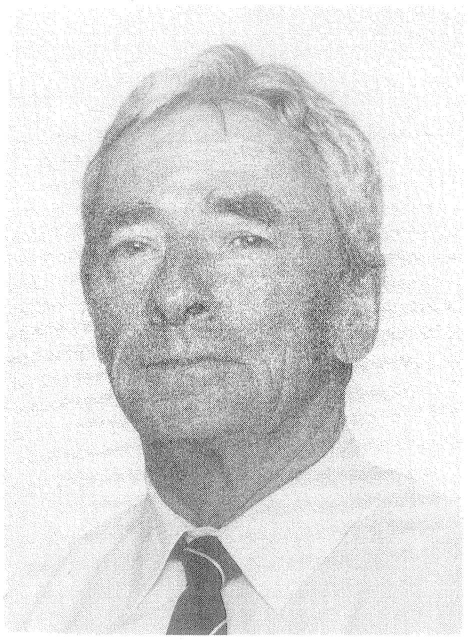
Dr. Marshall Davidson Hatch



Birth: December 24, 1932
Perth, Western Australia

Nationality: Australian

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Position: Chief Research Scientist, Division of Plant Industry, Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Education and Career:

1954	B. Sc. (Hon.), University of Sydney
1955−1959	Research Scientist, Plant Physiology Unit, CSIRO, Sydney
1959	Ph. D., University of Sydney
1959−1961	Post Doctoral Fellow, Department of Biochemistry, University of California
1961−1966	Research Officer and Head of Biochemistry Section, David North Plant Research Centre, CSR Co. Ltd., Brisbane, Queensland
1967	Reader, Botany Department, University of Queensland
1968−1969	Research Officer with CSR Co. Ltd. (as above)
1970−	Chief Research Scientist, Division of Plant Industry, CSIRO

Awards and Distinctions:

Clarke Medal, Royal Society of N. S. W., 1973
Lemberg Medal, Australian Biochemical Society, 1974
Fellow, Australian Academy of Science, 1975−
Charles Kettering Award for Photosynthesis, American Society of Plant Physiology, 1980
Fellow, Royal Society of London, 1980−
President, Australian Society of Plant Physiologists, 1980−1981
Member of the Order of Australia, 1981
Rank Prize, J. Arthur Rank Group, U. K., 1981
Foreign Associate, National Academy of Sciences (U. S. A.), 1990−

Representative Works:

1. Hatch, M.D. and Slack, C.R. (1966). Photosynthesis by sugar-cane leaves: A new carboxylation reaction and the pathway of sugar formation. *Biochem. J.*, **101**, 103-111.
2. Hatch, M.D. and Slack, C.R. (1970). Photosynthetic CO_2-fixation pathways. *Ann. Rev. Plant Physiol.*, **21**, 141-162.
3. Hatch, M.D. and Kagawa,T. (1974). NAD malic enzyme in leaves with C_4-pathway photosynthesis and its role in C_4 acid decarboxylation. *Arch. Biochem. Biophys.*, **160**, 346-349.
4. Hatch, M.D. (1978). Regulation of enzymes in C_4 photosynthesis. In "Current Topics in Cellular Regulation", Horecker, B.L. and Stadtman, E.R., eds., Vol. 14, 1-27. Academic Press, New York.
5. Hatch, M.D. and Boardman, N.K., eds., Vol.8 (1981) and Vol.10 (1987). Photosynthesis. In "The Biochemistry of Plants. A Comprehensive Treatise," Stumpf, P.K. and Conn, E.E., editors-in-chief. Academic Press, New York.
6. Ashton, A.R., Burnell, J.N. and Hatch, M.D. (1984). Regulation of C_4 photosynthesis: Inactivation of pyruvate, P_i dikinase by ADP-dependent phosphorylation and activation by phosphorolysis. *Arch. Biochem. Biophys.*, **230**, 492-503.
7. Hatch, M.D. (1986). Has plant biochemistry finally arrived? *Trends in Biochem. Sci.*, **11**, 9-10.
8. Hatch, M.D. (1987). C_4 photosynthesis: a unique blend of modified biochemistry, anatomy and ultrastructure. *Biochim. Biophys. Acta*, **895**, 81-106.
9. Jenkins, C.L.D., Furbank, R.T. and Hatch, M.D. (1989). Mechanism of C_4 photosynthesis: a model describing the inorganic carbon pool in bundle sheath cells. *Plant Physiol.*, **91**, 1372-1381.
10. Hatch, M.D. and Burnell, J.N. (1990). Carbonic anhydrase activity in leaves and its role in the first step of C_4 photosynthesis. *Plant Physiol.*, **93**, 825-828.

Academic Achievements:

Dr. Marshall Hatch (and his colleague) provided the first clear evidence for the existence of a new biochemical process for the photosynthetic assimilation of carbon dioxide. They named this process the C_4 dicarboxylic acid pathway of photosynthesis, now known simply as the C_4 pathway or C_4 photosynthesis.

Before this discovery, it had been generally assumed that the biochemical pathway known as the Calvin cycle (or photosynthetic carbon reduction cycle) was the universal mechanism for photosynthesis in all plants. In this process the 3-carbon compound 3-phosphoglyceric acid is the first product formed as carbon dioxide is assimilated. Using the energy of sunlight this product is transformed through several steps into the end-product: sugar and starch.

Dr. Hatch and his colleagues showed, in a series of carefully designed experiments with sugarcane leaves, that the first products of photosynthetic carbon dioxide assimilation were the C_4 dicarboxylic acids, oxaloacetate, malate and aspartate. The carbon assimilated into these acids was then transferred to 3-phosphoglyceric acid and then metabolized by the Calvin cycle. Dr. Hatch and his colleagues subsequently identified all but one of the ten key enzymes specifically involved in the C_4 pathway, including two novel enzymes, pyruvate, P_i dikinase and NADP malate dehydrogenase. They showed that both these latter enzymes are regulated by light but by quite different mechanisms. They also provided the first evidence that the initial reactions of the new C_4 pathway were located in mesophyll cells while the Calvin cycle reactions were confined to bundle sheath cells. So, while the two processes are functionally integrated at the biochemical level they are physically separated. Work over many years has confirmed that the function of the special reactions of C_4 photosynthesis is to concentrate carbon dioxide in bundle sheath cells for fixation by the Calvin cycle.

The plants with the C_4 pathway are called C_4 plants to distinguish them from C_3 plants which use only the Calvin cycle for photosynthesis. At present there are more than 1,300 species of C_4 plants known. They occur in two monocotyledonous families (Gramineae and Cyperaceae) as well as several dicotyledonous families.

C_4 plants are capable of higher rates of leaf photosynthesis than C_3 plants, especially at higher tremperatures, and they also show higher water-use efficiency. As a consequence, C_4 plants can grow more rapidly and produce more dry matter than C_3 plants under appropriate conditions. They are also commonly more tolerant to drought. These features can be explained in terms of their capacity to concentrate carbon dioxide for use by the Calvin cycle. The resolution of the mechanism and function of C_4 photosynthesis has been important in understanding the basis of plant productivity. The molecular biology of C_4 photosynthesis is now being actively pursued and possibilities for transforming plants to improve their agricultural usefulness are being considered.

These findings of Dr. Hatch and his colleagues stimulated many studies by different scientists throughout the world. The resulting comparative information has clearly shown that there are three subgroups of C_4 plants that use different mechanisms for decarboxylation in bundle sheath cells. Work with isolated cells and protoplasts has provided further information about the location of photosynthetic reactions. Many advances in knowledge have been made from the discoveries of Dr. Hatch and his research group. This work has influenced fields ranging from basic biochemistry and plant physiology to plant molecular biology and agriculture. He is one of the leaders in the field of plant biochemistry.

In recent research Dr. Hatch has elaborated on the detailed mechanism of C_4 acid decarboxylation in bundle sheath cells, provided quantitative information about the unique permeability characteristics of the mesophyll-bundle sheath cell interface to metabolites and carbon dioxide, and improved understanding of the nature of the inorganic carbon pool that develops in bundle sheath cells. In a recent article, Dr. Hatch said that in the past plant biochemists tended to be the poor relations of the biochemical disciplines, following them with 'me too' types of studies. However, nowadays, one can find plant biochemists at the leading edge, with discoveries of novel enzymes and new regulatory mechanisms. Besides the discovery of the C_4 pathway itself, subsequent resolution of the C_4 process has led to several novel and important findings of wide biochemical interest.