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Learning Set 2: Back to the Big Challenge (1 ½ Class Periods)

Overview

Students make recommendations for developing rice varieties that meet one of the two criteria — to produce more rice or to produce more nutritious rice — while also growing well in different kinds of weather. They use what they have learned about how dominant and recessive alleles are inherited to figure out how they can develop a hybrid with the desired phenotype. Then they share their recommendations with the class and work with their groups and the class to find a way to develop a rice plant that meets both criteria and grows well in different kinds of weather. Finally, they update the criteria and constraints for the challenge, identifying ways what they have learned affects what they need to accomplish and how they can accomplish it.

Targeted Concepts, Skills, and Nature of Science	**Performance Expectations**
Criteria and constraints are important in determining effective scientific procedures and answering scientific questions.	Students revise criteria and constraints for the challenge.
Scientists collaborate in their work and then share their findings. Sharing findings makes new information available and helps scientists refine their ideas and build on others' ideas.	Students work with their groups to find ways to develop varieties of rice with the desired traits, and then they share their work with the class.
Explanations are claims supported by evidence. Evidence can be experimental results, observational data, and other accepted scientific knowledge.	Students create recommendations, using claims, reasoning, and evidence.

Materials

1 per class	class's *Project Board*
1 per student	*Project Board* pages
1 per student	*Create Your Explanation* pages

Homework Options

Reflection

- **Science Content:** What science knowledge did you use to support your recommendations? Did other groups use different science knowledge? *(Students should list things about rice plants, genes, and inheritance that they've learned through their reading and that they used to support their recommendations.)*

- **Science Process:** How was the plan you described in your recommendations similar to the procedure Mendel used with pea plants? *(Students should have tested the effects of recessive alleles by breeding more than one generation, just as Mendel bred multiple generations and observed the effects of recessive alleles.)*

Back to the Big Challenge Implementation (1 ½ Class Periods)

Learning Set 2: Back to the Big Challenge (15 min.)

Have groups write recommendations for meeting one of the criteria of the challenge — developing rice plants that produce more rice or developing rice plants that produce more nutritious rice.

Engage

Remind students that the two criteria of the *Big Challenge* are to develop rice plants that produce more rice and to develop rice plants that produce more nutritious rice. Ask students what ideas they learned in this Unit that they can apply to meeting these criteria.

Guide

Next, read the letter on pages 83 and 84 with the class. The table of traits on page 84 will be important for this activity. Make sure students understand it.

Then let students know that each group will now write a recommendation for how to meet one of the criteria with a rice hybrid that grows well under different weather conditions. You may wish to assign each group to one of the criteria, or you may wish to have each group pick a criterion.

Then discuss how to construct a good recommendation. A recommendation is a type of claim, and groups should support their recommendations with evidence from their observations and from the reading. Writing a good recommendation is very much like writing an explanation, and groups should use *Create Your Explanation* pages to develop their recommendations.

Get Going

Once groups know which criterion they are making recommendations for, distribute *Create Your Explanation* pages and have them make their recommendations. Emphasize that they will need to make several recommendations.

Guide and Assess

As groups develop their recommendations, monitor their progress and guide them if they are having trouble. Emphasize that their recommendations should be practical guides for how to develop rice plants that produce more rice or produce more nutritious rice, and that they should support them with evidence from their observations and reading, just as they would an explanation.

Here's an example of a recommendation a group might write for developing more nutritious rice:

We know that rice type C has a lot of starch, so we want our rice plants to have that trait. We also know that rice Type A grows well in dry conditions, which is another trait we want our rice plants to have. Because we want a trait from rice Type C and rice Type A, we should try crossing these two varieties.

[begin meta note]

Some students may point out that rice plants are usually shown growing in rice paddies — fields of rice plants flooded with water. In fact, many traditional varieties of rice grow well in flooded conditions. Students need only ensure that their rice grows well in dry conditions.

[end meta note]

But we need to pay attention to how these traits are inherited. High starch content (we'll call it "C") is a dominant trait, while growing well in dry conditions (we'll call it "a") is a recessive trait. Because recessive traits may not show in first-generation hybrids, we should cross several generations of plants and observe the results. Mendel, for instance, found that when he crossed tall pea plants with short pea plants, the first generation consisted of all tall plants. It was only in the second generation that short hybrids appeared. Similarly, when we crossed red and white varieties of rice, it was only in the second generation that the recessive white trait appeared. Therefore, we recommend crossing the Type-C variety and Type-A variety once, carefully observing the offspring, and then crossing the offspring and carefully observing the second-generation offspring.

The following Punnett squares show the possible results of crossing these plants. We can partially determine the genotypes of C plants and Type-A plants from their phenotypes. Since growing well in dry conditions is recessive, Type-A rice must be homozygous for that trait. And since low starch content is recessive, plants that do not have high starch content (including Type-A) must be homozygous for that trait. This gives us the following:

For starch content, you'll get:

PBIS_GE_TE_LS2_BBC-1TA

	C	C or c
c	Cc	Cc or cc
c	Cc	Cc or cc

All offspring in this generation have high starch.

For growing in dry conditions, you'll get:

PBIS_GE_TE_LS2_BBC-2TA

	A (does not grow well in dry weather)	A
a	Aa	Aa
a	Aa	Aa

None of the offspring in this generation grows well in dry conditions.

To get a plant that is homozygous "a" (grows in dry conditions) and either Cc or CC, cross two hybrids. You'll get:

PBIS_GE_TE_LS2_BBC-3TA

	C or c	c
C	CC or Cc	Cc
c	Cc or cc	cc

Between ½ and ¾ of the offspring in the second generation will probably have high starch.

and

PBIS_GE_TE_LS2_BBC-4TA

	A	a
A	AA	Aa
a	Aa	aa

About one quarter of the offspring in the second generation will probably grow well in dry weather.

Because you cannot control which traits are inherited together, you may have to cross a large number of hybrids before you find any offspring with the combination of CC or Cc with aa — that is, the high-starch trait with the dry-weather trait. Once you have a rice plant with these traits, you can cross it with itself and observe the starch content of the offspring to see whether you have a homozygous dominant plant. If it is homozygous, all of the offspring will have high starch content, because there will be no alleles for low starch content. If it is heterozygous, about ¼ of the offspring will have low starch content, because ¼ of the offspring will inherit two recessive alleles, as shown in the Punnett square below. If it is heterozygous, you can repeat the experiment with one of the high-starch plants, until you get a generation of only high-starch plants.

PBIS_GE_TE_LS2_BBC-5TA

	C	c
C	CC	Cc
c	Cc	cc

To cross the rice plants, you will again need to get the pollen from one rice plant's flower onto the stigma of another rice plant's flower. Since rice plants are self-pollinating, and the pollen doesn't live long in the air, the pollen has to be transferred from one plant to another quickly. We recommend that you do this by cutting a stamen from one plant's flower and rubbing its anther on the stigma of another plant's flower. Because the anther produces pollen, which contains the

sperm cells, this will transfer pollen to the stigma. The pollen can then transfer the sperm cells through the stigma to the ovules, where fertilization can take place.

You will need to test the hybrids to see if they have high starch content and if they grow well in dry conditions. To test them for starch content, grind some dried rice grains from each hybrid into a powder and mix iodine with the powder. If the rice contains a lot of starch, the mixture will turn dark blue. We know this because when we mixed iodine with substances with a lot of starch, including powders made from rice with a lot of starch, the mixtures turned dark blue, while powders from rice with less starch turned lighter colors when we mixed iodine with them.

Testing the rice hybrids for whether they grow well in dry weather will require field experiments. We propose that you try planting them in dry weather and observing how well each grows.

Communicate Your Solution: *Solution Briefing* (20 min.)

Prepare students for their first Solution Briefing*. Then conduct group presentations of each group's recommendations.*

[begin meta note]

A solution briefing is a common pedagogical tool used in PBIS. In a *Solution Briefing* students present their ideas and hear other students' ideas so that students can build on each other's ideas.

[end meta note]

Guide

Remind students what a *Solution Briefing* is and how it works. Explain that they will be presenting their recommendations to share their ideas and gather advice. The goal is for the larger group (the class) to help each small group to make their solution better.

Now that you have all worked for a while on making recommendations, it is time for you to get some advice from outside of your group. Designers (and scientists) get together often to share their ideas and get advice from each other on ways to improve their designs (or recommendations). Remember that in PBIS we call this a *Solution Briefing*. We are going to have our first Solution Briefing so you can share your book support designs and get advice from the class. Everyone is encouraged to ask questions so they understand your design and then offer suggestions on ways to improve it.

Then describe how to prepare for a solutions briefing. Explain that their presentations should address the bulleted questions on pages 86 and 87. Also explain that the audience should ask clarifying questions and offer suggestions. Everyone should voice their questions and ideas, in a polite and considerate manner, using language such as "I agree with ... because..." or "I disagree with... because."

It is important that you all think about what you are going to say when you present your recommendations. On page 86 of the student text there is a list of questions that will help you think about what to talk about during your presentation. When you are in the audience or not presenting you will need to listen to make sure that you understand each design. You should also voice your opinions and ideas. Remember to always be polite and considerate whether you are presenting or are in the audience.

Get Going

First give students five minutes to prepare their presentation.

Then lead student groups in the *Solution Briefing*. Remind students that students in the audience should ask questions and give advice.

[begin meta note]

If students say that another group copied their idea, tell them this is an important issue and will be addressed in a little bit and continue with the presentations. After the presentations the class will discuss building on each other's ideas versus copying.

[end meta note]

Guide

After all groups have presented, wrap up the solutions briefing by asking students if they heard any interesting ideas or thought of new ideas they would like to use to improve their own book support design. Guide students to think about how sharing ideas will help them improve their own ideas.

Finally, compare this session with what scientists and designers do to improve their solutions. Reflect on the usefulness of iterations and record keeping. Tell students that scientists are always building on each other's ideas. Bring up the idea of giving credit to others when you build from their ideas. This is not copying. Emphasize that the difference between this and copying is that copying doesn't give credit to the people who thought of the ideas you used.

Reflect (30 min.)

Have students work on ways to develop a rice plant that meets both criteria, and lead a class discussion.

Guide

Next, have students work with their groups to come up with a way to develop a variety of rice that meets both criteria: that is, that produces more rice grains and produces grains that are more nutritious. The *Reflect* questions may help students think about things they can try. The first question should help them think of ideas from other groups that they can use. The second question should help them think about ways the recommendations for

meeting the two criteria overlap. The last question should help them see whether they have developed a stable line of hybrids or not, and whether the next generation has features might help them meet the criteria.

Guide a Discussion

When groups have finished devising ways of developing a variety of rice that meets both criteria, lead a class discussion of students' ideas. You might have each group briefly present their work, or you could ask the class specific questions about how they can develop a variety that meets both criteria. For example, you might begin by asking if their new procedure includes all of the steps of the procedure they developed for meeting one criterion.

Encourage students to ask each other questions. Help them to see what they need to do to agree on a way to combine the two traits they need in a new rice plant.

Update Criteria and Constraints (5 min.)

Lead a class discussion of the criteria and constraints for the challenge.

Guide

Next, review the criteria and constraints students identified with the class. Students may see inaccuracies in their list, or their criteria and constraints may not be specific enough.

Update the *Project Board* (15 min.)

Update the Project Board *with students' recommendations.*

Get Going

Once the class has shared and discussed their recommendations, record the recommendations in the last column of the *Project Board* and have students record them in their *Project Board* pages. Let students know that they will use the recommendations in the *Project Board* to address the *Big Challenge*.

Assessment Options

Targeted Concepts, Skills, and Nature of Science	**How do I know if students got it?**

Criteria and constraints are important in determining effective scientific procedures and answering scientific questions.	**ASK:** Why is it a good idea to update your criteria and constraints? **LISTEN:** This helps students to use everything they've learned to understand what they need to accomplish and how they can accomplish it.
Scientists collaborate in their work and then share their findings. Sharing findings makes new information available and helps scientists refine their ideas and build on others' ideas.	**ASK:** Why was it helpful to work with your groups, and then discuss your ideas with the class? **LISTEN:** Students should have developed some initial ideas with their groups, and then identified which ideas were useful and which weren't with the class.
Explanations are claims supported by evidence. Evidence can be experimental results, observational data, and other accepted scientific knowledge.	**ASK:** What were the claims in your recommendations? What evidence did you use? **LISTEN:** Students should draw claims and explanations from the recommendations they wrote.

Teacher Reflection Questions

- What difficulties did students have understanding how to use the table sent to them by the Rice for a Better World Institute? How can you help them with this?
- What kinds of questions were students asking during *Solution Briefings*? What can you do to get students actively thinking about what *Solution Briefings* should be telling them?
- What issues came up in the discussion of the *Solution Briefings*? How can you keep students engaged in answering the *Big Question*?