have answered; they argue that future flights should hold an equal number of scientific surprises.

One of Apollo's rivals, funded and approved for 1972, is the earth-orbital workshop, Skylab A, delayed since 1968 when it was called the Apollo Applications Program. This orbiting lab has the potential to demonstrate the usefulness of space to earth, and NASA is basing high hopes on the payoff. Experiments include 16 medical, 8 engineering and 17 scientific (including biological, astronomical and solar) and 9 technological programs.

Skylab B, to fly in late 1973 or 1974, is a possibility that has support, particularly from scientists who have been left out of Skylab A.

Regardless of the decisions concerning the Apollo-Skylab schedule, NASA is still faced with a manned flight gap from 1974 to 1978. The possible bridges across that gap include an intermediary space station using Apollo instead of space-station module hardware, the development of a prototype shuttle or an all out effort on the space station.

One way to maintain the operational level of manned flight is that of the intermediate space station, designed to house from 6 to 12 men. One of these could be launched in 1975-76 and another in 1977-78. Ideally, the space station could serve a purpose other than its scientific role: international cooperation. International involvement in the space probe is an avowed aim of NASA's administration and because of the increasing space costs, it has been gaining Congressional support.

Although the Apollo hardware space station would not be of the design and sophistication of the space station/base planned for the latter part of this decade, it could supply necessary data for such a program as well as filling a debilitating gap.

Another alternative is the flight of a prototype shuttle prior to the shuttle now planned for 1977-78. The two-step shuttle program has been gaining support from among scientists who like the idea of flight for nonastronauts.

The shuttle ultimately would allow the scientists to go up in shirt sleeves, with equipment for experiments ranging from a few days to weeks, and return to earth laboratories to reduce their data.

Considering these options, NASA Administrator Thomas O. Paine is expected to make some major decisions within the next two months as budget preparations for fiscal 1972 start.

"We would be most reluctant to give up any of the future moon flights," says Dr. Paine. "On the other hand, we are also determined to push forward in the areas of the space station and shuttle." □

MOLECULAR BIOLOGY

A two way street for genetics

Deoxyribonucleic acid, as every good biologist knows, is the master genetic chemical, containing as it does the blueprints for the design of all living substances. DNA, for example, transfers its architectural instructions to RNA (ribonucleic acid) which dutifully carries them to ribosomes, cellular factories where proteins are assembled according to the dictates set down by DNA. According to this now well established dogma, RNA is an essential link in the transfer of genetic information but is an Indian, not a chief.

Dogmas in science have a habit of undergoing change. The central thesis of molecular biology, that the genetic code passes from DNA to RNA along a one-way street, is no exception. New data, produced from three separate laboratories during the last few weeks, are forcing change: Information is transmitted from DNA to RNA most of the time, but sometimes, as in the case of tumor-causing RNA viruses, it goes in the opposite direction. RNA can code for DNA. The genetic code travels a two-way street.

The unorthodox idea that DNA can be produced from an RNA template was first proposed in 1964 by Dr. Howard Temin of the University of Wisconsin at Madison. Since then, he recounts, numerous papers have been published demonstrating that his hypothesis could not be true. But from experiments with the Rous sarcoma virus which causes tumors in birds, Dr. Temin now has evidence substantiating that this virus, consisting only of a core of RNA encased in a protein coat, can make DNA once it infects a cell. Further, this RNA-made DNA is passed to daughter cells, carrying with it instructions for the production of more cancerous cells.

The RNA-to-DNA inversion, Dr. Temin suggests, may explain the mechanism by which viruses known to induce cancer in animals work. With Dr. Satoshi Mizutani, he reported his findings in the June 27 NATURE. In the same issue, Dr. David Baltimore of the Massachusetts Institute of Technology reported verification of Dr. Temin's theory, now being referred to as Teminism in scientific circles, from experiments with another carcinogenic virus, the Rauscher leukemia virus, which induces tumors in mice.

There are many RNA viruses, including those that cause colds, flu and measles, that infect a cell and use its genetic machinery to produce more RNA viruses, which in turn spread to and infect other cells. These are not suspected of Teminism; where RNA tumors viruses differ is in that they somehow manage to induce a permanent infection, transmitting their carcinogenic genetic message into the genes of infected cells, not destroying them, but changing them so that they pass this deleterious information on in cell division. From observations of the biological behavior of cells infected by the Rous sarcoma virus, Dr. Temin reasoned that the RNA viral core must be able to produce DNA that is an image of itself. This, he suggests, is accomplished with the aid of unique enzymes, ones that could synthesize DNA from an RNA template.

Drs. Temin and Mizutani and Dr. Baltimore have evidence that such enzymes exist. Called RNA-dependent DNA polymerases, the enzymes, not yet isolated, appear to catalyze the synthesis of DNA but require an RNA template from which to work. Biochemical studies have indicated the presence in the virion or genetic core of both Rauscher and Rous viruses of polymerases specific for each of them. These polymerases apparently are not present in normal cells.

Impressed by the results of the experiments performed by the Wisconsin and Massachusetts scientists, Dr. Sol Spiegelman of Columbia University's Institute for Cancer Research attempted to repeat them. Originally as skeptical of Dr. Temin's hypothesis as other molecular biologists, Dr. Spiegelman has developed the ideas strongest confirmation so far. Testing a dozen RNA viruses for their ability to code for DNA, he finds that eight can and four cannot. The eight which produce DNA cause cancer in animals; the other four do not.

From the combined results of the work of these four scientists there emerges a new explanation of the mechanism of viral carcinogenesis, linking it directly to the phenomenon of the reverse transfer of genetic information. Additional work needs to be done to refine understanding of the specific polymerases involved in this process, but as it is accomplished—it is likely that numerous laboratories will begin working on Teminism—several results are possible:

- Detailed examination of the RNA-to-DNA pathway by means of a specific enzyme phenomenon could produce a way of predicting the carcinogenic potential of viruses;
- The work may offer clues to methods of inhibiting them.

On a broader scale, Dr. Temin suggests that his theory may lead to insights into the mechanism of information transfer in other biological systems, including the immune system and the process of cell differentiation. □