PRINCIPLE 1: NATURE RUNS ON SUNLIGHT

How does nature generate energy?





SUMMARY

This module is about energy. Most of the energy used in nature comes from the sun through photosynthesis. Students play the process of photosynthesis in two different ways.



Preparation:

about 20 min. (Activity 3 might take longer the first time it is delivered)

Activity:

about 45 min. / 1 lesson



 Science – Biology, Chemistry, Arts
Mathematics



Biomimicry principles; energy; photosynthesis

BIOMIMICRY PRINCIPLES



1 – Nature runs on sunlight

LEARNING OBJECTIVES

- Students understand the process of photosynthesis.
- Students understand why green plants are vital for life on Earth.
- Students understand how organisms are interconnected.

LEARNING OUTCOMES

- Students provide a practical demonstration of photosynthesis.
- Students reflect on the importance of this process.

BIOLEARN COMPETENCES

- Students are able to abstract principles of sustainability from the way the natural world functions.
- Students are able to work in groups.
- Students are more motivated in learning STEAM and experience that STEAM knowledge can be widely used.



SUMMARY OF THE ACTIVITIES

	Activity Name	Short description	Method	Duration	Location
1	Introduction	Presenting the principle 9_principles.ppt	Teacher presentationDiscussion	10	Indoor
2	Playing photosynthesis	Students understand the process of photosynthesis through a play	• Role play	20	Indoor/ outdoor
3	Modelling the reaction of photosynthesis	Students act out the chemical reactions of photosynthesis	• Role play	20	Indoor/ outdoor
4	Review	Discussion after the activities	Discussion	10	Indoor/ outdoor

Note: Activity 2 and 3 can be delivered in parallel, so the whole module can fit into 45 minutes. Activity 3 can be omitted if time is short.



OUTLINE OF THE MODULE

BACKGROUND FOR TEACHERS

See at Activity 1: Introduction.

For interconnections see *Nine Principles of Biomimicry* module.



» QUESTION

ACTIVITY DETAILS



1 INTRODUCTION



• PC, projector • <u>9 principles.ppt</u>, 2nd slide



Arrange the classroom for presentation and discussion.



Benyus, J. M. (2002): Biomimicry – *Innovation inspired by nature.* HarperCollins Publisher, New York, U.S.A.

Present the slide about Principle 1: 9_principles.ppt, slide 2.

Nature uses sunlight as the main source of energy. Organisms use heat and UV radiation from this never-ending source. So, we can say that nature is powered by sunshine. Humans use fossil fuels, these sources are not renewable, and burning them creates CO_2 which is one of the gases causing climate change. Why don't we do the same and prevent the climate crisis? A wise person would mimic nature and rely on renewable power.

Explanation to 9_principles.ppt, 2nd slide:

Photosynthesis is a chemical reaction that takes place inside a plant, producing food for the plant to survive. Carbon dioxide, water and light are all needed for photosynthesis to take place. Photosynthesis takes place in the part of the plant cell containing chloroplasts, these are small structures that contain chlorophyll. Photosynthesis takes place in two stages, the light reaction and the dark reaction. The light reaction converts the energy of sunlight into chemical energy (ATP – adenosine triphosphate and NADPH – nicotinamide adenine dinucleotide phosphate), and during the dark reaction chemical energy is converted to produce sugars from carbon dioxide (Calvin cycle).

The process is described by the equation:

 $6\text{CO}_2 + 12\text{H}_2\text{O} + \text{sunlight} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 + 6\text{H}_2\text{O}$

The slide shows a tree, leaves and chloroplasts in cells seen through a light microscope.

It is worth mentioning that there are bacteria that do not use sunlight to generate energy. They use chemical compounds (e.g. hydrogen, ammonia, iron, sulphur compounds), this is called chemosynthesis. One of them is chemolithotrophs which use an inorganic electron donor for breathing. These bacteria usually live in anaerobic condition like ponds, or in extremely mineralized areas where sunlight is completely missing, e.g. iron geysers and springs, deep sea smokers (volcanoes). All autotrophs (they build up organic matter from inorganic materials in their environment) use carbon dioxide as the carbon source for photosynthesis to build up their organic matter. Heterotrophic organisms derive their energy from organic materials produced by autotrophic organisms.



ACTIVITY DETAILS





» DISCOVER 🔘



• Student worksheets: <u>W2.1</u>, <u>W2.2</u>

 Any costumes, decorations for the play (students can prepare these before the class)



The play can be performed indoors or out. The costumes and decoration can be made by students, or place in the classroom a box with old clothes, rags, etc. so students can select what they need.

Print and cut as cards of <u>W2.1</u> and print <u>W2.2</u> by the number of students.



https://sbsciencematters.com /5th/life/5.15Photosynthesis Play.pdf

Key to life on Earth is that green plants produce organic compounds from water and carbon dioxide using sunlight. Energy can be stored in these organic compounds.

Probably all students have learnt about photosynthesis. The basic equation of photosynthesis is:

 $6CO_2 + 6H_2O + photon energy = C_6H_{12}O_6 (glucose) + 6O_2$

The real equation is $6CO_2 + 12H_2O + photon energy = C_6H_{12}O_6 (glucose) + 6O_2 + 6H_2O$, as oxygen molecules of O_2 come from H_2O .

Student worksheet W2.2 describes a photosynthesis play. In the play, students play the roles of different parts in the process of photosynthesis. Select students for the different roles and let them practise for a couple of minutes, and then have a performance. After the performance discuss with students, why are green plants are the basis of life on the Earth?

EXTENSION(S)

You can write/search for another version of the play together with students at a higher level, in case they have a deeper understanding of photosynthesis.

Resources:

https://teachers.yale.edu/curriculum/viewer/initiative_07.05.08_u day 5 Science and Plants in Schools (www.saps.org.uk) provides excellent resources for follow-up experiments.



ACTIVITY DETAILS



TOOLS AND MATERIALS

 Discs (about 10 cm diameter) attached onto kebab sticks (about 3–4 mm diameter and about 20 cm long) with the chemical symbols of the elements within the photosynthesis process: 6 discs with C; 18 discs with O; 12 discs with H. In case you choose to show the real equation another 6 O and 12 H are needed. See picture on <u>T3.1</u>.

• Hint: the diameter of the symbols can differ by the size of element: H can be the smallest, C medium and O the largest.

• Teacher's pages: <u>T3.1</u>, <u>T3.2</u>



Prepare the discs described above. You will need space either inside or outside for modelling the reaction with students.

3 MODELLING THE REACTION OF PHOTOSYNTHESIS

» CREATE

The second activity (above) requires only 8 students, the rest of the kids can play the scheme of photosynthesis.

Depending on the number of students, hand out the symbols of the elements e.g. if there are 12 students, 6 of them can hold the formula of water (H_2O) and another 6 the carbon-dioxide (CO_2). One pupil can play the role of light, and when he/she 'shines', the elements are rearranged: students become $6O_2$ and one $C_6H_{12}O_6$ (of course, in case you use the real equation, you need more elements.) You can find the arrangement for glucose in T3.2.

Students can prepare the plays/models of 2nd and 3rd activity in parallel and perform to each other after practicing.

EXTENSION(S)

You can learn how to make solar cell from here: https://www.learningwithnature.org/ Education Materials / Engineering Curricula – Middle/High School / 8. The Largess of Leaves (p. 96) / Activity procedure (p. 102)



» QUESTION

ACTIVITY DETAILS



4



Arrange the classroom for discussion.

REVIEW

After the activities talk with students about the principle:

- How does nature catch the energy of the sun? .
- Why do we say that the process of photosynthesis provides the basis of life . on Earth?
- Where and how could we mimic this process? .

LITERATURE, ADDITIONAL INFORMATION

Stier, S. (2014): Engineering Design Inspired by Nature. The Center for Learning with Nature, Coralville, U.S.A. https://www.learningwithnature.org/



T3.1 MODELLING THE REACTION OF PHOTOSYNTHESIS Picture of discs for the elements of photosynthesis



T3.2 MODELLING THE REACTION OF PHOTOSYNTHESIS The formula of a glucose molecule

GLUCOSE MOLECULE





PRINCIPLE 1: NATURE RUNS ON SUNLIGHT How does nature generate energy?

STUDENT WORKSHEETS W2.1 PLAYING PHOTOSYNTHESIS **Character Cards** Water Sun (H_2O) Norman, Sunlight the Plant Carbon Oxygen Dioxide (0_2) (CO_2) - 2 -- 2 Sugar Narrator $(C_6H_{12}O_6)$

oage



W2.2 PLAYING PHOTOSYNTHESIS Text

CAST OF CHARACTERS:

Narrator, Sun, Sunlight, Water (H₂O), Sugar (C₆H₁₂O₆), Carbon Dioxide (CO₂), Oxygen (O₂), Norman the Plant.

SETTING:

A garden (students may pick the specific location).

Narrator: There once was a handsome plant named Norman. He was green and lush. He was a happy plant with many other plant friends. But, one day he got really hungry. (*Sun and sunlight stand together on one side of the room and Norman the plant stands on the other side of the room.*)

Norman: I am starving! My friend Bob the Human and Vanessa the Cat eat with their mouth, but do you see a mouth on this face? Nope!

Narrator: Norman sure was hungry, so he lifted his leaves towards the sun.

Sun: What a beautiful day! Let me shoot my rays of sunlight down upon the Earth.

Sunlight: Here I come! (The sunlight moves quickly from the sun towards the plant).

Norman: Mmmmm, sunlight, yummy! (Sunlight high fives Norman's leaf (his hand)).

Narrator: The sunlight hits Norman's chloroplast and his lunch has begun.

Norman: I have begun to process the sunlight, but I am thirsty too. Water come here!

Water: I will travel through your roots and up your stem. (Water comes towards Norman's roots)

Norman: I have sunlight and water, now I need to suck in some carbon dioxide through my many stomata. *(Norman opens his mouth for the stomata).*

Carbon Dioxide: Here I come from the atmosphere! (Carbon Dioxide flows towards Norman)

Narrator: The process of photosynthesis is almost complete! Now, the sunlight, water, and carbon dioxide need to perform chemical reactions to produce Norman's lunch. (*Water, Sunlight and Carbon Dioxide link arms and walk in a circle around Norman*)

Norman: I am feeling a chemical reaction occurring. My lunch! My sugary lunch! (*Water, Sunlight and Carbon Dioxide sit down and out runs Sugar*)

Sugar: I am lunch! I can feed Norman's cells. Don't I look delicious? (Norman pretends to eat Sugar)

Norman: That was delicious, but now I have to take care of the oxygen I created. (Oxygen molecule comes and stands next to Norman)

Oxygen: Part of me stays in Norman to help him get energy in his cells. But most of me leaves Norman through his stomata. The good news is that I am then valuable to animals and humans. *(Oxygen walks away from Norman into the atmosphere)*

Narrator: As you can see, plants can make their own food through the process of photosynthesis. Thank you, Norman for demonstrating.