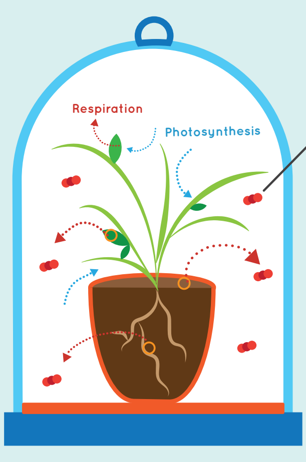
Carbon Cycle Tracers

Understanding the role of Carbon Cycle Tracers within our soils and how they function along side other natural components within our ecosystems.

Problem: CO_2 fluxes (photosynthesis and respirational) are bidirectional and difficult to resolve at the plant, ecosystem and global level.



Photosynthesis:

CO_2 taken up by the plant:

$$[\,6CO_2 + 6H_2O \xrightarrow{\text{Light}} C_6H_{12}O_6 + 6O_2\,]$$

CO_2 is also released by the plant, the bark, its roots and the microbes growing within the soil.

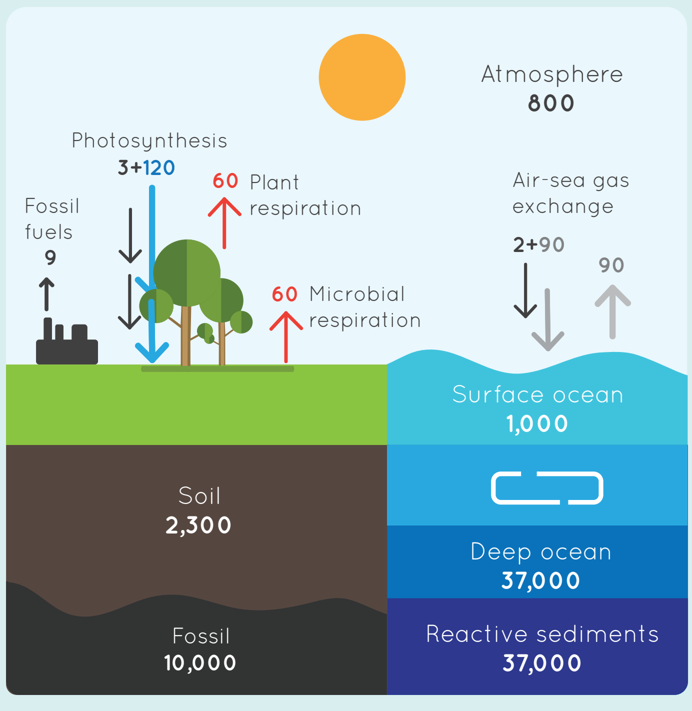
$$[\,C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O\,]$$

Changes in CO_2 concentration could arise from changes in photosynthesis, or respiration, or both, making it difficult to interpret observations of the net flux.

Net flux = Photosynthesis + Respiration

At a global scale, we have the same problem. How do we tell how much CO_2 is taken up by phosynthesis versus respired by terestial biosphere?

Global Cycle



New research

New research on soil fluxes of carbon cycle tracers is needed to account for these processes. It is likely that carbonic anhydrase enzymes in soil microbes drives the observed soil-level fluxes as it did the leaf-level fluxes. Microbes are known to encode for 6 different classes of carbonic anhydrase. This is an active area of study that is critical to the future of these carbon cycle tracers to help constrain the response of the terrestrial biosphere to global change.

Solution: Use gases that share common mechanisms with CO_2 fluxes as carbon cycle tracers. For example, COS and ^{18}O-CO_2 share common leaf-level mechanisms with photosynthesis.

Carbonic anhydrase

Carbon Dioxide, CO_2

Structure: O=C=O

Abundance: 400 parts per million (400 molecules of CO_2 out of 1,000,000 molecules of air) and rising!

Key features: The building block of life on Earth, most important greenhouse gas to climate change.

Carbonyl sulfide, COS or OCS

Structure: O=C=S

Abundance: 500 parts per trillion (500 molecules of COS out of 1,000,000,000,000 molecules of air)

Key features: Taken up by plants during photosynthesis, most abundant sulfur-containing gas in the atmosphere.

Oxygen isotopes of carbon dioxide, ^{18}O-CO_2 and ^{16}O-CO_2

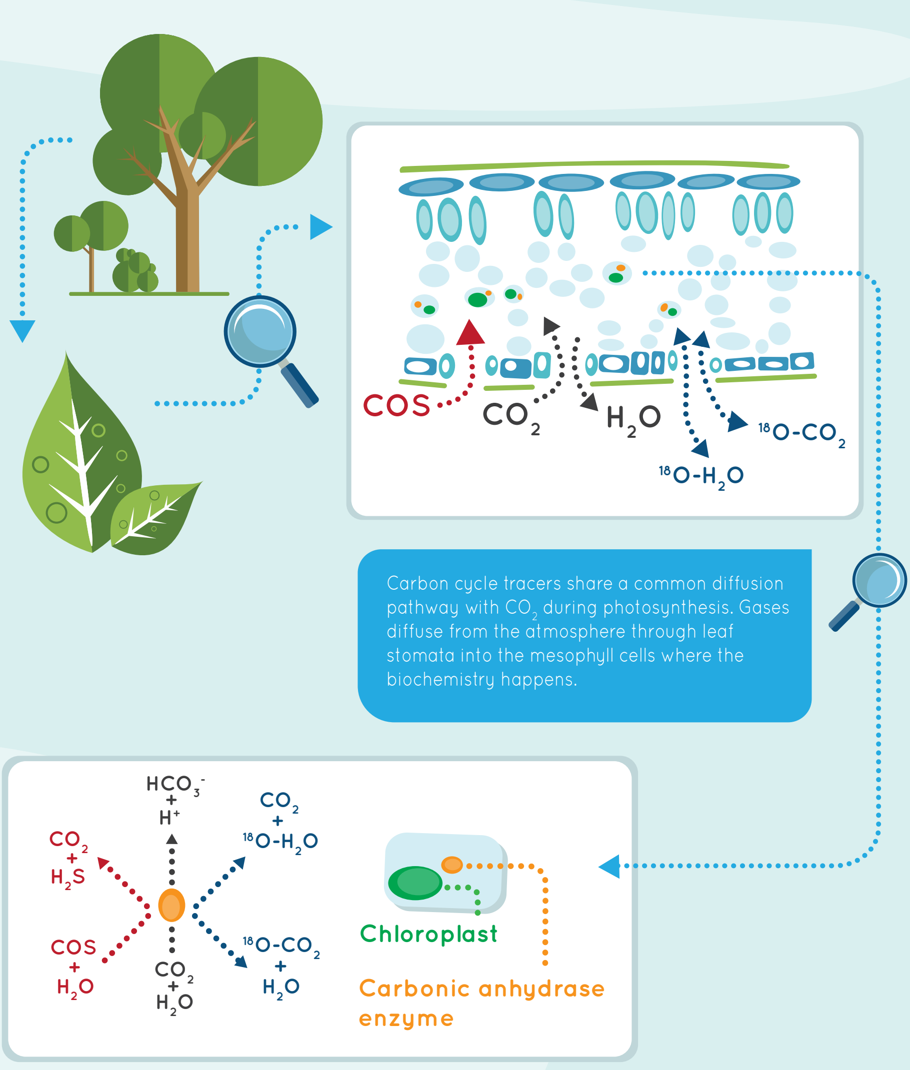
Structure: $^{18}O{=}^{12}C{=}^{16}O$ and $^{16}O{=}^{12}C{=}^{16}O$

Abundance: Most oxygen in the atmosphere is ^{16}O (99.8%), but a small portion (0.2%) is stable ^{18}O that has two additional neutrons.

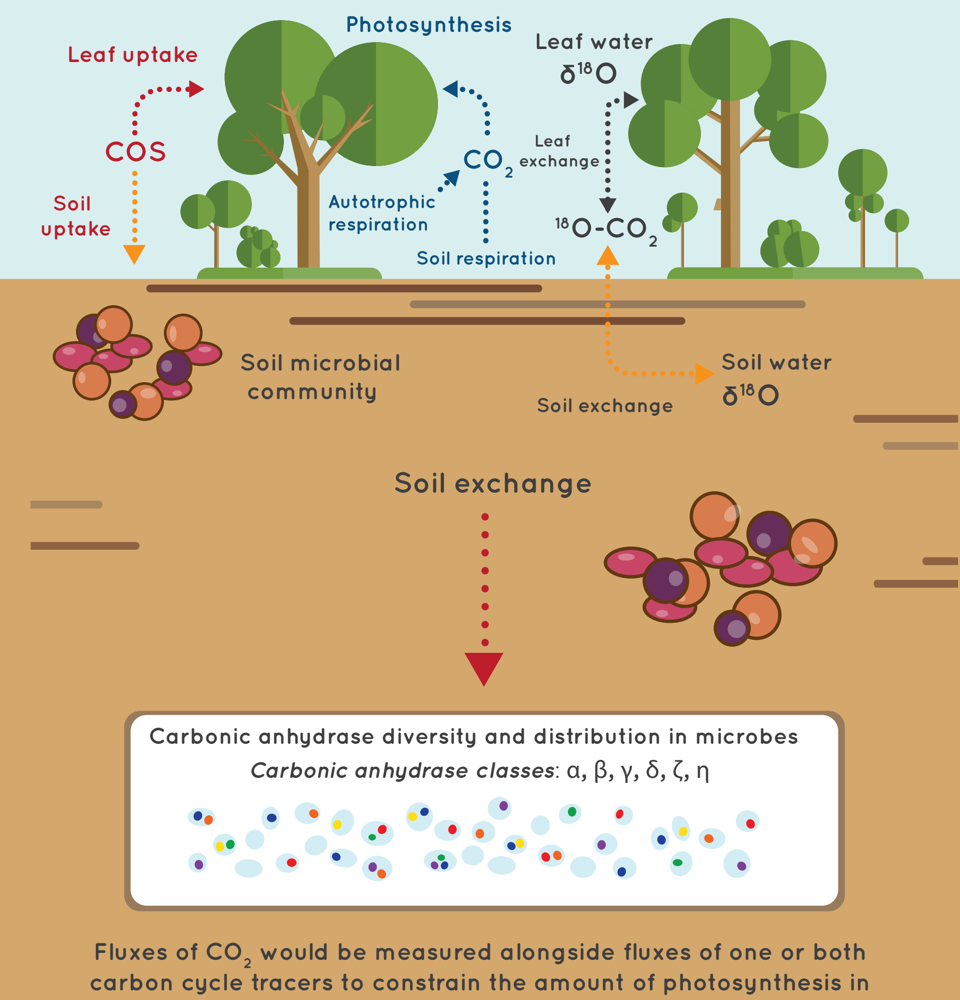
Key features: Oxygen isotopes of CO_2 affected by photosynthesis, an important tracer for carbon and water cycles.

COS and ^{18}O-CO_2

Common leaf-scale mechanisms allow COS and ^{18}O-CO_2 to be used as carbon cycle tracers



Ecosystem scale fluxes of CO_2 and carbon cycle tracers



Fluxes of CO_2 would be measured alongside fluxes of one or both carbon cycle tracers to constrain the amount of photosynthesis in the ecosystem. The net flux of CO_2 could then be partitioned to separately study photosynthesis from respiration including respiration from the plant itself (autotrophic) and fromsoil microbes). However, the carbon cycle tracers COS and ^{18}O-CO_2 have been observed to have soil fluxes (orange arrows), which complicate their use as carbon cycle tracers (no longer specific just for leaf-level mechanisms).

References by Dr. Laura Meredith
Graphics by Luke Williams and Melissa Yepiz