Genetic Timeline

1859

Discovery: Natural Selection

Charles Darwin wrote "On the Origin of Species by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life."

1865

Discovery: Heredity Transmitted in Units

Gregor Mendel's experiments on peas demonstrate that heredity is transmitted in discrete units. The understanding that genes remain distinct entities even if the characteristics of parents appear to blend in their children explains how natural selection could work and provides support for Darwin's proposal.

1869

Discovery: DNA Isolated

Frederick Miescher isolates DNA from cells for the first time and calls it "nuclein".

1879

Discovery: Mitosis Described

Walter Flemming describes chromosome behavior during animal cell division. He stains chromosomes to observe them clearly and describes the whole process of mitosis in 1882.

Genetic Timeline

1900

Discovery: Rediscovery of Mendel's work

Botanists DeVries, Correns, and von Tschermak independently rediscover Mendel's work while doing their own work on the laws of inheritance. The increased understanding of cells and chromosomes at this time allowed the placement of Mendel's abstract ideas into a physical context.

1902

Discovery: Chromosome Theory of Inheritance

Walter Sutton observes that the segregation of chromosomes during meiosis matched the segregation pattern of Mendel's

1902

Discovery: Orderly Inheritance of Disease

A British physician, Archibald Garrod, observes that the disease alkaptonuria is inherited according to Mendelian rules. This disease involves a recessive mutation, and was among the first conditions ascribed to a genetic cause.

1909

Discovery: The Word Gene is Coined

Wilhelm Johannsen coins the word "gene" to describe the Mendelian unit of heredity. He also uses the terms genotype and phenotype to differentiate between the genetic traits of an individual and its outward appearance.

Genetic Timeline

1911

Discovery: Chromosomes Carry Genes

Thomas Hunt Morgan and his students study fruit fly chromosomes. They show that chromosomes carry genes, and also discover genetic linkage.

1941

Discovery: One Gene, One Enzyme Hypothesis

George Beadle and Edward Tatum's experiments on the red bread mold, *Neurospora crassa*, show that genes act by regulating distinct chemical events. They propose that each gene directs the formation of one enzyme

1943

Discovery: DNA Has a Regular Periodic Structure

William Astbury, a British scientist, obtains the first X-ray diffraction pattern of DNA, which reveals that DNA must have a regular periodic structure. He suggests that nucleotide bases are stacked on top of each other.

1944

Discovery: DNA Transforms Cells

Oswald Avery, Colin MacLeod, and Maclyn McCarty show that DNA (not proteins) can transform the properties of cells -- thus clarifying the chemical nature of genes.

Genetic Timeline

1944

Discovery: Jumping Genes

Barbara McClintock, using corn as the model organism, discovers that genes can move around on chromosomes. This shows that the genome is more dynamic than previously thought. These mobile gene units are called transposons and are found in many species.

1952

Discovery: Genes Are Made of DNA

Alfred Hershey & Martha Chase show that only the DNA of a virus needs to enter a bacterium to infect it, providing strong support for the idea that genes are made of DNA

1953

Discovery: DNA Double Helix

Francis H. Crick and James D. Watson described the double helix structure of DNA. They receive the Nobel Prize for their work in 1962.

1955

Discovery: 46 Human Chromosomes

Joe Hin Tjio defines 46 as the exact number of chromosomes in human cells.

1955

Discovery: DNA copying enzyme

Arthur Kornberg and colleagues isolated DNA polymerase, an enzyme that would later be used for DNA sequencing.

Genetic Timeline

1956

Discovery: Cause of Disease Traced to Alteration

Vernon Ingram discovers that a specific chemical alteration in a hemoglobin protein is the cause of sickle cell disease.

1958

Discovery: Semiconservative Replication of DNA

Matthew Meselson and Franklin Stahl demonstrate that DNA replicates semiconservatively: each strand from the parent DNA molecule ends up paired with a new strand from the daughter generation.

1959

Discovery: Chromosome Abnormalities Identified

Jerome Lejeune and his colleagues discover that Down Syndrome is caused by trisomy 21. There are three copies, rather than two, of chromosome 21, and this extra chromosomal material interferes with normal development.

1961

Discovery: First Screen for Metabolic Defect in Newborns

Robert Guthrie develops a method to test newborns for the metabolic defect, phenylketonuria (PKU).

1961

Discovery: mRNA Ferries Information

Sydney Brenner, François Jacob and Matthew Meselson discover that mRNA takes information from DNA in the nucleus to the protein-making machinery in the cytoplasm.

Genetic Timeline

1966

Discovery: Genetic Code Cracked

Marshall Nirenberg and others figure out the genetic code that allows nucleic acids with their 4 letter alphabet to determine the order of 20 kinds of amino acids in proteins.

1968

Discovery: First Restriction Enzyme Described

Scientists describe restriction nucleases, enzymes that recognize and cut specific short sequences of DNA. The resulting fragments can be used to analyze DNA, and these enzymes later became an important tool for mapping genomes.

1972

Discovery: First recombinant DNA

Scientists produce recombinant DNA molecules by joining DNA from different species and subsequently inserting the hybrid DNA into a host cell, often a bacterium.

1973

Discovery: First animal gene cloned

Researchers fuse a segment of DNA containing a gene from the African clawed frog Xenopus with DNA from the bacterium E. coli and placed the resulting DNA back into an E. coli cell. There, the frog DNA was copied and the gene it contained directed the production of a specific frog protein.

Genetic Timeline

1975

Discovery: DNA Sequencing

Two groups, Frederick Sanger and colleagues, and Alan Maxam and Walter Gilbert, both develop rapid DNA sequencing methods. The Sanger method is most commonly employed in the lab today, with colored dyes used to identify each of the four nucleic acids that make up DNA.

1976

Discovery: First Genetic Engineering Company

Herbert Boyer founds Genentech. The company produces the first human proteinin a bacterium, and by 1982 markets the first recombinant DNA drug, human insulin.

1977

Discovery: Introns Discovered

Richard Roberts' and Phil Sharp's labs show that eukaryotic genes contain many interruptions called introns. These non-coding regions do not directly specify the amino acids that make protein products.

1981

Discovery: First Transgenic Mice and Fruit Flies

Scientists successfully add stably inherited genes to laboratory animals. The resulting transgenic animals provide a new way to test the functions of genes.

Genetic Timeline

1982

Discovery: GenBank Database Formed

Scientists begin submitting DNA sequence data to a National Institutes of Health (NIH) database that is open to the public.

1983

Discovery: First Disease Gene Mapped

A genetic marker for Huntington's disease is found on chromosome 4.

1983

Discovery: PCR Invented

The polymerase chain reaction, or PCR, is used to amplify DNA. This method allows researchers to quickly make billions of copies of a specific segment of DNA, enabling them to study it more easily.

1986

Discovery: First Time a Disease Gene is Positionally Cloned

A method for finding a gene without the knowledge of the protein it encodes is developed. So called, positional cloning can help in understanding inherited disease, such as muscular dystrophy.

Genetic Timeline

1987

Discovery: First Human Genetic Map

The first comprehensive genetic map is based on variations in DNA sequence that can be observed by digesting DNA with restriction enzymes. Such a map can be used to help locate genes responsible for diseases.

1987

Discovery: Yeast Artificial Chromosomes

Scientists discover that artificial chromosomes made from yeast can reliably carry large fragments of human DNA containing millions of base-pair pieces. Earlier methods used plasmids and viruses, which can carry only a few thousand base-pair pieces. The ability to deal with much larger pieces of DNA makes mapping the human genome easier.

1989

Discovery: Microsatellites Are New Genetic Markers

Repetitive DNA sequences called microsatellites are used as genetic landmarks to distinguish between people. Another type of marker, sequence–tagged sites, are unique stretches of DNA that can be used to make physical maps of human chromosomes.

1990

Discovery: Launch of the Human Genome Project

The Department of Energy and the National Institutes of Health announce a plan for a 15-year project to sequence the human genome. This will eventually result in sequencing all 3.2 billion letters of the human genome.

Genetic Timeline

1991

Discovery: ESTs, Fragments of Genes

An expressed-sequence tag (EST) an identified piece of a gene, is made by copying a portion of a messenger RNA (mRNA) molecule. As such, ESTs provide a way to focus on the "expressed" portion of the genome, which is less than one-tenth

1992

Discovery: Second-Generation Genetic Map of Human Genome

A French team builds a low-resolution, microsatellite genetic map of the entire human genome. Each generation of the map helps geneticists more quickly locate disease genes on chromosomes.

1994

Discovery: FLAVR SAVR Tomato

The Food And Drug Administration approves the sale of the first genetically modified food.

1995

Discovery: Ban on Genetic Discrimination in the Workplace

Protection under the American with Disabilities Act is extended to cover discrimination based on genetic information.

Genetic Timeline

1996

Discovery: Mouse Genetic Map Completed

The lab mouse is valuable for genetics research because humans and mice share almost all of their genes, and the genes on average are 85% identical. The mouse genetic map increases the utility of mice as animal models for genetic disease in humans.

1997

Discovery: E. coli Genome Sequenced

The complete sequence of the *E. coli* genome will help scientists learn even more about this extensively studied bacterium

1998

Discovery: M. tuberculosis Bacterium Sequenced

***Mycobacterium tuberculosis* causes the chronic infectious disease tuberculosis. The sequencing of this bacterium is expected to help scientists develop new therapies to treat the disease.**

1998

Discovery: Roundworm C. elegans Sequenced

The first genome sequence of a multicellular organism, the round worm, Caenorhabditis elegans, is completed.

Genetic Timeline

1999

Discovery: Chromosome 22 Sequenced

The first finished, full-length sequence of a human chromosome is produced. Chromosome 22 was chosen to be first because it is relatively small and had a highly detailed map already available. Such a map is necessary for the clone by clone sequencing approach.

2000

Discovery: Human Genome Working Draft Completed

By the end of Spring 2000, HGP researchers sequence 90 percent of the human genome with 4-fold redundancy. This working draft sequence is estimated to be 99.9% accurate.

2002

Discovery: Mouse Genome Working Draft Assembled and Analyzed

The Mouse Genome Sequencing Consortium publishes an assembled draft and comparative analysis of the mouse genome. This milestone was originally planned for 2003.

2002

Discovery: Rat Genome Working Draft Completed

By Fall 2002, researchers sequence over 90% of the rat genome with over 5-fold redundancy.

2003

Discovery: Completion of the Human Genome Sequencing

The finished human genome sequence will be at least 99.99% accurate.

The Future

It will take decades of research for scientists to understand all of the information that is contained within the human genome. In time, more human diseases will be understood at the level of the molecules that are involved, which could dramatically change the practice of medicine by leading to the development of new drugs, as well as to genetic testing to improve and individualize treatments.