ScienceNews

EDUCATOR GUIDE

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May 6, 2023 & May 20, 2023

Climate Change Spikes Baseball Homers

SOCIETY FOR SCIENCE

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About this Guide

Baseball fans love numbers and explaining every nuance of baseball statistics. In this Guide, students will learn how climate change is boosting home runs and study the physics behind the increase in homers.

This Guide includes:

Article-based Comprehension Q&A — Students will answer questions about the online *Science News* article "Baseball's home run boom is due, in part, to climate change," which explores how increases in temperatures boost home run numbers. A version of the article, "Climate change spikes baseball homers," appears in the May 6, 2023 & May 20, 2023 print issue of *Science News*. Related standards include NGSS-DCI: HS-ETS1; MS-PS1.

> **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 review the ideal gas law and use a simulation to explain the assumptions made in a recent study about how climate change is impacting baseball. Learning Outcomes: Exploration of the cause and effect of manipulating conditions of a gas using a simulation, identifying relationships of variables using a mathematical equation and application of theoretical concepts to real-world examples. Related standards include NGSS-DCI: MS-PS1; MS-PS2; HS-PS1; HS-PS3.

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

Science Bite Activity — In this quick activity, students will discuss confounding factors in their own lives and in scientific research to determine why it is important to identify and control for those factors. Learning Outcomes: Reviewing confounding factors and learning why it is important to identify them in science. Related standards include NGSS-DCI: MS-ETS1; HS-ETS1.

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

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Article-based Comprehension, Q&A

Directions for teachers: Ask students to read the online *Science News* article "Baseball's home run boom is due, in part, to climate change," and have them answer the following questions. A version of the article, "Climate change spikes baseball homers," appears in the May 6, 2023 & May 20, 2023 print issue of *Science News*.

1. What is sabermetrics? How can sabermetrics be used?

Sabermetrics is the study of baseball statistics. Teams use sabermetrics data to improve strategy, but this study demonstrates that the data also can be used in quantitative scientific studies.

2. In one sentence, state the scientific question Dartmouth's Christopher Callahan and his colleagues asked in their research.

Has human-caused climate change contributed to the increase in the number of home runs hit during Major League Baseball games?

3. In what ways did researchers investigate the relationship between the increase in temperature and the increase in home runs, and what did they find?

After looking at more than 100,000 MLB games, the researchers concluded that the number of home runs increased by almost 2 percent when the daily high temperature increased by 1 degree Celsius. The researchers estimated that, from 2010 to 2019, there were an average of 58 home runs per season that could be attributed to human-caused climate change. When researchers looked at the results for 220,000 batted balls, where they accounted for temperatures, wind speed and humidity, the scientists found that home runs increased with temperature.

4. What factors did researchers control for in their studies? Were there factors that the researchers could not control for given the study design?

Researchers used the Statcast system to analyze 220,000 individual batted balls and studied those that were hit in the same way (a controlled factor), but the temperatures were different on the days the balls were hit. By looking at balls that were hit in the same way, the scientists were controlling for ball speed, pitch type and contact location. The article also said the researchers controlled for wind speed and humidity. What is hard to know is how much improvement in batter abilities have contributed to the increase in the number of home runs over time. Are batters simply better today than they were in the past?

5. Explain why it makes sense that as air temperature increases, more home runs are hit. From the article, extrapolate the chain of cause and effect.

Hit baseballs follow the rules of physics. Is this study, the ideal gas law provides an explanation for the scientists' results. The ideal gas law says that when temperature goes up, air density drops. When air density drops, air resistance also drops. As air resistance declines, it becomes easier to hit a baseball a longer distance. Therefore, the number of home runs hit should increase with higher temperatures and lower air density, which is what the scientists found.

6. How could MLB mitigate the effects of climate change on the game?

MLB could decrease the number of day games and increase the number of night games; MLB could build more domes over stadiums.

7. What questions do you still have about the research described in the article?

It's not clear to me how the researchers controlled for factors such as wind speed and humidity during the study. I also don't understand how the researchers got to an average of 58 more home runs a season from 2010 to 2019 by running game-day temperatures through a climate model.

8. What's another scientific question you could ask using sabermetrics?

Student answers will vary but could include questions about the relationship between the time of day, temperature and number of hits or the speed of the ball pitched, temperature and the number of strikes. A sample scientific question: In afternoon and night games when temperatures are the same, do players average the same number of hits in the earlier and later games?

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Student Comprehension Worksheet

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1. What is sabermetrics? How can sabermetrics be used?

2. In one sentence, state the scientific question Dartmouth's Christopher Callahan and his colleagues asked in their research.

3. In what ways did researchers investigate the relationship between the increase in temperature and the increase in home runs, and what did they find?

4. What factors did researchers control for in their studies? Were there factors that the researchers could not control for given the study design?

5. Explain why it makes sense that as air temperature increases, more home runs are hit. From the article, extrapolate the chain of cause and effect.

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Cross-curricular Discussion, Q&A

Directions for teachers: This discussion activity can be used to help students understand and apply the ideal gas law. Before beginning this work, students should know the ideal gas equation and its components. Have students discuss the first two sets of questions with a partner. Students should then read the *Science News* article "Baseball's home run boom is due, in part, to climate change" and answer the last set. A version of the article, "Climate change spikes baseball homers," appears in the May 6, 2023 & May 20, 2023 print issue of *Science News*.

Want to make it a virtual lesson? Post the online *Science News* article to your virtual classroom. Discuss the article and questions with your class on your virtual platform.

Defining relationships from an equation

1. What is the ideal gas law equation, and what does it state? Name the components in the formula. Which of the components are variables?

The ideal gas law equation is PV=nRT**.**

*The ideal gas law says that for an ideal gas, pressure (*P*) times volume (*V*) equals the number of moles of gas (*n*) times the ideal gas constant (*R*) times temperature (*T*). The variables are pressure, volume, number of moles and temperature.* R *is a constant.*

2. What is a direct relationship between two variables? How is an indirect, or inverse, relationship between variables different? Give examples.

When variables have a direct relationship, they change in the same direction. For example, if variables x *and* y *have a direct relationship, when* x *increases,* y *also increases. In an indirect, or inverse, relationship, the variables go in opposite directions when they change. If variables* x *and* y *have an inverse relationship, when* x *increases,* y *will decrease.*

3. Write the equation with all variables on one side and the ideal gas constant (R) on the other. Explain the relationships between the variables in the equation. How do the variables in the numerator relate to each other, if those in the denominator stay the same? What about the variables in the denominator, if those in the numerator stay the same? What happens when you change one variable from the numerator and allow one from the denominator to change? Hint: If these questions are difficult, put in numbers for each variable to test what happens.

PV/nT = R *is the equation. The two variables, P and V, in the numerator have an inverse relationship; if either P or V goes up, while n and T stay the same, the other will have to go down. The same is true of n and T in the denominator, if P and V stay the same. But if P and T stay the same and you change either V or n, the other one of the pair will have to change in the same direction, and we say the variables have a direct*

relationship. If V increases, then n also increases. If you change P or T instead, keeping n and V the same, you again see a direct relationship. If P goes up, T has to go up. If P goes down, T has to go down.

Explaining relationships using a simulation

1. Click the "Gas Properties" PhET simulation. Determine how changing P, V, n or T will influence other gas properties. Then change one variable and hold the other three constant to see what happens. What do you observe?

Students should see that the relationships defined by the equation are shown in the simulation.

2. What happens to the speed of the gas particles when you increase the temperature of the gas in the simulation? If you can, use an equation to explain this relationship.

As the temperature of a gas increases, the gas particles appear to move faster. That makes sense because if temperature increases, that means that the kinetic energy of the gaseous particles increases. Kinetic energy equals 1/2 mass times (velocity squared), and for a gas, kinetic energy equals 3/2 (ideal gas constant times temperature). Setting the two equations equal shows that as temperature increases, the kinetic energy of the gas increases, which corresponds to an increase in the velocity of the gas particles.

3. Gas pressure is defined as the force exerted by a gas per unit area on the surface of a container or another substance. Higher-velocity and more frequent collisions of gas particles with another substance increase the pressure of the system. Pick two variables from the ideal gas equation and *explain* their relationship, stating how changing one will affect the environment and lead to a change in the other, when all other variables are constant. (Don't just state the relationship like you did above.)

Student responses will vary based on the variables selected. If the amount of a gas and the volume of a container are held constant, an increase in temperature will increase the kinetic energy of the gas, which increases the velocity of the gas and the number of times the gas particles collide with the surface of the container, therefore increasing the pressure of the system.

Applications of the ideal gas law

1. The article "Baseball's home run boom is due, in part, to climate change" focuses on the relationship between rising temperatures and increases in the number of home runs hit each year during the Major League Baseball season. The writer explained the roles temperature and air density played in increasing the number of home runs hit during the MLB season. Explain the relationship between temperature and air density using the ideal gas law.

As an extension, explain the relationship using the ideal gas law equation. Hint: Substitute mass of gas/molar mass of the gas (this fraction is the number of moles of the gas) for n and solve for mass of the

gas/volume (this fraction is density). You should arrive at an expression that has temperature in the denominator.

As the temperature increases, the kinetic energy of the gas and its particle velocity will increase. If pressure stays the same, the air will expand in volume, which will decrease the air density. According to the equation, density of a gas equals pressure times molar mass divided by (the ideal gas constant times temperature). Therefore, temperature and density are inversely related.

2. What other factor decreases when air density drops? What principle explains that direct relationship?

When the air density drops, the air resistance also drops on the ball, so the ball will travel farther in the air before falling to the ground under the influence of gravity. This is because in less dense air, the baseball will come in contact with fewer air molecules, so fewer forces are slowing the baseball. Newton's first law of motion about inertia states that "an object in motion will remain in motion, and an object at rest will remain at rest, unless acted upon by an outside force." So with fewer forces slowing it, the ball can travel farther before it hits the ground, which means more home runs!

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2. What happens to the speed of the gas particles when you increase the temperature of the gas in the simulation? If you can, use an equation to explain this relationship.

3. Gas pressure is defined as the force exerted by a gas per unit area on the surface of a container or another substance. Higher-velocity and more frequent collisions of gas particles with another substance increase the pressure of the system. Pick two variables from the ideal gas equation and *explain* their relationship, stating how changing one will affect the environment and lead to a change in the other, when all other variables are constant. (Don't just state the relationship like you did above.)

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2. What other factor decreases when air density drops? What principle explains that direct relationship?

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Science Bite Activity: Confounding Life and Science Research

Directions for teachers: Use this short activity as a warm-up or exit ticket in class. The activity asks students to discuss confounding factors in their own lives and in science research and learn why it is important to identify and control for them.

Confounding factors

1. Think about a recent athletic, musical, theatrical or other performance or presentation you have given. What are factors or extraneous variables that impacted your performance? Did you try to control for these factors? If so, how? Is it important to control for these factors? Why or why not?

Student answers will vary.

2. What is a confounding factor or extraneous variable in scientific research? Why should possible confounding factors be controlled for in a research study? What's the result of having confounding factors that aren't controlled for?

Confounding variables are factors other than the independent variable that may also affect the dependent variable. A good experiment should have one dependent variable and one or maybe two independent variables with value ranges that are methodically tested in the experiment. Confounding variables should be minimized by the experimental design, and any remaining confounding factors should be accounted for when the results are analyzed. If confounding factors aren't controlled for, data collected may present false or invalid relationships.

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Student Activity Worksheet: Confounding Life and Science Research

Directions: Please answer the following questions related to confounding factors in your own life and in science research.

Confounding factors

1. Think about a recent athletic, musical, theatrical or other performance or presentation you have given. What are factors or extraneous variables that impacted your performance? Did you try to control for these factors? If so, how? Is it important to control for these factors? Why or why not?

2. What is a confounding factor or extraneous variable in scientific research? Why should possible confounding factors be controlled for in a research study? What's the result of having confounding factors that aren't controlled for?

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