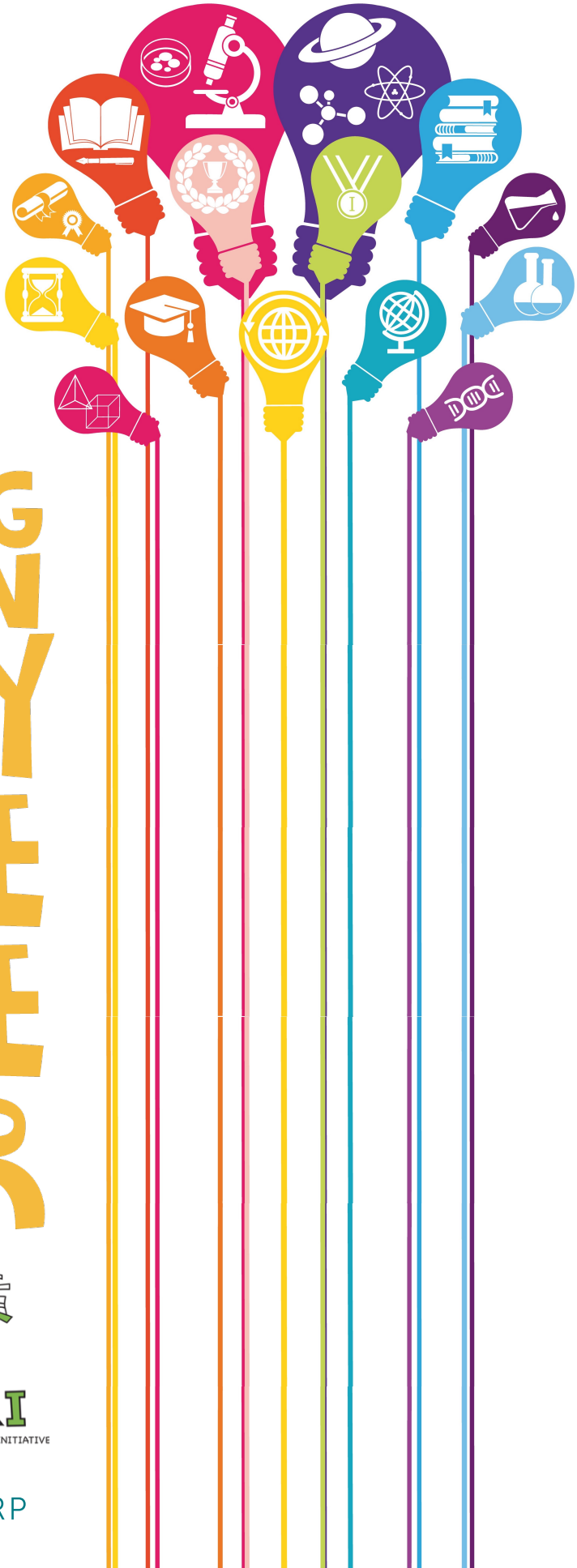


GETTING READY FOR THE SCIENCE FAIR

MSQI

MIDDLE SCHOOL QUALITY INITIATIVE

SERP

Designing a Fair Test

Developing and Testing a Hypothesis

Thinking About Testable Questions

Adapted From SERP Science Generation 6.04

Designing a Fair Test

Science Theater

Controlling Variables

Gregory pushed the door hard as he walked out of school. It had not been a good day. There had been a contest to figure out who was the best runner in the school. He had been sure that he would win, but he had lost to Evan. His friends Angelina and Monique were waiting for him when he came out the door.

Angelina: Why are you so mad about losing? Get over it. You lost.

Gregory: That contest was not fair!

Angelina: What do you mean "not fair?" You ran a race and you lost.

Gregory: But that's just it. I only got to run one race. I know I'm faster than Evan. He knows it too. If I had a chance to run again, I'm sure I'd beat him.

Monique was quiet. She had watched the race and was thinking about whether Gregory might have won if he had done multiple trials.

Monique: I don't know if you would have won if you got to run more than once. Evan ran pretty fast.

Gregory: I also had to run right after lunch. Everyone knows you never run your fastest right after eating. Evan had lunch an hour earlier!

Monique: Okay, I guess I can see how lunch might change how fast you can run.

While Monique agreed that eating lunch was a variable in the race, Angelina didn't think it was why Gregory lost.

Angelina: You can't say lunch was the problem. Maybe some people run faster after lunch because they have more energy. You lost. Stop whining.

Gregory: Oh come on. Evan also had on brand new sneakers. I just have my old ones. How is that fair?

Angelina: You both ran the same distance. He crossed the finish line before you. Finish lines don't lie.

Monique agreed that using the finish line was an objective way to figure out who was fastest, but she thought Angelina was being too tough on Gregory.

Monique: Gregory, you seem to think lots of things about this contest were unfair. What would you do differently?

Gregory: I just think the whole process is wrong. The way that they choose the BEST runner shouldn't come from only one race. Things have to be fairer. There needs to be some more rules.

Angelina: Like what? How are you going to make the contest better?

Gregory thought for a while. There had to be a way of controlling variables in the contest to make sure it actually tested who was the best runner in the school.

Gregory: Everyone should have to run in the morning. No one should get to wear brand new clothes or special shoes for running. I think things like that would make it more fair.

Angelina: I guess you have a point. Saying something is the best doesn't make a lot of sense unless the test is fair. Maybe next year you can see if the teachers will change some of the rules.

*You may hear a younger brother or sister say "that's not **fair**" when a parent allows an older child to attend an event late at night. This use of the word "**fair**" is subjective (not **objective**) and cannot be tested.*

WHAT'S THE POINT?

In science class, we use the word "fair" in a different way. To be fair, we measure and/or test something using a very specific process in order to get as close to the truth as possible. For example, if we want to find out if water or alcohol evaporates faster, we would control variables such as the amount of liquid, the shape of the container, and where they are placed in the sun.

Questions about the Science Theater:

1. Monique agrees that eating lunch before the race might have been a variable that affected Gregory's performance. What else does Gregory think was a variable in the race?

   a) The other boy got a head start.

   b) It was raining that day.

   c) The other student had new sneakers.

   d) The teachers liked the other student better than Gregory.

2. Why does Gregory want to do more than one trial for the running contest?

   a) He thinks he could win if he had a second chance.

   b) He always runs badly his first time.

   c) He ran in a different contest that allowed him more than one trial.

   d) He wants to run against people who are slower than him.

3. Why does Angelina finally agree with Gregory that the contest didn't determine the best runner in the school?

   a) She knows he is a good runner.

   b) She is a friend of Gregory's and wants him to be happy.

   c) She agrees that controlling other variables will make the contest better.

   d) Monique says that Gregory is right.

FOR DISCUSSION:

- ☐ What other variables could affect a race?
- ☐ Why is it important to do multiple trials in a race?
- ☐ In what other ways could this race have been changed in order to make it more fair?

Scientifically Speaking

Variables, Trials and Measurements

Gregory was persuaded that the contest to determine the best runner wasn't a fair test. What kind of things could you do in a race to make sure that it fairly determined a winner?

Here are complaints Gregory could make:	What is an idea for making things fairer?	Does this idea involve:
He raced immediately after eating and Evan raced an hour after eating.	have everybody race at the same time of day	☑ control of variables? ☐ multiple trials? ☐ objective measurement?
The decision about who was the best runner was based on only one race.	allow people to run the race three times and then average the times	☐ control of variables? ☑ multiple trials? ☐ objective measurement?
The coach watched the runners and picked out who seemed faster to be the winner.	the coach should use a stopwatch to time the runners	☐ control of variables? ☐ multiple trials? ☑ objective measurement?

WHAT'S THE POINT?

- CONTROL of variables: Making sure the only thing that changes in your test is what you plan on measuring.
- MULTIPLE trials: Making sure that you don't base your thinking on too few events.
- OBJECTIVE measurement: Making sure that you measure using a system that others can use in the same way.

Are there other ways in which a race could be **unfair**? How would you make sure things were **fair** on the day of the race?

Unfair way to set up a race	What is your idea for making it fairer?	Does this idea involve:
		☐ control of variables? ☐ multiple trials? ☐ objective measurement?
		☐ control of variables? ☐ multiple trials? ☐ objective measurement?
		☐ control of variables? ☐ multiple trials? ☐ objective measurement?

What's important for a fair test in science?

Here are some more situations where there is a problem with the way someone is thinking. Which science idea or ideas would help?

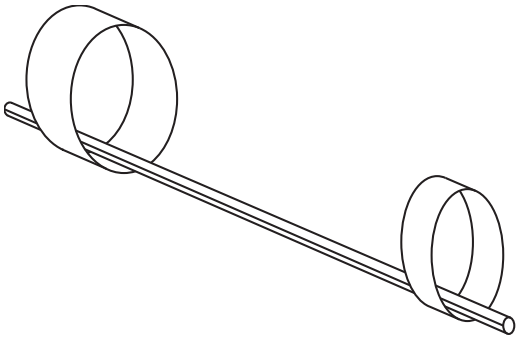
Situation	Scientific Thinking	Turn and Talk with Partner
Julio wanted to know which tomato plant grew the fastest. He tested many kinds of seeds, but he also used different types of soil.	Would you say that Julio should pay more attention to: ☐ control of variables? ☐ multiple trials? ☐ objective measurement?	What is a better process you would recommend to Julio?
Susan opened an ice cream stand at the beach. She sold more ice cream on a warm Tuesday than a chilly Saturday, so she decided to hire an extra employee for Tuesdays.	Would you say that Susan should pay more attention to: ☐ control of variables? ☐ multiple trials? ☐ objective measurement?	What is a better process you would recommend to Susan?
Tony watched a motor boat race in Boston Harbor. Since the German boat beat the Japanese and American boats, he decided that boats from Germany were the fastest in the world.	Would you say that Tony should pay more attention to: ☐ control of variables? ☐ multiple trials? ☐ objective measurement?	What is a better process you would recommend to Tony?
Leah determined that tennis balls were bouncier than lacrosse balls. Kay noticed that Leah was dropping the tennis balls on the tennis court but dropping the lacrosse balls on the grass.	Would you say that Leah should pay more attention to: ☐ control of variables? ☐ multiple trials? ☐ objective measurement?	What is a better process you would recommend to Leah?
Jackson decided that the paper towels his family buys are the best brand because they feel spongier and soak up most of the spills at his house.	Would you say that Jackson should pay more attention to: ☐ control of variables? ☐ multiple trials? ☐ objective measurement?	What is a better process you would recommend to Jackson?

Can you make up a different situation in which someone is NOT being scientific in the way they are thinking? What would you recommend to help them?

Lab: Collecting Data Fairly

Designing a Fair Way to Test Flyers

Lab Task #1 - Build a Flyer

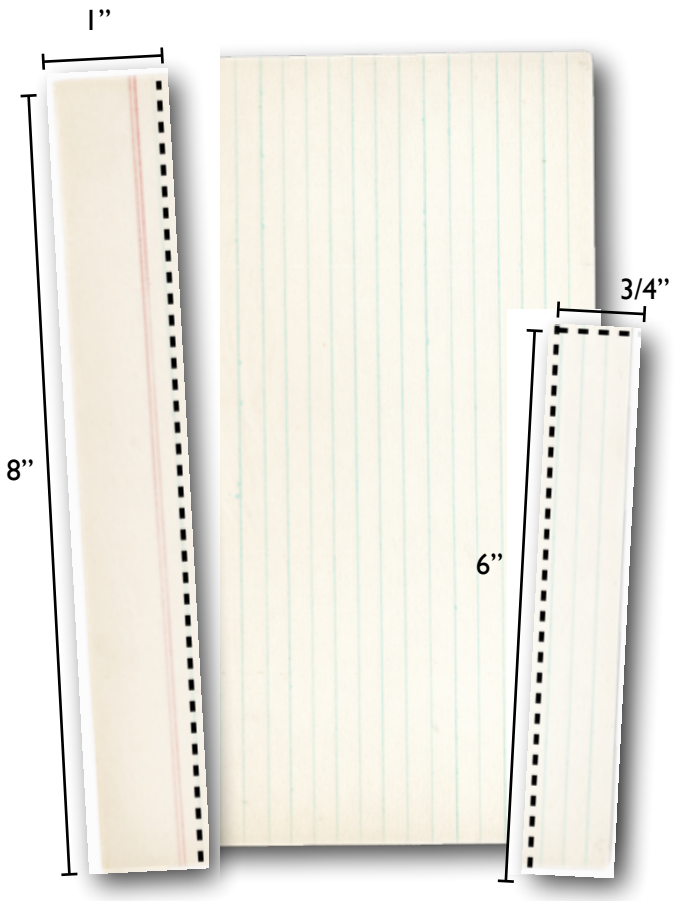


Materials:

- 1 straw
- 5”x8” index card (or similar)
- tape

Directions:

1. To make your straw flyer, cut out two strips from a large index card or similar paper. Write your name on one of the strips.
2. Roll them into loops and tape them to the straw like in the picture above.
3. Throw your straw flyer! (Hint: Keep the smaller loop in the front)



Lab Task #2 - Design a Fair Contest

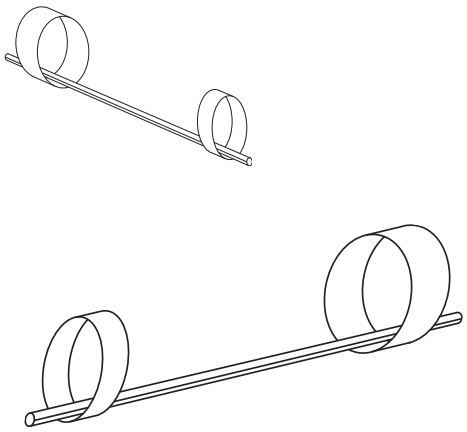
Think: *What makes a good straw flyer?*

- ➜ Flies the farthest?
- ➜ Goes the fastest?
- ➜ Hits a target?
- ➜ Stays in the air the longest?

With your group, you will need to design a fair test that will show you which of your straw flyers is best at one of the challenges above.

Remember that a fair test includes:

- ☐ a process to collect data
- ☐ multiple trials
- ☐ objective measurement
- ☐ a way of controlling your variables



PLANNING YOUR CONTEST:

1. **What does the contest measure?**
   example: It tests how long a straw flyer will stay in the air.

2. **What will each member of your group have to do for your contest?**
   example: Throw the straw flyer in the air and see how long it stays up.

3. **How will you make your contest fair?**
   example: There will be someone to say go so that a person knows when to throw the flyer. We will use a stopwatch to record the time.

Lab Task #3 - Collect Data Fairly

NAME OF YOUR CONTEST:

List the rules for your contest:

_____

_____

_____

_____

Name of each member of your group	RESULTS of Trial #1	RESULTS of Trial #2	RESULTS of Trial #3	AVERAGE

Bonus challenge: *If you complete your contest and have extra time, each member of your group is now allowed to modify his or her straw flyer in any way he or she wants. After all modifications are complete, do your contest again.*

Meeting of the Minds

Presenting Data and Findings

Contest Results

Be sure to bring:

- ☐ The rules of your group's contest
- ☐ Your data table with the results from the Straw Flyer Contest

Present your findings:

Step One:

Explain your event and make sure that everyone understands what you were measuring and how you measured it.

Step Two:

Announce the winner of your event.

Step Three:

Answer questions or respond to challenges about the way you planned or carried out your event.

Also, be ready to discuss:

Do you think that all the contests were **fair** or would you change some?
Do you think it's possible to determine the "best" flyer out of all those tested?
Why do you think that multiple **trials** are important when testing flyers? How did you use the data from more than one **trial**? Did you average? Take the best? Why?
What did you choose to measure in your contest? Did you use **objective** measurements?
How did you **control** your **variables** in your contest? For example, did people have to stand behind a certain line?

Writing

Is "Do or Die" or Multiple Trials Better?

Considering a New Situation

Examine this quotation:

> *"Many other countries select their Olympic athletes based on a variety of factors, including their record over the previous year. The United States Olympic Track Team is selected using only the results of a single meet called the Olympic Trials. It's a 'do or die' situation for the athletes."*

Respond to this prompt:

The new nation of Vocabulandia has decided to send a team to the Olympic Games. Please make a recommendation about how Vocabulandia should select athletes based on what you know about fair tests.

Adapted From SERP Science Generation 6.05

Developing and Testing a Hypothesis

Science Theater

A Controversial Hypothesis...

Stephanie grabbed her backpack and headed for the bus stop. Her friends Juan and Malik were standing at the corner talking so loudly that she could hear them half a block away.

Juan: I can't believe that game last night. That was crazy! Our new pitcher is amazing.

Malik: No kidding. No one on the other team could hit anything that he threw. It was awesome. We are totally going to win the World Series this year.

Stephanie: Are you guys talking about the baseball game last night? It looked like the other team was asleep every time they got up to bat. They just kept swinging way too late to hit anything.

Malik: Seriously. The batters looked like they were swinging in slow motion.

All three of them laughed and agreed that the batters on the other team seemed to have really slow ***reaction*** *times.*

Juan: Martinez just throws so fast! I know I wouldn't want to have to bat against him.

Stephanie: No kidding.

Malik: But these guys are supposed to be professionals! They're supposed to be able to hit anything.

Stephanie: Maybe they were just tired. Everybody has a bad day now and then.

Malik: Or maybe their team just stinks.

Juan: I don't know. I bet there are lots of things that affect how fast a batter reacts to a fastball.

Malik: Maybe. But what I do know is that boys can hit a fastball better than girls.

Stephanie: No way is that true! Look at Venus or Serena Williams hit a tennis serve and tell

me girls don't have reaction times that are as fast as boys. Maybe girls have even faster reaction times.

Juan: Maybe it has to do with being an athlete and not whether you're a boy or a girl. I think if you play sports a lot you're always improving your reaction time. What do you all think?

Malik: But guy athletes play baseball and girl athletes play softball. Softball is definitely a slower game. Girls have to play softball because they have slower reaction times. Stephanie just can't admit it.

Stephanie did not agree with Malik's hypothesis. It made her mad that Malik said she just wouldn't admit that boys are faster.

Stephanie: I won't admit it because it's not true. I'll bet my reaction time for returning a fastball is faster than most of the boys in our class.

Juan: Geez, you two. Don't you think there's some way to figure this out?

Malik: Come on Juan. You agree with me, right?

Juan didn't think Malik was right but didn't want to take sides. Juan thought that maybe he could identify other variables that might affect a person's reaction times.

Juan: I'm not taking sides. I think there are tons of things that can change how fast your reaction time is whether you're a boy or a girl. Like Stephanie said, the other team seemed asleep at the bat. Maybe being tired makes your reaction time worse.

Stephanie: Right, but both boys AND girls get tired. So you should be on my side, Juan.

Malik: Even if being tired matters, I bet tired boys are still faster than tired girls. But I do agree with Juan; we need to figure this out. How about a test? Stephanie, are you game?

Stephanie: I'm game! Let's get this done!

Just then, the bus pulled up and they climbed on, each one wondering how to come up with a plan to measure reaction times and to see what might affect them.

WHAT'S THE POINT?

➜ Scientists are always looking for answers to questions about the world around them. They come up with hypotheses and then have to test them. Testing a hypothesis requires developing a procedure and carrying out an experiment. This week it is your turn to develop a procedure to test what might affect reaction times.

Questions about the Science Theater:

1. Malik says boys have faster reaction times than girls because:
   a) His brother is the best batter on the school's baseball team.
   b) Boys play baseball and girls play softball.
   c) Venus and Serena Williams are not as strong as male tennis players.
   d) All of his male friends are a much better athletes than any female athlete at school.

2. What is Juan's response to Malik's claim that boys have faster reaction times than girls?
   a) Juan's response is to remain neutral because Malik is his friend and he doesn't want to argue with him.
   b) Juan's response is to suggest that there are many things that might affect a person's reaction time.
   c) Juan's response is to disagree with Malik because his mother is a great athlete and his dad isn't.
   d) Juan's response is to agree with Malik's claim because he knows that Stephanie is not faster than the boys in her class.

3. What do Malik and Stephanie finally agree on?
   a) Both agree that girls are better at playing baseball than boys.
   b) Both agree that Serena and Venus Williams have slow reaction times.
   c) Both agree that a test is needed to get a better sense of reaction times.
   d) Both agree that they need to practice hitting fastballs.

4. What was Stephanie's position about boys having faster reaction times?

5. What evidence did Stephanie share in the Science Theater that supported her position?

6. What was Malik's position about boys having faster reaction times?

7. What evidence did Malik share in the Science Theater that supported his position?

8. How is the Juan character approaching the disagreement?

Scientifically Speaking

Constructing a Hypothesis, Developing a Procedure

Constructing a hypothesis is an important part of thinking about and discussing science.

A hypothesis is a statement that

1. includes a view the person thinks is true
2. includes a reason or a cause that you can test with a measurement

Remember yesterday when Malik was expressing his view about the differences between boys and girls in sports?

The first chart below shows a hypothesis Malik might construct. But before you decide whether you agree or disagree with Malik, let's first check to see if his hypothesis contains the two important parts of a hypothesis.

"Boys are better at hitting fastballs than girls because boys have faster reaction times."	
1) Does this statement include a view that Malik thinks is true?	☑ yes ☐ no
2) Does this statement include a reason or a cause that you can test with a measurement?	☑ yes ☐ no

So, regardless of whether you agree or disagree with Malik, this statement does seem to be a hypothesis.

Now let's look at a statement based on what Stephanie said about the baseball team's loss:

"They lost because everybody has a bad day now and then."	
1) Does this statement include a view that Stephanie thinks is true?	☑ yes ☐ no
2) Does this statement include a reason or a cause that you can test with a measurement?	☐ yes ☑ no

So, even though what Stephanie said might be TRUE it still is not a hypothesis.

Are you starting to get this? It's tricky!

Recognizing a Hypothesis

Now it's time for you to practice identifying hypotheses. With a partner, read the following statements and decide whether or not they are hypotheses. Remember, a hypothesis must have the two important parts described on the previous page.

George's statement:

"The fish in the stream are dying because of the pollution from the factory."

1) Does this statement include a view that George thinks is true?	☐ yes ☐ no
2) Does this statement include a reason or a cause that you can test with a measurement?	☐ yes ☐ no

Do you think that George's statement is a hypothesis? Explain your thinking.

Christina's statement:

"Students who study for more hours get higher grades."

1) Does this statement include a view that Christina thinks is true?	☐ yes ☐ no
2) Does this statement include a reason or a cause that you can test with a measurement?	☐ yes ☐ no

Do you think that Christina's statement is a hypothesis? Explain your thinking.

Tashia's statement:

"I heard that there might be life on Mars."

1) Does this statement include a view that Tashia thinks is true?	☐ yes ☐ no
2) Does this statement include a reason or a cause that you can test with a measurement?	☐ yes ☐ no

Do you think that Tasha's statement is a hypothesis? Explain your thinking.

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The Importance of Procedures

María just started writing down in her lab book how she plans to do an experiment.

Evaluate how she's doing so far:

María

Experiment Title:

The Effect of Salt on Ice

Hypothesis:

An ice cube melts faster when sprinkled with salt than it does normally.

Procedure:

1. Pour 50 mL of water into two separate compartments of the same ice cube tray. Place tray in freezer until both are frozen solid.
2. Take the two ice cubes out of the tray and set them side by side (but not touching) on a sheet of foil. Label the cubes "salt" and "no salt".
3. Immediately sprinkle some salt on top of one of the ice cubes (the one labeled "salt").
4. Use a stopwatch to measure how long it takes each of the ice cubes to melt completely.
5. Record the time in minutes and seconds in a table.
6. Repeat the procedure.

In science class, a good procedure includes:

- ☐ Detailed directions for each step.
- ☐ The number of times you are going to repeat the **procedure**.
- ☐ Information about labeling and recording the data.
- ☐ Units of measurement that are easy for others to understand. For example, use *10 grams* which is explicit instead of *a little bit* or *some*.

DISCUSS:

How well did María do in writing her procedure?

Did she include the four things described above?

Can you and your partner mark up (edit) María's procedure to fix what she left out? You can add or delete information.

Lab: Procedures to Test Reaction Times

Writing and Following Procedures

Lab Task #1 - Practicing a Procedure to Test Reaction Times

Soon you will be testing your own hypothesis about reaction times. But before that, let's practice a procedure that is used to test how quickly a person can react when a ruler is dropped without warning.

1. Get a 30 cm ruler.
2. The person testing holds the ruler at the 30 cm mark and lets it hang vertically.
3. The person who is being tested for their reaction time (the subject) places his or her thumb and index finger at the 0 cm mark ready to catch - fingers should not touch the ruler.
4. Without warning the subject, the person holding the ruler lets it go and the subject tries immediately to catch the ruler. Hint: To prevent guessing, vary the wait time of each drop.
5. On the data table below, record the distance the ruler fell before being caught. You do this by reading where the ruler was caught by the subject (record the number mark just above the fingers).
6. Do the test a second time with the same person and then average the two distances.
7. Repeat steps so you're the subject and your partner is the experimenter.

Name of the person you are testing	**Drop #1** Distance of the fall (cm)	**Drop #2** Distance of the fall (cm)	**Average**

Lab Task #2 - Developing a Ruler-Drop Procedure to Test a Hypothesis

CONSIDER THESE HYPOTHESES:

- ☐ Reaction time improves with practice.
- ☐ Reaction times are faster when people are standing rather than sitting.
- ☐ Reaction times will be faster if you use the hand you write with.
- ☐ Reaction times will be slower if your heart is beating very fast.
- ☐ _____

1. With your partner, select a **hypothesis** from the list above (or make up your own).
2. Why do you believe the **hypothesis** is true?
3. On the next page, write down a **procedure** to test the **hypothesis**. Remember all the things you learned in the previous unit on **fair tests** - for example, the need for multiple trials, controlling variables, etc.

Here is a sample of another team's hypothesis and procedure. Reading this might help you get started.

Hypothesis:

People react faster when they hear the word "go" before a ruler is dropped rather than by just seeing a ruler drop.

Procedure:

1. Explain the two different versions of the test to the person you are testing.
2. Do Version 1: Drop the ruler without saying "go."
3. Record the distance the ruler falls.
4. Repeat Version 1 two more times. Record all data.
5. Do Version 2: Drop the ruler but say "go" as you let go of the ruler.
6. Record the distance the ruler fell.
7. Repeat Version 2 two more times. Record all data.
8. Average the data you recorded for each version.
9. Find additional subjects and repeat the experiment.
10. Compare the overall data.

Your Ruler-Drop Experiment

Write down the hypothesis you selected from the list:

Provide the details of your procedure:

☐ Get your procedure approved by the teacher.

Lab Task #3 - Using your Procedure to Test a Hypothesis - Data Table

Use your procedure to test your hypothesis. Use this space to make tables for collecting your data:

Collect and analyze all of your data. Does your evidence support your hypothesis? What are you now able to claim?

We claim that reaction times _____

_____ .

Our claim is supported by evidence that _____

_____ .

DISCUSS:

What can you now predict about other situations in which people must react quickly?

Meeting of the Minds

Analyzing Procedures, Making Claims, Considering Alternatives

Be sure to bring:

- ☐ Your hypothesis
- ☐ Your procedure
- ☐ Your data table
- ☐ Your claim

BE READY TO DISCUSS:

(space for notes provided):

➜ What claim could you make based on your test? Do other groups agree with your claim?

➜ Can you think of other possible experiments to test reaction times?

➜ How did you develop your procedure? Why did you choose the steps you did?

Writing

Summarizing Your Experiment

Write a summary of your experiment based on the data you gathered when you were testing your hypothesis about reaction times.

In your response, be sure to include:

- ☐ A claims - evidence statement
  For example: I claim that _____ because my evidence shows _____ .
- ☐ Reasons why you think your claim is true
- ☐ Ways to change your procedure to make it better
- ☐ Other possible experiments about reaction times and predictions of how they would turn out
- ☐ New questions you have about human reactions that you may want to learn more about

Adapted From SERP Science Generation 6.06

Thinking About Testable Questions

Science Theater

Deciding to Investigate

Erin scanned the crowded cafeteria and saw her friends Clara and Jose sitting at a table near the window. She quickly joined them, claiming the last empty seat at the table.

Clara: Hey Erin! Didn't you try out for the gymnastics team yesterday? How did it go?

Erin: It was really awful. I had to do all of these jumps and flips, which was fine. But sometimes the coach wanted me to land on one foot. I was not happy. I fell every time.

Clara: I'm sorry. That sounds really bad.

Erin: I just have no balance. I guess I'll never be on the team.

Jose: Don't think like that. You know what? I think I can help you improve your balance!

Erin: Really?

Jose: Really. So, last year my cousin got this special bracelet for Christmas which is supposed to help with balance. It had magnets or something in it. She said it helped her so much that she made the dance team on her first try.

Clara: Jose, do you actually believe that was why she made the team? How can a bracelet make you a great dancer?

Erin: I don't know. But, what if it really works?

Clara: I bet it's just another one of those silly things that people tell you on TV so they can take your money. Last year my dad bought some machine that was supposed to make his stomach flat. He still has a belly and the device is now in the closet.

Erin: How can a company say that? How can they make a claim like that without proof? I'm sure the company selling the bracelet tested it

to see if it really did help improve balance.

Jose: Well, I've got my evidence. It worked for my cousin, and that's enough for me.

Clara: I'm not so sure that the company conducted the kind of experiments that would prove the bracelet helps with balance. There are so many variables that can affect a person's balance. For example, I had an ear infection two weeks ago. One morning I almost fell getting out of bed because I was so dizzy. My Mom said that your inner ear plays a role in balance, which seems strange to me.

Erin: Well, why don't we conduct our own test? Let's buy a bracelet and see if it works under different conditions.

Erin believed that the claim that the bracelet could improve balance was definitely testable, and that conducting the test would show the bracelet worked. Clara was still skeptical, and Jose realized they might have a problem.

Jose: We could do an initial test with one bracelet, but I think in the end we'd have to test more than one of them and my cousin said they are expensive.

Clara: I think we will be better off if we investigate how other variables might affect Erin's balance in the tryouts. One variable could be the food you eat. It could be that your balance was off because you were feeling weak. Maybe all you needed was to eat breakfast. Another variable could be the amount of sleep you get. Maybe you didn't get enough sleep the night before the tryouts.

Erin: You really think there are that many variables that can affect balance? Variables–such a great word!

Clara: Of course. All we need to do is figure out, I mean determine, what might help you improve your balance so you make the gymnastics team.

Jose: Let's all investigate. And Erin, just remember, we can always buy you a bracelet if nothing else works!

The friends decided that they would investigate variables that might improve a person's balance. They made a plan to meet the next day.

Questions about the Science Theater:

1. What does Clara think?
   a) She thinks the bracelet company conducted the proper experiments to determine if the device works.
   b) She thinks the bracelet company should display their findings at a science conference.
   c) She thinks there are many variables that can affect a person's balance.
   d) She wants to make the gymnastics team so she wants a bracelet.

2. What does Jose think?
   a) He thinks the bracelet has been tested many times so it must work.
   b) He thinks if the bracelet helped his cousin make the dance team, it must improve balance.
   c) He thinks the company did not conduct proper testing to find out if the bracelet works.
   d) He thinks the bracelet will help him make the dance team.

3. What does Erin want?
   a) She wants to buy the bracelet if it will help her make the gymnastics team.
   b) She wants Jose to lend her money to buy a bracelet because it is expensive.
   c) She wants to do tests to get a better sense of reaction times.
   d) She wants to meet Jose's cousin to ask for more details about how the magnetic bracelet helped her make the dance team.

4. Think about ads that you have seen on TV or in magazines. Did you ever wonder if those claims were true? Which claim would you like to test? (Example: I would like to test the claim that a certain toothpaste really makes your teeth whiter.)

WHAT'S THE POINT?

Scientists do large amounts of research on a topic before they have enough data to make a claim. Once they gather data, they often present their research at a conference where other scientists can learn from them. They display their work on posters and give presentations about the experiments they have conducted. Scientists can then get suggestions and comments from others in their field and this improves their research.

Your team will be conducting your own experiment to investigate what might affect a person's balance. Your team will display and present your work to the rest of the class in a conference at the end of the week.

Scientifically Speaking

Determining if a Question is Testable, Considering if an Investigation is Practical

Scientists ask questions all the time, but some are better for investigation than others. When you come up with a question for an investigation, think about two things:

- ***Is the question testable?***
- ***Is the investigation practical?***

1. Testable Questions

In science, some questions are testable while others are too general to be tested. Scientists are often interested in general questions, but they learn about these by studying testable questions. A testable question is one where you ask whether changing one thing will have an effect on another. A testable question must be specific and be about variables that are measurable.

Look at the two examples below. These are examples of testable vs. untestable questions. Look closely at the differences between the two.

Untestable Question	Testable Question	Why is the question testable?
How do plants grow?	Will adding fertilizer make plants grow taller?	What you change: *add fertilizer*
		What could happen: *the plant might grow taller*
What prevents ice from melting?	Which is the best insulator to keep ice from melting? Aluminum foil or Wool?	What you change: *the insulator materials*
		What could happen: *the ice might melt slower*

ACTIVITY

Look at the questions in the chart below. The first two questions are done for you. Fill in the chart for the remaining two questions.

	Why is the question **NOT** testable?	Can you make a testable question about this same subject?
Does a fish get angry if you take away its food?	This is not testable because we have no way to measure fish anger.	Do fish lay fewer eggs when they have less food? *(The question is better because you can measure how much food the fish eats and how many eggs it lays.)*
Will dogs be affected by the weather?	This is not testable because it is not specific enough.	Does a dog shed more hair when the weather is warmer? *(This question is better because it asks specifically about what happens in warm weather.)*
Do plants like water?		
Will sleep affect a student?		

2. Practical Investigations

Do you have the materials and time to conduct your investigation?

Remember when Erin wanted to investigate the magnetic bracelets to see if they improved balance, and Clara pointed out that they didn't have any bracelets and buying them would be expensive? This is an example of not having the right materials needed for an investigation. When coming up with an investigation, make sure you have all the materials you need and that you have enough time to conduct the experiment.

ACTIVITY

Below are some examples of questions about balance. Do these questions meet the requirements for an investigation that can be carried out in a classroom? Would it be practical?

	Testable?	Practical?	Why or why not?
Can people balance on one foot longer if they are standing in a swimming pool?	☑ yes ☐ no	☐ yes ☑ no	The question is testable, but we don't have a swimming pool in the classroom.
Does eating a Power Bar affect your balance?	☐ yes ☐ no	☐ yes ☐ no	
Can people balance on one foot longer if they practice every day for a year?	☐ yes ☐ no	☐ yes ☐ no	
Does being sick make your balance worse?	☐ yes ☐ no	☐ yes ☐ no	

Lab: What Affects Balance?

Coming up with an Investigation and Conducting It

On the previous page, you looked at examples of questions for investigation and evaluated whether they were testable, the materials were available, and there was sufficient time to conduct the experiment. Now it is your team's turn to come up with an investigation about variables that affect balance. Your initial step is to come up with a question for investigation. Your team will work on your investigation for the rest of the week and will present results to the class at the end of the week during the conference.

In order to begin:

1. What is your investigable question about balance? Remember that it needs to be testable, and you need the right materials and enough time to conduct your investigation. (Example: *Does moving your arms around help with balance?*)

   Our question about balance is:

2. Write a scientific hypothesis statement about balance that addresses your question. Remember that a scientific hypothesis statement includes: a) a view based on what you know or think and b) a reason or a cause that you can test with a measure. (Example: *People will balance on one foot longer when they are allowed to move their arms.*)

   Our hypothesis about balance is:

3. Discuss a procedure for your experiment. (You will write your procedure on the next page.) Remember: In science class, a good procedure includes:
   - ➜ Detailed directions for each step
   - ➜ The number of times you will repeat the procedure
   - ➜ Information about labeling and recording the data
   - ➜ Units of measurement that are precise, so you or someone else could repeat the procedure exactly (e.g., use 10 grams instead of "a little bit" or "some")
4. List the materials you will need for your experiment:

5. Estimate how much time it will take to do your experiment:

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Now, write the procedure for your balance experiment:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Next, conduct your experiment. Use this space to record your data in a table.

CONCLUSION:

After your team has completed data collection, write a claims, evidence, reasoning statement based on the results of your experiment. Remember to look for patterns in your results to help you make your claim.

In writing your statement, be sure to answer the following questions:

- ☐ What can your team claim about the data?
- ☐ What is your evidence to support your claim?
- ☐ What reasons can you give to connect your evidence and your claim?

Assembling a Mini-Display

Making a Poster to Practice for Science Fair

Scientists sometimes present their work at conferences. In a similar way, each team in your class is now responsible for presenting your work to other students. Focus on the variables you tested that might affect a person's balance. To do this, your team will make a poster that displays the findings of your investigation. Be sure to include everything that is shown on the model below:

One more thing: Soon you will be presenting this information. Before then, think about:

What is a possible criticism of your investigation?

One possible criticism might be:

_____

_____

_____

_____

_____

Getting Feedback

Listening to Presentations and Offering Feedback

At conferences, scientists have a chance to ask each other questions about their research. Like them, each team will have a chance to listen to the investigation results of other teams. After you have listened to a presentation, your job is to come up with one general comment for each team as well as one question for clarification about how they conducted their investigation. Work together to come up with one question and one comment for each team.

For Team 1:

Comment: _____

_____

Question: _____

_____

For Team 2:

Comment: _____

_____

Question: _____

_____

For Team 3:

Comment: _____

_____

Question: _____

_____

For Team 4:

Comment: _____

_____

Question: _____

_____

Developed in Collaboration with MSQI

Your Science Fair Project

Getting Ideas from Other Students' Experiences

"Oobleck" Inspires this Team

Lucy, Shanelle, and Maria loved their study of states of matter in the spring of their 7th grade year. They were especially intrigued by the substance known as "oobleck." When they were given the opportunity to work on their science fair project together they easily agreed that they would like to develop an experiment around oobleck. They referred back to the notes in the science section of their binders. They also referred to books in the classroom describing states of matter and the properties associated with each state. With a bit of guidance from their teacher, they spent some time learning about viscosity, how it can be measured, and the relative viscosity of common substances.

They decided to test the viscosity of the oobleck by measuring the amount of time it takes for it to travel a pre-determined distance. The independent variable was the amount of water used to make the oobleck. There were a few challenges in the experiment, especially because they had to agree on a list of ingredients and decide who would bring in each thing in order to have enough material to complete all of the agreed-upon trials. In the end, they were able to get some materials from the science closet and the art teacher, and their parents helped by purchasing other materials at the grocery store.

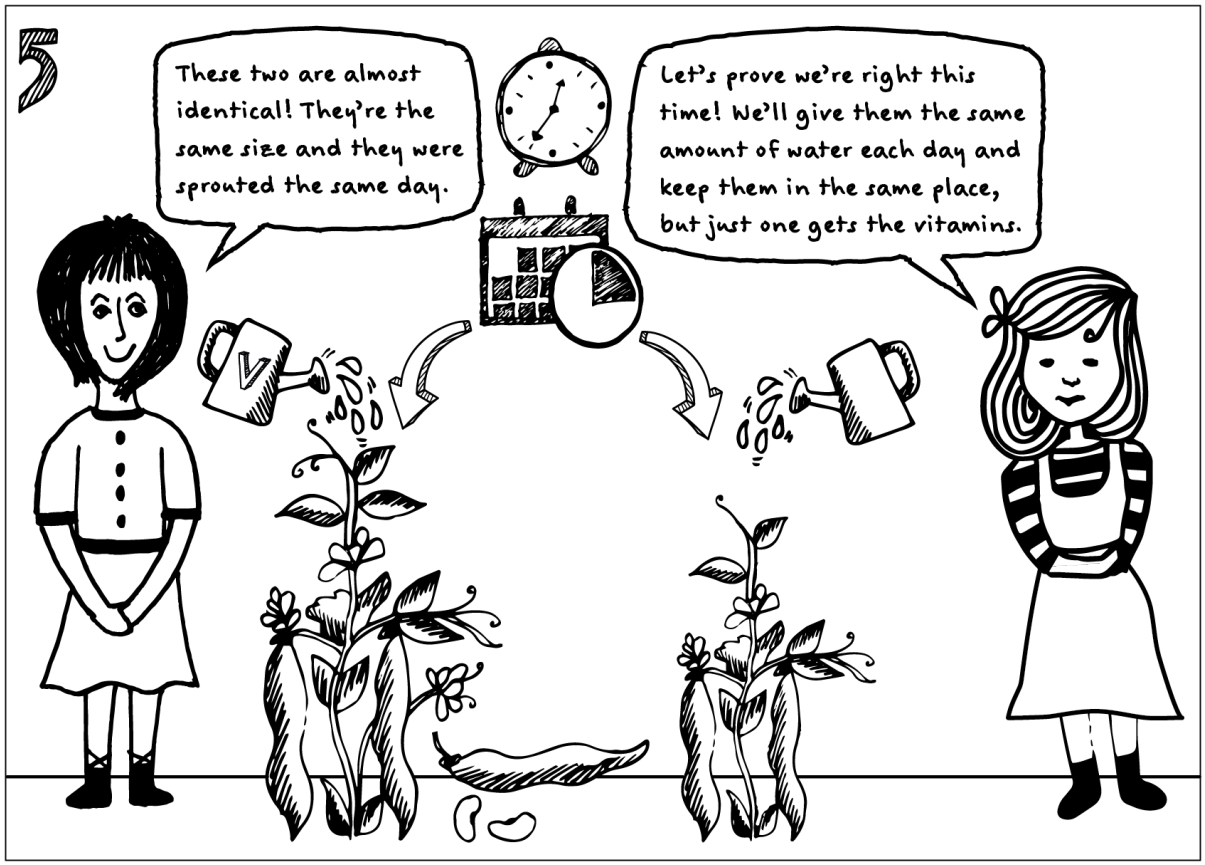
As part of their science fair presentation, they engaged their audience by having them make oobleck and teaching them some of the basics about viscosity. By the time they finished the project, this group had become experts on the non-Newtonian substance, and they were eager to learn even more about chemistry in high school.

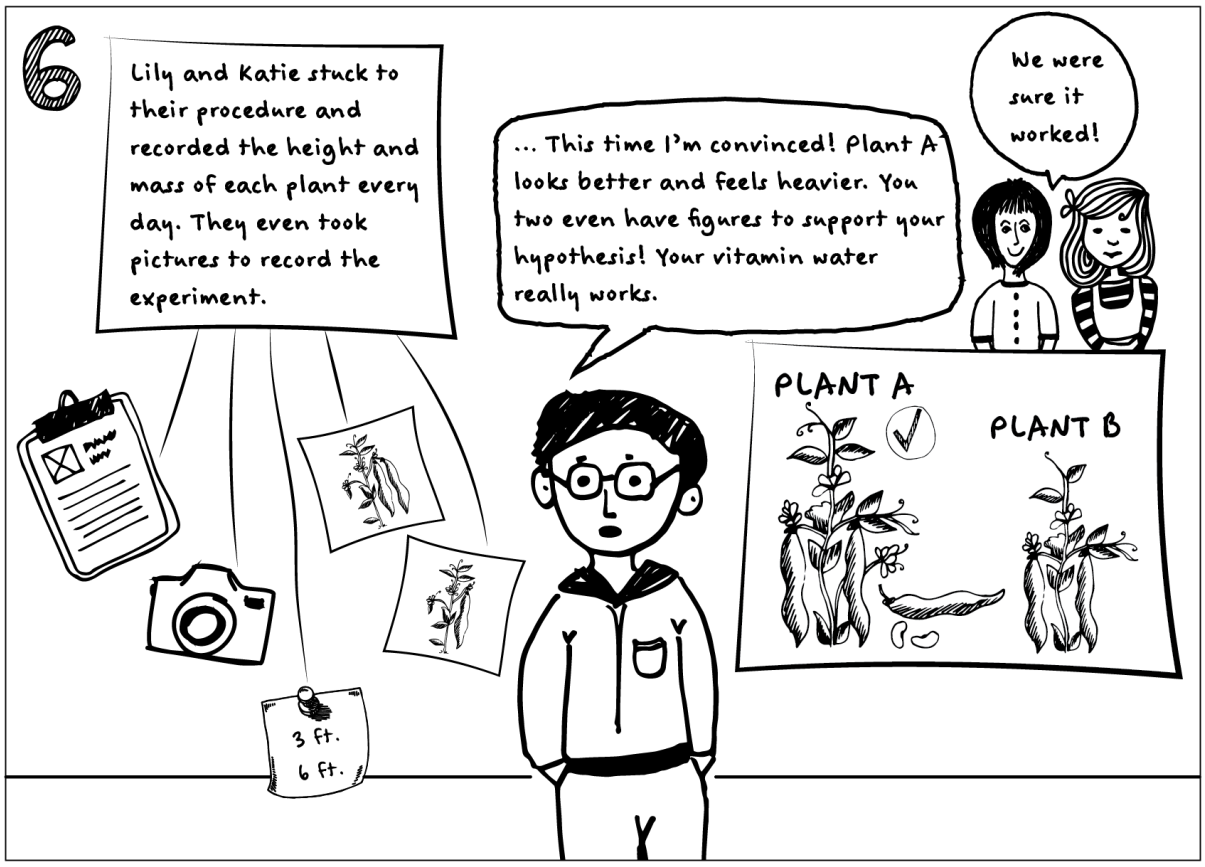
(Oobleck gets its name from the Dr. Seuss book Bartholomew and the Oobleck where a gooey substance, Oobleck, fell from the sky and created a nightmare situation for a fictional kingdom.)

Students Wonder If Vitamins Are Good for Plants


3
Not to be discouraged, Katie and Lily sprouted two new Scarlet Runner plants. They gave a Scarlet Runner plant water with vitamins and a Mung Bean plant water with no vitamins. When they showed the plants to Jackson three weeks later, he seemed convinced, but only for a moment.
Wait! Your results prove nothing! Even if you hadn't used your supplement, the Scarlet Runner plant would have been larger; the Mung bean plants don't grow as large as other bean plants.
Oh no! He's right! We can't tell how the plants might have compared without the supplement.


4
Let's try one more time. Our science class just sprouted a whole new bunch of the exact same kind of bean.
Let's go and see if there are any left.


5
These two are almost identical! They're the same size and they were sprouted the same day.
Let's prove we're right this time! We'll give them the same amount of water each day and keep them in the same place, but just one gets the vitamins.


6
Lily and Katie stuck to their procedure and recorded the height and mass of each plant every day. They even took pictures to record the experiment.
... This time I'm convinced! Plant A looks better and feels heavier. You two even have figures to support your hypothesis! Your vitamin water really works.
We were sure it worked!
PLANT A
PLANT B
3 ft.
6 ft.

A Step-by-step Approach

1. Deciding on an Investigation

- [ ] **Do some background reading.**
- [ ] **Brainstorm.**
- [ ] **Discuss ideas with other students.**
- [ ] **Conduct some informal research.**
- [ ] **Ask questions and make plans.**

Notes:

2. Developing a Question

- [ ] **Reread pages 31-33.**
- [ ] **Is your question is testable?**
- [ ] **Can your question lead to a practical investigation?**
- [ ] **Is there a way to change one thing in order to test?**
- [ ] **Is there a way to measure objectively?**

Notes:

3. Framing your Hypothesis

There are several good ways to frame a hypothesis. Here is one:

"If the ***INDEPENDENT VARIABLE*** changes, then the ***DEPENDENT VARIABLE*** changes because ***REASON***."

The thing you plan to change in your experiment is called the INDEPENDENT variable. The thing you measure is called the DEPENDENT variable.

For example, if you want to know if salt water boils faster than fresh water, you would boil a pot of fresh water and then boil a pot of salt water. The ***saltiness*** *of the water is the INDEPENDENT variable because it is the thing you changed.*

To do this experiment, you would need to time how long each pot took to boil. Then ***length of time*** *until boiling is the DEPENDENT variable.*

It's also important that you think about other variables for this to be a fair test. For example, were the starting temperatures of the pot and the water the same both times? Did you use the same amount of water? Was the heat source the same? Is "boiling" defined as when you see bubbles? How many?

For the boiling water example above, you could frame a hypothesis this way:

➜ If the SALTINESS OF THE WATER changes, then the TIME IT TAKES TO BOIL changes because it takes more energy to heat water than salt.

- ☐ **Reread pages 18-19.**
- ☐ **Consider all the variables involved in your investigation.**
- ☐ **Determine the independent and dependent variables.**
- ☐ **Write a hypothesis.**

Notes:

4. Designing an Experiment

- [ ] **Reread page 20.**
- [ ] **List your materials.**
- [ ] **Write your procedure.**
- [ ] **Think: Will your procedure test your hypothesis effectively?**

Notes:

5. Collecting Data

- [ ] **Reread pages 7-9.**
- [ ] **Create an organized way to collect and store data.**
- [ ] **Use objective units of measurements.**
- [ ] **Conduct multiple trials.**

Notes:

6. Making Conclusions

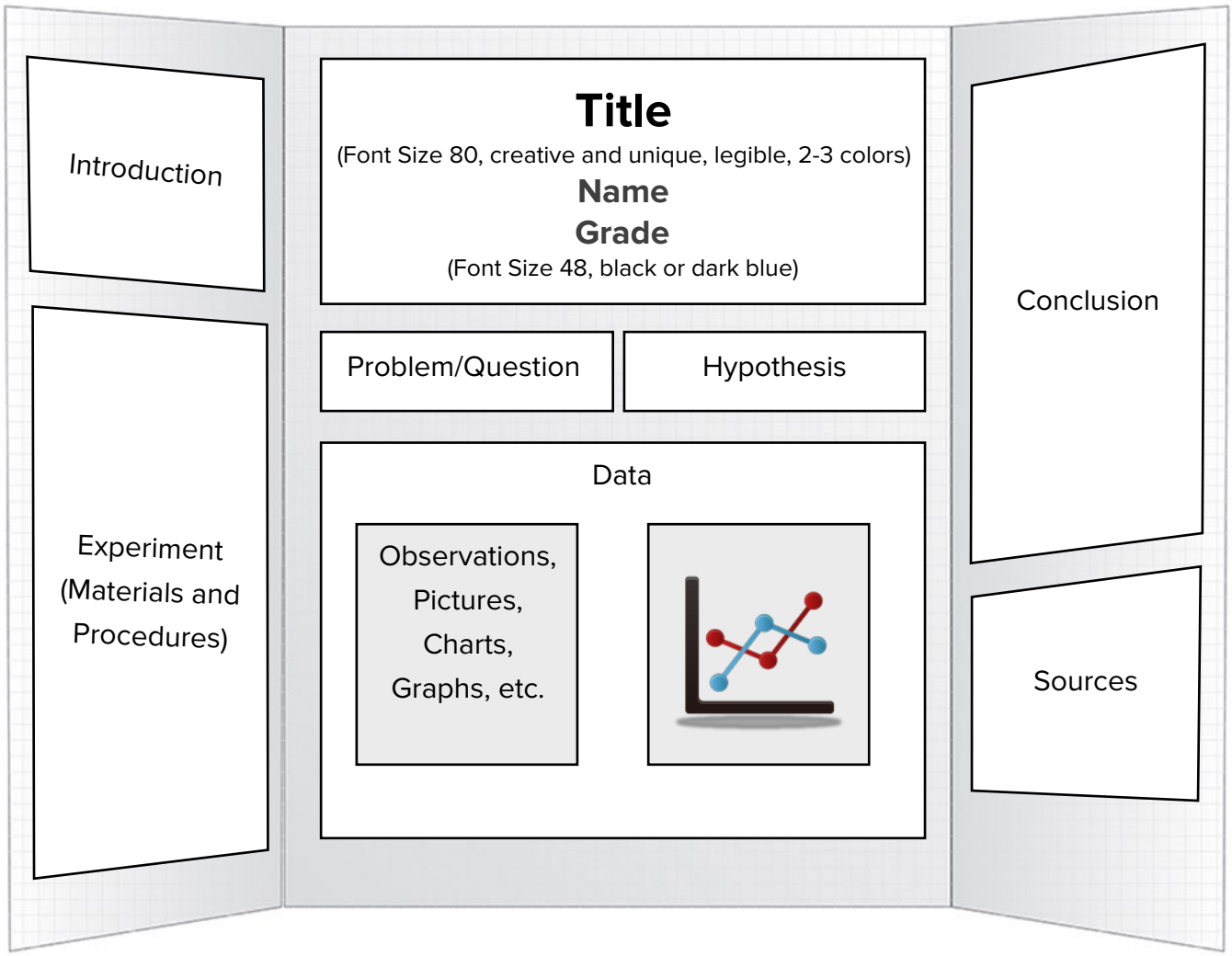
- [ ] **Explain what happened and why.**
- [ ] **Offer reasons and evidence.**

Notes:

Visual Display

Putting Your Board Together

Use the model below to create an informative and engaging display.



Oral Presentation

How to be Ready

Every student must give a short oral presentation to an audience. The talk should be at least 5 minutes long, at most 7 minutes. When you give your presentation you should include the following information:

- Introduce yourself
- Discuss the purpose of the experiment, question you wanted to answer
- Describe your hypothesis and the research that supports your hypothesis
- Mention any books or articles you may have read related to the topic
- How did you go about answering the question?
- What happened? What conclusion did you reach?
- Do you have any new questions based on the outcomes? Is there anything you wish you had done differently? What follow up experiments would you propose?
- Be prepared to answer questions from the audience.

Glossary

conduct

verb – to carry out a procedure or task

Scientists who conduct several trials produce better data than those who are satisfied with conducting a single trial.

determine

verb – to find out the facts about something

The fire chief determined the source of the fire was old electrical wires.

device

noun – a machine that does a specific task or job

The grocery store installed a device on its shopping carts that prevents people from stealing them.

fair

adjective – when everyone is treated in a way that is right or equal; in science, something is fair when variables are controlled so that they should not affect a test result

The teacher argued that the test was fair because every student got the same questions and had the same amount of time to take it.

hypothesis

noun – an idea about why something happens that needs to be supported with evidence

Manny wanted to test his hypothesis that paper airplanes will fly farther if their wings are longer.

investigation

noun – the process of trying to find out the truth about something by carefully studying the details

Popular TV shows like C.S.I. and JAG entertain viewers with exaggerated details from the investigation of crimes.

➜ **objective**

adjective – when you decide something based only on the facts, not how you feel about someone or something; in science, something is objective if it can be proved based on facts

To decide who wins an athletic contest, there should be an objective measure.

➜ **procedure**

noun – a way of doing something; a method

During a fire drill, students should always follow the procedure for exiting the building safely.

➜ **process**

noun – when someone takes several steps or actions to get a result; in science, part of the scientific process is to repeat trials and experiments to make sure that a result is correct

The process of testing the powder for toxins was complicated and dangerous.

➜ **testable**

adjective – able to be tested using procedures, measurements, and data to find out answers

The view that teens who play violent video games are more likely to commit violent acts is testable.

➜ **trial**

noun – a test or an experiment; in law, a trial is when lawyers from different sides present evidence to figure out if someone is guilty; in science, a trial is a test that is repeated as part of an experiment

The factory tested the safety of its new line of cars by driving them in trials in the rain, the snow, up hills, and in the fog.

➜ **variable**

noun – something that can change in different situations; in science, a variable is something that, if it changes, can lead to different results in a trial or experiment

Some of the variables that can affect how well a football player performs are how much he practices, how well he eats, and how much he works out.