Carbon Isotopes in Plants
13C has one extra neutron, 8% heavier than 12C!

98.9% abundance

1.1% abundance

\[ \delta^{13}C = \left( \frac{^{13}C/^{12}C_{\text{sample}}}{^{13}C/^{12}C_{\text{standard}}} - 1 \right) \times 1000 \]

expressed as a permill (‰)
What are plants made of?

- Hydrogen: 6.3%
- Nitrogen: 1.3%
- Carbon: 44%
- Oxygen: 45%
What are plants made of?

**Carbohydrates**
- Glucose
- Cellulose

**Proteins**
- Amino Acids

**Lipids**
How do plants get carbon?

[Diagram of the carbon cycle showing the flow of carbon from sunlight, through plant respiration, animal respiration, decay organisms, organic carbon, dead organisms and waste products, to fossils and fossil fuels.]
Photosynthesis

\[ 6 \text{CO}_2 + 6 \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2 \]
Photosynthesis and Carbon Isotopes

$6 \text{CO}_2 + 6 \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2$
$\delta^{13}C = -8\%$

$\delta^{13}C = ??$
Plants have $\delta^{13}\text{C}$ values around -12 to -31‰.

LOTS of $^{12}\text{CO}_2$

Not much $^{13}\text{CO}_2$
δ¹³C values can tell you about how plants are doing photosynthesis.
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Rubisco has a high affinity for ¹²CO₂

lower δ¹³C values

PEP carboxylase isn’t as picky as Rubisco

higher δ¹³C values
Different types of plants have different $\delta^{13}$C values

- $C_3$ Plants
- $C_4$ Grasses
Different types of plants have different $\delta^{13}C$ values.
Different types of plants have different $\delta^{13}C$ values.
Different types of plants have different $\delta^{13}C$ values.
Photosynthesis in water
Aquatic Inorganic Carbon Sources

\[
\begin{align*}
\text{HCO}_3^- &= 0\permil \\
\text{CO}_2(\text{atm}) &= -8\permil \\
\text{CO}_2(\text{diss}) &= -9\permil \\
\text{H}_2\text{CO}_3 &= -7\permil \\
\delta^{13}\text{C} &\sim -16\permil \\
\text{CO}_3 &= 1\permil \\
\delta^{13}\text{C} &\sim -24\permil
\end{align*}
\]
Increasing water velocity decreases algal $\delta^{13}\text{C}$ values in streams and rivers.
TAKE HOME POINTS

• Plants build their tissues with carbon

• They do this via PHOTOSYNTHESIS
  • They take in CO$_2$ and chemically convert it into sugars

• Because lighter goes faster, plants have more $^{12}$C than atmospheric CO$_2$
  • So, they have $\delta^{13}$C values that are lower than the $\delta^{13}$C value of atmospheric CO$_2$
The exact $\delta^{13}C$ values of plants are determined primarily by the type of photosynthesis they do: $C_3$, CAM, $C_4$.

For aquatic plants, the type of carbon they use impacts their $\delta^{13}C$ values.