PLANT PHYSIOLOGY

High hopes for C4 plants

Peter D. Moore

THE so-called C4 photosynthetic mechanism equips plants with valuable competitive advantages under conditions of high light intensity, high temperature and low water availability. Their greater efficiency in trapping carbon dioxide means that they can exert a tighter control over water balance than most C3 plants, but plants endued with the phosphoenolpyruvate (PEP) carboxylase initial carbon-fixing technique (which includes the crassulacean acid metabolism — CAM — plants) can also cope well with habitats in which CO_2 becomes scarce, as in the case of some aquatic environments in the middle of the day when planktonic photosynthesis is at its peak. It came as something of a surprise when CAM-type plants were first described from wet sites[1]. But now another remarkable claim has been put forward by V. S. Rama Das and S. K. Vats[2] of Palamur, India, who believe that C4 plants may be at an advantage at high altitudes because of lower levels of ambient atmospheric CO_2.

C4 plants operate a short-term mechanism for the fixation of CO_2 that involves the enzyme PEP carboxylase and results in the addition of the carbon from CO_2 onto a three-carbon receptor molecule, leading to a four-carbon product. This is then transported to specialized cells around the vascular bundles where the carbon is released once more and then permanently fixed by the conventional C3 system using the enzyme Rubisco. One important advantage of the C4 strategy is that PEP carboxylase has a higher affinity for CO_2 than Rubisco, so the C4 plant is able to maintain photosynthesis at lower CO_2 concentrations (that is, it has a lower CO_2 compensation point).

It has long been evident that the C4 photosynthetic mechanism is more commonly found at lower rather than higher latitudes. It occurs in a wide range of plant families, both dicotyledons and monocotyledons, but was first described in, and is perhaps most familiarly associated with, tropical grasses. As one moves polewards, the proportion of C4 grasses among the species of this family gradually decreases, and only a very few grasses of the cooler temperate zone are C4 in character[3]. One such genus is the cord grasses (*Spartina*)[4], which probably benefit from the water-relations advantages of the C4 mechanism (all species of this genus inhabit salt marshes, where salinity imposes physiological water stress).

The question of the competitive advantages or disadvantages of C4 photosynthesis under changed CO_2 conditions is currently topical because of the need to predict vegetation response to a green-

OBITUARY

Wolfgang Paul (1913–93)

ON 7 December Wolfgang Paul, who was awarded the Nobel Prize in Physics for his work in isolating ions and electrons, died at his home in Bonn.

Paul was born in 1913 in Lorenzkirch, a small town in Saxony. He studied physics in Munich and Berlin and obtained a doctorate in physics and engineering in Berlin in 1939. With his supervisor Hans Kopfermann he went to Kiel and then Göttingen. In 1952 he accepted the chair in experimental physics at the University of Bonn where he was director of the Physikalisches Institut until he retired in 1981.

Wolfgang Paul's broad interest in physics, his ingenuity and his experimental skills propelled the institute within a few years to international recognition in many areas of physics research. At all times he managed to inspire in his colleagues and students enthusiasm for new ideas and experiments. During his directorship he always led the institute according to the concept of 'guided anarchy', a term he coined himself, and which perhaps best illustrates his personal style of team research. Every student, graduate or even undergraduate, and every scientist of the institute had their own responsibility for a part of the experiment or accelerator, often in crucial areas. Of course, this did not always work ideally, and sometimes the topic of a student's thesis had to be changed at the last moment. Nevertheless, Paul kept to this concept of greatest possible freedom for the individual throughout his life. He believed this to be a key feature of university research and worked to integrate his concept into the cooperation between research centres and universities.

In the field of atomic and molecular physics, Wolfgang Paul and his co-workers developed innovative methods for focusing and storing ions so as to allow precise measurements of their properties. For his achievements he was awarded the Nobel Prize in 1989, which he shared with Norman F. Ramsey of Harvard and Hans Dehmelt of the University of Washington. In the 1950s, the first European electron synchrotron to use the newly discovered principle of strong focusing was built under Paul's guidance in Bonn. The machine, which produced electron energies of 500 MeV, was completed in 1959, remained in use until 1985, and is to be reassembled for display at the Bonn branch of the German Museum for Science and Technology. In the 1960s a larger synchrotron of 2.5 GeV electron energy followed at the institute, and this is still in service as injector to the electron stretcher ring ELSA.

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Wolfgang Paul, Nobel Prize winner in 1989.

Wolfgang Paul was faithful to the University of Bonn despite distinguished offers from elsewhere. In particular, he was active in promoting fundamental research in particle physics in Germany. He was one of the founding fathers of CERN and DESY (the accelerator centre in Hamburg), acting as research director at both institutes at different points in his career.

In later years, as president of the Alexander von Humboldt Foundation, Paul directed his attention to the support of young scientists from all over the world. In particular, he shaped the Feodor-Lynen-Program for young German scientists, and consistently followed the principle 'quality over quantity' for which the Alexander von Humboldt Foundation is renowned.

After his retirement from the university, he maintained his commitment to individual scientific independence. The responsibility was now his successors'. When asked for advice, he would typically suggest "One could try to . . .", but would always make it clear that the decision was to be made by someone else. As a result, his opinion was frequently sought and always much appreciated.

With Wolfgang Paul the University of Bonn loses an inspiring university teacher and an extraordinary scientist.

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