HISTORY OF DNA

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Introduction

DNA (deoxyribonucleic acid) is a nucleic acid containing the genetic information that is used in the functioning and development of all living organisms. In fact, there were many researches dedicated to the study of DNA, and they helped bring the study to the present stage. All achievements in this branch of science have opened the door for the future revolution in the sphere of biological and medical science. The span of one hundred years since 1900 to 2000 can be considered as the century of the DNA study. In that time, three events happened that proved to be very important for the development of the DNA research. Nevertheless, the further development of the DNA study was predetermined by various factors and many scientists had made their contribution. However, the discovery of the DNA structure has been described in many ways by many historians of science; nevertheless, the story is the most significant and fascinating discovery of the 20th century biology. In fact, there are many figures that made a great contribution to the study of DNA. This paper is dedicated to the history of the DNA research, and it gives historical background of the key experiments and discoveries that have helped explain the structure and function of DNA.

Friedrich Miescher

Friedrich Miescher was the first person, who identified and isolated the nucleic acid. In 1869, when he was working with the pus cells at Tubingen, he made his first discovery. It was known that such cells were made largely of protein; however, the scientist noted the presence of something that cannot be considered any of known protein substances. Miescher managed to demonstrate that it was not a protein, because there was no effect by the protein digesting enzyme pepsin. Besides, he showed that this new substance came from the nucleus of the cell, and consequently he named it nuclein.

Miescher showed that nuclein can be obtained from other cells with phosphorus together with usual organic molecules such as hydrogen, nitrogen, carbon, and oxygen (Dahm 2005). In 1871, Miescher's work was published by Hoppe-Seyler that wanted to confirm his findings. In this paper, Miescher announced that a non-protein phosphorus contained molecules present in the nuclei of a large number of cells.

However, the role of the molecule in the cell and the structure of the nucleic acid (it was renamed by Richard Altmann in 1889) were not revealed until 1953. They were described by Francis Crick and James Watson. In turn, Miescher continued to study the nuclein that was extracted from the sperm of the Rhine salmon. Moreover, he was working on it for the rest of his short life. He spent much time on chemistry of fertilization. He even asserted that if one wants to assume that a single substance was the cause of fertilization, one should go to nuclein. However, Miescher has not followed his own suggestions, and preferred to explore a physical model of fertilization. Nevertheless, his work was taken up by other scientists. In fact, Friedrich Miescher made a great contribution to the study of the DNA structure. Moreover, his work was a fundamental one; today, it is considered one of foundational principles of biology (Dahm 2005).

Gregor Mendel

A monk teacher and biologist, Gregor Mendel, is known today as the father of the modern genetics. His experiments were fundamental, and they established the field of modern genetics. In 1854, he began to study the transmission of the heredity traits in the plant hybrids. However, at the time of his researches, it was a commonly accepted fact that the heredity traits of the offspring were

the blending of the hereditary traits of their parents. Another fact that was generally accepted was that a hybrid would return to its original form; therefore, it was believed that the hybrid could not create a new form. However, the results of such studies usually were skewed by relatively short period of time (Yon 2009). The scientist conducted experiments that helped explain many processes and phenomena. Mendel had been conducting his research for over eight years from 1855 to 1863; it involved thousands of plants.

He used peas for his experiments, because there were varieties of this plant, and the offspring could be got easy and quickly. Mendel has cross-fertilized the pea plants that had opposite features – wrinkled with smooth, short with tall, plants that contained yellow seeds with those that contained green seeds. Hence, after having analysed his experiments, he established the two most important of his theories: the Law of Segregation and the Law of Independent Assortment. According to the theory of the Law of Segregation, there are recessive and dominant traits that are passed in a random way from parents to offspring. Concerning the Law of Independent Assortment, he has established that some traits are passed independently from the other traits from parents to offspring (O'Neil 2013).

In 1865, the Natural Science Society published results of Mendel's studies in its journal. The title of the article was "Experiments on Plants Hybrids." However, a few references from that time period indicate that Mendel's study was misunderstood. It was generally believed that Mendel had proved only what was already commonly known at that time – hybrids reverted to their original form. Moreover, his studies were not considered generally applicable. However, eventually, his system was proved to be generally applicable; now, it is the foundational principle of biology.

Frederick Griffith and Oswald Avery

Another important figure that made a contribution to the study of DNA structure was an army medical officer, Frederick Griffith. In 1928, he tried to find a vaccine against streptococcus pneumonia; however, instead of it, he made a breakthrough in the world of heredity. His experiments were quite simple; he injected bacteria into mice. He performed the first experiment, which suggested that protein was not a genetic material. First of all, he injected mice with a live strain of virulent bacteria, and mice died. Then, Griffith killed the bacteria cells by heating them, and injected these bacteria to mice, and mice did not die. In another set of mice, he injected a live non-virulent strain of bacteria, and these mice also did not die (O'Connor 2008).

However, the surprise came when he injected a set of mice with the heat-killed bacteria and both live non-virulent bacteria as some mice in that group died. Then Griffith examined the dead mice and found the live virulent bacteria in their blood. Therefore, Griffith made the conclusion that the genetic information in dead bacteria survived the heating and in some way incorporated into the genetic material of the non-virulent strain that made them virulent. Nevertheless, he knew that the heating process denatured protein; therefore, he suggested that the genetic material had to be something else. However, Griffith's experiment did not specifically point out DNA as a possibility (Carter 2004).

Oswald Avery followed up Griffith's experiments in the following decade. As well as Griffith, Avery used heating to kill virulent bacteria. Next, he extracted from dead cells all possible candidates for carriers of genetic information such as RNA (ribonucleic acid), DNA, lipids, carbohydrates, and proteins. Then, he added molecule of each to a culture of the living non-virulent bacteria, to estimate which of them was responsible for changing them into the virulent bacteria. Therefore, Avery concluded that only DNA was responsible for this change; hence, it was considered the genetic material.

Erwin Chargaff

In fact, Chargaff made one of the most important contributions to biochemistry, and it was his work with DNA. At that time, it was not known that genes consisted of DNA. Instead, it was commonly accepted that the twenty amino acids, which made the protein in the cell, were the carriers of the genetic information. Scientists believed that there were many amino acids in the cell, which could form a sufficiently complex basis for the gene. However, in 1944, Avery showed that DNA was a key component in the biological transformations (McCarthy n. d.).

Nevertheless, the two major facts about DNA were already known. The first was that it was present in nucleus of every living cell. Another fact was that DNA was composed of four nucleobases: guanine, adenine, thymine, and cytosine.

Chargaff conducted a series of experiments in order to test the idea that DNA might be a primary constituent of the gene. Then, he isolated DNA from nuclei and separated it into its nucleic acids. Next, he used paper chromatography in order to separate the pyrimidines and the purines. He then exposed the two components to the ultraviolet light. Due to this fact, he was able to determine how much of which substance were in DNA. He concluded that the amount of adenine always equalled to thymine, so did guanine and cytosine; however, the proportion between the two pairs is different depending on the organism. Therefore, Chargaff came up with a conclusion that it was DNA in nucleus of the cell that carried genetic information rather than protein. He also realized that there suppose to be different types of DNA molecules as there were numerous species. In fact, his conclusions made a breakthrough in the biological science (Lichtenstein 2008).

Rosalind Franklin and Maurice Wilkins

Rosalind Franklin and Maurice Wilkins were the first, who obtained good x-ray diffraction image of the DNA fibers. However, at the time, there was little known about the DNA structure. Nevertheless, on those images, there were needed patterns for the determination of position of the DNA molecule's atoms. With the help of these photos, Franklin determined that the DNA molecule was long and thin (Pray 2008).

However, all these study began in 1950 when Maurice Wilkins started to study DNA. He worked closely with the mathematician, Alec Stokes, and the PhD student, Raymond Gosling. Together they started to produce the first crystalline diffraction patterns. At the beginning of the study, Wilkins was convinced that a clear crystalline could be readily pursued. At the conference in Naples, Wilkins showed a slide of their studies that made people realize that the structure of DNA was possible to study (O'Connor 2008).

In 1952, Rosalind Franklin joined to Wilkins to work on the x-ray diffraction experiments on DNA. The scientists required a professional crystallographer for further study, but they split because of a mutual misunderstanding. Franklin continued to work on the x-ray diffraction of the A Crystalline Signer DNA. Meanwhile, Wilkins was working on the B form without access to Signer that was a very poor form of extracted DNA from the calf thymus cells. However, both teams worked effectively in isolation. Their contribution to the study of DNA is doubtless; however, in all perspective they could have made even more success together. Nevertheless, these studies helped establish and develop other theories that were relevant to the DNA structure research (Ardell 2009).

James Watson and Francis Crick

In the early 1950s, there was a race for discovery of DNA. As it was mentioned above, Rosalind Franklin and Maurice Wilkins were studying DNA at King's College in London. Meanwhile, at Cambridge University, just graduated student Francis Crick and his friend James Watson became interested in the study of DNA. However, Maurice Wilkins and Rosalind Franklin worked on the experimental approach, and they were looking at x-ray diffraction image of DNA. On the other hand, Watson and Crick wanted to make physical models in order to narrow down the possibilities and finally create a picture of the molecule (Smith 2008).

In 1951, Watson attended Franklin's lecture on her work. By that time, she had found that DNA could exist in two forms, and it depended on the relative humidity in the air, which surrounded it. Furthermore, it helped her deduce that a phosphate part of the molecule was on the outside. In fact, Watson was critical on her way of lecture performance and appearance, and that was why he had a rather muddy recollection of the facts presented by Franklin. However, based on this information, Crick and Watson made a failed model (Roberts 2010); moreover, it caused the head of their unit to stop DNA study, but the material just kept coming up.

In that time, Franklin found out that the x-ray diffractions indicated that the humid form of DNA, in the higher moisture, had all the features of a helix. She thought that all DNA had helical form, but she did not want to announce it until she had reasonable evidence. However, Wilkins showed Franklin's results to Crick and Watson. They decided to make a crucial conceptual step; they considered Franklin's finding that the molecule was made of two chains, and each of them had a helix form, but one went up, and another went down (Johnson n.d.).

However, in 1952, they just learned about Chargaff's studies about the base pairs. They added it to the model; therefore, the base pairs were interlocked in the middle of the double helix in order to keep distance between the chains of constant.

Watson and Crick have showed that each strand of the DNA was a template for the other. During cell division, the two stands separated and, on each strand, a new other half was built. In such way, DNA can reproduce its structure except for mutations, or occasional errors.
These findings were very important to biology. Moreover, the structure so perfectly fit the data that it was almost immediately accepted. In fact, the finding of DNA was called the most significant work in the sphere of biology. In 1962, Crick, Watson, and Wilkins were awarded the Nobel Prize for psychology medicine; by that time, however, Franklin died, and the Nobel Prize went only to alive recipients.

Arthur Kornberg

Arthur Kornberg is also known for his study of DNA; he succeeded in the unraveling coenzyme synthesis, which was discovered by him in the 1950s and established him as a biochemist. It also has been suggested that the other nucleic acids, DNA and RNA, could be synthesized in the same way. He started his study in the same year as Watson and Crick, and just like others, he tried to work on the structure of DNA. DNA has been shown to be the stuff of the genetic inheritance. Thanks to Erwin Chargaff and other scientist, its chemical composition was known. Chargaff, in turn, had noted that the amount of cytosine and adenine was always equal; the amount of guanine and thymine was also equal in any given DNA samples.

However, nobody cared for how cells actually made DNA (Kresge n. d.).

Since his first study on the functioning of the enzymatic synthesis of inorganic and coenzymes pyrophosphate, Kornberg had been interested in the synthesis of the nucleic acids, namely DNA. After the explanation of pyrimidines and purines nucleotide synthesis, he discovered the enzyme that made the building blocks into DNA, and it was named the DNA polymerase. This class of enzymes makes DNA; besides, it is essential in the replication, rearrangements, and repair of DNA. As a result, a lot of other enzymes of the DNA metabolism were found due to the start and elongation of the DNA chromosomes and chains. These enzymes were fundamental for further study of the DNA recombination; moreover, it helped ignite a revolution in the sphere of biotechnology (Kresge n. d.).

In 1991, however, Kornberg switched his study from the replication of DNA to inorganic polyphosphate. Nevertheless, Kornberg made a great contribution to the study of DNA; it is doubtless that his study was a breakthrough in the sphere of biotechnology.

Marshall Nirenberg

Nirenberg is also known for his work with DNA, namely solving the genetic code. He established the rules, according to which DNA transferred genetic information in proteins, the working parts of cells. The code is considered the basis of life, the solving of it was the turning point in the history of biology (Simons 2013).

He identified the codons in detail, which were sequence of three chemical units of DNA that specified each of twenty amino acids, with which protein molecules are constructed. The achievement

that he made in 1961 was very significant. He conducted an experiment to study which triplet corresponded to which amino acid. Nirenberg was a really amazed biologist. With his research fellow, the German scientist, Johann Heinrich Matthaei, he developed their identification of the first codon. He really surprised the scientific world, because he was only thirty-one at that time (Simons 2013).

However, it was not the end, and he made even bigger surprise when he beat out the famous scientists when he identified the other sixty-three codons in the genetic code. In 1968, he was awarded the Nobel Prize in Physiology (Medicine); two other scientists shared the Nobel Prize with him. It is doubtless that Dr. Nirenberg was an amazing mind, and his contribution to the study of DNA was very significant.

Conclusion

To sum up, there were many studies dedicated to DNA, and all of the above-mentioned figures have influenced the development of the studies. However, all the information that scientists have today was gained, because of the abovementioned scientists. In fact, each of them made his/her unique contribution to the study of DNA, but together their study made the full image of the today's knowledge about DNA. As it was mentioned above, all achievements in this branch of science had opened the door for the future breakthrough in the sphere of biological and medical science. There is no doubt that the span of one hundred years from 1900 to 2000 can be considered as the century of the DNA study, and it was revolutionary in the sphere of medicine. In fact, the story is the most significant and fascinating discovery of the 20th century in biology. All scientists that were covered in this paper have carried out experiments and made discoveries that now help explain the structure and functioning of DNA.

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