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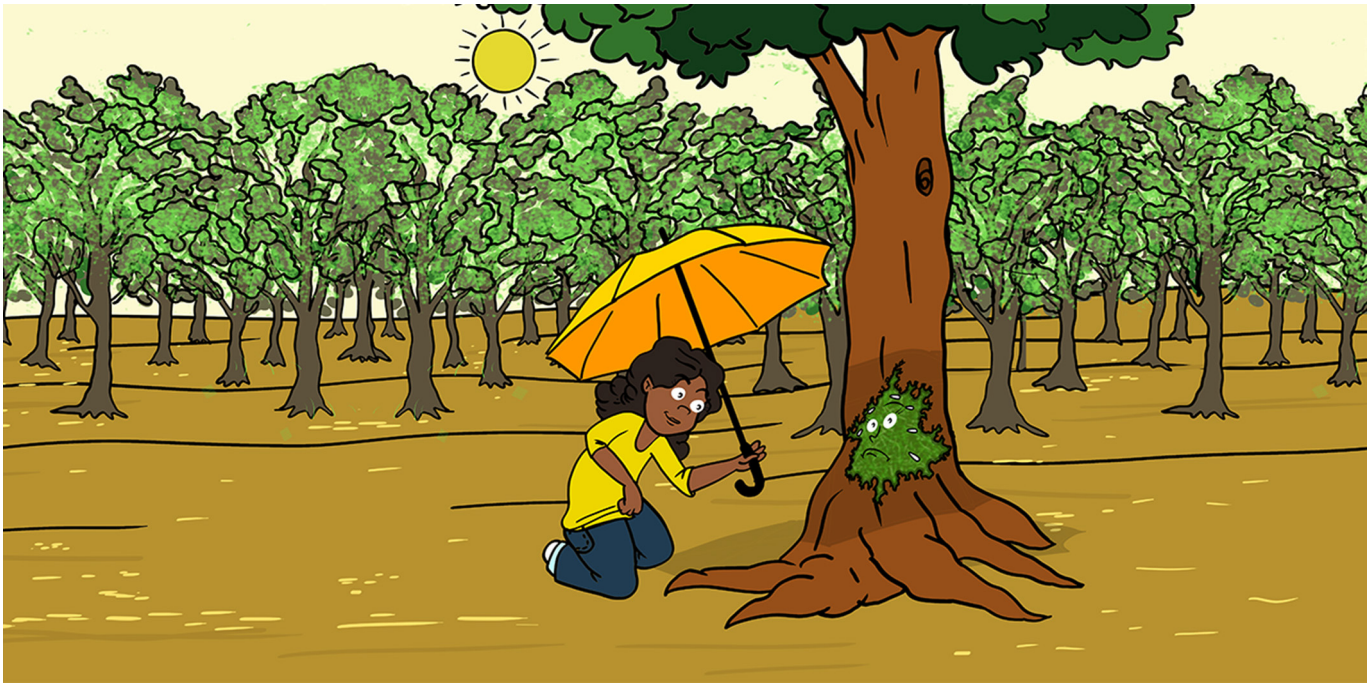

LUNG LICHENS FACE CHALLENGES FROM CLIMATE CHANGE

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YOUNG REVIEWER:

ADIA-MAE

AGE: 13

Lichens are a type of fungi that live in close relationships with algae or bacteria. Unfortunately, the future is not looking very bright for these organisms, because they have no protective structures and are sensitive to environmental change. The lung lichen is a large species that, in the upcoming years, will find itself in trouble. Climate change will reduce the amount of available water and increase air temperatures. Global warming is also expected to change the environments where the lung lichen lives. One of the main threats will be the expansion of some very competitive trees. Among them, the black locust has become invasive, forming dense woods that will replace the native tree species. Even though it seems like the situation is bad, there is still hope! Lichen scientists are trying to figure out how to prepare suitable shelters to save lung lichen from climate change.

A QUEEN IN THE FOREST

On a walk in a forest, even just outside the city, you may have seen strange organisms of various shapes and colors dwelling on the trees or rocks. Most likely these were **lichens**. Lichens are fungi that live in a close, mutually beneficial relationship, called a **symbiosis**, with single-celled green **algae** and/or a type of bacteria called **cyanobacteria**. Lichens have no protective tissues and therefore have no way of regulating the amount of water inside themselves. For this reason, they are extremely sensitive to any environmental changes. As with all groups of organisms, lichens include tough, hardy species, as well as species that are more delicate and sensitive. One of the more delicate species is called the lung lichen (*Lobaria pulmonaria)*, a very noticeable and rather rare species that lives on the bark of trees (Figure 1). It can only be found in older forests that have been preserved from over-use and that have ideal moisture and light conditions. Many lichenologists (people who study lichens) consider the lung lichen to be the "queen of the woods." But life is difficult, even if you are a queen. Others may be trying to steal your crown! Scientists think things will get even more difficult for the lung lichen soon.

LICHEN

A fungus living in symbiosis with a population of green algae and/or cyanobacteria.

SYMBIOSIS

An interaction between two different organisms (in the case of lichens, between a fungus and an alga or a cyanobacterium) that usually benefits both organisms.

ALGAE

A group of photosynthetic organisms that can form a lichen symbiosis with fungi.

CYANOBACTERIA

A group of bacteria that can perform photosynthesis and extract nitrogen directly from the atmosphere.

A DANGEROUS FUTURE

The biggest danger that lung lichen face is invisible, but unfortunately very real: climate change. Researchers have been trying to find out how climate change will affect the lung lichen on the Italian peninsula, from the warm Mediterranean coast to the cool forests of the Alps in the north. In Italy, between now and 2070, it is expected that temperatures will increase considerably and that there will be a drastic decrease in precipitation, as well as a general increase in extreme periods of weather such as chilly and/or very rainy days and long, dry heat waves. These are not exactly the ideal conditions for a species that likes to live quietly in a continuously humid atmosphere with moderate temperatures. Researchers' models predict that the areas with climate conditions that are ideal for lung lichens will almost completely disappear.

But the news gets even worse for the lung lichen. In addition to the direct effects of climate change, researchers predict that the lung lichen will also suffer other, indirect damage. The increase in temperature and the decrease in precipitation will make Italy a less hospitable environment for the trees on which lung lichens grow, which include mainly oaks, chestnuts, and beeches. So, it seems that the lung lichen may have fewer trees available to grow on in the future.

A NEW QUEEN?

As if the situation of the lung lichen is not bad enough, it is possible that an alien and invasive species might soon be battling the lung lichen for

Figure 1

The lung lichen (*Lobaria pulmonaria*) growing on mosses in a Mediterranean forest. The scientific name *Lobaria pulmonaria* and the common name (lung lichen) come from the fact that these lichens are shaped like the lobes of the lungs. Shining like gems, the orange spots are the reproductive structures of the lichens, called fruiting bodies, which are not frequently observed.

the crown of forest queen. An alien species is not an extraterrestrial of course! It is a species introduced, either accidentally or deliberately, into a natural environment where it is not normally found. Not all alien species are invasive, but all invasive species are dangerous to native plants and animals. Invasive species are tough. They grow quickly and spread rapidly and efficiently, over long distances. They can easily take over new environments and outcompete the native species, causing those native plants or animals to die off.

The invasive alien in question here is called the black locust (*Robinia pseudoacacia*). It is a tree of North American origin that has become invasive in Europe, where it poses a major problem for conservation of our native biodiversity. We have recently been trying to better understand the damage locust trees may cause to lung lichen. Will lung lichen be able to grow on black locust bark? Early results suggest that perhaps it could. But another problem could be the structure of the black locust woodlands. The black locust forms dense thickets, which do not give other tree species room to grow (Figure 2A). Black locust forests are extremely inhospitable to lung lichen because, being very dense, they greatly reduce the amount of light available to the lichens.

Figure 2

(A) A black locust grove in the Po Valley, Northern Italy. The dense, fast-growing black locust is replacing native forest species. (photo credit: Juri Nascimbene) **(B)** A possible micro refuge for the lung lichen in a shady Mediterranean forest, called "the dripping oaks," is an ideal place to find water and shade. (photo credit: Paolo Giordani).

SAFETY IN THE HIDDEN, FORGOTTEN CORNERS OF THE FOREST?

Although they are small organisms, lichens have important roles in the forest. For example, they are often used as shelter, food, or hunting grounds for small insects. Lichens are also used by small forest birds to build their nests. They also help to retain water and regulate the humidity of the forest. Additionally, since lichens are very sensitive to air pollution, they can give us an indication of the quality of the air around us. Despite all these important roles, lichens are not well-known to many people, so we risk not understanding what we are about to lose forever.

Is there any hope for the future of the lung lichen? We cannot know for sure. The ecologists who calculated the predictions sincerely hope they are wrong, but the numbers leave little doubt that these lichens are in danger. As with other species, we still do not know whether we can somehow protect lung lichens from the negative effects of climate change. But perhaps there is a way! The solution may lie in what are called microrefugia. Microrefugia are locations that, due to special favorable conditions such as dense forests or narrow valleys, can maintain a milder climate and serve as a home to fragile species (Figure 2B). Microrefugia might provide small, hidden corners of the forest where the right climatic conditions for lung lichens are maintained, even if the surrounding forest turns into an arid, desolate wasteland. Even a scanty group of trees, a few gnarled and shady oaks, perhaps covered with a sleeve of damp moss, might be enough for the lung lichen. Perhaps microrefugia will help lung lichens to hang on until we can prepare a better future for them!

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YOUNG REVIEWER

ADIA-MAE, AGE: 13

I love learning, reading, creative arts, helping others, coding, and school. I am passionate about conservation, social issues, all types of science, and all academic things. When I am not lost in a book, I participate in a variety of extra-curricular activities involving STEM, problem-solving, leadership, and sports. I find the teamwork, challenges, and camaraderie of group activities to be the most fun and fulfilling parts. I hope to positively impact others, animals, and the environment.

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