Science News
EDUCATOR GUIDE

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April 11, 2020
A Tiny Dino and Iron Rain

SOCIETY FOR SCIENCE & THE PUBLIC

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About this Guide

In this Guide, based on the *Science News* articles "This ancient dinosaur was no bigger than a hummingbird" and "Heavy metal may rain from the sky of an exoplanet," students will learn about the smallest-known Mesozoic dinosaur and use phase diagrams to explore meteorology on an exoplanet. In an activity, students will collect and analyze data in their own homes.

This Guide includes:

Article-based Comprehension Q&A — Students will answer questions about the *Science News* article "This ancient dinosaur was no bigger than a hummingbird" (Readability: 12.1), which reports on a fossil of a many-toothed, Mesozoic predator. Related standards include NGSS-DCI: HS-LS4; HS-LS2.

> **Student Comprehension Worksheet —** These questions are formatted so it's easy to print them out as a worksheet.

Cross-curricular Discussion Q&A — Students will use phase diagrams to explore how changes in temperature and pressure affect a substance's phase of matter before applying the concepts to meteorology on Earth and the exoplanet WASP 76b. This discussion is based on the *Science News* article "Heavy metal may rain from the sky of an exoplanet" (Readability: 10.7). Related standards include NGSS-DCI: HS-PS3; HS-ESS1.

> **Student Discussion Worksheet —** These questions are formatted so it's easy to print them out as a worksheet.

Activity: The Home as Laboratory

> **Summary:** Science isn't done just in a laboratory. Observing phenomena and collecting data in the real world are key parts of the scientific effort. This activity, designed for at-home learning, encourages students to collect and analyze data in their own homes to develop a research question for future exploration. Related standards include NGSS-DCI: HS-ETS1.
>
> **Approximate class time:** 1 class period (for data analysis).

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Article-based Comprehension, Q&A

Directions for teachers: After your students read "This ancient dinosaur was no bigger than a hummingbird," ask them to answer the following questions.

1. What is *Oculudentavis khaungraae*? Why does the story refer to the creature as a dinosaur and a bird?

Oculudentavis khaungraae is an ancient small, toothed bird. The story refers to *O. khaungraae* as a dinosaur and a bird because it is both; birds are a kind of dinosaur.

2. During what geologic era did *O. khaungraae* live? Where was it found?

O. khaungraae lived 99 million years ago during the Mesozoic era. The bird's skull was found in amber in Myanmar.

3. What makes the creature unique?

It is the smallest known dinosaur from the Mesozoic era.

4. What is the length of the creature's skull? Describe its relative length compared with the average length of a human thumb, which is around 6.6 centimeters.

The creature's skull is 14.25 millimeters long. The average length of the human thumb, 6.6 cm, converts to 66 mm. So about five skulls lined up would roughly be the same length as a human thumb.

5. What do scientists think *O. khaungraae* ate during its lifetime? How did they come up with this idea?

Based on the surprising number of teeth found in the bird's skull, scientists think that *O. khaungraae* was a predator that may have eaten small fish or invertebrates.

6. What modern animals is *O. khaungraae* compared to? How is *O. khaungraae* similar to these animals?

O. khaungraae's size is comparable to the bee hummingbird, the smallest known bird living today. *O. khaungraae*'s eye sockets, which are deep and conical in shape, are similar to those of modern owls.

7. How are *O. khaungraae*'s eyes different from one of the animals? What could explain this difference?

Though *O. khaungraae*'s eye socket shape and depth are similar to that of modern owls, the ancient bird's eyes are positioned on either side of its head, facing outward. An owl's eyes are positioned on the front of its head. Evolutionary miniaturization — the process whereby animals evolve smaller body sizes — could explain why *O. khaungraae*'s eyes are side-facing instead of front-facing.

8. Why might it be hard for scientists to figure out where this ancient bird fits on the tree of life?

Because this bird has a mix of odd features, it is hard to know what birds it is most closely related to.

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Student Comprehension Worksheet

Directions: After reading "This ancient dinosaur was no bigger than a hummingbird," answer the following questions.

1. What is *Oculudentavis khaungraae*? Why does the story refer to the creature as a dinosaur and a bird?

2. During what geologic era did *O. khaungraae* live? Where was it found?

3. What makes the creature unique?

4. What is the length of the creature's skull? Describe its relative length compared with the average length of a human thumb, which is around 6.6 centimeters.

5. What do scientists think *O. khaungraae* ate during its lifetime? How did they come up with this idea?

6. What modern animals is *O. khaungraae* compared to? How is *O. khaungraae* similar to these animals?

7. How are *O. khaungraae*'s eyes different from one of the animals? What could explain this difference?

8. Why might it be hard for scientists to figure out where this ancient bird fits on the tree of life?

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Cross-curricular Discussion, Q&A

Directions for teachers:
Ask your students to read the *Science News* article "Heavy metal may rain from the sky of an exoplanet," then collaborate to answer the partner questions about phase changes below. Finally, prompt students to imagine their own exoplanet and its atmosphere and develop related phase diagrams before sharing responses with classmates.

Want to make it a virtual lesson? Post the *Science News* article "Heavy metal may rain from the skies of planet WASP 76b" to your online classroom and ask students to read the article. Pair up students to discuss and answer the partner questions below using a video conferencing platform, or talking by phone. They can collaborate in a shared document during the conversation. Post the class discussion prompt to an online discussion board. Have students respond individually and give feedback or ask a question about a classmate's response.

Partner questions
1. What substance was identified as a gas in the atmosphere of exoplanet WASP 76b? When was the gas seen and when was it not seen in the atmosphere? What do scientists think happens to the substance over the course of a day and night on the planet? What does that mean in terms of the substance's phase of matter? (In explaining your answer, it might be helpful to sketch what happens to the substance during the transition from daytime to nighttime and back again.)

Iron gas was identified in the atmosphere of exoplanet WASP 76b where the planet transitions from daytime to nighttime. As nighttime approaches, scientists think that gaseous iron in the atmosphere condenses, meaning it turns from a gas to a liquid, and during the night that liquid iron falls toward the center of the planet.

2. Name the phases of matter of a substance, and describe the general differences in their shape and volume. Explain your answers in terms of the phase's relative strength of intermolecular attraction forces, or the forces of attraction between the atoms or molecules within a substance.

Atoms and molecules can exist in the solid, liquid or gaseous phase. Solids have a fixed shape, and liquids and gases take the shape of their container. Solids and liquids have a fixed volume, and gases take the volume of their container. The intermolecular attraction between atoms or molecules of a substance in a solid is stronger than the attraction between atoms or molecules in a liquid, which is stronger than the attraction within a gas. That's why gaseous molecules are free to move within a space, and atoms or molecules within a solid are essentially stuck.

3. Based on the article, what factor affects the phase of matter of a substance? Explain.

The article mentions that the temperature of a substance can affect its phase of matter. Where the atmosphere was transitioning from the dayside to the nightside on WASP 76b, an extreme decrease in temperature, almost a 1,000-degree Celsius decrease, appears to have caused the iron to condense and change phase from a gas to a liquid.

4. A phase diagram shows how temperature and external pressure on a substance affect its phase of matter. Draw a general phase diagram including regions for solid, liquid and gas. Use this Purdue University page as a reference, if needed. Label your axes with appropriate titles and units, and include regions for each phase of matter.

See the example on the website provided. The y-axis should be titled "Pressure (in atmospheres)" and the x-axis "Temperature (in degrees Celsius)." Starting near the origin and moving clockwise by region, the phases of matter are solid, liquid and then gas.

5. A normal boiling point is the temperature at which a substance in the liquid phase becomes a gas at an external pressure of 1 atmosphere. The term "normal" refers to an external, or atmospheric, pressure equal to 1 atmosphere. Assume that you drew the phase diagram for H_2O in the question above. Mark the normal melting, boiling and condensing points for water on the phase diagram, and appropriately label the points with pressure and temperature values. Then, explain how condensation differs from boiling in terms of energy. (Please note: The phase diagram for H_2O would actually have a negatively sloping line between the solid and liquid phase.)

Students should identify a pressure of 1 atmosphere on the graph and mark where the phase boundaries intersect that pressure. Moving from left to right, students should label the first point of intersection "freezing point" and the second point of intersection as both "boiling" and "condensing" points. The first point should be labeled: 1 atmosphere, 0° Celsius. The second point should be labeled: 1 atmosphere, 100° Celsius. In order for a substance to condense, energy must leave the system. The opposite is true for boiling.

6. How can a change in pressure affect the phase of matter of a substance at a constant temperature (assume the temperature is one where all three phases of matter can exist)? Explain your answer using the diagram and your knowledge about the strength of attraction between molecules.

At a specific temperature, as the pressure increases, the atoms or molecules are forced more closely together, strengthening their intermolecular attraction. At a temperature where all three phases of matter can exist, increasing the pressure of a gas would make it a liquid. With further increases in pressure, the liquid would become a solid. You can see these phase transitions on the graph if you follow a vertical line that passes through all three phase regions.

7. Based on the info in the article and your knowledge of iron, how do you think the phase diagram for iron would compare with the phase diagram of H_2O? Explain. Then draw a quick sketch of iron's phase diagram. Draw a line to represent the phase transition described in the article. Mark any data points that you can on the diagram.

The phase diagram of iron would likely have the same general shape as that of H_2O, but the boundaries between phase regions would occur at much more extreme temperatures and pressures relative to H_2O's phase diagram. From the article, the condensing and boiling points would be over 1,000° Celsius, for example, where H_2O's is 100° Celsius. On the phase diagram for iron, students should draw a horizontal line from the gas to the liquid region and indicate a change in temperature of nearly 1,000 degrees Celsius.

8. How do you think Earth's atmosphere compares with that of WASP 76b's? Explain your answer in terms of temperature and pressure and potential composition.

WASP 76b's atmosphere is considerably warmer than Earth's atmosphere during the day and night, so it may contain more elements with higher boiling points as gases. Iron may be one of many heavy metals in WASP 76's atmosphere. Also, smaller molecules made up of lighter elements that exist in Earth's atmosphere, such as water or carbon dioxide, might not be able to exist in the liquid phase in the extreme environment of WASP 76. We don't have much information on the relative atmospheric pressure of WASP 76b compared with Earth. If gases exist in the same abundance in both atmospheres, the higher temperature on WASP 76b might make its atmospheric pressure higher, too. Gases at higher temperatures move faster and exert a higher pressure.

9. What are some factors of the atmosphere that affect weather patterns? Given these factors, what might contribute to differences in wind weather patterns on WASP 76b and Earth? How does the "iron weather" on WASP 76b compare with "water weather" on Earth?

Air temperature, air pressure, humidity, wind speed and direction are all aspects of the atmosphere that affect weather patterns. WASP 76b has extreme temperature differences between daytime and nighttime that seem to cause at least one heavy metal to condense and potentially rain nightly. The stark temperature changes likely cause other weather events, such as high winds. On Earth, there are not temperature differences that are so extreme, and the phase of water molecules depends on air pressure and temperature. Water vapor in Earth's atmosphere condenses into clouds, which under the right conditions will cause rain, releasing the water out of the atmosphere to fall toward Earth.

Class discussion prompt

Imagine your own exoplanet with an atmosphere different from Earth's. Explain the general conditions on the planet, as well as the atmospheric composition and general weather patterns that make the planet special. Research an additional phase diagram to inform your answer. Include at least two data points from a substance's phase diagram in your response. For additional inspiration, check out NASA's Exoplanet Exploration, which describes known exoplanets.

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Student Discussion Worksheet

Directions:

After reading the *Science News* article "Heavy metal may rain from the sky of an exoplanet," answer the following questions.

Partner questions

1. What substance was identified as a gas in the atmosphere of exoplanet WASP 76b? When was the gas seen and when was it not seen in the atmosphere? What do scientists think happens to the substance over the course of a day and night on the planet? What does that mean in terms of the substance's phase of matter? (In explaining your answer, it might be helpful to sketch what happens to the substance during the transition from daytime to nighttime and back again.)

2. Name the phases of matter of a substance, and describe the general differences in their shape and volume. Explain your answers in terms of the phase's relative strength of intermolecular attraction forces, or the forces of attraction between the atoms or molecules within a substance.

3. Based on the article, what factor affects the phase of matter of a substance? Explain.

4. A phase diagram shows how temperature and external pressure on a substance affect its phase of matter. Draw a general phase diagram including regions for solid, liquid and gas. Use this Purdue University page (https://chemed.chem.purdue.edu/genchem/topicreview/bp/ch14/phase.php) as a reference, if needed. Label your axes with appropriate titles and units, and include regions for each phase of matter.

5. A normal boiling point is the temperature at which a substance in the liquid phase becomes a gas at an external pressure of 1 atmosphere. The term “normal” refers to an external, or atmospheric, pressure equal to 1 atmosphere. Assume that you drew the phase diagram for H_2O in the question above. Mark the normal melting, boiling and condensing points for water on the phase diagram, and appropriately label the points with pressure and temperature values. Then, explain how condensation differs from boiling in terms of energy. (Please note: The phase diagram for H_2O would actually have a negatively sloping line between the solid and liquid phase.)

6. How can a change in pressure affect the phase of matter of a substance at a constant temperature (assume the temperature is one where all three phases of matter can exist)? Explain your answer using the diagram and your knowledge about the strength of attraction between molecules.

7. Based on the info in the article and your knowledge of iron, how do you think the phase diagram for iron would compare with the phase diagram of H_2O? Explain. Then draw a quick sketch of iron’s phase diagram. Draw a line to represent the phase transition described in the article. Mark any data points that you can on the diagram.

8. How do you think Earth’s atmosphere compares with that of WASP 76b’s? Explain your answer in terms of temperature and pressure and potential composition.

9. What are some factors of the atmosphere that affect weather patterns? Given these factors, what might contribute to differences in wind weather patterns on WASP 76b and Earth? How does the “iron weather” on WASP 76b compare with “water weather” on Earth?

Class discussion prompt

Imagine your own exoplanet with an atmosphere different from Earth's. Explain the general conditions on the planet, as well as the atmospheric composition and general weather patterns that make the planet special. Research an additional phase diagram to inform your answer. Include at least two data points from a substance's phase diagram in your response. For additional inspiration, check out NASA's Exoplanet Exploration, which describes known exoplanets.

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Activity Guide for Teachers: The Home as Laboratory

Purpose: Science isn't done just in a laboratory. Observing phenomena and collecting data in the real world are key parts of the scientific effort. This activity, designed for at-home learning, encourages students to collect and analyze data in their own homes to develop a research question for future exploration.

Procedural overview: After a virtual introduction to the activity, students will identify a phenomenon that they can observe at home over time and track and record quantitative data about that phenomenon. Then, students will display their data visually, analyze their findings and compare their data with data from other students in the class. Students will use the data they collect to develop a specific research question and hypothesis, and to identify additional data they would need to test that hypothesis.

Approximate class time: 1 class period (for data analysis)

Supplies:
Clock
Pens or pencils
Graph paper
Computer with internet access
Virtual classroom space (for discussions and data sharing)
"The Home as Laboratory" student worksheet

Directions for teachers:
In this activity, students will identify quantitative data they can collect and analyze at home. This activity will remind students that science involves observations in the real world, not just experiments in a science laboratory. Because students will collect data at home, this activity is perfect for virtual learning. Discussions can be completed via Zoom, Skype or other suitable chat programs, while data can be shared via e-mail or through Google Docs, Sheets or Slides.

Teachers can choose a specific phenomenon for the class to explore, outlining what data students should collect, or can encourage students to identify their own phenomenon and data. Make sure the data collected are quantitative, so students can graph and analyze their results.

Two fairly simple investigations most students should be able to complete are tracking electricity usage in the home over time (this guide provides examples for that phenomenon) or tracking changes in the night sky over time. Other possibilities include collecting data on traffic patterns, changes in weather or temperature, the behavior of squirrels or other animals, or a family member's daily activities. You may want to assign a backup phenomenon for students to explore if their first choice becomes difficult (for example, if students do not have access to their electric meter or if it is a cloudy evening).

Teachers will also want to select a time period for the data to be collected, every hour over a 12-hour period, for example, or at the same time daily over the course of a week. Teachers should decide if and how they want to group students according to the phenomenon selected and what platforms students will use for virtual discussions and data-sharing.

After you present the phenomenon and explain the time period for data collection, students will use the background questions provided on the student worksheet to plan their investigations. Students will decide what quantitative data to collect and create a data table to record that data.

Once students have collected their data, they will analyze the data. They can do this by calculating differences over time periods, looking for trends or identifying outliers. Once the analysis is complete, students should also choose an appropriate means of displaying the data visually. This could include pie charts, bar graphs, line graphs, tables, maps or diagrams, depending on the data collected.

Students can then share their data with the other members of their group in a virtual space and discuss similarities and differences and identify any trends. Based on the group's data, students can formulate a research question. Once students identify a research question, they should formulate a hypothesis that can be tested through a future experiment.

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Teacher Answer Key: The Home as Laboratory

In this activity, students will observe and collect data on a phenomenon at home, then analyze that data to develop a research question and hypothesis. This answer key is one example of what students could do.

Background discussion questions
Scientists use observations to study the natural world and to formulate hypotheses for future experiments. These questions will ask you to think about the role of observations in science, as well as data collection and presentation.

1. Give a few examples of how scientists in particular subfields collect data through observation?

Answers will vary but may include biologists observing birds in the field to study mating rituals or geologists collecting data on seismic activity to study the sources and intensity of earthquakes.

2. What kinds of scientific data could you collect in or around your own homes?

Answers will vary but could include the length of television commercials on different channels, the air temperature outside compared with inside or the changes in sunrise times over the course of a month.

3. What does “quantitative data” mean? What forms can these data take? Give some examples of measurements that yield quantitative data.

Quantitative data are data that are expressed in numbers, such as a plant’s height in centimeters or the number of birds attracted to a pile of sunflower seeds. Quantitative data can be masses, number of occurrences, lengths of time, heights, temperatures and much more.

4. How do scientists display quantitative data?

Students may mention charts, graphs or data tables. How best to represent data often depends on the type of observations and the form of data. For example, an investigation showing some form of change over time may be best shown as a line graph. When showing data that adds up to 100 percent, a pie chart might be a better approach.

Group planning
You are now going to be collecting quantitative data in or around your home. Your teacher will assign a phenomenon or give you instructions for choosing your own, as well as explaining the timeline for data collection. You will need to establish a methodology in advance. If you are working in a group, you will need to discuss with your group how you can use similar methods so that you can successfully compare your data. If you are working on your own, you will still need to consider how to collect and record your data so that other scientists can interpret and repeat your investigation.

5. What phenomenon are you interested in that can be observed or tracked over time?

How the amount of electricity used in my home varies over time due to household activities.

6. How can you observe it in a quantitative way?

I will record the electric meter values over the course of a day and what activities were performed between each measurement.

7. What data will you collect and how (be sure to include the timeframe and time interval for data collection)?

I will collect data every hour from 8 a.m. to 8 p.m.

8. What background information do you need to know in order to collect this data?

I will need to find out where our electric meter is and determine if it is a digital meter or a dial. If it is a dial meter, I will need to learn how to properly read and record the values.

9. Do any necessary background research, taking notes you may need to reference in the space provided here.

Our meter is a dial meter and is located in the basement. The tens and thousands place dials run counterclockwise, while the other dials run clockwise.

Data collection and analysis

Now that you have determined your methodology, answer the following questions about how you will record and analyze your data. Your answers may differ from other members of your group since your phenomena may differ slightly.

10. Create a data table to record your findings. Be sure to include columns for the time (or time period) and any relevant observations or notes. Remember to indicate units.

Example table:

Time period	Meter reading at start of hour (kilowatts)	Activities during hour
8 a.m.–9 a.m.		
9 a.m.–10 a.m.		
10 a.m.–11 a.m.		
…9 p.m.		

11. How could the data you collect be analyzed? What general information would you find from that analysis?

Subtracting the initial value on the electric meter from the ending value for each hour or day will reveal how much electricity is used in that timeframe.

12. Now complete your observations over the time period and fill in your table with your data. Once completed, do your analyses (adding columns to your data table as necessary). Based on what you know about representing data, how could your data best be displayed? Why?

My data could best be displayed as a bar graph, because I am measuring the amount of electricity used over time. I can create a bar graph showing how much energy is used each hour.

13. What information will your display need to include? How can you make it easy to read? Be sure to be specific about what your axis labels will be and identify any information that should be included in the key.

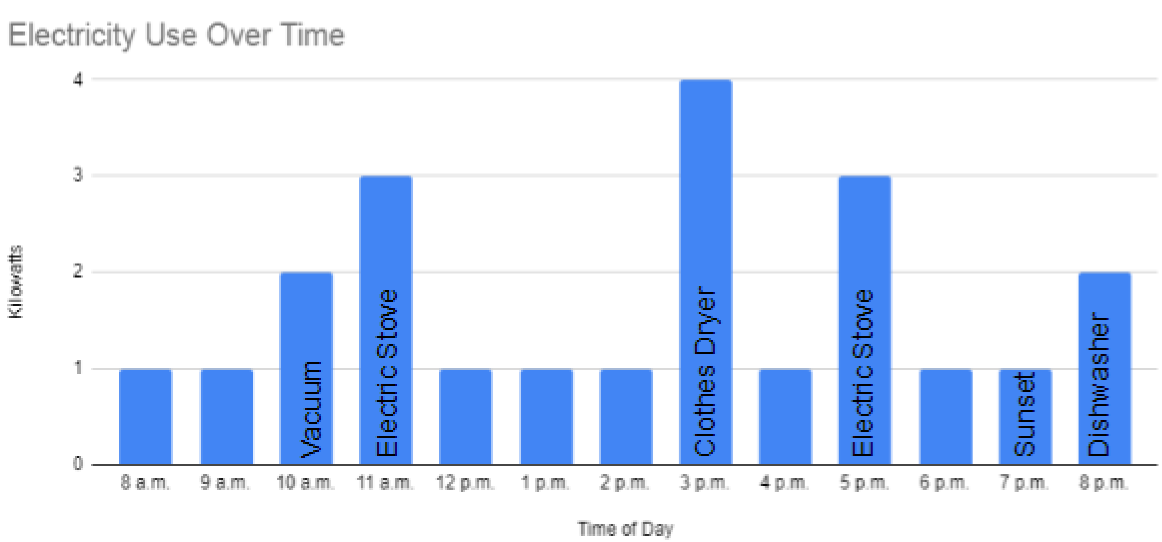
My bar graph will need to include the time of day on the x-axis because it is the independent variable and the amount of electricity in kilowatts on the y-axis because it is the dependent variable. I will also need to label the bars according to the major activities performed in each hour. I will also want to show when sunset is, since this is when my family turns on all the household lights.

14. How will you identify trends in your data?

I will examine which hourly values were the largest and which were the smallest. Additionally, I will look at how the data changed over time based on the activities performed.

15. Create your visual display of your data. Be sure to include your labels and/or a key as necessary.

Example visual display:



Data sharing
Work remotely with your group to review the outcomes from your investigations.

16. What trends did you notice in your own data?

The amount of electricity changes over the course of the day and depends on what appliances are being used. Using the clothes dryer and the electric stove had the greatest impact.

17. What trends did you notice in your group's data? Do these trends match the trend you found in your own data?

The amount of electricity changes over the course of the day and depends on what appliances are being used. Using the clothes dryer and the electric stove had the greatest impact. This matches the trend I found in my own data.

18. What do these trends suggest about electricity usage in your home?

During most hours, we used 2 kilowatts of energy regardless of what appliances were on, including lights and computers. The number only changed when large appliances such as the dryer were used. This trend indicates that lights do not use very much electricity.

19. Did anything surprise you about your data or your group's data?

Yes, I was surprised to find that more electricity was used during the day than at night. I had thought our family would use the most electricity once it was dark outside (and all the lights were on).

Developing a research question
20. What research questions could the data you collected help answer?

Answers will vary. Students may focus on how best to conserve electricity. Once they have identified which behaviors use the most electricity, they could propose alternatives that would reduce the amount used. Students may also want to determine how much energy each appliance uses or how much energy is used by a family over the course of a day.

21. Based on the data collected, what research question would you be most interested in exploring? Support your answer.

I collected data on how much electricity usage my family had over the course of a day. I would be interested in investigating how we could go about reducing that usage. I am always being told to "turn off the lights when I leave a room," so it would be interesting to investigate if turning off lights makes a difference. The research question could be, "Does turning off the lights meaningfully reduce the amount of electricity used in a home over time?"

22. How would you investigate that question? What additional observational data might be useful? What additional experimental data might be useful?

To investigate this research question, I could collect usage data for a period of time when only all the lights in the house were on and then have the same period of time when everything was off. These two values could *be compared to determine actual energy usage of the lights. Additionally, it would be helpful to measure how much electricity is used by other appliances in the home for the same time period, to determine what appliances use more electricity.*

23. What would your hypothesis be, based on the existing data?

Based on the data I have already collected, I think the lights do not use as much electricity as other appliances in the average household.

24. What steps would you take to design an experiment to test your hypothesis?

To design an experiment, I would first identify the variables that I would be testing, along with potential confounding variables. After defining the variables, I would determine how I intend to analyze the data (using a mathematical calculation or statistical test, for example). Then I would develop a protocol or procedure for testing (with a design to try to minimize the potential effects of confounding variables), run the experiment and collect and analyze the data. Finally, I would determine how to write and display my results.

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Activity Guide for Students: The Home as Laboratory

Directions:
Many scientific investigations can be made outside of the laboratory, without the use of beakers and microscopes. Look around your home. No matter where you live, there are many questions you could ask about what's going on around you. You might notice your little brother taking a long time to brush his teeth. Or how the temperature inside your home remains fairly constant even though the temperature outside is changing. These, and many other events, can provide data that can inspire research questions.

This activity is going to take place in your home, with discussions and data-sharing happening in a virtual environment. You are going to choose a phenomenon (or your teacher will assign one), create a methodology for observing this phenomenon, collect and analyze some data through observation and then develop a research question and hypothesis based on that data. Your teacher will provide instructions for participating in group discussions and sharing your data remotely.

Background discussion questions
Scientists use observations to study the natural world and to formulate hypotheses for future experiments. These questions will ask you to think about the role of observations in science, as well as data collection and presentation.

1. Give a few examples of how scientists in particular subfields collect data through observation?

2. What kinds of scientific data could you collect in or around your own homes?

3. What does "quantitative data" mean? What forms can these data take? Give some examples of measurements that yield quantitative data.

4. How do scientists display quantitative data?

Group planning
You are now going to be collecting quantitative data in or around your home. Your teacher will assign a phenomenon or give you instructions for choosing your own, as well as explaining the timeline for data collection. You will need to establish a methodology in advance. If you are working in a group, you will need to discuss with your group how you can use similar methods so that you can successfully compare

your data. If you are working on your own, you will still need to consider how to collect and record your data so that other scientists can interpret and repeat your investigation.

5. What phenomenon are you interested in that can be observed or tracked over time?

6. How can you observe it in a quantitative way?

7. What data will you collect and how (be sure to include the timeframe and time interval for data collection)?

8. What background information do you need to know in order to collect this data?

9. Do any necessary background research, taking notes you may need to reference in the space provided here.

Data collection and analysis
Now that you have determined your methodology, answer the following questions about how you will record and analyze your data. Your answers may differ from other members of your group since your phenomena may differ slightly.

10. Create a data table to record your findings. Be sure to include columns for the time (or time period) and any relevant observations or notes. Remember to indicate units.

11. How could the data you collect be analyzed? What general information would you find from that analysis?

12. Now complete your observations over the time period and fill in your table with your data. Once completed, do your analyses (adding columns to your data table as necessary). Based on what you know about representing data, how could your data best be displayed? Why?

13. What information will your display need to include? How can you make it easy to read? Be sure to be specific about what your axis labels will be and identify any information that should be included in the key.

14. How will you identify trends in your data?

15. Create your visual display of your data. Be sure to include your labels and/or a key as necessary.

Data sharing

Work remotely with your group to review the outcomes from your investigations.

16. What trends did you notice in your own data?

17. What trends did you notice in your group's data? Do these trends match the trend you found in your own data?

18. What do these trends suggest about electricity usage in your home?

19. Did anything surprise you about your data or your group's data?

Developing a research question

20. What research questions could the data you collected help answer?

21. Based on the data collected, what research question would you be most interested in exploring? Support your answer.

22. How would you investigate that question? What additional observational data might be useful? What additional experimental data might be useful?

23. What would your hypothesis be, based on the existing data?

24. What steps would you take to design an experiment to test your hypothesis?