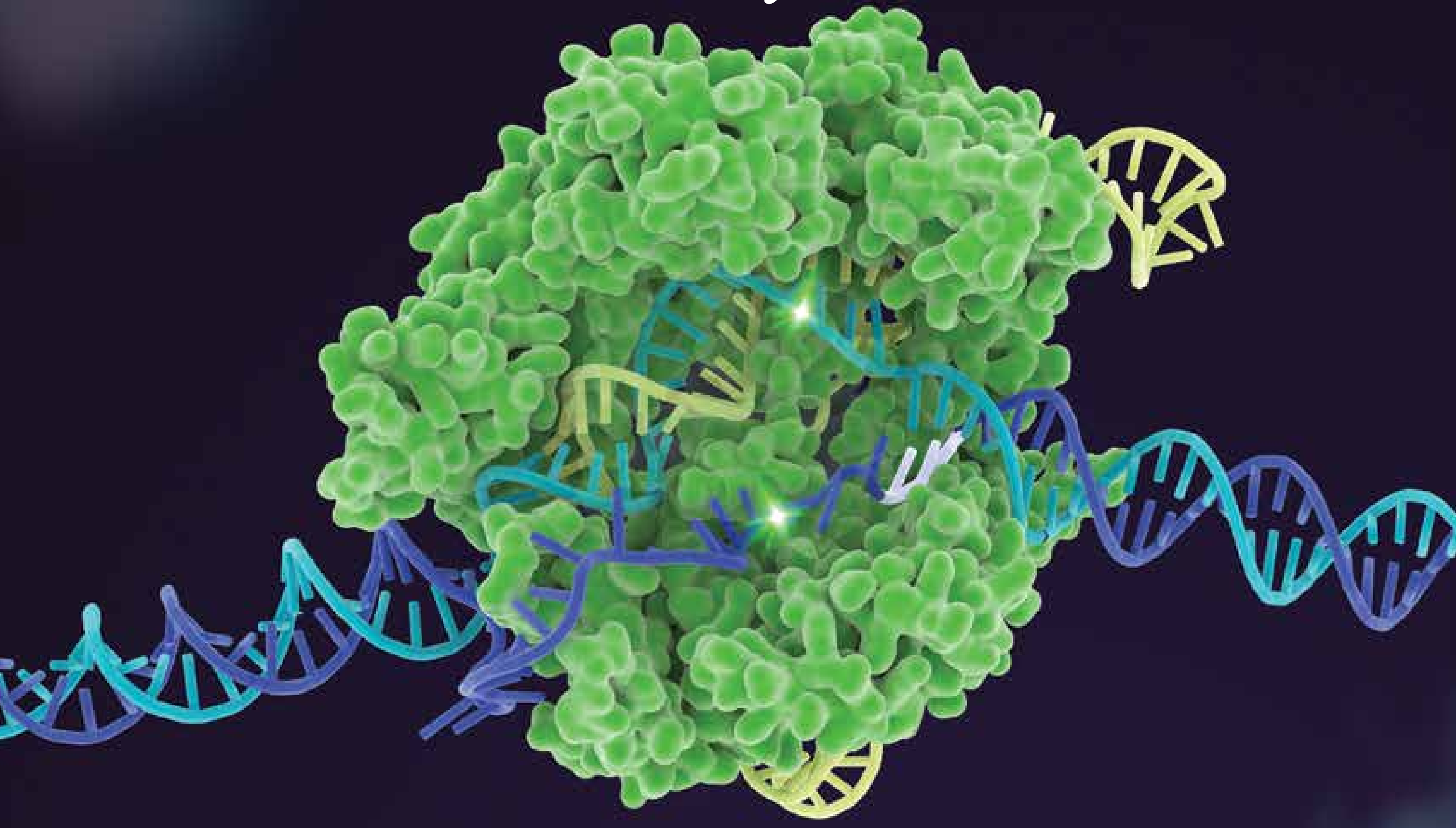
Article: Disease-Resistant Rice

Excerpt from

The Power of CRISPR



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Cover art: Cas9 (green) and guide RNA (gold) bound to a target DNA site (blue), making a cut in each strand (white flashes). Copyright © 2022, Janet Iwasa, for IGI.

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Article Introduction: The Ethics of CRISPR

In 2012, scientists developed CRISPR, a new gene-editing technology. However, the debate around whether scientists should edit organisms' genes has been around much longer. Scientists have been manipulating genes since the 1970s. Since that time, scientists and others have debated how and when this technology should be used. As technology improves, it becomes even more necessary to ask questions like these:

- Should people be able to edit organisms' genes?
- If people are able to edit organisms' genes, who should be able to do it, which organisms' genes should be edited, and for what purpose?
- How might changing an organism's genes affect the environment and future generations?
- Will gene editing be accessible to all people or to just a select few?

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Article: Disease-Resistant Rice

There are over 7 billion people living on Earth today, and that number is expected to reach nearly 10 billion by 2050. With an increasing population, providing enough resources, such as food, is a growing concern. One way to increase the amount of food is to make it easier to grow. This could include producing crops that grow faster, use fewer resources to grow, or resist disease or environmental changes, such as droughts. These types of changes may be possible using CRISPR, a gene-editing technology that allows scientists to change plant traits by changing the DNA inside plant cells.

Rice is a critical food source for more than 3 billion people worldwide, with rice consumption reaching nearly 500 million tons in 2019. It is projected that 650 million tons will be needed in 2050 to feed the increasing world population. Even though the need for rice is increasing, rice yield has been declining due to the emergence of pests and plant diseases, climate change, and other environmental issues.

Rice Blast Fungus

Rice blast fungus is the most destructive rice disease in the world. It kills 10–30% of all rice crops produced every year. One standard method for dealing with this disease is spraying fungicide. However, fungicides can have negative effects on the environment. In addition, blast fungus can become immune to fungicide over time, forcing scientists to create new fungicides.

Another method for combating blast fungus is to create strains of rice that are resistant to the fungus. To do this, scientists look for ways to change the rice plants' genes to give them the trait of blast fungus resistance. If rice plants had that gene, there would be no need for fungicide.

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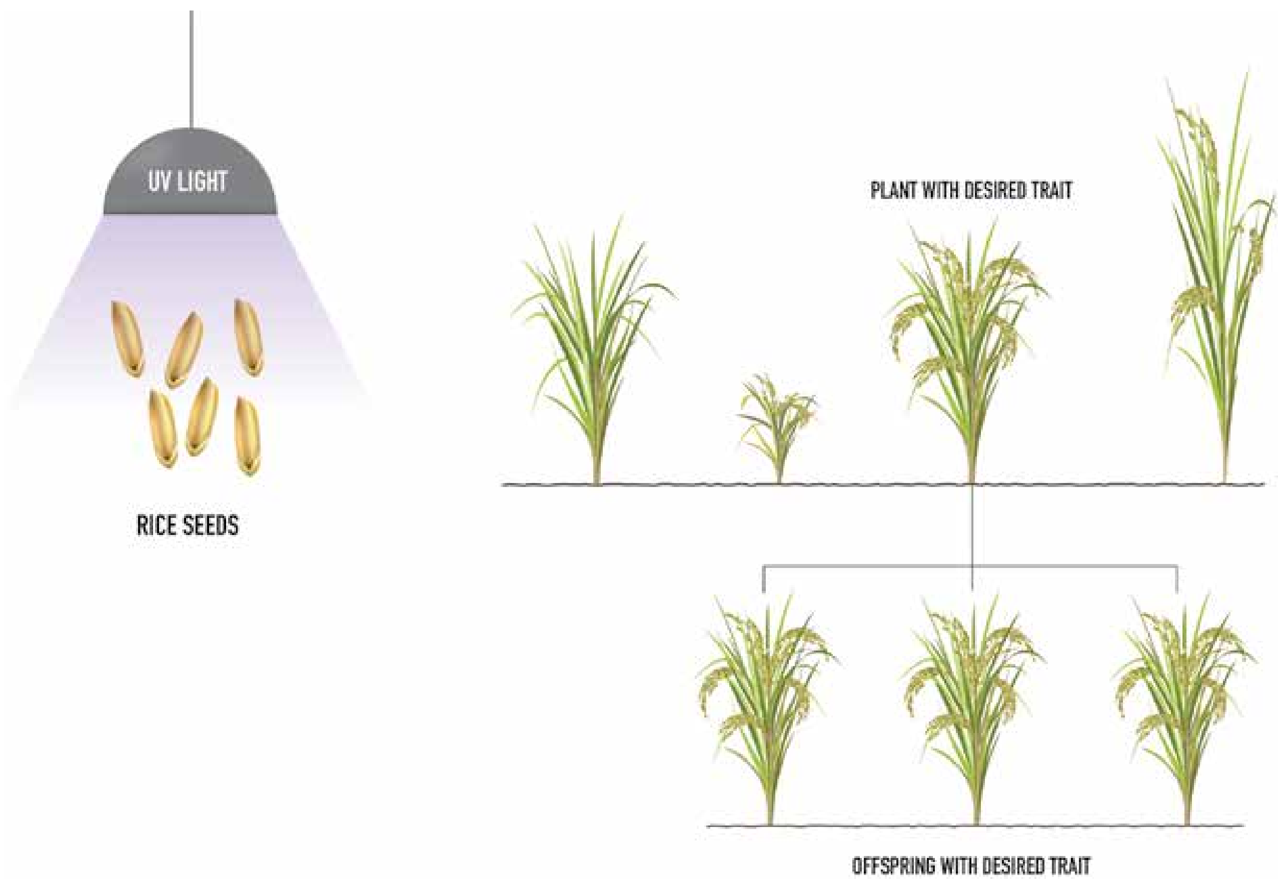
Article: Disease-Resistant Rice (continued)

Fighting Blast Rice Fungus with Mutagenesis

Long before scientists even knew about genes, farmers were practicing artificial selection in order to breed plants with the traits they most desired. This involves choosing plants with a particular trait and allowing them to reproduce. When those plants have offspring, the farmer would again choose the plants with the desired trait and allow them to reproduce. Since many traits are passed down to the next generation, this can eventually lead to an entire crop of plants having the desired trait.

Artificial selection requires either that a trait already exists in a population or that it comes about through a mutation. There is a low chance of having a particular trait come about by a mutation naturally, so scientists expose seeds to radiation to cause more mutations and a greater variety of traits. This is called *mutagenesis*. During this process, mutations occur randomly throughout the plant's genome. Some of these mutations lead to desirable traits, others cause undesirable traits, and still others make no changes to a plant's traits. If a scientist finds plants with the trait they are interested in, they select those plants to reproduce. Through this process, many new strains of rice and other crop plants have been developed, including some that are resistant to the blast fungus.



To cause mutations, scientists shine UV light on seeds. They grow the seeds, look for traits they desire, and then allow those plants to reproduce.

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Article: Disease-Resistant Rice (continued)

Fighting Rice Blast Fungus with CRISPR

More recently, CRISPR has been used to create strains of rice that are resistant to rice blast fungus. Using CRISPR to grow rice with specific desired traits is much more efficient than mutagenesis. While mutagenesis involves making many random changes throughout the genome, scientists can use CRISPR to precisely target their gene edits. Even though CRISPR can lead to *off-target effects* (unintended changes to other genes than the one of interest), the likelihood of off-target effects when using CRISPR in plants has been found to be low. Also, unlike with human patients, researchers can keep trying to make their desired edit until they generate a plant with the right change and no detectable off-target edits. As of 2021, disease-resistant rice produced via CRISPR technology is still undergoing testing and has not been approved for commercial release.

The effects of human interventions are not always predictable, especially when it comes to ecosystem changes. Using CRISPR to make disease-resistant crops may have future negative effects by ultimately decreasing the resilience of crops to environmental change. Crops with the edited genes may be more robust and outlive other crop varieties, leading to large areas that contain just a single variety of crop plant. This is known as a *monoculture*. Monocultures are vulnerable to diseases and other environmental changes. For example, if a farm has identical rice plants, a new pathogen can very quickly wipe out the entire harvest. Having a diversity of plants with different traits increases the chances that some will be resistant to the pathogen and will allow for the survival of some plants from a crop.

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