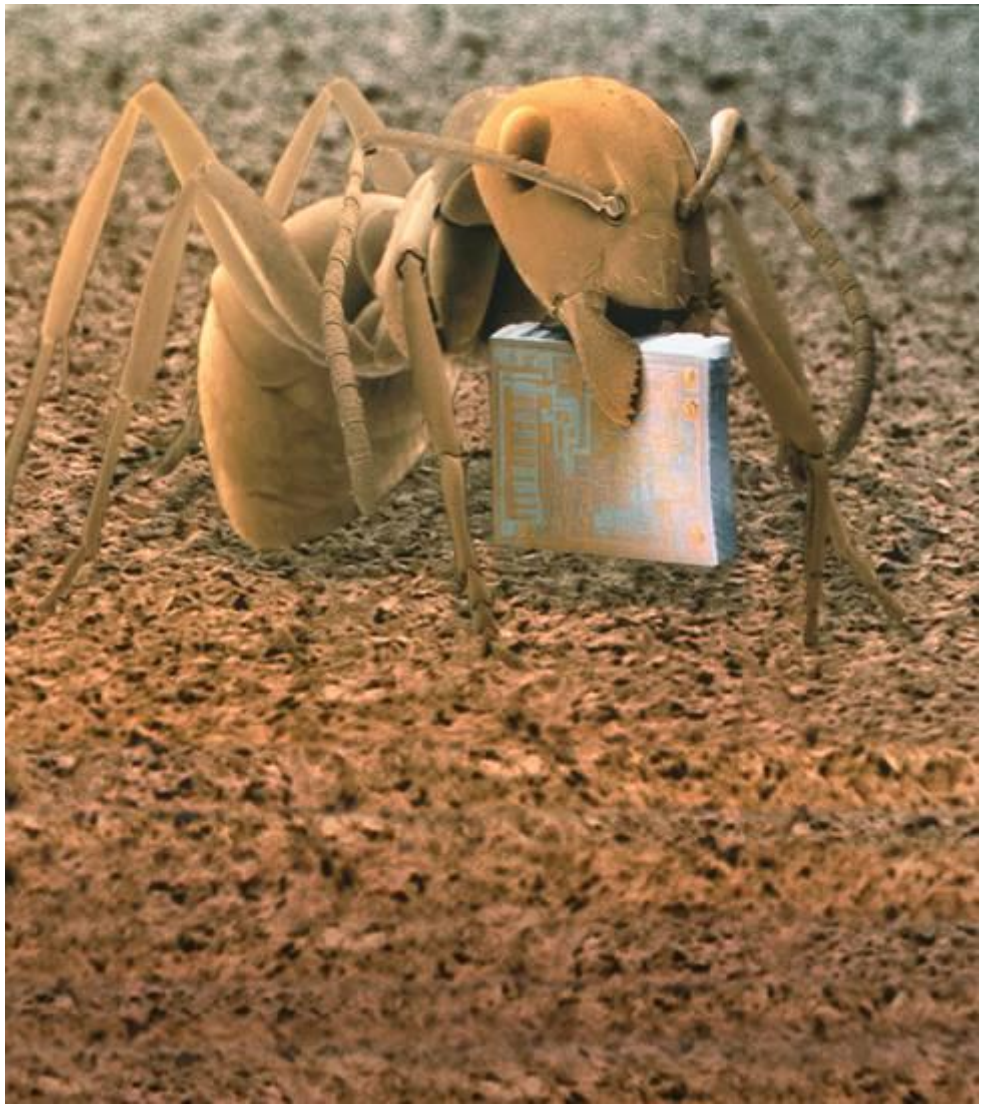
1-1 What Is Science?



The goal of science is to:

- **investigate and understand the natural world.**
- **explain events in the natural world.**
- **use those explanations to make useful predictions.**

Science is an organized way of using evidence to learn about the natural world.

The word *science* also refers to the body of knowledge that scientists have built up after years of using this process.

Thinking Like a Scientist

Scientific thinking begins with observation.

Observation is the process of gathering information about events or processes in a careful, orderly way.

The information gathered from observations is called **data.**

- Quantitative data are expressed as numbers, obtained by counting or measuring.
- Qualitative data are descriptive and involve characteristics that can't easily be measured.

Scientists use data to make inferences.

An **inference** is a logical interpretation based on prior knowledge or experience.

Explaining and Interpreting Evidence

A **hypothesis** is a proposed scientific explanation for a set of observations.

A hypothesis may be ruled out or confirmed.

A hypothesis must be proposed in a way that can be tested.

Hypotheses are tested by performing controlled experiments or by gathering new data.

Researchers often work in teams to analyze, review, and critique each other's data and hypotheses.

A review process helps ensure conclusions are valid.

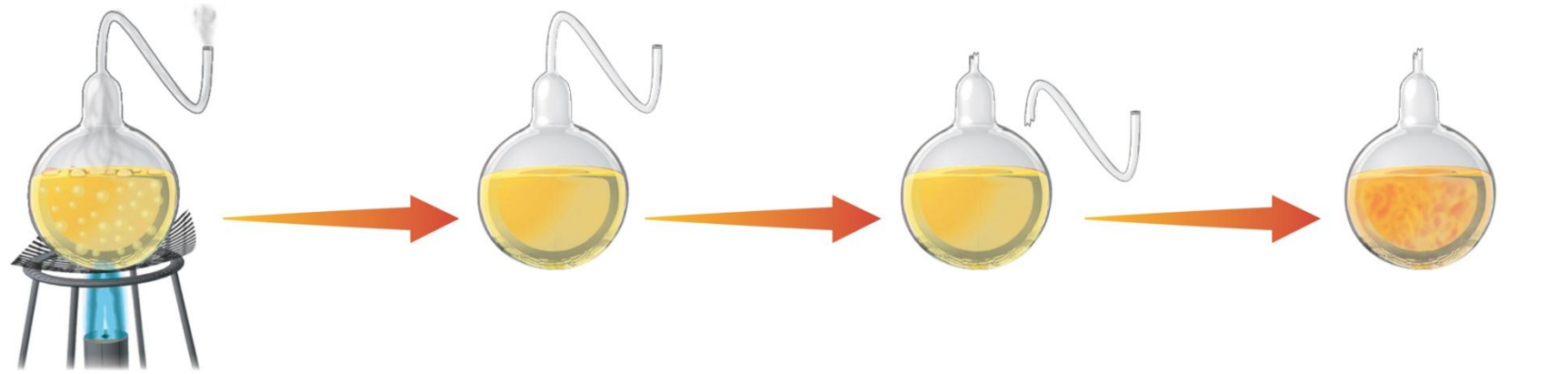
To be valid, a conclusion must be based on logical interpretation of reliable data.

Science as a Way of Knowing

Science is an ongoing *process* that involves:

- asking questions
- observing
- making inferences
- testing hypotheses

1-2 How Scientists Work



How do scientists test hypotheses?

Whenever possible, a hypothesis should be tested by an experiment in which only one variable is changed at a time. All other variables should be kept unchanged, or controlled.

Designing an Experiment

The process of testing a hypothesis includes:

- Asking a question
- Forming a hypothesis
- Setting up a controlled experiment
- Recording and analyzing results
- Drawing a conclusion

Asking a Question

Many years ago, people wanted to know how living things came into existence. They asked:

How do organisms come into being?

Forming a Hypothesis

One early hypothesis was **spontaneous generation**, or the idea that life could come from nonliving matter. For example, most people thought that maggots spontaneously appeared on meat.

In 1668, Redi proposed a different hypothesis: that maggots came from eggs that flies laid on meat.

Setting Up a Controlled Experiment

The variable that is deliberately changed is called the manipulated variable.

The variable that is observed and that changes in response to the manipulated variable is called the responding variable.

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Redi's Experiment

Redi's Experiment on Spontaneous Generation

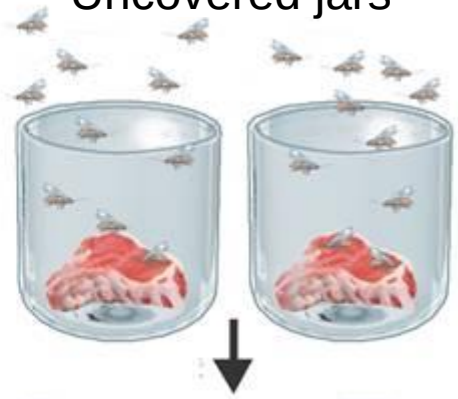
OBSERVATIONS: Flies land on meat that is left uncovered. Later, maggots appear on the meat.

HYPOTHESIS: Flies produce maggots.

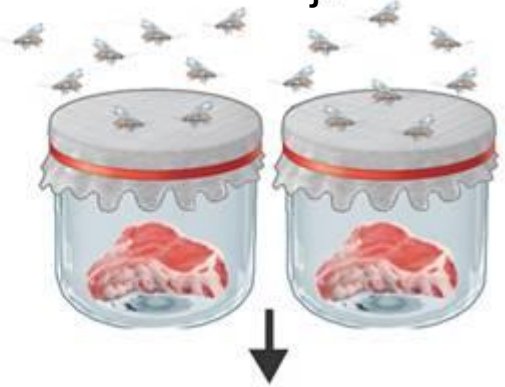
PROCEDURE

Controlled Variables: jars, type of meat, location, temperature, time

Uncovered jars



Covered jars

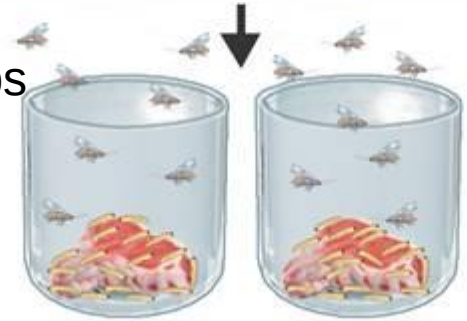


Redi's Experiment

Redi's Experiment on Spontaneous Generation

Manipulated Variable:
Gauze covering that keeps flies away from meat

Responding Variable:
whether maggots appear



Maggots appear.

Several days pass.

No maggots appear.

Redi's Experiment

Redi's Experiment on Spontaneous Generation

CONCLUSION: Maggots form only when flies come in contact with meat. Spontaneous generation of maggots did not occur.

Recording and Analyzing Results

Scientists keep written records of their observations, or data.

Sometimes drawings are used to record certain kinds of observations.

Drawing a Conclusion

Scientists use the data from an experiment to evaluate a hypothesis and draw a valid conclusion.

Redi's results supported the hypothesis that maggots were produced by flies, not spontaneous generation.

Repeating Investigations

Scientists repeat experiments to be sure that the results match those already obtained.

Needham's Test of Redi's Findings

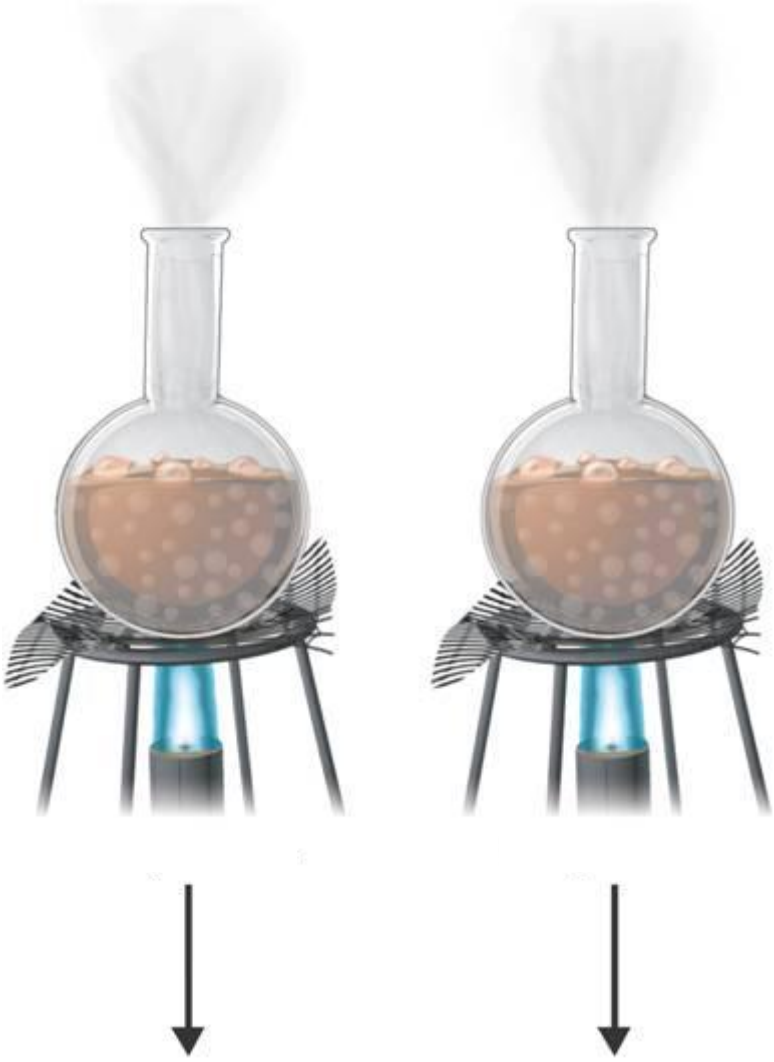
Needham challenged Redi's results by claiming that spontaneous generation could occur under the right conditions.

Needham's Test of Redi's Findings

- Needham sealed a bottle of gravy and heated it.
- After several days, the gravy was swarming with microorganisms.
- Needham concluded that these organisms came from the gravy by spontaneous generation.

Spallanzani's Test of Redi's Findings

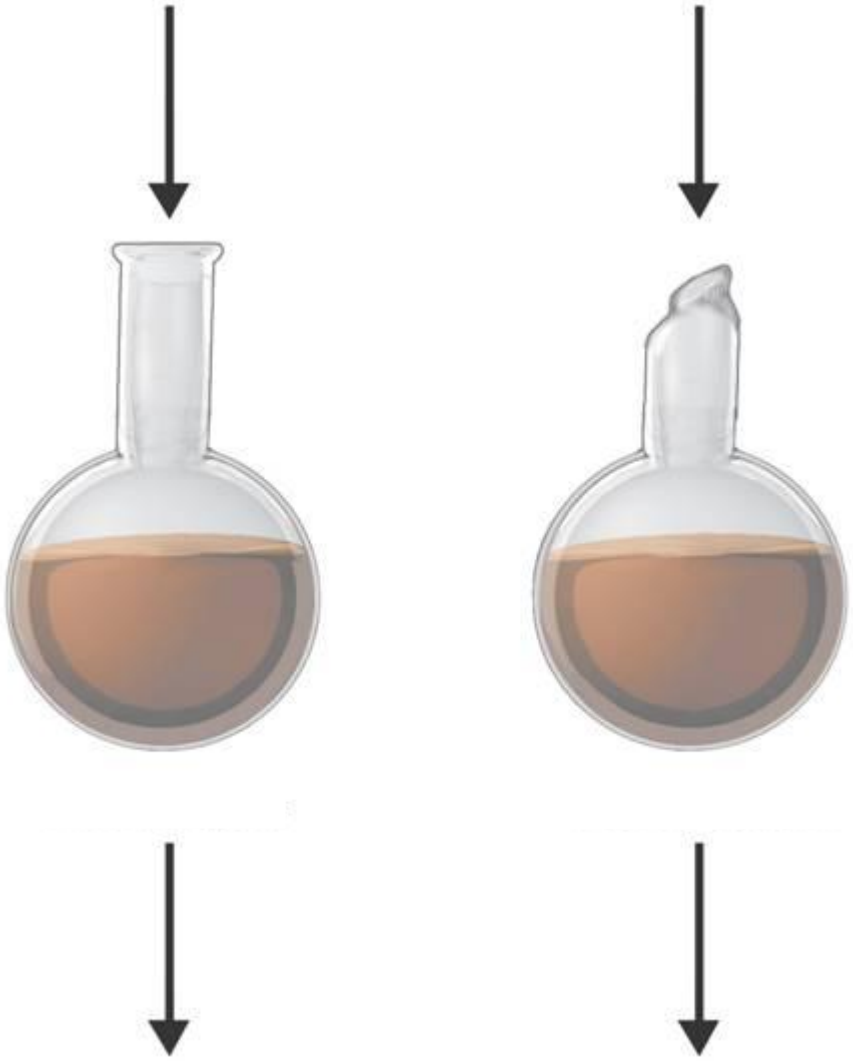
Gravy is boiled.



Gravy is boiled.

Spallanzani's Test of Redi's Findings

Flask is open.



Flask is sealed.

Spallanzani's Test of Redi's Findings

Gravy is teeming with microorganisms.

Gravy is free of microorganisms.

Pasteur's Test of Spontaneous Generation

- Louis Pasteur conclusively disproved the hypothesis of spontaneous generation.
- Pasteur showed that all living things come from other living things.

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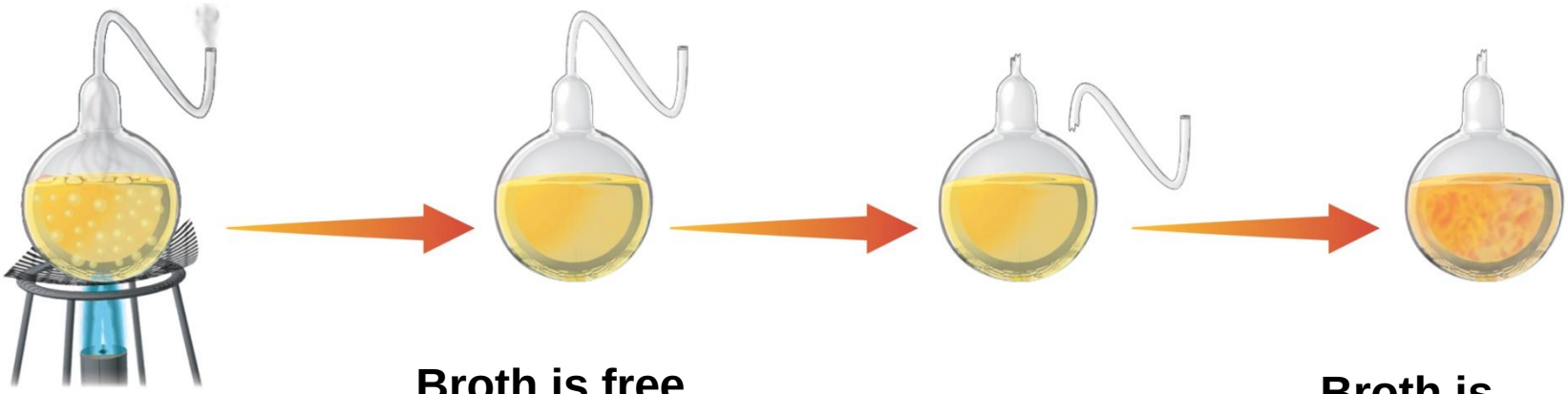
Pasteur's Experiment



Broth is boiled

Broth is free of microorganisms for a year.

Curved neck is removed.

Broth is teeming with microorganisms.

The Impact of Pasteur's Work

Pasteur saved the French wine industry, which was troubled by unexplained souring of wine.

He saved the silk industry, which was endangered by a silkworm disease.

He began to uncover the nature of infectious diseases, showing that they were the result of microorganisms.

When Experiments Are Not Possible

It is not always possible to do an experiment to test a hypothesis. For example:

- Wild animals must be observed without disturbing them.
- Ethical considerations prevent some experiments.

By carefully planning alternative investigations, scientists can discover reliable patterns that add to scientific understanding.

How a Theory Develops

In science, the word *theory* applies to a well-tested explanation that unifies a broad range of observations.