Portugal

Self-cleaning, long-lasting solar panels

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** How can we design solar panels that self-clean and maintain high efficiency over time? **1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.** Describe the context. e.g. Which are the groups that might be or are affected by the challenge? Which is the location or the setting in which your design will be implemented? The design needs to maintain high solar panel efficiency by preventing or removing surface buildup that reduces light absorption over time. Specifically, it should: ● **Prevent dust, sand, and pollutants** from accumulating on the surface to avoid frequent drops in energy output. ● **Respond to environmental conditions** by initiating cleaning or protective measures automatically, even in locations with minimal human maintenance. ● **Extend the operational life of the panels** by reducing wear and tear that traditional cleaning methods might cause. ● **Function across diverse climates**, including arid, polluted, or remote areas, without relying heavily on water, energy, or regular maintenance. **Target audience** ● **Solar energy companies**: Constant cleaning and maintenance of solar panels are costly, particularly for large solar farms. ● **Residents and businesses**: Solar panels on rooftops are often less efficient if not cleaned regularly, impacting energy savings. ● **Government and environmental organisations**: promoting clean, sustainable energy solutions aligns with goals for reducing carbon footprints and achieving energy independence.

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- **Communities in arid and dusty regions**: areas with frequent dust storms, dry weather, or limited rainfall experience faster efficiency loss due to panel soiling.

Location and context

- **Arid and dusty regions** that face rapid soiling due to dust and sand accumulation, reducing the efficiency of solar energy generation.
- **Urban environments**, especially in regions with high industrial emissions, are more prone to air pollution.
- **Remote or hard-to-reach areas**, where regular cleaning of panels can be challenging and costly.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Identify the opportunities and the constraints. For example, are there connections to other solutions or challenges? Are there favourable circumstances, initiatives, or legislations that might impact them? Are there specific limitations or risks that need to be considered?

Opportunities

- **Nature's inspiration:** Some plants and animals have self-cleaning surfaces. You could learn from these natural designs to help keep our solar panels clean.
- **New tech on the rise:** Advances in science have led to special coatings that make surfaces repel water and dirt. These breakthroughs might be the key to creating low-maintenance solar panels.
- **Growing support for green energy:** Governments and organisations around the world are backing new, sustainable energy solutions. This means that funding and support could be available for ideas like this.

Challenges

- **High-tech, high costs:** Utilising advanced materials and coatings can be expensive, which may make solar panels more costly to produce. You'll need to think about how to make them affordable.
- **Weather resistance:** Solar panels are exposed to the sun and elements all day, every day. Any self-cleaning feature you add must withstand harsh conditions without wearing out.
- **Environmental rules:** Some chemicals or materials might be effective, but they could also be harmful to the environment. Your solution has to be safe and eco-friendly.

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- **Long-term reliability:** Solar panels last for years, so any self-cleaning feature you design should work just as well 10 or 20 years down the line as it does on day one.

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Non-toxic antifouling solutions for ships

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** Define the challenge as a question How can we develop a non-toxic solution that prevents marine life from attaching to ships' hulls, keeping them clean and fuel-efficient while minimising harm to ocean ecosystems? **1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.** Describe the context. e.g. Which are the groups that might be or are affected by the challenge? Which is the location or the setting in which your design will be implemented? The design must keep marine life from adhering to ship hulls, such as algae, barnacles, and mussels. By doing this, the design could avoid the discharge of hazardous chemicals into the ocean and minimise drag, increasing ships' fuel efficiency. **Target audience** ● **Shipping companies:** They need effective solutions to keep ships clean and fuel costs low. ● **Environmental and regulatory agencies:** They aim to minimise pollution and protect marine life, promoting non-toxic antifouling methods. ● **Fishing and tourism industries:** These industries rely on ocean health and could benefit from eco-friendly antifouling solutions that protect marine biodiversity. **Location and context** The design will be used in **global ocean environments**, including commercial shipping routes, port areas, and coastal waters. Ships operate in diverse conditions—from tropical to polar regions—so the solution must be effective across various climates and environmental conditions. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.** Identify the opportunities and the constraints. e.g. Are there connections to other solutions or challenges? Are there favourable circumstances, initiatives or legislations that might

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impact Are there specific limitations or risks that need to be considered?

Opportunities

- **Nature's smart solutions:** In nature, some ocean animals have special skin that naturally prevents things from sticking. By studying these creatures, you could discover new ways to keep ship hulls clean without using chemicals.
- **Advances in safe coatings:** Scientists are making progress with eco-friendly materials that repel marine life without hurting it. These coatings could be an effective way to stop barnacles and algae from building up on ships
- **Support for a cleaner ocean:** Many countries and organisations want to protect marine life and reduce pollution in the oceans. They're supporting research and innovation in non-toxic antifouling methods, which could help make your solution easier to fund and test.

Challenges

- **Cost of high-tech materials:** Non-toxic coatings and advanced materials can be expensive. Making these solutions affordable for shipping companies may be a challenge, so you need to think of ways to keep costs down.
- **Extreme ocean conditions:** The ocean is a tough place! Ship hulls face constant waves, salt, temperature changes, and sun exposure. Any antifouling solution you create has to be strong enough to last for years under these conditions.
- **Environmental regulations:** Some antifouling methods are already banned because they harm marine life. You need to make sure any new solution is completely safe for the environment and can pass all the strict regulations in different countries.
- **Long-term effectiveness:** Ship hulls spend months or even years at sea, so your solution needs to work for a long time without losing its effectiveness. If it wears off or needs frequent reapplication, it might be too costly or impractical.
- **Efficiency Trade-Offs:** Some antifouling coatings could slightly affect the speed of a ship or increase drag, which would use up more fuel. You'll need to find a balance between keeping hulls clean and keeping ships fast and fuel-efficient.

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Self-healing road infrastructure

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** How can we design roads that repair themselves, keeping them safe and long-lasting without constant maintenance? **1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.** Describe the context. e.g. Which are the groups that might be or are affected by the challenge? Which is the location or the setting in which your design will be implemented? Roads that are capable of self-repairing minor cracks and damage must be designed. Roads would last longer, be safer, and require less regular maintenance as a result. The road surface could self-heal by employing self-healing materials, avoiding cracks, lowering repair expenses and annoyance. **Target audience** ● **City and national road management agencies**: Responsible for maintaining roads and would benefit from reduced repair costs. ● **Local communities and drivers**: They rely on safe, well-maintained roads for daily travel and transport. ● **Environmental organisations**: They support solutions that reduce resource use, pollution, and the environmental impact of road construction and repair. **Location and context** The design will be applied to urban and rural roads, highways, and other paved areas where heavy traffic and weather conditions lead to frequent wear and tear. Roads in areas with extreme climates (e.g., freezing winters, hot summers) are especially vulnerable and would benefit from self-healing technology. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.** Identify the opportunities and the constraints. For example, are there connections to other solutions or challenges? Are there favourable circumstances, initiatives, or legislations that might

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impact them? Are there specific limitations or risks that need to be considered?

Opportunities

- **Smart materials in action:** Recent advances in materials science have led to “self-healing” materials that can close cracks automatically when exposed to sunlight, air, or moisture. Using these materials on roads could create surfaces that fix themselves.
- **Support for Infrastructure Innovation:** Governments and cities are actively investing in innovative infrastructure solutions. This support may include funding for the research and testing of self-healing roads.
- **Environmental benefits:** Reducing the need for constant repairs means fewer construction materials and less pollution from machinery, which benefits the environment. Self-healing roads could also result in fewer traffic jams due to roadwork, thereby reducing car emissions.
- **Related research areas:** Other fields, such as aerospace and medical implants, are also exploring self-healing materials. These developments could lead to new ideas or materials for road construction that you can adapt for self-healing pavement.

Challenges

- **High cost of new materials:** Self-healing materials are more expensive than traditional asphalt or concrete, making them affordable for widespread use a challenge.
- **Extreme weather conditions:** Roads in areas with heavy rainfall, extreme cold, or high heat face extra challenges, as these conditions may interfere with how well self-healing materials perform.
- **Traffic load and durability:** Roads carry heavy traffic every day, which means any self-healing feature must be durable enough to withstand wear and tear. Ensuring these materials work effectively under constant pressure and movement is essential.
- **Long-term reliability:** Self-healing materials are still relatively new, and their long-term performance is not yet fully understood. Roads need to last a long time, so any new material must demonstrate its effectiveness over decades.
- **Adapting to current infrastructure:** Most roads are constructed with traditional asphalt or concrete, making it challenging to integrate self-healing materials into existing infrastructure.

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Waste-free packaging alternatives

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** How can we design packaging that doesn't create waste, keeps products safe, and is convenient for people to use? **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** Describe the context. e.g. Which are the groups that might be or are affected by the challenge? Which is the location or the setting in which your design will be implemented? The design must include packaging that preserves the product while producing no trash after usage. This could imply designing packaging that can be completely recycled, reused, or even composted. The objective is to protect goods during storage and transportation while making sure that packaging doesn't contaminate the environment or wind up in landfills. **Target audience** ● **Companies and brands**: Businesses want packaging that aligns with eco-friendly goals to reduce waste and appeal to environmentally conscious consumers. ● **Consumers**: Shoppers are increasingly looking for sustainable packaging that doesn't contribute to pollution or waste. ● **Environmental groups and governments**: They are interested in reducing plastic pollution and waste, pushing for new packaging standards that benefit the planet. **Location and context** Waste-free packaging can be used in **retail stores, online shopping, grocery stores, restaurants, and beyond**. Packaging waste is a global problem, affecting landfills, oceans, and communities around the world. Creating waste-free packaging alternatives would help reduce landfill waste, lower pollution, and give people an easy way to make eco-friendly choices. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.**

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Identify the opportunities and the constraints. e.g. Are there connections to other solutions or challenges? Are there favourable circumstances, initiatives or legislations that might impact Are there specific limitations or risks that need to be considered?

Opportunities

- **Innovative materials:** New materials like biodegradable plastics, edible packaging, and plant-based fibres are being developed that can break down naturally. These materials could make waste-free packaging a reality.
- **Consumer demand for eco-friendly products:** more people are choosing products with sustainable packaging. This growing interest means companies are more likely to invest in waste-free solutions.
- **Supportive policies and initiatives:** Many governments are implementing policies to reduce plastic use and promote sustainable packaging. These rules could help make waste-free packaging more common.
- **Technology and design innovations:** Advances in technology are enabling us to create packaging that's both durable and compostable or recyclable. Innovations in design could also help create reusable packaging systems.

Challenges

- **High costs of new materials:** Biodegradable or reusable packaging materials are often more expensive than traditional plastics, so making them affordable for all products is a big challenge.
- **Durability and protection needs:** Packaging must protect products from damage, moisture, and bacteria. Some eco-friendly materials may not yet be as strong as plastic, so you'll need to make sure the packaging can still do its job.
- **Infrastructure for recycling and composting:** Not all places have facilities to handle recyclable or compostable packaging. For waste-free packaging to work everywhere, you would need better systems for collection and processing.
- **Consumer behaviour:** Some waste-free packaging solutions, like reusable containers, require people to change their habits. Not everyone may be willing to return or compost packaging, so designs need to be user-friendly.
- **Long-term impact and safety:** Some new materials break down into microplastics or may have unexpected environmental effects. You need to ensure that any waste-free packaging is safe and truly eco-friendly over time.

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BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** How can we develop an effective method to remove microplastics from the ocean without harming marine life or disrupting ecosystems? **1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.** Describe the context. e.g. Which are the groups that might be or are affected by the challenge? Which is the location or the setting in which your design will be implemented? The design must detect and remove microplastic particles from the ocean water. Despite being too small to see, these particles have a significant negative impact on ocean health and marine life. The solution must specifically target microplastics without harming fish, plants, or other marine life. To have a significant effect, it must also be effective and operate on a wide scale. **Target audience** ● **Environmental organisations:** They work to protect the oceans and would be interested in practical ways to clean up microplastics. ● **Researchers and scientists:** They study the impact of microplastics and could use this solution to understand and reduce pollution. ● **Government agencies:** They are responsible for maintaining ocean health and may support or fund ocean cleanup projects. ● **Industries that rely on healthy oceans:** Fisheries, tourism, and coastal communities, are affected by ocean pollution and would benefit from a cleaner marine environment. **Location and context** The design will be used in **ocean and coastal areas worldwide** where micro-plastics have accumulated, often in hotspots like garbage patches or near river mouths, where plastic waste enters the sea. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.** Identify the opportunities and the constraints. e.g. Are there connections to other solutions or challenges? Are there favourable

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circumstances, initiatives or legislations that might impact Are there specific limitations or risks that need to be considered?

Opportunities

- **Growing awareness and support:** People and governments are more aware of ocean plastic pollution than ever. This attention creates support, funding, and a push for solutions that can help clean the oceans.
- **Innovative materials and technologies:** Scientists are developing materials and devices that attract or capture microplastics. Some of these materials can be used in filters or ocean-cleaning devices, making it easier to collect tiny particles from the water.
- **Connections with existing cleanup efforts:** There are already ocean cleanup projects focusing on larger plastics, and combining these with microplastic removal efforts could be very effective.

Challenges

- **Harm to marine life:** Many methods for removing microplastics could accidentally trap fish, plankton, or other small ocean creatures. Your design must be able to separate plastic from marine life to avoid harm.
- **Tiny size and widespread distribution of microplastics:** Microplastics are incredibly small, often measuring less than 5mm, and are spread throughout the ocean, making it challenging to locate and remove them on a large scale.
- **High cost and energy requirements:** Cleaning up oceans requires technology that can operate over large areas and for extended periods. This could be expensive and energy-intensive, so finding ways to make it affordable and sustainable is key.
- **Risk of releasing microplastics back into the water**: During the collection process, some methods might accidentally release microplastics back into the ocean. Ensuring that captured plastics stay out of the water is essential.
- **Lack of recycling or disposal options**: Once collected, microplastics need to be disposed of safely. Without good recycling or disposal options, there's a risk of reintroducing plastic pollution back into the environment.

Now it's your turn!

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BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** How can we create sustainable light sources that don’t rely on electricity and are eco-friendly? **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** Describe the context. e.g. Which are the groups that might be or are affected by the challenge? Which is the location or the setting in which your design will be implemented. The design needs to provide a source of light that doesn’t use electricity or require a connection to the power grid. It should be safe, long-lasting, and ideally work in any environment. This type of light could be especially useful in areas without reliable electricity or during emergencies when power is unavailable. **Target audience** ● **Rural or remote communities**: in areas without access to the electrical grid, people need alternative ways to light their homes, workplaces, or pathways. ● **Emergency relief organisations**: they help in disaster areas where power may be out, so having electricity-free light sources can make a big difference. ● **Outdoor enthusiasts**: campers, hikers, and explorers often rely on light sources when far from electricity and would benefit from sustainable, reliable light. ● **Environmentally conscious consumers**: people interested in reducing their carbon footprint and conserving energy could also benefit from alternative, sustainable lighting solutions. **Location and context** Off-grid locations, disaster areas, outdoor spaces, and even environmentally conscious residences around the world could all make use of the idea. By developing light that doesn't require electricity, we can decrease energy use, increase safety, and assist populations without reliable power access. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.**

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Identify the opportunities and the constraints. e.g. Are there connections to other solutions or challenges? Are there favourable circumstances, initiatives, or legislations that might impact the situation? Are there specific limitations or risks that need to be considered?

Opportunities

- **Inspiration from nature:** Some organisms, such as fireflies and certain algae, produce their own light through bioluminescence. Studying these natural lights could inspire ways to create eco-friendly light sources.
- **Growing demand for green tech:** As more people look for sustainable alternatives, eco-friendly lighting solutions are in high demand.
- **Advances in bioluminescent and glow materials:** Scientists are developing materials that can glow in the dark or emit light without power. These materials could be used to create electricity-free lighting for indoor or outdoor use.
- **Potential to improve lives in remote areas:** Creating a reliable light source for off-grid areas could benefit millions, providing light for studying, working, or moving safely at night without needing electricity.

Challenges

- **Brightness and duration:** Light sources that don't rely on electricity often have limited brightness and may not last as long as electric lights. Making sure they're bright and long-lasting enough to be practical is a challenge.
- **Dependence on natural resources:** Some options, such as solar-powered lights, rely on sunlight, which isn't always available in certain locations or under specific weather conditions.
- **Cost of new materials:** Developing sustainable light sources with unique materials, such as bioluminescent substances, can be expensive. Making them affordable for widespread use, especially in low-income areas, is essential.
- **Durability and maintenance:** Light sources used outdoors or in remote areas need to be sturdy and low-maintenance. Some sustainable light materials might not be as durable as traditional lighting, which could limit their use in harsh environments.
- **Potential environmental impact:** Although eco-friendly, some alternative lighting materials may have unforeseen effects on local ecosystems if not used with care. Testing for safety and sustainability over the long term is key.

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Safe and silent wind energy generation for urban areas

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** How can we design wind energy systems that are safe, quiet, and efficient for use in cities? **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** Describe the context. e.g. Which are the groups that might be or are affected by the challenge? Which is the location or the setting in which your design will be implemented? The design must produce wind energy systems that generate power from the wind in metropolitan locations while making no noise pollution or safety issues. These systems need to be effective, mix in with the urban environment, and function well in urban settings where wind patterns might change suddenly. The objective is to make wind energy a practical choice for metropolitan areas, offering a sustainable and clean energy source without interfering with day-to-day activities. **Target audience** ● **City planners and local governments:** They need energy solutions that work in urban settings, helping cities meet sustainability goals while minimising environmental impact. ● **Urban residents:** individuals living in cities who seek access to cleaner, renewable energy sources without the drawbacks of traditional energy production. ● **Environmental groups and activists:** focused on reducing carbon emissions and pollution would support the use of clean energy alternatives, such as wind power. ● **Businesses and industries:** Companies looking to reduce their energy costs and carbon footprint might adopt urban wind energy systems to power their operations. **Location and context** The design will be used in urban settings with limited space and variable wind conditions. It will be necessary to modify urban wind energy systems to fit on rooftops, in parks, or alongside streets without endangering the safety of people or wildlife.

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Identify the opportunities and the constraints. For example, are there connections to other solutions or challenges? Are there favourable circumstances, initiatives or legislations that might impact Are there specific limitations or risks that need to be considered?

Opportunities

- **Growing interest in clean energy:** As cities strive to reduce their carbon footprints and decrease reliance on fossil fuels, there is growing support and funding for clean energy solutions, including wind power.
- **Technological innovations:** advances in wind turbine design, such as smaller, quieter, and more efficient turbines, make it possible to harness wind energy even in urban areas with limited space.
- **Space-saving solutions:** In dense cities, there may be opportunities to use underutilised spaces, like rooftops, to install wind turbines, which helps avoid conflicts with other land uses.
- **Environmental benefits:** Wind energy is a clean, renewable source with minimal environmental impact. It doesn't pollute the air or contribute to climate change, which is particularly important for cities already facing air pollution and high energy demands.
- **Complementing other renewable energy sources:** Urban wind energy can be combined with other renewable sources like solar power to create a balanced, sustainable energy solution for cities.

Challenges

- **Noise and vibration:** Traditional wind turbines can be noisy, which could be a problem in densely populated urban areas. Ensuring the turbines are quiet enough not to disturb residents is essential.
- **Unpredictable wind patterns:** In urban areas, wind speed and direction can vary significantly due to buildings, traffic, and other factors. Designing turbines that work effectively in these conditions is challenging.
- **Space limitations:** Urban spaces are already crowded, and finding areas for installing wind turbines can be difficult. Rooftops, public spaces, or smaller installations may be options, but space for large turbines is limited.
- **Safety concerns:** Wind turbines need to be designed so that they are safe for both people and animals. High winds, storms, or accidents could pose risks, so the design must ensure safety in all conditions.

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	- **Cost and installation:** Urban wind turbines can be expensive to install and maintain, and the costs might be a barrier to widespread adoption, especially for smaller communities or businesses. **Now it's your turn!**

Wildfire prevention and early detection

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** How can we develop a system that prevents wildfires or detects them early enough to stop them from spreading? **1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.** Describe the context. e.g. Which are the groups that might be or are affected by the challenge? Which is the location or the setting in which your design will be implemented? The design must prevent wildfires from starting or identify them in their early stages, allowing them to be contained quickly. This entails developing systems that can monitor the environment, detect fire threats, and notify people before a fire gets out of control. Reducing wildfires, minimising damage, and safeguarding people, property, and ecosystems are the objectives. **Target audience** ● **Firefighters and emergency responders:** Early warnings enable these professionals to react more quickly, thereby increasing their chances of controlling the fire. ● **Government agencies and forest managers:** They are responsible for monitoring and protecting public lands and forests, so reliable detection systems could improve their ability to prevent or respond to fires. ● **Communities in fire-prone areas:** Individuals residing near forests or in high-risk areas could greatly benefit from faster, more effective fire prevention and early warning systems. ● **Environmental and conservation groups:** These groups work to protect wildlife and habitats and would support efforts to prevent wildfires that threaten ecosystems. **Location and context** Forests, grasslands, and locations close to towns or cities where there is a significant risk of wildfire are among the fire-prone environments where the idea might be used. Efficient wildfire prevention and early detection technologies would protect residential areas, natural landscapes, and the air quality of impacted areas.

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Identify the opportunities and the constraints. For example, are there connections to other solutions or challenges? Are there favourable circumstances, initiatives or legislations that might impact? Are there specific limitations or risks that need to be considered?

Opportunities

- **Advances in technology:** Innovations in sensors, drones, satellite imaging, and artificial intelligence can help detect fires early or prevent them by monitoring conditions such as humidity, temperature, and wind patterns.
- **Growing awareness and support for climate resilience:** With increasing wildfires due to climate change, there is public and governmental support for solutions that help communities become more resilient and better prepared.
- **Collaboration across organisations:** Many organisations, from fire departments to conservation groups, are working to address wildfire risks. Combining resources and expertise could lead to more effective solutions.
- **Potential for real-time data and communication:** Systems that provide real-time data can alert communities and emergency responders, allowing them to act quickly before a fire spreads.
- **Focus on protecting ecosystems and biodiversity:** Preventing wildfires benefits wildlife and preserves ecosystems, which is especially important in regions with rare or endangered species.

Challenges

- **Cost and accessibility:** High-tech systems, such as satellite monitoring or advanced sensors, can be expensive to install and maintain, which may limit their use in remote or underfunded areas.
- **False alarms or detection errors:** Some systems may mistake other events (such as controlled burns or BBQ smoke) for wildfires, leading to unnecessary responses and potential mistrust in the system.
- **Challenging terrain and large coverage areas:** Wildfire-prone regions often cover vast, rugged terrain, which can make monitoring difficult and expensive.
- **Extreme weather conditions:** High winds, storms, or other extreme weather conditions can interfere with monitoring systems, either making them less reliable or causing them to fail.
- **Privacy and environmental concerns:** Some surveillance methods, like drones or cameras, could raise privacy issues,

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and using certain chemicals or devices to prevent fires might impact local wildlife or ecosystems.

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Urban flood management systems

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** How can we design systems to manage and reduce flooding in cities, keeping people safe and protecting homes and buildings? **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** **Describe the context. e.g. Which are the groups that might be or are affected by the challenge? Which is the location or the setting in which your design will be implemented.** The design should assist cities in controlling or reducing floods during large rainstorms by identifying safe ways to manage excess water. These might include devices that absorb water, reduce its flow, or divert it from potentially troublesome regions. The objective is to prevent flood damage to houses, businesses, streets, and neighbourhoods. **Target audience** ● **City planners and local officials:** They need flood management systems to protect neighbourhoods, roads, and public spaces. ● **Urban residents and business owners:** Especially in flood-prone areas, would benefit from safer streets and properties. ● **Emergency responders:** Good flood control helps keep neighbourhoods safer, reducing the need for emergency rescues and making responders' jobs safer. ● **Environmental groups and community activists:** Can help protect green spaces, reduce pollution, and make neighbourhoods cleaner and healthier. **Location and context** Flood management systems are needed in urban areas that face flooding risks, especially where there isn't enough drainage or natural land to absorb heavy rain. These systems can help cities stay safe and strong, even when facing more intense weather **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.**

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Identify the opportunities and the constraints. e.g. Are there connections to other solutions or challenges? Are there favourable circumstances, initiatives, or legislations that might impact the situation? Are there specific limitations or risks that need to be considered?

Opportunities

- **Green infrastructure**: like rain gardens, green roofs, and sidewalks that let water soak through can help absorb rainwater and reduce flooding naturally.
- **Growing support for climate resilience**: as more people realise how important it is to prepare for extreme weather, there is growing support for projects that protect cities from floods.
- **Smart technology and real-time monitoring**: sensors and other smart devices can track water levels and weather, giving cities an early warning to start flood prevention measures.
- **Combination with urban improvement projects**: Flood management systems can be combined with other city improvements, like adding parks or green spaces, which also make neighbourhoods nicer to live in.
- **Community support and awareness**: many city residents know about the risks of flooding and want to see their cities prepared, especially if the changes also make the area look better and feel safer.

Challenges

- **High costs**: building new flood control systems can be expensive. Finding the funds to build and maintain them can be challenging for some cities.
- **Limited space**: in crowded urban areas, finding space for things like water channels or retention ponds can be tough without disrupting other buildings or public spaces.
- **Unpredictable weather patterns**: as climate change makes weather more unpredictable, flood management systems need to be flexible enough to handle unusual or extreme conditions.
- **Regular maintenance**: some flood control systems, like pumps or drainage areas, require regular maintenance to work well, which can be costly and time-consuming.
- **Environmental and community impact**: some solutions, like large barriers, may block views, affect wildlife, or change the way neighbourhoods look and feel. It's important to balance flood control with community needs.

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Enhanced medical diagnostic tools

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** How can we develop more effective diagnostic tools to help doctors detect diseases earlier and more accurately? **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** Describe the context. e.g. Which are the groups that might be or are affected by the challenge? Which is the location or the setting in which your design will be implemented? To help physicians identify illnesses, the design must make medical instruments more precise, quick, and user-friendly. Better methods of testing for diseases, systems that display results fast, or instruments that can identify diseases even in their early stages could all fall under this category. The intention is to improve health outcomes by providing physicians and healthcare teams with the information they need to treat patients more quickly and efficiently. **Target audience** ● **Doctors and healthcare providers**: Better diagnostic tools enable them to detect health problems earlier, providing patients with better chances for successful treatments. ● **Patients**: Individuals with health issues benefit directly from faster, more accurate diagnoses, which can lead to quicker treatments and improved recovery. ● **Medical researchers and scientists**: Enhanced diagnostic tools can help researchers study diseases, develop new treatments, and prevent future health crises. ● **Hospitals and clinics**: Improved diagnostics can make the healthcare system work more efficiently, reducing waiting times and improving patient care. **Location and context** The design would be used in hospitals, clinics, and other healthcare settings where quick and accurate disease detection is critical. Effective diagnostic tools can help prevent the spread of disease, reduce costs for patients, and save lives by catching diseases early. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.**

Identify the opportunities and the constraints. e.g. Are there connections to other solutions or challenges? Are there favourable circumstances, initiatives or legislations that might impact Are there specific limitations or risks that need to be considered?

Opportunities

- **Advancements in technology:** New technologies like AI, machine learning, and advanced imaging can help create tools that recognize disease patterns, analyse large amounts of data, and make accurate predictions.
- **Growing focus on preventative healthcare:** As more people focus on catching health issues before they get serious, there is strong support for tools that help with early detection.
- **Personalised medicine:** Diagnostic tools that can analyse a person's specific health data allow for more personalised and effective treatments, which can improve outcomes for patients.
- **Global health improvement:** Better diagnostics could be shared globally, allowing low-resource areas to access affordable, portable, or easy-to-use diagnostic tools.
- **Collaboration with technology and health fields:** Diagnostic tools can benefit from collaboration between medical experts, tech companies, and researchers, leading to faster innovation and practical solutions.

Challenges

- **High development costs:** Advanced medical diagnostic tools can be very expensive to research and develop, making it challenging to get them widely adopted.
- **Data privacy concerns:** With more digital diagnostics, data security becomes essential to protect patient information, which requires strict privacy measures.
- **Complexity of diseases:** Many diseases are hard to diagnose accurately, especially if symptoms vary widely or overlap with other conditions. Diagnostic tools need to be highly reliable to avoid misdiagnoses.
- **Accessibility and affordability:** New diagnostic tools need to be affordable and accessible to all types of healthcare facilities, from large hospitals to small clinics.
- **Regulatory approval:** Medical diagnostic tools must pass strict testing and get regulatory approval, which can be a long and costly process before they're available for use.

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Microplastic pollution in oceans prevention

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe the specific challenge.** ● Microplastics are a major environmental issue, accumulating in oceans and harming marine life. These tiny particles are difficult to filter out and often originate from larger plastics breaking down or synthetic fibres released during washing. **Challenge question** ● How can we develop a system to capture microplastics before they enter waterways? **Explanatory questions** ● How does nature filter small particles from liquids? ● Which organisms have efficient filtration mechanisms? **Primary goals** ● Prevent microplastics from entering aquatic ecosystems. ● Create a scalable, low-maintenance solution. **1.b Describe what the design needs to do, the Target audience, and the context.** **What the design needs to do** ● Capture microplastics from wastewater systems or other sources before they reach natural water bodies. **Target audience** ● Industries using synthetic materials, water treatment facilities, and policymakers focused on ocean conservation. **Context** ● The solution would primarily be implemented in industrial wastewater treatment plants, residential washing machines, and urban drainage systems. Coastal areas with significant plastic waste leakage are a key focus. **1.c Identify the opportunities and/or constraints.** **Opportunities** ● Growing awareness and legislative push for reducing microplastic pollution. ● Innovations in filtration and biomimicry offer promising new approaches.

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- Potential for public-private partnerships to implement the solution.

Constraints

- Technical challenges in filtering particles without disrupting water flow.
- High costs for retrofitting existing systems.
- Resistance from industries due to increased operational costs.

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Urban flooding management

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe the specific challenge.** Urban flooding is becoming an increasingly common problem due to rapid urbanization, poor drainage systems, and climate change. During heavy rain, the existing infrastructure often cannot handle the volume of water, resulting in road and property damage, traffic disruptions, and contamination of water sources. **Challenge question** ● How can we reduce urban flooding and improve the city's resilience to extreme rainfall? **Explanatory questions** ● How do natural ecosystems manage excess water from heavy rains? ● What organisms or natural systems regulate water efficiently in flooding conditions? ● Can natural water-retention strategies be integrated into urban design? **Primary goals** ● Reduce the risk of urban flooding during extreme weather events. ● Enhance water infiltration and retention in urban areas. ● Provide a scalable, cost-effective solution that integrates into existing urban infrastructure. **1.b Describe what the design needs to do, the Target audience, and the context.** **What the design needs to do** ● The design should mimic natural water retention and drainage systems that absorb excess rainwater efficiently. ● The solution should reduce the need for expensive and extensive infrastructure upgrades, such as large-scale stormwater tunnels or reservoirs. **Target audience** ● City planners, civil engineers, architects, and urban developers. ● Environmental agencies, local governments, and flood prevention organisations. **Context**

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- The solution would be implemented in urban areas with inadequate or overwhelmed drainage systems, particularly those prone to heavy rainfall or located near rivers or coasts.
- The design should consider areas already experiencing frequent flooding, such as metropolitan regions or cities with large amounts of impervious surfaces (concrete, asphalt, etc.).

1.c Identify the opportunities and/or constraints.

Opportunities

- Increasing awareness and demand for sustainable urban planning solutions.
- Innovations in biomimicry could offer low-cost, low-maintenance solutions.
- Urban areas are actively seeking ways to incorporate green infrastructure to meet environmental sustainability goals.
- Potential for partnerships with municipal governments and NGOs to address flooding in vulnerable communities.

Constraints

- Existing infrastructure and the high costs of retrofitting cities with nature-inspired solutions.
- Resistance from developers or municipalities prioritizing conventional flood management systems.
- Technical challenges in designing solutions that effectively handle large volumes of water without disrupting urban life or infrastructure.

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Reducing noise pollution in urban areas

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe the specific challenge** Noise pollution in urban areas is a growing problem, negatively impacting human health, wildlife, and the overall quality of life. High levels of traffic, construction, and industrial activity contribute to constant noise exposure, leading to issues such as stress, hearing loss, and sleep disturbances. **Challenge question** ● How can we reduce urban noise pollution in a natural and sustainable way? **Explanatory questions** ● Which natural systems or organisms reduce noise or absorb sound effectively? ● How do plants, animals, or natural environments mitigate sound in their surroundings? ● Can nature-inspired solutions be integrated into urban environments to reduce noise without relying on mechanical or chemical solutions? **Primary goals** ● Reduce the impact of noise pollution in urban areas, particularly in residential zones, schools, and healthcare facilities. ● Provide a cost-effective, scalable solution that integrates with city infrastructure. ● Ensure the solution supports overall environmental and public health goals. 1.b **Describe what the design needs to do, the Target audience, and the context.** **What the design needs to do** ● The design should mimic natural sound-dampening systems that absorb or block unwanted noise. ● The solution should provide a passive, low-maintenance way to reduce sound pollution in various urban settings, such as streets, parks, and buildings. **Target audience** ● Urban planners, architects, environmental consultants, and noise pollution experts.

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- City governments, residential communities, and businesses aiming to improve living conditions.

Context

- The solution would be applicable in busy, high-traffic urban areas where noise pollution from vehicles, industry, and human activity is prevalent.
- The design can be implemented on various scales, from small residential areas to entire city districts.

1.c Identify the opportunities and/or constraints.

Opportunities

- Rising concern over the impact of noise pollution on public health and well-being.
- Strong demand for sustainable urban design solutions that promote environmental quality.
- Potential for integrating noise-reducing solutions into green infrastructure projects such as parks, gardens, and green walls.
- Government and municipal interest in improving urban living conditions through innovative and cost-effective solutions.

Constraints

- Potential space limitations in dense urban environments for the implementation of noise-reduction features.
- Financial constraints for cities, especially in developing regions, when considering new design strategies.
- The challenge of ensuring that the solution does not interfere with other urban functions, such as air circulation, safety, or aesthetics.

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<table>
<tr><th>BIOMIMICRY DESIGN</th><th>Description</th></tr>
<tr><td>Step 1 – Define the challenge</td><td>
1.a Describe the specific challenge.
Water scarcity is a major challenge in agriculture, particularly in regions prone to droughts or with limited freshwater resources. Current irrigation methods often lead to water wastage due to evaporation, runoff, and inefficient distribution.
Challenge question
How can we develop a water-efficient irrigation system that minimises water loss while ensuring optimal crop growth?
Explanatory questions
How do plants and ecosystems manage water efficiently?
Are there natural systems or organisms that conserve water in arid conditions?
Can the way nature distributes or stores water be applied to modern agricultural systems?
Primary goals
Design an irrigation system that minimises water wastage and enhances efficiency.
Develop a scalable solution that can be implemented in different agricultural settings, particularly in regions with water scarcity.
Minimise the environmental impact and cost of water usage in farming.
1.b Describe what the design needs to do, the Target audience, and the context.
What the design needs to do
The design should mimic natural water distribution and conservation strategies.
The solution should improve water retention in soil and ensure even water distribution to crops, reducing reliance on extensive irrigation systems.
Target audience
Farmers, agricultural companies, water management experts, and policy makers in regions facing water scarcity.
Context
The solution would be applicable to both large-scale industrial agriculture and smallholder farming systems in
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drought-prone areas or regions facing climate change challenges.

- It would ideally work in tandem with existing irrigation infrastructure to optimize water usage.

1.c Identify the opportunities and/or constraints.

Opportunities

- Growing concern over water scarcity and its impact on agriculture and food security.
- Innovations in technology and biomimicry present new solutions for water conservation.
- Government and environmental organisations may support sustainable agricultural practices, including water-efficient technologies.
- Potential for cost savings for farmers through reduced water usage and lower irrigation infrastructure costs.

Constraints

- Initial costs of implementing new water management systems could be high, especially for smallholder farmers.
- Limited access to technology and resources in rural or underdeveloped areas.
- Potential resistance to change from traditional farming communities or industries with established irrigation practices.

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BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe the specific challenge.** Many industries, such as manufacturing, chemical production, and mining, consume large amounts of energy, contributing to high operational costs and environmental impact. Current energy systems often rely on fossil fuels or inefficient methods that waste energy. **Challenge question** How can we reduce energy consumption in industrial operations through more efficient processes? **Explanatory questions** ● How do natural systems optimise energy use and minimise waste? ● Which organisms or ecosystems have evolved to use energy efficiently? ● Can natural energy cycles, such as those found in photosynthesis or animal metabolism, be applied to industrial systems? **Primary goals** ● Reduce energy consumption in industrial operations. ● Improve energy efficiency by mimicking natural systems. ● Lower carbon footprints and operational costs through sustainable energy solutions. **1.b Describe what the design needs to do, the Target audience, and the context.** **What the design needs to do** ● The design should mimic the energy-efficient mechanisms found in nature, such as heat regulation in animals, energy conservation in plants, or optimal movement in animals. ● The solution should minimise energy waste, reduce carbon emissions, and be adaptable to different types of industrial processes. **Target audience** ● Industrial companies in energy-intensive sectors such as manufacturing, mining, and chemical processing. ● Engineers, energy consultants, and sustainability officers in industries focused on reducing energy costs and environmental impact. **Context**

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- The solution would be implemented in industries that rely heavily on energy for heating, cooling, processing, or transport. It could apply to both existing plants and new construction or manufacturing processes.
- Ideally, the solution should enable industries to meet their sustainability goals and comply with environmental regulations regarding energy usage and emissions.

1.c Identify the opportunities and/or constraints.

Opportunities

- Increasing pressure from governments and consumers to adopt sustainable practices.
- Technological advancements in biomimicry and renewable energy offer potential solutions.
- Potential for long-term cost savings due to lower energy consumption.
- Access to government incentives for energy efficiency improvements or green certifications.

Constraints

- High initial investment for integrating new energy-efficient technologies into existing systems.
- Potential resistance from industries with established energy use patterns or reluctance to change.
- Challenges in scaling the solution for large or highly complex industrial operations.

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Wastewater treatment and resource recovery

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe the specific challenge.** Many wastewater treatment plants are energy-intensive and generate substantial quantities of sludge, which often necessitates costly disposal. Current systems also struggle to recover valuable resources, such as nutrients or water, from the wastewater. **Challenge question** How can we develop a more efficient wastewater treatment process that reduces energy consumption and recovers resources? **Explanatory questions** ● How do natural systems filter and purify water efficiently? ● Which organisms are capable of extracting nutrients or toxins from water? ● Can natural processes such as phytoremediation or biofiltration be applied to improve wastewater treatment? **Primary goals** ● Reduce the energy footprint of wastewater treatment processes. ● Enable the recovery of valuable resources (water, nutrients, energy) from wastewater. ● Improve the sustainability of wastewater treatment by mimicking nature's recycling and purification processes. **1.b Describe what the design needs to do, the Target audience, and the context.** **What the design needs to do** ● The solution should aim to filter and purify water with minimal energy input, using natural systems or materials. ● It should include mechanisms for resource recovery, such as extracting nutrients for fertilizer or harnessing energy from organic matter. ● The solution should be scalable, adaptable, and cost-effective for both large-scale urban treatment plants and smaller rural systems. **Target audience** ● Municipal wastewater treatment plants, environmental engineers, water management authorities, and organisations focused on sustainable resource recovery. **Context**

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- The solution would primarily be applied to municipal and industrial wastewater treatment plants. It could also be extended to agricultural wastewater management systems, where water quality and resource recovery are critical concerns.
- Urban and rural areas with growing water scarcity and environmental concerns are key focus regions.

1.c Identify the opportunities and/or constraints.

Opportunities

- Increasing global demand for sustainable and circular economy solutions.
- Advances in biotechnology and biomimicry offer innovative solutions for water purification and resource recovery.
- Potential to reduce operational costs and environmental impact of wastewater treatment plants.
- Governments may support wastewater management improvements with funding or regulatory incentives.

Constraints

- High initial costs to retrofit existing wastewater treatment infrastructure.
- Technical challenges in scaling nature-inspired solutions for large, complex systems.
- Resistance to change in established practices and technologies.

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Sustainable cooling inspired by nature

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe the specific challenge.** The increasing demand for air conditioning in urban areas leads to high energy consumption and contributes to global warming. Current cooling technologies often rely on refrigerants that are harmful to the environment and require significant electricity. **Challenge question** How can we design an eco-friendly cooling system inspired by natural mechanisms for heat dissipation? **Explanatory questions** ● How do plants and animals regulate their temperature in hot climates? ● What natural processes dissipate heat efficiently without requiring external energy? **Primary goals** ● Develop a sustainable cooling solution that minimises energy consumption. ● Eliminate the use of harmful refrigerants. **1.b Describe what the design needs to do, the Target audience, and the context.** **What the design needs to do** Replicate natural cooling methods to regulate indoor temperatures in residential, commercial, and industrial buildings. **Target audience** Building designers, architects, and HVAC system manufacturers are interested in sustainable and energy-efficient technologies. **Context** The solution should be applicable in urban and rural areas with high temperatures, particularly in regions prone to heat waves. It should also align with modern building standards. **1.c Identify the opportunities and/or constraints.** **Opportunities** ● Growing demand for energy-efficient cooling solutions. ● Advances in biomimicry and material science.

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	● Increased adoption of green building certifications. **Constraints** ● Adapting natural cooling methods to various building sizes and climates. ● Balancing cost-effectiveness with advanced biomimetic technologies. ● Scalability and ease of integration into existing infrastructure. **Now it's your turn!**

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Preventing soil erosion in agriculture

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<tr><td>Step 1 – Define the challenge</td><td>
1.a Describe the specific challenge:

Soil erosion is a critical issue in agriculture, leading to the loss of fertile topsoil, reduced crop yields, and sedimentation in nearby water bodies. Current solutions often involve chemical stabilizers or costly mechanical interventions, which can harm the environment.

Challenge question

How can we develop sustainable methods to prevent soil erosion in agricultural fields?

Explanatory questions

How do natural ecosystems prevent soil from eroding in the face of wind and water?
Which organisms or systems, such as plant roots or microbial networks, stabilize soil effectively?
Can we design an erosion control solution inspired by these natural mechanisms?
Primary goals.
Stabilize soil to maintain its fertility and prevent loss due to wind or water erosion.
Develop a cost-effective and eco-friendly solution suitable for farmers worldwide.
Minimise environmental impact while maintaining long-term soil health.

1.b Describe what the design needs to do, the Target audience, and the context.

What the design needs to do

Prevent the topsoil from being displaced by wind and water.
Enhance soil structure and increase its ability to retain water and nutrients.
Be scalable, cost-effective, and easy for farmers to implement.

Target audience

Farmers, agricultural policymakers, and organisations working on sustainable farming practices.

Context

The solution would primarily target regions prone to soil erosion due to heavy rains, droughts, or over-cultivation.
Applicable to diverse agricultural settings, from smallholder farms in developing countries to large-scale agricultural operations in industrialized nations.

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1.c Identify the opportunities and/or constraints.

Opportunities

- Increased global focus on sustainable agricultural practices to ensure food security.
- Growing interest in regenerative farming techniques, such as permaculture and agroecology.
- Potential to use biomimicry to create multi-functional systems that stabilize soil and improve fertility.

Constraints

- Limited financial resources and technical knowledge among farmers in some regions.
- Resistance to change from traditional farming methods.
- Variability in soil types and climatic conditions, requiring adaptable solutions.

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<table>
<tr><th>BIOMIMICRY DESIGN</th><th>Description</th></tr>
<tr><td>Step 1 – Define the challenge</td><td>
1.a Describe the specific challenge:

Urban areas face significant challenges with noise pollution caused by traffic, construction, and densely packed living spaces. Prolonged exposure to noise pollution can harm public health, causing stress, sleep disturbances, and cardiovascular problems. Current noise reduction systems, such as walls and barriers, are often bulky, visually unappealing, and only partially effective.

Challenge question

How can we create efficient, visually appealing, and sustainable systems to reduce urban noise pollution?

Explanatory questions

How do organisms or ecosystems naturally dampen sound or manage vibrations?
Can sound-absorbing mechanisms in nature, like animal fur or dense vegetation, inspire noise-reduction technologies?
How might we create urban infrastructure that incorporates these principles?

Primary goals

Reduce the impact of noise pollution on human health and well-being.
Design sustainable and aesthetically pleasing noise-dampening systems for urban areas.
Develop a solution that integrates seamlessly into existing urban infrastructure.

1.b Describe what the design needs to do, the Target audience, and the context.

What the design needs to do

Absorb or diffuse sound effectively, reducing noise levels in urban environments.
Be sustainable, cost-effective, and easy to implement in diverse urban contexts.

Target audience

Urban planners, architects, local governments, and construction companies.

Context
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- The solution would primarily be implemented in noise-heavy zones, such as near highways, industrial areas, and densely populated neighborhoods.
- Applicable globally, with adaptations based on climate and urban design preferences.

1.c Identify the opportunities and/or constraints.

Opportunities

- Increasing demand for livable cities with reduced environmental and noise pollution.
- Innovations in biomimicry, offering new approaches to sound absorption.
- Urban renewal projects can integrate biomimetic noise reduction solutions.

Constraints

- Limited space in urban areas for bulky noise barriers.
- Resistance from developers to adopt new designs due to perceived costs.
- Need for the solution to perform well in diverse environmental conditions, such as heavy rains or extreme heat.

Now it's your turn!

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BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe the specific challenge.** Access to freshwater is a critical issue in many regions due to climate change, population growth, and overuse of water resources. Desalination, the process of removing salt from seawater, is one solution but is highly energy-intensive, expensive, and environmentally harmful due to the discharge of concentrated brine. **Challenge question** How can we improve desalination methods to be more energy-efficient, sustainable, and eco-friendly? **Explanatory questions** ● How do natural systems, such as mangrove roots or salt-tolerant plants, filter and manage salt? ● What mechanisms do marine organisms use to regulate salt concentration in their bodies? ● Can these processes be adapted for large-scale desalination? **Primary goals** ● Develop an energy-efficient desalination process. ● Minimise environmental impact, particularly brine discharge. ● Provide an affordable and scalable solution for water-scarce regions. **1.b Describe what the design needs to do, the Target audience, and the context.** **What the design needs to do** ● Remove salt from seawater effectively while using less energy. ● Ensure the process is environmentally sustainable, with no harmful brine discharges. **Target audience** ● Governments, water resource managers, and industries in arid and coastal regions. **Context** ● The solution would target water-scarce regions globally, particularly in areas where current desalination processes are cost-prohibitive or environmentally damaging. ● Applicable for both industrial-scale and small-scale desalination projects. **1.c Identify the opportunities and/or constraints.**

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	Opportunities ● Increasing global demand for freshwater due to urbanization and population growth. ● Availability of advanced biomimetic technologies and materials. ● Potential for partnerships with NGOs, governments, and private sectors to fund and implement solutions. **Constraints** ● High initial costs for research and development of biomimetic desalination technologies. ● Resistance to adopting new technologies due to existing infrastructure investments. ● Ensuring that the system works in diverse saline conditions across the globe. **Now it's your turn!**

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Greece

Efficient heat dissipation in electronics inspired by nature

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<tr><td>Step 1 – Define the challenge</td><td>
1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.
How can we design an efficient heat dissipation system for electronics that mimics natural processes to ensure optimal performance, reduce energy consumption, and enhance longevity?
Explanatory questions

How do organisms in nature manage heat efficiently in extreme conditions?
What natural structures or mechanisms could inspire innovative cooling designs?
How can the solution be integrated into existing electronic devices or manufacturing processes?

Primary goals

Create a bio-inspired solution for heat management in electronics.
Enhance energy efficiency and reduce the risk of overheating in electronic devices.
Develop a design that is sustainable, scalable, and compatible with diverse electronic applications.

1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.
Electronics generate significant heat during operation, which, if unmanaged, can lead to reduced performance, shorter lifespans, or complete failure. Current cooling solutions, like fans and heat sinks, often consume extra energy or are bulky, limiting design innovation.
What the design needs to to

Efficiently dissipate heat without adding significant weight, cost, or energy consumption.
Be adaptable for use in a wide range of devices, from smartphones to industrial machinery.
Be sustainable and environmentally friendly, reducing reliance on traditional cooling methods.

Target audience
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- **Electronics manufacturers:** Companies seeking innovative, efficient cooling systems for consumer electronics, industrial devices, and renewable energy systems.
- **Consumers:** Individuals seeking devices that are more reliable, durable, and environmentally friendly.
- **Sustainability advocates and researchers:** Groups focused on minimising the environmental impact of electronics production and use.

Location and context

This solution can be implemented globally in the electronics industry, addressing challenges in both high-tech sectors and emerging markets. Effective heat dissipation improves device efficiency, prolongs usability, and supports environmental sustainability.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Opportunities

- **Biological inspiration:** Nature offers numerous heat management strategies, such as the vascular systems of leaves or the thermoregulation in animals like camels and penguins.
- **Demand for compact and efficient solutions:** Modern electronics require miniaturized designs that maximise efficiency. Nature-inspired methods could provide innovative, space-saving designs.
- **Advances in materials science:** The Development of new materials, like bio-inspired polymers and thermal conductors, makes it feasible to mimic nature's strategies.
- **Energy efficiency prioritisation:** With increasing focus on energy conservation, bio-inspired cooling solutions align with market trends and regulatory requirements.

Challenges

- **Complexity of natural mechanisms:** Translating intricate biological systems into practical designs can be technically challenging and time-intensive.
- **Manufacturing constraints:** Incorporating bio-inspired designs into existing production lines may require new technologies or redesigns, increasing costs.
- **Material durability:** Ensuring that bio-inspired materials perform well under prolonged exposure to heat and stress is critical for reliability.
- **Cost and accessibility:** Making these solutions affordable and scalable for mass production is essential to ensure widespread adoption.

Now it's your turn!

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Explore biological systems, collaborate with materials scientists, and design a solution that merges nature's efficiency with modern electronics needs!

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BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** How can we design urban spaces that mimic natural processes to reduce heat buildup, improve thermal comfort, and mitigate the Urban Heat Island (UHI) effect? **Explanatory questions** ● How do natural ecosystems regulate temperature effectively? ● What biological features can inspire designs to cool urban areas naturally? ● How can these solutions integrate into existing urban infrastructure? **Primary goals** ● Develop bio-inspired designs to reduce heat absorption and enhance cooling in cities. ● Increase the use of sustainable and eco-friendly materials and techniques in urban planning. ● Improve the quality of life for city dwellers by creating cooler, more livable environments. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** Urban heat islands occur when cities experience higher temperatures than surrounding rural areas due to the presence of heat-absorbing materials like asphalt and concrete, the lack of vegetation, and waste heat from human activities. These elevated temperatures can lead to health issues, increased energy consumption, and environmental stress. **What the design needs to do** ● Reduce heat absorption in urban areas by using bio-inspired materials, structures, or landscaping methods. ● Enhance natural cooling through shading, wind flow optimization, or water retention. ● Be practical, scalable, and sustainable for urban planners and developers to implement. **Target audience** ● **Urban planners and architects**: Professionals aiming to design cooler, more sustainable cities.

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- **Municipal governments and policymakers**: Authorities seeking strategies to reduce energy costs, improve public health, and combat climate change.
- **City residents and communities**: Individuals directly affected by Urban Heat Island (UHI) effects, seeking comfortable and sustainable urban living spaces.

Location and context

These solutions can be implemented in urban areas worldwide, especially in regions experiencing extreme heat or rapid urbanisation. Urban heat mitigation strategies are crucial for both developed and developing cities to ensure resilience against climate change.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Opportunities

- **Natural cooling mechanisms:** Many ecosystems, such as forests and wetlands, regulate temperature through shading, evaporation, and reflectivity. These can inspire urban solutions.
- **Growing awareness of climate issues:** Public and governmental focus on mitigating climate change creates demand for innovative cooling strategies.
- **Innovative materials and technologies:** Advances in reflective coatings, porous surfaces, and biophilic design allow for nature-inspired cooling solutions.
- **Integration with green policies:** Initiatives like urban greening and sustainable city planning align with bio-inspired heat mitigation strategies.

Challenges

- **Space limitations:** Implementing large-scale natural solutions, such as urban forests, in densely populated cities may be difficult.
- **Costs and resources:** Developing and maintaining bio-inspired solutions may initially require high investment and specialized knowledge.
- **Community engagement:** Gaining public support for large-scale changes to urban infrastructure is essential but may face resistance.
- **Scalability and longevity:** Ensuring these solutions remain effective as cities grow and climate conditions evolve is a key concern.

Now it's your turn!

Draw inspiration from forests, wetlands, and desert ecosystems to create urban environments that remain cool and comfortable while promoting sustainability.

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Anti-reflective surfaces for enhanced solar panel efficiency

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1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.
How can we design solar panels with anti-reflective surfaces inspired by nature to increase energy absorption and improve overall efficiency?
Explanatory questions

How do natural surfaces, such as insect eyes or lotus leaves, minimise reflection and maximise light absorption?
What structural or material innovations can replicate these biological features?
How can anti-reflective surfaces be cost-effectively integrated into existing solar technologies?

Primary goals

Develop bio-inspired, anti-reflective surfaces that enhance solar panel energy efficiency.
Reduce energy loss caused by reflection in diverse environmental conditions.
Ensure the solution is scalable, durable, and sustainable for widespread adoption.

1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.
Solar panels convert sunlight into electricity but lose efficiency due to reflection, especially during low-angle sunlight conditions or in cloudy weather. Creating anti-reflective surfaces can optimize light absorption, thereby increasing energy output and making solar power more cost-effective and sustainable.
What the design needs to do

Reduce the amount of light reflected off solar panel surfaces.
Be durable and functional in various weather conditions (e.g., rain, snow, and intense sunlight).
Be compatible with existing solar panel manufacturing processes.

Target audience

Solar energy companies and manufacturers: Seeking innovations to improve panel performance and competitiveness.

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</table>

- **Environmental organisations and policymakers:** Interested in accelerating the transition to renewable energy by improving efficiency.
- **Homeowners and businesses:** Benefiting from more efficient solar panels for energy cost savings.

Location and context

This solution applies globally, as solar panels are deployed in diverse climates and regions. Enhancing panel efficiency is particularly relevant in areas with high solar potential but limited space for installations.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Opportunities

- **Nature's anti-reflective strategies:** Surfaces like moth eyes and butterfly wings are excellent at minimizing reflection. These can be replicated to improve solar panel design.
- **Increasing demand for solar power:** Growing adoption of solar energy creates a market for innovations that enhance performance.
- **Material and manufacturing advances:** Nanotechnology and advanced coatings offer potential to create durable, scalable anti-reflective surfaces.
- **Supportive policies and incentives:** Governments worldwide are incentivizing solar energy, encouraging the adoption of more efficient technologies.

Challenges

- **Durability in harsh conditions:** Anti-reflective coatings or structures must withstand exposure to UV radiation, temperature fluctuations, and abrasive conditions over time.
- **Cost implications:** Implementing nature-inspired surface designs might increase production costs, which could hinder adoption.
- **Complex manufacturing:** Precision in creating microscopic or nanoscopic patterns is essential and may require specialized equipment.
- **Long-term maintenance:** Solutions must resist dirt and weathering to ensure sustained performance.

Now it's your turn!

Look to nature's ingenious designs, like moth eyes and lotus leaves, to craft anti-reflective solar panel surfaces that boost efficiency and drive the renewable energy revolution!

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Bio-inspired traffic flow optimization in smart cities

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<tr><td>Step 1 – Define the challenge</td><td>

1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.

How can we optimize traffic flow in smart cities by drawing inspiration from nature's efficient movement systems, such as ant colonies or bird flocks?

Explanatory questions

- How do natural systems like ant trails or fish schools manage to avoid congestion and maintain efficient movement?
- What algorithms or design principles can mimic these biological systems to improve urban traffic?
- How can bio-inspired solutions integrate with smart city technologies such as IoT and AI?

Primary goals

- Develop a traffic management system inspired by nature to minimise congestion and maximise efficiency.
- Enhance the reliability and sustainability of urban transportation systems.
- Ensure adaptability and scalability for cities of various sizes and traffic conditions.

1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.

Traffic congestion is a major issue in modern cities, leading to wasted time, increased pollution, and economic losses. Natural systems demonstrate remarkable efficiency in managing large-scale movement without collisions or bottlenecks. Mimicking these systems can help create smarter, more responsive traffic networks.

What the design needs to do

- Optimize traffic flow by dynamically adjusting signals, routes, and public transport schedules.
- Reduce travel time and emissions caused by idling vehicles.
- Enhance the safety and accessibility of transportation for all city residents.

Target audience

- **City planners and transportation authorities**: Responsible for implementing smart city initiatives and improving urban mobility.

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- **Technology companies**: Developing IoT, AI, and big data solutions for traffic management.
- **Urban residents and commuters:** Benefiting from reduced congestion and smoother travel experiences.

Location and context

This solution applies to densely populated urban areas facing chronic traffic problems. It aligns with global smart city initiatives aimed at leveraging technology for sustainable urban development.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Opportunities

- **Biological inspiration:** Nature offers numerous models, such as the self-organising behaviour of ants, to optimise traffic without centralised control.
- **Advancements in smart city technology:** IoT sensors, AI algorithms, and big data analysis can be harnessed to implement bio-inspired traffic systems.
- **Growing smart city investments:** Cities worldwide are investing in infrastructure upgrades, providing a platform for innovative traffic solutions.
- **Environmental benefits:** Improved traffic flow reduces fuel consumption and air pollution, contributing to sustainability goals.

Challenges

- **Complex urban dynamics:** Unlike natural environments, cities have diverse and unpredictable traffic patterns influenced by human behavior.
- **Integration with existing systems:** Implementing bio-inspired solutions requires compatibility with current infrastructure and technologies.
- **Scalability and cost:** Developing and deploying these systems on a city-wide scale may be resource-intensive.
- **Data privacy and security:** Utilising real-time traffic data and IoT devices raises concerns about privacy and cybersecurity.

Now it's your turn!

Take inspiration from the harmony and efficiency of natural systems to design smarter, sustainable, and adaptive traffic flow solutions for tomorrow's cities!

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Improved structural stability for bridges using biomimicry

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** How can we design bridges that are more structurally stable, durable, and adaptable to environmental stresses by drawing inspiration from natural structures like bones, trees, or seashells? **Explanatory questions** ● What natural structures exhibit exceptional strength and resilience, and how can their principles be applied to bridge design? ● How can biomimicry improve the efficiency and longevity of bridges under environmental loads like wind, water, and seismic activity? ● What materials and construction techniques can be inspired by nature to reduce maintenance costs and environmental impact? **Primary goals** ● Enhance the stability and durability of bridge structures using biomimetic principles. ● Minimise environmental impact by utilizing efficient and sustainable design practices. ● Ensure safety and adaptability to withstand dynamic environmental conditions. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** Bridges are critical infrastructure that must endure heavy loads, dynamic forces, and environmental challenges like wind, floods, and earthquakes. Inspired by nature's efficient designs, such as the internal structure of bones or the branching patterns of trees, we can create bridges that are both lightweight and highly resilient. **What the design needs to do** ● Provide a stable structure capable of handling both static and dynamic loads. ● Resist environmental stresses such as corrosion, high winds, and seismic forces. ● Offer a sustainable, cost-effective solution with minimal maintenance requirements. **Target audience**

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- **Civil engineers and architects:** Developing and implementing biomimetic bridge designs.
- **Government agencies and urban planners:** Overseeing bridge construction and maintenance projects.
- **Communities:** Benefiting from safer, longer-lasting, and environmentally friendly bridges.

Location and context

The solution is particularly relevant to areas prone to natural disasters or regions requiring new infrastructure that minimises environmental disruption. Bridges built with biomimetic designs could serve both urban and rural communities, adapting to local conditions.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Opportunities

- **Inspiration from nature:** Structures like bird bones, coral reefs, and spider webs provide models for lightweight, resilient designs.
- **Material innovations:** Advances in biomimetic materials, such as self-healing concrete and fibre-reinforced composites, can improve durability.
- **Integration with emerging technologies:** IoT sensors and AI can monitor the performance of biomimetic bridges in real-time.
- **Growing interest in sustainable infrastructure:** Many governments and organisations are prioritizing eco-friendly construction methods.

Challenges

- **High initial costs:** Biomimetic materials and technologies may have higher upfront expenses compared to traditional methods.
- **Technical complexity:** Translating complex natural designs into scalable construction practices requires advanced engineering.
- **Environmental constraints:** Building in sensitive environments may require additional planning and permitting.
- **Resistance to change:** Engineers and stakeholders may be hesitant to adopt unconventional design methods.

Now it's your turn!

Let nature's timeless engineering principles guide the future of bridge design, combining strength, efficiency, and sustainability for the challenges of tomorrow!

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BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** How can we design food storage systems that provide better insulation, reduce energy consumption, and extend food shelf life by mimicking natural insulation mechanisms? **Explanatory questions** ● What natural structures or materials offer superior thermal insulation, and how can they be adapted for food storage systems? ● How can biomimicry reduce the energy demands of refrigeration while maintaining food safety and quality? ● What designs or materials inspired by nature could make storage systems more sustainable and cost-effective? **Primary goals** ● Develop an innovative food storage system that leverages nature-inspired insulation to maintain consistent temperatures. ● Reduce energy consumption and environmental impact while preserving food quality. ● Offer a scalable and cost-effective solution for use in households, transportation, and commercial settings. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** Food storage and refrigeration systems are critical for preventing spoilage and reducing waste. However, they are energy-intensive and often rely on materials or processes with a high environmental impact. Natural insulation mechanisms—like the hollow fur of polar bears or the layered feathers of birds—can inspire designs that improve thermal performance and sustainability. **What the design needs to do** ● Provide effective insulation to minimise temperature fluctuations in food storage systems. ● Reduce energy requirements for refrigeration and cooling. ● Be environmentally friendly, using sustainable or biodegradable materials wherever possible. **Target audience**

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- **Food industries and logistics companies:** Seeking better insulation for transporting perishable goods while cutting costs and emissions.
- **Households and consumers:** Interested in reducing energy bills and preserving food longer.
- **Developing regions:** Providing reliable food storage in areas with limited access to electricity or cooling infrastructure.

Location and context

The solution is applicable globally, with particular importance in regions with high energy costs, hot climates, or underdeveloped cold chain systems. It is especially relevant for addressing food insecurity and minimizing food waste in resource-constrained areas.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Opportunities

- **Biomimetic inspiration:** Nature provides numerous models, such as the cellular structure of cork, the lightweight insulation of polar bear fur, or the wax-coated structures of honeycombs.
- **Energy efficiency trends:** Increasing global demand for energy-efficient technologies supports innovation in food storage systems.
- **Sustainability drive:** Growing awareness of the need for eco-friendly solutions opens markets for systems using biodegradable materials or renewable energy.
- **Advances in materials science:** Progress in materials like aerogels and bio-based polymers can complement biomimetic designs.

Challenges

- **Cost of materials:** Sustainable, high-performance materials may be initially more expensive than traditional options.
- **Durability and maintenance:** Ensuring that biomimetic materials maintain their performance over time and in varied conditions.
- **Compatibility:** Integrating new insulation methods with existing refrigeration or storage systems may require redesigns or retrofits.
- **Consumer adoption:** Educating users and industries on the benefits of biomimetic solutions to encourage adoption.

Now it's your turn!

Revolutionize food storage by harnessing the power of nature-inspired insulation to ensure fresher food, lower energy costs, and a healthier planet!

Enhanced food storage systems with nature-inspired insulation

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Explanatory questions

What natural structures or materials offer superior thermal insulation, and how can they be adapted for food storage systems?
How can biomimicry reduce the energy demands of refrigeration while maintaining food safety and quality?
What designs or materials inspired by nature could make storage systems more sustainable and cost-effective?

Primary goals

Develop an innovative food storage system that leverages nature-inspired insulation to maintain consistent temperatures.
Reduce energy consumption and environmental impact while preserving food quality.
Offer a scalable and cost-effective solution for use in households, transportation, and commercial settings.

1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.
Food storage and refrigeration systems are critical for preventing spoilage and reducing waste. However, they are energy-intensive and often rely on materials or processes with a high environmental impact. Natural insulation mechanisms—like the hollow fur of polar bears or the layered feathers of birds—can inspire designs that improve thermal performance and sustainability.
What the design needs to do

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Reduce energy requirements for refrigeration and cooling.
Be environmentally friendly, using sustainable or biodegradable materials wherever possible.

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Location and context

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- **Sustainability drive:** Growing awareness of the need for eco-friendly solutions opens markets for systems using biodegradable materials or renewable energy.
- **Advances in materials science:** Progress in materials like aerogels and bio-based polymers can complement biomimetic designs.

Challenges

- **Cost of materials:** Sustainable, high-performance materials may be initially more expensive than traditional options.
- **Durability and maintenance:** Ensuring that biomimetic materials maintain their performance over time and in varied conditions.
- **Compatibility:** Integrating new insulation methods with existing refrigeration or storage systems may require redesigns or retrofits.
- **Consumer adoption:** Educating users and industries on the benefits of biomimetic solutions to encourage adoption.

Now it's your turn!

Revolutionize food storage by harnessing the power of nature-inspired insulation to ensure fresher food, lower energy costs, and a healthier planet!

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Nature-inspired methods to reduce urban light pollution

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** How can we design urban lighting systems that reduce light pollution while maintaining visibility and safety, inspired by natural methods of light control and diffusion? **Explanatory questions** ● How do natural systems, such as bioluminescent organisms or the structures of nocturnal animals, optimize light usage? ● What biomimetic principles can guide the creation of urban lighting that minimises skyglow and glare? ● How can urban lighting systems balance ecological needs, human safety, and energy efficiency? **Primary goals** ● Develop innovative urban lighting solutions inspired by natural systems to reduce light pollution. ● Improve nighttime visibility and safety without over-illuminating environments. ● Protect ecosystems and human health from the adverse effects of excessive artificial lighting. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what the context of the challenge is.** Light pollution disrupts ecosystems, affects human health, and obscures the night sky. Current urban lighting systems often prioritise brightness over efficiency, leading to unnecessary light scatter and energy wastage. Nature offers models for efficient light management, such as fireflies' directional bioluminescence or the reflective structures in the eyes of nocturnal animals. **What the design needs to do** ● Control and direct light effectively to reduce upward and horizontal scattering. ● Adapt to environmental and human needs, providing adequate illumination without contributing to skyglow. ● Use sustainable and energy-efficient technologies that align with urban sustainability goals. **Target audience** ● **City planners and municipalities:** Responsible for designing and implementing urban lighting systems.

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- **Environmental organisations:** Advocating for solutions to protect ecosystems and wildlife from light pollution.
- **Urban residents and businesses:** Seeking safer, more efficient, and aesthetically pleasing lighting solutions.

Location and context

Urban and suburban areas worldwide are increasingly impacted by light pollution, with densely populated cities facing the most significant challenges. Solutions are needed to balance visibility, energy efficiency, and environmental health in streets, public spaces, and private properties.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Opportunities

- **Biomimetic inspiration:** Nature offers numerous models for light management, including firefly lanterns, moth eyes, and anglerfish bioluminescence.
- **Growing awareness:** The increased recognition of light pollution's ecological and health impacts is driving demand for more effective solutions.
- **Energy efficiency technology:** Advancements in LED and smart lighting systems enable more precise control and reduced energy consumption.
- **Policy and regulation:** Many cities are enacting light pollution reduction policies, creating opportunities for innovative solutions.

Challenges

- **Cost of implementation:** Replacing existing lighting infrastructure with new systems could be expensive for municipalities.
- **Resistance to change:** Stakeholders may prioritize traditional lighting over innovative but unfamiliar designs.
- **Technical feasibility:** Ensuring that biomimetic designs provide sufficient illumination while meeting urban safety standards.
- **Maintenance and durability:** Nature-inspired designs must be robust enough to withstand weather and urban wear-and-tear.

Now it's your turn!

Illuminate urban spaces sustainably by harnessing nature's strategies for efficient light control, creating environments that are safer, healthier, and more connected to the night sky!

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Anti-Erosion techniques for coastal protection based on mangroves

<table>
<tr><th>BIOMIMICRY DESIGN</th><th>Description</th></tr>
<tr><td>Step 1 – Define the challenge</td><td>
1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.
How can we design coastal protection systems inspired by mangroves to reduce erosion, safeguard communities, and preserve ecosystems?
Explanatory questions

How do mangroves naturally stabilize coastlines and dissipate wave energy?
What biomimetic principles from mangrove structures can be applied to artificial coastal protection systems?
How can these designs be integrated with local ecosystems to enhance biodiversity and environmental resilience?

Primary goals

Create innovative coastal protection systems that mimic mangrove functions to prevent erosion and reduce wave impact.
Enhance resilience against climate change effects such as rising sea levels and stronger storms.
Support biodiversity and ecosystem health alongside effective coastal defense.

1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.
Coastal erosion threatens communities, ecosystems, and economies worldwide. Mangroves, with their dense root systems and ability to dissipate wave energy, naturally protect coastlines while supporting rich biodiversity. However, mangrove deforestation and human activities have reduced these natural defenses. Biomimetic solutions can recreate the protective benefits of mangroves in areas where restoring them may not be immediately feasible.
What the design needs to do

Reduce wave energy and stabilize soil to prevent coastal erosion.
Adapt to changing water levels and resist strong storm surges.
Be environmentally friendly, supporting or enhancing local ecosystems rather than disrupting them.

Target audience

Coastal communities and municipalities: Facing erosion threats and seeking sustainable protection solutions.

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- **Environmental organisations and researchers:** Advocating for eco-friendly approaches to coastal management.
- **Marine engineers and urban planners:** Designing infrastructure to mitigate erosion and protect coasts.

Location and context

Areas experiencing severe coastal erosion, such as low-lying islands, river deltas, and tropical coastlines, are most at risk. The solutions can also benefit locations facing rising sea levels and frequent storms due to climate change.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Opportunities

- **Proven natural model:** Mangroves have been extensively studied for their ability to stabilize coastlines, offering clear biomimetic principles.
- **Sustainability demand:** There is growing interest in eco-friendly coastal protection measures as alternatives to hard infrastructure like seawalls.
- **Multifunctional benefits:** Mangrove-inspired systems could support biodiversity, act as carbon sinks, and boost eco-tourism.
- **Global policy support:** International efforts to combat coastal erosion and climate change align with biomimetic, nature-based solutions.

Challenges

- **Cost of implementation:** Installing and maintaining biomimetic systems may require significant investment.
- **Scalability and replication:** Designs need to be adaptable to various coastal geographies and climates.
- **Ecosystem compatibility:** Artificial systems must integrate harmoniously with local marine and terrestrial ecosystems.
- **Climate change variability:** Rising sea levels and unpredictable weather patterns may challenge the effectiveness of these solutions.

Now it's your turn!

Emulate the resilience and ingenuity of mangroves to develop coastal protection systems that secure communities, preserve ecosystems, and adapt to the changing climate.

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Durable, lightweight exoskeletons for worker safety

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<tr><td>Step 1 – Define the challenge</td><td>
1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.
How can we design lightweight yet durable exoskeletons inspired by nature to enhance worker safety and reduce strain during physically demanding tasks?
Explanatory questions

What structural and functional traits from nature provide both strength and flexibility?
How can the design optimize weight distribution to reduce fatigue for users?
How can the exoskeleton be made adaptable to various work environments and user needs?

Primary goals

Develop a durable and lightweight exoskeleton that minimises physical strain on workers and prevents injuries.
Enhance productivity and worker endurance in physically demanding roles.
Create a comfortable and adaptable design that encourages widespread use across industries.

1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.
Many industries, including construction, manufacturing, and healthcare, require workers to perform repetitive, physically demanding tasks, leading to fatigue, injuries, and long-term health issues. Inspired by natural exoskeletons found in insects and crustaceans, biomimetic designs can create robust yet lightweight systems that assist workers in handling heavy loads and repetitive motions safely and effectively.
What the design needs to do

Provide ergonomic support to reduce strain on the back, arms, and legs.
Offer flexibility for a wide range of motion while maintaining structural integrity.
Be lightweight and non-intrusive for comfort during extended use.

Target audience
</td></tr>
</table>

- **Industrial workers:** Labourers in construction, logistics, and manufacturing who perform physically taxing tasks daily.
- **Healthcare workers:** Professionals who lift and move patients, reducing the risk of back and joint injuries.
- **Emergency responders:** Personnel requiring additional strength and protection in disaster zones or rescue operations.
- **Employers:** Organizations aiming to reduce workplace injuries and enhance worker productivity.

Location and context

The solution can be implemented in industrial, healthcare, and emergency response environments globally. These settings demand tools that enhance safety while meeting specific task requirements and environmental constraints.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Opportunities

- **Nature-Inspired models:** Organisms like crabs and beetles possess exoskeletons that are lightweight, durable, and flexible, offering design inspiration.
- **Advancements in materials:** The development of lightweight, high-strength materials like carbon fibre and graphene can improve durability without adding bulk.
- **Increased focus on workplace safety:** Regulatory agencies and industries are prioritising worker safety, creating demand for innovative solutions like exoskeletons.
- **Customisation and modularity:** Modular designs can cater to various roles and industries, increasing adoption and usability.

Challenges

- **Cost and accessibility:** High costs of advanced materials and technologies may limit initial adoption, particularly for small businesses.
- **User comfort and adaptability:** Designs must balance functionality with user comfort, ensuring that workers can wear exoskeletons for extended periods without discomfort.
- **Power and maintenance requirements:** Advanced exoskeletons may require energy sources or regular maintenance, posing logistical challenges.
- **Resistance to change:** Workers may be hesitant to adopt new technologies, necessitating training and demonstration of tangible benefits.

Now it's your turn!

Leverage the ingenuity of nature to design exoskeletons that protect and empower workers while ensuring comfort and adaptability in diverse industries.

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Romania

Develop the smallest, lightest, fastest ever built micro-robot that can also lift 2000 times its own weight

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** How can we develop the smallest, lightest, fastest ever built micro-robot that can lift 2000 times its own weight, which can navigate complex environments and perform precise tasks? **Explanatory questions** How do specialized sensors reduce the need for extensive data processing in robotic systems? How does the small size and community structure of ants contribute to their success in various environments? **Primary goal** The primary goal is to design efficient and cooperative robots that can be used in difficult environments or for issues such as warehouse monitoring, gas leak detection, and pest detection in greenhouses. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** **What the design needs to do** The design needs to enable tiny robots to navigate efficiently over long distances with minimal computational power by mimicking ants' pheromone trail-following behavior. These robots must exhibit cooperative behaviors, working together seamlessly to achieve tasks. They should be versatile enough to handle various applications, such as warehouse monitoring, gas leak detection, and pest detection in greenhouses, requiring appropriate sensors and actuators. **Context** Researchers are developing tiny robots with similar cooperative behaviors like ants. These robots, equipped with sensors and actuators, can navigate efficiently by leaving "pheromone" trails, much like ants. This approach is being used to create lightweight, autonomous robots that can navigate long distances with

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minimal computational power, inspired by ants' navigation strategies.

These tiny robots have potential applications in various industries, such as warehouse monitoring, gas leak detection, and pest detection in greenhouses, thanks to their small size and safety around humans.

Target groups

- Manufacturing and industrial workers.
- Logistics, supply chain companies and transportation.
- Medical and healthcare sectors.
- Construction and infrastructure sectors.
- Defence and security agencies.
- Robotics and AI developers.
- Environmental and conservation organisations.
- Agriculture and farming communities.
- Academic and research institutions.
- Regulatory bodies and governments.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Connections to other solutions or challenges

- Miniaturisation and nanotechnology.
- Swarm robotics and distributed systems.
- Precision medicine and minimally invasive surgery.
- Logistics, automation, and smart factories.
- Environmental and ecological applications.
- Defence, security, and surveillance.
- Energy efficiency and sustainability.
- Human-machine collaboration and augmentation.

Favourable circumstances, initiatives or legislations

- The EU Horizon Europe program.
- The National Science Foundation (NSF) and the Defence Advanced Research Projects Agency (DARPA)
- Japan's Robot Revolution Initiative (RRI).
- "Shaping Europe's Digital Future"
- UN Sustainable Development Goals (SDGs)
- Green Deal initiatives.
- Circular Economy Action Plan.
- EU's AI Act.
- United States AI in Government Act.
- Industry 4.0: Germany's Industrie 4.0 or China's Made in China 2025.
- In Europe, the European Defence Fund (EDF) .
- Biomedical Advanced Research and Development Authority (BARDA) .

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- IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems.
- The ISO (International Organization for Standardization).
- Innovation hubs like the Robotics Hub (U.S.) or the European Robotics Forum .
- Partnerships between tech giants and governments .

Limitations or risks

- Material limitations.
- Energy efficiency and power supply.
- Precision and control mechanisms.
- Manufacturing and scalability.
- Durability and environmental stressors.
- Ethical and privacy concerns.
- Environmental impact.
- Safety and security risks.
- Legal and regulatory challenges.
- Human-robot interaction (HRI).

Now it's your turn!

Explore nature solutions, like insects, to develop such micro robots for navigating complex environments and performing precise tasks.

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Create a new tough, flexible and light material for body armours

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** ● How can we create a new, though, flexible and light material that can be used to make body armour? **Explanatory questions** ● How important is it for body armour to maintain comfort and mobility? ● In what ways could the new body armour be adapted to protect against different types of threats, such as high-impact projectiles? **Primary goal** The primary goal is to create lightweight, flexible, and highly protective armour that can adapt to various threats and potentially have applications in different high-risk fields. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** **What the design needs to do** The design aims to provide high levels of protection while maintaining mobility and comfort, making it suitable for soldiers, law enforcement, and civilians in high-risk environments. **Context** Researchers are developing a new type of body armour inspired by the Arapaima fish, known for its tough, flexible scales that protect it from piranha attacks. This bio-inspired armour aims to provide high levels of protection while maintaining mobility and comfort, making it suitable for soldiers, law enforcement, and civilians in high-risk environments. The Arapaima's scales have a hard, mineralized outer layer and a tough, collagen-based inner layer, allowing them to deform without breaking. This structure provides a model for creating advanced body armour that balances toughness and flexibility. Modern body armour needs to adapt to various threats, including high-impact projectiles, while ensuring the wearer remains agile.

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Materials scientists are utilising advanced techniques, such as 3D printing and nanoengineering, to replicate and enhance the natural structure of Arapaima scales. By combining strong nanomaterials with bio-inspired designs, they aim to develop lightweight, flexible, and highly protective armour. These innovations could also have applications in the aerospace industry.

Target group

- Military personnel.
- Law enforcement and security forces.
- Defence contractors and manufacturers.
- Research institutions and universities.
- Medical and healthcare professionals.
- First responders and aid workers.
- Civilians and high-risk professionals.
- Legal and Regulatory Bodies.
- Economists and environmentalists.
- Insurance companies.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Connections to other solutions or challenges

- **Other bio-inspired solutions:** Spider silk-inspired fibres, Abalone shell-inspired ceramics, Shark skin-inspired surfaces.
- **Nanotechnology and advanced composites:** Carbon nanotubes, Graphene.
- **Smart materials and adaptive armour:** Shear-thickening fluids (STF), Self-healing materials.
- **Environmental sustainability:** Biodegradable or renewable polymers, Circular economy.
- **Human factors and ergonomics:** Augmented reality displays, Health monitoring systems.
- **Logistics and supply chain efficiency:** Reduced fuel costs.
- **Health and safety impacts:** Back and joint pain prevention.
- **Defence against emerging threats:** Laser and directed energy weapons.

Favourable circumstances, initiatives or legislation

- Defence research programs.
- Public-private collaborations.
- Sustainability and environmental legislation.
- Patent protection for bio-inspired materials.
- Next-generation soldier programs.
- Health and safety legislation.

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- Technological standards and testing protocols.
- Global defence trade agreements.

Limitations or risks

- **Performance and testing uncertainty:** Unknown long-term durability, Complex threat spectrum.
- **Complexity in material synthesis and engineering:** Replicating the hierarchical structure, Materials compatibility.
- Manufacturing challenges and scalability: Scaling up production, cost of production.
- **Weight vs. protection trade-off:** Balancing lightness with protection.
- **Integration with other technologies:** Compatibility with existing armour systems, Smart armour integration.
- **Regulatory and certification challenges:** Meeting regulatory standards, Unforeseen regulatory barriers.
- **Supply chain vulnerabilities:** Dependence on specialized materials.
- **Environmental and ethical concerns:** Ethical considerations.

Now it's your turn!

Explore nature-inspired solutions, such as those found in fish, to develop micro-robots for navigating complex environments and performing precise tasks.

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Design a digital mobile phone camera with a wide-angle field of view, high acuity to motion and an infinite depth of field

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** How can we design a digital mobile phone camera with a wide-angle field of view, high acuity to motion and an infinite depth of field by using a nature inspired design? **Explanatory questions** How to overcome limitations like narrow fields of view and slow focusing? **Primary goal** The primary goal is to provide high-quality and versatile imaging experiences for both casual and professional use of mobile phones, including for augmented reality applications. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and which is the context of the challenge.** **The design needs to do / solve** The design aims to overcome limitations of mobile phone cameras in terms of narrow fields of view, motion blur, and wide-angle distortion, making it more suitable for both casual and professional use. **Describe the context** The development of a wide-angle, high-motion-acuity, infinite-depth-of-field mobile camera is part of the broader trend of biomimicry, where technology mimics biological systems. This innovation addresses challenges in smartphone photography, such as depth of field, motion blur, and wide-angle distortion. It caters to the growing demand for powerful, adaptable cameras in compact smartphones, suitable for both casual and professional use, including augmented reality (AR). Driven by advancements in camera

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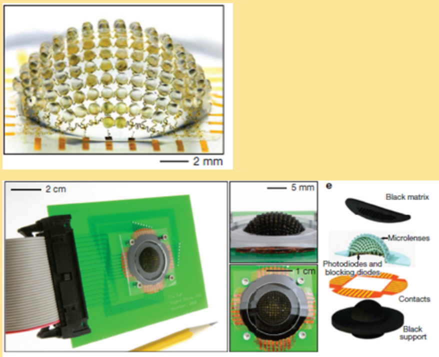
hardware and computational photography, this technology aims to deliver high-quality, versatile imaging experiences by overcoming limitations like narrow fields of view, slow focusing, and difficulty capturing fast-moving subjects.



https://rogersgroup.northwestern.edu/files/2013/insecteye.pdf

https://rogersgroup.northwestern.edu/files/2013/insecteye.pdf

Target groups

- Photographers and videographers.
- Travelers and adventure enthusiasts.
- Sports enthusiasts.
- Architects and interior designers.
- Real estate professionals.
- Journalists and documentarians.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Connections to other solutions or challenges

- Imaging technology and optical design.
- Motion detection and high acuity to motion.
- Infinite depth of field.
- Artificial vision systems in robotics and drones.
- Augmented Reality (AR) and Virtual Reality (VR), and depth perception in AR applications.
- Bio-inspired robotics.
- Medical imaging and diagnostics.

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	● Surveillance and security systems. **Favourable circumstances, initiatives or legislations** ● Technological advancements and research funding: Government research grants and initiatives, AI and computational photography Initiatives. ● Intellectual property and patent incentives: Favourable IP laws, Patent pools and cross-licensing. ● Environmental and energy efficiency regulations. ● 5G and next-generation network deployments. ● Consumer privacy and data security legislation. ● Health and safety standards: safety and standards for autonomous vehicles. ● Military and defence initiatives. ● Standards for smartphone cameras. **Limitations or risks** ● Complexity of design and miniaturization. ● Data processing and power consumption. ● Optical limitations. ● Low Light performance. ● Manufacturing complexity and cost. ● User experience and usability. ● Privacy and ethical concerns. **Now it's your turn!**

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Create an online algorithm for more efficient transportation routes

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<tr><td>Step 1 – Define the challenge</td><td>
1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.

Define the challenge as a question
● How can we develop an online algorithm to optimise transportation routes? .

Explanatory questions
● How does traffic congestion influence ecological damage?
● How can a self-organising online routing system ensure the validity of driver directions when executed?

Primary goal
The primary goal is to develop a self-organising online routing system that efficiently manages the dynamic complexity of individual vehicle traffic in large traffic systems.

1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.

What the design needs to do
The design aims to reduce traffic congestion, thereby minimising economic and ecological costs.

Describe the context
Traffic congestion in densely populated areas leads to significant economic and ecological costs. Vehicle routing problems, which involve determining the optimal routes for vehicles, are NP-hard problems, meaning they are computationally intractable due to their complexity.

For effective online vehicle routing in large traffic systems, driver directions must be transmitted and processed quickly, and they must remain valid when executed. Solutions need to be dynamic, scalable, and robust, but current approaches do not meet all these requirements.

A proposed solution is a self-organising online routing system using autonomous agents (navigators) that coordinate area information through a multi-layer communication structure. This system aims to handle the dynamic complexity of individual vehicle traffic efficiently.
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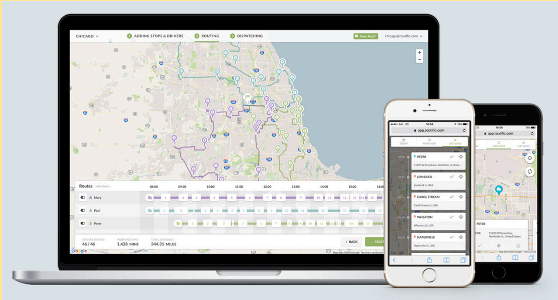

https://www.fastcompany.com/3062836/this-bee-inspired-algorithm-helps-delivery-companies-plan-the-most-effi

Target groups

- Logistics and transportation companies.
- Ride-sharing and taxi services
- Urban planners and municipal transport authorities.
- Supply chain and warehouse managers.
- Environmental and sustainability groups.
- Emergency response teams.
- Researchers and academia.
- Automotive and autonomous vehicle manufacturers
- Consumers and end-users.
- Small and Medium Enterprises (SMEs).
- Insurance companies.
- Retailers and e-commerce platforms.
- Telecommunications and network providers
- Government and policy makers.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Connections to other solutions or challenges

- Other routing and optimization algorithms.
- Real-time data and IoT (Internet of things) .
- Environmental sustainability.
- Supply chain management and Industry 4.0.
- Artificial Intelligence (AI) and Machine Learning (ML).
- Cybersecurity and data privacy.
- Human factors and user experience.
- Real-World Challenges in Disaster and Emergency Management.

Favourable circumstances, initiatives or legislations

- Advances in 5G and communication networks.
- Legislation and regulatory support for sustainable transportation.

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- Growth in electric vehicle (EV) and autonomous vehicle (AV) adoption.
- Government and private sector support for AI and optimisation technologies.
- Supportive data sharing policies and open data initiatives.
- Digitalisation of supply chains and logistics.
- Environmental and energy regulations.
- Emergence of the collaborative economy and sharing models.
- Research and development incentives.
- Ethical AI and algorithmic accountability.
- Disaster preparedness and resilience programs.

Limitations or risks

- Scalability and computational complexity.
- Data quality and real-time data availability.
- Cybersecurity and data privacy risks.
- Dynamic environments and adaptation limits.
- Energy efficiency and environmental impact.
- Hardware and network dependencies.
- Cost of implementation and maintenance.
- Complexity of regulatory compliance.
- Algorithmic bias and ethical concerns.
- Human-AI collaboration challenges.
- Security of data transmission and storage.
- Adaptation to rapid technological changes.

Now it's your turn!

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Create a new self-cleaning, antibacterial and waterproof surface

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** ● How can we create new self-cleaning, antibacterial and waterproof surfaces? **Explanatory questions** ● How can self-cleaning surfaces be applied to everyday objects like windows and camera lenses? ● How can super-hydrophobic coatings prevent frost? **Primary goal** The primary objective is to create surfaces that replicate the self-cleaning properties of certain creatures and plants, thereby reducing microbial contamination and the need for maintenance. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** **What the design needs to do** The design needs to address the issue of microbial contamination, reducing the need for frequent cleaning and the use of harsh chemicals and to prevent frost and moisture accumulation on surfaces **Describe the context** Nature continuously inspires scientific innovations. Some ideas, like beaver-inspired wetsuits, are still in research, while others, such as Velcro and the Japanese bullet train, are already in use. Various creatures, like butterflies, geckos, and certain plant leaves, have self-cleaning properties that scientists are studying. Microbial contamination is a significant issue in many industries, and current solutions like surface coatings and antibiotics have limitations. Future innovations may include self-cleaning surfaces for windows, solar panels, and camera lenses, as well as super-hydrophobic coatings to prevent frost. Nature-inspired designs, such as efficient solar panels and well-ventilated buildings, highlight the importance of preserving and understanding nature to improve our infrastructure and technology. **Target groups** ● Doctors.

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- Contractors and material manufacturers.
- Appliance, furniture, textile, and cleaning product manufacturers.
- Automotive, aerospace, and public transport manufacturers.
- Processing plants, kitchens, and packaging manufacturers.
- Hospitality industry (Hotels, resorts, vacation rentals).
- Manufacturing and industrial actors (factories, pharmaceuticals, electronics).
- Regulatory agencies (health, safety, and environmental bodies).
- Environmental groups (NGOs, sustainability advocates).
- Legal and insurance.

Location or the settings for implementations

- Healthcare (hospitals, clinics, laboratories).
- Public/commercial buildings (restrooms, offices, schools, shopping centres).
- Residential spaces (kitchens, bathrooms, furniture).
- Food and beverage spaces (restaurants, commercial kitchens, food processing plants).
- Transportation (public transit, automobiles, airplanes).
- Industrial/manufacturing (factories, clean rooms).
- Hospitality spaces (hotels, resorts, vacation rentals).
- Public infrastructure (parks, government buildings).
- Consumer electronics (smartphones, wearable devices).

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Connections to other solutions or challenges

- Public health (infection control, antibiotic resistance).
- Environmental sustainability (reduced use of chemicals, water conservation, waste reduction).
- Smart cities and buildings (green building certifications, urban infrastructure).
- Technological advancements (nanotechnology, wearable technology).
- Cost-efficiency (reduced maintenance costs, energy efficiency).
- Healthcare solutions (hospital-acquired infections, telemedicine).
- Consumer product hygiene (food safety, household products).
- Supply chain (material sourcing, compatibility).
- Regulatory and safety challenges (approval, consumer health).
- Climate change adaptation (weather-resistant infrastructure).

Favourable circumstances, initiatives or legislations

- Public health and hygiene initiatives (pandemic response, infection control).
- Environmental regulations (chemical safety, waste reduction).

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	● Health and safety legislation (HAI prevention, workplace safety). ● Funding and innovation programs (R&D grants, clean technology funds). ● Climate and environmental policies (water efficiency, climate change). ● Nanotechnology and materials innovation (government support, collaborations). ● Circular economy and product lifecycle Legislations (EPR laws, sustainable packaging). ● Industry-specific regulations (food safety, transportation standards). **Limitations or risks** ● **Material performance:** Longevity, wear resistance, and durability under harsh conditions. ● **Cost:** High production costs and affordability for consumers. ● Regulatory and safety concerns: Health risks, biocompatibility, and environmental regulations. ● **Efficacy against pathogens:** Limited range of effectiveness and potential for resistant bacteria. ● **Environmental issues:** Ecosystem impact, disposal challenges, and chemical persistence. ● **Technological limitations:** Manufacturing complexity and integration with existing products. ● **User acceptance:** Aesthetic concerns and scepticism about new technologies. ● **Market risks:** Competition with traditional cleaning methods and emerging alternatives. ● **Ethical considerations:** Job displacement and privacy concerns. **Now it's your turn!**

Design a micro-drone that can be carried, has a decent range and can deal with turbulent wind conditions

BIOMIMICRY DESIGN	**Description**
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question**

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- How can we design a micro-drone that can be carried, has a decent range and can deal with turbulent wind conditions? .

Explanatory questions

- What specific needs do emergency response teams have that a portable micro-drone could address?
- How can AI-based flight controls improve the stability and efficiency of micro-drones in turbulent wind conditions?

Primary goal

The primary objective is to design a portable micro-drone that balances a decent operational range with the ability to effectively handle turbulent wind conditions.

1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.

What the design needs to do

The design aims to enhance wind stability, optimise power efficiency with cutting-edge materials and power systems, ensure portability by being lightweight and compact, and adapt to various applications such as emergency response, military operations, environmental monitoring, agriculture, and recreational activities.

Describe the context

The design of a portable micro-drone with a decent operational range and the ability to handle turbulent wind conditions is driven by technological advancements, practical applications, and market demands. These drones are increasingly relevant in various fields, including emergency response, military applications, environmental monitoring, agriculture, and recreational use. The primary challenge is balancing portability with performance, particularly in terms of wind stability, power efficiency, and flight range.

Advances in materials, power systems, AI-based flight controls, and biomimetic designs are enabling the creation of small drones that can operate reliably in challenging conditions. Researchers are inspired by nature, but imitating nature's gravity-defying designs, such as flapping wings, is a significant challenge. Designing a functional ornithopter (an aircraft that flies by flapping its wings) has proven difficult. However, researchers have started building a micro-drone with wings inspired by flapping flight, attracting military funding. These wings are more efficient than propellers and allow for hovering

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in strong gusts, although they are challenging to emulate. The drone's four flapping wings offer several advantages.

Target groups

- Military and defence forces.
- Law enforcement and security agencies.
- Wildlife conservationists and environmental researchers.
- Delivery and logistics companies.
- Construction and infrastructure inspection.
- Filmmaking and photography.
- Emergency and disaster response teams.
- Hobbyists and enthusiasts.
- Urban planning and surveying professionals.
- Academic and research institutions.
- Enemy combatants and adversaries.
- Civilian populations in conflict zones .
- International policy and human rights organisations.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Connections to other solutions or challenges

- Surveillance and monitoring technologies.
- Artificial intelligence and automation.
- Power and energy challenges.
- Data collection and processing.
- Defence and security.
- Emergency response and disaster relief.
- Urban and rural development.
- Innovation in miniaturization and material science.
- Environmental impact and sustainability.

Favourable circumstances, initiatives or legislations

- Technological advancements and research funding.
- Military and defence initiatives.
- Regulatory frameworks for drone integration.
- Public-private partnerships.
- Climate change and environmental monitoring initiatives.
- Standards and certifications.
- Innovation in drone logistics and delivery.
- National security and counter-drone initiatives.

Limitations or risks

- Power supply and battery life.
- Weight and payload limitations.
- Stability and flight control in windy conditions.
- Signal interference and communication challenges.

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	● Durability and structural integrity. ● Limited sensing and obstacle avoidance in turbulent conditions. ● Legal and regulatory constraints. ● Cost vs. performance trade-offs. ● Environmental and weather-related risks. ● Cybersecurity and data Privacy risks. ● Manufacturing and supply chain constraints.

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Create a soft power cell device that could power artificial human organs (medical implants)

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** ● How can we create a soft power cell device that could power medical implants? . **Explanatory questions** ● How can the biocompatibility of these new power sources be tested and ensured over the long term in the human body? ● What are the challenges in converting biological chemical energy into electrical energy suitable for medical implants? **Primary goal** The primary goal is to develop safer, biocompatible power sources for medical implants. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** **What the design needs to do** The design needs to be flexible, safe for use within the human body without causing adverse reactions, and capable of harnessing chemical energy from biological systems, ultimately eliminating the toxicity, bulk, and frequent recharging associated with traditional batteries. **Describe the context** Scientists are developing safer, biocompatible power sources for medical implants, inspired by high-voltage organisms. These new devices are flexible, transparent, and could power pacemakers, prosthetics, and augmented reality contact lenses. Unlike conventional batteries, they are designed to be soft, flexible, and able to harness chemical energy from biological systems. This technology, though preliminary, promises to eliminate the toxicity, bulk, and frequent recharging associated with traditional batteries, potentially leading to bioelectric systems that generate electricity from natural body processes.

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Target groups

- **Patients with medical implants:** Chronic illness patients, the elderly and vulnerable populations.
- **Medical device manufacturers:** Innovators, startups and established companies.
- **Healthcare providers and surgeons**: Cardiologists, neurologists, hospitals and clinics
- **Research and academia:** Biomedical engineers, materials scientists, university labs and research institutions.
- **Regulatory bodies and government agencies:** Food and Drug Administration (FDA), European Medicines Agency (EMA) and health insurance providers.
- **Environmental and ethical group:** Sustainability advocates and ethics committees.
- Wearable and consumer technology companies.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Connections to other solutions or challenges

- Energy harvesting and self-sustaining devices:.
- Biological energy harvesting.
- Wireless charging and energy transmission.
- Advances in flexible electronics:.
- Wearable devices.
- Flexible solar cells.
- Challenges of biocompatibility and longevity:.
- Biocompatible materials.
- Medical implant longevity.
- Healthcare challenges.
- Minimizing invasive procedures.
- Remote health monitoring.
- Sustainability and environmental impact.
- Cross-disciplinary collaboration.

Favourable circumstances, initiatives or legislations

- Regulatory support and fast-track approvals:.
- FDA Breakthrough Devices Program (U.S.).
- European Medical Device Regulation (MDR).
- Funding Initiatives for medical innovatio:.
- Government grants and research funding.
- Private sector investment.
- Legislation on sustainability and environmental impact:.
- E-Waste reduction policies.
- Circular economy initiatives.
- Advances in bio-integrative materials.
- Biocompatible materials.

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	- Nanotechnology. - Healthcare system reforms and value-based care. - Global focus on personalized medicine. **Limitations or risks** - Energy output and density. - Efficiency of energy conversion. - Biocompatibility. - Durability and mechanical properties. - Heat Generation and management. - Integration with existing medical devices. - Regulatory and approval hurdles. - Energy storage. - Size and implantability. **Now it's your turn!**

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Design a non-disruptive and energy efficient underwater robot that could clean up oceans

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** ● How can we design a non-disruptive and energy-efficient underwater robot that could clean up seas and oceans? **Explanatory questions** ● How do pollutants affect marine life and ecosystems? ● How does marine litter affect the health of aquatic organisms and humans? ● How can robots minimise their environmental impact while maximising their operational capabilities? **Primary goal** The primary objective is to develop advanced underwater robots that can effectively collect and transport organisms and litter from water bodies, thereby aiding in environmental protection and pollution mitigation. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and which is the context of the challenge.** **What the design needs to do** The design needs to ensure flexibility and agility to navigate complex terrains and access hard-to-reach areas, while operating quietly to minimise disturbance to marine life. They should efficiently collect samples of organisms and litter without causing harm, and be made from durable, environmentally friendly materials to withstand harsh conditions and minimise ecological impact. **Describe the context** Waterbodies cover over 70% of the earth, but 80% remain unexplored, especially the benthic habitat. This is urgent for environmental protection as many waterbodies are highly polluted. Coral reefs, though only 0.1% of the ocean, support 25% of marine species. Marine litter, mostly plastics, sinks to the seabed and poses health risks. Proper investigation and

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recycling are needed to prevent irreversible environmental damage.

Current robots are bulky, rigid, and noisy and therefore, there is an urgent need for underwater robots to sample and transport organisms and litter, as these tasks are labour-intensive.

Target groups

- Environmental organisations and conservationists.
- Government agencies and policymakers.
- Ocean-based Industries.
- Marine scientists and research Institutions.
- Non-governmental organisations (NGOs).
- Technology developers and start-ups.
- Local coastal communities.
- Environmental law and policy experts.
- Philanthropic foundations and funding organisations.
- General public and environmental advocates.
- International organisations and global partnerships.
- Waste management and recycling industries.

Location or the settings to be implemented

- Coastal areas and beaches.
- Coral reefs and marine protected areas (MPAs).
- Offshore and open ocean garbage patches.
- Harbours, ports, and shipping lanes.
- Estuaries and river mouths.
- Mangrove forests and seagrass beds.
- Marinas and tourist resorts.
- Aquaculture facilities.
- Pollution monitoring zones.
- Deep-sea environments.
- Underwater infrastructure zones.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Connections to other solutions or challenges

- Marine pollution and waste management solutions.
- Complementing traditional ocean clean-up technologies.
- Plastic waste reduction initiatives.
- Another bio-inspired robotics.
- Sharkskin-inspired coatings for ships to reduce drag and improve fuel efficiency.
- Fish- and turtle-inspired robots used in scientific research and environmental monitoring.
- Energy efficiency and sustainable technologies.

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- Low-carbon footprint operations.
- Environmental monitoring and data collection:.
- Combining clean-up with monitoring.
- Smart ocean network.
- Ocean health and climate change Challenges.
- Coral reef protection and restoration.
- Microplastic filtration systems in wastewater treatment plants.
- Circular economy and recycling solutions:.
- Chemical recycling of plastics or plastic-to-fuel conversion technologies.
- Marine plastic upcycling initiatives for recycled ocean plastic products.
- Marine ecosystem protection and restoration:.
- Complementing marine protected areas (MPAs).
- Ocean acidification.
- Challenges in deep-sea exploration and pollution:.
- Deep-sea exploration technologies that map the ocean floor and discover new species.
- Deep-Sea Mining and Resource Extraction.
- Maritime industry and ocean engineering Challenges.
- Cleaning up oil spills and industrial pollution.
- Monitoring and maintaining offshore infrastructure **.**

Favourable circumstances, initiatives or legislations

- Global environmental goals and international agreements:.
- United Nations Sustainable Development Goals (SDGs): Specifically, SDG 14: Life Below Water aims to conserve and sustainably use the oceans, seas, and marine resources.
- The Paris Agreement.

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- Government and industry support for ocean clean-up initiatives:.

- Ocean clean-up programs.

- The Ocean Decade (2021-2030).

- National Initiatives, such as NOAA's Marine Debris Program in the U.S.
- Growing public and private investment in clean technologies:.

- Blue economy initiatives.

- Private sector interest in sustainable solutions. Major companies like Patagonia, Adidas, and IKEA have invested in cleaning up ocean plastics, and similar private sector initiatives could support the technology’s growth.
- Advancements in biomimicry and robotics research:.

- Biomimicry research grants.

- Robotics and artificial intelligence in environmental applications.

- Collaboration with research institutions.
- Marine protection legislation and regulations.

- Marine litter legislation.

- Plastic waste reduction laws.

- Extended producer responsibility (EPR) laws.
- Conservation initiatives and marine protected areas (MPAs):.

- Support from conservation NGOs.

- Protection of MPAs.
- Global action on microplastics and marine pollution:.

- Microplastic reduction efforts.

- Collaboration with anti-pollution efforts.
- Innovation competitions and environmental awards:.

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- Prize competitions.
- Environmental technology grants and awards.

Limitations or risks

- Technical and design challenges.
- Durability and reliability in harsh ocean environments.
- Power supply and energy efficiency.
- Navigation and obstacle avoidance.
- Complex maintenance and repair.
- Interference with other maritime operations.
- Environmental risks and ecosystem interference:.
- Impact on marine life.
- Potential for ecosystem imbalance.
- Biofouling and invasive species.
- Operational and logistical challenges.
- Coverage and scalability.
- Deployment in remote or deep-sea areas.
- Waste processing and disposal.
- Economic and financial risks.
- High development and operational costs.
- Competition with other clean-up solutions.
- Regulatory and legal considerations.
- Compliance with international and local marine regulations.
- Liability for environmental damage.
- Permits for ocean operations.
- Public perception and acceptance:.
- Social and environmental concerns.
- Misalignment with broader sustainability goals.

	● Data privacy and security concerns:. ● Cybersecurity risks. ● Data collection ethics. **Now it's your turn!**

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Develop a new generation of space x-ray telescope

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** ● How can we develop a new space x-ray telescope to precisely locate, characterize and alert other observatories to the source of gravitational waves? . **Explanatory questions** ● What are cosmic X-rays, and why are they important for understanding our galaxy and the universe? ● How does a wide field of view enhance the detection of transient astronomical events? **Primary goal** The primary goal is to significantly advance our ability to study gravitational wave sources and contribute to a deeper understanding of the universe. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** **What the design needs to do** The design must capture a wide field of view and focus light from a broad area into a single image, enabling the detection of transient astronomical events with high sensitivity and resolution. Additionally, the design must enable the telescope to continuously survey the entire sky in X-rays, allowing for the identification and monitoring of transient events. **Describe the context** For over fifty years, scientists have been exploring cosmic X-rays to understand our galaxy and the universe. Interestingly, lobsters have inspired a new approach to this research. Lobsters have specialized reflective eyes that can sense motion in low-light environments, which has led to the development of lobster-eye optics technology. This technology mimics the structure of lobster eyes, allowing light from a wide area to be focused into a single image, making it possible to detect and image transient astronomical events. The Einstein Probe, launched in January 2024, is a space telescope that uses lobster-eye optics to survey the entire sky in

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X-rays. This innovative design, inspired by the unique eye structure of lobsters, allows the telescope to capture a wide field of view and detect X-ray transients, such as stellar flares and neutron star collisions. The Einstein Probe represents a significant advancement in space science, combining cutting-edge technology with biological inspiration to explore the universe in unprecedented detail.

Target groups

- Astronomical and scientific community.
- Space Agencies and research institutions.
- Tech and engineering companies.

Location or the setting to be implemented

- Space-based observatory (satellite or spacecraft):.
- Low Earth orbit (LEO).
- Geostationary orbit (GEO).
- Lagrange points (L1 or L2).
- Deep space missions.
- Onboard space stations.
- International Space Station (ISS).
- Future space stations.
- Ground-based facilities (for initial testing or prototyping).
- Global network of ground observatories (for Coordination).
- International space collaboration projects.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Key opportunities and constraints overview

Opportunities	Constraints
New Discoveries	Technical Challenges
Advancement in Astrophysics	Data Interpretation
Technological Innovation	Funding and Resources
International Collaboration	Environmental Factors

Connections to other solutions or challenges

- Multi-messenger astronomy observations.
- Data processing and AI.
- Space debris and environmental sustainability.

Favourable circumstances, initiatives or legislations

- **International space collaboration initiatives:** The Artemis accords, United Nations Outer Space Treaty (1967), Committee on Space Research (COSPAR).
- **National space policies and legislation:** European Union space strategy (EU space policy), China's national space policy.
- **Funding and research initiatives:** Horizon Europe (EU funding), NASA’s astrophysics explorer program, The National Science Foundation (NSF), Private sector investments.
- **Legislation supporting commercial space activity:** U.S. Commercial Space Launch Competitiveness Act (2015), Space Resources Legislation.
- **Multi-messenger astronomy and gravitational wave initiatives:** The LIGO Scientific Collaboration (LSC), Einstein Telescope and Laser Interferometer Space Antenna (LISA).
- Technological advancements in space optics and sensors: Advancements in space technology.
- **Environmental and space sustainability policies:** Space debris mitigation guidelines, The clean space initiative).
- **Public awareness and support for space science:** Raising awareness of the public on the importance of space science.

Limitations or risks

- **Technological challenges:** Lobster-Eye Optics Complexity, X-ray Detection Sensitivity, Radiation Exposure.
- **Data overload and processing:** Large data volume, Real-time alerts.
- **Coordination with other observatories:** Multi-messenger coordination, Alert reliability.
- **Orbital and space debris risks:** Collision risk with space debris, Orbital lifetime.
- **Cost and funding risks:** High development and launch costs, Budget overruns.
- **Launch and operational risks:** Launch failures, Operational malfunctions.
- Environmental and space sustainability concerns: Space debris contribution, End-of-life disposal.
- **Technological obsolescence:** Rapid advances in technology., Gravitational wave detector sensitivity.
- Scientific uncertainty and data interpretation: Unknown x-ray sources, Competing hypotheses.
- **Legal and regulatory considerations:** Frequency spectrum allocation, International legal and policy challenges.

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Now it's your turn!

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Create a super elastic material that can be used for thermal insulation

BIOMIMICY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** ● How can we develop a highly elastic material suitable for thermal insulation? **Explanatory questions** ● What materials or structures can be used to achieve effective thermal insulation? ● How can we strike a balance between the need for lightweight design and the requirements for thermal insulation and durability? ● How can we ensure that the material remains flexible and durable under various conditions? **Primary goal** The primary goal is to develop a super-elastic material that can be used for thermal insulation. This material should ideally combine the properties of elasticity, lightweight, and effective thermal insulation. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** **What the design needs to do** The design must ensure effective thermal insulation while maintaining super-elastic properties for flexibility and durability in various applications. Additionally, the material should be lightweight for ease of use in garments and other portable items. Additionally, the material should be durable and washable, retaining its insulating properties after washing. Finally, the design should explore versatile applications beyond textiles, including uses in adsorption, separation, optics, energy, and biomedical science. **Describe the context** Nature has inspired many innovative designs and materials. Polar bears, with their unique fur and fat layers, are fascinating. Their fur consists of dense underfur and hollow guard hairs, which help them stay warm and float in water. Researchers have mimicked these structures to create materials with applications in antifouling, antifreeze, oil-water separation, and more.

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A team from the University of Science and Technology of China developed a carbon tube aerogel (CTA) inspired by polar bear hair, which is super-elastic and thermally insulating. Another team from Zhejiang University created a durable encapsulated aerogel fibre (EAF) that mimics the structure of polar bear fur. This fibre can be used to make warm, lightweight, and washable garments. The EAFs have potential applications beyond textiles, including in adsorption, separation, optics, energy, and biomedical science.

Target groups

- **Construction and housing:** Building insulation, Green building initiative.
- **Clothing and outdoor gear manufacturers:** Winter wear and outdoor clothing, sports and adventure gear.
- **Aerospace and automotive industries:** Space exploration, Automotive insulation.
- **Renewable energy and environmental technology:** Energy-efficient products, climate adaptation technologies.
- **Military and defence:** Military uniforms and equipment, Shelter and infrastructure.
- Environmental and climate advocacy groups: Polar region protection.
- **Marine and arctic industries:** Shipping and offshore industries.
- Healthcare and medical technology: Medical insulation.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Connections to other solutions or challenges

- Biomimicry and nature-inspired engineering.
- Sharkskin-inspired coatings for drag reduction
- Lotus leaf-inspired surfaces for self-cleaning properties.
- Energy efficiency and sustainable building.
- Extreme environment settings.
- Flexible and durable materials for wearable technology.

Favourable circumstances, initiatives or legislations

- Environmental regulations and energy efficiency policies.
- Building energy codes.
- Zero-energy buildings.
- Climate change mitigation initiatives.
- Paris agreement.
- Green New Deal initiatives.
- Green New Deal.

3. Research funding and innovation support

- Grants for biomimicry and sustainable materials
- Public-private partnerships.

4. **Sustainability certifications and industry standards**

- LEED certification and passive house standards.
- Circular economy initiatives.

5. **Aerospace and automotive regulations**

6. **Consumer demand for sustainable products**

Limitations or risks

- **Material performance and durability:** Thermal insulation efficiency, elasticity vs. insulation, durability and longevity.
- Scalability and manufacturing challenges: Cost of production, mass production.
- **Environmental concerns:** Sustainability of materials, environmental footprint of production.
- **Regulatory and safety standards:** Compliance with building codes and addressing health and safety risks.
- **Economic viability and market acceptance:** Competing with established materials and achieving market adoption.
- **Risk of over-reliance on biomimicry:** Other methodologies may also be beneficial.

Now it's your turn!

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Create a tough adhesive for diverse wet surfaces

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** ● How can we develop a tough adhesive for diverse wet surfaces? **Explanatory questions** ● How can the adhesive be made nontoxic and safe for different purposes (e.g., medical use)? ● What are the mechanical properties required for the adhesive to function effectively on wet surfaces? **Primary goal** The primary goal is to develop a robust adhesive that can effectively bond to a wide range of wet surfaces. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what the context of the challenge is.** **What the design needs to do** The design must allow for an effective bond to wet surfaces without compromising strength, be non-toxic and safe, and remain flexible and stretchy. **Describe the context** Scientists have developed a super-strong surgical adhesive inspired by the slime of the garden slug, Arion subfuscus. This adhesive, composed of a gummy-like gel and a glue inspired by the slug, is non-toxic, stretchy, sticky in wet environments, and strong enough to hold onto a beating heart. It offers a less painful alternative to stitches and promotes healing. The adhesive's unique properties allow it to stay in place and absorb body movements without tearing. This technology has been licensed to a medical device company for potential use in oral surgery and could eventually replace stitches or act as a wound barrier in dental practices. **Target groups** ● Medical professionals and healthcare providers, such as surgeons and other healthcare workers. ● Patients undergoing surgery. ● Medical device and pharmaceutical companies.

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- Industrial workers and contractors.
- Environmental conservation and restoration specialists.
- Researchers and academic institutions.
- Manufacturers and suppliers.
- Consumers: People who perform repairs or home improvement in wet conditions.
- Regulatory bodies and health organisations.
- Environmental and ethical advocacy groups.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Connections to other solutions or challenges

- Biomimicry and nature-inspired solutions.
- Gecko-Inspired adhesives.
- Mussel-Inspired adhesives.
- Medical adhesives and wound care.
- Soft robotics and flexible materials.
- Underwater and marine applications.
- Sustainable and eco-friendly materials.
- Biodegradable adhesives.
- Green chemistry.
- Industrial and construction adhesives.
- Drug delivery systems.
- Mucosal adhesion in drug delivery.
- Tissue engineering.
- Adhesion and friction challenges in automotive and aerospace.
- Oil spill clean-ups.
- Consumer products for extreme environments.

Favourable circumstances, initiatives or legislations

- Government funding and innovation grants.
- Sustainability and green innovation policies.
- Healthcare regulations and advancements.
- Military and defence research.
- Environmental legislation and conservation efforts.
- Construction and industrial safety regulations.
- Climate change mitigation and disaster response.
- Patent laws and intellectual property rights.
- Public-private partnerships.
- Open innovation platforms.

Limitations or risks

- Material performance and durability.
- Scalability of production.
- Environmental impact.
- Regulatory and safety concerns.

	● Market acceptance and perception. ● Temperature sensitivity. ● Competitive market and Intellectual Property (IP) risks. ● Storage and shelf life. ● Ethical and environmental considerations in bioengineering. **Now it's your turn!**

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Coordinated robot swarm

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** ● How can a swarm of robots autonomously and efficiently coordinate their movement in a dynamic environment, while maintaining energy efficiency, environmental responsiveness, and collision avoidance, without relying on a central control system? . **Explanatory questions** ● How do swarm robots detect and respond to changes in their environment? ● How can the algorithms ensure energy efficiency and collision avoidance? ● What are the challenges and solutions for maintaining effective communication in a dynamic environment? **Primary goal** The primary goal is to develop a swarm of robots that can autonomously and efficiently coordinate their movements in a dynamic and challenging environment. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what the context of the challenge is.** **What the design needs to do** The design must enable a swarm of simple robots to coordinate their movements autonomously in dynamic environments. It must ensure energy efficiency, responsiveness to environmental changes, and effective collision avoidance, all without relying on a central control system. **Describe the context** Swarm robotics is a field that explores how large groups of simple robots can work together to perform complex tasks without a central control system. Inspired by the behaviour of social insects like ants and bees, these robots rely on local interactions and decentralised control to coordinate their movements. The challenge is to ensure that the robots can move efficiently in dynamic environments while maintaining energy efficiency, responding to changes in their surroundings, and avoiding collisions. Researchers use various algorithms and

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techniques to achieve these goals, enabling the swarm to operate autonomously and effectively.

Target groups

- Robotics engineers and researchers.
- Environmental scientists and ecologists.
- Search and rescue teams.
- Military and defense.
- Agriculture and farming.
- Manufacturing and warehousing.
- Urban planners and city developers.
- Technology and software developers.
- Public and consumers.
- Ethicists and policy makers.

Location or the setting to be implemented

- Urban environments.
- Disaster or emergency zones.
- Agricultural fields or farms.
- Forests or natural habitats.
- Underwater environments.
- Industrial or manufacturing settings.
- Military or defense operations.
- Space exploration.
- Healthcare environments.
- Remote and hazardous locations.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Key opportunities and constraints overview

Opportunities	**Constraints**
Advancements in artificial intelligence (AI) and swarm intelligence	Communication limitations
Improved sensor technology	Environmental complexity
Energy efficiency and battery advancements	Energy constraints
Interdisciplinary collaboration	High development and deployment costs
Wide applicability across industries	Safety and ethical concerns

Connections to other solutions or challenges

- Artificial intelligence and machine learning connection.

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- Decentralised systems and distributed computing.
- Autonomous vehicles and drones connection.

Cost

Considering the factors above, the total cost of implementing autonomous coordination in dynamic robot swarms can vary significantly based on the scale and complexity of the system. For a small, elemental swarm, initial costs may range from $200,000 to $500,000, while for large-scale, advanced swarm systems, the costs can escalate to $1 million or several million dollars.

Favourable circumstances, initiatives or legislations

- Favourable circumstances:.
- Technological advancements.
- International collaboration.
- Initiatives.
- NASA's LEXI Mission.
- XRISM spacecraft.
- Legislation.
- Space policy directives.
- Environmental regulations.

limitations or risks

- Limitations.
- Technical challenges.
- Data interpretation.
- Environmental factors.
- Risks.
- Space radiation.
- Instrument failure.
- Funding and resource constraints.

Now it's your turn!

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Tangle-proof grooming brush

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** ● How can we design a grooming brush that effectively detangles hair without causing pain or breakage? **Explanatory questions** ● How can we ensure the brush is easy to handle and use for extended periods? ● What non-toxic and hypoallergenic materials can be used in the brush to ensure safety for both pets and humans? ● How can the brush be designed to cater to different hair types and lengths? ● How can we design the brush to be recyclable or biodegradable? **Primary goal** The primary goal is to create a brush that detangles hair effectively without causing pain or breakage, while addressing user comfort, safety, market demand, environmental sustainability, and the diverse needs of different users and settings. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what the context of the challenge is.** **What the design needs to do** The design has to focus on the following key aspects: ● **Gentle detangling:** The brush must be able to detangle hair without causing pain or breakage. This involves designing bristles or teeth that can glide through hair smoothly, removing knots and tangles efficiently. ● **Comfortable use:** The brush should be comfortable to hold and use for extended periods. This includes ergonomic features such as a non-slip handle and a shape that fits well in the hand, reducing strain on the user's wrist and arm. ● **Durability:** The materials used in the brush should be high-quality and durable, ensuring that the brush maintains its effectiveness over time and withstands regular use.

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- **Safety:** The brush must be made from safe, non-toxic materials that are gentle on both human hair and pet fur. This is crucial to prevent any adverse reactions or injuries during grooming.
- **Versatility:** The brush should be versatile enough to be used on various hair types and lengths, making it suitable for a wide range of users, including different breeds of pets and individuals with different hair textures.
- **Ease of cleaning:** The design should allow for easy cleaning of the brush to maintain hygiene and prolong its lifespan. This could include features like removable bristles or a self-cleaning mechanism.
- **Enhanced functionality:** Additional features, such as massaging elements or anti-static properties, can enhance the grooming experience and provide added benefits to the user.

Describe the context

The challenge of effectively detangling hair without causing pain or breakage is significant for both pet owners and individuals with long hair. Traditional grooming brushes often fail to address this issue adequately, leading to discomfort and frustration.

The challenge is set within the broader context of improving the grooming experience for pets and individuals with long hair, considering aspects such as: user comfort, effectiveness in detangling, safety of materials, market demand for innovative grooming tools, environmental sustainability, and the diverse needs of different users and settings. This includes addressing the discomfort and inefficiency of traditional brushes, ensuring the brush is gentle and effective, using non-toxic and eco-friendly materials, meeting the growing consumer demand for high-quality grooming products, and providing a versatile tool that can be used in homes, grooming salons, and veterinary clinics.

Target groups

- Pet owners.
- Pets.
- Professional groomers.
- Individuals with long hair.
- Parents and caregivers.
- Veterinarians and veterinary staff.

Benefits

- Improved grooming experience.
- Reduced hair damage.
- Enhanced comfort.
- Versatility.

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	● Durability. ● Safety. ● Ease of cleaning. ● Market appeal. ● Environmental sustainability. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome. Identify the opportunities and the constraints.** **Favourable circumstances, initiatives or legislations** ● Growing demand for eco-friendly products. ● Technological advancements. ● Regulatory standards. ● Industry standards. ● Environmental initiatives. **Limitations or risks** ● Material safety. ● Cost vs. quality. ● Consumer acceptance. ● Durability. ● Regulatory compliance. ● Market competition. ● Environmental impact. ● User experience. **Now it's your turn!**

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A better sewage treatment system

<table>
<tr><th>BIOMIMICRY DESIGN</th><th>Description</th></tr>
<tr><td>Step 1 – Define the challenge</td><td>
1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.
Define the challenge as a question
● How can we develop a sustainable and efficient microplastic removal in sewage treatment plants?
Explanatory questions
● What are the primary sources of microplastics entering sewage treatment plants?
● How do the physical and chemical properties of microplastics affect their removal during treatment processes?
● What are the potential environmental and health impacts of microplastics that are not removed during treatment?
Primary goal
The primary goal is to develop a robust, efficient, and sustainable solution for removing microplastics from sewage treatment plants, effectively capturing and removing microplastics of various sizes and types, and minimising environmental and health risks associated with microplastics.
1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.
What the design needs to do
The design has to focus on the following key aspects:
● Effectively remove microplastics: The primary function is to capture and remove microplastics of various sizes and types from wastewater before it is released into the environment.
● Integrate with existing systems: It should be compatible with current sewage treatment infrastructure to allow for easy implementation and minimal disruption.
● Ensure environmental safety: The process must not introduce new pollutants or harmful by-products into the water or surrounding ecosystem.
● Be cost-effective: The solution should be economically viable for both large-scale municipal plants and smaller, decentralized systems.
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- **Be scalable and adaptable:** The design should be flexible enough to be scaled up or down depending on the size and capacity of the treatment facility.
- **Promote sustainability:** It should use sustainable materials and processes, minimising energy consumption and waste.

Describe the context

One specific challenge in sewage treatment is the inefficient removal of microplastics from wastewater. Microplastics, which are tiny plastic particles less than 5mm in size, pose significant environmental and health risks as they can pass through conventional treatment processes and enter water bodies, affecting aquatic life and potentially entering the human food chain.

The challenge arises from the increasing presence of microplastics in the environment, which are not effectively removed by conventional sewage treatment processes. Microplastics can originate from various sources, including synthetic textiles, personal care products, and industrial processes. They pose significant risks to aquatic life and human health as they can accumulate in the food chain. Addressing this issue is critical for environmental protection, public health, and compliance with stricter environmental regulations. Therefore, the design must provide a robust, efficient, and sustainable solution to enhance current sewage treatment capabilities.

Target groups

- Municipalities and local governments.
- Environmental agencies.
- Sewage treatment plant operators.
- Researchers and innovators.
- General public.

Potential benefits

The challenge could offer several potential benefits, such as:

- Improved water quality.
- Healthier ecosystems.
- Public health protection.
- Regulatory compliance.
- Economic savings.
- Sustainability.
- Innovation and leadership.
- Increased public awareness.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

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	Opportunities ● Technological innovations such as advances in filtration technologies. ● Environmental grants and funding. ● Public awareness campaigns. ● Regulatory frameworks. ● International collaboration. ● Legislative initiatives. **Limitations or risks** ● High initial costs. ● Technical integration. ● Operational complexity. ● Maintenance requirements. ● Regulatory compliance. ● Environmental Impact. ● Public acceptance. **Now it's your turn!**

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BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** ● What are the most environmentally friendly ingredients and packaging options to minimise the ecological impact of the product? **Explanatory questions** ● How do biodegradable ingredients impact terrestrial and marine ecosystems differently compared to conventional ingredients? ● How can packaging design be optimized to reduce waste and improve recyclability or compostability? ● What specific biodegradable ingredients are most effective for sun protection, and how do they compare to traditional ingredients in terms of performance and safety? **Primary goal** The primary goal is to reduce the environmental footprint by focusing on biodegradable ingredients, eco-friendly packaging, and sustainable production practices, while using biodegradable materials that do not harm terrestrial and marine life. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** **Describe the context** The context of the challenge lies at the intersection of several growing global trends and concerns, which include health and wellness, environmental sustainability, skin inclusivity, and consumer demand for more ethical products. These broader themes shape the need for innovative, effective, and eco-friendly sun protection products. **What the design needs to do** ● **Skin sensitivity:** The product must be safe for sensitive skin, avoiding irritation or allergic reactions commonly triggered by chemical sunscreens. ● **Inclusivity:** It should be suitable for a wide range of skin tones, ensuring that it doesn't leave a white or ashy cast

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when applied, which is a common issue with mineral-based sunscreens.

- **Environmental impact:** It needs to be made from eco-friendly, biodegradable ingredients and packaged in a way that minimises environmental harm, particularly in marine ecosystems.
- **Long-lasting protection:** The sunscreen must provide durable protection in real-world conditions, including water exposure, sweat, and daily wear, reducing the need for frequent reapplication.
- **Convenience:** The design should be user-friendly, easy to apply, and cater to diverse lifestyles and routines, encouraging consistent and adequate sun protection.

Target groups

- Individuals with sensitive skin.
- People with darker skin tones.
- Environmental and ecological groups.
- Active outdoor enthusiasts and athletes.
- Eco-conscious consumers.
- Health-conscious consumers.

Potential benefits

- Enhanced skin protection and health.
- Inclusivity for all skin tones.
- Environmental benefits.
- Reduced skin cancer and premature aging.
- Increased consumer trust and brand loyalty.
- Long-term cost savings.
- Educational impact on sun protection habits.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Opportunities

- Rising consumer demand for eco-friendly and ethical products.
- Advancements in skincare technology.
- Increased public awareness of skin health.
- Global movement toward inclusivity in beauty.
- Partnerships and collaborations with environmental organisations.
- Government regulations and incentives.

Constraints

- Formulation challenges for sensitive skin.
- Ingredient availability and cost.
- Regulatory hurdles.
- Consumer misunderstanding or scepticism.

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	● Development of non-white cast formulas for diverse skin tones. ● Environmental impact of packaging. ● Market competition. ● Water resistance and durability. **Now it's your turn!**

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Developing more energy-efficient artificial light sources

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** ● How can we design more energy-efficient artificial light sources to reduce energy consumption and environmental impact? **Explanatory questions** ● What are the most environmentally friendly materials currently available for manufacturing artificial light sources? ● How can we improve the energy conversion efficiency of artificial light sources? ● How can we extend the lifespan of artificial light sources to reduce waste? **Primary goal** The primary goal is to minimise the environmental impact of artificial lighting, encompassing both the materials used and the energy consumed. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what the context of the challenge is.** **What the design needs to do** The design needs to: ● **Enhance energy efficiency:** Explore solutions to reduce the energy consumption of artificial light sources while maintaining or improving light quality. ● **Minimise environmental impact:** Investigate identifying sustainable materials and manufacturing processes to reduce the overall ecological footprint. ● **Ensure cost-effectiveness:** Provide solutions that are affordable for both consumers and businesses, promoting widespread adoption. ● **Improve practicality and usability:** Look into solutions that can be implemented in various settings, such as homes, offices, and public spaces, without requiring significant changes to existing infrastructure.

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- **Promote innovation:** Look into the use of new technologies or the enhancement of existing ones to create more sustainable lighting solutions.

Describe the context

The context of the given challenge is set against the backdrop of increasing global energy consumption and environmental concerns.

With the growing need for sustainable practices, this challenge aims to address the urgent requirement for more energy-efficient and environmentally friendly lighting solutions.

Target groups

- Consumers.
- Businesses.
- Public sector.
- Designers and engineers.

Potential benefits

- Reduced energy consumption.
- Environmental sustainability.
- Enhanced light quality.
- Longer lifespan.
- Economic growth.
- Regulatory compliance.
- Improved public health.
- Increased property value.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Opportunities

- Technological advancements.
- Public authorities incentives.
- Consumer demand.
- Integration with smart systems.
- Daylighting.

Constraints

- Initial costs.
- Technological limitations.
- Regulatory challenges.
- Consumer awareness.
- Compatibility issues.

Now it's your turn!

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BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** ● How can we create high-performance biocomposites for a sustainable future by fusing the sustainability of wood with the performance and productivity of advanced composites? **Explanatory questions** ● What innovative manufacturing processes can be developed to enhance the cost-efficiency of biocomposite production? ● How can we optimise the sourcing of sustainable raw materials to reduce costs without compromising quality? ● What are the potential challenges associated with adopting this new manufacturing process within existing construction practices? **Primary goals** The primary goal of this challenge is to find a way to combine the sustainability of wood with the functionality and versatility of composite materials, allowing for more innovative and fluid architectural designs while maintaining the environmental benefits of using wood. Essentially, it's about creating construction materials that are both eco-friendly and capable of supporting complex, resilient structures. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** **What the design needs to do** ● **Sustainability:** It should use materials that are environmentally friendly and renewable, like wood, to reduce the carbon footprint of construction. ● **Strength and durability:** The materials must be strong enough to support large structures and withstand various environmental stresses over time. ● **Flexibility in design:** The design should allow for more fluid and innovative architectural shapes, moving beyond the limitations of traditional straight beams and planks.

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- **Efficient use of resources:** It should minimise the use of energy and resources in the production and construction processes, making it more cost-effective and less wasteful.
- **Avoidance of weak joints:** The design should address the issue of weak joints that can compromise the integrity of the structure, ensuring that connections between materials are robust and reliable.

Describe the context

While high-performance biocomposites offer significant sustainability benefits and advanced performance characteristics, they can often be more expensive to produce compared to traditional materials. This cost factor can be a barrier to widespread adoption, especially in industries where cost efficiency is critical. Developing cost-effective manufacturing processes and sourcing sustainable raw materials at a competitive price point will be crucial to overcoming this challenge.

Target groups

- Architects and designers.
- Construction industry.
- Environmental organisations.
- Governments.
- Manufacturing of building materials.
- Property owners.
- Local communities.

Locations to be implemented

- Urban development projects.
- Educational institutions such as campuses or libraries.
- Public infrastructures such as parks, recreational facilities, and walkways.
- Residential areas.
- Commercial buildings.

Potential benefits

- Environmental sustainability, such as carbon sequestration and the use of renewable resources.
- Health and well-being by focusing on the improvement of indoor air quality, reducing of stress and improving the overall well-being of the occupants/people.
- Design flexibility, such as innovative architectural design, customisation of areas/ spaces.
- Economic benefits such as the implementation of cost-effective constructions and designs and long-term savings.

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	• Energy efficiency focusing on thermal insulation and energy savings. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.** **Opportunities** • Innovative architectural designs. • Enhanced building performance. • Sustainable urban development. • Economic growth. • Public infrastructure projects. • Education and research. **Constraints** • Material availability. • Cost considerations. • Design and constructing challenges. • Durability and maintenance. • Regulatory and code compliance. • Environmental impact. **Now it's your turn!**

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Smart fishing nets to avoid capturing threatened species

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** ● How can we develop smart fishing nets equipped with sensors inspired by nature to avoid capturing threatened species? **Explanatory questions** ● How can sensors be integrated into fishing nets to identify and avoid threatened species accurately? ● What types of sensor technologies (e.g., AI, machine learning, hydroacoustic sensors) are most effective for real-time species identification in fishing nets? ● How can the data collected by these sensors be used to improve fishing practices and reduce bycatch? How can we ensure that the smart fishing nets are durable and reliable in various marine environments? **Primary goals** The primary goal of this challenge is to develop and deploy smart fishing nets equipped with advanced sensors inspired by nature that can accurately identify and avoid capturing threatened species in real-time. This technology aims to significantly reduce bycatch, enhance the sustainability of fishing practices, and protect marine biodiversity by ensuring that only target species are captured while non-target and endangered species are safely guided away from the nets. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what the context of the challenge is.** **What the design needs to do** ● **Accurate species identifications:** The smart nets must be able to accurately identify different species of fish in real-time to ensure that only target species are captured while threatened or non-target species are avoided. ● **Real-time data processing:** The smart nets need to process data quickly and efficiently to make immediate decisions about which species to capture or release. This involves integrating AI and machine learning algorithms to analyse sensor data

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- **Durability and reliability:** The smart nets must be durable enough to withstand harsh marine environments, including varying water pressures, temperatures, and salinity levels.
- **Energy efficiency:** The smart nets and associated electronics must be energy-efficient to operate for extended periods without requiring frequent maintenance or battery replacements.
- **Minimising bycatch: The** design of the smart nets should effectively reduce bycatch by guiding non-target species away from the nets, thereby protecting marine biodiversity and reducing waste.
- **Ease of integration:** The smart nets should be easy to integrate with existing fishing equipment and practices to encourage widespread adoption by the fishing industry.
- **Cost-effectiveness:** The smart nets must be cost-effective to produce and maintain, ensuring they are accessible to a wide range of fishing operations, from small-scale fishers to large commercial fleets.
- **Compliance with regulations:** The design must comply with international and local fishing regulations and standards to ensure legal and sustainable fishing practices.

Describe the context

The challenge of developing smart fishing nets with sensors inspired by nature is set against the backdrop of increasing concerns about overfishing, bycatch, and the sustainability of marine resources. Modern fishing practices often result in the unintentional capture of non-target species, which can harm marine biodiversity and disrupt ecosystems. There is a growing demand for innovative solutions that can help fishermen target specific species more accurately while avoiding threatened or endangered species. This challenge is also influenced by advancements in sensor technology, artificial intelligence, and machine learning, which offer new possibilities for improving the selectivity and efficiency of fishing operations.

The challenge involves creating innovative fishing nets that use advanced sensor technology, to selectively capture target species while avoiding threatened or non-target species. This approach aims to reduce bycatch, protect marine biodiversity, and promote sustainable fishing practices.

Target groups

- Fishermen and fishing communities.
- Marine conservation organisations.
- Regulatory bodies and governments.

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- Seafood Industry.
- Researchers and scientists.
- Consumers.

Potential benefits

- Reduction in bycatch.
- Sustainable fishing practices.
- Economic benefits for fishermen.
- Enhanced data collection.
- Compliance with regulations.
- Consumer confidence.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Opportunities

- Enhanced selectivity:.
- Targeted fishing.
- Improved data collection.
- Sustainability and conservation:.
- Reduced bycatch.
- Compliance with regulations.
- Economic benefits:.
- Cost savings.
- Market advantage.
- Technological Innovation:.
- Advancements in AI and sensors.
- Collaboration opportunities.

Constraints

- Technical Challenges.
- Sensor accuracy.
- Durability.
- Cost and accessibility:.
- High initial costs.
- Maintenance and repairs.
- Integration with existing practices:.
- Adoption barriers.
- Compatibility.
- Regulatory and ethical considerations:.
- Regulatory approval.
- Ethical concerns.

Now it's your turn!

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Miniaturized and light-weight sensors to assist unmanned underwater vehicles

<table>
<tr><th>BIOMIMICRY DESIGN</th><th>Description</th></tr>
<tr><td>Step 1 – Define the challenge</td><td>
1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.
Define the challenge as a question

How can the development of miniaturised and lightweight sensors enhance the capabilities of unmanned underwater vehicles (UUVs) in performing precise and efficient operations in challenging underwater environments?

Explanatory questions

How do oil contamination and other dangerous conditions impact the operation of UUVs?
How can UUVs be designed to withstand harsh underwater conditions?
What are the potential risks associated with human divers in hazardous underwater environments?

Primary goals
The primary goal is to develop advanced unmanned underwater vehicles (UUVs) that can efficiently navigate and operate in constricted, hazardous underwater environments. These UUVs should be capable of performing detailed inspections and maintenance tasks, thereby improving operational efficiency and reducing the risks associated with human intervention.
1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what the context of the challenge is.
What the design needs to do
The design needs to explore ways to improve the navigation capabilities of unmanned underwater vehicles (UUVs) in tight and complex underwater terrains. This includes ensuring they can move efficiently and avoid obstacles in constricted spaces. Additionally, the UUVs must be capable of withstanding harsh conditions, such as oil contamination and other hazardous environments.
Describe the context
Inspecting certain underwater areas presents significant challenges due to their constricted and hard-to-reach nature. These environments often pose additional hazards, such as oil
</td></tr>
</table>

contamination or other dangerous conditions, making it difficult and unsafe for human divers to operate. The complexity of these underwater terrains requires specialized equipment capable of navigating tight spaces and withstanding harsh conditions.

Traditional unmanned underwater vehicles (UUVs) have been employed to address these challenges, but they often fall short in terms of propulsion and maneuverability. These limitations hinder their effectiveness in performing detailed inspections and maintenance tasks in such demanding environments. The need for advanced UUVs that can efficiently navigate and operate in these difficult conditions is critical for ensuring the safety and success of underwater operations.

The development of more sophisticated UUVs with enhanced propulsion systems and improved maneuverability could revolutionize underwater inspections. By overcoming the current limitations, these advanced vehicles would be able to access and work in previously unreachable areas, providing valuable data and performing essential maintenance tasks. This innovation would not only improve operational efficiency but also significantly reduce the risks associated with human intervention in hazardous underwater environments.

Target groups

- Oil and gas industry.
- Environmental agencies.
- Marine construction firms.
- Naval forces and security agencies conducting surveillance and mine detection.
- Universities and research centers.

Potential benefits

- Enhanced safety: Reduces the need for human divers in hazardous environments, minimizing the risk of accidents.
- Improved efficiency: Advanced UUVs can perform detailed inspections and maintenance tasks more quickly and accurately than traditional methods.
- Cost savings: Decreases operational costs by reducing the need for manned missions and extensive support vessels.
- Access to inaccessible areas: Capable of navigating tight and complex underwater terrains that are otherwise unreachable.
- High-quality data collection: Equipped with advanced sensors and cameras, UUVs can gather precise and comprehensive data.

	1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome. **Opportunities** ● Technological advancements: Continuous improvements in AI, sensor technology, and propulsion systems enhance the capabilities of UUVs. ● Growing market demand: Increasing need for underwater inspections in various industries, including renewable energy and infrastructure development. ● Collaborative projects: Opportunities for partnerships among private companies, government agencies, and research institutions to develop and deploy advanced underwater unmanned vehicles (UUVs). ● Regulatory support: Potential for favourable regulations and funding from governments to promote the use of UUVs in critical sectors. **Constraints** ● High initial costs. ● Issues related to navigation, communication, and power supply in underwater environments. ● Variability in underwater conditions, such as currents and visibility. ● Navigating complex regulatory frameworks for the deployment of autonomous systems in different regions. **Now it's your turn!**

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Enhancing airplane gliding efficiency to reduce greenhouse gas emissions

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** How can greenhouse gas emissions of planes be reduced by improving gliding efficiency? **Explanatory questions** What role do weather conditions play in gliding efficiency, and how can pilots leverage this information? How can advancements in aerodynamics enhance gliding performance? How does gliding efficiency compare to other emission reduction strategies in aviation? **Primary goal** The primary goal of this challenge is to reduce greenhouse gas emissions from aviation by enhancing the efficiency of aeroplanes' gliding. This involves Optimising flight operations to minimise fuel consumption, thereby contributing to a more sustainable and environmentally friendly aviation industry. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** **What the design needs to do** The design needs to look into solutions of improving aerodynamic design to reduce drag and enhance lift, leveraging real-time data for optimal gliding paths, and integrating advanced weather forecasting. Comprehensive pilot training and continuous support are essential for mastering gliding techniques. The focus should be on reducing fuel consumption and monitoring the impact on emissions. **Describe the context** Globally, air travel contributes about 2.5% of total carbon dioxide (CO_2) emissions. When considering transportation emissions specifically, aviation accounts for approximately 11.6%. This makes it a significant, though not the largest, contributor to transportation-related emissions. Thus, the more planes glide, the less fuel they consume. **Target groups** ● Airlines and aviation companies. ● Pilots and flight crew. ● Aerospace engineers and researchers.

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- Regulatory bodies and policymakers.
- Environmental organisations.
- Passengers and the general public.

Environmental impact

- **Reduced emissions:** Enhancing gliding efficiency can significantly lower fuel consumption, leading to a reduction in CO_2 emissions and other greenhouse gases.
- **Sustainability:** Contributing to global sustainability goals by making air travel more environmentally friendly.

Economic savings

- **Fuel cost reduction:** Airlines can save on fuel costs, which is one of the largest operational expenses.
- **Operational efficiency:** Improved fuel efficiency can lead to more cost-effective operations and potentially lower ticket prices for passengers.

Technological advancements

- **Innovation:** Encourages the development of new technologies and materials that can be applied to other areas of aviation and beyond.
- **Enhanced performance:** Better aerodynamic designs and real-time data utilization can improve overall aircraft performance and safety**.**

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Opportunities

Research and development

- **New technologies:** Investing in R&D to develop advanced materials and aerodynamic designs that enhance gliding efficiency.
- **Data analytics:** Utilising big data and real-time analytics to optimise flight paths and gliding phases.

Regulatory support

- Incentives: Governments and regulatory bodies can provide financial incentives or subsidies to encourage airlines to adopt fuel-efficient practices.
- Standards and policies: Establishing industry standards and guidelines that promote sustainable aviation practices.

Collaboration

- **Industry partnerships:** Collaborating with aerospace manufacturers, research institutions, and environmental organisations to drive innovation and implementation.
- **Pilot training programs:** Developing comprehensive training programs to equip pilots with the skills needed to maximise gliding efficiency.

Constraints

	Design limitations: Achieving an optimal balance between lift and drag while maintaining structural integrity can be a complex task. **Weather dependency:** Gliding efficiency can be affected by varying weather conditions, which are often unpredictable. **Initial investment:** High upfront costs for developing and implementing new technologies, as well as training programs. **Cost-benefit analysis:** Airlines must balance the initial investment with long-term savings, which can vary depending on the scale of implementation. **Integration with existing systems:** Ensuring that new strategies and technologies can be seamlessly integrated into current flight operations without disrupting schedules or compromising safety. - Regulatory hurdles: Navigating the regulatory landscape to gain approval for new technologies and practices can be time-consuming and complex. **Now it's your turn!**

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Turkey

Affordable carbon capture and storage

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** Human-developed carbon capture technologies are expensive and energy-intensive, lacking the efficiency and affordability of natural systems. ● How can we design a cost-effective and energy-efficient method for capturing and storing carbon dioxide? **Explanatory questions** ● How do trees and plants capture and store carbon efficiently? ● What makes photosynthesis sustainable and adaptable across various ecosystems? **Primary goal** Develop a scalable and affordable carbon capture solution for industrial and urban settings. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** **Design needs** Create a method that captures CO_2 while using minimal energy and resources. **Target audience** Industries emitting large amounts of CO_2, such as power plants, and urban communities are affected by high carbon emissions. **Setting** Industrial zones and urban areas with high air pollution. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.** Identify the opportunities and the constraints. **Opportunities** ● Increasing awareness of climate change and funding for carbon capture research.

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	● Potential partnerships with renewable energy initiatives. **Constraints** ● High initial costs of implementing biomimetic designs. ● Limited public awareness of bio-inspired solutions. **Now it's your turn!**

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Efficient vertical farming for urban food production

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** Vertical farms face high energy and water demands, making widespread adoption challenging. ● How can we optimise resource use in vertical farms by mimicking nature's multilayered ecosystems? **Explanatory questions** ● How do rainforests distribute sunlight and nutrients across layers? ● How do symbiotic relationships among species enhance growth? **Primary goal** Reduce energy and water consumption in vertical farming systems. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** **Design needs** Ensure efficient use of light, water, and nutrients. **Target audience** Urban farmers and food producers. **Setting** Densely populated cities with limited land availability. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.** **Opportunities** ● Growing demand for locally sourced food. ● Emerging technologies in controlled environment agriculture. **Constraints** ● High initial costs of vertical farming setups. ● Dependence on consistent energy supply for lighting and water systems. **Now it's your turn!**

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Eco-friendly pest control

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** Pesticides are widely used but lead to resistance, environmental harm, and biodiversity loss, while biomimetic alternatives are underdeveloped. ● How can we develop natural, non-toxic methods for controlling agricultural pests? **Explanatory questions** ● How do predator-prey dynamics in nature regulate pest populations? ● What natural substances repel pests without harming ecosystems? **Primary goal** Minimise crop losses while reducing chemical pesticide use. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** **Design needs** Provide effective pest control without ecological harm. **Target audience** Farmers and agricultural cooperatives. **Setting** Diverse farming environments, from small farms to industrial agriculture. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.** **Opportunities** ● Consumer demand for organic produce. ● Advances in biological pest control. **Constraints** ● Potential resistance from pests over time. ● Need for widespread adoption to make an ecological impact.

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Now it's your turn!

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BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the primary goals.** **Define the challenge as a question** ● How can we create sustainable, durable, and lightweight building materials by mimicking natural processes? **Explanatory questions** ● How do seashells or spider silk achieve high strength with minimal materials? ● How does nature create structures that are self-assembling and repairable? **Primary goal** Design building materials that reduce reliance on non-renewable resources while improving efficiency and longevity. **1.b Describe what the design needs to do or solve (not what you will make or design), who your target audience is, and what is the context of the challenge.** **Design needs** Provide an alternative to traditional, resource-intensive construction materials. **Target audience** Construction companies, architects, and urban planners. **Setting** Residential and commercial construction sites worldwide. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.** **Opportunities** ● Rising demand for green buildings and eco-certifications. ● Potential cost savings through lightweight and self-repairing materials. **Constraints** ● Resistance to adopting new materials in conventional construction practices. ● High costs of research and development. **Now it's your turn!**

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Increasing the efficiency of light-emitting devices while reducing energy waste

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the main goals.** **Define the challenge as a question** ● How can we make LEDs more energy-efficient and sustainable? **Explanatory questions** ● How do fireflies achieve such high light efficiency? ● Can this mechanism be integrated into LED design? **Primary goal** Reduce energy consumption in lighting systems globally. **1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.** **Design needs** Enhance light output and reduce heat loss. **Target audience** ● **Manufacturers:** More energy-efficient LED lights. Maximised light output with minimised energy consumption, thus reducing overall operational costs and aligning with the growing demand for energy-saving solutions. ● **Urban planners:** Enhanced urban lighting with minimal energy consumption, supporting sustainable city initiatives. ● **Urban residents:** Enhanced street lighting improves safety while lowering municipal energy consumption costs. ● **Households:** Lower electricity bills and improved lighting quality with brighter, more energy-efficient LEDs. ● **Energy conservationists:** Advocate for the widespread adoption of energy-efficient lighting to combat climate change. ● **Environmental advocates:** Reduced energy demand leads to lower carbon emissions and less strain on power grids. **Context** Urban and rural lighting systems, including streetlights and household use. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.** **Opportunities**

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	● Growing adoption of LED lighting. ● Supportive policies for energy-efficient technologies. **Constraints** ● Initial R&D costs. ● Compatibility with existing LED production methods. **Now it's your turn!**

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Reducing glare and improving visibility in optical devices and solar panels

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the main goals.** **Define the challenge as a question** ● How can we reduce glare and improve the efficiency of optical devices and solar panels? **Explanatory questions** ● How do moth eyes minimize light reflection? ● Can this principle be applied to glass or plastic surfaces? **Primary goal** Increase visibility and efficiency in optical devices and energy systems. **1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience and what is the context of the challenge.** **Design needs** Reduce glare in devices and enhance light absorption in solar panels. **Target audience** ● **Solar energy providers:** Increased panel efficiency leads to more energy production and profitability. ● **Electronics manufacturers:** Develop products with enhanced screen clarity, improving user satisfaction. ● **Eco-conscious consumers:** Access to products that maximise energy use and minimize light waste. ● **Consumers**: Enhanced screen visibility for electronics, improved solar panel efficiency, and better user experience with anti-glare products. ● **Environmental advocates:** More efficient solar panels contribute to increased renewable energy adoption and reduced carbon emissions. **Context** Devices like smartphones, tablets, and outdoor solar installations. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.** **Opportunities** ● Demand for improved device screens and renewable energy. **Constraints**

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	● Precision required for nanoscale manufacturing. ● Durability of coatings in harsh conditions. **Now it’s your turn!**

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Lightweight, durable materials for space exploration

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the main goals.** **Define the challenge as a question** ● How can we create lightweight, durable materials for spacecraft and habitats by studying nature's structural designs? **Explanatory questions** ● How do structures like bones or honeycombs achieve strength with minimal weight? ● What natural systems can self-heal under stress? **Primary goal** Enhance material performance under extreme conditions while reducing launch costs. **1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience and what is the context of the challenge.** **Design needs** Provide innovative materials for space exploration. **Target audience** Space agencies and private aerospace companies. **Setting** Spacecraft, space habitats, and extraterrestrial environments. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.** **Opportunities** ● Increasing investments in space exploration. ● Collaboration opportunities with advanced material science labs. **Constraints** ● Harsh conditions in space that test material limits. ● High costs of experimentation and prototyping. **Now it's your turn!**

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Smog-reducing urban infrastructure

<table>
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<tr><td>Step 1 – Define the challenge</td><td>
1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the main goals.
Define the challenge as a question
How can we design urban structures that reduce air pollution by mimicking natural processes?
Explanatory questions
How do forests filter pollutants and produce clean air?
What surfaces in nature naturally capture airborne particles?
Primary goal
Reduce smog levels in urban environments through biomimetic design.
1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience and what is the context of the challenge.
Design needs
Address air pollution in cities with high vehicular emissions and industrial activity.
Target audience
City planners, environmental organisations, and governments.
Setting
High-density urban areas with poor air quality.
1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.
Opportunities
Public health initiatives aimed at reducing air pollution.
Emerging technologies in air filtration and green infrastructure.
Constraints
High costs of retrofitting existing infrastructure.
Limited space for large-scale green projects.
Now it’s your turn!
</td></tr>
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BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the main goals.** **Define the challenge as a question** ● How can we design efficient cargo transportation systems by mimicking nature's energy-saving movement strategies? **Explanatory questions** ● How do migratory animals optimise their energy use over long distances? ● What mechanisms help organisms transport heavy loads efficiently? **Primary goal** Reduce energy consumption in cargo transport and increase efficiency. **1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.** **Design needs** Optimize logistics for large-scale cargo movement while reducing emissions. **Target audience** Logistics companies, freight industries, and environmental organisations. **Setting** Global shipping routes include land, sea, and air. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.** **Opportunities** ● Advances in smart transportation technologies. ● Growing pressure to decarbonize freight systems. **Constraints** ● High upfront costs for bio-inspired innovations. ● Regulatory challenges in international logistics. **Now it's your turn!**

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BIOMIMICRY DESIGN	**Description**
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the main goals.** **Define the challenge as a question** ● How can we efficiently generate renewable energy from slow-moving water by mimicking natural hydrodynamics? **Explanatory questions** ● How do fish and aquatic plants extract energy from slow currents? ● What natural mechanisms enhance energy transfer in low-flow environments? **Primary goal** Develop low-impact, efficient systems for harnessing energy from slow-moving rivers and streams. **1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.** **Design needs** Meet energy demands in regions lacking high-flow water bodies while preserving aquatic ecosystems. **Target audience** Energy providers, rural communities, and environmental organisations. **Setting** Small rivers, canals, and irrigation systems in energy-scarce regions. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.** **Opportunities** ● Growing demand for decentralised renewable energy systems. ● Advances in biomimetic turbine design. **Constraints** ● Limited flow rates in small water bodies. ● Potential disruptions to aquatic habitats. **Now it's your turn!**

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Spain

Create a new tough, flexible and light material for body armours

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the main goals.** **Define the challenge as a question** How can we create a new, though, flexible and light material that can be used to make body armour? **Explanatory questions** How important is it for body armour to maintain comfort and mobility? In what ways could the new body armour be adapted to protect against different types of threats, such as high-impact projectiles? **Primary goal** The main goal is to create lightweight, flexible, and highly protective armour that can adapt to various threats and potentially have applications in different high-risk fields. **1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.** **Design needs** The design aims to provide high levels of protection while maintaining mobility and comfort, making it suitable for soldiers, law enforcement, and civilians in high-risk environments. **Context** Researchers are developing a new type of body armour inspired by the Arapaima fish, known for its tough, flexible scales that protect it from piranha attacks. This bio-inspired armour aims to provide high levels of protection while maintaining mobility and comfort, making it suitable for soldiers, law enforcement, and civilians in high-risk environments. The Arapaima's scales have a hard, mineralized outer layer and a tough, collagen-based inner layer, allowing them to deform without breaking. This structure provides a model for creating advanced body armour that balances toughness and flexibility. Modern body armour needs to adapt to various threats, including high-impact projectiles, while ensuring the wearer remains agile.

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Materials scientists are utilising advanced techniques, such as 3D printing and nanoengineering, to replicate and enhance the natural structure of Arapaima scales. By combining strong nanomaterials with bio-inspired designs, they aim to develop lightweight, flexible, and highly protective armour. These innovations could also have applications in the aerospace industry.

Target group

- 1. Military personnel.
- 2. Law enforcement and security forces.
- 3. Defence contractors and manufacturers.
- 4. Research institutions and universities.
- 5. Medical and healthcare professionals.
- 6. First responders and aid workers.
- 7. Civilians and high-risk professionals.
- 8. Legal and regulatory bodies.
- 9. Economists and environmentalists.
- 10. Insurance companies.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Connections to other solutions or challenges

- **Other bio-inspired solutions:** Spider silk-inspired fibres, Abalone shell-inspired ceramics, Shark skin-inspired surfaces.
- **Nanotechnology and advanced composites:** Carbon nanotubes, Graphene.
- **Smart materials and adaptive armour:** Shear-thickening fluids (STF), Self-healing materials.
- **Environmental sustainability:** Biodegradable or renewable polymers, Circular economy.
- **Human factors and ergonomics:** Augmented reality displays, Health monitoring systems.
- **Logistics and supply chain efficiency:** Reduced fuel costs.
- **Health and safety impacts:** Back and joint pain prevention.
- **Defence against emerging threats:** Laser and directed energy weapons.

Favourable circumstances, initiatives or legislation

- Defence research programs.
- Public-private collaborations.
- Sustainability and environmental legislation.
- Patent Protection for bio-inspired materials: .
- Next-Generation soldier programs.
- Health and safety legislation.
- Technological standards and testing protocols.
- Global defence trade agreements.

Limitations or risks

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	● **Performance and testing uncertainty:** Unknown long-term durability, Complex threat spectrum. ● **Complexity in material synthesis and engineering:** Replicating the hierarchical structure, Materials compatibility. ● Manufacturing challenges and scalability: Scaling up production, Cost of production. ● **Weight vs. protection trade-off:** Balancing lightness with protection. ● **Integration with Other Technologies:** Compatibility with existing armour systems, Smart armour integration. ● **Regulatory and certification challenges:** Meeting regulatory standards, Unforeseen regulatory barriers. ● **Supply chain vulnerabilities:** Dependence on specialized materials. ● **Environmental and ethical concerns:** Ethical considerations. **Now it's your turn!**

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Preventing landslides inspired by tree root systems

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<tr><td>Step 1 – Define the challenge</td><td>
1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the main goals.
● Define the challenge as a question
How can we stabilise soil on slopes to prevent landslides using a biomimetic strategy inspired by tree root systems?
Explanatory questions
● How do trees use root systems to stabilise themselves and the surrounding soil?
● Can we replicate the root anchoring function with human-made materials or structures?
● What role do soil composition and water flow play in slope failure?
Primary goal
The primary objective is to develop a structural system or surface treatment that mimics root systems to stabilise soil on steep slopes and prevent landslides, particularly in vulnerable or deforested areas.
1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.
Design needs to do
● Prevent or delay landslides by improving slope stability.
● Function in areas where tree planting is not immediately viable.
● Be compatible with soil and hydrological conditions.
● Be affordable, durable, and environmentally friendly.
Describe the context
Landslides are a significant hazard in mountainous or deforested regions, causing loss of life, damage to infrastructure, and environmental degradation. Trees naturally stabilise soil with their root networks. In many degraded environments, reforestation is too slow or not possible due to terrain or weather. A nature-inspired mechanical or structural system can provide immediate stabilisation.
Target groups
● Civil and environmental engineers.
● Disaster relief agencies.
● Municipal governments.
● Road and rail infrastructure authorities.
● Communities in landslide-prone zones.
1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.
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</table>

Connections to other solutions or challenges

- Erosion control systems.
- Geoengineering and landscape design.
- Ecosystem restoration and land reclamation.
- Soil health and hydrology management.

Favourable circumstances, initiatives, or legislation

- Climate adaptation programs.
- Infrastructure resilience grants.
- Policies promoting green and bioengineered solutions.
- Increased awareness of climate-induced hazards.

Limitations or risks

- Variability in slope and soil condition
- Installation costs and time
- Material biodegradability vs. longevity
- Need for maintenance or monitoring

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Reducing vehicle drag using boxfish-inspired aerodynamics

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the main goals.** **Define the challenge as a question** ● How can we reduce aerodynamic drag in vehicles without compromising stability and safety, using nature-inspired shapes? **Explanatory questions** ● How do aquatic animals manage efficient movement through dense fluids? ● What features of the boxfish's shape help it move efficiently? ● Can a boxy yet aerodynamic form be applied to land vehicles to improve fuel efficiency? **Primary goal** The goal is to create an energy-efficient vehicle body design that minimises drag and turbulence while maximising stability, inspired by the hydrodynamic properties of the boxfish. **1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.** **Design needs** ● Reduce aerodynamic drag and improve fuel efficiency. ● Maintain safety, handling, and interior space. ● Be manufacturable and aesthetically acceptable for road use. **Describe the context** As the automotive industries strive for greater energy efficiency and reduced emissions, aerodynamics plays a crucial role. Streamlined, nature-inspired vehicle designs can reduce drag and improve fuel economy. The boxfish, despite its angular shape, demonstrates low drag and high stability due to unique flow dynamics around its body. Translating this into vehicle design could offer surprising benefits. **Target groups** ● Automotive manufacturers and designers. ● Electric vehicle developers. ● Transportation policy and sustainability consultants. ● Urban mobility solution providers. **1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.** **Connections to other solutions or challenges**

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	● Vehicle efficiency standards. ● Lightweight and aerodynamic materials. ● Smart city and e-mobility initiatives. ● Marine and aerospace bioinspired transport design. **Favourable circumstances, initiatives, or legislation** ● Growing EV market. ● Fuel economy regulations. ● Innovation grants for sustainable mobility. ● Consumer interest in eco-friendly design. **Limitations or risks** ● Public perception of unconventional vehicle shapes. ● Manufacturing feasibility and material limits. ● Regulatory crash testing and safety standards. ● Aerodynamic vs. structural trade-offs. **Now it's your turn!**

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Anti-clogging medical stents inspired by shark skin

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<tr><td>Step 1 – Define the challenge</td><td>
1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the main goals.

Define the challenge as a question
● How can we design medical stents that resist clogging and bacterial biofilm formation without using drugs or chemicals?

Explanatory questions
● How does shark skin resist microbial colonization in marine environments?
● What surface textures or microstructures in nature reduce adhesion?
● Can those principles be applied to tiny, medical-grade devices like stents?

Primary goal
The goal is to develop medical stents with passive, drug-free surface structures inspired by shark skin to reduce the risk of clogging, bacterial growth, and complications in long-term use.

1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.

Design needs
● Prevent biofilm and clot formation in stents and catheters.
● Avoid reliance on chemical coatings or antibiotics.
● Maintain function and flow in medical implants over time.

Describe the context
Stents and catheters are commonly used medical devices that can become blocked by biological buildup. Current solutions use drug-eluting coatings, which may cause resistance or complications. In nature, shark skin prevents microbial buildup via a pattern of tiny, diamond-shaped scales (dermal denticles) that disrupt bacterial attachment. Mimicking this strategy offers a passive solution for long-term medical implants.

Target groups
● Biomedical device manufacturers.
● Hospitals and clinics.
● Researchers in biomaterials and microfabrication.
● Regulatory agencies promoting low-risk implantable devices.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.
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	Connections to other solutions or challenges ● Anti-fouling marine surfaces. ● Antimicrobial surfaces for high-touch environments. ● Drug-free medical technologies. ● Microfabrication in medical device innovation. **Favourable circumstances, initiatives, or legislation** ● Push for antibiotic-free infection control. ● Advances in nanostructured material production. ● Favourable patent environment for bioinspired materials. **Limitations or risks** ● Difficulty in replicating microscopic patterns on medical-grade materials. ● Biocompatibility testing requirements. ● Scalability for mass production. ● Long-term validation in clinical settings. **Now it's your turn!**

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Earthquake-resilient buildings inspired by bamboo flexibility

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the main goals.** ● **Define the challenge as a question** How can we design buildings that withstand earthquakes by incorporating flexible and energy-dissipating structures inspired by bamboo? **Explanatory questions** ● How does bamboo maintain strength while bending in high winds or during seismic activity? ● What natural materials or structural arrangements offer shock absorption and flexibility? ● Can we mimic bamboo's segmented yet unified architecture in modern building design? **Primary goal** To develop building structures that flex and absorb seismic energy, reducing collapse risk, inspired by the segmented, flexible, and strong morphology of bamboo culms. **1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.** **Design needs** ● Withstand seismic forces by dissipating energy through structure. ● Remain safe and functional after seismic events. ● Be applicable to urban or rural environments, especially in earthquake-prone areas. **Describe the context** Conventional buildings often fail under seismic stress due to their rigidity. In contrast, bamboo sways and bends during strong winds or tremors, reducing stress concentrations. Its natural segmentation, hollow structure, and fiber-reinforced nodes offer a model for designing earthquake-resilient structures that bend rather than break. **Target groups** ● Architects and civil engineers. ● Emergency housing designers. ● Municipalities in seismically active regions. ● NGOs working on resilient infrastructure.

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	1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome. **Connections to other solutions or challenges** ● Sustainable and disaster-resilient architecture. ● Use of renewable materials in construction. ● Modular and prefabricated housing innovations. **Favorable circumstances, initiatives, or legislation** ● Earthquake rebuilding grants. ● Green building initiatives promoting local, natural materials. ● Urban resilience policies in vulnerable cities. **Limitations or risks** ● Need for rigorous safety testing and certification. ● Community resistance to new or unfamiliar materials. ● Supply and processing of bamboo or bamboo-inspired materials. ● Integration with existing building codes and construction systems. **Now it's your turn!**

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Pollution-filtering urban walls inspired by coral reefs

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the main goals.** **Define the challenge as a question** ● How can we design building facades or urban walls that passively filter air and water pollution in cities, inspired by coral reef structures? **Explanatory questions** ● How do coral reefs filter particles from water while maintaining flow? ● What surface features in coral enable trapping of particulates and microbial processing? ● Can these structures be mimicked in a durable and scalable architectural form? **Primary goal** To develop multifunctional urban walls or facades that **capture pollutants from air and water runoff** through coral-inspired surface complexity and bioactivity, improving urban environmental quality. **1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.** **Design needs** ● Withstand seismic forces by dissipating energy through the structure. ● Remain safe and functional after seismic events. ● Be applicable to urban or rural environments, especially in earthquake-prone areas. **Design needs** ● Remove or capture pollutants like PM2.5, dust, NOx, and heavy metals from rainwater. ● Work passively with air or water movement. ● Blend into or enhance architectural spaces. **Describe the context** Urban areas are affected by high levels of **airborne and waterborne pollutants**, often with limited space for traditional filtration systems. Coral reefs passively filter water, trap sediments, and even host microbes that break down contaminants. Urban architecture can adopt these design strategies to purify runoff and improve air quality with minimal energy use.

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Target groups

- Architects and urban designers.
- City councils and environmental departments.
- Developers of smart buildings or eco-infrastructure.
- Green wall and façade manufacturers.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Connections to other solutions or challenges

- Vertical gardens and green facades.
- Rainwater management systems.
- Passive filtration of stormwater and smog.
- Bio-integrated or nature-based infrastructure.

Favorable circumstances, initiatives, or legislation

- Green infrastructure incentives.
- LEED and BREEAM certifications.
- EU urban sustainability targets.
- Circular economy initiatives in construction.

Limitations or risks

- Pollution build-up and clogging over time.
- Need for periodic maintenance.
- Structural integration and load considerations.
- Climate-specific effectiveness (rain, air flow, etc.).

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Noise-reducing barriers inspired by owl feathers

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<tr><td>Step 1 – Define the challenge</td><td>
1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the main goals.
Define the challenge as a question
How can we design noise-reducing barriers that absorb or scatter sound efficiently without relying on heavy or synthetic materials, inspired by owl feathers?
Explanatory questions
How do owls achieve silent flight?
What structures in owl feathers reduce aerodynamic noise?
Can these features be translated into surfaces that minimize sound reflection and transmission?
Primary goal
To create passive acoustic barriers or panels that dampen environmental noise using surface structures inspired by the microgeometry of owl feathers.
1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.
Design needs
Reduce unwanted noise in urban, transport, or indoor environments.
Be light, sustainable, and adaptable to various structures.
Work passively, without requiring energy input.
Describe the context
Noise pollution from traffic, trains, airports, and construction sites negatively impacts human health and quality of life. Traditional sound barriers are often bulky, unattractive, or ineffective at high frequencies. Owls use a combination of serrated leading edges, velvety surfaces, and fringed trailing edges on their wings to fly silently, offering a natural blueprint for sound-dampening design.
Target groups
City planners and architects.
Transportation authorities.
Acoustic engineers.
Designers of public spaces and interiors.
1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.
Connections to other solutions or challenges
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	● Urban noise mitigation programs. ● Smart materials for acoustic control. ● Green and livable city initiatives. ● Wildlife-safe transport infrastructure. **Favourable circumstances, initiatives, or legislation** ● Regulations limiting decibel levels in residential zones. ● Building standards for acoustics in public buildings. ● EU “Quiet Cities” directives and traffic noise buffers. **Limitations or risks** ● Durability of microstructured materials outdoors. ● Cost of manufacturing complex geometries. ● Performance consistency across frequency ranges. ● Maintenance and cleaning of textured surfaces. **Now it’s your turn!**

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Light-capturing solar panels inspired by butterfly wings

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the main goals.** **Define the challenge as a question** ● How can we increase the light absorption efficiency of solar panels, especially under diffuse light or oblique angles, by mimicking the structural colouration and light manipulation strategies of butterfly wings? **Explanatory questions** ● How do butterfly wings reflect and refract light to create vivid colours? ● What microscopic structures enable butterflies to capture or redirect light? ● Can these natural features be replicated on solar panel surfaces to improve efficiency? **Primary goal** To enhance the energy capture efficiency of solar panels utilising light-scattering microstructures inspired by the wings of butterflies, particularly under non-optimal lighting conditions such as cloudy weather or low-angle sunlight. **1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.** **Design needs** ● Maximise solar energy collection in variable light conditions. ● Reduce energy losses from light reflection or shallow incidence. ● Enhance efficiency without significantly increasing cost or material use. **Describe the context** Conventional photovoltaic (PV) panels lose efficiency under low light, shade, or oblique sun angles. Butterflies—especially species like the **blue morpho**—have evolved complex wing microstructures that scatter, trap, or manipulate light for visibility and heat absorption. These same principles can be applied to **enhance light capture in solar panels**, improving energy yields in real-world conditions. **Target groups** ● Solar panel manufacturers and engineers. ● Architects working with building-integrated photovoltaics (BIPV).

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- Energy providers in cloudy or high-latitude regions.
- Environmental technology developers.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.

Connections to other solutions or challenges

- Transparent or semi-transparent solar technologies.
- Self-cleaning or anti-reflective coatings.
- Passive light concentrators for photovoltaics.

Favourable circumstances, initiatives, or legislation

- Renewable energy subsidies.
- Climate action policies supporting solar R&D.
- Building codes encouraging BIPV integration.

Limitations or risks

- Cost and scalability of nano-texturing techniques.
- Durability of surface structures under environmental exposure.
- Tradeoffs between transparency and absorption in thin-film applications.

Now it's your turn!

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Self-cleaning textiles inspired by lotus leaves

<table>
<tr><th>BIOMIMICRY DESIGN</th><th>Description</th></tr>
<tr><td>Step 1 – Define the challenge</td><td>
1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the main goals.
Define the challenge as a question
How can we design textiles that naturally repel water and dirt, reducing the need for frequent washing and harsh detergents?
Explanatory questions

How do lotus leaves stay clean despite being in muddy environments?
What surface features prevent water and particles from adhering to lotus leaves?
Can we replicate this “self-cleaning” mechanism in wearable fabrics?

Primary goal
To develop durable, breathable, and water-repellent textiles that stay clean through passive surface design, minimising water use and chemical cleaning.
1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.
Design needs

Repel water, oils, and dirt from clothing or gear.
Be breathable and skin-friendly.
Remain effective over time and after washing cycles.

Describe the context
Washing textiles contributes to water consumption, chemical runoff, and microplastic pollution. Lotus leaves repel dirt and water by combining micro- and nano-scale surface textures with hydrophobic wax coatings. Mimicking this strategy could help create eco-friendly, low-maintenance clothing and technical fabrics for various applications.
Target groups

Fashion and textile designers.
Outdoor and sportswear brands.
Hospitals and medical clothing producers.
Uniform suppliers for military, emergency, or industrial use.

1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome.
</td></tr>
</table>

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	Connections to other solutions or challenges ● PFAS-free water-repellent treatments. ● Sustainable fashion and closed-loop textile production. ● Hygiene and health care textiles. ● Anti-stain and odour-resistant materials. **Favourable circumstances, initiatives, or legislation** ● Growing ban on harmful chemical coatings (PFAS). ● Support for eco-fashion and green chemistry. ● Consumer demand for durable, easy-care clothing. **Limitations or risks** ● Cost and durability of microstructured textile surfaces. ● Performance degradation after washing or abrasion. ● Ensuring softness, stretch, and comfort with added features. **Now it's your turn!**

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Algae-inspired water collection in arid regions

BIOMIMICRY DESIGN	Description
Step 1 – Define the challenge	**1.a Describe a specific challenge that you have identified and that you want to solve through your design. Define the exploratory questions and set the main goals.** **Define the challenge as a question** ● How can we collect water from the air or dew in arid and semi-arid environments by mimicking strategies used by algae and other moisture-capturing organisms? **Explanatory questions** ● How do algae survive and absorb water in dry, low-humidity environments? ● What microstructures or chemical adaptations do they use? ● Can these features be translated into passive water-harvesting technologies? **Primary goal** To develop **passive, low-energy water collection systems** for dry regions, inspired by **algae's ability to absorb and retain moisture from the air**, dew, or fog. **1.b Describe what the design needs to do or solve (not what you will make or design), who is your target audience, and what is the context of the challenge.** **Design needs** ● Capture and store water from ambient air sources (dew, fog, humidity). ● Function in remote, arid environments without external energy. ● Be simple to install, scalable, and sustainable. **Describe the context** Water scarcity is one of the most urgent global challenges, particularly in **desert and mountain communities** where groundwater is unavailable and rainfall is scarce. Algae (and other extremophile organisms) have evolved **surface structures and hydrophilic molecules** that allow them to collect water from the air and retain it for survival. Replicating these strategies can support **off-grid water supply solutions**. **Target groups** ● Communities in dry and remote regions. ● Humanitarian aid and disaster relief organisations. ● Agricultural developers in arid zones. ● Designers of portable water systems for nomadic or military use.

	1.c Identify the opportunities and/ or constraints that might impact achieving a successful outcome. **Connections to other solutions or challenges** ● Fog-harvesting mesh technology. ● Dew condensers and atmospheric water generators. ● Smart textiles and hydrophilic surface coatings. **Favourable circumstances, initiatives, or legislation** ● SDG Goal 6 (Clean Water and Sanitation). ● UN water resilience projects. ● Government subsidies for drought resilience innovation. **Limitations or risks** ● Variability in air humidity. ● Material degradation in desert environments. ● Community adoption and maintenance training. ● Harvesting limits based on geography and season. **Now it's your turn!**

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To be filled in by students during piloting

BIOMIMICRY DESIGN	Description
Step 2 – Biologise	2.a Ask yourself “How can nature solve this?” 2.b Ask yourself “What do I want my design to do?” 2.c Flip the question.
Step 3 – Discover	3.a Search for natural models that match the same functions and context as your design solution. 3.b Identify experts & connect to communities of biologists and naturalists.
Step 4 – Abstract	4.a Summarise the key elements of the biological strategy. Highlighting the core functions and keywords. If possible, make a diagram/ drawing and/ or find images that can inform the design. 4.b Translate lessons from nature into design strategies. Rewrite the strategy without using biological terms and connect it to the functions and the context from a human perspective.
Step 5 – Emulate	5.a List your key information and explore as many ideas as possible. 5.b Organise your ideas into categories that include the features, the context, the constraints, etc. and select the design concepts that best fit your solution.
Step 6 – Evaluate	6.a Evaluate the design concept(s) concerning their alignment with the design challenge's criteria and constraints, as well as their compatibility with Earth's systems. Assess the feasibility of both the technical and business models. 6.b Revise and revisit previous steps as necessary to generate a viable solution.

Additional resources:

https://biomimicry.org

https://asknature.org

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