# Introduction to Biomimicry and Environmental Engineering

## Overview

Humans can't live without the essentials of sunlight, air, water and soil provided by the natural environment. Environmental Engineers are concerned with the interactions among the natural and human-built environments by assessing the impact a project (any development) has on the air, water, soil and noise.

**Part 1** of the activity (optional) involves a visit to Mt Coot-tha Botanical Gardens.

**Part 2** of the activity introduces students to environments, ecosystems and Environmental Engineers and the roles they play in improving communities and ecosystems.

**Part 3** introduces students to adaptations by plants and animals and the idea of biomimicry and how engineers imitate nature in the design of new products and the science, technology and mathematics principles associated with the interactions of an environment.

In this unit, students will complete an engineering activity that addresses the requirements of the Technology KLA, making use of students' prior learning in Science and Maths. The activity addresses aspects of Year 5 Science and Maths from the Australian Curriculum (ACARA) and C2C as well as Essential Learnings for Technology (QCAR).

## Objectives

- Explain the role of Environmental Engineers in society.
- Appreciate the degree to which living and non-living things depend on each other and their interactions.
- Identify that adaptations of living things are linked to the environment in which they live.
- Define biomimicry and provide examples from the natural world that have been copied by humans.
- Explain how engineers use biomimicry to enhance engineering design.
- Design and test a new seed model to be spread by wind.

**Class Time:** 3 x 2.5 hour lessons (includes visit to Botanical Gardens, Mt Coot-tha)

**Materials**

- Biomimicry and Environmental Engineering Activity – Teacher Guide Booklet
- Biomimicry and Environmental Engineering Activity - Student Design Workbook (1 per student)
- QUT supplied DVD containing:
  - a. eGFI Dream Up the Future Engineering Card – Environmental Engineers
  - b. Engineering Design Model
  - c. Life as an Environmental Engineer (http://science360.gov/obj/video/4eb822c7-aca2-4c3b-b278-9e16ff46820a)
  - d. Graph Paper Template
  - e. Link to slide show - Animal Camouflage Pictures (http://www.discovery.com/tv-shows/curiosity/topics/animal-camouflage-pictures.htm)
  - f. Link to online book – Animal Adaptations (http://tarheelreader.org/#2010/02/22/animal-adaptations/23/?&_suid=138933592432202650529741470776)
  - g. Nature is Smarter Than Us (http://www.youtube.com/watch?v=4vq8ci4RTUs)
  - h. Infamous Inventors (http://videos.howstuffworks.com/howstuffworks/35522-infamous-inventors-velcro-video.htm)
  - i. Burdock Velcro Comparison Photograph
  - j. Link to Biomimicry Matching Game (http://kidsciencechallenge.com/archiveyeartwo/index.php?linkTo=3c)
  - k. Dandelion Photograph
  - l. Link to Seed Aviation Video (http://www.bbc.co.uk/nature/adaptations/Seed_dispersal#p00lxw4t)
  - m. Dispersal of Seeds (http://www.onlinemathlearning.com/seeds-dispersal.html) – 6 videos
  - n. Web Interactions Index Cards Template
  - o. Design Challenge – Seed Model PowerPoint (additional teacher support material)
- Pencil, rubber, ruler, scissors, glue stick, clipboard, dictionary – student supplied
- Mt Coot-tha Botanical Gardens Education Centre worksheets – Adaptations in the Gardens
- Pre-prepared index cards (soil, tree or flower, air, sunlight, water, spider, cloud, rock) – one set per group of 6 – 10 students
- Ball of wool – one per group of 6 – 10 students
- Masking tape – one roll per class
- Piece of Velcro® (both hook and loop) – one per group of 3 – 4 students
- Magnifying glass – one per group of 3 – 4 students
- Bag of seed samples – one per group of 3 – 4 students
- Design supplies to construct artificial seeds – tape, scissors, glue, pipe cleaners, feathers, tissue paper, cotton wool balls, toothpicks, straws, post-it notes, thread, rubber bands, paperclips
- Small fan – 2 – 3 per class
- Tape measure – 2 -3 per class
- Stop watch – 1 per group of 3 - 4 students
- Non-permanent marker pen – 1 per group of 3 – 4 students

## Curriculum Links

| Technology | Science | Maths |
|---|---|---|
| **Essential Learnings *by the end of* Year 5 (QCAR)**<br><br>**Ways of Working**<br><br>• Identify and apply safe practices<br><br>• Reflect on and identify the impacts of products and processes on people and their communities<br><br>**Knowledge and Understanding**<br><br>*Technology as a human endeavour*<br><br>• Different ideas for designs and products are developed to meet the needs and wants of people, their communities and environments<br><br>*Information, materials and systems (resources)*<br><br>• Resources have particular characteristics that make them more suitable for a specific purpose and context | **Science as a Human Endeavour (ACARA)**<br><br>• Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena (ACSHE081)<br><br>• Scientific knowledge is used to inform personal and community decisions (ACSHE217)<br><br>**Biological Science (ACARA)**<br><br>• Living things have structural features and adaptations that help them to survive in their environment (ACSSU043)<br><br>**Elaborations (C2C)**<br><br>• Understand how environmental factors influence living things within habitats<br><br>• Understand interactions and connections between living things such as plants and animals within a habitat<br><br>• Understand there are a variety of interrelationships between plants, animals and humans in an environment | **Measurement and Geometry (ACARA)**<br><br>*Using units of measurement*<br><br>• Choose appropriate units of measurement for length, area, volume and mass (ACMMG108)<br><br>**Statistics and Probability (ACARA)**<br><br>*Data representation and interpretation*<br><br>• Construct displays including column graphs, dot plots and tables, appropriate for data type, with and without the use of digital technologies. (ACMSP119)<br><br>• Describe and interpret different data sets in context (ACMSP120)<br><br>**Elaborations (C2C)**<br><br>• Explore ways of displaying data and representing the results of investigations<br><br>• Interpret data from class displays to conclude an answer to an inquiry question |

BRISBANE

BOTANIC GARDENS

Mt. Coot-tha

## PART 1: VISIT TO MT COOT-THA BOTANICAL GARDENS
### Adaptations in the Gardens

**Activity Rationale:**
The students will be guided by Education Officers from Brisbane City Council (BCC) through an investigation of two environments (Australian Rainforest and Arid Zone) examining plant and animal adaptations evident in those environments.

**Objectives:**
- The students will use the knowledge gained to assist them to develop an understanding of plant and animal adaptations.
- The students will use the knowledge gained to enhance their understanding about the relationships between living things and their environments.

**Lesson Overview:**
In this activity the students will be visiting the Australian Rainforest and the Arid Zone. The students will be guided in their investigation of some of the adaptations found in these places. During the guided walks the students will record data in each environment (abiotic factors), record adaptations seen, discuss possible reasons for the adaptations and compare and contrast the adaptations found in each environment.

**Pre Visit:**
Before visiting the Gardens the students may have participated in activities such as:
- Discussing the purpose of the visit to the Gardens
- Making predictions about what they may see at the Gardens
- Investigating plant and animal adaptations of some living things found in the school grounds
- Investigating the general features of rainforests and deserts so that the students have some background knowledge of what to expect in these environments

**Materials Required:**
BCC supplied worksheets to be filled in by students
Pencils
Clipboard

**Duration:**
Time required is 1.5 hrs for tour plus travel from school.

**PART 2A: INTRODUCTION TO ENVIRONMENTAL ENGINEERS**
(Student Workbook page 1)

Hand out Student Workbook and ask students to record their name, other group members' names, group number, class, and school name on the front.

Explain to students: Today we are going to learn more specifically about the work of an engineer who specialises in the natural and human-made environment, an Environmental Engineer.

Ask students if they have heard of Environmental Engineers before?

*Optional: Revisit the eGFI Dream Up the Future Engineering Cards and get a student to read the Environmental Engineers Card to the class. A copy of the card can be found on the QUT supplied DVD.*

# BIOMIMICRY AND ENVIRONMENTAL ENGINEERS

## Year 5

# STUDENT WORKBOOK

Name: ______________________________________________

Other group members: ______________________________________

______________________________________

______________________________________

Group Number: ____________________ Class: ________________________

- **Stimulation**

(Student Workbook pages 3 - 5)

Show Video - Life as an Environmental Engineer (First 7min):
http://science360.gov/obj/video/4eb822c7-aca2-4c3b-b278-9e16ff46820a

After watching the video ask students to fill in Student Workbook:

Q1. What is the main area of the environment that Tamar works in?
A: Water
Q2. Complete this sentence: A good Environmental Engineer has a strong interest in ................. and ................. and .................
A: People, maths, science or chemistry

Explain to students: In the video Tamar talked about engineers solving problems and how they keep working on them. Engineers use a process called engineering design to solve all sorts of problems.

# PART 2A

## INTRODUCTION TO ENVIRONMENTAL ENGINEERS

1. **Watch** the video “Life as an Environmental Engineer” (Tamar).

2. While watching, see if you can **find answers** to these questions about Environmental Engineers.

a. **What** is the main area of the environment that Tamar works in?

______________________________________________________________________

b. **Complete this sentence**: A good Environmental Engineer has a strong interest in

________________________________ and ________________________________

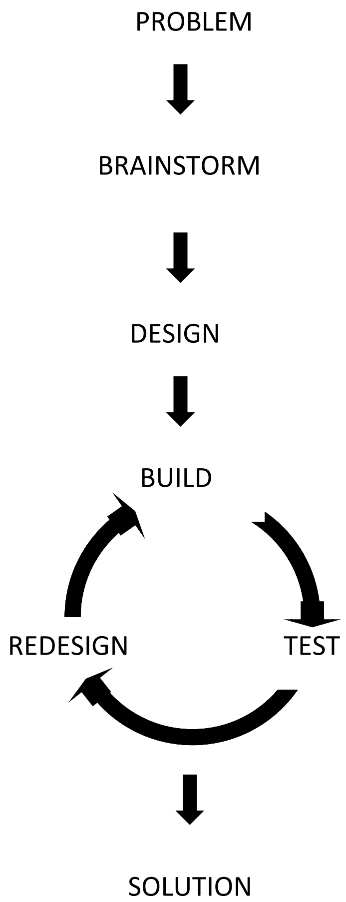
and ________________________________.

Ask: Can anyone remember the Engineering Design Model you worked with during the engineering activities last year?

Conduct a class discussion about the Engineering Design Model and have students complete the blank model in their Workbooks. A copy of the completed model can be found on the QUT supplied DVD.

## Engineering Design Model

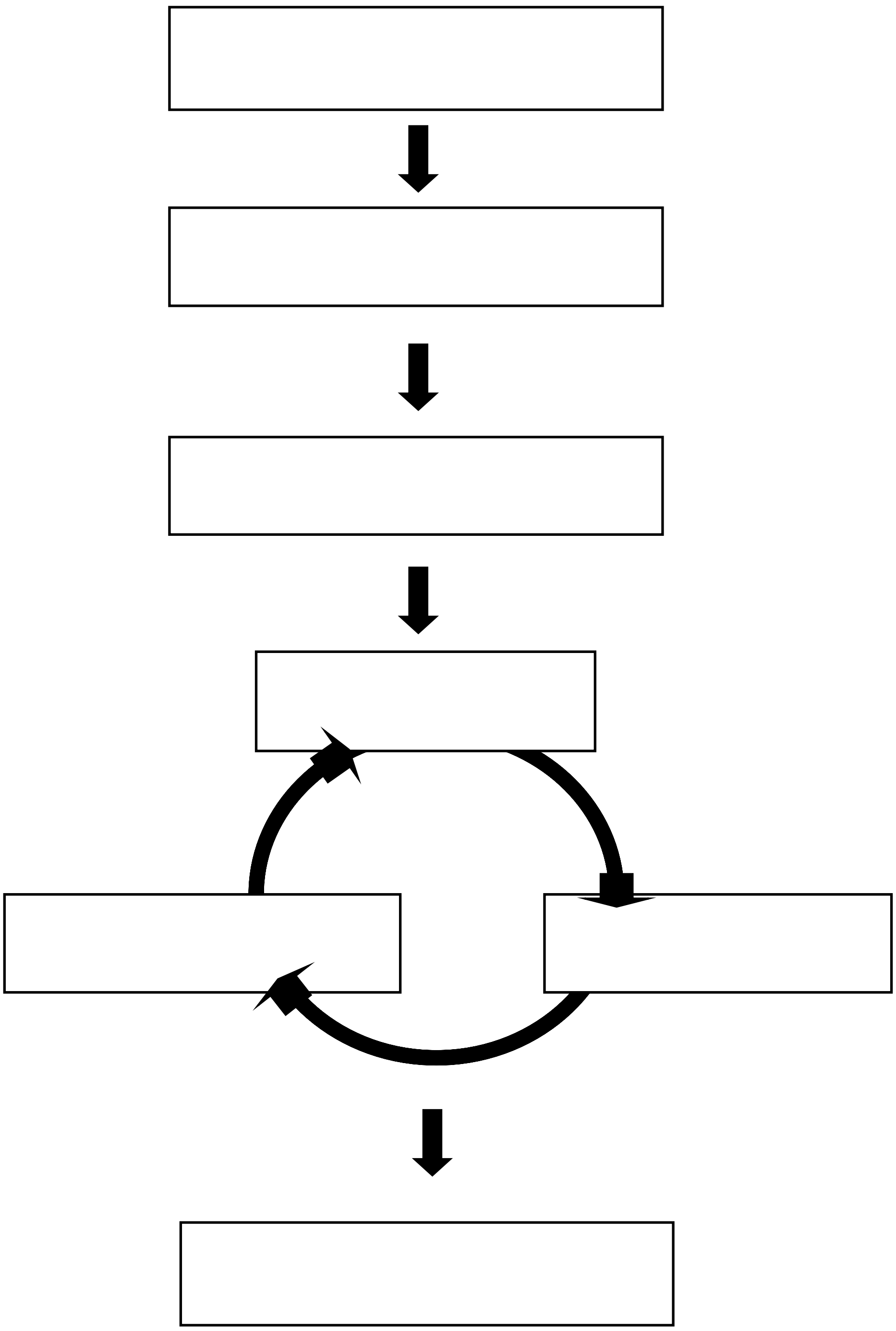



Model adapted from pbs.org model

3. **Complete** the engineering design model below.

## ENGINEERING DESIGN MODEL



Model adapted from pbs.org model

- **Motivation**

(Student Workbook pages 7 – 9)

Remind the students of the visit to Mt Coot-tha Botanical Gardens and their investigations of environments.

Start by asking students if they can remember and name the environments they explored at Mt Coot-tha Botanical Gardens. *(Rainforest and Arid Zone)*
Ask: What other examples of environments can you think of? *(Could include Desert, Grassland and Arctic)*

As a class, compose definitions for environment and ecosystem. Dictionaries can be used to help here. Have students record the definitions in their Student Workbook.

Sample definitions:

- An **environment** is the surrounding area in which an organism lives, including the air, water, food and energy required for an organism to survive.
- An **ecosystem** includes all the living organisms and the non-living things in an area that are linked together through the flow of nutrients and energy.

The following information can be found in the Student Workbook. Read and discuss with the class:

There are two types of environments that exist:

a) the *natural* environment, and
b) the *human-made* environment.

The **natural environment** is split into two parts: living things, which we call *biotic*, such as plants and animals; and non-living things, which we call *abiotic*, such as water, soil, air and sunlight.

There are a lot of **interactions** between living (*biotic*) and non-living (*abiotic*) things in the environment.

**An interaction is when one thing has a relationship with something else.** For example, a flower needs to use water to live, so the flower and water interact so that the flower lives.

4. **What** is an environment?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

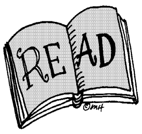
5. **What** is an ecosystem?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________




6. **Read** the information about environments.

There are two types of environments that exist:

a) the *natural* environment, and
b) the *human-made* environment.

The **natural environment** is split into two parts: living things, which we call *biotic*, such as plants and animals; and non-living things, which we call *abiotic*, such as water, soil, air and sunlight.

There are a lot of **interactions** between living (*biotic*) and non-living (*abiotic*) things in the environment.

**An interaction is when one thing has a relationship with something else.** For example, a flower needs to use water to live, so the flower and water interact so that the flower lives.

Ask students to identify the natural things in the environments they investigated - Arid Zone or Rainforest. *(soil, water, sun, plants, animals, air)* Have students record this in their Student Workbook.

Ask: Can you think of things in those environments that were human-made? *(paths, buildings, clothes, etc.)* Have students record this in their Student Workbook.

Discuss why we should care about the environment. *(So all life can survive; basic needs like food, shelter, health; provides a safe place to live)* Have students record their ideas in their Student Workbook.

**Conduct a class discussion:** *Why do Environmental Engineers need to understand environments and ecosystems?*

Environmental Engineers need to understand which plants and animals live in an environment and their ecosystems and how they interact. Environmental Engineers use their understanding of environments and ecosystems and their respective climates/weather types to design buildings, to inform the layout of communities, design and build systems that provide clean water and protect water supplies and make the environments in which we live adapted to our needs.

7. **Think** back to your visit to Mt Coot-tha Botanical Gardens to help you answer the following questions.

a. **List** the *natural things* in the environment at Mt Coot-tha you visited?

| NATURAL THINGS |
| --- |
| |

b. **List** the *human-made things* in the environment at Mt Coot-tha you visited?

| HUMAN-MADE THINGS |
| --- |
| |

8. **Why** should you care about the environment?

**PART 2B: ENVIRONMENTAL INTERACTIONS ACTIVITY**
(Student Workbook pages 11 – 13)

## ➢ Materials Required

- Masking tape
- Pre-prepared index cards **(**Suggestions - soil, tree or flower, air, sunlight, water, spider, cloud, rock. Add a plant and/or animal if a larger group is necessary. A template can be found on the QUT prepared teacher DVD.)
- Ball of wool

## ➢ Preparation

- Decide where students are going to work so that they can spread out (playground, gym, common area, classroom).
- Tear enough 50mm pieces of masking tape so that each student has one strip.
- Consider using one group to model the activity before asking each group to do it on their own.

## ➢ Creating a Web (Activity)

- Divide the students into groups of 6 – 10. It might be useful to have 1 student be scribe for the group. If at all possible, try not to go above 8 students per group, including the scribe.
- Distribute an index card and a piece of tape to each student. Ensure each person in the group has a different thing written on their index card.
- Ask each student to tape the index card to the front of her/his shirt.
- Get students (including the scribe) to write the things from their group in the appropriate column in the table of living and non-living things in their Workbook.
- Ask the members of each group (excluding the scribe) to sit or stand in a circle. The scribe sits or stands close by.
- Distribute a ball of wool to one member of each group.
- The student with the ball of wool should hold the end of the wool and then pass the ball to another member of the group to whom s/he is "related" based on their index card identifications (e.g., a "fish" passes the ball of wool to the "water," because a fish needs water to live).
- The student who passed the ball of wool must explain his/her "relationship" with the next student (e.g., "a fish needs water to swim in and help it breathe").
- The next student continues in the same fashion (see Figure over page). For example, the "water" holds the wool and passes the ball to a "flower" and then explains their relationship (i.e., water is what allows a flower to grow and survive).
- Ensure students understand not to let go of the wool.
- To avoid problems arising if wool is let go, it may be beneficial to tape the wool to the floor in front of the student to whom it is passed. This could be a job for the scribe.
- Be aware that the wool may come to a student more than once and that student has to hold a new connection before passing the end of the wool on.

# PART 2B

## ENVIRONMENTAL INTERACTIONS ACTIVITY

**Listen** carefully to the teacher's instructions for this activity.
You will be placed in groups by the teacher and given a card with the name of something from the environment written on it. One group member will be the scribe and be responsible for the web tally sheet.

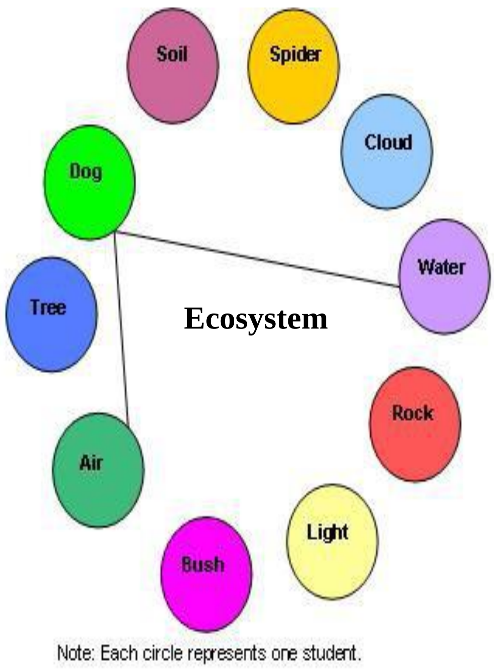
1. **Construct** a table of living (biotic) and non-living (abiotic) things from your group's cards.

| Biotic | Abiotic |
|---|---|
| | |
| | |
| | |
| | |
| | |

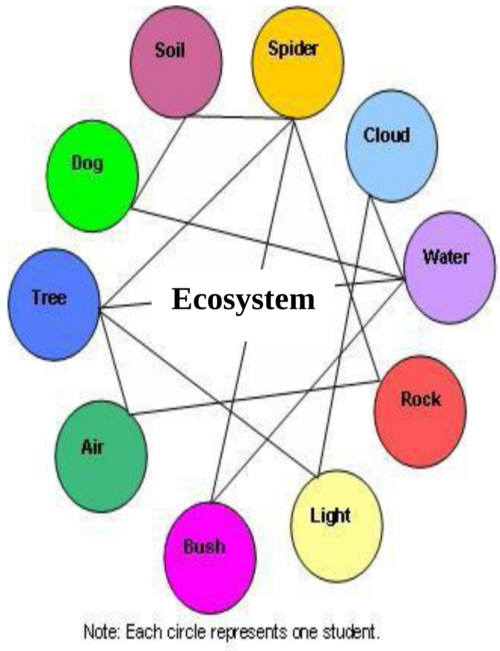
2. **Work with your group** to create an *interaction web*.

- All members of the group sit or stand in a circle, except the scribe.
- One member of the group starts with a ball of wool. He/she holds the end of the wool and passes the ball to another member of the group to whom he/she is related, based on their card identification (e.g., a 'fish' passes the ball to the 'water' because a fish needs water to live).
- The group member who passed the ball of wool must explain his/her 'relationship' with the next student (e.g., 'a fish needs water to swim in and help it breathe').
- The next student continues in the same fashion (e.g., the 'water' holds the ball of wool and passes it to a 'flower' and then explains their relationship i.e., water is what allows a flower to grow and survive).
- Continue passing the ball of wool around the group, showing and explaining the interactions.
- The wool may be passed to you more than once. Make sure you DO NOT let go of the wool.
- Each group member counts how many connections they have.
- The scribe records the number of connections for each group member on the web tally sheet.




**Initial Environmental Interactions**




**Completed Web**

- At this point, ask each student to count how many connections they have. Ask students to remember this number or get the scribe to record on the web tally sheet in their Workbook.

3. **Record** the number of interactions for your group on the *web tally sheet* below. You can get the information for this from your group's scribe.

| Environmental Thing | Number of Connections - Tally Marks | TOTAL |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |
| 7. | | |
| 8. | | |
| 9. | | |
| 10. | | |

illustration by Jeff Grader / property of Delta Education

- **Graphing**

(Student Workbook page 15)

- In order to graph, students will need to fill in the web tally sheets in their Workbook immediately after counting their web connections. Letting go of and then picking up the wool may likely cause mass chaos, so a scribe would be useful here as suggested. The scribe can announce the number of connections for each group member in order for them to fill out their web tally sheet.
- Ask students to complete their web tally sheets and create their graph.
- Using the grid paper in their Workbooks, students should make a bar graph that represents the number of connections each thing in the group has.
- *As a class (interactive)* – The teacher could create a class bar graph using the web connections for the entire class. For example, if more than one person in the class represents "air," then just add the number of connections from all the "air" students to record in the graph. A grid template is included on the QUT supplied DVD.

*Optional: Data can be converted to percentage and a pie graph created instead of a bar graph. Ask students how else they could represent the data?*

4. Use the information from your *web tally sheet* to **graph** your results.

**Environmental Interactions**

### ➢ Reflection

(Student Workbook page 17)

Get the students to reflect on what they have learnt.

Have students complete the following questions in their Workbook.

- What things had the most interactions or connections? *(Water and air)*

- Think about the connections to water and air. Why are there so many? *(Most living things require these two non-living factors to survive.*)

Conduct a class discussion. Some questions that can initiate a discussion may include:

- What things make up an environment? *(Your environment is everything that surrounds you, both natural and human-made items.)*
- What are some examples of an environment's **biotic** factors? *(The plants and animals)*
- What are some examples of **abiotic** factors? *(The natural environment of light, air, water and soil as well as the human-made such as houses, Ipads, tennis shoes, lolly wrappers, etc.)*
- What part(s) of the environment would you not want to be destroyed? Why? *(We would not want the non-living things in the natural environment — especially air, soil, sun and water — to be destroyed. Students may also have additional opinions. Accept most answers as long as the students provide justification.)*

Conclude with a brief discussion about the work of Environmental Engineers and their role in understanding and managing the natural and built environment (human-made) and how environmental change impacts on the health and well-being of societies.

*Humans have modified the natural environment in many ways through agriculture, architecture, industry and transportation. As a result of an ever growing population in the world, the human-made environment is blamed for the majority of environmental problems (including air and water pollution, soil degradation and climate change). Environmental Engineers help solve the most challenging environmental problems through understanding environmental interactions.*

The Environmental Engineers Card could be revisited at this point.

Collect Student Workbooks until next session.

5. **Record** answers to the following questions about the *Environmental Interactions Activity*

a. What things had the **most interactions or connections**?

______________________________________________________________________

b. Think about the connections to water and air from the activity. **Why** are there so many?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

## PART 3A: ADAPTATIONS AND BIOMIMICRY

- **Adaptations**

(Student Workbook pages 19 – 21)

- Read and discuss the information about adaptations with the class.

Compared to many animals and plants, humans are not very physically adapted to the environments in which they live. We comfortably tolerate only a small temperature range, between 17 and 37° Celsius. As a result, we tend to adapt our environment to our needs rather than doing much adapting ourselves.

- Ask students what we do when it is very hot or very cold.

*Example solutions include air conditioning, stay inside, stay in the shade, apply sunscreen, remove layers of clothing when it is hot and heaters, insulation, add layers of clothing when it is cold.*
*Humans adapt their environment to their needs.*

- Ask students what animals do when it is very hot or very cold.

*Example solutions could be they grow more fur in winter, they hibernate, they migrate, nocturnal animals hunt at night.*

- Explain to students:

Engineers can study the way nature has approached solutions to these challenges to improve their own designs. For example, a plant has to find ways to transport nutrients to its leaves and petals just like humans have to find ways to transport water and air through buildings. An engineer may design a water and air transport system that is more "plantlike". Another example can be found in the ocean, where sea creatures must find ways to build strong shells — just like we have to design ways to build strong houses. As engineers, we can consult nature to improve upon our existing designs and products.

Plants and animals adapt in response to the environment they live in. Adaptation is a characteristic of a plant or animal that increases the chance of their survival. Camouflage is an important adaptation.

- Show the first 10 to 15 slides from the link below and see if students can spot the camouflaged animals: http://www.discovery.com/tv-shows/curiosity/topics/animal-camouflage-pictures.htm

- As a class, read the online book - Animal Adaptations: http://tarheelreader.org/#2010/02/22/animal-adaptations/23/?&_suid=138933592432202650529741470776

Discuss the difference between structural and behavioural adaptations here. *Structural (or physical)* adaptations are physical features of an organism like the beak of a bird or the fur on a bear. Other adaptations are *behavioural*. Behavioural adaptations are the things organisms do to survive. For example, bird calls and migration are behavioural adaptations.

- Hand out the Student Workbooks.

# PART 3A

## ADAPTATIONS AND BIOMIMICRY

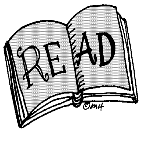

1. **Read** the information about adaptations.

Compared to many animals and plants, humans are not very physically adapted to the environments in which they live. We comfortably tolerate only a small temperature range, between 17 and 37° Celsius. As a result, humans tend to adapt our environment to our needs rather than doing much adapting ourselves.

Engineers can study the way nature has approached solutions to these challenges to improve their own designs.

Plants and animals adapt in response to the environment they live in. Adaptation is a characteristic of a plant or animal that increases the chance of their survival. Camouflage is an important adaptation.

2. **Watch** the online slide show “Animal Camouflage Pictures” and see if you can spot the camouflaged animals.




3. **Read** the online book “Animal Adaptations”.

- Have students complete the table in their Workbook regarding both structural and behavioural adaptations of animals in the book or from the slide show.

| Animal | Structural Adaptation | Behavioural Adaptation |
|---|---|---|
| Sea Horse | Plant like | Stays close to plants |
| | Colour | Not moving |
| Shark | Fins and gills | |
| | Sharp teeth | |
| Fish | Colour | Stay together |
| | | Not moving |

- Ask: Can anyone tell me why a fish can swim faster than you?

Explain: The bodies of fish are shaped like smooth ovals so that water can flow around them without *resistance*, or without getting in the way of movement (i.e., the water moving around the fish's body). Also, the fins of fish are shaped to help effectively push water and make movement faster.

- **Introduce Biomimicry**

(Student Workbook page 21)

- Ask: Has anyone heard of the word Biomimicry?

Explain: We can guess what the word means by breaking it into smaller words. "Bio" means "life," and "mimic" means "to imitate." Biomimicry, then, is precisely that — imitating life or objects in nature to solve human challenges.

- Show video - Nature is Smarter Than Us (3min): http://www.youtube.com/watch?v=4vq8ci4RTUs

Explain: Biomimicry can help solve *some human challenges that we face*. It can provide possible answers to harnessing energy, food and farming, building shelter, and creating new materials and products.

- Have students write a definition for biomimicry in their Workbooks.

4. **List** both *structural (physical)* and *behavioural* adaptations of animals from the book.

| Animal | Structural Adaptation | Behavioural Adaptation |
|---|---|---|
| Sea Horse | | |
| | | |
| | | |
| Shark | | |
| | | |
| | | |
| Fish | | |
| | | |
| | | |

5. **Watch** the video “Nature is Smarter Than Us”.

6. **Write** a definition for biomimicry.

- **Activity: Biomimicry?**

(Student Workbook pages 23 – 25)

- Students work in groups of 3 or 4.
- Give each group a piece of Velcro® (both hook and loop) and a magnifying glass.
- Reveal that the design for Velcro® came from something in nature. Give the students a few minutes to examine the Velcro® with the magnifying glass and talk between themselves to guess where in nature the design came from and what evidence they have. Have students record ideas in their Workbook.

Ask: Do you use Velcro® on anything at school or home? Why is Velcro® better than other kinds of attachment mechanisms i.e., buttons, snaps, zippers, buckles? Have students record their ideas in their Workbook.

7. Your group will be given an example of a *biomimicry invention* and a *magnifying glass*. The design for this invention came from something in nature. **Examine** the invention with the magnifying glass and **discuss** it with your group.

8. **Write** answers to the following questions.

a. **Where** in nature do you think the design came from? **Why** do you think this?

b. Do you **use** this invention anywhere at home or at school? If so, give an **example** of where you use it.

c. **Why** is this invention better than other kinds of attachment mechanisms?

Reveal: The inspiration for Velcro® was the seed of the burdock plant (bur). Show students video - Infamous Inventors: http://videos.howstuffworks.com/howstuffworks/35522-infamous-inventors-velcro-video.htm (1min 26sec) - for explanation.

Show the photo comparing the burdock plant with Velcro® from the QUT supplied DVD. Conduct a class discussion about Velcro®. The key question to explore is, "Why does Velcro® tend to attach more quickly and readily (i.e., to a variety of surfaces) than other attachment mechanisms?" Start your discussion by asking students: What function does the inspiration for Velcro® — seeds of burdock plants — perform? Why do burdock plants produce seeds? Why do their seeds attach to passing animals? Why is it important for plants to disperse their seeds?

Explain: Seeds of burdock plants must adhere to passing animals in order to disperse. They must accomplish this in an uncertain climate (wet, dry, cold, hot), to any number of different kinds of animals (each with different kinds of fur), each of which contact the burdock seeds at various angles and speeds. In other words, the habitat conditions under which burdock plant seeds must perform well are fairly challenging. As a consequence, burdock seeds use a mechanism of attachment which is correspondingly effective — if they didn't, burdock plants would not have survived as a species.

- **Optional Activity: Velcro® Race Game**

- Ask students how one could test whether Velcro® attaches more quickly and with greater ease than other kinds of attachment mechanisms. Then, tell them that you are going to test this assumption by having two volunteers come up and each put on an article of clothing (e.g., fluoro safety vest) at the same time, one attached by Velcro® and the other by another attachment mechanism, and that the activity will be timed. Alternatively, a race to put shoes on could be conducted – one person with laces, the other with Velcro®.
- Conduct the experiment several times, and record the times on the board so students can see the comparison.

- **Matching Game**

(Student Workbook page 25)

- As a class, play the 10 question game matching human-made products with the natural objects that inspired them: http://kidsciencechallenge.com/archiveyeartwo/index.php?linkTo=3c
- Have students write about an example of biomimicry that they know in their Workbook.

9. **Watch** the video “Infamous Inventors” to see where this invention came from.

10. **Play** the *Biomimicry Matching Game*. Your teacher will guide you.

11. Can you think of any other examples of *biomimicry*? **Write** about them below.

12. **Read** the information below about *biomimicry*.

Biomimicry is an approach to problem-solving and design and impacts on the way engineers design products and systems. We are discovering that for every human challenge, nature has a time-tested solution. All things in the environment (nature) have a purpose.

## ➢ **Sum Up and Reflection**

(Student Workbook page 25)

- Read and discuss the information about biomimicry with the class.

As an approach to problem-solving and design, biomimicry is impacting the way engineers design products and systems. So you can see, engineers are consulting nature's genius to answer pressing questions such as, "How will we harness energy?" or "How will we make our materials?" and "How will we come up with new product designs to compete in a global marketplace?"  We are discovering that for every human challenge, nature has a time-tested solution. All things in the environment (nature) have a purpose.

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## PART 3B: ENGINEERING DESIGN CHALLENGE - DESIGN A WIND SEED MODEL

➢ **Introduction**

(Student Workbook page 27)

- Explain: Not all seeds have burs or prickles so they attach to passing animals or humans and spread to other places.

- Ask students if they can think of other ways seeds can be spread? *(Wind, water, animals eating and pooing, attached to animals or stored by animals e.g., squirrels, self dispersal e.g., heavy fruits like apples fall from the tree and roll away)* Have students list some of these methods in their Workbook.

- Ask students if they can think of any examples they have *seen*?

Explain: Seeds are dispersed in several different ways. In flowering plants like pine trees, one or more seeds are housed within a fruit. Sweet fruit, like apples, are eaten by animals that disperse the undigested seeds. Some fruits can be carried by water, like the coconut. Burdock burs have hooks that attach to an animal's furry coat. Dandelion fruits are suspended from feathery "parachutes" that are carried on the wind. The fruit of maple and ash trees have wings that let them float on air.

- Show photo of dandelion from QUT supplied DVD. Discuss the dandelion with students as an example of wind dispersal.

Explain: If you have ever made a wish and blown the fluff of a dandelion, you have witnessed how some plants are adapted to spreading their seeds using the wind. The tiny, furry parachute allows the seeds to be picked up by the wind and to be carried far away from their parent plant.

 

# PART 3B

## ENGINEERING DESIGN CHALLENGE: DESIGN A WIND SEED MODEL

### 1. Introduction:

a. Not all seeds have burs or prickles so they attach to passing animals or humans and spread to other places. **List** some other ways seeds can spread that you may have seen or know of.

b. **Watch** the videos “Seed Aviation” and “Dispersal of Seeds”.

### 2. Scenario:

Your **small engineering team** (group of three or four students) has been invited to work with genetic plant scientists to design a **new seed shape** for a drought tolerant crop. The aim is to produce food for livestock in drought affected areas of Australia. The plant scientists have asked for your help in designing a model seed shape for the plant that can be dispersed by wind. Wind dispersal was seen as the best option because seeds only need to be spread on top of the soil for them to germinate. This will also reduce the use of labour and machinery on farms and will help farmers survive changing climates.

### 3. Challenge:

Your challenge is to **design** a new seed model to be spread by wind. You will design and make seed models to investigate dispersal by wind. You will look at the relationship between the shape of the seed and its ability to be spread by the wind.

### 4. Problem:

Your team will design a seed shape model based on biomimicry and **measure** two important qualities that improve spreading by wind:

- distance travelled and
- time in the air.

Remember to follow the **Engineering Design Model**.

 

Watch videos - Seed Aviation and Dispersal of Seeds:
http://www.bbc.co.uk/nature/adaptations/Seed_dispersal#p00lxw4t (2min 25sec)
http://www.onlinemathlearning.com/seeds-dispersal.html (There are 6 short videos in this series – approx. 1min or less each. Teachers may choose to show all videos or just the first two – Introduction and Wind Dispersal.)

Discuss: Why is it important for the survival of a plant species for their seeds to disperse from the parent plant? *(Dispersal of seeds is important for the continued survival of a plant species. If plants grow too closely together, they compete for light, water, and nutrients. Seed dispersal allows offspring to be spread over a wide area and decreases the competition between offspring.)*

Ask students if they can think of any other issues that are important in seed dispersal. *(Even distribution, stop birds from eating)*

- **Scenario** (Student Workbook page 27)

The scenario is summarised in the Student Workbook. Explain the scenario to students:

Your small engineering team (group of 3 – 4 students) has been invited to work with genetic plant scientists to design a new seed shape for a drought tolerant crop. The aim is to produce food for livestock in drought affected areas of Australia. The plant scientists have asked for your help in **designing a model seed** shape for the plant that can be dispersed by wind. Wind dispersal was seen as the best option because seeds only need to be spread on top of the soil for them to germinate. This will also reduce the use of labour and machinery on farms and will help farmers survive changing climates.

- **Challenge**

The challenge is summarised in the Student Workbook. Explain the challenge to students:
In this challenge you will design and make seed models to investigate dispersal by wind. You will look at the relationship between the shape of the seed and its ability to be spread by the wind.

- **Problem**

The problem is summarised in the Student Workbook. Explain the problem to students:

You will design your own seed model and measure two important qualities that improve dispersal in the wind: (i) distance travelled and (ii) time in the air.

Focus the students' attention on what's important to consider in their designs. Students need to think of what they are measuring i.e., distance and time, and explore possible concepts/ideas which will make their design effective.

Ask: What features will your seed need to allow it to travel far and stay in the air for a long time? *(Light and aerodynamic to allow the seed to float.)*

In their groups, students can discuss possible design features for their seed so that it is light and aerodynamic. *(Possible responses might be: less materials make the model light; wings can help aerodynamics; weight distribution is important.)*

Remind students to follow the *Engineering Design Model*.

 

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## ➢ Materials and Equipment

(Student Workbook page 29)

The materials and equipment are listed in the Student Workbook. Clarify these with students and inform them as to where and how they can be collected.

- design supplies to construct artificial seeds (tape, scissors, glue, pipe cleaners, feathers, tissue paper, cotton wool balls, toothpicks, straws, post-it notes, thread, rubber bands, paperclips)
- small fan
- tape measure
- stop watch
- marker

Remind students to think carefully about what materials they use based on their design strategy i.e., light and aerodynamic.

## ➢ Brainstorming and Design Thinking

Continue to focus the students' attention on what's important to consider in their designs (design strategy). Students need to think about what they are measuring (distance and time) and explore possible concepts/ideas which will make their design light and aerodynamic:

- How can you make your seed model light?
- How can you make your seed model aerodynamic?
- How should you weight your seed model to ensure it goes a long way and stays in the air for a long time?

Allow groups time to discuss their ideas and record them in their Student Workbook.

Distribute a bag of seed samples to each group and allow groups time to examine the design of the different seeds, taking particular notice of the seed shape, size and weight.

Groups should discuss the following questions:

- How do you think each of the seeds might be dispersed? Why?
- Which seed do you think is the best? Why?

 

## 5. Materials:

- design supplies to construct artificial seed models (tape, scissors, glue, pipe cleaners, feathers, tissue paper, cotton wool balls, toothpicks, straws, post-it notes, thread, rubber bands, paperclips)
- small fan
- tape measure
- stop watch
- marker

## 6. Brainstorming and Design Thinking:

- **How** can you make your seed model **light**?

____________________________________________________________

____________________________________________________________________

- **How** can you make your seed model **aerodynamic**?

____________________________________________________________________

____________________________________________________________________

- **How** should you **weight** your seed model to ensure it goes a long way and stays in the air for a long time?

____________________________________________________________________

____________________________________________________________________

- **Draw** and **label** some draft designs in the 'Thinking Space' on page 28.

Your group will be given a bag of seed samples to **examine**. Take notice of the shape, size and weight of each seed.

**Discuss** the following questions with your group:

- How do you think each of the seeds might be dispersed? Why?
- Which seed do you think is the best? Why?

 

- **Experimenting and Designing**

(Student Workbook page 31)

Allow groups time to draw and label a wind seed model.

- Draw and label your first design.
- Experiment and think about how to design your seed model to allow it to be spread by wind. Focus on what shape and size and material used will allow your model to travel the farthest and stay in the air for the longest amount of time.

**Teachers are to take a supportive role in the design component. One example would be rather than "telling" students how to do the design, suggest they use their creativity to design their own model. Also, rather than answering questions directly guide the students to resources where they can research the answers for themselves.**

 

## 7. Experimenting and Designing:

- **Draw** and **label** your first design.
- Experiment and think about how to design your seed model to allow it to be spread by wind. Focus on what shape and size and material used will allow your model to travel the farthest and stay in the air for the longest amount of time.

 

➢ **Construction** (Student Workbook page 33)

Allow groups time to build their model seed.

➢ **Testing**

Explain the testing procedure to students.

a. Set up the fan on a table blowing horizontally across the room.
b. Establish a standard drop site above the fan and set up a tape measure along the floor beneath the fan.
c. Each seed model should be dropped at least three times from the same point above the fan. Experiment with your set-up to find the best height, and then use that height consistently for all trials.

Allow groups time to test their seed model.

- One group member drops the seed saying ‘go’ when they let go and ‘stop’ when it lands.
- One group member listens for the calls of ‘go’ and ‘stop’ and uses the stopwatch to time how long the seed is in the air.
- One group member measures the distance travelled.

Students will need to record their results in the table in their Workbook.

➢ **Recording Results**

Clarify with students how to record the results (time in air and distance travelled) in the table in their Workbook. Results will be recorded after each trial in the Model #1 section.

Example Data Table:

| **Seed Dispersal Data Table** | | | | | |
|---|---|---|---|---|---|
| | | **Time in Air (s)** | **Distance Travelled (cm)** | **Average Time in Air (s)** | **Average Distance Travelled (cm)** |
| **Model #1** | Trial #1 | | | | |
| | Trial #2 | | | | |
| | Trial #3 | | | | |
| **Model #2** | Trial #1 | | | | |
| | Trial #2 | | | | |
| | Trial #3 | | | | |

More able students may like to calculate an average time in the air and distance travelled.

 

## 8. Construction:


**Build** your model seed using any materials supplied.

## 9. Testing:

a. Set up the fan on a table blowing horizontally across the room.
b. Establish a standard drop height above the fan and set up a tape measure along the floor beneath the fan.
c. Each seed model should be **dropped at least three times** from the same point above the fan. Experiment with your set-up to find the best height, and then use that height consistently for all trials.

## 10. Recording Your Results:

**Record** the **time** in the air and the **distance** travelled for each trial in the table below (Model #1).

***Optional: Calculate the average time in air and distance travelled.***

**Seed Dispersal Data Table**

| | | Time in Air (s) | Distance Travelled (cm) | Average Time in Air (s) | Average Distance Travelled (cm) |
|---|---|---|---|---|---|
| **Model #1** | Trial #1 | | | | |
| | Trial #2 | | | | |
| | Trial #3 | | | | |
| **Model #2** | Trial #1 | | | | |
| | Trial #2 | | | | |
| | Trial #3 | | | | |

 

- **Redesigning and Retesting**

(Student Workbook pages 35 - 37)

- Allow groups time to design another prototype seed.

 

## 11. **Redesigning and Retesting:**

- **Design** another prototype of a flying seed model to **improve** on your first design. **Draw** and **label** your design below.

 

- Have students record the changes they made to their seed model and why they made these changes in their Workbooks.
- Groups can then use the supplied materials to create a second flying seed model.
- Teams will then test their second model using the same testing procedure as the first model.
- Results will be recorded in the table in the Model #2 section.

 

Record **how** you changed your seed model and **why**.

12. **Construction:**


**Build** your new improved seed model.

13. **Retesting:**

**Retest** your second seed model using the same procedure as the first.

14. **Recording Your Results:**

**Record** your results on the table on page 33 (Model #2).

 

- **Reflecting**

(Student Workbook page 39)

Examine the different results obtained.  Discuss with class:

- Is there a link (relationship) between maximum time in the air and the distance each seed travelled?
- What is the best way to graph your results?

Have students record answers to the following questions in their Workbook:

- Which was your best design and why?
- What would you do to improve your design?

Display the Environmental Engineers Card and allow students to complete the following question in their Workbook.

- Re-read the Environmental Engineers Card and think about what you have learned about Environmental Engineers.  What are Environmental Engineers interested in?

 

## 15. **Reflecting:**

**Write** answers to the following questions.

a. **Which** was your best design and **why**?

b. **What** would you do to **improve** your design?

c. **Re-read** the Environmental Engineers card and **think** about what you have learned about Environmental Engineers. **What** are Environmental Engineers interested in?

- **Feedback**

(Student Workbook page 41)

Finally, have students complete the *Biomimicry Challenge Feedback* by colouring in the face to show how they felt about the different parts of the *Biomimicry Challenge.*

 

# BIOMIMICRY CHALLENGE FEEDBACK

Please **colour in the face** to show how you felt about the different parts of the *Biomimicry Challenge*.

| **Did you like:** | **Did not like it** | **Not sure** | **Liked it** |
|---|---|---|---|
| 1. ... the activity about Biomimicry? | | | |
| 2. ... having a real problem to solve? | | | |
| 3. ... watching the videos? | | | |
| 4. ... designing a seed model? | | | |
| 5. ... making the seed models? | | | |
| 6. ... testing your seed models? | | | |
| 7. ... recording the results of your seed model? | | | |
| 8. ... thinking about how to make your seed model better? | | | |

**Next time I would like to:**

**Additional Teacher Information**
*What is Biomimicry (2min)*
http://www.youtube.com/watch?v=FBUpnG1G4yQ&feature=youtu.be
*Natures Spiral (2min)*
http://www.youtube.com/watch?v=UmU0NmIDETI&feature=youtu.be
*Bio Inspired Design*
http://kidsciencechallenge.com/archiveyeartwo/index.php?linkTo=3a
*Matching Game*
http://kidsciencechallenge.com/archiveyeartwo/index.php?linkTo=3c
*Curiosity, Discovery and Gecko Feet - Robert Full (9min)*
http://www.youtube.com/watch?v=TlyvS1ckDZM
*Animal Adaptations Book*
http://tarheelreader.org/#2010/02/22/animal-adaptations/23/?&_suid=138933592432202650529741470776
*Plant Survivors*
http://splash.abc.net.au/media/-/m/86152/how-plants-survive-in-different-places?source=upper-primary-science
*Nature is Smarter Than Us*
http://www.youtube.com/watch?v=4vq8ci4RTUs
*Story of Velcro®*
http://videos.howstuffworks.com/howstuffworks/35522-infamous-inventors-velcro-video.htm
*BioInspiration*
http://science.kqed.org/quest/video/bio-inspiration-nature-as-muse/
*Seed Dispersal*
http://www.youtube.com/watch?v=6hcjxaBz8mw
*BBC David Attenborough Seed Aviation (2min)*
http://www.bbc.co.uk/nature/adaptations/Seed_dispersal#p00lxw4t
*Dispersal of Seeds*
http://www.onlinemathlearning.com/seeds-dispersal.html
*Game On Living / Non-Living Things*
http://www.pbslearningmedia.org/asset/lsps07_int_ecosystem/
*NatureWorks Video Adaptations (14min)*
http://video.nhptv.org/video/1492015101/
*Biomimicry: From Adaptations to Inventions*
http://mathinscience.info/public/biomimicry/biomimicry_lesson_plan.htm

**Example innovations inspired by animals and plants:**
Aeroplanes modelled after birds (wing and body shapes)
Swimsuits worn by Olympic athletes that imitate dolphin and shark skin membranes
Radar and sonar navigation and medical imaging inspired by the echo-location abilities of bats
Re-usable adhesives inspired by the powerful adhesion abilities of geckos and lizards
Super-strong and waterproof silk fibres made without toxic chemicals by spiders
A better ice-pick for mountain climbers designed after the woodpecker
Glow sticks made with light-up chemicals, just like fireflies
Very efficient pumps and exhaust fans applying the spiraling geometric pattern found in nautilus seashells, galaxies and whirlpools
Hook and loop material (Velcro®) inspired by cockleburs
Solar cells inspired by plant leaves (photosynthesis, capturing energy from sunlight)
A wind-driven planetary rover design that maximizes drag, learned from the tumbleweed
Self-cleaning exterior paint, tiles, window glass and umbrella fabric inspired by the slick leaves of the lotus flower plant and its natural ability to wash away dirt particles in the rain

 