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Isabela Madrigal can save the ocean

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Abstract
Isabela, a member of the magical Madrigal family in Disney's Encanto, can grow and control all types of flowers and plants. This power can help her increase the pH of the ocean. Ocean acidification has left many marine animals and plants in danger. She can increase high carbon neutralising plants such as seagrass and mangroves and can make them survive in areas where they usually would not grow in.

Keywords: *Film; Biology; Ecology; Ocean Acidification; Disney; Encanto; Isabela Madrigal*

Introduction
The Madrigals are a magical family from Disney's Encanto, where each member of the family has a unique power [1]. Isabela Madrigal, known for her beauty, grace and perfection, has the power to grow and control all types of flowers and plants. For most of the movie, this power is primarily used to decorate the 'Casita' (house). However, near the end, she learns how to grow different types of crops and plants. Her powers could potentially be used for greater things [1]. The ocean plays a big part in stabilising the climate but due to increased carbon emissions, it is undergoing significant chemical changes that Isabela can help combat [2].

Ocean Acidification
Often donned as 'The World's Largest Carbon Sink', the ocean is vital in steadying the Earth's climate; it releases 50% of the oxygen that is needed by the organisms on Earth, absorbs 25% of all carbon emissions and seizes 90% of the excess heat in the environment [4]. The ocean has absorbed around 525 billion tonnes of CO_2 [5]. The absorption of CO_2 by seawater is shown in the following equation [6]:

$$H_2O_{(l)} + CO_{2(g)} \rightarrow H_2CO_{3(aq)}$$

The carbonic acid (H_2CO_3) is a weak acid and dissociates:

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

Figure 1 – Isabela Madrigal is posing with the flowers she has grown [3].

The H^+ is acidic- an increase of H^+ correlates to higher acidic levels. As the CO_2 levels increase in the atmosphere, the amount absorbed by the ocean increases which in turn, acidifies it. In the last 200 years, the oceans pH levels have decreased from 8.2 to around 8.1 – due to the logarithmic nature of the pH scale, this is a 30% increase [6]. The pH is expected to decrease to 7.7 by the year 3000. This change in the chemistry of the ocean is detrimental for the residents of the waters [5]. For example, coral reefs erode due to the acidity causing a loss to habitats. Animals such as urchins struggle to make their carbonate shells in acidic conditions, so they have a higher chance of being crushed and therefore eaten by predators easily. This again disturbs the ecosystem [5].

Seagrass

Seagrass is a flowering plant found in the shallow parts of seas and oceans. Seagrass meadows thrive in acidic conditions and are hugely beneficial for the marine ecosystems [7]. Its appearance is very similar to terrestrial grass; this is misleading as it is the most like terrestrial orchids [8]. It is predicted that seagrass makes up 0.2% of the ocean floor, yet it absorbs around 10% of the carbon that is in the ocean. It can increase pH by using the dissolved CO_2 for photosynthesis. It has increased pH in ecosystems along the California coast by 30% [9].

Despite this, the number of seagrass meadows are decreasing. A reason for this is the limited access to sunlight due to algae bloom [8]. The increased nutrients such as phosphorous and nitrogen being washed up to the oceans from fertilisers, promote rapid algae growth on the surface of the waters which limits the sunlight from reaching the plants at the seabed. Lower light intensity decreases the rate of photosynthesis which means seagrass becomes less productive and die due to the lack of photosynthesis. With no access to nutrients, the algae eventually die too. The decomposing algae gives off toxins which increase the H^+ content of the ocean. In addition to this, more CO_2 by the respiration of the bacteria when it decomposes the plants and algae, is released. The bacteria use up the oxygen in the water for respiration. This means that marine animals in that environment do not have enough oxygen for respiration and the CO_2 becomes toxic to them, causing them to die. This process is called Eutrophication.

To combat this, Isabela could use her powers to increase the meadows of seagrass around all coastlines in the world. She can genetically manipulate them so that they can function optimally, even in low light intensities so they will not be affected by algae bloom. This will mean the effects of eutrophication will not be as detrimental to aquatic creatures such as fish as they will still have access to the oxygen produced during seagrass photosynethesis. Seagrass can be affected by protists *Labryrinthula zosterae* which form a microscopic slime on the surface of seagrass, causing it to waste away [10]. Isabela can boost the plant's immunity and make it resistance to these diseases. The increase in seagrass will help reduce the acidity of the ocean, boost the marine ecosystems and overall help decrease the temperature of the ocean.

Mangroves

Mangroves, seen in figure 2, is the collective name given to trees and shrubs that have aerial roots and can grow in soils that are rich in carbon and in waters with high salt content [11]. They are known as natural buffers as they increase the alkalinity of the oceans by up taking dissolved CO_2 from the oceans and pumping dissolved inorganic carbon (DIC) back into the water increasing its pH [12]. Mangroves take up 2.5×10^9 moles of carbon every year [12]. They can be particularly beneficial in areas where there are coral reefs as they can protect the coastlines. As well as this, animals such as manatees, tigers and sea lions are dependent on them to provide a balance ecosystem [13]. A reduction in mangroves has been seen- Tampa Bay has lost 50% of its mangrove forests. This is mainly because of the harmful chemicals found in agricultural waste which pollutes the waters, disturbs the salt balance, and dries up the mangroves [13]. To combat this, Isabela could influence a mutation in the plants so that they can grow even in high salinity conditions. An example mutation the mangroves could have would be salt glands, which would allow them to secrete the salt [14]. Usually, they only grow in tropical areas but they can be advantageous in other areas so Isabela can make them suitable to thrive on any coastline.

Figure 2 – Mangroves growing in Los Haitises in the Dominican Republic [15].

Conclusion

Isabela can save the ocean and its residents. Her powers would mean she can grow high carbon intaking plants such as seagrass and mandrakes, even in climates where they normally would not grow. This would massively help the aquatic ecosystem and protect the ocean from increased carbon emissions. However, this is not an overnight fix. Her efforts will have to be continuous over many years and in numerous areas around the world to see significant change.

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