# Chapter 1
# The Chemical World

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Chem 118
Introductory Chemistry

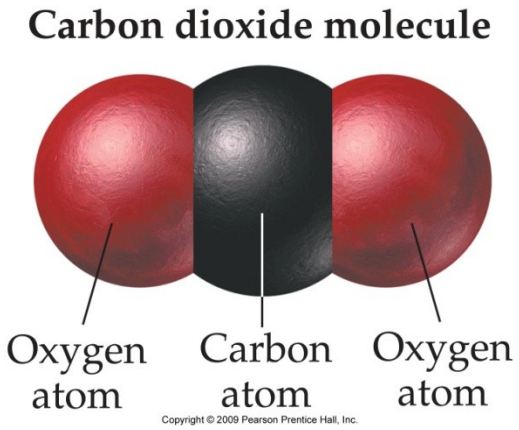

Map: Introductory Chemistry (Tro) https://chem.libretexts.org/@go/page/45050 (accessed Mar 25, 2022).

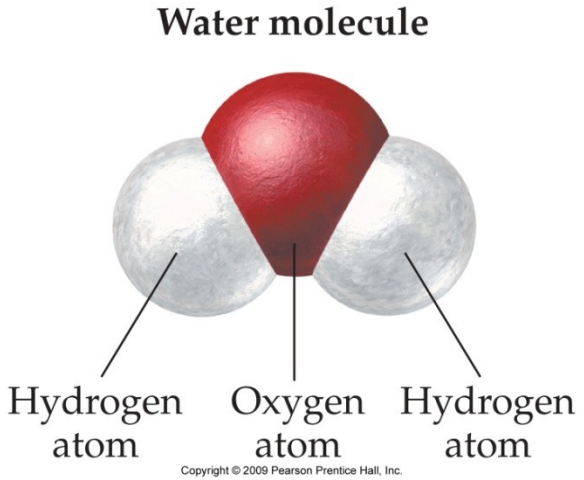
# What Is Chemistry?

- What chemists try to do is discover the relationships between the particle structure of matter and the properties of matter we observe.
- Chemistry is the science that seeks to understand what matter does by studying what atoms and molecules do.

# Structure Determines Properties

- Everything is made of tiny particles called **atoms** and **molecules.**
- Chemists believe that the properties of a substance are determined by the type, amount, and intractions between these pieces.



# The Scientific Method

- A process for trying to understand nature by observing it and analyzing the way it behaves. Hypothesis are formed and tested through experimentation

- Key characteristics of the scientific method include **Observation**, formulation of **Hypotheses**, **Experimentation**, and formulation of **Laws and Theories.**

# Why Aren't the Philosophers Considered Scientists

Philosophers:

- Observe nature.
- Explain the behavior of nature.
- Communicate and debate ideas with other philosophers.
- Truth is revealed through logic and debate.

Scientists:

- Observe nature.
- Explain the behavior of nature.
- Communicate and debate ideas with other scientists.
- Truth is revealed through experimentation.

# Observation

- A way of acquiring information about nature.
- The information obtained from observation is known as **Data**.
- Some observations are simple descriptions about the characteristics or behavior of nature.
  - ✓ "The soda pop is a liquid with a brown color and a sweet taste. Bubbles are seen floating up through it."
- Some observations compare a characteristic to a standard numerical scale.
  - ✓ "A 240-mL serving of soda pop contains 27 g of sugar."

# Hypothesis

- A tentative interpretation or explanation of your observations.
  - ✓"The sweet taste of soda pop is due to the presence of sugar."
- A good hypothesis is one that can be tested to be proven wrong.
  - ✓Falsifiable.
  - ✓One test may invalidate your hypothesis.

# Experiments

- Tests of hypotheses, laws, or theories.
- Can you think of a way to test whether the sweet taste of soda pop is due to the presence of sugar?
- Results either validate (confirm) or invalidate (deny) your ideas.
  - ✓ Invalidate = Discard or Modify
    - ➢ Many times experiments invalidate only parts of the hypothesis or theory, in which case the idea is modified.
  - ✓ Validate ≠ Proof your idea will always hold

# Laws

- Summary of observations that combines all past observations into one general statement.
  - ✓**Law of Conservation of Mass—** "In a chemical reaction matter is neither created nor destroyed."
- Allows you to predict future observations.
  - ✓So you can test the law with experiments.
- Unlike state laws, you cannot choose to violate a scientific law.

# What's the Difference Between an Observation and a Law?

- An **observation** tells you what happened in a single event.
- A **law** summarizes ***all*** the observations, effectively telling you what you will observe in future events.

# Theories

- General explanation for the characteristics and behavior of nature.
- Models of nature.
  - ✓Dalton's Atomic Theory
- Can be used to predict future observations.
  - ✓So they can be tested by experiments.

# What's the Difference Between a Hypothesis and a Theory?

- A **hypothesis** is an explanation of a single or small number of observations.
- A **theory** is an explanation that extends beyond individual observations to an understanding of the underlying causes for the way nature is or behaves.

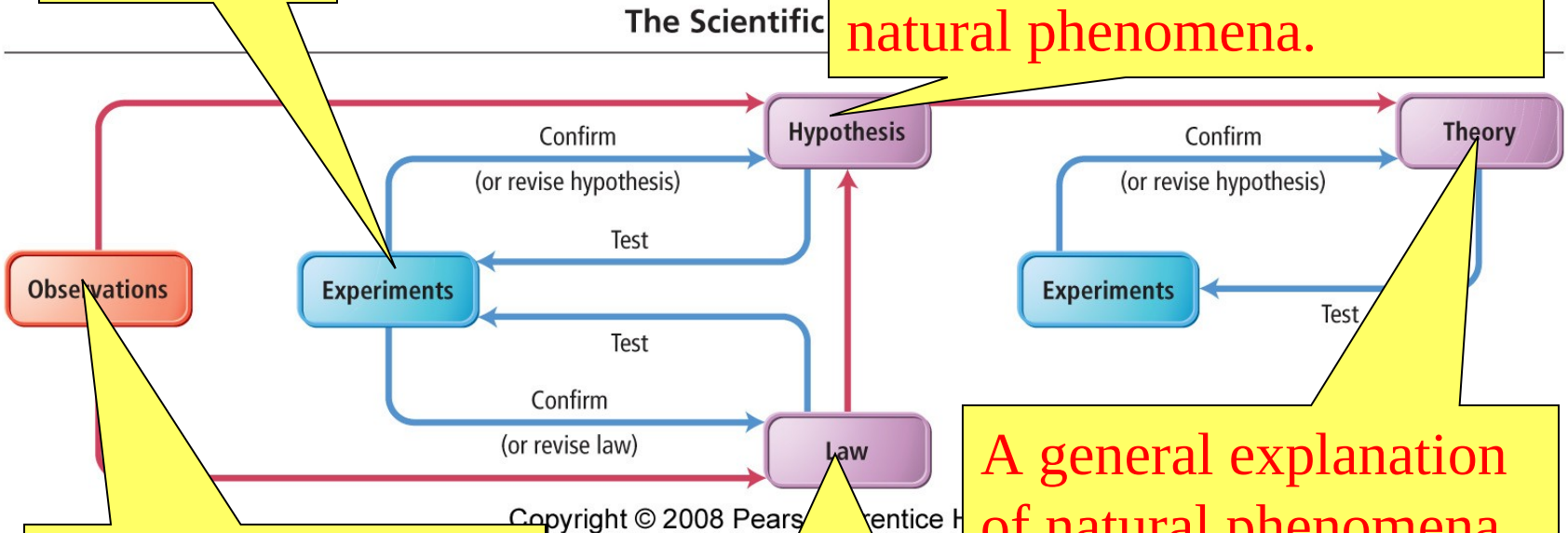
# What's the Difference Between a Law and a Theory?

- **Laws** answer the question "***What*"** will happen.
- **Theories** answer the question "***Why*"** does something happen.
  - ✓Theories allow to extend your predictions to a wider set of circumstances.

# Scientific Method

A test of a hypothesis or theory.

A tentative explanation of a single or small number of natural phenomena.




The careful noting and recording of natural phenomena.

A generally observed natural phenomenon.

A general explanation of natural phenomena.

# Relationships Between Pieces of the Scientific Method

| | Applies to single or **small number** of events | Applies to **all** events |
|---|---|---|
| Describes ***what*** happens | observation | law |
| Explains ***why*** things happen | hypothesis | theory |

# An Example

You have probably noticed that soda pop fizzes when the bottle is opened.

- Step 1: State the problem. Why does soda pop fizz?
- Step 2: Gather information.
  - ✓ Examine soda pop's properties.
    - ➢ Its color, taste, etc.
    - ➢ It bubbles and fizzes when opened.
  - ✓ Examine soda's composition.

# An Example, Continued

- Step 3: Organize the information.
  - ✓ All the stuff around you is composed of chemicals.
  - ✓ The three main chemical ingredients of soda pop are water, sugar, and carbon dioxide
    - ➢ Sugar = sweetness
    - ➢ Water = liquid
    - ➢ Carbon dioxide = gas
- Step 4: Look for patterns.
  - ✓ **Structure determines properties**, so the fizzing of soda must have something to do with what's in it!
  - ✓ We know that:
    - ➢ If we blow air, a gas, into water, bubbles form.
    - ➢ Bubbles are like soda fizz.

# An Example, Continued

- Step 5: Propose a hypothesis.
  - ✓ Since the only gas in soda is carbon dioxide,

    "The reason soda pop fizzes is because the carbon dioxide is coming out of the soda."
- Step 6: Test your hypothesis.
  - ✓ How would you test it?

# Another Example from History—Why Do Some Things Burn?

- Observations
  1. Things would stop burning when placed in a closed container.
  2. Many metals burn to form a white powder called ***calx.***
  3. Metals can be recovered from their calx by roasting it with charcoal.

# Why Do Some Things Burn? Phlogiston Theory

- Explanation of combustion in early/mid-1700s.
- Combustible substances contained a substance they called **phlogiston**.
- When a substance burned it released all or some of its phlogiston into the air .

# How Does Phlogiston Theory Explain the Observations?

- When a substance is burned in the open, all the phlogiston is released.
- When a substance is burned in a closed container, the phlogiston is released until it saturates the container, at which point the combustion stops.
- A metal's calx is what is left after it releases all its phlogiston.
- When roasted with charcoal the calx reacquires phlogiston from the charcoal.
  - ✓ Charcoal is rich in phlogiston, that's why charcoal burns.

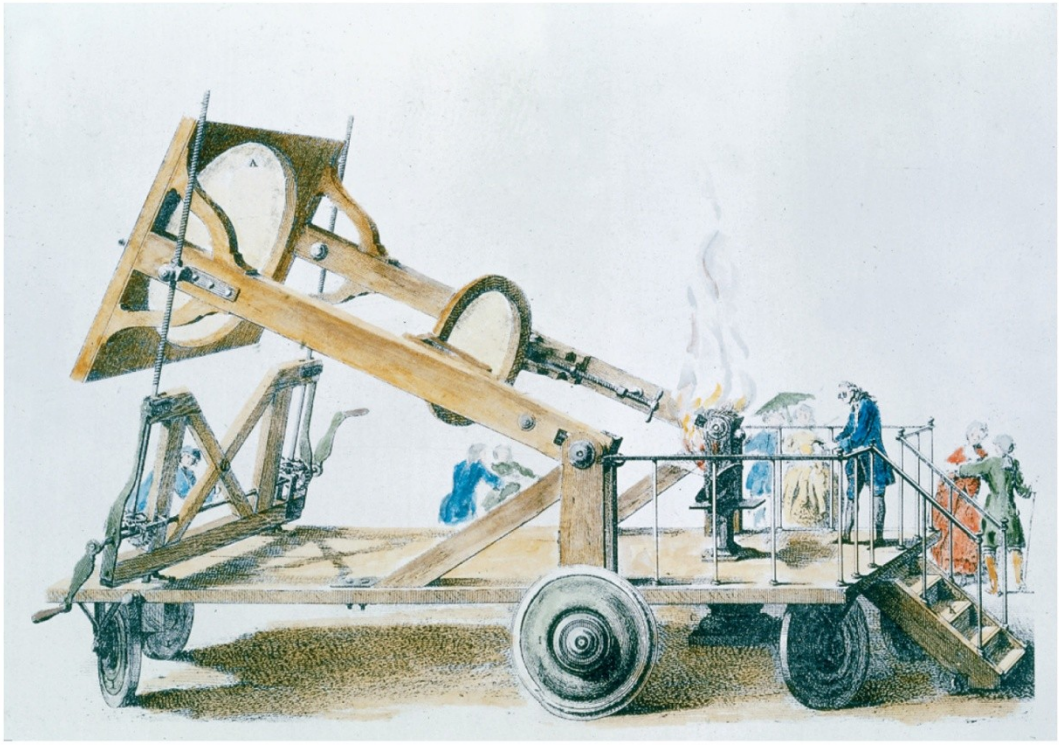
# How Was Phlogiston Theory Put to the Test?

- Prediction of Phlogiston Theory—If phlogiston is lost when metals burn, then the metals should lose weight when burned.
- Morveau's experiments showed that when a piece of metal burned, the resulting calx weighed more than the original metal.
- Do Morveau's observations validate or invalidate the Phlogiston Theory?

# How Was Phlogiston Theory Put to the Test?, Continued

- Prediction of Phlogiston Theory—If a calx is heated, it should remove phlogiston from the air as the calx is converted to the metal.
- Lavoisier roasted many calx with a large lens and observed that material he called “fixed air” was released into the air.
- Do Lavoisier’s observations validate or invalidate the Phlogiston Theory?

# The Great Burning Lens



# A Better Theory of Combustion

- Lavoisier proposed an alternative theory of combustion.
- When materials burn, they remove and combine with fixed air from the air.
- Does Lavoisier's idea explain all the previous observations?
- How could you test Lavoisier's idea?

# How to Succeed in Chemistry

- Be curious and use your imagination.
  - ✓Explore and investigate.
- Quantify and calculate
  - ✓Even small differences can be important!
- Commitment
  - ✓Work regularly and carefully.

# The Best Approach to Learning Chemistry

- Learn the vocabulary of chemistry.
  - ✓ Definitions of terms.
  - ✓ How common vocabulary is applied to chemistry.
- Memorize important information.
  - ✓ Names, formulas, and charges of polyatomic ions.
  - ✓ Solubility rules.
- Learn and practice processes.
  - ✓ Systematic names and formulas.
  - ✓ Dimensional analysis.
- Do the questions and exercises in the chapter to test your understanding and help you learn the patterns?