

Chloroplasts and solar panels are constructed from simple repeating parts to form complex structures

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Rule to Build By:

Rule number 1 from the Living Architecture web site states: “To maximize flexibility of architectural form, assemble complex structures from simple repeating units” (Morris and Lane).

What:

A nature built object that meets these guidelines are chloroplasts found in plant cells. A human built structure that upholds these principles can be seen with solar panels.

How:

Chloroplasts are organelles that can only be found in plant cells. They are found in these cells because chloroplasts perform photosynthesis, which converts energy from the sun into energy for the cell. They are green in color, which explains why the leaves, stems, and other plant parts are green. For example, the leaves on a tree are green because the leaves contain cells with chloroplasts, which perform photosynthesis. The tree bark is not green because the bark does not play a role in converting energy from the sun into energy for the tree. Atmospheric carbon dioxide is transformed into oxygen, which is then released back into the environment as a waste product. It is believed that plants were one of the organisms likely to have provided our present day atmosphere with the levels of oxygen that we have now (Alberts et al., 2010).

Chloroplasts have three internal compartments. The outer membrane is very permeable, while the inner membrane is less permeable. These membranes and the space in between them form the chloroplast envelope. The inner membrane surrounds the inner space of the organelle, called the stroma (Wikipedia, 2012). A third membrane, called the thylakoid membrane, surrounds an internal third compartment. This membrane contains electron-transport chains, ATP synthase, and the light-capturing systems of the chloroplast. The structure of a chloroplast is critical for the production of energy for the entire plant cell (Alberts et al., 2010).

Like mitochondria, chloroplasts are considered to be the energy producing organelles of a plant cell. In order to produce energy for a plant cell, sunlight is absorbed by a chloroplast. Chlorophylls take up this energy, which is transferred to a reaction center within the chloroplast. At this reaction center, an electron transport chain produces the carrier molecule, NADPH. Both ATP and NADPH are made after the absorption of photons of light from the sun. These molecules are then used to produce sugars, which can be used for energy for the plant cell. This sugar-producing process is known as carbon fixation. Sugars are created from carbon dioxide and water, which can then either be stored as starch, or consumed to produce ATP. This process occurs in each chloroplast when exposed to sunlight. While the energy produced from one chloroplast may be small, multiple chloroplasts will produce ample energy for a cell. A plant cell can have several hundred chloroplasts in one cell. With each chloroplast creating a small amount of energy, the combined energy production from several hundred chloroplasts will provide enough energy for that cell to function. Therefore, in order to create a complex energy-making machine, many chloroplasts come together to form a complex energy-producing machine (Alberts et al., 2010).

Solar panels are man-made structures that are composed of single panels lined up next to each other to form rectangular panels. Each single panel is composed of silicon crystals, which transform the energy from the sun into electrical energy. Other materials can be used instead of silicon to

reduce the price of buying a solar panel (such as copper or indium) but they are not as effective as silicon crystals. By combining multiple panels together, a whole sheet of solar panels can be constructed to allow even more energy from the sun to be converted into electricity (Locke, 2008).

Why:

It is evolutionarily advantageous for plant cells to convert the energy from the sun into energy that they can use to fuel their cell processes. While a single chloroplast can transform sunlight into workable energy for a cell, this one chloroplast will not provide enough energy to power the entire cell. Therefore, multiple chloroplasts are needed in order to convert enough energy through photosynthesis. The more chloroplasts a cell has, the more energy that can be created, stored, and used for cellular processes. It is evolutionary advantageous for plant cells to have multiple chloroplasts so that they can convert enough energy from the sun into usable energy that they can use. Rule-to-build-by number 1 accurately represents how one chloroplast can become more effective by combining with several hundred chloroplasts to create a complex structure of organelles to provide a plant cell with the energy that it needs to survive (Alberts et al., 2010).

Solar panels are also engineered to have multiple panel squares in one solar panel so that more electricity can be generated from the sun. A group of solar panels will generate more energy combined, than if only one square was present. In this way, both man-made solar panels and nature-made chloroplasts are similar and both follow the rule-to-build-by number 1 because they both take one structure with one function and combine it to form a complex structure with more energy generation (Locke, 2008).

Figures:

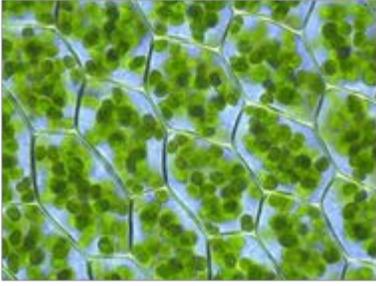


Figure 1. When combined together, Chloroplasts can create enough energy to sustain an entire plant cell.



Figure 2. A solar panel is comprised of many smaller panels which combine to form a large solar panel capable of producing larger amounts of energy.

References:

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- Locke, S. (2008). “How Does Solar Power Work?”. *Scientific American*. Accessed online. <<http://www.scientificamerican.com/article.cfm?id=how-does-solar-power-work>>
- Morris, Robert; Lane, Evie. “Living Architecture”, Norton, MA: Wheaton College. <<http://acunix.wheatonma.edu/rmorris/la/index.html>>
- Wikipedia (2012). “Chloroplast”. *Wikipedia*/ Accessed online <<http://en.wikipedia.org/wiki/Chloroplast>>

Picture References:

Figure 1. Wikipedia. <http://en.wikipedia.org/wiki/>

Figure 2. MidSouth Building Supply

<http://www.msbs.net/Exteriors/Solar/MonocrystallineVsPolycrystallineSolarPanels/tabid/168/Default.aspx>