PRINCIPLE 5: NATURE REWARDS COOPERATION

Cooperation or competition?

Erasmus+

AGE RANGE

11–13

DURATION

Preparation:
about 20 min.

Activity:
about 45 min. / 1 lesson

KEYWORDS

Biomimicry principles; diversity; cooperation

SUMMARY

We tend to think that nature is based mostly on competition. If we look closer, it is clear that cooperation is more rewarding. In this module students practice cooperation and consider which is better: cooperation or competition?

BIOMIMICRY PRINCIPLES

5 – Nature rewards cooperation

LEARNING OBJECTIVES

- Students understand that cooperation is more rewarding in nature than competition.
- Students understand that everything is interconnected in nature.
- Students learn that diversity is necessary in a natural living community.

LEARNING OUTCOMES

- Students research a natural living community, e.g. an oak forest.
- Students make connections between the members of the community.
- Students see how these interconnections can work: how diversity can make a system stable.

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 abstract principles of sustainability from the way the natural world functions.
- 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 work in groups.

SUMMARY OF THE ACTIVITIES

	Activity Name	Short description	Method	Duration	Location
1	Introduction	Talking about 6th slide of 9_principles.ppt	• Teacher presentation • Discussion	10	Indoor
2	Playing oak forest	Students become members of an oak forest and search for interconnections	• Role play	25	Indoor/ outdoor
3	Honeybee dancing (optional extension)	Students will role play how honey-bees use dance to communicate	• Role play	25	Indoor/ outdoor
4	Review	Discussion after the activity	• Discussion	10	Indoor/ outdoor

Note: You can choose either Activity 2 or 3, or both if you have time.

BACKGROUND FOR TEACHERS

See at Activity 1: Introduction.

For interconnections see *Nine Principles of Biomimicry* module.

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.

LOCATION
Indoor

TOOLS AND MATERIALS

- 9_principles.ppt; 6th 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.

1| INTRODUCTION

» QUESTION

Present the slide about Principle 5: 9_principles.ppt, slide 6.

We see competition in nature, but only when it's impossible to avoid; in general competition costs too much energy. On the other hand, very little in nature exists in isolation. Plants cooperate with pollinators to disperse seeds, and the pollinators feed on nectar. Ladybirds feed on aphids and help plants to stay healthy. Nature favours cooperation because it maintains the health of the whole system.

Explanation to 9_principles.ppt, 6th slide:

In all habitats, populations of different species live together influencing each other's life processes and functions, and therefore interacting with each other. It can be positive, negative or neutral. Here are some examples:

Commensalism (table community) – when one species benefits another species but does not interact. An example of this are sparrows nesting in a stork's nest; they receive food without disturbing the stork.

Antibiosis – the presence of one species is clearly harmful to another species. It is predominantly micro-organisms, the metabolism of one species adversely affecting the other. A typical example is penicillin, a substance that inhibits the growth of bacteria.

Competition – harmful to both species, but sometimes necessary. This happens when, for example, food or habitat is not sufficient for all populations living there. Typically, one species disappears. Another example is when plants out compete each other for light.

Predation (catching prey) – herbivores eat plants, predators eat the flesh of herbivores, decomposing organisms eat dead plant and animal parts.

Parasitism – there is a host organism and a parasite that feeds on it. Living together is beneficial for the parasite but it is harmful for the host organism, even if it does not die immediately. An example of this is the downy mildew on vines or tapeworms in vertebrates.

ACTIVITY DETAILS

Mutualism – one of the most typical relationships that benefits both species. There are many examples of this relationship between plants and animals. In obligatory mutualism, the two species cannot live without each other, while optional mutualists can. Symbiosis means close and lasting coexistence, whereas other forms of mutualism do not necessarily involve the continuous coexistence of partners.

Examples:

- Azotobacter (nitrogen-fixing bacteria) in the root tissue of *Papillonaceae* fix ammonia from nitrogen in soil-air for the plant.
- Mycorrhiza – root connections between fungi and plants; the former helps in the absorption of inorganic substances, the latter provides organic compounds to the fungi.
- Lichen – coexistence of algae and fungi.
- Vitamin-producing bacteria living in the human intestine.
- Insects pollinate plants – there are plants that can be pollinated by several species, and some that have special flowers, so only a certain species can pollinate them.
- Ants and aphids – the latter absorb the sap of the plants and pick out the dew which the ants prefer to consume, in return the ants protect the aphids and carry aphids from one plant to another.
- Cleaning fish and their host fish – smaller fish remove parasites from the mouth of larger fish.
- Cellulose-degrading bacteria in ruminants.
- Hydrates live in symbiosis with green algae; algae are not digested, algae produce organic matter and oxygen from hydra-produced materials, which is good for the hydra.

LOCATION
Indoor / Outdoor

TOOLS AND MATERIALS

- ball of string
- student worksheet: W2.1
- clips (equal number with the number of students)

PREPARATIONS

This activity can be implemented either indoors or outdoors, ensuring there is sufficient space for all students to form a circle.

Cut W2.1 into cards so that there is one card per student.

RESOURCES

Sweenex, L. B.; Meadows, D., Mehers, G. M. (2011): *The System Thinking Playbook for Climate Change*. Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH, Eschborn, Germany p. 136–142.

2| PLAYING OAK FOREST

» DISCOVER

Use the cards from W2.1 (organisms in an oak forest) or cards with organisms from any living community in your locality. Students can draw pictures of their organism to become more familiar with them.

Give one card to each student, asking them to clip it onto their clothing. Form students into a circle. They will form the living community of an oak forest and the inorganic surroundings. The first student (the Sun) holds the string and searches for someone who he/she is connected e.g. one of the plants. The student (Sun) keeps the end of the string in one hand and gives the ball to the 'plant'. The next student (plant) does the same, looks for someone with a connection, holds the string and gives the ball to the next connection. Continue until everybody holds the string and are connected.

Talk about the role of this web of connections and each element within it. What will happen if we withdraw one or two organisms? Are some elements more important than others? How many elements can be removed without losing the sustainability the habitat?

LOCATION
Indoor / Outdoor

TOOLS AND MATERIALS

- pieces of paper with a number between 8 and 32, and divisible by 4 (e.g. 8,12,16, etc.)
- pieces of paper with movements on them (e.g. figure-eights, hopping)
- two hats/boxes to draw pieces of paper from
- pieces of candy to hide
- tape measure

PREPARATIONS

You need an outdoor area with about 30 m² of grassy space or more.

RESOURCES

https://askabiologist.asu.edu/bee-dance-game/introduction.html

3| HONEYBEE DANCING (OPTIONAL EXTENSION)

» DISCOVER

Honeybees have a very clever way of communicating where flower patches are to the rest of the colony. They communicate this information by doing a dance involving waggle movements. The orientation of the dance conveys the direction of the flower patch. The length of the waggle movements indicates the distance to the flower patch.

Steps:

1. Students assemble outdoors and learn how bees convey information about flower resources using waggle dancing.
2. Two students volunteer to be waggle dancers.
3. The rest of the students close their eyes while the two volunteer waggle dancers pick a piece a paper out of a hat with a number on it, divisible by 4 (between 8 and 32, i.e. 8, 12, 16, 20, etc.), which represents distance and corresponds to number of meters. The waggle dancers pick a direction and hide a couple pieces of candy in that direction, the number of meters written on their piece of paper, and return.
4. Students open their eyes and the two waggle dancers then pick a piece of paper that has a motion, e.g.
    a) figure of eight
    b) hopping
    c) squats.
5. The waggle dancers then face in the direction of the candy, and do their motion a number of times that corresponds to the distance to the candy (the number of meters divided by 4). For example, if they hid candy 8 meters from the station, the dancers do their motion twice.
6. During the waggle dance, the rest of the students need to pay attention to the number of motions and their orientation. When the waggle dancers are done, the students go and try to find the candy.
7. A new pair of volunteers then does the waggle dance.

LOCATION
Indoor / Outdoor

PREPARATIONS

Arrange classroom for discussion.

4| REVIEW

» QUESTION

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

- What other examples do you know about in nature where organisms work together more than against each other?
- Can you find examples where humans could mimic this feature of nature?

W2.1 – PLAYING OAK FOREST

Cards

Sun	Water	Soil	Air
Bramble-berry	Sessile oak	Common hornbeam	Common hazelnut
Squirrel	Fox	Wild boar	Roe-deer
Deer	Decaying wood	Great spotted woodpecker	Woodworm
Aphid	Ladybird	Stag beetle	Great tit
Blackbird	Coralwort	Corydalis	Wasp-fly

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