

Are you what you eat?

Summary

Case Study Problem No. 1 C-643 Intermediary Metabolism

Comments on Case Study: Photosynthesis is a key process supporting life on earth. Yet, with the emphasis on human metabolism in most biochemistry courses, the topic is not covered or is only touched upon. Because virtually all carbon in living systems must have been derived from atmospheric CO₂, photosynthesis seemed to be an appropriate topic for the first PBL problem in a course on intermediary metabolism. In order to provide human interest, I framed the case study around an anthropological question that seems totally unrelated to photosynthesis (the domestication of corn) and a chemical phenomena (kinetic isotope effects) not often covered in undergraduate courses. Among the issues I expect students to address in this problem are:

- The relationships among pathways and their regulation, e.g. the Calvin-Benson Cycle, glycolysis, and the pentose phosphate pathway.
- Relationship between photosynthesis and respiration.
- The Calvin-Benson Cycle (C₃ Pathway) and the Hatch-Slack (C₄ Pathway).
- The origin of kinetic isotope effects in CO₂ fixation reactions, their measurement, and their use in answering some interesting questions.
- The use of radioisotopes in elucidating metabolic pathways.
- Mechanism of ribulose-1,5-bisphosphate carboxylase.
- Mechanism of transketolase and thiamin-dependent reactions.
- Metabolic regulation based on oxidation-reduction in plants.
- Respiration and other pathways in plants.
- Origin of life on earth and early importance of photosynthesis.

Selected References:

Ambrose, S. H. (1993) Isotopic analysis of paleo diets: methodological and interpretive considerations/investigations of ancient human tissues. In *Investigations of Ancient Human Tissues: Chemical Analysis in Anthropology*, Sanford, M. K. Ed. Gordon and Breach Science Publishers: Langhorne, PA pp 59 - 130.

Bassham, J. A. (1971) The control of photosynthetic carbon metabolism. [Science 172, 526 - 534](#) (Source of Fig 1 & 2)

Bennett, C. L. (1979) Radiocarbon dating with accelerators. [American Scientist 67](#), 450 - 457.

- Buchanan, B. B. (1991) Regulation of CO₂ assimilation in oxygenic photosynthesis: the ferredoxin/thioredoxin system. [Arch. Biochem. Biophys. 288, 1 - 9.](#)
- Calvin, M. (1962) The path of carbon in photosynthesis. [Science 135, 879 - 889.](#) (Nobel lecture) See also an article with the same title by Bassham in the June 1992 Scientific American.
- DeNiro, M. J. (1987) Stable isotopy and archaeology. [American Scientist 75, 182 - 191.](#)
- Deuser, W. G. and Degens, E. T. (1967) Carbon Isotope Fractionation in the system CO₂ (gas) - CO₂ (aqueous)-HCO₃⁻ (aqueous) [Nature 215, 1033-1035.](#)
- Doner, L. W. and White, J. W., Jr. (1977) Carbon-13/carbon-12 ratio is relatively uniform among honeys. [Science 197, 892 - 892.](#)
- Eisenreich, W., Strauss, G., Werz, U., Fuchs, G., and Bacher, A. (1993) Retrobiosynthetic analysis of carbon fixation in the phototrophic eubacterium *Chloroflexus aurantiacus*. [Eur. J. Biochem. 215, 619 - 632.](#)
- Gutteridge, S. (1990) Limitations of the primary events of CO₂ fixation in photosynthetic organisms: the structure and function of rubisco. [Biochim. Biophys. Acta 1015, 1 -14.](#)
- Levings, C. S., III and Siedow, J. N. (1995) Regulation by redox poise in chloroplasts. [Science 268, 695 - 696.](#)
- Maugh, T.H., II (1978) Radiodating: Direct detection extends the range of the technique. [Science 200, 635 & 637.](#)
- Schidlowski, M. (1988) A 3,800-million-year isotopic record of life from carbon in sedimentary rocks. [Nature 333, 313 - 318.](#)
- Smith, B. D. (1989) Origins of agriculture in eastern North America. [Science 246, 1566 - 1571.](#)
- Van der Merwe, N. J., Roosevelt, A. C., and Vogel, J. C. (1981) Isotopic evidence for prehistoric subsistence change at Parmara, Venezuela. [Nature 292, 536 - 538.](#)
- Van der Merwe, N. J. (1982) Carbon isotopes, photosynthesis, and archeology. [American Scientist 70, 596 - 606.](#)
- Wolosink, R. A., Ballicora, M. A., and Hagelin, K. (1993) The reductive pentose phosphate cycle for photosynthetic CO₂ assimilation: enzyme modulation. [FASEB J. 7, 622 - 637.](#)

Written by Harold B. White, Department of Chemistry and Biochemistry, University of Delaware