

Module.4

Nature Inspired Materials and Mechanisms.

1. What is Echolocation? In brief, describe Echolocation. And write the applications.

Echolocation is a physiological process for locating distant and invisible objects. Using sound waves reflected to the emitter by the objects. It is a biological mechanism used by some animals such as bats, Whales, and Dolphins to navigate and find prey/hunt in their environment.

Echolocation involves the following steps

- (a) Emitting Sound Waves: The animal emits a series of high-frequency sound waves, Which are usually in audibles to humans.
- (b) Sound Waves reflection: When these sound waves hit an object, they bounce back and reflect off the object, creating an echo.
- (c) Reception of Echo: The animal then listens for the echoes that bounce back by the object. Which provides information about the location, size, and shape of the object.
- (d) Interpretation of Echo: The animal's brain processes the information provided by the echoes and uses it to create an image of the object, its location, and its characteristics.

This procedure is an effective way for animals to navigate and find food even in complete darkness. Similarly, Echolocation helps humans to navigate and detect objects in low visibility environments, underwater, and in smoke-filled rooms.

Applications:

Medical Imaging: Ultrasound imaging uses high-frequency sound waves to create images of internal organs and tissues. This technique is non-invasive and can be used for a variety of diagnostic purposes such as monitoring fetal development during pregnancy and detecting tumors.

Sonar Technology: Sonar technology is used for navigation and detection in a variety of applications. Such as in submarines, boats, and aircraft.

Robotics: Some robots are equipped with sensors that emit sound waves and listen for echoes to find the location of obstacles and navigate around them.

Conservation: Echolocation is used in conservation efforts to study and protect animal populations.

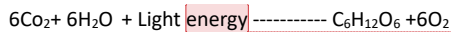
Accessibility: Echolocation can be used as a sensory aid for people with visual impairments. Some individuals have developed the ability to use echolocation to navigate their environment by emitting, clicking sounds, and listening to their echoes to detect obstacles and navigate around them.

2. In brief explain photosynthesis.

Photosynthesis is a process by which green plants among algae and some bacteria convert light energy into chemical energy in the form of organic compounds like glucose. This process is essential for life on Earth as it provides the energy source for all living organisms.

The process of photosynthesis takes place in chloroplast, organelles found in the cells of green plants and algae. Chloroplast contains chlorophyll a pigment that absorbs light energy from the sun. The

absorbed light energy is used to power a series of chemical reactions that convert carbon dioxide and water into organic compounds like glucose. The overall equation for photosynthesis is:



This equation shows that six molecules of carbon dioxide and six molecules of water react with light energy to produce one molecule of glucose and six molecules of oxygen.

Photosynthesis can be divided into two stages

1. Light-dependent reaction
2. Light independent reaction

1. light-dependent reaction

This reaction takes place in the thylakoid membranes of the chloroplast and requires light energy during this reaction light energy is absorbed by chlorophyll and converted into chemical energy in the form ATP and NADPH. Water molecules are also split during this stage releasing oxygen gas.

2. light-independent reaction

The biological reaction takes place in the stroma of the chloroplast and does not require light energy. During these reactions, carbon dioxide is converted into organic compounds like glucose using the ATP and NADPH produced during the light-independent reactions.

3. In detail explain the lotus leaf effect

It refers to the unique self-cleaning and water-repellent properties of the lotus plant's leaves. This effect is achieved through a combination of the two physical properties of the surface of the leaf. (a) Its microstructure (b) Its chemical composition.

The surface of the Lotus leaf is covered with microscopic bumps or papillae. Which are a few micrometers in size. The papillae are covered with even smaller wax crystals. Which gives the surface a rough and uneven texture. The combination of papillae and the wax crystals creates a high contact angle between water droplets and the surface. This allows the droplets to roll off the surface easily, carrying any dirt with them. This self-cleaning property is known as the "Lotus effect"

The Lotus leaf effect has been replicated in various materials and surfaces, such as textiles, building materials, and solar panels to improve their water-repellent and self-cleaning properties. This lotus leaf effect has also been applied in medical devices, such as catheters and implants, to prevent bacterial adhesion and biofilm formation.

4. Explain Velcro concerning Burr seeds. And write the applications of Velcro.

Plant burrs are also known as burr seeds. These are small, prickly seeds that are found in many types of plants. They are often covered in tiny hooks or barbs that allow them to stick to fur or clothing and be transported to new locations. Also, the burr can become tagged in animal fur and this can lead to the seeds being dispersed over large distances as animals move around. Based on burr seeds Velcro was invented by Swiss engineer George de Mestral. Velcro consists of two strips of fabric one with a surface covered in small hooks and the other with a surface covered in loops. When the two strips are pressed together the hooks are one side attached to the other side creating strong temporary bonds. Velcro is designed to be easy to use durable & reusable. Making it popular alternating to other types of fasteners like zippers & snaps

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Applications of Velcro :

1. sports equipment: Velcro is used in a variety of sports equipment including gloves, patches & straps. It can also be found in gym equipment like weight lifting belts & straps.
2. Automotive industry: Velcro is used to fasten seat covers headliners and door panels in automobiles.
3. 3. Medical industry: It is used in medical devices braces, splints & prosthetics.
4. Home & office organization: It is used to organize cables, cards & tools and can be used in office organizes, computer desks & backpacks.
5. Military & Defence: It is used in military clothing & equipment such as tactical vests and pouches to provide a source & easy-to-use fastening system.
6. Aerospace industry: It is used in spacecraft & satellites to fasten equipment and hold components in planes during launch & zero gravity environment.

5. Discuss the application of Shark skin-inspired swimsuits.

OR

Discuss Shark skin technology applications in friction-reducing swimsuits.

Sharkskin technology has been applied in the design of swimmer wear. The surface of shark skin has tiny, V-shaped scales known as dermal denticles. Which reduces drag and turbulence in water allowing sharks to swim more efficiently.

Scientists and engineers have replicated this pattern in synthetic materials, to create swimsuits that mimic the properties of shark skin. These swimsuits have been shown to reduce drag and improve swim times in competitive swimming. This technology was first used in the 2008 Beijing Olympics. Where several world records were broken by swimmers wearing this suit. Since then the use of shark skin technology in swimwear has become widespread in competitive swimming.