

Monarchs and Milkweed: Energy Cycles in the Biological World

by

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Part I – Butterflies in the Park

“I bet it will be 108 more years before your beloved Cubbies win another title,” Morgan playfully teased Chris as the two friends relaxed in a waterfront park, sipping coffee. The students had spent the morning walking along the Lakefront Trail, swapping stories about their first semester in college, and enjoying the sights and sounds of their hometown of Chicago. They felt fortunate that they had been able to coordinate a long weekend home together, allowing them to catch up and take a break from their studies. Before Chris could get out a well-planned comeback, however, a group of butterflies caught Morgan’s attention.

“Oh look! A monarch butterfly!” Morgan exclaimed. Chris was quite familiar with monarchs, thanks to Aunt Pat’s stunning vacation photos of millions of monarchs overwintering in Mexico’s monarch Butterfly Biosphere Reserve. “I’ve only seen photos of them in Mexico. What are they doing in Chicago?” Chris wondered.

“My little sister’s third grade class planted a milkweed garden at a local park to create a ‘monarch rest stop’ to feed the monarchs on their journey to Mexico,” Morgan remembered. “But how do these small butterflies make it all the way to Mexico—and how are milkweed plants involved?”

The two spent a few minutes researching monarch butterfly migration on Wikipedia on their phones (Morgan made a mental note to tell her biology professor that there were some good uses for smartphones).

Here is what they discovered:

- The monarch butterfly (*Danaus plexippus*) feeds on the nectar of milkweed (*Asclepias syriaca*, other species of *Asclepias*, and many other plants).
- It does this in order to build up energy reserves in the form of lipids for its migration to south-central Mexico.
- The journey usually begins in late summer (August to September) and can take several months (approximately three to four generations), with the majority of monarchs reaching Mexico in early November.



Figure 1. Monarch rest stop with milkweed. ©Andrew Sabai | Dreamstime.com, ID 57041683.

Part II – Nectar Production by Milkweed Plants

Chris thought about the connections between producers and consumers. “We’ve been learning about cellular respiration and photosynthesis in my intro bio class.”

“Yeah, same here. We learned about how plants make sugar using photosynthesis and how cells (both plant and animal cells) can use this sugar as an energy source to produce ATP,” Morgan added.

“So how do these processes apply to the monarchs and their food sources?” Chris wondered.

So much for the friends’ plans to avoid thinking about school for a few days. Their interest piqued, Chris and Morgan thought more about these connections. Anyway, maybe this would be helpful for their upcoming midterm exams.

Questions

1. Outline the major steps performed in photosynthesis, being sure to include any necessary inputs and outputs.
2. What is the primary product of the Calvin cycle?
3. How is sucrose (the major carbon source of nectar) produced from the end products of photosynthesis? Use your knowledge of the biochemical pathways in your answer.
4. Brainstorm a list of all of the reasons milkweeds plants produce sugar.

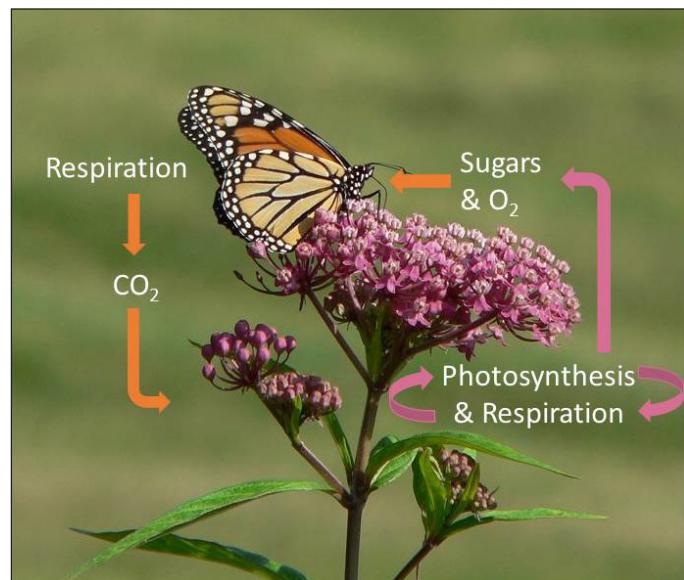


Figure 2. The energy cycles of *D. plexippus* (monarch butterflies) and *A. syriaca* (milkweed). Both photosynthesis and respiration (pink arrows) occur in *A. syriaca*, while only respiration (orange arrows) occurs in *D. plexippus*. Photo by Teune, CC BY-SA 3.0, <<https://bit.ly/2MjQtAm>>, with text overlay by authors.

Part III – Monarchs Use Nectar for Their Own Benefit

Morgan considered the information about photosynthesis. “So, plants use photosynthesis to produce sugar to grow, develop, and attract pollinators. Where does the monarch butterfly fit in?”

Questions

5. Describe the metabolic pathways in the monarch butterfly that take advantage of milkweed nectar to convert it into an energy currency.
 - a. Include details about the three phases of cellular respiration as they relate to sugar metabolism.
 - b. Where (or how) would sucrose enter the pathways?
6. How are intermediates of these pathways converted into lipids for energy storage during the long flight?

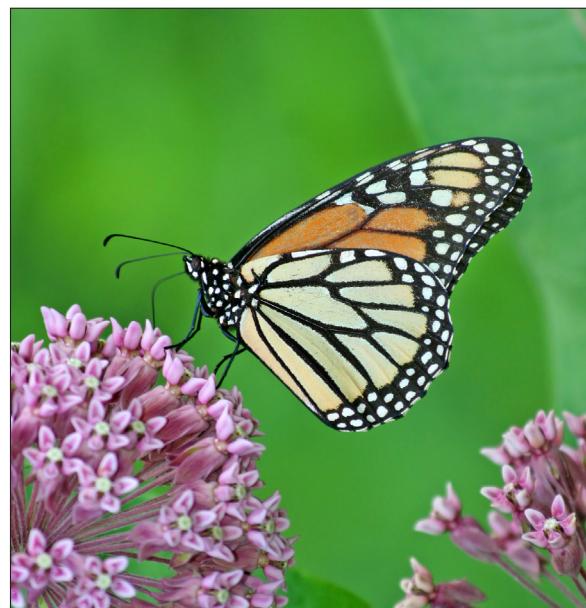


Figure 3. Monarch butterfly collecting nectar. ©Ctppix | Dreamstime.com, ID28648102.

Part IV – Making Connections

Having discussed both photosynthesis and respiration, Chris's attention was once again drawn to the beautiful group of monarch butterflies. "So the monarch consumes the nectar produced by the milkweed, uses some of the energy immediately, and stores the rest as fat. I guess that's one of the reasons why monarch rest-stop gardens contain so many milkweeds. Is there any benefit to the milkweed?"

Questions

7. Make connections between the biochemical processes that occur in milkweed plants and monarch butterflies. Be sure to list inputs and outputs of respiration and photosynthesis in your answer.

<i>Process</i>	<i>Inputs</i>	<i>Outputs</i>
Photosynthesis		
Respiration		

8. What would happen to the monarch butterflies if milkweed were extinct? And vice versa?
9. Given your answers to Questions 7 and 8, how does the concept of metabolic pools relate to the survival of both monarchs and milkweed?



Figure 4. Butterflies in the monarch sanctuary in Michoacan, Mexico. ©Avi Dolgin, CC BY-NC-SA 2.0, <https://bit.ly/2MrdLFj>.