PRINCIPLE 3: NATURE FITS FORM TO FUNCTION

How does nature match its form to deliver functions efficiently?

Erasmus+

AGE RANGE

11–13

DURATION

Preparation:
about 20 min.

Activity:
about 45 min. / 1 lesson

KEYWORDS

Biomimicry principles; function; form

SUMMARY

Nature is a skilful designer. Each form created fits to deliver a specific function, and in addition nature can be beautiful. In this module students investigate how nature fits form to function.

BIOMIMICRY PRINCIPLES

3 – Nature fits form to function

LEARNING OBJECTIVES

- Students understand that everything in nature has a function.
- Students understand how form and function complement each other.
- Students are able to recognise form and function in nature.

LEARNING OUTCOMES

- Students recognize natural and artificial objects using different senses.
- Students identify the functions of objects.
- Students compare functions between natural and human-made objects.

SUBJECT(S)

This module is part of a series of modules introducing the nine principles of biomimicry. The table below shows possible KS3 Programme of Study links for all the modules. Many of the activities will also be suitable for upper KS2.

This learning module can be used flexibly within the curriculum to support key knowledge about Biology and develop working scientifically competences. The learning links with the Sustainable Development Goals and provides a broader context for student learning. It is suitable for adapting as a STEM activity or Eco Club.

Programme of Study Reference	Working Scientifically
Biology: Material cycles and energy - Photosynthesis • the reactants in, and products of, photosynthesis, and a word summary for photosynthesis. • the dependence of almost all life on Earth on the ability of photosynthetic organisms, such as plants and algae, to use sunlight in photosynthesis to build organic molecules that are an essential energy store and to maintain levels of oxygen and carbon dioxide in the atmosphere. • the adaptations of leaves for photosynthesis. Interactions and interdependencies – Relationships in an ecosystem • the interdependence of organisms in an ecosystem, including food webs and insect pollinated crops. • how organisms affect, and are affected by, their environment, including the accumulation of toxic materials. Genetics and evolution – Inheritance, chromosomes, DNA and genes • changes in the environment may leave individuals within a species, and some entire species, less well adapted to compete successfully and reproduce, which in turn may lead to extinction. • the importance of maintaining biodiversity and the use of gene banks to preserve hereditary material.	Students successfully completing this module will have had the opportunity to access these statements: **2a, 2b, 3b, 3c, 3d, 3f**. See Annex 1 for full statements.

BIOLEARN COMPETENCES

- Students are able to identify functional design in nature, develop greater awareness and appreciation for design excellence in nature, and appreciate how nature works as a system which is elegant and deeply interconnected.
- Students are able to identify important needs and opportunities that can be addressed through design innovation for products, processes and systems.
- Students are able to work in groups.
- Students are more motivated in learning STEAM and experience that knowledge of STEAM can be widely used.

SUMMARY OF THE ACTIVITIES

	Activity Name	Short description	Method	Duration	Location
1	Introduction	Presenting the principle 9_principles.ppt	• Teacher presentation • Discussion	10	Indoor
2	Recognising forms and functions	Exploring the function of natural and artificial objectives	• Observation • Exploration	25	Indoor/ outdoor
3	Review	Discussion after the activity	• Discussion	10	Indoor/ outdoor

BACKGROUND FOR TEACHERS

See at Activity 1: Introduction.

For interconnections see *Nine Principles of Biomimicry* module.

During the lessons, students will become familiar with the terms function and strategy. It is important to be clear about these terms and we offer the following definitions:

Functions: In biomimicry a function refers to an organism's adaptations which help it survive. For example, the purpose of bear fur is to keep warm, in technical terms its function is to conserve heat (insulation). A leaf is made to biodegrade, so one function of a leaf is to 'break down' after use. Human products also have functions; a kettle has the functions to both contain water and heat water (modify its physical state). In brief, a function is 'what it does.'

Health and Safety
Appropriate consideration needs to be given to health and safety when working outdoors, but this should not prohibit regular use of the outdoor learning environment.

For guidance on using the outdoor learning environment review the Council for Learning Outside the Classroom suggestions on Plan and Deliver. CLEAPSS also provides guidance for members. We recommend you read and act on L196 – Managing Risk Assessment in Science. Finally, check your school policy on learning outside the classroom.

The Institute for Outdoor Learning provides a good overview into the risks and benefits of outdoor learning here. They also offer specific guidance and advice for schools here.

ACTIVITY DETAILS

LOCATION
Indoor

TOOLS AND MATERIALS

- 9_principles.ppt; 4th slide

PREPARATIONS

Arrange classroom for presentation and discussion.

RESOURCES

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

Steven Vogel: Comparative Biomechanics: Life's Physical World, Second Edition June 17, 2013 (https://asknature.org/strategy/specialized-teeth-wear-down-but-remain-effective/#.XoRouHJS-Ht)

1| INTRODUCTION

» QUESTION

Present the slide about Principle 3: 9_principles.ppt, slide 4.

A tree is rooted in the ground to draw water and nutrients from the soil; it spreads its branches and leaves wide to increase surface area and absorb the sunlight to produce energy and grow. Seeds are lightweight and some even come equipped with a sort of umbrella so they can float in the air. Nature creates designs for the function they provide, so should our buildings, transportation systems and schools.

Explanation to 9_principles.ppt, 4th slide:

"Grazing has perhaps elicited the most dramatic dental specializations in mammals. About twenty million years ago, grasses and grasslands appeared on earth. Grass provides poor fodder. It yields little energy relative to its mass, so a grazer has to process huge volumes. Much of that energy comes as chemically inert cellulose, which mammals hydrolyze only by enlisting symbiotic microorganisms in rumen or intestine. It's full of abrasive substances like silicon dioxide and has lengthwise fibres that demand cross-wise chewing rather than rapid tearing. Long-lived grazers, concomitantly, have special teeth, with their components typically layered side by side. This odd-looking arrangement ensures that, while teeth may wear down, they won't wear smooth. The harder material (enamel, most particularly) will continue to protrude as the softer materials (cementum and dentine) wear down between them." (Vogel 2003:333)

The fruits and seeds of plants are designed to facilitate their propagation. They are designed to catch the wind, float in water, stick to animals etc to ensure they are spread far and wide. The fruit of the maple tree, for example, flies like a helicopter; this is made possible by the streamlined, slightly inclined 'wing'. The thistle seed has hook-and-loop parts that easily get caught in animal fur. Some plants even have a mechanism to 'shoot' their seeds away from the plant.

Birds also have a beak shaped for feeding on specific foods or prey. For example, predator birds have a hook on the beak that can easily tear their prey.

Penguin bodies are spindle shaped. This makes it difficult for them to move on land, but it is extremely streamlined in water; beside their bodies, the movement of the water is laminar, and turbulence occurs just behind their body, resulting in very low water resistance enabling them to swim faster.

LOCATION
Indoor / Outdoor

TOOLS AND MATERIALS

- Student worksheet: W2.1
- Teacher's page: T2.1
- pen/pencil
- (clipboard)
- natural and artificial objects for pairs of students
- a blindfold for each pair of students

PREPARATIONS

This activity can be implemented in- or outdoors. Print W2.1 so there is one per pair.

RESOURCES

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

2| RECOGNISING FORMS AND FUNCTIONS

» DISCOVER

In this activity, students observe the attributes of different objects and detect what their function is.

Arrange students into pairs. One member of each pair is blindfolded and handed an object. The blindfolded students explore the object provided with all of their senses except their sight and taste. Their task is to notice as much as possible about the object (not try to guess what the object is) and describe each object using adjectives. The unblindfolded partner will write down the adjectives used.

After the blindfolded partner has explored 2 objects (1 human-made, 1 natural), the unblindfolded partner reads back the adjectives one-by-one to the blindfolded partner. For each adjective (e.g. sharp), the blindfolded partner hypothesizes what potential function is (e.g. sharp is for protection).

You can ask pairs to swap after each object, or after each has experienced one natural and human-made object.

After the activity talk with students about function and attributes in natural and human made objects.

You can find an example at T2.1.

EXTENSION(S)

After discussing that nature fits form to function, and sharing examples (including student's own examples), ask students consider all the things a human hand can do. Then, for half the students, tape their thumbs to their index fingers. Then ask students to move wet marbles from one bowl to another. See how many marbles they can move in 60 seconds. How do the students with taped thumbs do compared to the students without taped thumbs?

LOCATION
Indoor / Outdoor

PREPARATIONS

Arrange classroom for discussion.

3| REVIEW

» QUESTION

After the activity/ies talk with students about the principle:

- What examples did you find in nature for form and function coming together?
- Is it always true for human-made objects?
- Why is this attribute (form and function fits together) so important in nature?

T2.1 RECOGNISING FORMS AND FUNCTIONS

Examples:

Object	Attributes	Possible function
Medicine bottle	Ridged at one end	Easy to grip
	Sounds hollow	Can contain or carry things
	Raised lines, maybe lettering	Convey information
Pine cone	Light	Easy to hold up
	Sharp thorns	Protection
	Series of flaps	Access to interior

W2.1 RECOGNISING FORMS AND FUNCTIONS

Table for discovery

NATURAL OBJECT:

Name of the object	Attribute	Possible function

ARTIFICIAL OBJECT:

Name of the object	Attribute	Possible function

ANNEX 1

Key Stage 4 Working Scientifically Statements

Through the content across all three disciplines, students should be taught so that they develop understanding and first-hand experience of:

1. THE DEVELOPMENT OF SCIENTIFIC THINKING	a. the ways in which scientific methods and theories develop over time b. using a variety of concepts and models to develop scientific explanations and understanding c. appreciating the power and limitations of science and considering ethical issues which may arise d. explaining everyday and technological applications of science; evaluating associated personal, social, economic and environmental implications; and making decisions based on the evaluation of evidence and arguments e. evaluating risks both in practical science and the wider societal context, including perception of risk f. recognising the importance of peer review of results and of communication of results to a range of audiences
2. EXPERIMENTAL SKILLS AND STRATEGIES	a. using scientific theories and explanations to develop hypotheses b. planning experiments to make observations, test hypotheses or explore phenomena c. applying a knowledge of a range of techniques, apparatus, and materials to select those appropriate both for fieldwork and for experiments d. carrying out experiments appropriately, having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations e. recognising when to apply a knowledge of sampling techniques to ensure any samples collected are representative f. making and recording observations and measurements using a range of apparatus and methods g. evaluating methods and suggesting possible improvements and further investigations
3. ANALYSIS AND EVALUATION	a. applying the cycle of collecting, presenting and analysing data, including: i. presenting observations and other data using appropriate methods ii. translating data from one form to another iii. carrying out and representing mathematical and statistical analysis iv. representing distributions of results and making estimations of uncertainty v. interpreting observations and other data, including identifying patterns and trends, making inferences and drawing conclusions vi. presenting reasoned explanations, including relating data to hypotheses vii. being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error b. communicating the scientific rationale for investigations, including the methods used, the findings and reasoned conclusions, using paper-based and electronic reports and presentations

4. VOCABULARY, UNITS, SYMBOLS AND NOMENCLATURE	a. developing their use of scientific vocabulary and nomenclature b. recognising the importance of scientific quantities and understanding how they are determined c. using SI units and IUPAC chemical nomenclature unless inappropriate d. using prefixes and powers of ten for orders of magnitude (e.g. tera, giga, mega, kilo, centi, milli, micro and nano) e. interconverting units f. using an appropriate number of significant figures in calculations