THE KEY AND THE LOCK

Transfer-RNA deciphered

In April 1953, after a year and a half of thinking and tinkering in laboratories and coffee shops at Cambridge University, James Watson, Francis Crick and Maurice Wilkins announced the structure of DNA (deoxyribonucleic acid), the large and complex molecule in which heredity resides.

Discovery of the double helix thrust molecular biology headlong into the forefront of research which has since produced profound insights into the function of DNA and RNA (ribonucleic acid), the molecule that carries the coded message for protein synthesis from DNA to manufacturing plants in the cell.

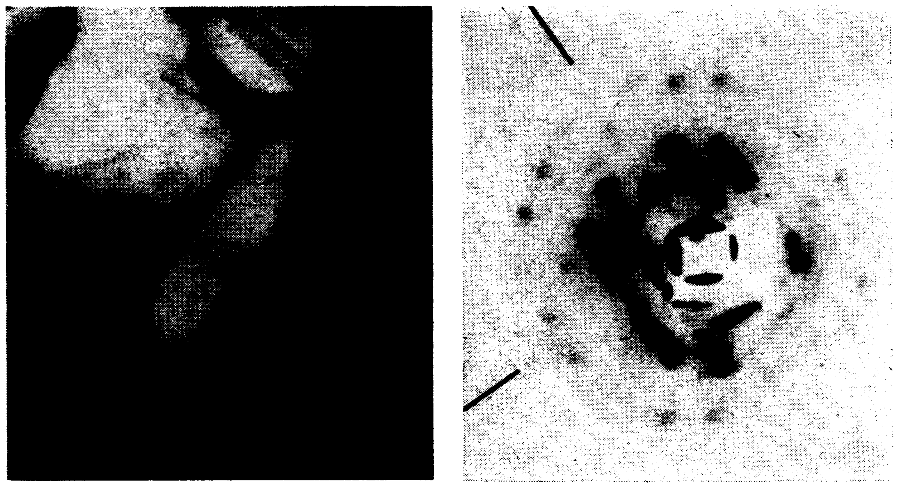
But for all that is known, nucleic acid research is really just beginning. Detailed understanding of the process that begins with DNA and ends with a newly made protein, and, in fact, confirmation of the double helix—postulated by fitting limited evidence to theory—requires atom by atom blueprints of the architecture of nucleic acids.

One of the best methods of deciphering three-dimensional structure—one which has been used successfully with proteins—is X-ray crystallography. Penetrating X-rays bounce off atoms within molecules, producing a scatter pattern that shows just where each atom is positioned. Evidence that DNA is a double helix came from crystallographic work, but because the Cambridge group studied DNA fibers, rather than pure crystals, they got only two dimensional information.

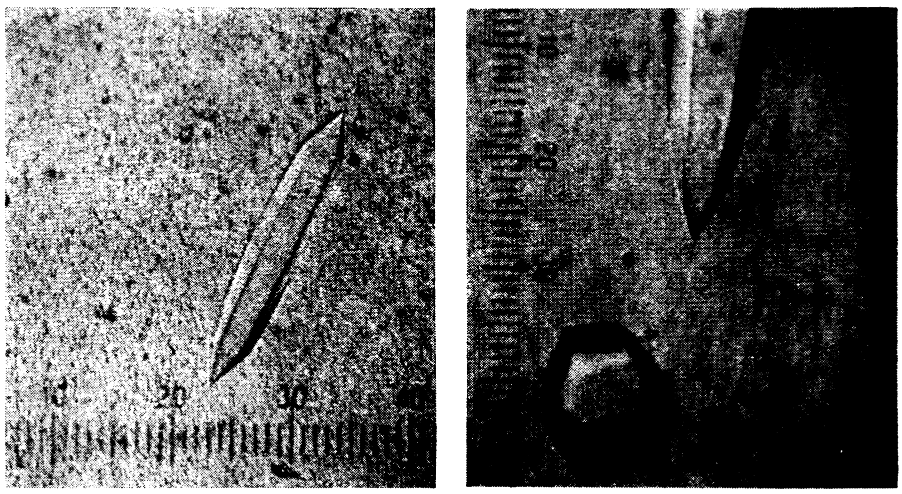
So far, DNA crystals have not been obtained, but researchers in Massachusetts and Wisconsin have produced the first pure crystals of a nucleic acid with crystallization of transfer-RNA. Now, with a minimum of difficulty, X-ray crystallographers will be able to reveal the architecture of this clover leaf molecule, the molecule that picks up protein-making instructions from messenger RNA, retrieves the appropriate protein-building amino acid from the cytoplasm and transfers it to ribosomes—the manufacturing plants. Knowing its crystalline structure is a first step to solid understanding of its function.

"Once we know its structure," says Dr. Alexander Rich of the Massachusetts Institute of Technology, "we'll know which of its surfaces are exposed, how they're constructed and how they fit into the molecules with which they interact."

While DNA and m-RNA molecules are thought to be in linear arrangements when carrying out their biological functions, t-RNA is thought to maintain its convoluted shape while at work.



Crystals, X-ray pattern of one form of bacterial tRNA obtained at MIT.



Another form of bacterial tRNA, grown at Wisconsin from Escherichia coli.

Dr. Rich, who with Dr. Sung-Hou Kim reported t-RNA crystallization in the Dec. 20 issue of SCIENCE, compares t-RNA to a key that fits into a lock—in this case, ribosomes and molecules known as activating enzymes. "The shape of the key will tell us the shape of the lock. We'll learn the mechanism for the essential step in protein synthesis, the transfer of genetic information."

Difficulty in crystallizing a nucleic acid, long an aim of researchers, "may be due to the lack of a systematic approach to crystallization which is still as much an art as a science," observes Dr. Arnold Hampel who, with associates at the University of Wisconsin in Madison, also reports t-RNA crystallization in the Dec. 20 SCIENCE. Transfer-RNA takes at least 20 different forms, one specific to each type of amino acid. One problem lay in obtaining a single form of t-RNA, another in creating conditions in which it would hold that configuration and crystallize.

In addition to studying the function of t-RNA, the Wisconsin researchers' long range plans include collaboration with Dr. H. Gobind Khorana, one of this year's Nobel Prize winners (SN: 10/26/68, p. 411) who is working on synthesis of the first artificial gene.

PULSARS

The lighthouse effect

Neutron stars, one of the early suggestions as to the identity of pulsars, are now returning to favor, but not in quite the way they were first presented. They now appear as rotating bodies rather than pulsating ones.

New evidence regarding the slowing down of the objects' rate seems, at least for the present, to rule out both binary and pulsating sources as explanations.

A month earlier (SN: 11/23/68, p. 521) one pulsar that seemed to be slowing down was reported. Now there are four, says Dr. A. G. Lyne of Jodrell Bank Observatory in England. He presented data to the Fourth Texas Symposium on Relativistic Astrophysics meeting at Dallas that show a general increase in period for pulsars CP 0834, 0950, 1133 and 1919.

This indicates, says Dr. Lyne, "a real slowing of the mechanism." Dr. Anthony Hewish of Cambridge agrees and points out that Cambridge observations tally with those of Jodrell Bank.

The slowing down allows astronomers to figure probable ages for the pulsars whose deceleration rates are known, and Dr. Lyne gives lifetimes of 8 million years for CP-0834, 300 million for 0950, 9 million for 1133 and 40 million for 1919.

The new evidence means that the pulsar's timekeeping cannot be governed by either the rotations of a binary star or the pulsations of a single star. In either of those cases the system would lose energy by gravitational radiation, and this would result in the period getting faster instead of slower.

All this fits into the ideas of Prof. Thomas Gold of Cornell University, who was one of the earliest proponents of the model in which a pulsar is a rotating neutron star.

This neutron star has a strong radially directed magnetic field attached to it and rotating with it. If, says Prof. Gold, there is some mechanism that could eject charged particles from a spot on the surface of the star, the configuration of the field would hold this plasma in a narrow wedge. The plasma would radiate radio waves, and every time its sector came around with the rotation, a burst of radiation would come toward the observer, very much like a rotating lighthouse beam.

This model could do more than explain a pulsar, says Prof. Gold. It could also explain some mysteries of the Crab Nebula. In order to glow the way it does, the Crab has to have a continually replenished supply of charged particles moving at speeds close to the speed of light. These, says Prof. Gold, could come from the pulsar in the Crab if that pulsar fits his model.

In the model, the plasma ejected from the star gradually drifts outward. As it does so, it must move faster and faster to keep up with the rotation. Eventually individual particles reach speeds near the speed of light. At this point, the speed-of-light shell, the plasma ceases to be an electrical conductor because its particles are too heavy—they gain mass because of relativity effects—and cannot respond well to electric forces. This neutral shell cannot be penetrated by the magnetic field. Any particles that cross it, and some will, will no longer be bound to the star's rotation but will fly off tangentially with speeds near that of light.

These spun off particles are enough to replenish the Crab, says Prof. Gold. He calculates the energy lost by the pulsar in the Crab as it slows down and finds more than enough to account for the amount of relativistic plasma necessary for the Crab's glow.

Another rotating pulsar model, presented by Dr. Franco Pacini of the Laboratorio Astrolfisica at Frascati, Italy, starts out with a superdense star, not necessarily a neutron star, that has an unsymmetrical magnetic field. If this star has a plasma cloud surrounding it, the skewness of the magnetic field will produce shock waves in the plasma, which will produce two emitting regions on two sides of the star and give a double pulse effect.

Although Soviet opinion tends to agree with Prof. Gold, says Prof. I. S. Shklovsky of Moscow State University, "Today is maybe too early to give a quantitative theory of pulsars." But he wants to draw his colleagues' attention to a "strange distribution" of pulsars in the sky.

The short period pulsars are concentrated toward the center of the galaxy, while the long period ones are concentrated away from it. The young pulsars would thus appear to be near the center, the old ones away from it.

Prof. Shklovsky suggests that "the young pulsars are near where they were born; the old ones far away." He suggests that in a supernova explosion, if this is where a pulsar comes from (SN: 12/14/68, p. 592), velocities necessary to move them away from the place of birth may be imparted. He also points out that between 30 and 50 percent of the stars in the universe are in double systems and suggests that "maybe a pulsar is a member of a double system." The two components, he feels, would be separated by several hundred million miles, and their rotation might have a period like 10,000 years.

EUROPE'S ACCELERATOR

A critical step forward

The outlook has definitely brightened for the European 300 GeV accelerator project being sponsored by CERN, the European Organization for Nuclear Research.

Prospects were gloomy last June, when Britain, tightening her financial belt, announced that she was unable to participate (SN: 7/13/68, p. 30). Cheer soon peeped through, however. First there was the submission by Italy and West Germany, in August and September, followed by Switzerland, in December, of letters of intent to take part in the project. This made six countries in all—with Belgium, Austria and France—which had agreed to date to join the undertaking.

The second encouraging news was a CERN feasibility study which concluded that the green light could be given the basic project, reduced by 25 percent from the original cost estimate of 1,776 million Swiss francs, which had been made in the expectation of a British contribution. With a revised total project budget of 1,335 million Swiss francs (about $309 million), no design changes in the accelerator would be required. Major savings could be achieved through a two-year delay in pushing the accelerator to its potential maximum, and by cutting to the bone general laboratory facilities (SN: 10/19/68, p. 387).

Now a new, and critical, step forward has been taken. Meeting on December 18-19 at its headquarters in Meyrin outside of Geneva, the governing Council of CERN has decided to appoint a Project Director. Slated for the post is John Bertram Adams, past Director-General of CERN (1960-61) and, since 1966, full-time member of the United Kingdom Atomic Energy Authority (UKAEA) as Member for Research.

The choice has been greeted enthusiastically throughout CERN, in whose eyes he wears a hero's mantle gained in the organization's early days when he led the team which built the 28 GeV proton synchrotron. Apart from some U.S. scientists of comparable stature, Adams is considered at CERN to be the best man in the world available for the job.

Eager to see the project take concrete form, with construction getting under way possibly in the second half of 1970, the CERN governing council decided that a final vote on the site should be taken at its June 1969 meeting. Geotechnical and other information on the proposed sites are expected to be made available before next June.

At the present time, five sites seem to be strongly in the running. They are: Göpfritz, Austria; Le Luc, France; Doberdo, Italy; Drensteinfurt, Germany; and Focant, Belgium. An additional site prospect, Uppsala, Sweden, may also forge to the front, if, as was suggested at the December 18-19 council meeting, Sweden decides to become the seventh country to join the project.

Final site selection will be based on such criteria as availability of sufficient electrical power and cooling water, as well as an adequate manpower supply. The area must offer living and working conditions attractive to an international staff, and must meet high geotechnical standards.