walther Flemming describes chromosomes and examines their behavior during cell division.

**1884–1885**: Oscar Hertwig, Albrecht von Kölliker, Eduard Strasburger, and August Weismann independently provide evidence that the cell's nucleus contains the basis for inheritance.

**1889**: Richard Altmann renames “nuclein” to “nucleic acid.”

**1900**: Carl Correns, Hugo de Vries, and Erich von Tschermak rediscover Mendel's Laws.

**1902**: Theodor Boveri and Walter Sutton postulate that the heredity units (called “genes” as of 1909) are located on chromosomes.

**1902–1909**: Archibald Garrod proposes that genetic defects result in the loss of enzymes and hereditary metabolic diseases.

**1909**: Wilhelm Johannsen uses the word “gene” to describe units of heredity.

**1910**: Thomas Hunt Morgan uses fruit flies (*Drosophila*) as a model to study heredity and finds the first mutant (*white*) with white eyes.

**1913**: Alfred Sturtevant and Thomas Hunt Morgan produce the first genetic linkage map (for the fruit fly *Drosophila*).

**1928**: Frederick Griffith postulates that a “transforming principle” permits properties from one type of bacteria (heat-inactivated virulent *Streptococcus pneumoniae*) to be transferred to another (live nonvirulent *Streptococcus pneumoniae*).

**1929**: Phoebus Levene identifies the building blocks of DNA, including the four bases adenine (A), cytosine (C), guanine (G), and thymine (T).

**1941**: George Beadle and Edward Tatum demonstrate that every gene is responsible for the production of an enzyme.

**1944**: Oswald T. Avery, Colin MacLeod, and Maclyn McCarty demonstrate that Griffith's “transforming principle” is not a protein, but rather DNA, suggesting that DNA may function as the genetic material.

**1949**: Colette and Roger Vendrely and André Boivin discover that the nuclei of germ cells contain half the amount of DNA that is found in somatic cells. This parallels the reduction in the number of chromosomes during gametogenesis and provides further evidence for the fact that DNA is the genetic material.

**1949–1950**: Erwin Chargaff finds that the DNA base composition varies between species but determines that within a species the bases in DNA are always present in fixed ratios: the same number of A's as T's and the same number of C's as G's.

**1952**: Alfred Hershey and Martha Chase use viruses (bacteriophage T2) to confirm DNA as the genetic material by demonstrating that during infection viral DNA enters the bacteria while the viral proteins do not and that this DNA can be found in progeny virus particles.

**1953**: Rosalind Franklin and Maurice Wilkins use X-ray analyses to demonstrate that DNA has a regularly repeating helical structure.

**1953**: James Watson and Francis Crick discover the molecular structure of DNA: a double helix in which A always pairs with T, and C always with G.

**1956**: Arthur Kornberg discovers DNA polymerase, an enzyme that replicates DNA.

**1957**: Francis Crick proposes the “central dogma” (information in the DNA is translated into proteins through RNA) and speculates that three bases in the DNA always specify one amino acid in a protein.

**1958**: Matthew Meselson and Franklin Stahl describe how DNA replicates (semiconservative replication).

**1961–1966**: Robert W. Holley, Har Gobind Khorana, Heinrich Matthaei, Marshall W. Nirenberg, and colleagues crack the genetic code.

**1968–1970**: Werner Arber, Hamilton Smith, and Daniel Nathans use restriction enzymes to cut DNA in specific places for the first time.

**1972**: Paul Berg uses restriction enzymes to create the first piece of recombinant DNA.

**1977**: Frederick Sanger, Allan Maxam, and Walter Gilbert develop methods to sequence DNA.

**1982**: The first drug (human insulin), based on recombinant DNA, appears on the market.

**1983**: Kary Mullis invents PCR as a method for amplifying DNA in vitro.

**1990**: Sequencing of the human genome begins.

**1995**: First complete sequence of the genome of a free-living organism (the bacterium *Haemophilus influenzae*) is published.

**1996**: The complete genome sequence of the first eukaryotic organism—the yeast *S. cerevisiae*—is published.

**1998**: Complete genome sequence of the first multicellular organism—the nematode worm *Caenorhabditis elegans*—is published.

**1999**: Sequence of the first human chromosome (22) is published.

**2000**: The complete sequences of the genomes of the fruit fly *Drosophila* and the first plant—*Arabidopsis*—are published.

**2001**: The complete sequence of the human genome is published.

**2002**: The complete genome sequence of the first mammalian model organism—the mouse—is published.

Today, DNA is considered far more than just a molecule. It has become the icon of the modern biosciences. Understanding its structure and how it functions has fundamentally changed our world. Most of modern biology relies heavily on molecular genetics techniques, be it directly to elucidate the functions of cellular components or indirectly, for example, in the form of molecular phylogenetic trees that aid in reconstructing the evolution of life. Also other disciplines, such as psychology, criminology, and most notably medicine benefit increasingly from our knowledge of DNA.

The most recent breakthrough in the history of DNA research has been the publication of the very nearly complete sequence of the human genome in 2001 ([Lander et al., 2001](https://www.sciencedirect.com/science/article/pii/S0012160604008231%22%20%5Cl%20%22bib25), [Venter et al., 2001](https://www.sciencedirect.com/science/article/pii/S0012160604008231%22%20%5Cl%20%22bib94)) an achievement deemed utterly impossible only two decades ago. However, despite impressive advances in the past decades, our understanding of how DNA works is still far from complete. Nearly 150 years after Miescher's first experiments, there still remains a lot to discover.

Great discoveries often result from a combination of serendipity and an openness to accept (and follow up) an unexpected result. However, the breakthroughs in thought that follow great discoveries depend both on a mind prepared to change previously held concepts and a context of preexisting knowledge. This context determines if the significance of a discovery can be appreciated. In the case of Miescher, serendipity and the prepared mind were there: He had set out to characterize proteins and discovered DNA, which he recognized as being very worthy of further investigation. However, the breakthrough in thought that his discovery deserved only occurred half a century after his death, when the data necessary to fully grasp the significance of DNA's function were emerging. In many ways, Miescher's discovery was well ahead of its time.

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