now appears to be developing between laboratory chemistry groups and astronomers in pursuit of the mystery particles. Let us hope that the chemists and the astronomers continue to talk to each other, so that the many astronomical constraints are not overlooked by the chemists, and so that the context and implications of the laboratory work are fully understood by the astronomers.

But is progress being made? It is difficult to say, until more precise matches can be found. One hopes that it will soon

become possible to make laboratory measurements of candidate molecules and molecular ions in the gas phase, eliminating solid-state matrix effects. Despite the elusiveness of the DIB carriers, today one senses a new optimism that has been lacking in the past. Surely, it is tempting to think, we are on the right track, and it is only a matter of time until the definitive experiment is done.

Of course, the result may not be simple. We may find that several different species of molecules are involved, and that each is

responsible for one or at most a small number of the DIBs. If so, it will take time to unravel the entire problem. But when this is done, a wealth of new information on interstellar physics and chemistry will have been revealed, and a most intriguing astronomical mystery will have been solved. □

Theodore P. Snow is in the Center for Astrophysics and Space Astronomy, University of Colorado, Campus Box 389, Boulder, Colorado 80309, USA.

OBITUARY

Severo Ochoa (1905–93)

As one of the very few who stayed in the rapidly moving spotlight of biochemistry for five decades, Severo Ochoa bridged the evolution of the discipline from its origins in physiology to the heyday of enzymology and into the currents of molecular biology. With his death in Madrid on 1 November, Spain lost its most celebrated scientist and the international community an exemplar of science and statesmanship. The award of the Nobel Prize for Physiology or Medicine in 1959 made him the only other Spanish laureate in science since the neuroanatomist, Ramon y Cajal, who was so honoured in 1906.

Ochoa was born in Lueca, a coastal town in the Asturias region of northern Spain. When he entered the University of Madrid in 1922, Cajal had just retired but the aura of his 'heroic research' had remained. Ochoa obtained a medical degree, then the only course generally available in Europe for a career in physiology. With the enthusiasm and energy that characterized him throughout his life, he plunged into research in physiological chemistry in the laboratory of Juan Negrin, who later became the president of the short-lived Spanish Republic.

Studies of the action of guanidine on frog melanophores and the development of a micromethod for assaying creatine in muscle, were followed by two years in Otto Meyerhof's laboratory, first in Berlin and then in Heidelberg, exploring the energetics of muscle contraction. Except for a few brief stays in Madrid, he worked abroad — on glycolysis in muscle extracts at the National Institute for Medical Research in London with Harold W. Dudley in 1932; with Meyerhof again in Heidelberg in 1936 on phosphorylation in invertebrate muscle; in Plymouth with marine biologists in 1937; on demonstrating with Sir Rudolph A. Peters in Oxford in 1938 that thiamine pyrophosphate is the vitamin B₁ coenzyme of carboxylase; and finally in St Louis, Missouri, with Carl F. and Gerty Cori in 1940, on the isolation and characterization of fructose 1-phosphate and inorganic pyrophosphate. Buffeted by turbulence and wars in Spain, Germany and Britain, his steadfastness and

devotion to science were severely tested, but he never wavered.

When I joined him as a postdoctoral fellow in 1946, he was assisted by one technician and a graduate student (Alan H. Mehler) in borrowed space in the department of biochemistry in the New York University College of Medicine, having been

Severo Ochoa, 1956.

evicted from the psychiatry department. He was pursuing what I regarded to be the holy grail of biochemistry — the soluble enzymes that make ATP upon oxidation of carbon compounds in the citric acid (Krebs) cycle. Although the key event of ATP synthesis was later shown to reside in the indissoluble mitochondrion, Ochoa did more than anyone else to resolve the enzymes and clarify the mechanisms that generate and use citric acid at the hub of intermediary metabolism. Insights and techniques that emerged from these studies led him to explore and understand stages in the synthesis of fatty acids and the conversion of light to chemical energy in photosynthesis.

Most noted of his myriad contributions was the serendipitous finding by a postdoctoral fellow, Marianne Grunberg-Manago, of an enzyme, polynucleotide phosphorylase, that made an RNA-like polymer from nucleotides. Whereas the physiological function of the enzyme proved to be the breakdown of RNA, its capacity to syn-

thesize RNAs of defined composition made it a key reagent in deciphering the genetic code. These studies set the stage for discoveries of RNA synthetases encoded by RNA viruses and the mechanisms of translational processes in protein synthesis, particularly the direction of translation, termination codons and a menagerie of initiation factors.

A courtly, charming El Greco-like figure, Ochoa played host to a legion of postdoctoral fellows, students and sabbatical guests who came from every corner of the world and left to become leaders in science. His many medals, diplomas, citations and honorary degrees are displayed in a handsome museum founded by a distinguished disciple, Santiago Grisolia, and located in Valencia near a street that bears his name (as do other streets in most cities in Spain). Don Severo Ochoa was a name and face nearly as well known to the Spanish cab driver and housewife as that of King Juan Carlos. The Severo Ochoa Centre for Molecular Biology, founded with Ochoa's guidance and patronage and directed by another disci-

ple, Margarita Salas, has become one of Europe's leading centres of molecular biology.

Upon retirement from New York University in 1974, Ochoa commuted to the Roche Institute in Nutley, New Jersey, where as a Distinguished Member he continued a vigorous programme on various aspects of protein synthesis. When the attachments to his beloved New York were weakened by the departure of most of his contemporaries in science, he and Carmen, his wife for 52 years, responded to entreaties to return to Spain in 1985. Her death soon after was a devastating loss from which he never recovered. The biochemist's biochemist, revered teacher, international citizen and loyal friend to so many has now left us too.

Arthur Kornberg

Arthur Kornberg, joint winner with Ochoa of the Nobel Prize for Physiology or Medicine in 1959, is in the Department of Biochemistry, Stanford University School of Medicine, Stanford, California 94305, USA.