

Sweet Beets: Making Sugar Out of Thin Air

Part I – First Fall in the Red River Valley

Jack knew that things would be different for him when he made the move from sunny Miami up to North Dakota to play college football. He was anticipating the upcoming long winter, and wondered how cold it would be for morning practices; he was happy that he had insulating football gloves!

On a Sunday night in late September, after a light rain, Jack and a couple of his teammates decided to go out for 25-cent wing night and watch the game. Their college was a little out of the city, and shortly after turning on to the county highway Jack hit a huge mud slick on the road and slid into the ditch! Luckily, there wasn't any snow yet, so he was able to drive right out and they were again on their way to catch the game and the wing special.

One of Jack's teammates, a longtime resident of North Dakota, explained that muddy roads are a big problem during the fall, especially after a rain. He said that beet trucks drag dirt and mud out of the fields and make a huge, slippery mess with every harvest.

"Beets! You're not in Florida any more," Jack thought to himself.



Part II – Mountains on the Prairie

Located a few states north of Oklahoma, the landscape of eastern North Dakota and western Minnesota runs along the beds of the Red River of the North and provides some of the flattest farm land in the world. The Northern Great Plains' lack of terrain and trees allows a person to see for miles on end. However, each fall, gigantic mounds of sugar beets are stockpiled up and down the valley, creating what appears to be mountains in the distance.



Figure 2. Sugar beet stockpiles, October 2013.

Question

1. Sugar beets (*Beta vulgaris*) are a major crop in the Red River Valley of the North. Why do you think the beets have to be harvested and stockpiled in September?

Part III – Making Sugar

Like all land plants, *Beta vulgaris* is a photoautotroph. This means that it generates its own energy supply by capturing energy from the sun and using it to make carbohydrates. This process is called *photosynthesis* because molecules are being synthesized with light energy. Some of the carbohydrates made during photosynthesis are used directly by the plant for energy to carry out life's processes. Any remaining carbohydrates are stored within plant tissue.

Plant photosynthesis takes place in chloroplasts, which are organelles found mainly in leaf cells. The carbon source for carbohydrate production comes from carbon dioxide (CO₂) taken directly from the air around the plant. Water (H₂O) is also utilized during photosynthetic reactions, which produces oxygen (O₂) as a byproduct. The following equation summarizes the overall general reaction:



In the above general reaction, 6 molecules of CO₂ and 12 molecules of H₂O are taken into the plant and, with the energy from the sunlight, 1 molecule of the carbohydrate glucose (C₆H₁₂O₆) is made along with 6 molecules of H₂O and 6 molecules of O₂.

Photosynthesis in *Beta vulgaris* follows the general equation above and makes glucose for energy and structural growth. Any glucose not used directly by the plant is further modified and stored in the “sink tissue” (the beet) as sucrose (C₁₂H₂₂O₁₁). Sucrose is more commonly known as “table sugar” and is made up of a glucose molecule joined to a fructose (another carbohydrate) molecule.

Questions

2. Photosynthesis requires a supply of CO₂ as well as H₂O and sunlight. How do plants obtain these resources? (*Hint: refer to plant anatomy.*)

Part V — Connecting to the Larger Picture

Global atmospheric CO₂ levels are monitored closely by the National Oceanic and Atmospheric Administration (NOAA). The tables below provide two years of data collected by the NOAA Southern Great Plains station located in Oklahoma.

Year	2012											
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CO ₂ (ppm)	398	398	395	391	394	396	394	393	396	398	400	403

Year	2013											
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CO ₂ (ppm)	404	404	403	400	399	397	394	392	394	398	402	404

Data are reported as numbers of molecules of CO₂ per total molecules of air (excluding water vapor) and expressed as parts per million (ppm). Data was retrieved from Dlugokencky, 2015.

Questions

3. Create a line graph for the data in the tables above. What trends in CO₂ levels do you notice over the course of a year?
4. What may be some possible contributors to the higher carbon dioxide levels found during the fall and winter months vs. the summer months?
5. How do those trends correspond to the *Beta vulgaris* growing season in the Red River Valley of the North?
6. Provide an explanation of how *Beta vulgaris* plays a role in the movement of carbon atoms between living and non-living systems.