Fundamental knowledge on stable isotopes

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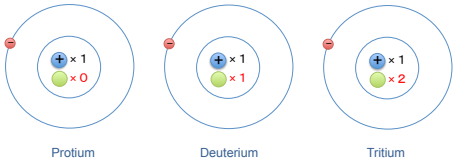
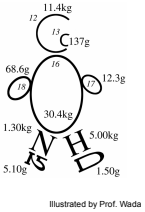
Potential power of stable isotopes

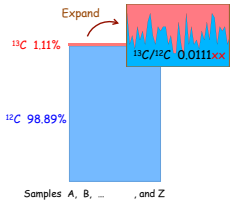
Isotopes of a given element that have the same number of proton ⊕ and electron ⊖ , but different number of neutron ○ .



There is a very very small but certain variation in the ratio of isotopes among natural samples. Indeed, some of you have a bit larger amount of heavy isotope than the others, depending on e.g., diet preferences (beef vs. fish vs. vegetable).

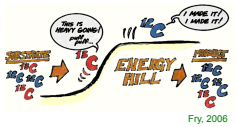
Element	%
^{1}H	99.9844
^{2}H(D)	0.0156
^{12}C	98.890
^{13}C	1.110
^{14}N	99.635
^{15}N	0.365
^{16}O	99.760
^{17}O	0.040
^{18}O	0.200

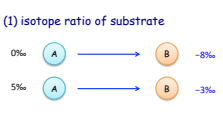




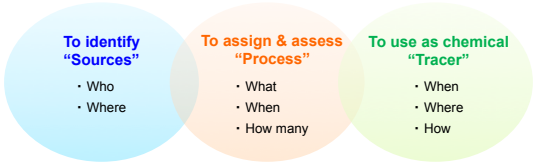
Such difference in the weight between isotopes always leads to "different reactivity" between them, which causes "isotopic fractionation".

In general, the degree of isotopic fractionation is highly dependent on (1) the isotope ratio in substrate, (2) process, and (3) substrate/product balance in the reaction.



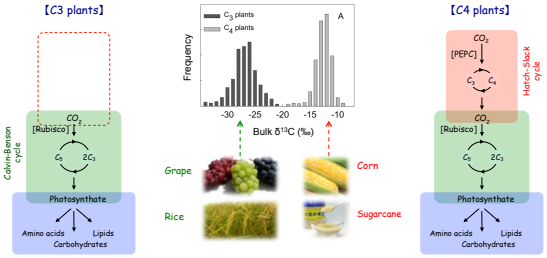


Resulting in, you can find critical answers for 5W2H in the complex biogeochemical process in our planet, if you can use "isotope ratios" very well, smartly, as a master key in your challengings.

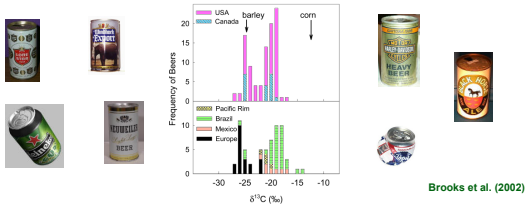


Application to food authenticity

There are two types plants with respect to photosynthetic properties: C3 vs. C4, as Hatch-Slack cycle in C4 efficiently brings CO_2 into Calvin-Benson cycle. This distinct "process" of photosynthesis cases unique $^{13}C/^{12}C$ balance ($\delta^{13}C$, vs. VPDB) of photosynthate in C3 vs. C4 plants.

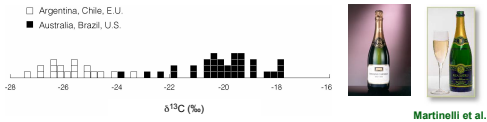


For instance, $\delta^{13}C$ of many commercial products tell you "source" of them. As you knows very well, beers are made with barley, so $\delta^{13}C$ should be fall in a range of C3 plants (−35 to −25‰). However, some have very positive $\delta^{13}C$ from much contamination of C4 products (e.g., sugar).



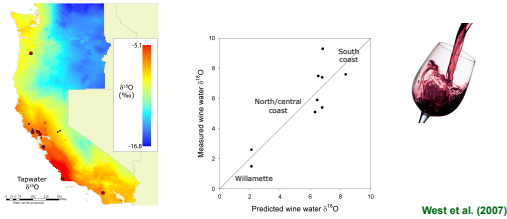
Brooks et al. (2002)

Very like beer, some wines too have very positive $\delta^{13}C$ as high as C4 plants.



Martinelli et al. (2003)

Also, $^{18}O/^{16}O$ balance ($\delta^{18}O$ vs. VSMOW) can be useful to identify the geographical origin of wines. This is based on Isoscape map (i.e,. spatial graduation) in $\delta^{18}O$ cased by dynamic hydrological cycle in the Earth surface.

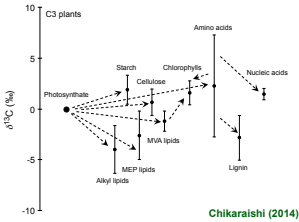


West et al. (2007)

Isotope physiology

Photosynthate is solo substrate for the biosynthesis of various functional organic compounds in biomass.

In general speaking, light isotopes (e.g., ^{12}C, ^{14}N, etc) are preferentially reacted, accumulating light one for products, while leaving behind heavy one on the residual pool. As a result, a large variety of δ values are observed in the organic compounds within a single organism.



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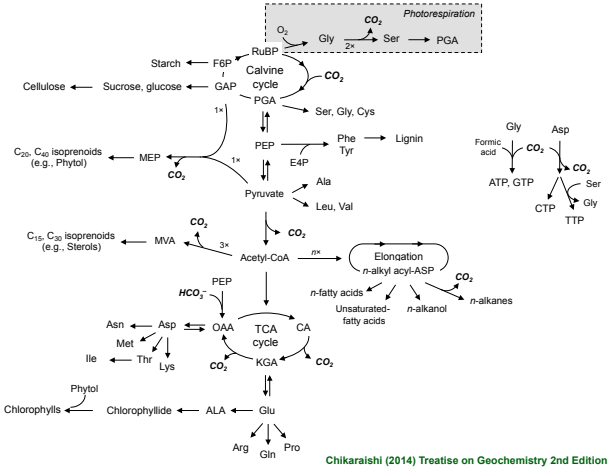
Biosynthesis of these organic compounds is accomplished by a very complex network or array of multiple enzymatic reactions. These reaction networks, empirically those where carbon, hydrogen, and/or nitrogen are added or removed in specific enzymatic reactions and are separated at branching points, potentially lead to much or less isotopic fractionation.



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We would love to contribute to the understanding in-depth the complex biogeochemical cycle in our planet. To do that, we now are challenging:

(1) Illumination of "key process" responsible for controlling molecular and stable isotopic compositions of organic compounds in organisms' physiology,

(2) Assessment of "universality & predictable fluctuation" or "homogeneity & heterogeneity" in the isotopic fractionation of the "key process", and

(3) Illustration of "energetic transfer" in biogeochemical cycles.