*The Nature of Science*

Biology is a science, but what exactly is science? What does the study of biology share with other scientific disciplines? **Science** (from the Latin scientia, meaning “knowledge”) can be defined as knowledge about the natural world. Science is a very specific way of learning, or knowing, about the world. The history of the past 500 years demonstrates that science is a very powerful way of knowing about the world; it is largely responsible for the technological revolutions that have taken place during this time. There are however, areas of knowledge and human experience that the methods of science cannot be applied to. These include such things as answering purely moral questions, aesthetic questions, or what can be generally categorized as spiritual questions. Science can not investigate these areas because they are outside the realm of material phenomena, the phenomena of matter and energy, and can not be observed and measured.

The **scientific method** is a method of research with defined steps that include experiments and careful observation. One of the most important aspects of this method is the testing of hypotheses. A **hypothesis** is a suggested explanation for an event, which can be tested. Hypotheses, or tentative explanations, are generally produced within the context of a scientific theory. A **scientific theory** is a generally accepted, thoroughly tested and confirmed explanation for a set of observations or phenomena. Scientific theory is the foundation of scientific knowledge. In addition, in many scientific disciplines (less so in biology) there are **scientific laws**, often expressed in mathematical formulas, which describe how elements of nature will behave under certain specific conditions. There is not an evolution of hypotheses through theories to laws as if they represented some increase in certainty about the world. Hypotheses are the day-to-day material that scientists work with and they are developed within the context of theories. Laws are concise descriptions of parts of the world that are amenable to formulaic or mathematical description.

The scientific community has been debating for the last few decades about the value of different types of science. Is it valuable to pursue science for the sake of simply gaining knowledge, or does scientific knowledge only have worth if we can apply it to solving a specific problem or bettering our lives? This question focuses on the differences between two types of science: basic science and applied science.

* Basic science or “pure” science seeks to expand knowledge regardless of the short-term application of that knowledge. It is not focused on developing a product or a service of immediate public or commercial value. The immediate goal of basic science is knowledge for knowledge’s sake, though this does not mean that in the end it may not result in an application.
* In contrast, applied science or “technology,” aims to use science to solve real-world problems, making it possible, for example, to improve a crop yield, find a cure for a particular disease, or save animals threatened by a natural disaster. In applied science, the problem is usually defined for the researcher.

Some individuals may perceive applied science as “useful” and basic science as “useless.” A question these people might pose to a scientist advocating knowledge acquisition would be, “What for?” A careful look at the history of science, however, reveals that basic knowledge has resulted in many remarkable applications of great value. Many scientists think that a basic understanding of science is necessary before an application is developed; therefore, applied science relies on the results generated through basic science. Other scientists think that it is time to move on from basic science and instead to find solutions to actual problems. Both approaches are valid. It is true that there are problems that demand immediate attention; however, few solutions would be found without the help of the knowledge generated through basic science.

One example of how basic and applied science can work together to solve practical problems occurred after the discovery of DNA structure led to an understanding of the molecular mechanisms governing DNA replication. Strands of DNA, unique in every human, are found in our cells, where they provide the instructions necessary for life. During DNA replication, new copies of DNA are made, shortly before a cell divides to form new cells. Understanding the mechanisms of DNA replication enabled scientists to develop laboratory techniques that are now used to identify genetic diseases, pinpoint individuals who were at a crime scene, and determine paternity. Without basic science, it is unlikely that applied science would exist.

Another example of the link between basic and applied research is the Human Genome Project, a study in which each human chromosome was analyzed and mapped to determine the precise sequence of DNA subunits and the exact location of each gene. (The gene is the basic unit of heredity; an individual’s complete collection of genes is his or her genome.) Other organisms have also been studied as part of this project to gain a better understanding of human chromosomes. The Human Genome Project (**Figure 1**) relied on basic research carried out with non-human organisms and, later, with the human genome. An important end goal eventually became using the data for applied research seeking cures for genetically related diseases.

While research efforts in both basic science and applied science are usually carefully planned, it is important to note that some discoveries are made by serendipity, that is, by means of a fortunate accident or a lucky surprise. Penicillin was discovered when biologist Alexander Fleming accidentally left a petri dish of Staphylococcus bacteria open. An unwanted mold grew, killing the bacteria. The mold turned out to be Penicillium, and a new antibiotic was discovered. Even in the highly organized world of science, luck—when combined with an observant, curious mind—can lead to unexpected breakthroughs.

Biology plays an important role in the understanding of complex forms of life involving humans, animals and plants. Understanding these intricate details of life helps humans understand how to care for themselves, animals and plants in the proper manner. Biology helps individuals understand the interaction between humanity and the world. It also develops interests in the lives of living organisms in an effort to preserve them.

Through studying biology, pathologists understand the human body, the functions of various organs, how diseases affect the body and ways to effectively control diseases. Veterinarians have to study biology to appreciate the functions of animals, including marine animals and creatures that live on land. Environmentalists rely on the study of biology to learn how man’s actions affect his surroundings and the ecosystems of other living beings.

Studying biology is the foundation of all characteristics of life on Earth. Apart from creating solutions to the challenges many living organisms face, it paves the way for inventions and discoveries that improve the quality of life. Without studying biology, humans would probably never realize how important maintaining a healthy ecology is for themselves, animals and plant life. Additionally, studying biology enables the use of forensics to trace and arrest errant members of the society. It also allows agriculturalists to rear unique breeds of plants and animals.

Biology is one of the three essential studies of science. In classrooms all around the world people study biology, chemistry, and/or physics. Chemistry of course looks at the different kinds of substances and molecules that exist, and physics looks at the way the world and the universe work. Biology is the fascinating study of life and is incredibly important for the advancement of modern society.  
  
Biology is important for a number of reasons, but in particular because it is used in nearly every field. If we did not have a firm understanding of biology then nobody would be able to understand how bodies work, and of course, how other life on earth (e.g. Plants) functions.  
  
If it were not for biology, we would not be able to understand the environment in which we live. Biology involves and contains many secrets of nature. Biology is incredibly complex and vast and possesses the ability to explain many myths and problems found within nature every day by individuals and scientists. It allows us to build upon the technology that allows people to be cured from illnesses or diseases and allows for society to obtain better overall well-being and health.  
  
Without biology there would be no doctors. There would be no hospitals and there would be no real way to help people with the problems that they experience with their body. It is because of the progression of biological studies that the world's population is healthier than ever before.  It's incredibly important for biology to continue being studied for this reason. That's why it's promoted so highly in educational establishments.

# 6 Reasons That Emphasizes The Importance Of Biology

There are many facets that point to the **importance of biology**. First and foremost, the science of biology is mainly studying about life.

Second, it provides an in-depth, scientific understanding of how all living and nonliving organisms interact with each other.

Third, it gives insights into how diverse life forms are. Moreover, biology encompasses other fields of research that are related to the sustainability of life, including the environment, ecosystem, food quality, causes of illnesses, the development of medicines, the [**study of the human body**](https://www.bioexplorer.net/divisions_of_biology/anatomy/), to name a few.

Apparently, the [**study of life**](https://www.bioexplorer.net/history_of_biology/) has, somehow, helped in shaping the world. It has also given so many credible and reliable answers that explain why things happen in a more scientific manner.

But to make it more interesting, here are the six reasons why everyone should know the importance of biology.

## ****1. Explains the Changes of the Human Bodies****

Humans beings are scientifically known as home sapiens. They have similar characteristics with apes but are more developed in terms of body shape and erection, speech, and reasoning. And being considered as the highest form of animals, humans have bodies that are complicated to comprehend.

But by studying biology, everyone will know the reasons behind the sudden changes happening in their respective bodies. For instance, when kids unexpectedly grow taller and they experience changes in their physical appearances and sleeping patterns, these mean that their bodies have started releasing hormones in preparation for their puberty stage.

Also, the importance of biology has produced the scientific branch called [**Pathology**](https://www.bioexplorer.net/divisions_of_biology/immunology/), which studies the different kinds of diseases and how they affect the bodies of both humans and animals. It can also develop or discover new medications that will alleviate some health conditions without medicines yet.

## ****2. Shapes Different Careers****

Biology is one of the basic subjects that everyone has to take in school. With this being said, it helps in shaping the professional careers of every person. Be it a [**doctor**](https://www.bioexplorer.net/types-of-doctors/), chemist, engineer, environmentalist, nurse, psychologist, scientist, teacher, or other professions that are not inclined to science, studying the scientific concepts of life and other living organisms is going to be a useful tool in achieving success in any chosen field of study. You have different [**branches of biology**](https://www.bioexplorer.net/divisions_of_biology/) to choose from and specialize in.

Even beauticians and beauty therapists need to learn and understand the basic importance of biology since they mainly deal with the skin, fingers, and nails, which are significant parts of the human body.

## ****3. Provides Answers to Large-scale Problems****

Learning the importance of biology can be the answer to some world problems. It will provide answers to large-scale concerns that may affect anyone from different parts of the world. It can even offer solutions to [**environmental issues**](https://www.bioexplorer.net/current-environmental-issues-usa.html/) without compromising or sacrificing anything along the way.

For example, when a country is experiencing food shortages, the biological ideologies can be utilized to develop efficient and long-lasting methods for producing more food to sustain life. Another instance, which is currently one of the most evident problems, is the existence of pollution. This branch of knowledge can supply the solutions to eradicate such environmental issue that has become much worse than before.

Furthermore, the significance of biology can be the key to forming a healthy biosphere where all living things and nonliving things have a balanced interaction. Unfortunately, as of the present time, human beings have become the primary cause why other living organisms start to deplete in number. Hopefully, biologists will be able to bring back the sustainability of life here on Earth.

## ****4. Teaches Concepts on Basic Living****

Despite being a small-scale concept, the basic way of how human beings live is also covered by the importance of biology. It teaches people how to [**plant**](https://www.bioexplorer.net/divisions_of_biology/plant_physiology/) for food consumption. Furthermore, it tells what food is appropriate to consume and what is not.

In some cases, biology has provided useful concepts and ideas in building shelters effectively. It may seem an obvious factor, but it is only through comprehending and interpreting the temperature of the human body and how it mainly works that everyone can know what he or she needs to eat and how to sleep comfortably.

## ****5. Helps in Answering the Fundamental Questions About Life****

The importance of biology can lead to the answers of life’s fundamental questions such as; How and [**where did life begin**](https://www.bioexplorer.net/divisions_of_biology/evolution/)? Where do humans come from? Was it God that made human beings? Or were they formed according to Charles Darwin’s theory of evolution?

Although there have been many instances when science explained how life came to be, those explanations have never been fully accepted due to beliefs and principles related to religion. There is still a great portion that believes in what the sacred scripture says. However, biology has been consistent in explaining how life came to be despite having no strong evidence of its claims. But its theories remain to be important as of the present day.

## ****6. Paves Way for Scientific Investigations****

Perhaps, one of the best (if not the best) **importance of biology** is paving the way for humans to conduct scientific investigations, which are very useful in discovering new things, through the scientific method. Biologists do experiments to learn significant and interesting facts about the world. They also do fieldwork, having expeditions and explorations into unknown lands to gather more information about life.

These are just some of the few reasons why people should know the importance of biology. It provides and is continuously providing everyone with vital information about living organisms here on Earth. It does not stop looking for solutions that can completely eradicate the [**different environmental issues**](https://www.bioexplorer.net/current-environmental-issues-usa.html/) still persisting today. Instead, it pursues in getting strong evidence on how life came to be.

# Biology

## Important discoveries in biological science

Biology is the scientific study of all forms of life, including plants, animals, and [**microorganisms**](https://science.jrank.org/pages/4305/Microorganisms.html).

Among the numerous fields in biology are microbiology, the study of microscopic organisms like [**bacteria**](https://science.jrank.org/pages/714/Bacteria.html); [**cytology**](https://science.jrank.org/pages/1939/Cytology.html), the study of cells; [**embryology**](https://science.jrank.org/pages/2452/Embryology.html), the study of development; [**genetics**](https://science.jrank.org/pages/2994/Genetics.html), the study of heredity; [**biochemistry**](https://science.jrank.org/pages/859/Biochemistry.html), the study of the chemical structures in living things; morphology, the study of the [**anatomy**](https://science.jrank.org/pages/347/Anatomy.html) of plants and animals; [**taxonomy**](https://science.jrank.org/pages/6711/Taxonomy.html), the identification, naming, and classification of organisms; and [**physiology**](https://science.jrank.org/pages/5218/Physiology.html), the study of how organic systems function and respond to stimulation. Biology often interfaces with subjects like [**psychology**](https://science.jrank.org/pages/5565/Psychology.html). For example, [**animal**](https://science.jrank.org/pages/372/Animal.html) behaviorists would need to understand the biological nature of the animal they are studying in order to evaluate the animal's **[behavior](https://science.jrank.org/pages/817/Behavior.html)**.

The history of biology begins with the careful observation of the external aspects of organisms and continues with investigations into the functions and interrelationships of living things.

The ancient Greek philosopher Aristotle is credited with establishing the importance of observation and analysis as the basic approach for scientific investigation. By A.D. 200, studies in biology were centered in the Arab world. Most of the investigations during this period were made in medicine and agriculture. Arab scientists continued this activity throughout the Middle Ages.

When ancient Greek and Roman writings were revived in [**Europe**](https://science.jrank.org/pages/2595/Europe.html) during the Renaissance, scientific investigations began to accelerate. Leonardo da Vinci and Michelangelo, Italian Renaissance artists, produced detailed anatomical drawings of human beings. At the same time others were dissecting cadavers (dead bodies) and describing internal anatomy. By the seventeenth century, formal experimentation was introduced into the study of biology. William Harvey, an English physician, demonstrated the circulation of the [**blood**](https://science.jrank.org/pages/965/Blood.html) and so initiated the biological discipline of physiology.

So much work was being done in biological science during this period that academies of science and scientific journals were formed, the first of which being the Academy of the Lynx in Rome in 1603. In Massachusetts, the Boston Philosophical Society was founded nearly a hundred years before the American Revolution. The first scientific journals were established in 1665 with the *Journal des Savants* (France) and in Great Britain with the *Philosophical Transactions of the Royal Society*.

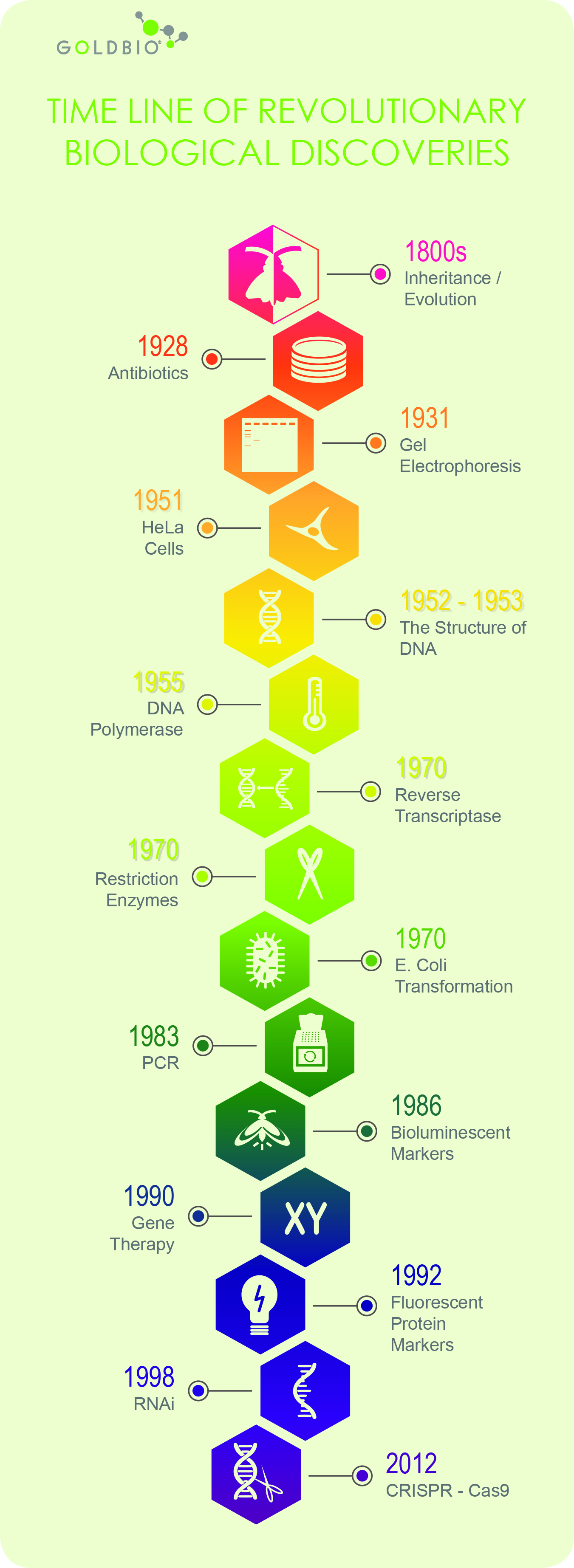
The invention of the light [**microscope**](https://science.jrank.org/pages/4310/Microscope.html) opened the way for biologists to investigate living organisms at the cellular level, and ultimately at the molecular level. The first drawings of magnified life were made by Francesco Stelluti, an Italian who published drawings of a honeybee at a 10-times magnification in 1625.

During the eighteenth century, Carolus Linnaeus proposed a system for naming and classifying plants and animals which is still used today. In his book, *Species plantarum*, which was written in 1753, Linnaeus described 6,000 plants, each one assigned a binomial name—genus and [**species**](https://science.jrank.org/pages/6353/Species.html). For example, the binomial name for the wolf is *Canis lupus*, and for humans, *Homo sapiens.* In the nineteenth century, many explorers contributed to biological science by collecting [**plant**](https://science.jrank.org/pages/5277/Plant.html) and animal specimens from around the world. In 1859, Charles Darwin published *On the Origin of Species,* in which he outlined the theory of [**evolution**](https://science.jrank.org/pages/2607/Evolution.html) by means of natural [**selection**](https://science.jrank.org/pages/6068/Selection.html). This was an important discovery; it disproved the idea that organisms generated spontaneously. Later, French chemist Louis Pasteur confirmed Darwin's findings by the discovery of certain bacteria caused diseases. Pasteur also developed the first vaccines. By the end of the nineteenth century the [**germ theory**](https://science.jrank.org/pages/3035/Germ-Theory.html) of [**disease**](https://science.jrank.org/pages/2114/Disease.html) was established by Robert Koch, and by the early twentieth century, chemotherapy was developed. The use of [**antibiotics**](https://science.jrank.org/pages/407/Antibiotics.html) began with penicillin in 1928 and steroids were discovered in 1935.

From the nineteenth century until the present, the amount of research and discovery in biology has been voluminous. Two fields of rapid growth in biological science today are [**molecular biology**](https://science.jrank.org/pages/4402/Molecular-Biology.html) and [**genetic engineering**](https://science.jrank.org/pages/2981/Genetic-Engineering.html).

In the long history of biology, there have been so many amazing discoveries! Advancements in the origins of life, the mechanisms of life, cures, new (and some rediscovered) maladies, and so many other interesting things in between are what consistently make biology one of my favorite subjects.

And while nearly all scientific discoveries help us understand a little more about this amazing world in which we live, some discoveries help us to ***Discover More***. Below are 15 scientific breakthroughs that have helped scientists see even more deeply into life, the universe and everything.



[**Inheritance/Evolution (1800s)**](https://www.goldbio.com/articles/article/15-Great-biological-discoveries-that-revolutionized-life-science#_Toc31005012)

[**Antibiotics (1928)**](https://www.goldbio.com/articles/article/15-Great-biological-discoveries-that-revolutionized-life-science#_Toc31005013)

[**Gel Electrophoresis (1931)**](https://www.goldbio.com/articles/article/15-Great-biological-discoveries-that-revolutionized-life-science#_Toc31005014)

[**HeLa Cell Discovery (1951)**](https://www.goldbio.com/articles/article/15-Great-biological-discoveries-that-revolutionized-life-science#_Toc31005015)

[**The Structure of DNA (1952-1953)**](https://www.goldbio.com/articles/article/15-Great-biological-discoveries-that-revolutionized-life-science#_Toc31005016)

[**DNA Polymerase (1956)**](https://www.goldbio.com/articles/article/15-Great-biological-discoveries-that-revolutionized-life-science#_Toc31005017)

[**Reverse transcriptase (1970)**](https://www.goldbio.com/articles/article/15-Great-biological-discoveries-that-revolutionized-life-science#_Toc31005018)

[**Restriction enzymes (1970)**](https://www.goldbio.com/articles/article/15-Great-biological-discoveries-that-revolutionized-life-science#_Toc31005019)

[**E. coli transformation (1970)**](https://www.goldbio.com/articles/article/15-Great-biological-discoveries-that-revolutionized-life-science#_Toc31005020)

[**PCR (1983)**](https://www.goldbio.com/articles/article/15-Great-biological-discoveries-that-revolutionized-life-science#_Toc31005021)

[**Bioluminescent markers (1986)**](https://www.goldbio.com/articles/article/15-Great-biological-discoveries-that-revolutionized-life-science#_Toc31005022)

[**Gene Therapy (1990)**](https://www.goldbio.com/articles/article/15-Great-biological-discoveries-that-revolutionized-life-science#_Toc31005023)

[**Fluorescent protein markers (1992)**](https://www.goldbio.com/articles/article/15-Great-biological-discoveries-that-revolutionized-life-science#_Toc31005024)

[**RNAi (1998)**](https://www.goldbio.com/articles/article/15-Great-biological-discoveries-that-revolutionized-life-science#_Toc31005025)

**[CRISPR-Cas9 (2012)](https://www.goldbio.com/articles/article/15-Great-biological-discoveries-that-revolutionized-life-science" \l "_Toc31005026)**

## Inheritance/Evolution (1800s)

By now, the stories of Charles Darwin’s finches, Gregor Mendel’s peas, and Alfred Wallace’s wide traveling naturalist studies have become common lore both in and outside the world of biological sciences. But their long reaching conclusions helped to spur the explosion of growth in the area of biology for the last 170 years. And while it would take the discovery of DNA in the 1950s to sow the seeds of genetic evolutionary studies, we all owe a debt to these naturalist founders who laid the groundwork for many of the things we now take for granted while conducting our research.

## Antibiotics (1928)

Alexander Fleming wasn’t setting out in 1928 to revolutionize biological science when he discovered that something in Penicillium mold spores was able to kill staphylococcal bacteria in a petri dish. As is often the case in science, discoveries make remarkable impacts on research that are totally unrelated to the field they were created to help. Fleming was just trying to find a way to prevent anaerobic infections from being so deadly, not looking to find the world’s first antibiotic. But along the way, the discovery of antibiotics have been utilized in innumerable research, as selection tools in transformation and cell culture, as well as a host of other fields and studies.

## Gel Electrophoresis (1931)

It’s difficult to imagine any of my labs without the ever-present bench of gel rigs, either humming with the sound of electrical current, dutifully separating proteins, DNA or RNA; or sitting vacant and patiently waiting for another agarose or acrylamide gel. It is just as remarkable to realize that electrophoresis, as we know it, was discovered in 1931 by Arne Tiselius and even earlier work was done in the early 1800s that provided the groundwork for the Tiselius apparatus to differentiate between proteins. But it wasn’t until the 1940s that scientists started using gel matrices to separate compounds into discrete bands. And it wasn’t until the 1960s that gel electrophoresis would really be used to start identifying DNA and other biological molecules that would give birth to the field of molecular biology.

## HeLa Cell Discovery (1951)

The cervical cancer cells that were taken from Henrietta Lacks before she died in 1951 have become a benchmark in the history of cancer research and knowledge. The immortal HeLa cells made medical research easier, more robust and repeatable. The cell line is what allowed for the creation of Salk’s first polio vaccine in 1952. Since its discovery, there have been over 11,000 patents created involving the HeLa cells. It is safe to say that without Henrietta’s cells, a great body of research would have been slower and biomedical advancements a great deal more ponderous.

## The Structure of DNA (1952-1953)

As with the discovery of inheritance and evolution, the story of the discovery of the structure DNA is well known; starting with the Rosalind Franklin’s first image of the double helix in 1952 and then subsequently James Watson’s and Francis Crick’s model of the double helix structure in 1953. However, Oswald Avery had already identified DNA in 1944 as the primary point for hereditary information. But the structure of DNA cannot be overlooked for its relevance in our understanding of so much of what is now considered common knowledge in biological sciences.

## DNA Polymerase (1956)

In 1956, Arthur Kornberg and his lab forever changed the world of molecular biology with the discovery of DNA polymerase from E. coli cells. In one instant, scientists were now finally capable of synthesizing new DNA sequences onto an existing DNA strand. The use of the original DNA Polymerase and subsequent polymerases discovered by Arthur’s son, Thomas Kornberg, and others have created the bedrock of molecular biology in regards to PCR, cloning, transformation and sequencing. Without these workhorses of the lab, much of what we currently understand about our DNA and life would be nonexistent.

## Reverse transcriptase (1970)

Reverse transcriptase was independently discovered by both Howard Temin and David Baltimore in 1970. As a revolutionary tool, RT finally allowed scientists to synthesize cDNA (and double stranded DNA) from RNA, bridging the large gaps in knowledge of the character and sequence of RNA by use in PCR. Discovering the roots of RNA and its translation into proteins is a fundamental necessity of biology and the realization that RNA could be transcribed into DNA was paramount in the understanding of retroviruses and, later, antiviral drugs.

## Restriction enzymes (1970)

The first restriction enzymes were discovered in the early 1950s by Salvadore Luria, Jean Weigle and Giuseppe Bertani. But the enzymes they found were all type I enzymes that cleaved DNA randomly from a recognition site. In 1970, Hamilton Smith and associates discovered the more popular type II restriction enzymes that cleave at their site of recognition, and Daniel Nathans showed that by cleaving in those places, they could separate the fragments via gel electrophoresis in order to map the DNA. The use of restriction enzymes to produce a predictable cleaving pattern to work from has become a benchmark in cloning and mapping.

## *E. coli* transformation (1970)

Bacterial transformations have been around since the 1920s. Escherichia coli was being utilized as a model organism in microbiology and other biological fields for most of the 20th century, but was considered intractable to transforming until Morton Mandel and Akiko Higa were able to induce it to take up DNA with the use of calcium chloride. The discovery of artificially induced competent E. coli cells created one of the easiest and most efficient transforming bacteria which allows for even simpler cloning methods in all of biological science. The use of E. coli has only grown in popularity as one of the most common model organisms in science, and was one of the first organisms to be completely sequenced in 1997.

## PCR (1983)

Few discoveries have revolutionized their fields as much as polymerase chain reactions (PCR). Likewise, PCR owes its own revolution to the previously discovered thermally stable DNA polymerase. Prior to Kary Mullis’s work in reinventing an enzymatic assay to utilize a DNA template, primers and heat cycles (first described in the Journal of Molecular Biology in 1971 by Kjell Kleppe), cloning was slow and tedious. And even in the early days of PCR, the heat cycles would denature the polymerase, requiring it to be added anew every cycle. PCR may be the single most indispensable technique used in modern biology.

## Bioluminescent markers (1986)

Bioluminescence has been observed for millennia, but the understanding of its nature and the reaction that produces it remained a mystery. In 1955, Osamu Shimomura was the first to crystallize luciferin from ostracods, and was later instrumental in the discovery of GFP in jellyfish. Firefly luciferase was finally cloned in 1985, but the use of bioluminescence as a marker really began in 1986 when it was first utilized as a gene marker in both tobacco and Arabidopsis plants. And by 1988, it was being used in mammalian cell lysates as a prominent tool for in vivo studies of gene regulation. Bioluminescent imaging is still one of the most widely used applications in both in vivo and in vitro research in nearly every biological system.

## Gene Therapy (1990)

Gene therapy had been seen as science fiction for most of the 20th century; a nearly magical way to cure genetic diseases. In 1972, Theodore Friedmann and Richard Roblin first introduced the possibility that it might become reality someday, even if they believed that humanity needed to be extremely cautious about taking that giant leap into the unknown of genetic manipulation. But by 1990, William French Anderson was given permission by the US National Institute of Health to conduct a clinical trial for a patient with a severe immune system deficiency. Cancer gene therapy trials were approved by 1992 and many other genetic disease therapies have been conducted in the decades since. While gene therapy remains a miraculous opportunity for many of our worst genetic diseases, there is also much to be concerned with over its possible misuse and the ethics surrounding it.

## Fluorescent protein markers (1992)

Along with bioluminescence, fluorescent markers have made an unequivocal impact on research. Perhaps it is appropriate then that Osamu Shimomura would have been instrumental in discovering both. Green fluorescent protein (GFP) was first discovered by Osamu in jellyfish in the 1960s along with the blue aequorin protein. Later, Douglas Prasher utilized GFP and reported its genetic sequence in 1992, which allowed it to be expressed in E. coli in 1994 and later in C. elegans. The use of bioluminescent and fluorescent markers have let us visualize the mysteries of the cell, protein-protein interactions inside, outside and even in between cells. We can see how cancers react with cell lines or even inside the bodies of experimental animals. Due to the enormous range of colors that species have developed through evolution, we now have the capability to personally the magnitude of microscopic interactions that were only imagined before.

## RNAi (1998)

Scientists had been aware of a system of co-suppression or quelling for quite a while. Plant biologists had been aware that sometimes, overexpression of genes in plants to create more vibrant colors would unexpectedly produce plants with variegated color patterns or even no pigment at all.In 1998, Craig Mellows and Andrew Fire published their work documenting the intentional silencing of genes in C. elegans via a new process called RNA interference, in which they combined both a sense and anti-sense sequence of a gene. The process would evolutionarily be used to defend against viruses that try to insert themselves into the DNA. The use of RNAi has become critical in the development of gene expression and suppression, in identifying components of cellular processes, and as a practical tool in many other biological fields.

## CRISPR-Cas9 (2012)

CRISPR was first described, unknowingly, in 1987 by Yoshizumi Ishino. However, it wasn’t fully characterized as “Clustered Regularly Interspaced Short Palindromic Repeats” until 2001 by Francisco Mojica and Ruud Jansen. The magnificence of CRISPR as a gene editing tool finally came about when Jennifer Doudna and Emmanuelle Charpentier reengineered the Cas9 endonuclease and showed that the new system could be programmed to target any DNA sequence for cleavage. But the future, and real value, of CRISPR-Cas9 might lie far beyond its targeted gene therapy in a **variety of CRISPR adaptions.**

All of these discoveries have affected nearly every facet of biological science and have driven research into new and ever expanding directions. It is always amazing to look back and wonder at the greatness of all of these discoveries. At the time of these discoveries, these scientists saw their work as simply solving a problem on their bench in order to discover the answer to their particular project. Sometimes that is both the beauty and the pain of research, that the relevance of any particular result aren’t fully realized until years (or even decades) later. But we can be comforted that our research, even our [**research failures**](https://www.goldbio.com/articles/article/Publishing-Failure-in-Science), can be used to further the overall understanding of the world in which we live. And every discovery we make might be used by someone else down the research pathway to **Discover More**. Isn’t that what we are all really trying to do anyway?