PACKAGING

How can nature help us design more sustainable packaging?

AGE RANGE

11–15

DURATION

Preparation: 30 min.

Activity: 95 min. / 2 lessons

KEYWORDS

Packaging; biology; protect; communicate and redesign

SUMMARY

Like our food and many other products, every organism is packaged. Our skin, the armour of a crab, the peel of a banana, the shell of an oyster, the bark of a coconut, a pineapple (seed pack) and every cell in our body has its own packaging. How can nature's different ways of packaging help us design solutions to our own packaging challenges?

BIOMIMICRY PRINCIPLES

3 – Nature fits form to function
4 – Nature recycles everything
6 – Nature banks on diversity
7 – Nature demands local expertise

LEARNING OBJECTIVES

- Students understand the range of functions different types of packaging perform.
- Students are able to identify these functions in nature.
- Students understand how nature performs functions such as: protecting things from damage, keeping things airtight, keeping things watertight, communicating, etc.
- Students are able to apply biomimicry principles to redesigning packaging materials.

LEARNING OUTCOMES

- Students define at least three different functions for each type of packaging material presented to them.
- Students find at least five different examples in nature that perform functions of interest for their packaging challenge.
- Students sketch a new design for packaging material with at least one biomimicry principle integrated in the design.

SUBJECT(S)

This learning module can be used flexibly within the curriculum to support key knowledge about Biology, Design Engineering & Technology, 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: KS4 Ecosystems • how materials cycle through abiotic and biotic components of ecosystems. • the role of microorganisms (decomposers) in the cycling of materials through an ecosystem. • organisms are interdependent and are adapted to their environment. KS3 Relationships in an ecosystem • how organisms affect, and are affected by, their environment, including the accumulation of toxic materials. **Design, Technology and Engineering:** KS4 • Technical principles (links with most areas) • Design and making principles (links with most areas). KS3 • Design, Make, Evaluate (links with most areas).	Students successfully completing this module will have had the opportunity to access these statements: **2a, 2c, 2d, 2e, 3b, 3c, 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 use analogical creativity to innovate, using biological models to inspire solutions to design challenges.
- 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	Description	Method	Duration	Location
1	Can we package smarter?	Students explore several examples of packaging and consider the functions they fulfil	• Analysis	15	Indoor
2	Biologize your question	Students develop biologized questions	• Synthesis	20	Indoor
3	Superior models	Students start their research in nature	• Research • Surveying	30	Indoor/ outdoor
4	Use nature in your design	Students explain how nature can help rethinking their packaging design	• Design activity	20	Indoor

BACKGROUND FOR TEACHERS

Everyday new products are produced, packaged and loaded into trucks for delivery. These are then bought and sold across the world, ending up in our homes. Packaging keeps our products safe, clean and intact. But over time many of these packages lead to waste and pollution. Is there a better way to package the products and services we use daily?

When we look at nature there are signs that the answer is yes. Just like the things we buy, every organism is packaged; our skin, the armour of a crab, the peel of a banana, the shell of an oyster, the bark of a coconut, a pineapple (seed pack) and every cell in our body has its own packaging.

How can nature's designs help us create solutions to our own packaging challenges? What do the folded wings of a flying insect teach us about durable yet flexible materials? How does nature build breathable containers? What ideas from nature could help us design protective packaging that serves an extra use after the product has been removed? Just like us, the rest of nature is constantly changing and transporting goods. These questions will get you started in this module. You can explore these questions from the point of view of many subjects, but they particularly lend themselves to biology and design technology, providing students with opportunities to infuse and broaden their subject knowledge.

ACTIVITY DETAILS

LOCATION
Indoor

TOOLS AND MATERIALS

- At least two different types of packaging per group; ask students to bring examples from home
- Student worksheets: W1.1, W1.2

PREPARATIONS

Indoor: arrange tables for group work.

1 | CAN WE PACKAGE SMARTER?

» QUESTION

When a product is wrapped, the purpose is not only to pack the product. We also want to create other functions and use packaging as a means. Just think of a water bottle. Is the purpose to pack the water? No, what we want is to ensure that the water stays together and does not leak away, or that we can transport water when we are out and about.

The banana is a good example of an object in nature that is packaged. The peel of the banana gives signals to its surroundings. When the peel of the banana is green it is not yet ripe for eating. When the skin has become brown, the banana is no longer edible. Communication of signals can, therefore, be a function of packaging.

Different types of packaging: Explain to your students that there are many examples of packaging produced by humans. Not every design is optimal, whether it is the functionality or how recyclable the materials are. See some examples on W1.1.

Your students have either brought some packaging with them, or you have brought it yourself. In this assignment, students compare their packaging with the examples of two or three other students. They ask each other the following questions:

- What are the functions of the package?
- Which aspects of the package would you like to improve?

Students complete W1.2 with their group for all the different types of packages in their group, based on their examples.

ACTIVITY DETAILS

LOCATION
Indoor

TOOLS AND MATERIALS

Student worksheet: W2.1

PREPARATIONS

Indoor: arrange tables for group work.

2| BIOLOGIZE YOUR QUESTION

» CREATE

The packaging we produce needs to meet different requirements: they must be resealable, air or waterproof, they must not tear, they should be easy to open, they must be sturdy, they must be able to communicate the content (product information), they should be able to change in size, etc. Discuss with your students and see if they can come up with more requirements.

In this assignment the students are going to start work on redesigning packaging. This may be redesigning one of the packages they have explored in Activity 1, or they may design completely new packaging. The central question they will ask today is:

"How would nature (waterproof, resealable, etc. enter a function here) packaging?"

In this challenge, students identify one or more functions of packaging, and then write questions which will help them explore nature to find solutions. It is important to ask questions that nature can answer; we need to create 'biologized' questions. This means that you ask the question: *"How does nature...?"* To biologize the question means to translate the terms in the question into words/phrases that are in a general enough form that we might think of biological analogies. For instance, if we ask, *"how would nature write computer code?"* we might not think of anything because nature does not write computer code. But if we translate the question into *"how does nature use clear, sequential steps in order to solve a challenge?"* then we can begin to find biological models for computer programs.

To help your students get started, they complete W2.1 based on their chosen packaging.

ACTIVITY DETAILS

LOCATION
Indoor / Outdoor

3| SUPERIOR MODELS

» DISCOVER

TOOLS AND MATERIALS

- access to the internet
- biology books
- student worksheets: W3.1, W3.2

PREPARATIONS

Indoor and outdoor: arrange tables for group work indoors. You can also go outside for this part of the module. Any place where students can find a range of different plants and animals will work, for example a school garden, park or zoo.

In this next part of the module, students investigate nature for the functions they have identified, using the questions developed in Activity 2. To help students we have listed a few examples. These natural models can be used for inspiration, and they provide students an idea of how they can find functions in nature. You can find the examples in W3.1.

Students discover natural models. They can use books, the internet and their own knowledge. They complete W3.2. The Ask Nature website is a good starting point (www.asknature.org) but getting outside and exploring nature directly is really important.

Special quality or characteristic

» QUESTION

What is the special characteristic that makes this organism a champion in performing this function? This could be something that is very obvious (green plants can absorb light; elephants have large ears).

LOCATION
Indoor

4| USE NATURE IN YOUR DESIGN

» CREATE

TOOLS AND MATERIALS

Student worksheet: W4.1

PREPARATIONS

Indoor: arrange tables for group work.

RESOURCES

Ask Nature website: www.asknature.org

In this final assignment students will work on their own packaging design. They choose the functions they want to focus on in their design and determine (with their group) which natural models best serve as inspiration. They use W4.1 to describe the mechanism of this natural model; how does this organism ensure that the function is fulfilled? Then they write how they want to apply this mechanism in their design.

W1.1 CAN WE PACKAGE SMARTER?

Different types of packaging

Packaging from nature

The banana is a good example of an object in nature that is packaged. The peel of the banana gives signals to its surroundings. When the peel of the banana is green it is not yet ripe to be eaten. When the skin has become brown, the banana is no longer edible. The communication of signals can, therefore, be a function of packaging.

Tangerines in plastic

This example shows exactly what it is all about. It is not necessary to pack all our products in plastic; nature often has solutions for this. In this case, tangerines are peeled first, and then rewrapped in plastic. Is this really necessary?

Earphones with your mobile phone

With your mobile phone you often get earphones to listen to music. All the different parts that come with a phone are often packaged separately in plastic. Because of this we produce more plastic waste than necessary.

Pizza boxes

Pizza boxes, and many other takeaway containers, are made from recyclable materials, but when cheese or other food residues stick to the cardboard, they are no longer recyclable. The problem is that oil often seeps into the cardboard. The oil cannot be separated from the packaging making the material less valuable and less marketable for buyers.

Coffee cups

Although they consist mostly of paper, disposable coffee cups are lined with plastic which is firmly attached to the paper so that the cups are watertight and can therefore contain liquid. The difficulty of recycling coffee cups is increased by the fact that they are contaminated with liquids. This means that cups cannot be recycled in standard recycling plants and should instead be taken to special facilities. The reality is that less than 1% of coffee cups are ever recycled.

W1.2 CAN WE PACKAGE SMARTER?

Improvement ideas

Today you are exploring examples of packaging to investigate how well designed they are. Compare your packaging with examples from three other students. Ask each other the following questions:

- What are the functions of the packaging?
- Which aspects of the packaging would you like to improve?

Complete the table with your group for all the different types of packaging you have selected.

Packing example	Function(s)	Improvement
PICKWICK TEA	Airtight, hygiene, waterproof	Both in a box and also separated by plastic

W2.1 BIOLOGIZE YOUR QUESTION

In this challenge, you identify the different functions of packaging and then write questions which will help you explore nature to find solutions. In order to find the right solutions in nature, it is important that you look for them in the right way. It helps to create a 'biologized question'. This means that you ask the question: *"How does nature...?"*

To help you get started, you can fill in the table below:

Packaging	Function	Biologized question
WATER BOTTLE	Waterproofing	How does nature ensure water resistance?
WATER BOTTLE	Keep cool	How does nature lower temperatures?

W3.1 SUPERIOR MODELS

Examples

VENUS FLY TRAP

The 'Venus Fly Trap' is a carnivorous plant that catches prey within its folded leaves. The plant does this when the hairs on the outside of the trap are touched by prey, signalling to the leaves to close around its prey. It is important how many hairs are touched, but also how much time there is between the moments of contact.

➔ ***Function: open and close when necessary***

COCONUTS

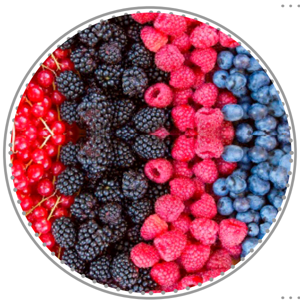
The coconut palm spreads its seeds in a hard shell that contains everything needed for a long journey. Inside there is a stock of food, the so-called meat, and a half gallon of water. On the outside it provides a fibre raft that lets the seeds float on water.

➔ ***Function: keep the item you package fresh***

CHESTNUTS

Chestnut nuts are wrapped in an envelope which protects the nuts from other organisms. Because of the fuzzy spikes on the outside of the fruit, they are less attractive for animals that would otherwise eat the chestnuts before they are ripe.

➔ ***Function: protection***



BERRIES

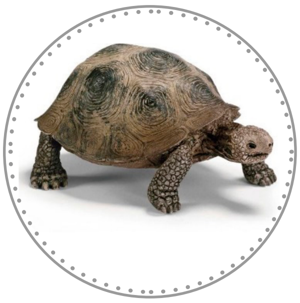
There are different types of berries, each with different colours. With these colours they send signals to other organisms. The colours say something about the taste, toxicity and maturation of the berries.

➔ ***Function: communication***

CEREBRAL FLUID

Around the human brain you find a layer of liquid. This liquid prevents the brain from becoming damaged if, for example, we bump our head. The liquid has an absorbing effect.

➔ ***Function: protection***



TURTLE

The turtle protects its body by carrying a large shell. The shell places important organs in the abdominal cavity of the turtle, safely protected from outside influences.

➔ ***Function: protection***

W3.2 SUPERIOR MODELS

Tasks

Go look for inspiration from nature. You can use books, the internet and your own knowledge.

Special quality or characteristic

What is the special characteristic that makes this organism a champion in performing this function? This could be something that is very obvious (green plants can absorb light; elephants have large ears).

W4.1 USE NATURE IN YOUR DESIGN

Choose the features you want to focus on in your design and determine (with your group) which natural models best serve as inspiration. In the table below, write what the mechanism of this natural model is; how does this organism ensure that the function is fulfilled? Then write how you want to apply this mechanism in your packaging design.

Function	Natural model	Mechanism	Application
PROTECTION	Spiked chestnut	Sharp spikes protect the seeds from damage	Special adjustments on the outside of the packaging for protection

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