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How Biomimicry Inspires New Innovations



BIOS4YOU
AR 2.0

BIO-INSPIRED STEM TOPICS FOR ENGAGING YOUNG GENERATIONS
THANKS TO THE USE OF AUGMENTED REALITY

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General topic of the learning path	Understanding how natural strategies inspire human technologies.
Specific name of the learning unit	How Biomimicry Inspires New Innovations
Age of the target users	14-18 years
Requirements for the learner	<ul style="list-style-type: none"> • Basic understanding of biology (plants, animals, ecosystems). • Interest in science, technology, and sustainability. • Curiosity for exploring connections between nature and human design. • Openness to teamwork, creativity, and problem-solving.
Description of the learning unit	This learning unit introduces students to biomimicry, the practice of studying natural structures, processes, and systems to inspire human innovation. Through case studies such as the lotus leaf (self-cleaning surfaces), shark skin (antibacterial textures), and termite mounds (sustainable architecture), students see how evolution has already solved many design problems.
Subject: Parties involved	Biology, Environmental Science, STEM, Design & Technology, Ethics. Parties involved: Students, teachers (facilitators), optional guest speakers like biologists, architects working with biomimicry.
Keywords	Biomimicry, Sustainability, Innovation, Nature-Inspired Design, Lotus Effect, Shark Skin, Termite Architecture, Bio-Inspiration, AR Learning
Key qualifications, skills and knowledge that can be acquired	Knowledge: Principles of biomimicry (form, process, system). Case studies of nature-inspired





	<p>innovations (Velcro, Shinkansen train, termite-inspired buildings). Links between biology, engineering, and sustainability.</p> <p>Skills: Analyzing natural strategies and translating them into design ideas. Using AR tools to visualize microscopic and systemic natural processes. Teamwork, creativity, and problem-solving in design challenges. Reflecting on ethical and environmental implications of biomimicry.</p> <p>Competences: Applying biological principles to real-world problems. Evaluating sustainability and efficiency in technology. Developing responsible, innovative approaches to environmental challenges.</p>
Resources and didactic aids used	<p>Videos & Media:</p> <p>Biomimicry in Action Janine Benyus TED Talk</p> <p>What is Biomimicry? Biomimicry Institute.</p> <p>Websites:</p> <p>Asknature.org – Biomimicry case study database.</p> <p>Biomimicry Institute resources.</p>
Assessment criteria and evaluation	<p>Evaluation is formative (ongoing feedback during activities) and summative (final group presentations, AR-based assessments, and reflections).</p>

Introduction

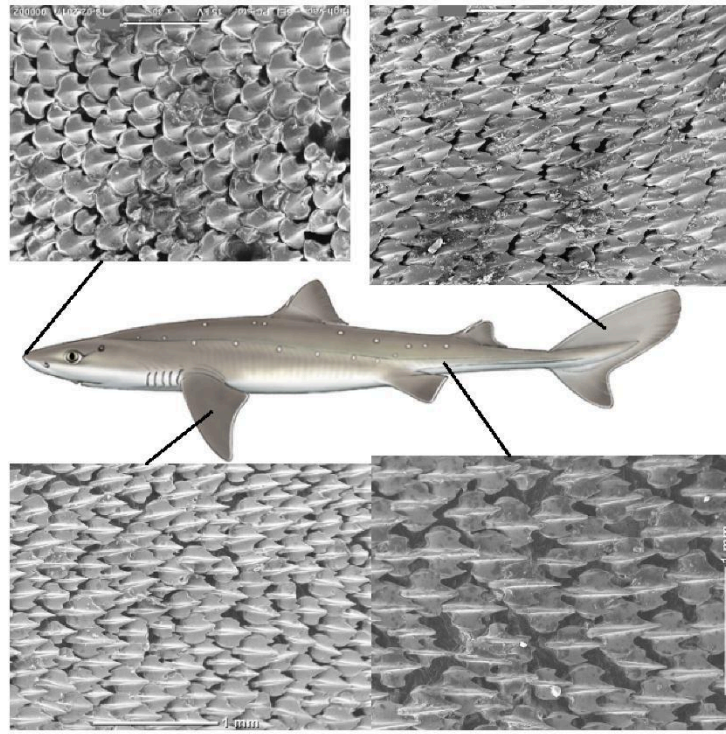
Everywhere we look, nature offers intelligent solutions to problems that humans also face. Birds, insects, plants and even microorganisms have taken billions of years to evolve and develop ways to survive, adapt and thrive. Today, scientists and engineers are studying these solutions in detail through a field called biomimicry, which literally means “imitating life”. Biomimicry is not about blindly copying nature's designs, but learning from its principles to create sustainable, efficient and innovative technologies for our world.

This learning unit will guide students through the fascinating world of biomimicry. Using the three E's methodology — Explore, Execute, Enhance, learners will first discover the science behind nature-inspired





designs, then engage in hands-on and AR-supported activities, and finally reflect on how biomimicry could solve real-world problems.



What is Behind the Structure of Biomimicry in Nature?

Nature's designs are never random. They are the product of millions of years of trial and error through evolution, where only the most efficient and resilient solutions survive. Every leaf, feather, shell, or ecosystem we encounter carries within it a blueprint that has been tested and refined over countless generations. Biomimicry is the science and the art of paying attention to these natural blueprints, learning from them, and applying their lessons to human challenges.

When scientists and engineers study biomimicry, they often look at nature on three interconnected levels. The first is form the shape or physical structure of an organism. A simple yet powerful example is the lotus leaf: covered in microscopic waxy bumps, its surface repels water and dirt, a phenomenon that has inspired self-cleaning paints and glass.

The second level is process how something works or functions in nature. The kingfisher bird, for instance, dives into water with almost no splash





thanks to the perfect proportions of its beak. By mimicking this design, Japanese engineers reshaped the nose of the Shinkansen bullet train, making it faster, quieter, and more energy-efficient.

The third level is system how different parts of nature interact in harmony. A forest, for example, operates as a closed-loop system where every resource is recycled and nothing is wasted. On a smaller scale, termite mounds reveal natural ventilation systems that keep their interiors cool in extreme African heat. Inspired by this, architects in Zimbabwe created sustainable buildings that regulate temperature without the need for air conditioning.

Even the seemingly rough texture of shark skin hides a remarkable secret: tiny ribbed scales called dermal denticles. These scales reduce drag in water and prevent microorganisms from attaching. This discovery has led to faster swimsuits and antibacterial surfaces in hospitals, where reducing infection risk is critical.

Together, these examples reveal a powerful truth: nature is not just a source of beauty but also of brilliant engineering solutions. By studying its designs whether at the level of form, process, or system we can create technologies that are not only innovative but also sustainable, helping us build a future that works in harmony with the planet rather than against it.



Figure 1-A termite mound next to the Eastgate building.

1- Explore:

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At this stage, students are introduced to the idea that nature has already solved many of the challenges facing humans. For billions of years, plants, animals and microorganisms have designed, tested and refined survival strategies through evolution. Every feather, leaf or shell is the result of countless “experiments” in efficiency and adaptation.

This is the heart of biomimicry, a concept famously described by Janine Benyus as “innovation inspired by nature”. Students explore how biomimicry can occur at three levels: form (physical shape, such as the protuberances on a lotus leaf that repel water), process (functional strategies, such as the kingfisher's splash-free diving) and system (ecosystem-level design, such as forests that recycle everything without producing waste).

To bring these concepts to life, students are presented with famous case studies. They see how thorns attached to a dog's fur inspired the invention of Velcro, how termite mounds led to the design of sustainable buildings in Zimbabwe, and how the adhesive capabilities of gecko feet opened new doors in robotics and materials science.

The classroom becomes a space for curiosity: students can watch a TED Talk by Janine Benyus, compare images of a lotus leaf next to a self-cleaning glass pane, or examine a diagram of shark skin next to an athlete's wetsuit. Teachers guide them to ask questions such as, ‘If nature is such a brilliant designer, why don't we always use its solutions?’ These discussions help students understand that sometimes nature's designs challenge our way of thinking and that adopting them requires imagination, creativity, and open-mindedness.

By the end of this section, students understand that biomimicry is more than just imitation: it is a way to learn from nature as the ultimate innovator and apply these lessons to human challenges.

2- Execute:

After building their knowledge base, students are ready to move on to practice. At this stage, they begin to see and interact with nature's designs in ways that would be impossible in a traditional classroom. Through





augmented reality (AR), students can zoom in on microscopic worlds, exploring the intricate protrusions of a lotus leaf, the ridges that reduce drag on shark skin, or the ingenious airflow systems inside termite mounds.

The AR environment becomes their laboratory.

- In one mission, students virtually examine the microstructure of the lotus leaf and are challenged to design a product—such as a self-cleaning water bottle or stain-resistant fabric—inspired by its water-repellent properties.
- In another, they study the skin denticles of shark skin in 3D and are tasked with creating a material that reduces drag in water.
- In a group challenge, students select a natural wonder, such as spider silk or gecko feet, and reflect on how to apply its structure or process to human inventions.

These exercises are directly linked to real-world innovations. Students learn how architecture classes in Zimbabwe studied termite mounds to create office buildings that stay cool without air conditioning, or how engineers in Europe designed insect-inspired drones that fly more efficiently.

3- Enhance:

In the in-depth phase, the classroom moves from learning facts to critical and creative thinking about the future. AR technology now becomes a learning tool, allowing students to simulate complex systems and imagine how biomimicry could solve challenges in the world.

For example, they could use AR to compare different types of designs in architectural structural design. Or they could “delve into” shark skin-inspired materials in a simulated water flow to understand aerodynamic drag reduction. They could even model a forest ecosystem, visualising how it recycles energy and nutrients without producing waste, and then ask themselves, “How can human cities function in this way?”

To make learning more engaging, the process is gamified: Students earn points and badges for completing AR biomimicry missions. Leaderboards encourage teamwork and friendly competition. Missions and levels guide





them from simple tasks, such as designing Velcro from thorns, to complex challenges, such as reimagining entire cities as circular systems inspired by ecosystems. In collaborative missions, groups might be asked to design a “sustainable city of the future” based entirely on nature's principles.

During this phase, students understand that biomimicry is not just about ingenious inventions, but also about rethinking the way we live. Tools such as Asknature.org provide them with engaging examples and a database of natural models.

Through a combination of creativity, technology and collaboration, students begin to see biomimicry as a path to sustainability, not just innovation.

Conclusion:

By the end of this learning journey, students come to see that nature is not just scenery around us, it is the greatest innovator we have.

In the **Explore** stage, they discovered how billions of years of evolution have refined structures, processes, and systems into elegant survival strategies. They learned that the bumps of a lotus leaf can teach us how to create self-cleaning surfaces, that the ridges of shark skin can inspire antibacterial materials, and that the beak of a kingfisher can reshape the way we design high-speed trains.

In the **Execute** stage, knowledge came alive through practice. Using Augmented Reality, students stepped into the hidden worlds of leaves, feathers, and mounds, interacting with nature’s designs in ways no textbook could provide. They experimented, built, and reflected seeing for themselves how simple ideas from the natural world can be transformed into powerful human solutions.

Finally, in the **Enhance** stage, students pushed beyond examples into possibilities. With the help of AR and gamified learning, they imagined new ways biomimicry could address the greatest challenges of our time: reducing energy use, creating sustainable cities, and designing materials that work in harmony with the planet.





The use of AR technology made the invisible visible, turning microscopic structures and complex systems into tangible, interactive lessons. Gamification added curiosity and collaboration, transforming the classroom into a space of creativity and shared discovery.

The key lesson of this unit is that biomimicry is more than copying nature, it is learning to see the world as a model, a mentor, and a measure. By studying and respecting nature’s wisdom, we can design innovations that are not only clever but also sustainable, ensuring that our future thrives alongside the natural systems that sustain us.

Phase	Description
Explore	- Research and Discovery: Students learn that nature has been solving problems for billions of years through evolution. Case studies like the lotus leaf’s self-cleaning surface, shark skin’s drag-reducing texture, and termite mounds’ natural cooling systems show how biomimicry works in real life.
	- Content Development: teachers use videos, images, and simple experiments to explain biomimicry at three levels: <i>form</i> (shape), <i>process</i> (function), and <i>system</i> (ecosystems).
	- Needs Analysis: Because microscopic and complex natural designs are hard to visualize, students need AR tools and models to make the invisible visible and connect ideas to real-world applications.
Execute	- Curriculum Implementation: Students move from theory to practice using AR applications to explore natural structures and apply them in design challenges.
	- Interactive Exercises: <ol style="list-style-type: none"> Investigating the lotus leaf in 3D to design a self-cleaning product. Exploring shark skin to design antibacterial or drag-reducing materials. Group projects creating inventions inspired by geckos, spiders, or termites.
	- Feedback Collection: AR apps provide instant feedback, teachers assess teamwork and creativity, and students reflect in digital journals on how nature shaped their solutions.
Enhance	- AR Integration: AR helps students simulate complex biomimetic systems, such as comparing airflow in traditional vs. termite-inspired buildings or modeling forest ecosystems that recycle resources.
	- Interactive Learning: Learners discuss how biomimicry could solve global challenges — from sustainable cities to renewable energy and waste reduction.

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**Gamified Content:**

- Points and Badges reward successful AR challenges.
- Leaderboards motivate collaboration and friendly competition.
- Quests and Levels guide students from simple tasks (Velcro from burrs) to advanced ecosystem-inspired designs.
- Rewards for Exploration celebrate creative, outside-the-box thinking.
- Collaborative Tasks push groups to design sustainable cities inspired by nature.

AR-Based Assessments:

Students present their designs and reflections using AR visuals, evaluated on creativity, scientific accuracy, and ability to connect biomimicry to real-world solutions.

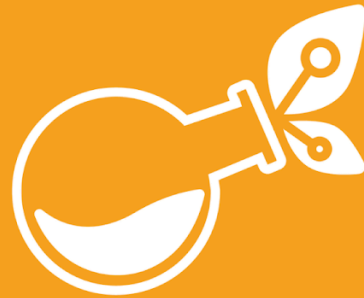
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