

# Masterclass Biomimicry

## Challenge I

### Student manual

Are you not afraid to take on a challenge? Ready to create an innovative design as a solution to a question? To use the knowledge that we can find in nature? Then you are ready to tackle this biomimicry challenge!

*The word biomimicry is a combination of the Greek words bios, meaning 'life', and 'mimesis' which means imitating. So, biomimicry means 'imitating life' or you could also say; following successful strategies from nature.*

These materials are developed by biomimicryNL ([www.biomimicrynl.org](http://www.biomimicrynl.org)) in collaboration with the Peelland College in Deurne (NL). This Challenge is meant for the first level VWO (special top class of secondary school).

The total package consists of two separate parts. This is Part I: a first introduction to biomimicry. Part II assumes that you know a number of basic concepts and the assignments are freer. You will be challenged more!

## Introduction to the challenge

### *The challenge*

In biology you learn about nature; how animals live and what type of trees there are. In biomimicry we learn from nature, and we view it as a model and a mentor. As a *model* because plants and animals have developed numerous genius solutions that can inspire us. As a *mentor*, because in biomimicry we always ask the question: "how would nature solve that?". Biomimicry is about how we can translate knowledge from nature into sustainable solutions for our human challenges. It requires a different approach. With this challenge you get acquainted with biomimicry, what you can do with it and how you can use it. As far as we are concerned, biomimicry is the future and it will help us to solve a large number of social issues and challenges and make the world more sustainable.

### *What do we hope to achieve*

This challenge aims to give you a lot of insights and hopefully makes you enthusiastic about biomimicry. We have drawn up a number of learning objectives. Your 'grade' is determined on the basis of achieving these learning objectives.

### *Learning goals*

After doing this challenge:

- You understand what biomimicry is and you can apply the methodology.
- You can, on the basis of a 'challenge', investigate a specific problem, derive solutions and work with this method.
- You are able to make a design based on biological design principles.
- You and your group will have experience with creating and presenting your design with the aid of a poster collage.

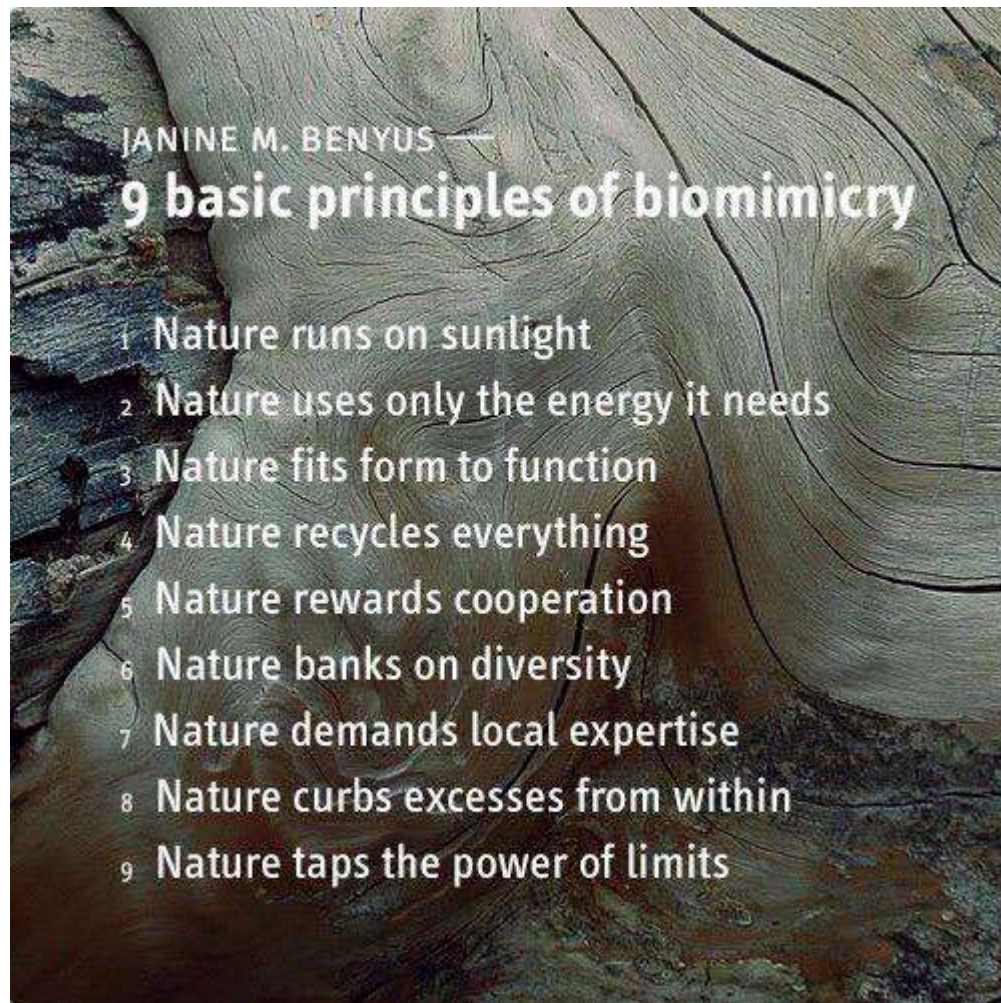
This alone is probably already exciting! This masterclass consists of two challenges in total. Both challenges are structured in 6 modules of two hours each. You need approximately one hour of self-study per module to get your design ready. What else do you need? A notebook, pencil, colored pens, etc.

<b>Module 1</b>	Lesson 1 and 2	Introduction to biomimicry
<b>Module 2</b>	Lesson 3 and 4	Formulating a question
<b>Module 3</b>	Lesson 5 and 6	Do research
<b>Module 4</b>	Lesson 7 and 8	The best solution from nature
<b>Module 5</b>	Lessons 9 and 10	Create a design
<b>Module 6</b>	Lesson 11 and 12	Preparing for the presentation (design)

### *What information can you use and where can you find it?*

During the lessons the theory is explained by the teacher. We also made an introduction video for you. A special website helps you find the answers you are looking for. You are also

free to use other sources like the library or the internet. In short, we have selected a number of sources for you, but there is enough space to make new discoveries as a real scientist!



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### *Use of Icons*

In this challenge we use three different types of icons. Below you can find the meaning:



This icon indicates where you can find information, or what is good to view now. If you follow this, it will help you to understand the concepts better.



This icon means there is a question or a thought. Stop here and think about this. The question helps you to get a better understanding of the substance.



Now you are going to do something! An assignment or an action on your own or with your group.



See this icon? You have a homework assignment.

### 1. *The challenge*

The teacher will make groups of 3-4 students. Each group receives a research question that you are going to investigate in the coming challenge. You will also create a design as a solution for 'the problem'. Eventually you make a nice 'visual' (poster) of how your solution works, for which design problem, and on which organisms your solution is inspired. Your design will be assessed by your teacher on the basis of a number of criteria (see appendix I).



Go sit with your group. Think about a nice appropriate name for your group and tell your teacher why you chose this name.

### 2. *Bio-what?*

We have mentioned it a number of times, but what is 'Biomimicry'? Biomimicry (pronounced in English as: *baajoomihmihrwie* and in Dutch as: *biejoomiemiekrie*) comes from the Greek words 'bios' meaning life and 'mimesis' which means imitating or following. So you follow nature's ideas for resolving human challenges.

#### *Let's start at the beginning*

Man is accustomed to getting things out of nature for his own use. Fruit on the trees, eggs of the chickens, leather for clothes, wood for houses, oil for fuel... People knew that nature carries many useful things and also a lot of wisdom. For example, the first people used many herbs and plants to cure diseases. People are connected to and part of nature. But nowadays we think more and more in *us* (people) and *they* (the rest outside, nature). Due to the industrial revolution, the arrival of cities, we have forgotten that we are also a part of nature. For centuries the economy continued to grow, man became richer and we increasingly lived with the idea that we are not a part of nature, but a better and greater power. People use everything from nature! But, wait a minute...

#### *What is nature?*

Nice story about nature, but what is that actually, nature? We see nature as all the life and non-life around us that is not made by people. Nature includes both living things such as bacteria, trees, birds, and also non-living things such as stones, water and wind that interact with living things. We also see people as nature, we are all part of nature, but sometimes we forget that. We forget that we are all part of the same system, and that it is our responsibility to treat each other and all things as we want to be treated ourselves, what do you think?





*What do you think of nature?*

Are people nature? This is an interesting question, because people give different answers here. Many scientists and biologists say that people are part of an evolutionary process and are certainly part of nature, while others will say that people are separate from the rest of nature. So again, what do you think ? What does belong to nature and what is not nature? Are people nature? And the things we make? What makes us people and what is the relationship between people and (the rest of) nature?

Answer these questions with your group in a maximum of 250 words. Then discuss this in class. Also consider the following questions: do you think the same about nature? And the role / place of people in it? If not, what are the differences? You have 10 minutes for this assignment. *Tip: create a mind map to organize your thoughts*

### **We are a young species**

We realize that people might have taken away too much from nature. All sorts of animals and plants get extinct and the climate is warming up due to an increase in CO<sub>2</sub> in the air. We humans are only 'just' around 200.000 years on this planet. That sounds like a long time, but if you consider that the first life on earth already exists for 3.8 billion years, man is only a baby in relation to other plants and animals that have existed for a long time. We may already think we know everything, but nature is full of smart solutions that have proven themselves over time, and where we can still learn a lot from.

Many plants and animals have through their longer existence learned how to adapt and survive. Can we learn from nature, see nature as a teacher / mentor and give ourselves the modest role of an eager pupil?



*What is the difference between 'using' something from nature and 'applying' biomimicry? And what then is the difference between learning about nature and learning from nature?*

### *A solution with biomimicry*

We at biomimicryNL want people to be inspired by nature and go back into nature to get answers to our social questions . You can safely say that there is an answer to every question to be found in nature, you only have to find it!



### Super fast train

The Japanese super train Shinkansen suffered from noise, loss of energy and counter pressure when entering and leaving tunnels. For the design of a new nose the kingfisher was taken as an example. The kingfisher dives and cuts through the surface of the water. The shape of its beak was the key to minimize resistance at high pressure transitions. You can see that the beak is already in the water, but no ripples to be seen.



Biomimicry applies natural solutions to 'human' questions. A nice example is the train in Japan whose nose is an imitation of the beak of a kingfisher. And naturally, when applying the solution, we also want to use natural (and therefore non-polluting) materials.

### Life 's Principles

When using Biomimicry we use the so-called 'life's'. These principles help you to find solutions the way nature does. The more you incorporate these principles into your solution, the better your result will be! Why? Because all organisms in nature make use of all of these principles. So by using them all you know for sure that you mimic nature as well as possible!

The 6 'life's principles' are (see module 2 lesson 3 for the scheme):

- Use life-friendly chemistry
- Be well attuned to your local environment
- Integrate development with growth
- Adapt to changing circumstances
- Deal efficiently with raw materials
- Evolve to survive

In the next module the 'life's principles' will be discussed in detail.



Introductory film biomimicry

Look at this movie about a 'Spiral'

<https://www.youtube.com/watch?v=BwCKJ9bTsvw>)

You can also go to: [www.biomimicryNL.org](http://www.biomimicryNL.org)

Now that you have received more background, it is time for the first assignment. The assignment will make clear what you already know and what questions you still have. You can do this assignment at home.



## 2. *Tell it at home*

To learn to understand biomimicry well, it helps to tell someone who does not know anything about it yet. So it does not make much sense to explain it to someone in your class (although you may want to practice it). Give it a try during your evening meal to your parents / brothers / sisters! Maybe they ask very good questions, and you can figure this out together. Write down all your questions and take them to the next lesson, who knows who else could answer that question, or do you come out with the whole class!



## 3. *Nature experience*

At the end of this module you will do another assignment. This assignment is intended to connect with nature.

You will carry out a project assignment in which you will experience nature in a place that you may not expect; near school. The basis of this assignment comes from a philosophical movement called 'phenomenology'. The word phenomenon is derived from Greek and literally means 'something that can be seen'. This movement is based on direct experiences and through these experiences gives meaning to what you observe (phenomenon).

Phenomenology has a lot to do with experiencing nature. It gives peace and attention to the beauty around you. If you open up to that, think about what you like, and try to put it into words, you are involved in phenomenology. Not everything is understandable, and certainly not everything can be put into words. But in trying and experiencing it outside you will also learn a lot about yourself and your own feelings.

### **Goal**

The purpose of this assignment:

'By using your different senses when you experience nature, you also learn about yourself and your feelings'

### **Method**

Work alone or with someone with whom you feel comfortable. It should not cost more than half an hour. So do not think too long and go to work quickly!

### **Necessities**

- This student manual
- A pencil, eraser and a pen

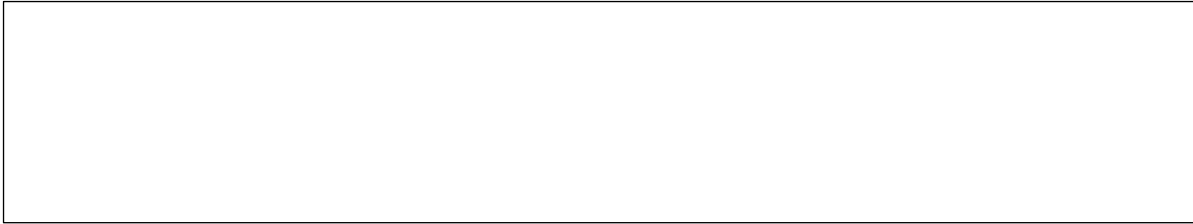


- Two separate A4 sheets (to lay out your drawings / sketches)
- Something on which you can make the drawings (eg a book that serves as an underlay)

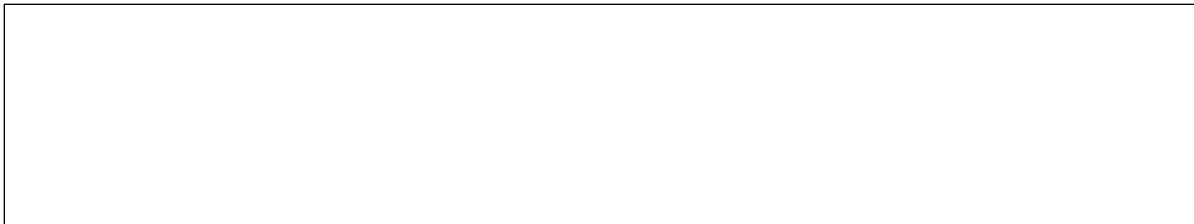
### Exercises

Find a nice place that has to do with nature.

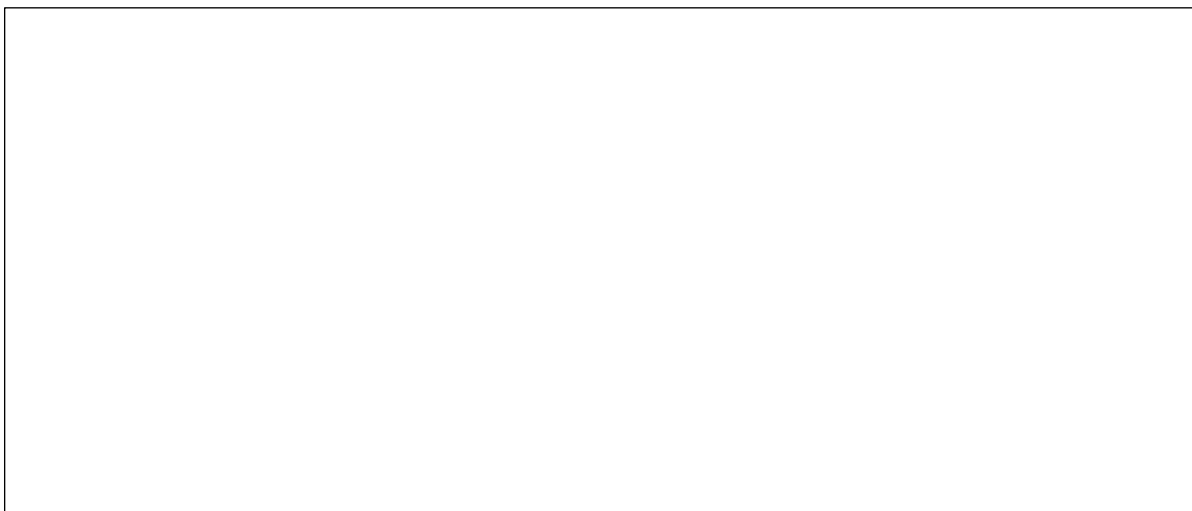
*Exercise 1*      *Where are you? Describe this in a few sentences.*



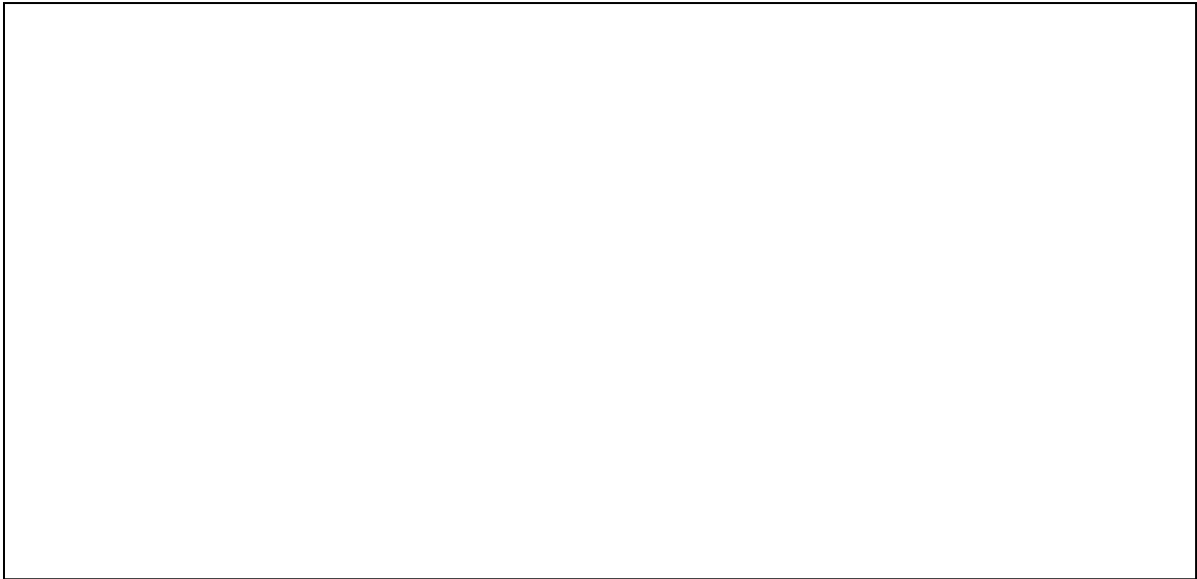
*Exercise 2*      *Why did you choose this location? Explain your choice.*



*Exercise 3*      Sit down and look around and listen, feel, if possible. Start looking around and don't forget to look really close by. What do you notice? What do you like? What is bothering you? Try to observe this with different senses and put it in words or drawings.



Assignment 4: Now make a sketch or drawing of something that you really like or what stands out for you. Explain your choice. It does not matter if you do not know the name of the organism!



Assignment 5: With other senses: smell, feel or experience: choose. Write something about it.



***Good luck!***

### 3. Get started!

We discussed the challenge, the learning objectives, the reason why we present this challenge to you. We have discussed the theory behind biomimicry and you have explored what you yourself mean by nature. Now it's time to go to work!



#### 1. *Check-in and discuss findings*

To understand biomimicry well you were asked to tell other people about it . How did it go? What questions did you receive or do you still have? How did your family or friends react to this topic? Discuss the questions you have written down in response to the homework assignment in the classroom.

Besides talking about biomimicry, you will of course also do something! The next assignment you can put into practice this week. In any case, bring your findings to the next lesson!



#### 2. *Starbursting: Observe and ask questions*

*An important part of biomimicry is observing. Those who want to learn from nature will have to learn to look at plants and animals in a different way. Becoming curious about the natural world is about learning to ask good questions.*

'Starbursting' is a technique for generating questions about a new idea, or in this case, an organism that can form the basis for (natural) scientific research. In order to get the most out of this approach, it is important that the questions are asked in a systematic and comprehensive way. Go out and find an organism to focus on and , without trying to answer something , can you develop different specific questions for each point of the star (see next page)?

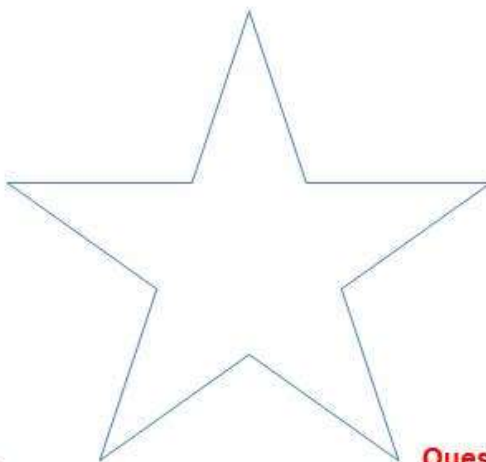
**Good luck!**

**Questions about environment (habitat)**

- 1. ....
- 2. ....
- 3. ....
- 4. ....
- 5. ....
- 6. ....
- 7. ....
- 8. ....
- 9. ....
- 10. ....

**Questions about food**

- 1. ....
- 2. ....
- 3. ....
- 4. ....
- 5. ....
- 6. ....
- 7. ....
- 8. ....
- 9. ....
- 10. ....



**Questions about physical characteristics**

- 1. ....
- 2. ....
- 3. ....
- 4. ....
- 5. ....
- 6. ....
- 7. ....
- 8. ....
- 9. ....
- 10. ....

**Questions about Lifecycle**

- 1. ....
- 2. ....
- 3. ....
- 4. ....
- 5. ....
- 6. ....
- 7. ....
- 8. ....
- 9. ....
- 10. ....

**Questions about threats and survival**

- 1. ....
- 2. ....
- 3. ....
- 4. ....
- 5. ....
- 6. ....
- 7. ....
- 8. ....
- 9. ....
- 10. ....

**1. Check-in and discuss findings**

The past lessons were an introduction to biomimicry. You have also done some assignments that helps you understand biomimicry. Discuss the findings and the sketches you made in the classroom.



Watch this video about Dolphins

<https://www.youtube.com/watch?v=I4TOcSGKmsM> (in Dutch)

Can you think of the question that led to the solution you see in this video?

**2. A good research question is half the work**

In this challenge you will find a solution for a 'human' challenge in your group using biomimicry. In this first challenge, there are four possible challenges where you can choose from. You and your group have ten minutes to choose a challenge. Inform your teacher about your choice.

*Do you want to know what a good research question is?*

Take a look at part 2: what was a good research question? Or watch this movie from the '[Questions Machine](#)'. The question machine helps you to investigate whether a question is a good research question. You will be guided through various criteria. The question falls from the machine once it does not meet one of the criteria. The question can then be adjusted and retrieved by the machine, or a new question can be inserted. Here the criteria of the Question Engine:

- Does it fit with the theme?
- Can you learn from it?
- Is it a precise question?
- Can you do this?

**Research topic 1: Function shoes**

Problem: For different sports you need different shoes. Shoes for indoors, on a tennis court, football or hockey field. Shoes for athletics, ballet and even 'shoes' for in the water (surfing, sailing, swimming). Depending on the sport you do, your shoe must be able to do certain things. It must be able to break or absorb shocks, have grip, be light, be waterproof, or able to slide (think of skates). They must be easily taken on and off, stay firmly in place. And they must of course be comfortable. In top sport, people are always looking for better material and better designs to be able to deliver a better performance.



*Challenge: What can we learn from nature for a properly functioning sports shoe?*

In this research question you will look at how other animals move (over land). How they walk, jump, run, climb, turn, slide, stop, etc. In mud, water, mountains, rocks, grass etc. For some inspiration look at this video from Festo: <https://www.sciencedoc.eu/documentary/festo-what-we-can-learn-from-a-kangaroo/>

Tip: choose a specific sport. Think about in what kind of sport movement is the most important (which is supported by sports shoes) and try to think about what 'a better sports shoe' could mean for that sport. Where should it be improved? Or go for a sports shoe that you could use well for multiple sports. Which functions must it meet?

### **Research topic 2: Material Sport shoes**

Most sports shoes are made of materials that are not degradable or recyclable. Sometimes even toxic substances are used during the production process (making the shoes) or at least unhealthy substances, or a lot of energy or water. Organisms usually use as little material and energy as possible to provide certain functions. And the materials used to 'work' are degradable in particles that are not bad for the environment. Don't we want that too?

*Challenge: How would nature make an environmental friendly sports shoe?*

### **For inspiration: example sport shoes**

Below you see an example of a nature-inspired shoe. Researchers from Nike, Inc. designed Goatek Traction after studying the feet of mountain goats in the Oregon Zoo. Goatek Traction is a shoe with a sole that mimics the soft fat pad in the middle of the goat's foot, the surrounding nail that digs in soft surfaces, and an articulated toe that allows the animal to jump safely between narrow rocky ridges. The sole was removed from the market after one season due to poor sales, despite the fact that the shoe functioned as intended.



How does nature create grip?

Nike Goatek

### **Research topic 3 : Packaging and Waste**

Problem: In the Netherlands we produce almost 500 kilos of waste per person per year (that's about 50-60 garbage bags per person per year, imagine that they would all be in your room!). More than half of our waste is collected in separated parts so that it can be recycled. The rest is burned. A large part of our waste consists of packaging. A lot of those packages are only used briefly and then thrown away, sometimes on the street or in the forest so it

ends up in rivers and the sea and pollutes the environment. In nature there is also a lot of 'packaging'. But there is no residual waste. Everything is used again for something without polluting the environment. What can we learn from this?

*Challenge: What can we learn from nature about packaging with regard to the prevention of waste and stimulate re-use?*

#### **Research topic 4: Functions of Packaging**

Our skin, the armor of a crab, the skin of a banana, the shell of an oyster, the bark of a coconut, a pine cone (seed packaging) and every cell in our body has its own packaging. And all those packaging must meet many, sometimes contradictory requirements: they must be resealable, air- or waterproof, they must not tear, they must be easy to open, they must be sturdy, they must be able to communicate the contents (product information), they must be able to change in size, etc.

In this challenge you pick one or more functions of a package and you search in nature for organisms that are champions in getting this function done.

*Challenge: How would nature (waterproof, reseal ..... fill in a function ..... ) package?*

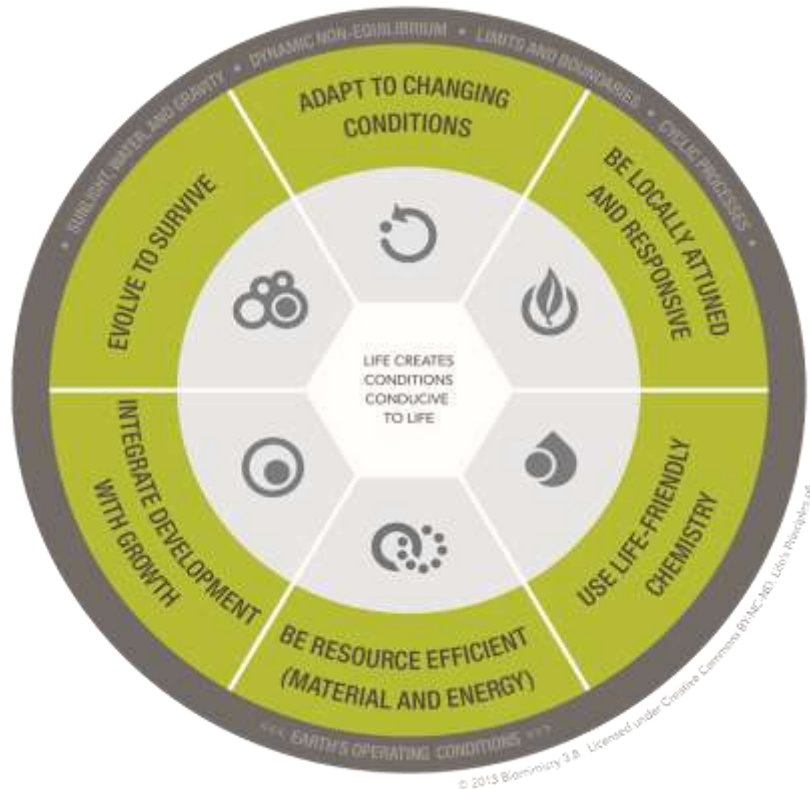
#### **Inspiration: packaging**

When a company was looking for better resealable packaging, they asked biomimicry experts "What would nature do in this case?" The innovation process then started with biologists and designers. They found more than 60 biological strategies and mechanisms that can help resealable packaging to which everyone immediately understands how it works, which is not too expensive and ensures that the product cannot come into contact with other substances. One of the ideas and designs was inspired by the 'venus flytrap'; a carnivorous plant that shuts its leaves to catch a prey.



### 3. Life's Principles

During the last lesson they were briefly discussed; the life's principles. You had already read that the more of these life's principles come back in your design, the better your design will be! Nature always uses these principles. Let's take a closer look at these principles.



Life's Principles can be seen as a "Manual for Life On Planet Earth. Scientists have researched how many things can be done by plants and animals as they have often been living successfully on earth for millions of years . How do they do that? We want that too!

Below we explain the life's principles on the basis of an example. With each principle there is an example from nature and its application. After the example you will receive an assignment. Do all six assignments together with the group as far as you can. Not in the lesson? Complete the assignments at home.

#### 1. Use life-friendly chemistry



##### *Degradable and edible*

Animals and plants use natural resources. This also applies to the blue mussel. Mussels themselves make a glue with which they can stick to rocks so that they are not washed away by waves. Mussel glue works on almost every surface, even in water, and is biodegradable. Our glue does not do well in water and is full of all kinds of toxic substances. What can we learn from

that mussel glue? More and more products are degradable. There are styrofoam granules of potato flour, corn flour sticks and even edible coffee cups.



### *Assignment 1*

Life-friendly chemistry means that used substances are not harmful to organisms (plants and animals). Make a list with the group of substances that often appear in sports shoes or packaging (depending on your chosen assignment). Think of the different parts. Are they life-friendly? Which substances are there that are not life-friendly?

Make a list of at least ten substances that you know that they are living friendly and note why.

## **2. *Be locally attuned and responsive (attuned to your environment)***



### *Use what is available*

The larvae of water stick damselfly live on the riverbed. They do not yet have a skeleton (armor). To protect themselves they secrete a sticky substance causing grains of sand and gravel from the river bottom to glue together providing a hard shell. In nature, most types of material and energy use what is abundantly available locally, because it costs the least effort!

Local products are becoming increasingly popular. More and more products from the region are available in (super) markets. Local materials are also being used more and more in construction.

The Ecover company makes its packaging (cleaning product) from ocean plastic and Adidas has developed 3 models of sneakers of ocean plastic. They want to sell a million pairs of them - that works easily because there is unfortunately more than enough ocean plastic available.



### *Assignment 2*

Making use of what is (locally) present is a good example of being locally attuned. Can you as a group come up with another example from the nature of local attunement.

### 3. *Integrate development with growth*



#### *Growth AND development*

All vertebrates develop and grow bones and they are uniquely adapted to the individual in which they grow. By integrating growth and development, bone cells develop material in response to pressure and damage so that they only grow when needed, and where it is needed.

Almost 300 million children walk barefoot, because shoes are simply too expensive for them. The American Kenton Lee came up with the solution: he invented *The Shoe That Grows*. Kenton came up with the idea when he was in Kenya in 2007. He saw a girl with too small shoes and wanted to do something about it. Because many parents in developing countries do not have the money to buy new shoes every time, he developed a shoe that grows with the foot of the child. The shoe will last for about 5 years and can grow up to 5 sizes. The design is made so that the shoe can be enlarged in 3 different places.



#### *Assignment 3*



Integrating development and growth is one of the life's principles. Sounds logical! But do we apply that principle to the design of products? Can you with your group come up with an example?

### 4. *Adapt to changing conditions*



#### *The same idea in a different way*

Octopus have very specialized skin cells that can adjust their color to every situation. By adapting to changing conditions, they can camouflage to protect themselves from predators and the other moment they switch to beautiful bright colors to attract a partner.

Imagine that your shoes could adapt to changing weather conditions. Or that a package can grow bigger automatically if necessary. Whoever is going to look into nature will find solutions that can make that possible!

#### *Assignment 4*



Animals are very good at adapting to unexpected disruptions like a forest fire, for example, or an obstacle in their way. Find with your group two other beautiful example of this 'being able to adapt to change'.



## 5. *Be resource efficiently*



### *Endless using of what is valuable*

In a forest, the 'waste' of one organism is the food of the other. Every ecosystem recycles all materials and thus creates a very efficient and self-healing environment where nutrients flow and circulate constantly through the system.

Taking back and re-using or recycling of products such as washing machines, cars, and material like glass and plastic are good examples of efficient use of raw materials. We use a lot of packaging for a very short time. They are not bio-degradable and are not very easy to recycle. How can we use them for a much longer time, or take them much more quickly in a cycle? There is good news. Ikea has already replaced many of its styrofoam packaging with packaging made of mycelium (fungi / mushrooms) and sports fields made of ground sports shoes.



### *Assignment 5*

Not every Acorn becomes an oak tree again. And not every seed of the sunflower will produce another sunflower. Why not? And what can we learn from this when it comes to recycling?

## 6. *Evolve to survive*



### *Using the unexpected*

In reproduction, both parents contribute to the gene pool of the next generation. When mixing and transmitting hereditary material (DNA) sometimes 'mistakes' occur. These are called mutations. Sometimes these mutations are harmful and cause diseases, sometimes they provides an advantage. Some birds got another beak because of a DNA mutation, so that they could eat other seeds than other birds.

Another example of birds is that of the bearded vulture or the crow. Both have learned to drop food (bones in the case of the bearded vulture and seeds, snails or shells for the crow) from a great height onto hard ground so that they open. This has probably happened 'accidentally' for the first time. Can you learn something about this for your own packaging issue?

And back to our shoes. What about a mal functioning shoe that makes you slip along a surfaces? Are they perhaps suitable for something completely different?



### *Assignment 6*

Why is it useful for a bird to be able to eat other seeds than what it's used to? This has to do with the life principle 'Evolve to survive' (and specific; using unexpected events). Consider another example together.

*Preparation for the next lesson:*

As indicated earlier, a good research question is half the work. You have also become acquainted with the life's principles. For the next lesson we ask you to reformulate your research question (with a main question and maybe sub questions) and finish the assignments of the life's principles (if you did not completed that yet).

***Good luck!***

### 1. *Check-in and discuss findings*

In the previous lesson you have immersed yourself in the life's principles and we discussed the research questions. Did you succeed? Share your research question with the class. Can you also tell us why you have chosen this? Discuss this in class.



Watch the video of a 'Tsunami '

([https://www.youtube.com/watch?v=z749sZHlmaU&list=PL3yKJIO1tMj0mFr\\_4behzy2tIToObAkr&index=4](https://www.youtube.com/watch?v=z749sZHlmaU&list=PL3yKJIO1tMj0mFr_4behzy2tIToObAkr&index=4))

This video contains a nice example of how a need or desire that we like 'being alerted in time for tsunamis' led to biological research (about how do dolphins communicate under water) and how this is translated into a product (tsunami warning system). Isn't it cool to be able to design something that can save lives? How? Ask nature!

### 2. *Applying the biomimicry method*

In this challenge you will finally create a design; a biomimicry design. Before you can make this and before preparing the presentation it is important to do good research. You have learned a lot about biomimicry. It's time to actually apply it!

In this module we will go through a number of steps:

1. What do you want your solution to **do** ?
2. Under what **circumstances or conditions** should your solution operate. What is the **context** (weather, time, who is it, etc.)
3. **Biologize** the question (ask nature about a **function**, for example: How would nature 'filter water' on the next page are some examples )
4. Find **natural models**
  - a. Think about different habitats (a habitat is a living environment such as: desert, ocean, forest, mountains, etc.)
  - b. There are many ways to get information
  - c. find the 'champions' in nature.

ad 1) The most important thing to start biomimicry is to ask yourself: "What do I want my design **to do**?" So you wonder what the **function** your sports shoe or package should have instead of what they should look like. A function of a sports shoe can for example be: having grip on a slippery surface. Or convert energy into jumping power. With packaging you can think of: 'keeping it water tight', or 'keeping it air-tight'. Note: there must always be a VERB in it! Now you can ask the question; "How would nature fulfil this function?"

If your challenge concerns material use and / or waste (of shoes or packaging) you can think of functions such as: 'reusability' or 'minimizing material use' or 'breaking down material'.

ad 2) The **context** of the use of the sports shoe or the packaging is also important! What does the environment look like? What kind of surface is there? What kind of movements are involved in the sport? How often are they used?

And with packaging: How long does the actual product have to stay fresh? How big should the packaging be? Does it have to be transported? Is your product wet or dry? Who is the product for (children, elderly). Under what limitations should the solution function?



#### *Function and context*

Put function and context in your research question by making a list of 'functions' and adding the characteristics of the 'context'. Sometimes it can help to make a quick sketch. You have 10 minutes for this assignment. Share some examples with the rest of the class, maybe you give each other ideas.

Ad 3) **Biologizing** the question is reformulating your research question (or questions) in a way nature can understand. Here are a few examples:

- How would nature cool a space?
- How would nature gently land on the ground?
- How would nature something waterproof to make ?
- How would nature perishable true save ?
- How would nature seduce to be eaten?
- How Nature would keep grip on ice and snow ?
- So: How would nature ... (and then fill in a verb, the function you are looking for a solution for)

*Tip: it is also interesting to check how nature does NOT do that function. That says a lot about whether something is a good and sustainable solution or not.*

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See your question as a 'google search'; if it is a very 'broad, general' question you get too many answers; and if you make it too 'narrow, too precise' you get very few answers. By adding context you can make a question wider or more narrow. For example: 'how does nature make something watertight under water?' makes the question more precise. And 'how does nature close something for water?' makes the question wider.

Now that you have a picture of the context and function for yourself, you have made big steps. Now it's time to start researching for solutions that nature has found for your design problem. You do not yet have to find the best answer for your challenge. Go for as many options as possible. At this moment all ideas are welcome. If you find possible solutions, write them down.



Now ask yourself: is my research question clear, do I understand well what the context and function look like? What search terms would I use?



Try using the site: [www.asknature.org](http://www.asknature.org). Try to formulate a question together with which you want to find an answer with this site. This may be for your research

question, but this may also be another question. Formulate your question in English: How does nature ... (filter, protect , cool, attract , etc.) You have 10 minutes for this assignment.

Ad 4) Finding natural models is perhaps the best part of biomimicry. Now you are looking for examples from nature / biology that can help you with your research. You will find out below how this works.



### 3. *Doing research*

It's time to get started! You are looking for as many ideas from nature as possible that can solve your design problem. We will help you get started with some examples that we have collected for you. Of course you can use it, but look for more possible solutions, especially on the internet and in the library! And do you have biologists or ecologists in your family and at school? Ask them! Before you start divide the tasks and make agreements on what every group member has to do.

Tip: share your design ask on in several sub-questions.

#### *Example shoes*

Main question / Main function : How does nature keep a grip on ice and snow?

Sub question /functions : 'Keep grip on ice / snow during (fast) exercise'. 'Braking / coming to a standstill on ice / snow'.

Derived question / function: How does nature prevent from getting cold feet on ice / snow?

You see, you can go in all directions. Choose questions that have something to do with each other and that you are interested in. What are you curious about?

#### *Example packaging*

Main question / Main function : How does nature 'pack' something waterproof?

Sub question / function : How does nature make something waterproof without using extra material? Additional function: How does nature ensure that something can be opened and closed repeatedly?

Look on [www.asknature.org](http://www.asknature.org) and use your English search terms for this.

On [www.biomimicrynl.org](http://www.biomimicrynl.org) 'Focus on beta' you will find a number of examples per research question (in Dutch).

#### *Preparing for the next lesson:*

Start researching with your group! Think of as many solutions as possible for your research question, be creative. Consult various sources such, internet, the library etc.

***Good luck!***



## Module 4

## The best solution from nature

Lesson 7 module 4

### 1. *Check-in and discuss findings*

The previous lesson you have started doing the research. We assume you have written down a large number of possible solutions for your challenge / research. How did the research go? What did you encounter? How did you solve this? Was it difficult to find the solutions and have you been able to come up with solutions yourself? What did you learn from this? Discuss your progress in the classroom.



Watch the video about the 'Giraf' ( [https://www.youtube.com/watch?v=ul66KAL0070 & t = 10s](https://www.youtube.com/watch?v=ul66KAL0070&t=10s) ).

The movie shows that most plants and animals have multiple smart strategies (adaptations) to achieve a goal. What adjustments does the giraffe have so that enough blood can go all the way to his head?



### 2. *The best solution from nature*

Together as a group you are going to choose the best solutions. The questions below will help you do that.

- Make a list of all the solutions you have found in module 3.
- Draw a large table (like below) and fill in all found solutions.
- Choose together 2 or 3 solutions that you think are best suited to your challenge.
- You have 15 minutes for this assignment

Here is an example:

Idea no	Challenge	Function	Context	Biologized question	Inspirational Organism
1	<i>A sports shoe that does not slip on ice</i>	<i>Hold a grip on slippery surfaces</i>	<i>Cold, smooth, wet surface, for a person standing on 2 legs</i>	<i>How would nature keep grip on a slippery surface? Or: How does nature prevent slipping?</i>	<i>Polar bear</i>
2					
3					
4					

5
6

Idea no	Working mechanism (how does the function of the organism work?)	Is the operating mechanism applicable in other situations?	Is the working mechanism easy or difficult to imitate?	Can it contribute to a sustainable solution?	Top 3
1	<i>Polar bears have legs with a rough underside that provide anti-slip and sharp curved claws on their front legs that work like hooks to climb out of the ice.</i>	<i>Yes, we think so.</i>	<i>The rough bottom is easy to mimic, the hooks maybe a bit more difficult.</i>	<i>Yes, depending on the material.</i>	
2					
3					
4					
5					
6					



### 3. Apply to your challenge

You are now going to 'translate' your solution to the design challenge. It is important that you fill in table (from left to right). And then make a drawing of each solution (construction). You have 15 minutes for this.

#### **Solution 1**

What is the working principle from nature?	How can you imitate this in your context?	What materials do you need if you would make it?

#### **Solution 2**

What is the working principle from nature?	How can you imitate this in your context?	What materials do you need if you would make it?

#### **Solution 3**

What is the working principle from nature?	How can you imitate this in your context?	What materials do you need if you would make it?

You have now examined three solutions and made one drawing of a possible design. Assess the three designs in your group. Do you want to use all three solutions or is one of the solutions the best?



Make a choice and a first setup for the presentation of your solution in poster form that you want to use. Also think about which materials you would need if you are actually going to make the design. Use this whole lesson, if it is not finished then this is homework for your group.

Lesson 8 module 4

**4. Life's principles, there we go !**

In module 2 we practiced with the Life's Principles. The more life's principles you can apply to your design, the better it will be. How many Life's Principles have already been incorporated in your design? Take a very critical look. Would you be able to process a few more? You will certainly improve your design!



*Life's Principles in practice*

Go (with your group) over all these questions:

- Are you using materials efficiently?
- Where do your materials come from?
- Do you really use the minimum to this?
- Are the materials nature-friendly or could you choose more nature-friendly materials?
- Have you taken the seasons into account?
- Have you taken into account some variation in use over the year?
- Is your design completely fixed or can it take other forms?
- Can your design fulfil multiple functions?
- Can your design be easily recycled?



*Preparing for the next lesson:*

For the next lesson you have to prepare a list of requirements (criteria) that the design must meet and try to find as much information as possible about the solution you have chosen. The criteria should be based on the Life's Principles. The better you understand how this works, the easier it becomes to translate it to a good design.

<b>Requirements</b> (which Life's Principles MUST be applied to the design)	<b>Desires</b> (of which Life's P you would also like the principle to be met by the design)	How does your solution meet the Requirements and Wishes?	Anything else to improve the solution?

***Good luck!***

**1. Check-in and discuss findings**

In the previous lesson you have chosen the best solution from nature. Was this difficult? Why did you choose this solution? Could you translate it correctly into your challenge and what did you learn from that? Discuss this in class.



Watch the video about 'Carpet' ( [https://www.youtube.com/watch?v=irjhcYi1884 & t = 110s](https://www.youtube.com/watch?v=irjhcYi1884&t=110s) )

What do you think of the solution that the company has chosen? Which organism (or system) has inspired them? What was the working principle? Which Life's Principles do you recognize?

**2. Making a poster to make; the preparation**

You have deepened in finding solutions from nature, and you also have made a list of requirements that your design should meet. This lesson you are going to make a poster of your design.

During the research you have thought a lot about the function and context, now we are going to think about what the design (or prototype) will look like. We will summarize the previous modules. Check your findings.

1. You have a research question and important (search) terms.
2. You have described the function.
3. You know in which context you have to place the whole.
4. You have found a solution from nature and investigated further.
5. You have examined which of the Life's Principles you can apply to your design (you've been thinking about for example materials, resource, or a variable shape or solid form, etc.).



Find a place with your group, and think about how you are going to make the design. Use your building plan for this. Pay attention: this lesson you will have to finish all the preparations of your poster (first sketch, etc.).

Tip: experiment with this, make a few versions.



In this lesson you are going to prepare your group presentation. Discuss the line of the story and how you can make it interesting and clear for your class and the teacher. Take a good look below which elements your poster should contain.





*Preparing for the next lesson:*

Make sure your poster is completely finished for the next lesson. This is very important, because you are going to present the poster.

What does your poster look like? But make sure that in any case it contains the following elements:

- Design assignment.
- Function / context.
- Organism (s) that inspired you.
- Colourful drawing showing how the working principle (or working principles if you have combined ideas) can be applied from nature to solve your problem.
- Space in which you specify how your design meets the Life's as possible Principles.
- List of materials that you would use to make your design.

Also have a look at the assessment model in Appendix 1!

Other criteria for your poster presentation;

- Up to 10 minutes of presentation.
- A good picture of the research and the results.
- A translation of the solution from nature to your challenge.

***Good luck!***

**1. Check-in and discuss findings**

The previous lesson you have made a design based on the best solution from nature. What kind of design did you make? Does it still look like the technique you have learned from nature? Does it meet the Life's Principles? Discuss what you have learned in class.

**2. Presenting your design**

The final step in this challenge for your group is to present your poster. In this lesson three groups present their poster, the next lesson the other three.

Your poster contains in each case the following elements:

- Design assignment
- Function / context
- Organism (s) that inspired you
- Colourful drawing showing how you working principle (or principles) from nature to have to you solve the problem.
- How your design meets as many Life's as possible Principles.
- List of materials that you would use to make your design.

Where should the poster presentation further meet

- Up to 10 minutes at presentation
- A good picture of the research and results.
- A translation of the solution from nature to your challenge.

**3. The presentation round**

Some more tips that you can pay attention to when evaluating the poster presentations:

1. Is the research question clear?
2. Does the solution come from nature?
3. Does it work well? In other words: does it solve something, does it answer the question?
4. Is it a sustainable solution?
5. Is the whole well presented?

**Good luck!**

***Appendix 1 Assessment model Poster***