GENETICS

In the Beginning—DNA

Less than 20 years ago biologists discovered DNA was involved in the genetic code. Progress has been made toward daring experiments in human heredity, Faye Marley reports.

➤ THE MOST DARING EXPERIMENTS in human heredity lie ahead as the consequence of breaking the genetic code. The two hereditary materials, DNA and RNA (deoxyribonucleic acid and ribonucleic acid) are involved in the "reading" of the code, which may make possible the correction of hereditary diseases and the cure of cancer in the distant but foreseeable future.

Before life began, scientists tell us the stuff of life (DNA) was probably in the waters of the shapeless world.

Its connection with heredity remained unrecognized, however, until 1944 when a group of scientists at Rockefeller Institute discovered that this nucleic acid was the transforming substance of pneumococci, and proved conclusively that DNA was genetic material.

Since then DNA and its sister nucleic acid and messenger, RNA, have been conspicuous in the news. Nobel prizes have been awarded for work in this field, including synthesis of the two acids.

But it was not until last August in Moscow, during the International Biochemical Congress, that scientists got the important news that the genetic code had been cracked.

Credit for "reading the first words" of the code in 1961 went to two young scientists, Drs. Marshall W. Nirenberg and J. Heinrich Matthaei from the National Institute of Arthritis and Metabolic Diseases, Bethesda, Md.

Future Implications Focused

An interview with Dr. Nirenberg in his laboratory brings the work and its future implications into focus. (Dr. Matthaei, who is a plant physiologist, has left the National Institutes of Health to return to Germany, where he will work at the University of Tubingen.)

"We built on the work of others," Dr. Nirenberg told SCIENCE SERVICE. "But for 20 years in the field of molecular biology scientists have been puzzled by two questions that blocked their progress: 1. What is the genetic code? 2. What is the method of turning genes off and on? (This refers to the induction or repression of enzymes.) Protein synthesis has been so complicated up to now that we could not work in a completely cell-free system."

The two life builders, DNA and RNA, which are present in every cell, are similar in composition, but different in their biological function.

DNA, the gene substance, synthesizes messenger RNA to carry genetic information to the ribosomes (small particles between cells where proteins are sythesized). The ribosomes are found both in the nucleus and in the cytoplasm surrounding it.

DNA can be obtained chemically by extraction from viruses and bacteria as well as from such materials as wheat germ and calf thymus gland. It can be crystallized as sodium DNA or kept in liquid state.

DNA is composed of sugars and phosphoric acid groups to which four nitrogen bases—adenine, thymine, guanine and cytosine—are attached.

RNA's job as a biochemical middleman, Dr. Nirenberg explained, is dependent on its own bases, which are slightly different from those of DNA. One of the differences is that uracil is substituted for thymine. The sequence of these four bases determines how some 20 different amino acids will be linked to form specific protein molecules.

Drs. Nirenberg and Matthaei used bacterial *(Escherichia coli)* solutions containing the 20 amino acids, adenosine triphosphate (ATP), ribosomes and cytoplasmic fluids. *Escherichia coli,* commonly found in the intestines, has up to now been unstable but the scientists added a reducing agent, mercaptoethanol, which stabilized the organism.

Then they added polyridylic acid (poly-U), a synthetic RNA containing only the base uracil, with the result that only one amino acid, phenylalanine, out of all the available 20 was incorporated in the polypeptide (amino acid chain). Only "single-stranded" RNA fibers were found to be active in the system.

Since a minimum of three bases is believed needed to impart the necessary information for the use of any one amino acid, uracil-uracil-uracil, or U-U-U, contains information for using phenylalanine.

Dr. Nirenberg said that with this cell-free system it seems likely that any type of protein can be made corresponding to a meaningful informational RNA. He knows which bases are involved in the coding units for 15 of the 20 amino acids.

Dr. F. H. C. Crick, of Cambridge, England, who with the American scientist, James D. Watson, announced the DNA coil, or helix, in 1953, said that Nirenberg's and Matthaei's discovery meant the beginning of the end of an era in molecular biology.

"From now on," said Dr. Crick, "we shall have to study the more intricate parts of cell biology. The most immediate problem is that of gene control." Dr. Crick went on to say technical difficulties would be overwhelming.

"I agree with Dr. Crick," Dr. Nirenberg said, "except that I do not believe the future work will be overwhelming."

Dr. Nirenberg was asked what he, as a basic scientist, thought of the possibilities for using the genetic code to improve life.

"I believe we have laid the foundation for uses undreamed of," he answered. "No one could foresee the ultimate uses of elec-

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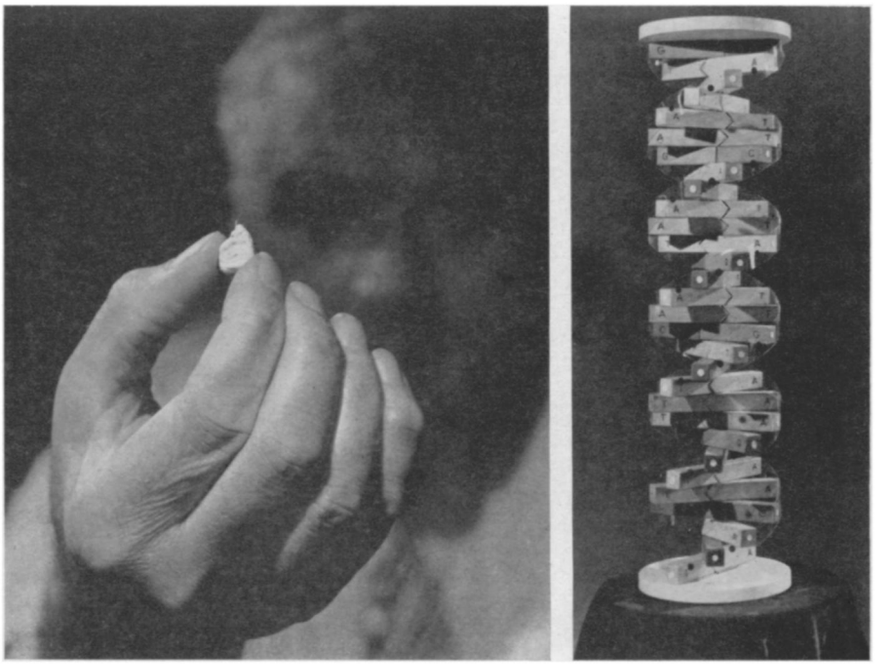

STUFF OF LIFE—The wad of DNA, or deoxyribonucleic acid (left), is the substance that holds the pattern of life. The model on the right shows the DNA double helix, or coil, with the four nitrogen bases.

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Sciences. Vol. 4. Biologically Oriented Fields: Their Place in Psychology and in Biological Science—Sigmund Koch, Ed.—*McGraw*, 731 p., illus., $12.50.

REPORT OF THE COMMITTEE ON ENVIRONMENTAL HEALTH PROBLEMS to the Surgeon General—Paul M. Gross, Chmn—*PHS (GPO)*, 288 p., paper, $1. Review of programs and recommendations on toxicology, air pollution, food protection, occupational health, radiological health and water pollution.

THE SCIENCES AND THE ARTS: A New Alliance—Harold Gomes Cassidy—*Harper*, 182 p., illus., $4.75. Yale Professor of Chemistry examines some complementary aspects of the arts and sciences.

THE SCIENTIFIC RENAISSANCE, 1450-1630—Marie Boas—*Harper*, 380 p., illus., $6. Describes the early stages of the scientific revolution which opened the physical universe to cumulative explorations.

SMOKING AND HEALTH: Summary and Report of The Royal College of Physicians of London on Smoking in Relation to Cancer of the Lung and Other Diseases—*Pittman*, 70 p., paper, $1. See story, SNL March 24, 1962, p. 181.

THE STORY OF A NATURAL HISTORY EXPEDITION—Russell Francis Peterson—*Doubleday*, 56 p., illus. by author, $2.95. Pictures a museum search for rare animals in New Guinea, for young readers.

SUCCESSFUL MINERAL COLLECTING AND PROSPECTING—Richard M. Pearl—*New Am. Lib.*, 164 p., illus., paper, $2.95. Well-illustrated guide for prospector and hobbyist.

THE THINKING MACHINE—John Pfeiffer—*Lippincott*, 242 p., illus., $5.95. Story of the electronic computers that run factories, figure bank balances, place long-distance phone calls, analyze cancer cells and brain waves, and translate languages.

A TREASURY OF WORLD SCIENCE—Dagobert D. Runes, introd. by Wernher von Braun—*Philosophical Lib.*, 978 p., illus., $15. Anthology of samples from the lucid writings of pioneering scientists, from Agricola to Volta and from Archimedes to Niels Bohr.

TREE GROWTH—Theodore T. Kozlowski, Ed.—*Ronald*, 442 p., illus., $12. Reference work on the main aspects of the nature, control and measurement of the growth of trees.

WINTER TWIGS—Helen M. Gilkey and Patricia L. Packard—*Ore. State Univ. Press*, 109 p., illus. by authors, $2.50. Wintertime key to deciduous trees and shrubs of northwestern Oregon and western Washington.

THE WORLD OF ICE—James L. Dyson—*Knopf*, 305 p., photographs, maps, $6.95. Geologist describes the world of permafrost, glaciers, icebergs, climate changes, and man's explorations.

• Science News Letter, 81:268 April 28, 1962

GENERAL SCIENCE

97% of Fair Participants Plan Science Careers

➤ YOUNG PEOPLE soon to exhibit their outstanding science projects at the 13th National Science Fair-International to an extent of 97% are planning their futures in science. Only two percent look forward to careers in fields outside of science, while one percent have made no choice at all, based on the first 200 of an expected 400 entries.

The medical sciences attract the largest number. Almost a quarter, 24%, of the teen-aged finalists plan to enter medicine. Engineering attracts 14%, biological sciences 13%, and physics 12%.

Future teachers among the finalists who plan to combine teaching with their professional specialties account for 9%.

Chemistry and mathematics each will claim 7% of the total, while unspecified fields of science and research are in the futures of 11% of the young scientists.

The National Science Fair-International is conducted by SCIENCE SERVICE, Washington, D. C. This year the event is being held May 2-5 in connection with the Seattle World's Fair.

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tricity at first, or even now. We believe the genetic code may eventually help cure hereditary defects and make cancer less mysterious."

"If we can find out how genes are activated and deactivated," he said, "we can know how cells differ from each other. We can find out why the cancer cell is different from the normal cell, and in the far future this knowledge may be used to cure thousands of people who have cancer."

"Within a year we should be able to use synthetic genes. Many problems remain, but most of them have been solved. We have evidence that the genetic code is partially universal. The similarities are strong."

At Sloan-Kettering Institue, New York, Dr. Ellen Borenfreund, who with Dr. Aaron Bendich first isolated DNA in a chemically intact form from human and other mammalian sperm, reported that their work is in very early research stages.

"We have not even been able to get the nucleic acid into the egg yet," she said.

Searching questions remain before experiments with the living organisms can attain the results dreamed about. There are skeptics such as Dr. Erwin Chargaff, professor of biochemistry at Columbia University, who challenge the prevailing view that a chain of biologic information universally exists.

But the fairy tale picture painted by some geneticists and biologists who forecast future achievements because of present accomplishments is no more fantastic than the developments following the Curies' discovery of radium.

Dr. Thomas M. Rivers of the National Foundation says the fact that we have reached the point where we can study life in terms of molecules is a marker in history that is likely to bear more weightily on human destiny than the hydrogen bomb or rockets in space.

When man can manipulate the nucleic acid in the cells of intact living bodies, Dr. Rivers believes, he can determine to some degree, yet immeasurable, what kind of human beings will inhabit the earth.

• Science News Letter, 81:263 April 28, 1962

Bee colonies die within 24 hours when no water is available and air temperatures exceed 100 degrees Fahrenheit.

The U.S. Department of Agriculture has established a Boll Weevil Research Laboratory at State College, Miss., to develop improved methods of *boll-weevil* control.

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