

The scientific method is a process that helps you find answers to your questions about the world. The process starts with a question and your answer to the question based on experience and knowledge. This "answer" is called your hypothesis. The next step in the process is to test your hypothesis by creating experiments that can be repeated by other people in other places. If your experiment is repeated many times with the same results and conclusions, these findings become part of the body of scientific knowledge we have about the world.

### Steps to the Scientific Method

1. Ask a question.
2. Formulate a hypothesis.
3. Design and conduct an experiment to test your hypothesis.
4. Collect and analyze data.
5. Make a tentative conclusion.
6. Test your conclusion, or refine the question, and go through each step again.

Maria and Elena are preparing for a party. Maria realizes she forgot to fill the ice cube trays in order to have ice for the punch. Elena says that she remembers reading somewhere that hot water freezes faster than cold water. Maria is skeptical. She learned in her physics class that the hotter the liquid, the faster the molecules are moving. Since hot water molecules have to slow down more than cold water molecules to become ice, Maria thinks that it will take hot water longer to freeze than cold water.

The girls decide to conduct a scientific experiment to determine whether it is faster to make ice cubes with hot water or cold water. Answer the following questions about the process they used to reach their conclusion.

#### 1. Asking a question

What is the question that Maria and Elena want to answer by performing an experiment?

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## 2. Formulate a hypothesis

What is Maria's hypothesis for the experiment? State why Maria thinks this is a good hypothesis.

## 3. Design and conduct an experiment

1. **Variables:** There are many variables that Maria and Elena must control so that their results will be valid. Name at least four of these variables.

2. **Measurements:** List at least two types of measurements that Maria and Elena must make during their experiment.

3. **Procedure:** If Maria and Elena want their friends at the party to believe the results of their experiment, they need to conduct the experiment so that others could repeat it. Write a procedure that the girls could follow to answer their question.

#### 4. Collect and analyze data

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The girls conducted a carefully controlled experiment and found that after 3 hours and 15 minutes, the hot water had frozen solid, while the trays filled with cold water still contained a mixture of ice and water. They repeated the experiment two more times. Each time the hot water froze first. The second time they found that the the hot water froze in 3 hours and 30 minutes. The third time, the hot water froze in 3 hours and 0 minutes.

1. What is the average time that it took for hot water in ice cube trays to freeze?

2. Why is it a good idea to repeat your experiments?

#### 5. Make a tentative conclusion

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Which of the following statements is a valid conclusion to this experiment? Explain your reasoning for choosing a certain statement.

- a. Hot water molecules don't move faster than cold water molecules.
- b. Hot water often contains more dissolved minerals than cold water, so dissolved minerals must help water freeze faster.
- c. Cold water can hold more dissolved oxygen than hot water, so dissolved oxygen must slow down the rate at which water freezes.
- d. The temperature of water affects the rate at which it freezes.
- e. The faster the water molecules are moving, the faster they can arrange themselves into the nice, neat patterns that are found in solid ice cubes.

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## 6. Test your conclusion or refine your question

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Maria and Elena are very pleased with their experiment. They ask their teacher if they can share their findings with their science class. The teacher says that they can present their findings as long as they are sure their conclusion is correct.

Here is where step 6 is important. At the end of any set of experiments and before you present your findings, you want to make sure that you are confident about your work.

1. Let's say that there is a small chance that the results of the experiment that Maria and Elena performed were affected by the kind of freezer they used in the experiment. What could the girls do to make sure that their results were not affected by the kind of freezer they used?
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2. Conclusion (b) in part 5 is a possible reason why temperature has an affect on how fast water freezes. Refine your original question for this experiment. In other words, create a question for an experiment that would prove or disprove conclusion (b).
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