13 Testing Medicines: A Clinical Trial

INVESTIGATION

3 CLASS SESSIONS

ACTIVITY OVERVIEW

NGSS CONNECTIONS

In this investigation, students take part in a simulated clinical trial of a headache medicine and then analyze and interpret the data they collect. They use the evidence from their analysis to engage in an argument about the potential use of this medicine. They begin to think about the role of body system interactions when developing new medicines for human use. This activity provides an opportunity to apply Performance Expectation MS-LS1-3.

NGSS CORRELATIONS

Performance Expectations

Applying MS-LS1-3: Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

Disciplinary Core Ideas

MS-LS1.A Structure and Function: In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.

Science and Engineering Practices

Engaging in Argument from Evidence: Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon.

Analyzing and Interpreting Data: Analyze and interpret data to determine similarities and differences in findings.

Crosscutting Concepts

Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural systems.

Systems and System Models: Systems may interact with other systems; they may have subsystems and be a part of larger complex systems.

Connections to Nature of Science: Science Is a Human Endeavor: Scientists and engineers are guided by habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.

Common Core State Standards—ELA/Literacy

RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

WHST.6-8.1: Write arguments focused on discipline-specific content.

INVESTIGATIVE PHENOMENA AND SENSEMAKING

Medicines can treat diseases but can have unintended consequences.

Students model a simulated trial to investigate and make sense of how medications are tested. They consider how understanding the interactions of body systems is critical to studying medicines and disease.

WHAT STUDENTS DO

Students simulate a clinical trial to investigate how medicines are tested. In this model, students participate in a taste test to simulate the clinical trial of a new headache medicine. Students pool their results and draw conclusions based on their data.

MATERIALS AND ADVANCE PREPARATION

- *For the teacher*
  - 1 Visual Aid 13.1, "Results of a Clinical Trial"
  - 1 Visual Aid 13.2, "Analysis of Class Data"
  - 1 Visual Aid 13.3, "Bar Graphing Checklist" (optional)
  - 1 Scoring Guide: ANALYZING AND INTERPRETING DATA (AID)
  - 1 Scoring Guide: EVIDENCE AND TRADEOFFS (E&T)
  - 1 tube of edible red food coloring
  - 1 2-cup measuring cup
  - 1 1/2-cup measuring cup
  - 1 dropper
- * 1 large stirring spoon
- * 1 permanent-ink marker
- * 1 2-quart container
- * 2 1-quart containers

- *For the class*

  1 packet of unsweetened powdered lemon drink mix
* 1/2 cup of sugar
* 2 quarts of water

- *For each group of four students*

  2 tall 7-oz. plastic cups

- *For each student*

  1 Student Sheet 13.1, "Analysis of Clinical Trial"
  1 Scoring Guide: ANALYZING AND INTERPRETING DATA (AID) (optional)
  1 Scoring Guide: EVIDENCE AND TRADEOFFS (E&T) (optional)
  1 small tasting cup

* *not included in kit*

The ANALYZING AND INTERPRETING DATA (AID) and EVIDENCE and TRADE-OFFS (E&T) Scoring Guides can be found in the Assessment tab in the back of this Teacher Edition. Students can find the "Bar Graphing Checklist" in Appendix C: Science Skills.

Be certain that all containers, cups, etc., are completely clean, because students will use them to taste drinks.

By following the directions on the next page, you will end up with 1 quart of lightly sweetened yellow lemon drink, 1/2 quart of lightly sweetened pink lemon drink, and 1/2 quart of more highly sweetened pink lemon drink. This is enough for one class of 32 students. Prepare the lemon drink samples as follows:

1. Yellow Lemon Drink (representing the headache)

   In a 2-quart container, mix the following ingredients, making sure that all the drink-mix powder has dissolved:

   - 1 packet of unsweetened lemon drink mix
   - 1/4 cup of sugar
   - 2 quarts of water

2. Pink Lemon Drink Without Sugar (representing the placebo)

   Pour 1 quart (4 cups) of the yellow lemon drink into another container, and add 2 drops of edible red food coloring. If using a gel food coloring, add just enough coloring to make the drink a light pink color. Stir thoroughly.

3. Pink Lemon Drink with Sugar (representing the medicine)

   Pour 2 cups of the pink lemonade into a third container. Add another 1/4 cup of sugar to this third container, and stir thoroughly.

Each group of students should receive one 7-oz. cup, approximately half full, of yellow lemon drink.

Each group of students should also receive one of the two pink lemon drink samples: Half the groups should receive a 7-oz. cup (approximately half full) of the lightly sweetened pink lemon drink, and half the groups should receive a 7-oz. cup (approximately half full) of the more highly sweetened pink lemon drink. Important: Students *must not know* that there is more than one kind of pink lemon drink. Code the 7-oz. cups by numbering them: Odd-numbered cups can contain the less sweet pink lemon drink that represents the placebo; even-numbered cups can contain the more sweet pink lemon drink that represents the medicine.

SAFETY NOTE

Make sure that all student work areas and materials being used for the activity are clean and free of any unnecessary equipment or other materials not being used. Check that students are not allergic to lemons or other citrus fruits, juice drinks, or sugar, or have any other health issue, such as diabetes, that limits what they can eat or drink. If students in your class have any such conditions, do not allow them to taste the drink samples in the activity.

TEACHING SUMMARY

GET STARTED

1. Prepare students to simulate a clinical trial.
    a. Introduce the clinical trial scenario.
    b. Explain the model of a clinical trial.
    c. Have students read the introduction, or read it aloud.

DO THE ACTIVITY

2. Connect students' classwork to real life by having them simulate a clinical trial.
    a. Review the directions.
    b. Have students complete the Procedure and record their data.
3. Discuss the class's results, and introduce the use of a control (placebo) group.
    a. Record students' responses on Visual Aid 13.1, "Results of a Clinical Trial."
    b. Explain to students that only some of the groups got the "real medicine"—the pink drink with additional sugar.
    c. Develop the concept of a control by asking, "Why was it important to have a group who did not receive the medicine?"

d. Sort the class data based on which groups received the "medicine" (additional sugar) and which did not.

e. Use the second table on Visual Aid 13.2 to summarize data from several classes. (optional)

BUILD UNDERSTANDING

4. (AID ASSESSMENT; E&T ASSESSMENT) Discuss the Analysis items, and summarize the key points of the activity.

   a. Review the data students collected in the investigation.

   b. Have the class summarize what they focused on in terms of the safety and effectiveness of the headache medicine.

   c. Assess students' ability to analyze and interpret data and to explain evidence and trade-offs.

TEACHING STEPS

GET STARTED

1. Prepare students to simulate a clinical trial.

   a. Introduce the clinical trial scenario.

      Remind students of the real-life scenario in the "The Pellagra Story" activity, when Dr. Goldberger was investigating the disease pellagra. Return to the driving question introduced in that activity: How do scientists ensure that a medication to treat a health condition works and is safe? Review the questions and ideas that students generated.

      Ask students to imagine the following: You work for a company that develops medicines. You have developed a medicine for severe headaches and have tested it on rats and mice to see if it has any negative effects. The tests on animals showed no harmful effects, even at much higher doses than you plan to use on humans. Now it is time to test the medicine on human volunteers in a clinical trial. What could happen to these volunteers after they take the medicine? (Some people might feel better, whereas some might not improve or might even feel worse or display side effects.) If necessary, review with students what side effects are. For example, one possible side effect of taking aspirin is an upset stomach. Ask students to respond in their science notebooks to the question, "How would you test the medicine to be sure that it is safe and that it improves the health of headache patients?" Give students 5 minutes to work on this, and then discuss their responses.

b. Explain the model of a clinical trial.

Tell students that they will participate in a model of the trials that are used to determine whether medicines are effective and safe for people. Review with them the meaning of the word *model*. In this case, a *model* is an experience that is meant to mimic, or be like, another experience.

c. Have students read the introduction, or read it aloud.

The introduction includes a scenario of a clinical trial. Review the reasons for simulating a clinical trial rather than completing an actual test of a medicine, which would not be an appropriate classroom activity. Be sure students understand that in this model, a taste test represents the trial of a new headache medicine. Use the figure in the introduction to review the relationship between the tasting of the lemon drinks and the model. The taste of the yellow lemon drink represents the headache. A perception that the pink lemon drink tastes better than the yellow lemon drink represents feeling better. A perception that the pink lemon drink tastes the same as the yellow lemon drink represents no change in the headache. A perception that the pink lemon drink tastes worse than the yellow lemon drink represents an improvement in the headache but with side effects.

DO THE ACTIVITY

2. Connect students' classwork to real life by having them simulate a clinical trial.

a. Review the directions.

Teacher's Note: It is *very important* that you do not let students know that there is more than one kind of pink lemon drink.

Review the Safety Note. Be sure students understand that eating and drinking are not usually allowed in the science classroom; use this activity to emphasize routine safety rules. Students should wash their hands before they do the activity. Emphasize the need to keep track of the individual tasting cups and not to contaminate the larger cups of lemon drink.

Distribute a 7-oz. cup of plain lemon drink, a 7-oz. cup of pink lemon drink, and eight tasting cups to each group. Be sure that the groups with odd-numbered cups receive the less-sweet pink drink, and the groups with even-numbered cups receive the more-sweet pink drink. Tell students to pour the lemon drink from the larger cups into their tasting cups. Do not allow students to dip their tasting cups into the larger cups.

b. Have students complete the Procedure and record their data.

3. Discuss the class's results, and introduce the use of a control (placebo) group.

   a. Record students' responses on Visual Aid 13.1, "Results of a Clinical Trial."

      As students share their data, fill in the table by listing the number of students within a group that indicated each response. Ask, "Based on these results, does the 'medicine' appear to have worked?" It is likely that most members of the even-numbered groups (who received the sweeter drink) will report that the pink drink tasted better, thus simulating improvement, and most members of the odd-numbered groups will report that they "feel the same."

      Some students in both groups will report that the lemon drink tastes worse. This simulates that the medicine worked (even though it may be from the control or placebo group) but that there were side effects. Later in the activity, the severity of side effects and their implications for the clinical trial will be addressed.

   b. Explain to students that only some of the groups got the "real medicine"—the pink drink with additional sugar.

      Tell students that as they may have guessed, there were two different kinds of pink lemon drink. All of the lemon drinks were originally the same; however, some students tasted a pink lemon drink that was identical to the yellow lemon drink except for an inactive (in this model, flavorless) ingredient—red food coloring. Other students tasted a sample of the pink lemon drink that also had additional sugar (the "medicine"). Identify which groups had pink lemon drink without the added sugar and which had the pink lemon drink with the added sugar. Only the groups receiving the pink lemon drink with additional sugar actually tested the "medicine." They were in the "treatment" group. The others got a drink that looked like it had the real medicine in it but didn't. They were in the "control" group.

   c. Develop the concept of a control by asking, "Why was it important to have a group who did not receive the medicine?"

      Begin to develop the idea that a control group allows for comparison and helps investigators evaluate if changes are due to the medicine or to some other factor. Remind students about Dr. Goldberger's experiments on the prisoners from "The Pellagra Story" activity. Dr. Goldberger did not have a control in his experiment, but he could have included prisoners who continued to receive a healthy diet but underwent all the other conditions of those who were on the restricted diet.

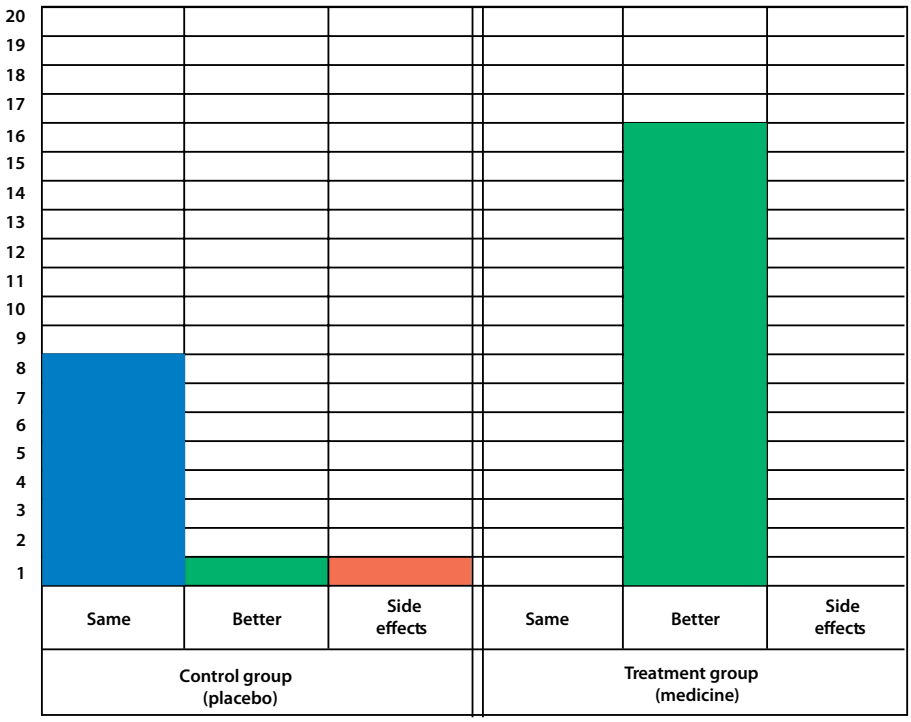
      Tell students that a placebo simulates a medicine but doesn't have the active ingredient in it, so it can be used for the control group. Emphasize that this

helps investigators be sure that any improvement is due to the medicine and not to other factors. Explain that in a real test of a medicine, one group receives a pill or liquid containing inactive ingredients, while another group receives a pill or liquid containing the medicine. In this model, the red food coloring represents the idea of taking a pill or liquid, whereas the additional sugar represents the active ingredient in the medicine.

d. Sort the class data based on which groups received the "medicine" (additional sugar) and which did not.

Summarize the class data in the top table of Visual Aid 13.2, "Analysis of Class Data." As an example of one set of results, in a class of 26 students, 16 were given the pink lemon drink with additional sugar (representing the medicine) and 10 were given the pink lemon drink with no additional sugar (representing the placebo). Sample results for the activity are shown in the following table. Note that two students claimed that their pink lemon drink with no additional sugar tasted better or worse, respectively, than the yellow lemon drink, even though the two drinks are identical. These results are an example of the placebo effect, which is a beneficial effect produced by a placebo that cannot be attributed to the properties of the placebo itself and must therefore be due to the patient's belief that the placebo is beneficial. The results in this example correlate to a slight placebo effect and a very successful medicine. Point out that such clear results are unusual in real clinical trials. A high number of students preferring the pink lemon drink without additional sugar over the yellow lemon drink would simulate a significant placebo effect. A high number of students disliking the pink lemon drink without additional sugar compared with the yellow lemon drink would simulate a significant placebo effect for improvement with side effects. A significant number of students disliking the drink with sugar would simulate a significant group of people with side effects from the actual medicine.

SAMPLE CLASS RESULTS



e. Use the second table on Visual Aid 13.2 to summarize data from several classes. (optional)

If you are using this course with multiple classes, have students compare the other classes' results to their own class's results. Are they the same? Discuss the fact that not every subgroup will be representative of a larger population. Review reasons that not all people reacted the same to the samples of lemon drink. Use this to reinforce the variation among people and the idea that different people can respond differently to the same stimulus.

BUILD UNDERSTANDING

4. (AID ASSESSMENT; E&T ASSESSMENT) Discuss the Analysis items, and summarize the key points of the activity.

a. Review the data students collected in the investigation.

You may need to review how to complete a bar graph. If so, you can use Visual Aid 13.3, "Bar Graphing Checklist," to help students construct their graphs and/or refer them to Appendix C: Science Skills in the Student Book. The axes are set up for students on Student Sheet 13.1. To view typical data, see the Sample Student Response to Student Sheet 13.1 at the end of this activity.

b. Have the class summarize what they focused on in terms of the safety and effectiveness of the headache medicine.

Students will likely mention the following:

Safety:

1. The number of people who reported side effects
2. The severity of the side effects
3. The trade-offs of using medicine with side effects

Effectiveness:

1. The number of people compared with the total who reported improvement
2. Whether many people reported side effects
3. Whether many people in the placebo group reported improvement

c. Assess students' ability to analyze and interpret data and to explain evidence and trade-offs.

You can use the ANALYZING AND INTERPRETING DATA (AID) Scoring Guide and the EVIDENCE AND TRADE-OFFS (E&T) Scoring Guide to assess students' responses to Analysis item 2 and Analysis item 4, respectively. Sample Level 4 responses can be found in the Sample Responses to Analysis.

For Analysis item 4, you may have to help students distinguish the more serious symptoms in this question from those described in Procedure Step 10. Use this item to introduce the idea of weighing health benefits vs. side effects. Be sure to use the concept of trade-offs in your discussion. In this case, the side effects may be severe enough to outweigh the benefits of the medicine, and most people would not be willing to accept this trade-off.

For Analysis item 5, students' responses should fit with the evidence collected. For instance, if most people reported improvement from the treatment and very few people reported side effects, this provides evidence that the medicine is likely safe and effective. If many people reported side effects, students should question the safety or note the trade-offs of using a medicine with side effects. If many students in the placebo group reported improvement, students should mention these results and question the effectiveness of the medicine.

STRATEGIES FOR TEACHING DIVERSE LEARNERS

Below are suggestions for differentiating instruction and assessment in this activity for diverse learners in your classroom:

- Students with learning disabilities: Have students discuss their ideas for the assessment in Analysis item 1 before writing individual responses.
- English learners: In their small groups, have students read and help revise one another's responses to Analysis item 1.
- Academically gifted students: Have students complete the Extension.

SAMPLE RESPONSES TO ANALYSIS

1. What body systems are a headache medicine likely to affect? Explain.

   A headache medicine will likely affect the nervous system, because you feel the pain in your head. It might possibly affect the digestive system, because that's where it's absorbed into the bloodstream.

2. (AID ASSESSMENT) In this activity, what evidence do you have that the medicine does or does not have the desired effect of improving headaches?

   Students' responses will likely vary, depending on their class results.

   Teacher's Note: This question can serve as practice for the ANALYZING AND INTERPRETING DATA (AID) Scoring Guide. Students should begin to relate the data from the model to their conclusions.

   SAMPLE LEVEL 4 RESPONSE

   In our class, 16 people received the pink lemon drink with additional sugar, which represented the medicine. Of those 16 people, 14 thought it tasted better than the yellow lemon drink. One person thought it tasted the same, and one thought it tasted worse. This means that 15 out of 16 people felt better after taking the medicine (although one suffered side effects). This shows that the medicine works to improve headaches.

3. Who was the control group in this model of a clinical trial? Why is a control group included in clinical trials?

   In this model, the control group is the people who got the drink with red food coloring added but no additional sugar, because the sugar represented the medicine. A control group is included because members' results can be compared with the treatment group, so the researcher can tell if the medicine is working or if there is something else happening to make people feel better.

4. (E&T ASSESSMENT) In this activity, if a person finds that the sweetened pink lemon drink (the medicine) tastes worse than the yellow lemon drink, their headache is gone, but there are side effects. If the side effects were serious, such as a risk of serious heart problems, would you recommend selling the medicine to people suffering from headaches? Explain your decision. What are the trade-offs involved in your decision?

SAMPLE LEVEL 4 RESPONSE

If the medicine had a serious side effect, like the risk of serious heart problems, I would not recommend selling the medicine to people. Heart problems are too risky, and someone might die from them. The trade-off is that they would still have headaches, but that is better than possibly having serious heart problems or dying from a heart condition.

5. In this activity, if a person finds that the medicine tastes better or worse than the yellow lemon drink, their headache is gone. Review the results of this model. Think about whether the medicine works and how often side effects occur. What would you conclude about the safety and effectiveness of this medicine for treating headaches? Support your conclusion with evidence.

   Students' results will likely vary, depending on their class results. A sample response is shown here:

   Fifteen out of 16 people reported an improvement. (They thought the pink lemon drink with additional sugar tasted better or worse than the yellow lemon drink.) Of those 15 people, one person reported a side effect because she thought it tasted worse than the original drink. The medicine is effective because most people (94%) reported an improvement, and it is safe because only one person (6%) had a side effect.

6. **Revisit the issue:** How do the effects of the medicines described in this activity demonstrate interactions between body systems?

   In this activity, a medicine that you drink helps with a headache. This demonstrates that the digestive system, where the medicine was taken, interacts with the circulatory system because that is the only way it could get to your head to stop the headache.

7. If you were considering participating in a clinical trial for a new medication, what questions would you ask? What information would you want to know?

   Students' answers will likely vary. A sample response is shown here:

   I would want to know if there were any known side effects. I would also want to know which body systems the medicine is supposed to affect.

EXTENSION

Have your students compare their class data to those gathered by classes from other schools. Visit the *SEPUP Third Edition Body Systems* page of the SEPUP website at **www.sepuplhs.org/middle/third-edition** for instructions on how to post your class's data.

REVISIT THE GUIDING QUESTION

How are medicines tested during a clinical trial?

Clinical trials have a control group, that receives no medicine, and a group that receives the medicine being tested. Participants do not know which group they are in. Scientists analyze the results for both groups to determine if the medicine is working, if it is safe, and if it has any side effects.

ACTIVITY RESOURCES

KEY VOCABULARY

clinical trial

control

evidence

trade-off

Name_____ Date_____

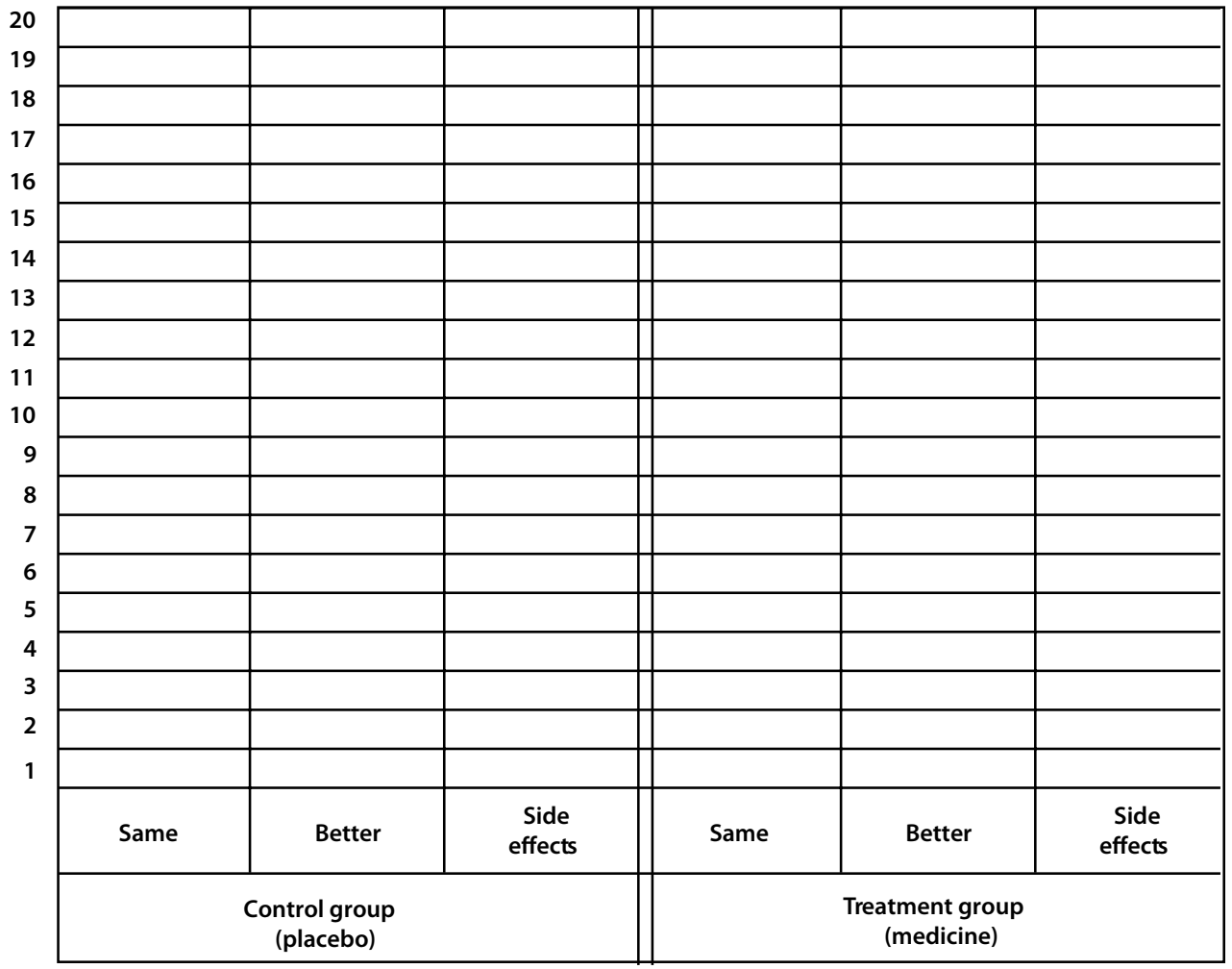
STUDENT SHEET 13.1

ANALYSIS OF CLINICAL TRIAL

Response to Treatment vs. Placebo (our class)

	Same as yellow lemon drink (headache the same)	Better than yellow lemon drink (headache better)	Worse than yellow lemon drink (headache better, but side effects)
Control group (received placebo)			
Treatment group (received medicine)			

Figure 1: Graph of Class Data



Name *Sample student response* Date_____

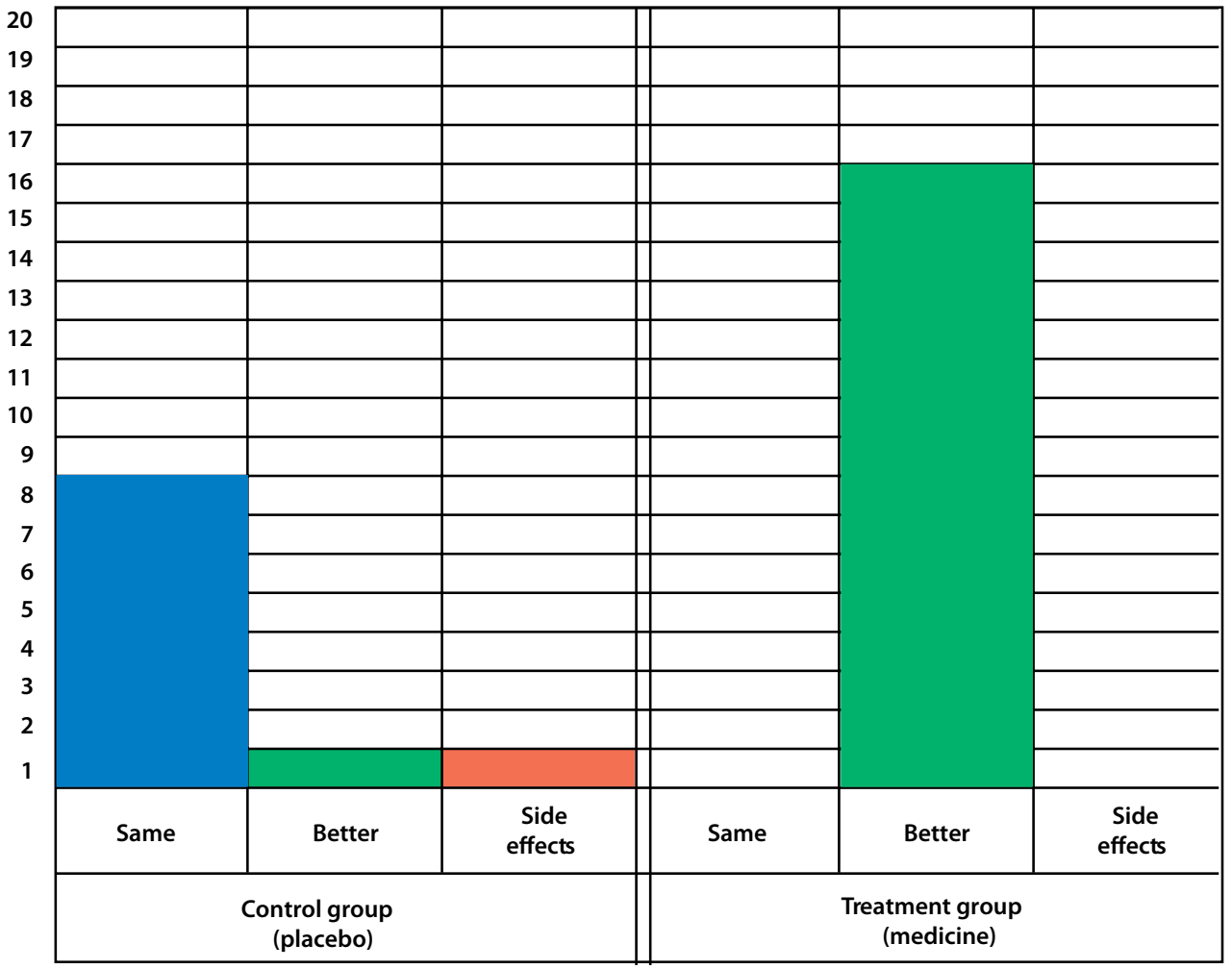
STUDENT SHEET 13.1

ANALYSIS OF CLINICAL TRIAL

Response to Treatment vs. Placebo (our class)

	Same as yellow lemon drink (headache the same)	Better than yellow lemon drink (headache better)	Worse than yellow lemon drink (headache better, but side effects)
Control group (received placebo)	*8*	*1*	*1*
Treatment group (received medicine)	*0*	*16*	*0*

Figure 1: Graph of Class Data



VISUAL AID 13.1

RESULTS OF A CLINICAL TRAIL

Cup number	Same as yellow lemon drink	Better than yellow lemon drink	Worse than yellow lemon drink
1			
2			
3			
4			
5			
6			
7			
8			
Total			

VISUAL AID 13.2

ANALYSIS OF CLASS DATA

Response to Treatment vs. Placebo (our class)

	Same as yellow lemon drink (headache the same)	Better than yellow lemon drink (headache better)	Worse than yellow lemon drink (headache better, but side effects)
Control Group (received placebo)			
Treatment Group (received medicine)			

Response to Treatment vs. Placebo (all classes)

	Same as yellow lemon drink (headache the same)	Better than yellow lemon drink (headache better)	Worse than yellow lemon drink (headache better, but side effects)
Control Group (received placebo)			
Treatment Group (received medicine)			

VISUAL AID 13.3

BAR GRAPHING CHECKLIST

Sample Graph

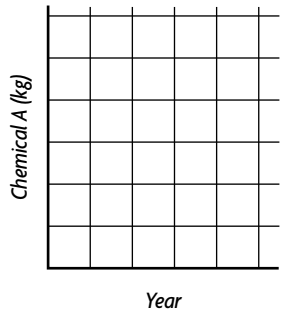
Follow the instructions below to make a sample bar graph.

☐ Start with a table of data. This table represents the amount of Chemical A that the Acme Company used each year from 2011 to 2015.

Year	Chemical A used (kg)
2011	100
2012	80
2013	110
2014	90
2015	105

☐ Determine whether a bar graph is the best way to represent the data.

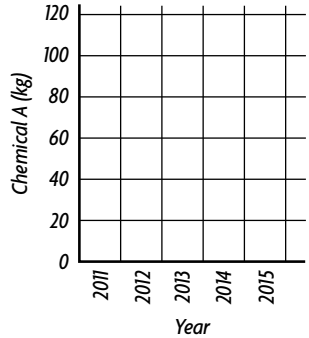
☐ Draw the *x*- and *y*-axes for the graph. Label them with the names and units of the data.



☐ Decide on a scale for each axis. Be sure there is enough space for all the data and that it's not too crowded.

Year axis: *1 block = 1 year*
Chemical A axis: *1 block = 20 kilograms*

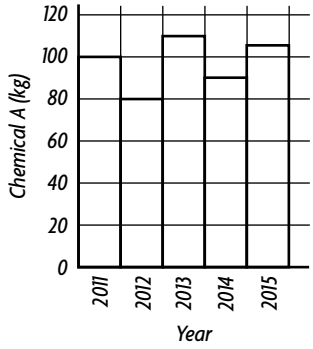
☐ Mark intervals on the graph, and label them clearly.



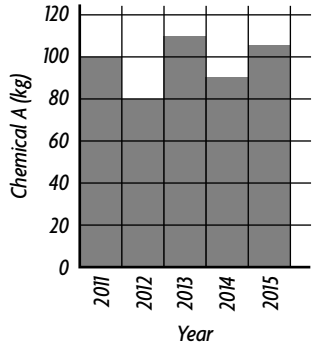
VISUAL AID 13.3 *(continued)*

BAR GRAPHING CHECKLIST

☐ Plot your data on the graph.



☐ Fill in the bars.



☐ Title your graph. The title should describe what the graph shows.