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Teacher's Brief:

The Magnificent Mangrove

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Introduction

A mangrove refers to the plant, and mangal is the plant community where mangroves live, where water is mostly salty or brackish water and under extreme conditions. Their tolerance to salty water is remarkable, having glands to emit the salt from seawater. They are also able to store water like cactuses to thin out high concentrations of salt. The roots of the mangroves are very special, like every other plant they need oxygen to survive. Since there is no oxygen in the muddy ground where the roots are, Mangroves have developed aerial roots growing from the ground upwards and even beyond the surface of the sea, and can be 30 centimeters or even up to 3 meters long, called pneumatophores, and this is how mangroves breath. Mangroves can reach up to a height of 30 meters under excellent conditions, or even up to 40 or 50 meters. Some species can be smaller in size, no taller than 1.5 or 2 meters.

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Mangrove Ecosystem

Mangrove Ecosystems are very unique with animals like birds living in their trees, various fish and other marine animals live in their roots. A variety of flora and fauna lives from and within mangrove forests, making the mangrove ecosystem one of the most productive ones.

There are a lot of different mangrove species all over the world and all of them are able to adapt and overcome problems of anoxia, high salinity and tidal flooding. Each species has its own physiological adaptation to these problems. And that's why mangrove trees show distinct zonation on some shorelines, with some species at the waterfront and others that are closer to the land.

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Adapting and Surviving

Mangroves produce floating seeds that disperse in water, which is different from other animals. Most mangrove species' seeds germinate while still attached to the mother plant, growing inside the fruit or out of it, those species are called viviparous. Once the propagules mature (become healthy seedlings) they drop into the water and often transport long distances by the currents, looking for a suitable environment. Propagules can survive drying up (desiccation) and may remain hibernated for as long as a year, and until they find a suitable location to grow and flourish. Once it's ready to take root, it changes density so it can switch from floating horizontally to vertically to become more likely to get lodged within the mud or roots. And if it fails set and root, it changes its density back to float horizontally continuing the search for a better home.

Stilt roots allow red mangroves to prop themselves up above water level and can take in air through pores in their bark. Grey mangroves live on higher ground and make specialized straw-like structures that sticks up out of the soil and water surface to breathe, called "pneumatophores", and are covered in lenticels. These -breathing straws usually reach thirty centimeters of height, and up to three meters in some species.

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Mangroves have a significant impermeable root system that acts as an ultra-filtration tool to exclude salts from the rest of the plant. According to an analysis of the water inside mangroves, it showed that anywhere from 90% to 97% of salt is excluded at the roots. Any salt which does accumulate in the shoot is concentrated in old leaves which then fall. Other mangroves can excrete salts directly through the glands located at each leaf base.

Because the limited supply of freshwater in the salty soils of intertidal zones, mangroves have developed ways of limiting the amount of water they lose through leaves, and like succulents they can restrict their pore openings, which exchanges carbon dioxide gas and water vapor during photosynthesis. They also vary the orientation of their leaves to avoid the harsh sunlight and reduce evaporation.

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Benefits and Importance

Mangroves are a multiple-function resource, important for both the environment and the humans. Mangroves provide food and shelter for various species and organisms. Mangroves also protect the coast from erosion, storms, and typhoons. Their massive root system dissipates wave energy efficiently. They also slow down tidal water enough for its sediment to settle as the tide comes in and is not re-suspended when the tide leaves. Mangrove ecosystems are often the object of conservation programs because of how unique and biodiverse they are and their ability to protect coastlines from erosion.

Mangrove forests bring many benefits, including:

- Protecting coastlines from erosions.
- Protecting and stabilizing low lying coastal lands against strong winds, waves and floods.
- Storing carbon dioxide more than any other ecosystem on earth.
- Mangrove trees absorb pollutants from sewage and water wastes, acting as a sink.
- Supports a complex food web and a unique aquatic habitat.
- Acts as a nursery for fish and is a rich habitat of fish, shellfish, oysters, shrimp and other crustaceans.
- Serves as nesting areas for birds.
- Mangrove leaves provide fodder for livestock such as camels.
- Mangrove flowers can be used to produce honey.
- Provides excellent opportunities for eco-tourism.

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Mangrove Ecosystem Threats

Mangroves can be found in tropical and subtropical countries. According to experts, Earth has lost a third of its mangrove forests due to urban development and intensified aquaculture since World War 2. What's even more worrying is that the decline is still occurring at an alarming rate of about 2.1% annually.

Due to its harsh environment, the Red Sea has relatively experienced less human activity than other places on Earth. Over the last 40 years or so, satellite images of Red Sea mangrove forests showed growth instead of decline. The total coverage of Red Sea's mangrove forests in 1972, 2000 and 2013 was 120, 132 and 135 km2, respectively. Much of the growth was due to rehabilitation projects along the African shores, including those in Yanbu, Saudi Arabia.

This demonstrates that afforestation efforts have an impact on mitigating mangrove decline. However, researchers also found that coastal development, logging and camel grazing generally led to the loss of mangrove forests. In particular, the biggest decline occurred in Al Lith, Saudi Arabia, which is one of the world's largest shrimp farm sites. Mangrove forests in this area decreased from 2.33 km2 in 1972 to 0.18 km2 in 2013.

Direct human intervention

- Conversion of Mangrove forests into fishponds, shrimp farms and salt beds
- Reclamation for housing projects, human settlements. other construction developments and infrastructure projects
- Over grazing by camels and other livestock
- Pollution and Salinization
- Overexploitation / Urbanization

Indirect threats (natural phenomena)

- Pests and diseases
- Typhoons and heavy storms
- Global warming and climate change

Impacts Due to Climate Change

Change in weather patterns, like global warming, is a huge threat to the mangrove ecosystem. Mangroves are losing their habitats from rising sea level and the brackish water becoming saltier. Extreme weather events such as typhoons and floods become more likely and more often, causing destruction of mangrove forests and habitats.

Effects of Sea Level Rise

It can have multiple consequences for mangrove forests all over the world.

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A. Lowering sea level (relative to the mangrove surface), forces the seaward and landward boundaries to migrate seaward.
B. Rising sea level (relative to the mangrove surface), the mangrove's margins move landward when possible, enabling them to maintain their preferred environmental conditions.
C. No change in sea level (relative to the mangrove surface), the mangrove margins will remain in the same location.
D. Mangrove community extinction, depends on the ability of individual species to colonize new habitat at a same rate as the relative sea level rise, the slope of adjacent land, and the presence of obstacles to landward migration, like seawalls and other shoreline protection structures.

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Mangroves at KAUST

KAUST is the custodian of a significant span of coastal water and a unique marine ecosystem. Thanks to local conservation efforts, the mangrove forests at KAUST have increased by over 45 percent since 2005. The University now hosts more than 110 hectares (1,100,000 square meters) of mangroves. The dominant mangrove plant found at KAUST is the grey mangrove (Avicennia marina). There is a small area at KAUST near the south beach that has different mangrove species, the Red Mangrove (rhizophora mangle).

The management of the KAUST mangroves falls under the Health, Safety and Environment Department. In June 2017, KAUST set aside 152 hectares as a Nature Conservation Area that includes a mangrove forest. This formal designation is a clear testimony of the University's commitment to protecting and enhancing the unique local biodiversity within the University. The health and wellbeing of the KAUST mangrove forest is continuously evaluated using different key performance indicators such as areal coverage over the years, counts of pneumatophores, crab burrows, gastropods, height, and width of mangrove trees, as well as mangrove sapling density per area. The nature conservation area is also home to Ibn Sina Field Research Station that hosts some long-term experiments and monitoring programs that help KAUST researchers gather important information about mangrove, local biodiversity and its global contribution.