ibc Interdisciplinary Bio Central

Open Access

IBC 2013;5:4, 1-3 • DOI: 10.4051/ibc.2013.5.2.0004

ESSAY

Development of Information Biology (II)

Yoshio Tateno*

School of New Biology, Daegu Gyeongbuk Institute of Science and Technology, Daegu, Korea

Subject areas; Bioinformatics/Computational biology/Molecular modeling

Author contribution; Y.T. wrote this article.

***Correspondence** and requests for materials should be addressed to Y.T. (yt.tateno@gmail.com)

Editor; Hong Gil Nam, Daegu Gyeongbuk Institute of Science and Technology, Korea

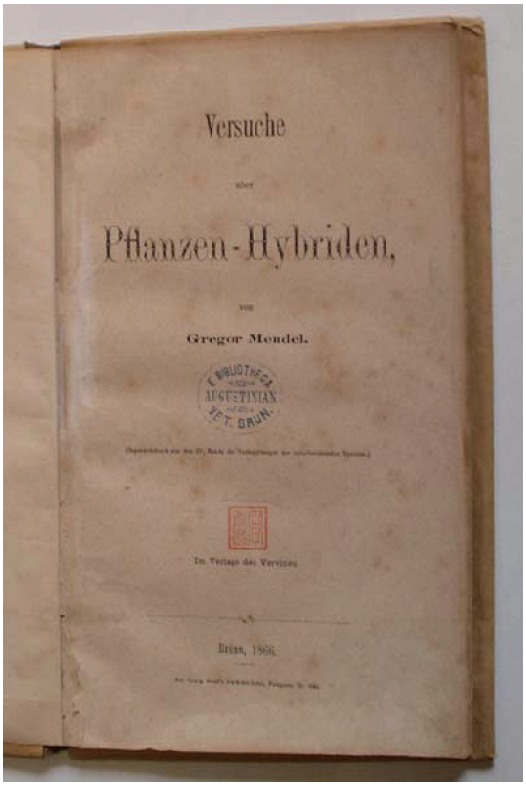
Received April 22, 2013
Accepted May 06, 2013
Published May 06, 2013

Citation; Tateno, Y. Development of Information Biology (II). IBC 2013, 5:4, 1-3. doi: 10.4051/ibc.2013.5.2.0004

Competing interest; All authors declare no financial or personal conflict that could inappropriately bias their experiments or writing.

SYNOPSIS

A history of discoveries of a gene and DNA was viewed with respect to people, time and places. It started with G. Mendel and J. Meisher, who discovered a gene in a plant species in 1866 and DNA in animals in 1869, respectively. With recognition that DNA was a chemical substance, A. Kossel identified the four chemical components of DNA without knowing their biological function around the turn of the 19th century. On the other hand F. Griffith found a peculiar activity in a bacterial species in 1928, but victimized by the war before understanding what it was. Those discoveries were made in Europe, but they were still fragmentary. Then, in USA, O. T. Avery, A. Hershey, M. Nirenberg and other scientists organized the European discoveries and elucidated their coordinated biological functions in 1950's and 1960'.



Key Words: gene; DNA; bacterial transformation; phage; genetic code

Now let us trace back to the discoveries of gene and DNA, because they are basic materials in information biology.

In 1866 Gregor Mendel in Heinzendorf bei Odrau (now Hynčice, Czech Republic) published his one and only paper, "Experiments in plant hybridization" (see Figure 1), in which he showed his discoveries of a gene and the law of inheritance. If you read his paper, you would be convinced that he was not a biologist but an interdisciplinary scientist. On the basis of the combined knowledge of biology, statistics and mathematics he could predict and derive the law.

Three years later in 1869 Johan Meischer, who worked under the guidance of Ernest Hoppe-Sayler at Greifswald in Strasburg succeeded in isolating a substance from leukocyte of the pus of discarded surgical bandages, and named it "nuclein", which R. Altmann renamed "nucleic acid" later. Hoppe-Sayler may be the first biochemist, who had the idea that life was chemical reactions and solved by chemistry. After coming back to his native place, Basel, Switzerland, Meischer kept on working on nuclein that he then isolated from salmon sperms. However, he switched his research interest from it to protamine, a protein found in the sperm. That was because he was contested by researchers in Germany, France and England who did not believe the existence of nuclein in the nucleus on baseless ideas. In 1885 Meisher suffered from pleurisy and died of it at the age of 51 years old. In his obituary, C. Ludwig (Meisher's former teacher) stated "… as men work on the cell in the course of the following centuries, your name will be gratefully remembered as the pioneer of this field.", and he was right.

There was another young researcher working under Hope-Sayler, Albrecht Kossel. He was interested also in nulein for its chemical components, and finally succeeded in identifying the four components, Adenine (A), Thymine (T), Guanine (G) and Cytosine (C) in the period from 1885 to 1901. For that achievement he won the Nobel Prize for Physiology or Medicine in 1910. Actually, Kossel was influenced by Emil Fischer, who received the Nobel Prize for Chemistry in 1902 on the recognition of the discovery and synthesis of purine and the derivatives. It was known by then that DNA was composed of just four components or written by four letters, so simple in spite of controlling complicated biological functions. We have so many letters in our own languages, but often face difficulty in communicating with others including spouses. The letters were found, but how were they used for? Remember that by that time there was no connection found between a gene and DNA. Mendel and Meisher were contemporary to one another, and worked at places not too far from each other, but they were too early to enjoy the international communication and the Nobel Prize.

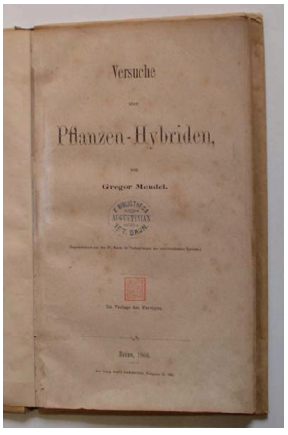

Versuche
über
Pflanzen-Hybriden,
von
Gregor Mendel.

Figure 1. Mendel's one and only paper published in *Proceedings of the Natural History Society of Brünn* in 1866. This is one of the first copies kept in National Institute of Genetics, Japan.

In 1928 Fred Griffith published a paper about the bacteria, *Pneumococcus*, which was the causal agent of pneumonia[1]. In the paper he stated that there were two types of them, one is virulent (S) and the other was non-virulent (R), and when cultivated them together R was transformed into S. He named that the bacterial transformation. He was a typical scientist, who devoted only to pursuing experiments and publishing a paper but never to presenting his paper at a public meeting. In 1941 while he was working in his laboratory in London, he was killed by a bombard by the German air force. His unfinished problem was to identify the agent that transformed from S to R. The problem was taken over to another bacteriologist and his colleagues over the Atlantic Ocean.

Oswald Avery and his colleagues worked on identifying the agent that caused the bacterial transformation at the Rockefeller Institute in New York during the Second World War. It is said that Avery paid a sincere respect to Griffith and put his photograph on the desk of the laboratory. They then published a paper in 1944 in which they proved that the transforming agent was DNA[2]. They at last connected Mendel and Meisher. In retrospect, we may exclaim, "that's it, and their work is worth the Nobel Prize." But, in reality, that was not so. Their paper was subject to the strong opposition that such a simple substance could not be responsible for inheritance that was quite complicated, or that protein instead of DNA was the agent for the transformation. Those oppositions were again baseless. Another unfortunate situation against them was that the paper was published in the wartime, which prevented it from international circulation. The next problem thus was to eliminate the possibility of protein involvement.

In 1915 Frederick Twort of the University of London discovered bacteriophages (or phages) that infected bacteria. They do not have the replicating mechanism, and thus infect bacteria in which they borrow bacteria's mechanism to replicate. Then in 1940's Max Delbruck and his colleague opened the Phage School at the Cold Spring Harbor Laboratory in New York and educated students and researchers the use of phages in experiments. It is said that the Phage School opened the new field, molecular biology. When I was invited to give a lecture at a ses-

sion of the HUGO conference in the laboratory in 1995, I walked around there to find the place where the Phage School was held, but could not find it. In any event, Alfred Hershey perhaps was one of the trainees in the school.

Hershey and Martha Chase worked on phage infection to bacteria by using a Waring blender, a blending tool. It was known by then that a phage attached on a bacterial cell wall and injected its DNA only into its inside where three activities were triggered; the first was to replicate the DNA itself, the second was to synthesize its coat proteins by using the information on the DNA, and finally many progeny phages were formed and burst out of the poor bacterium. In the first two activities the bacterial mechanisms were used without permission. Therefore, their idea was to put the phages and bacteria together in a Waring blender, and blending them strongly, and separate a phage just finished the injection (or the protein coat) from the bacteria into which the phage DNA was injected. In that way they showed that those phages formed inside the bacteria depended only on their parental DNA, and eliminated the possibility of parental protein involvement[3]. Avery's nightmare was over, and Hershey shared the Nobel Prize for Physiology or Medicine in 1969 with M. Delbruck and S. Luria.

When Marshall Nirenberg, Her Khorana, Robert Holly and Severo Ochoa found the genetic code in 1960's, the role of the four letters of DNA was elucidated[4]. They thus connected DNA and protein through the genetic code. For that discovery, the first three scientists won the Nobel Prize for Physiology or Medicine in 1968. The genetic code is common to all organisms in viruses, bacteria, plants and animals. This fact reminds us that all organisms ever existed and exist now on the earth have been diverged from the common ancestor in evolution in the past 3.5 billion years.

It is noted that those discoverers used or devised simple experimental tools only, but made their brains work hard. It is also reminded that there were many failures behind the scene.

The journey of discovery from Germany to England to USA has reached the oasis where we enjoy the fact that the basic unit of information biology is the four letters of DNA.

REFERENCES

1. Griffith, F. (1928). The Significance of Pneumococcal Types. *The Journal of Hygiene* 27, 113-159.
2. Avery, O. T., Macleod, C. M., and McCarty, M. (1944). Studies on the Chemical Nature of the Substance Inducing Transformation of Pneumococcal Types: Induction of Transformation by a Desoxyribonucleic Acid Fraction Isolated from Pneumococcus Type Iii. *The Journal of Experimental Medicine* 79, 137-158.
3. Hershey, A. D., and Chase, M. (1952). Independent functions of viral protein and nucleic acid in growth of bacteriophage. *The Journal of General Physiology* 36, 39-56.
4. Leder, P., and Nirenberg, M. W. (1964). Rna Codewords and Protein Synthesis, 3. On the Nucleotide Sequence of a Cysteine and a Leucine Rna Codeword. *Proceedings of the National Academy of Sciences of the United States of America* 52, 1521-1529.