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CHEMISTRY AND MATERIALS
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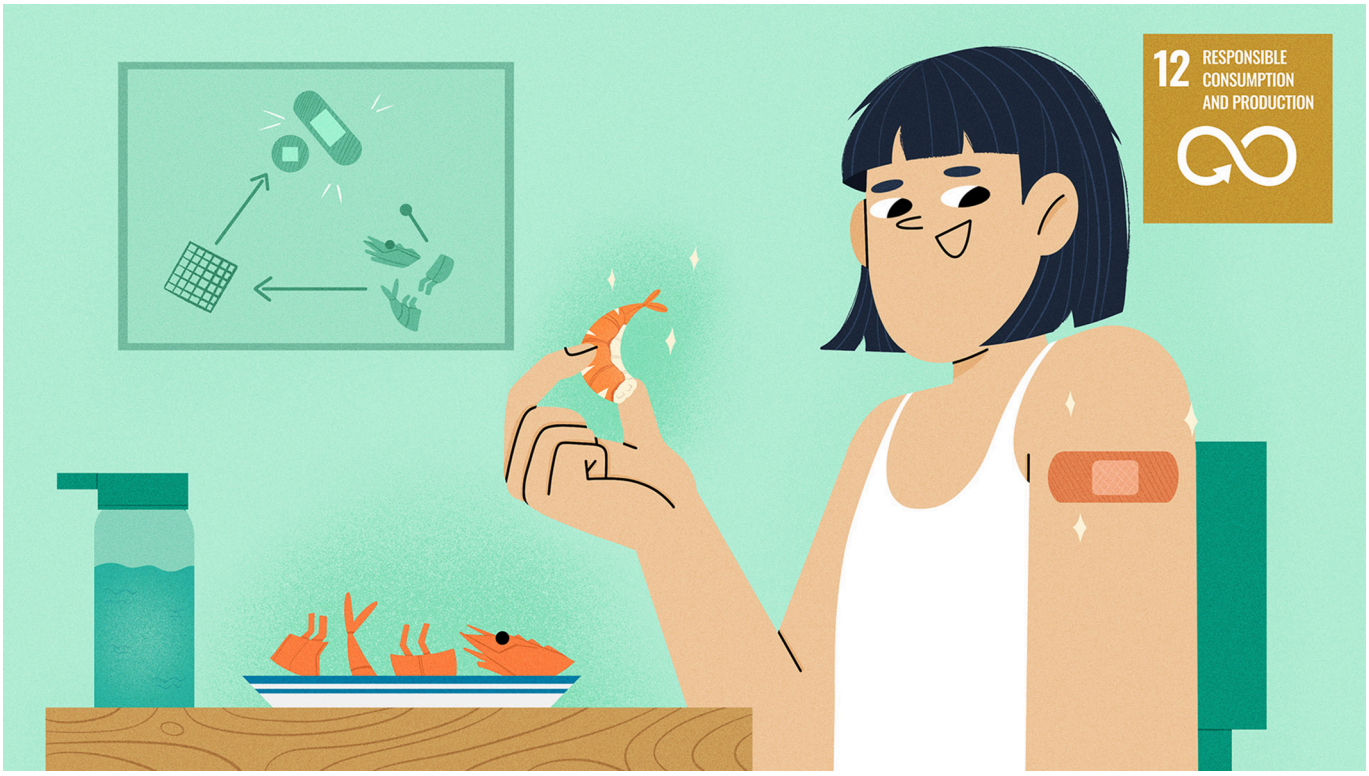

TOWARDS SDG 12: UPCYCLING BIOMASS AND WASTE TO VALUABLE PRODUCTS

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YOUNG REVIEWERS:


KARIM
AGE: 12


SANTI
AGE: 11


SARAH
AGE: 14


ARNAU
AGE: 12

Sustainable Development Goal 12 (SDG 12) is a goal of the United Nations that focuses on responsible consumption and production... but what does this mean? It means that we should use the materials around us in ways that prevent them from being wasted, and that we should produce them without harming the planet. SDG 12 aims for a better world. It is important to work toward this goal because Earth's population is growing, and more resources are being used. Eventually humans will ruin the planet if we do not start acting. We must make sure we are protecting the planet and its resources for the people born in the future. Science can help achieve this goal in many ways. In this article, you will learn about several environmentally friendly methods of producing new materials from waste, including the use

of normally discarded parts of living things, like plant leaves and shrimp shells.

Watch an interview with the authors of this article to learn even more! (Video 1).

VIDEO 1

Watch an interview with the authors of this article to learn even more!

SUSTAINABLE DEVELOPMENT GOAL 12

Sustainable Development Goal 12 (SDG 12) is all about responsible consumption (use of resources) and production (creation of materials). The aim of SDG 12 is for all the world's countries to promise to take care of our planet. Reducing the amount of waste materials humans produce is good for the environment and also helps to save important resources, like plants, food, and energy. If we do not conserve them, resources will be used up and will not be available for future generations. This is where SDG 12 comes in, to help us find **sustainable** materials such as wood and solar energy, which can help us to keep the planet beautiful and healthy for the future.

SUSTAINABILITY

It is a common goal for people to be able to co-exist on Earth over a long time. It takes into account the needs of future generations.

There are several important ways to achieve SDG 12 (Figure 1) [1]. **Recycling** is perhaps the best-known way. For example, we can dispose of recyclable materials in special bins instead of throwing them into the trash. These materials then go to a factory where they are destroyed and made into new versions of the same (or very similar) material. For example, glass bottles can be made into new bottles or glass jars. Other factories use even more science to transform waste materials into goods that are quite different from the original material, which is called **upcycling**. In upcycling, a material that is not needed anymore is used to create something useful, with higher value than the original material. For example, if you take a t-shirt you no longer

RECYCLING

Taking waste material, such as empty water bottles, to be processed, cleaned, and fixed to be used again.

UPCYCLING

Transforming old materials to make new and exciting things of higher value. For example, turning an old, unsafe ladder into a fancy bookshelf.

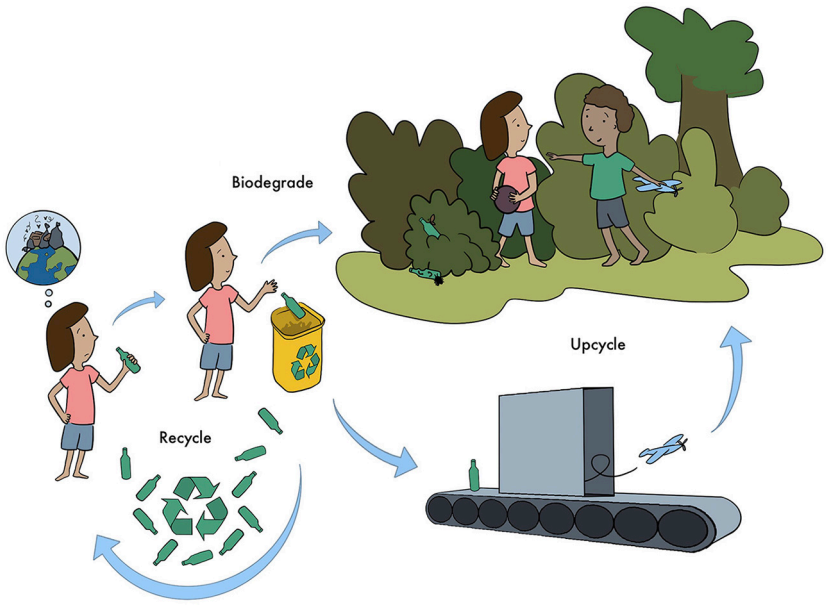

Figure 1

Our trash can pile up and pollute the environment, or it can be recycled into the same product, upcycled into more valuable products, or can break down naturally in the environment (biodegrade) if it is made of the right materials. Which choice do you think is better and why? Do you know what happens with your waste at home and school?

Figure 1

need and turn it into a tote bag, this is upcycling—you have completely changed the t-shirt into something new and useful! Both recycling and upcycling help to achieve SDG 12, as things that we are throwing away become usable products.

MATERIALS THAT BREAK DOWN NATURALLY

BIOMASS

Waste parts from plants and animals that can be renewed or regrown. Biomass can be used to make new and useful things.

BIODEGRADE

When waste materials, often made from biomass, are broken down in nature.

Have you noticed that shopping bags used to be made from harmful plastic, but some shops have replaced these bags with paper bags or with new kinds of plastics that can break down naturally in the environment? When the older type of plastic bags are thrown in the trash, they pollute the land and the oceans, and they stick around for centuries. But new bags are made of a natural material called **biomass**, and they **biodegrade**. Biodegrading means that these bags are part of a natural cycle—they break down in the environment and become part of new plants.

Biodegrading is a good method of breaking down materials. The way we currently handle most of our trash is not very good for the environment. Landfills are getting full because there is so much waste, and as landfills grow, they have negative effects on the people and animals nearby. Scientists are looking at ways to manage all the trash better. They are trying to create products in ways that use less energy and make less mess, to protect our planet and continue to work toward SDG 12 and other environmental goals [2].

WHAT IS BIOMASS?

RENEWABLE

Renewable resources replenish themselves at similar rate they are used, while a non-renewable resources continuously deplete and have limited supply.

MEMBRANE

A thin sheet with holes in it that allows some things to go through but not others, often dependent on size.

Biomass is a very cool mix of materials made by living organisms, such as plants and animals. For example, farming waste, including the leaves of corn plants or date palms, and animal waste, such as bones or fat, are types of biomass. These materials will always be available because they are constantly produced, and they are compatible with natural cycles. A material that will never run out is called **renewable**. It is sustainable because we can get more of it like a gift that will never run out, so it will also be available for the people of the future.

Biomass is a big deal in science and engineering because of its good properties. It is available worldwide and it does not produce any chemical waste, which is great for nature. When we finish using products made from biomass, we can easily get rid of them because they do not contain any harmful stuff that will harm the environment when they break down.

Membranes are one class of useful things that can be made of biomass. A membrane is a thin layer that can act as a wall to separate objects according to their sizes. Figure 2 shows examples of membranes, some of which are useful in our everyday lives. Currently, many membranes are made from fossil-based chemicals.

Figure 2

A pasta strainer is used as a membrane to keep pasta in, while letting water drain away. A tea bag is also a membrane, as it keeps the tea leaves inside and allows the water and flavors through. A filter in a fish tank keeps the dirty stuff out of the water, keeping the tank clean so the fish stay alive. A face mask acts as a membrane because it allows air to pass through but keeps viruses and bacteria out to prevent illness. On a very tiny scale, membranes are used to filter water and remove nasty chemicals.

NANOFILTRATION

The process of separating very small molecules that cannot be seen by the naked eye.

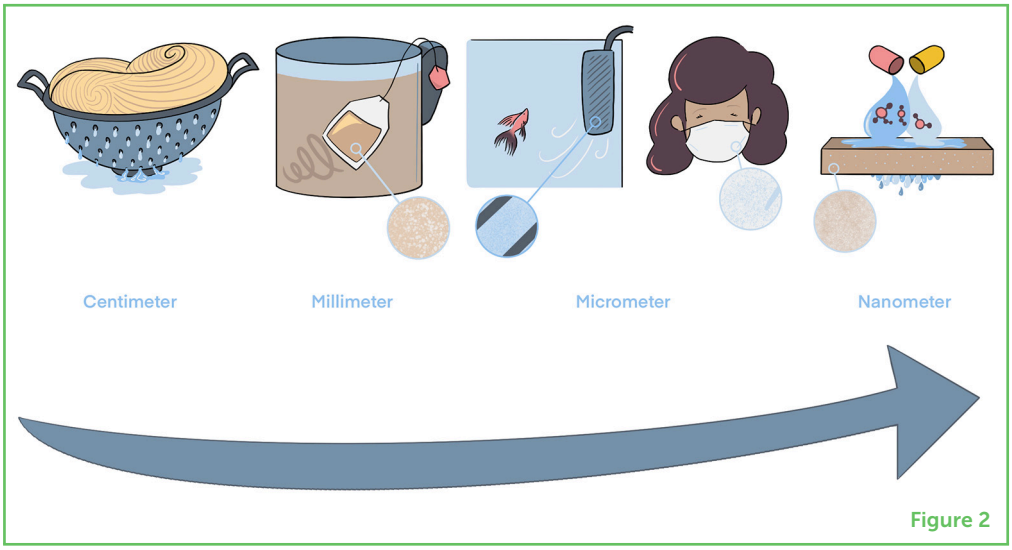

Figure 2

Membranes with extremely small holes can be used to separate things that are not visible by your eyes, for example, to remove poisonous chemicals from water or medicines. To do so, scientists make membranes with tiny holes, called **nanofiltration** membranes. These membranes are often built from microscopic building blocks, similar to Lego® pieces. Can you think of other membranes that you have seen at home or school?

MEMBRANE APPLICATIONS

Our team, called the Sustainable Separation Engineering Research Group, focuses on using stuff in nature to make membranes that can be used to make our everyday lives more convenient and enjoyable. Figure 3 shows three examples of biomass that we successfully upcycled into nanofiltration membranes.

Saudi Arabia and the Middle East are known for their very delicious dates. When you eat a date, there is a seed in the middle that is generally thrown away. Our research at KAUST uses these seeds to make membranes. The process involves grinding the seeds into a powdery material that it is then cleaned and processed. Finally, the material goes through a machine that forms the powdered date seeds into a flat, thin layer of membrane. This is a very interesting process and it helps to work toward SDG 12, as it is an example of upcycling [3].

Another interesting membrane-making method uses the shells of shrimp. When people eat shrimp, they usually get rid of the shells. Our team of scientists removes a special substance called chitin from shrimp shells. Chitin can be used for many things including bandages, medicines, and as a nutritional supplement. Membranes made with chitin as well.

Figure 3

Biomass, for example, date seeds, shrimp shells, and algae, are renewable resources, and we upcycle them into nanofiltration membranes, which can be used to filter water and remove poisonous chemicals.

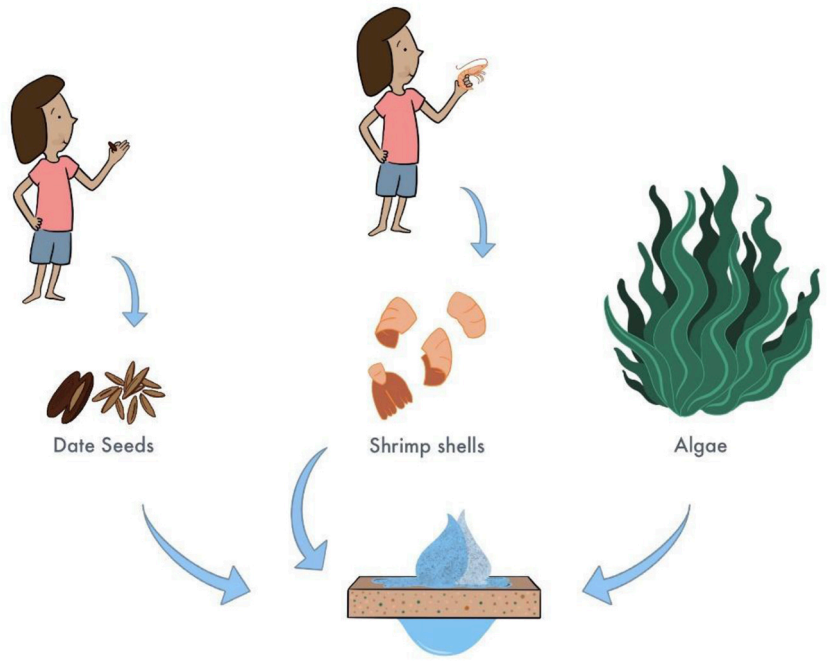

Figure 3

Algae are another interesting biomass source that can be used to make membranes. Algae are plant-like organisms that range in size from microscopic to giant seaweeds, living mostly in water and using sunlight to make their food, similar to land plants. A chemical inside the algae is recovered and mixed with liquid, then it goes through a machine in which a thin layer of membrane is produced. Imagine growing a vegetable in your garden and, once it grows, you harvest it and clean it to make your dinner. Well, this is the same idea but, with the help of science, algae are used to make membranes [4].

Making membranes from date seeds, shrimp shells and algae are all examples of upcycling waste materials and helping the world to achieve SDG 12.

TRASH TO TREASURE

Now you have seen how things from nature, such as biomass, can be used to make membranes—potentially replacing the unsustainable materials that are currently used. SDG 12 aims to make us mindful of how we create and use materials and how we get rid of materials after use. By finding creative ways of using biomass, we can create materials that are less toxic and reduce the amount of harmful chemicals needed to produce useful things. Further, using biomass can reduce the total amount of waste we create. Science is making great strides toward helping our planet by reducing the amount of waste that ends up in landfills. You can help too, by doing things like recycling at home, continuing to learn how to make the world better by reducing waste,

and sharing your knowledge about upcycling biomass with the people you know. Remember, all these actions help us to meet SDG 12—and we can all play a part.

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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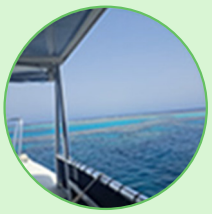
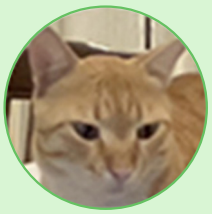


KARIM, AGE: 12
I am a curious person with a love of math and research!

SANTI, AGE: 11
I am a Grade 6 Spanish student that loves science, math, and design. I have a lovely family, I live here on earth and I go to school!



SARAH, AGE: 14
Hi, I am Sarah. I love reading and I am currently in my "Colleen Hoover" era. When I grow up I would love to be a doctor in the NICU or a biologist. My favorite food is Indian at the moment but closely followed by Tex-Mex. I love planes, whether plane disasters or just following them or identifying them. However, I am one of those people who loves the airport more than the ride!

ARNAU, AGE: 12
Hello my name is Arnau and I am twelve years old. I like science, reading, cooking and travelling the world.

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Lana earned her B. Eng. degree from the University of Surrey, where she continued to further her education and completed an M. Sc. degree in Chemical Engineering from University College London. Lana worked for 3 years in industry in a membrane filtration company after which she decided to pursue a Ph. D. degree. She joined the Szekely Group as a Ph. D. student to investigate organic solvent nanofiltration membranes using machine learning.

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