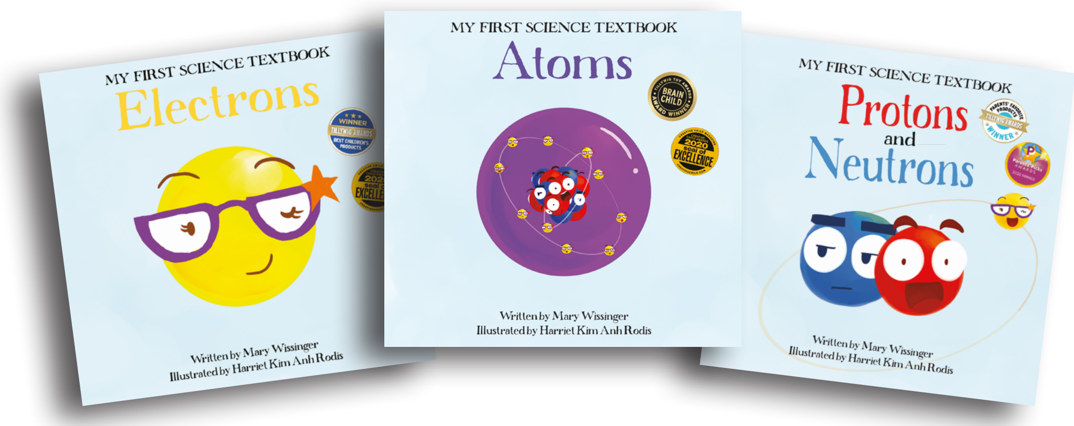
My First Science Textbook series
Teacher's Guide

Written and designed by Caroline Greaney

To be used with

My First Science Textbook: Atoms
My First Science Textbook: Electrons
My First Science Textbook: Protons and Neutrons

Written by Mary Wissinger
Illustrated by Harriet Kim Anh Rodis



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Sparking curiosity through reading

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Sparking curiosity through reading
1140 3rd Street NE, Suite 200, Washington, DC 20002
Tel: 202-465-4798
www.ScienceNaturally.com
Info@ScienceNaturally.com

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Words that can be found in the glossary will be shown throughout this guide as bold and as a color other than black. Example: **atom**

Introduction

Does it matter? Yes, it does!

Chemistry is the study of matter and the changes that take place with that matter. Everything on Earth, everything in the Solar System, everything in our galaxy, and everything in the universe is made of matter. All that matter is made up of atoms, which are the building blocks of our universe. They, in turn, are made up of three particles -- protons, neutrons, and electrons.

It can be hard to teach children about tiny things they cannot see, smell, or touch. While children have limited life experience and knowledge, they are open to understanding things big and small. The capacity of their minds is vast, fueled by unlimited imaginations.

Ian Stuart, a former chemistry teacher, found this to be true when he explained high school level atomic theory to his 8-year-old son. Through experiments and other activities, Stuart's son and his classmates were able to comprehend abstract chemistry topics such as atoms and matter. Teaching young children these subjects enables them to go on to great success as they further their science education.

Fortunately, there are lots of wonderful tools to help educators and parents introduce the concepts and vocabulary of atoms. Visit the websites and watch some of the TED Talks and videos listed below, use this Teacher's Guide, and show your students that even small things really matter!

Youtube Videos to share with students:
- Teaching Atoms and Molecules K-6
- What is an atom? Educational Videos for Kids
- What is an atom? Basics for Kids
- Atoms for Kids. What is an atom?
- What is an atom? Dr. Binocs Show
- What is an atom and molecule?
- What are atoms?
- How small is an atom?
- What are atoms? An explanation for kids

Ted Talks for educators and parents:
- Ian Stuart | I discovered that my 7-year old son could understand Atomic Theory
- Jordin Metz | Chemistry is fun. No, seriously!
Andrew Szydlo | An Explosive Passion for Teaching Chemistry

Websites:
- Ducksters.com posts educational articles that are easy to read and interesting. The atom section includes an informative article as well as activities.
- Chem4kids.com covers a wide range of topics in chemistry, such as matter, atoms, and the periodic table. Important terms are hyperlinked to their definitions, and related videos are embedded, as well.
- The Chemistry Educational Foundation has more activity guides you can use with your students. Their guides cover Properties of Matter, Chemical Reactions, and more.
- Science Kids is a great resource for anything you may need for a day of chemistry. Their website includes games, activities, quizzes, and so much more.
- The American Chemical Society has great educational resources for elementary and middle school teachers. In addition to lesson plans in chemistry, they provide safety tips and remote learning lessons.

We hope this Teacher's Guide will help you introduce these big concepts to small people -- because matter matters!

Welcome to the *My First Science Textbook* series

Dear Reader,

We're excited to introduce you to the *My First Science Textbook* series. These beautifully illustrated, information-packed titles introduce youngsters to the fascinating world of chemistry through fun, expressive characters.

Scientific curiosity begins in childhood, even prior to the start of formal education. Exposure to chemistry—whether in a lab or in a book—is often at the root of a child's interest in science. Through the study of chemistry, children can gain an understanding of the substances that make up everything in our world and the interactions between the tiniest particles that go unnoticed by the naked eye. As the many activities in this Guide will prove, it also provides the perfect opportunity for education to become hands-on and interactive.

Chemistry might be a complex subject, but introducing children to challenging subjects early in life makes it easier to succeed later on. This is particularly true for children below kindergarten, who will be better prepared to start school as they begin engaging in scientific inquiry and asking questions about the concepts discussed in these books. Spark curiosity in a child and watch them develop a lifelong enthusiasm for learning.

The *My First Science Textbook* series encourages all children to make real-world connections that sharpen their analytical skills and give them a head start in STEM (science, technology, engineering, and math). An easy choice for the home, library, or classroom, our books have something to create and sustain budding curiosity in any child.

Enjoy!

Dia

Dia L. Michels
Publisher, Science Naturally

About the Author: Mary Wissinger

Mary Wissinger was born in Wisconsin where she spent most of her childhood singing, reading, and daydreaming. She dove into storytelling through acting, singing, and writing (and writing and writing!). In addition to writing the "My First Textbook" 3-book series on particles, she is also the author of the "Science Wide Open" book series on famous female scientists in biology, chemistry, and physics. A former teacher, she can now be found at her standing desk in St. Louis, MO, writing stories that inspire curiosity about the world and connection with others. She can be reached at Mary.Wissinger@ScienceNaturally.com.

About the Illustrator: Harriet Kim Anh Rodis

Harriet Kim Anh Rodis began illustrating books at the age of 17 and has been a part of several publications since. She enjoyed the challenge of making microscopic particles come to life for children. She dedicates her career to her dad, who has supported her and her love of books, and who has encouraged her to pursue illustration. She lives in the Philippines. She can be reached at Harriet.Kim.Anh.Rodis@ScienceNaturally.com.

My First Science Textbook series: Contributors

Science Naturally would like to thank the following people for their hard work, invaluable insight, and dedicated time in creating the *My First Science Textbook* series and its accompanying Teacher's Guide:

Caroline Greaney
Writer, Designer

Marlee Brooks
Editor

Emma Ferdinandi
Editor

Hannah Thelen
Editor

Harriet Kim Anh Rodis
Illustrator
MFST series

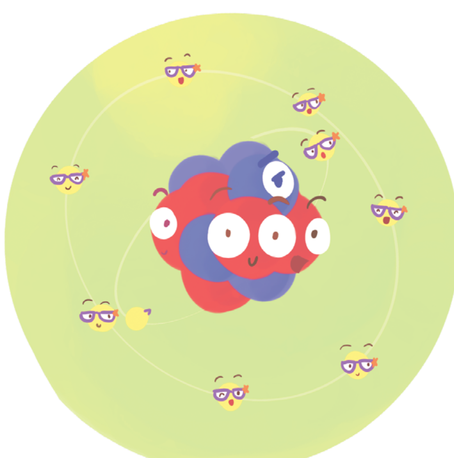
John Coveyou
Editor/Creator
MFST series

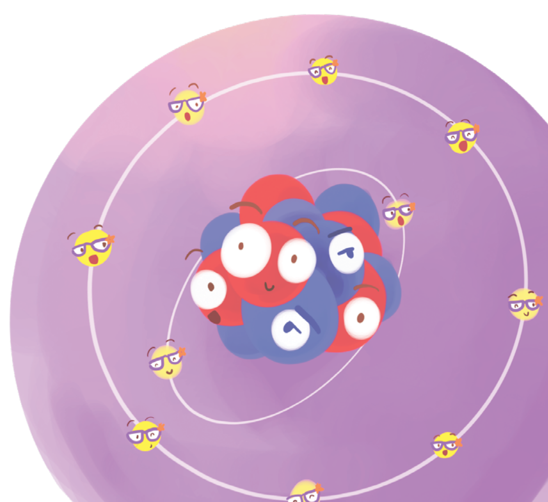
Mary Wissinger
Author
MFST series

Victoria Stingo
Editor

Section 1:
Book-Based Activities

These books use colorful, dynamic, and expressive characters to make the challenging concepts in chemistry understandable for kids. The activities in this section use the book to explore basic ideas in chemistry and help students begin thinking about the building blocks of life that they cannot see.





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Pre-Reading: Book Walk

Grades
Pre-K–4

Subjects
Reading,
Language Arts

Skills
Active listening,
critical thinking,
making predictions

Materials
My First Science Textbook series

NGSS Practices
1: Asking Questions and Defining Problems
7: Engaging in Argument from Evidence

Common Core English Language Arts
CCSS.ELA-LITERACY.RL.K.1
CCSS.ELA-LITERACY.RI.K.5
CCSS.ELA-LITERACY.RL.K.7
CCSS.ELA-LITERACY.RL.1.1

A book walk is a pre-reading activity that aids in reading comprehension and builds curiosity and enthusiasm about reading these books. It prepares students to think about the important questions they should be asking as they read. For younger students, this book walk (or picture walk) will help develop reading skills. Kids will learn to use the visual text of the pictures to understand what the story means and make educated guesses about unfamiliar words.

Get set up for story time. Have students sit in a circle so they can all see you and can talk with one another.

Tell your students that ***you*** will be reading three books in a chemistry series called *Atoms, Electrons*, and *Protons and Neutrons*. Discuss and ask them: What do you think these books will be about?

Ask your students questions. ***What do you think we are made of? Do you think there are things going on inside our bodies that we can't see? What do you know about chemistry? What words do you know that are related to chemistry?***

Then, show them the cover of each book and ask them new questions. ***Now what do you think it will be about? Can you be more specific than before? What do you think the characters on the covers are? Do we see these characters in real life, or are they invisible? Why are some of them stuck together and some of them by themselves? What do you think their expressions mean?***

Slowly flip through each book, page by page (or looking at a few pages you selected in advance), without reading any of the words. Ask your students questions about the pictures they see. ***What is going on here? Who are the characters on the page? What do you think their relationship is? What are they doing? Is this character doing the same thing as the page before? What don't you understand?***

Give vague responses that don't give away the story. Say things like, ***"Are you sure about that?"*** or ***"That's possible!"*** or ***"What makes you think that?"*** This will plant the seed for an enthusiastic discussion while you read the book or when the reading is done.

Flip the book over and read the back cover, then start your usual read-aloud session.

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Activity: What Are You Made Of?

Grades
Pre-K–3

Subjects
Atoms, matter

Skills
Identifying, observation

Materials
My First Science Textbook: Atoms

NGSS
5-PS1-1: Matter and Its Interactions
2-PS1-3: Matter and Its Interactions

Common Core English Language Arts
CCSS.ELA-LITERACY.RI.2.3

Background
All of the **atoms** on Earth came from outer space. When the **Big Bang** happened, it created many different atoms, but other atoms came from collisions between stars. Fully, 98% of the **matter** in the universe is made of two different types of atoms: **helium** and **hydrogen**. This is because helium and hydrogen atoms make up most of the stars in the universe, including our Sun. However, there are many different types of atoms. The different types of atoms are called **elements**.

Activity
1. Review the background information as a class.

2. Read through *Atoms* with students, paying special attention to the pages that introduce atoms as the building blocks of the universe. Ask students the following questions: ***How can atoms be both inside of us and outside? Have you heard of helium, and where else can it be found? What other elements have you heard of? Where can you find them?***

3. Ask students what they think "matter" is. Can they come up with three types of matter? (can be themselves, any object in the room, etc.). Ask students to think about which of their chosen types of matter weigh the most, and which weigh the least. Some matter might weigh more because it has more atoms.

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Activity adapted from the American Chemical Society, acs.org.

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Activity: Hunting for Electrons

Grades
Pre-K–4

Subjects
Electrons, electricity

Skills
Vocabulary retention, recalling information, critical thinking

Materials
My First Science Textbook: Electrons

NGSS
4-PS3-2: Energy

Common Core English Language Arts:
CCSS.ELA-LITERACY.W.4.7
CCSS.ELA-LITERACY.W.4.8

Background
Electrons are responsible for the electricity that lights our homes at night and gives us a **static shock**. **Electricity** is generated when electrons move from the negatively charged parts of circuits to the positively charged parts. The negatively charged parts of circuits always have extra electrons, while the positively charged parts of circuits always want more. When the electrons move, they move so quickly that an **electric current** forms.

Electricity Quiz

- Electrons are usually hard at work creating electricity in circuits, but they can also be stored for later use. Where do we usually store electricity? ***Batteries***
- Can you name three places where you might see electricity in your daily life? ***Night lights, computer cords, lamps, etc.***
- Where can you find electricity in this classroom? ***Lights, projector, etc.***
- True or False: electricity can be found in our own bodies. ***True! Whenever we move one of our muscles, it is because our brain is sending an electrical signal to this part of our body and telling it to move. A system of pathways called nerves transmits the electrical signals.***
- Name three ways that people produce electricity. ***Wind, coal, oil, gas, solar, hydro, nuclear, biofuels***
- How do we measure electricity? ***Volts***

Activity
1. Go over the background information with students.

2. Read through *Electrons* with students, pausing on the pages that show how electrons play a role in electricity. Ask students why they think electricity is so important, then go through the quiz with them. The objective is for students to understand the connection between the movement of electrons and electricity.

3. Return to the Teacher's Guide for answers. With each answer you go over, ask students where they have seen examples of the quiz answers play out in their everyday lives (e.g. using batteries in a device, flipping a light switch).

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Activity adapted from fumcr.com and ducksters.com

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Activity: How Much Mass?

Grades
Pre-K–4

Subjects
Mass, matter, subatomic particles

Skills
Abstract thinking, making comparisons, classifying materials, collaboration

Materials
My First Science Textbook: Protons and Neutrons

NGSS
2-PS1-1: Matter and Its Interactions

Common Core English Language Arts:
CCSS.ELA-LITERACY.W.2.7
CCSS.ELA-LITERACY.W.2.8

Background
Mass is a measure of how much matter is in an object, regardless of where it is in the universe and how much **force** is applied to it. **Matter** is anything in the world that takes up space and has mass. **Subatomic particles**—**protons**, **neutrons**, and **electrons**—are the smallest units of matter in the world, and they are therefore the smallest things that have mass. The mass of electrons, protons, and neutrons is quite different. Electrons are tiny and have very little mass because they need to zoom quickly around the atom's **nucleus**. Protons and neutrons are massive by comparison, containing much more mass, because they are located in the nucleus and comprise the main body of the atom. In fact, protons and neutrons have 2,000 times the mass of electrons! If electrons were the size of a penny, protons and neutrons would be roughly the size of a bowling ball.

Activity
1. Review the background information as a class.

2. Read through *Protons and Neutrons* with students, pausing on the pages that discuss Ned the Neutron's mass (pages 14 and 15). Ask students: ***what do you think mass means? Why do you think neutrons have so much mass that they make up half of our bodies? Why do you think that electrons have such little mass? Do you think atoms would be the same if electrons had more mass than protons and neutrons? Why or why not?***

3. Building off of the bowling ball and penny comparison in the background information, ask students to get in pairs and think about two other objects that one could use to compare the mass of electrons to the mass of protons and neutrons.

4. Come together as a class and have students share their answers. Why did they pick the specific objects that they did? What about these objects' properties make these objects useful for comparing the masses of the different subatomic particles? Did students think mostly about size, or did they also take shape and weight into account as well?

—
Activity information from Chemistry LibreTexts, chem.libretexts.org.

Section 2:
Concepts in Chemistry

The *My First Science Textbook* series introduces children to the most basic theories and ideas in chemistry, setting them up for further exploration of these subjects in later years. The activities in this section enable kids to think creatively about the topics explored in the book through drawing, storytelling, and collaborative work.

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Activity: Matter in Everyday Life

Grades
K–3

Subjects
Structure and properties of matter

Skills
Observation, recalling past information, planning and conducting investigations, collaboration

Materials
My First Science Textbook: Protons and Neutrons, paper, colored pencils, photo of a solid, photo of a liquid, photo of a gas

NGSS
2-PS1-1: Matter and Its Interactions

Common Core English Language Arts
CCSS.ELA-LITERACY.W.2.7
CCSS.ELA-LITERACY.W.2.8

Background
There are three main states of matter that we encounter in our everyday lives: **solids**, **liquids**, and **gases**. Each of these types of matter are composed of **molecules**. In solid form, molecules are packed tightly together, and they do not move much. As a result, solids have a definite shape. In a liquid, molecules are more loosely packed together and move around constantly, which gives the liquid an indefinite shape that conforms to the container it is placed in. The molecules in a gas are spaced very far apart, which causes them to expand into space.

Activity
1. To provide context for the activity, show students page 17 in *Protons and Neutrons*, with the illustration of the proton and neutron next to the three types of matter. On the board, hang up three images of any solid, liquid, or gas.

2. Divide students into pairs. Pass out paper and colored pencils. Ask students to talk with their partner about things they see in their everyday lives that look and act like the solid, liquid, and gas on the board. Instruct them to describe to their partner what their selections see and feel like—what are the colors and textures?

3. Listening carefully to their partner, students will draw each of the things their partner describes and write down the color, texture, and behavior of each one (e.g. for "solid," a student might suggest a baseball because it is hard, round, and never changes shape. Their partner will draw a baseball and write down its description.)

4. When students are done, go around the room and have them share what things they selected and the reason why. While one partner is talking, the other partner will hold up their drawings.

5. Return to the Teacher's Guide and go over the Discussion section.

Discussion

Ask students why they selected the particular things they did, where they see their selections most often (in a glass cup at dinner, in the classroom at school, etc.) and how their selections are similar to or different from the images on the board. Were there a lot of different objects and materials to think about and choose from? Explain the distinctive characteristics of each state of matter to students (per the background information) and return to page 17 in *Protons and Neutrons* to describe how the molecules in that state of matter behave. Note: Students may mention gasoline that goes into their parents' cars as a gas. Gasoline sold to consumers in the US is a liquid, even though it is called gas. Natural gas, used to fuel some commercial vehicles, is an actual gas.

Activity: Life of a Particle

Grades
2–4

Subjects
Subatomic particles, atoms

Skills
Observation, inference, researching, identifying relevant information

Materials
My First Science Textbook: Electrons, *My First Science Textbook: Protons and Neutrons*, printout pages from each book

NGSS
2-PS1-1: Matter and Its Interactions

Common Core English Language Arts
CCSS.ELA-LITERACY.W.2.7
CCSS.ELA-LITERACY.W.2.8

Background
Each of the three subatomic particles within atoms—protons, neutrons, and electrons—serve a different function within the atom and therefore behave a bit differently. Neutrons and positively charged protons are packed together in the nucleus of an atom, making up most of its mass, while negatively charged electrons are constantly racing around the outside of the nucleus.

Activity

1. To provide context, show students the opening pages of *Electrons* and *Protons and Neutrons* to re-introduce the particle characters.

2. Ask students to observe the images on the board** and describe the particle characters' personalities based on the characters' facial expressions and what they are doing. Write the words and phrases that students come up with on the board next to the corresponding character images.

3. Instruct students to choose Ellie the Electron, Pete the Proton, or Ned the Neutron and write a one-page story about their daily life, using the descriptions written on the board to think about what activities these particles might enjoy doing. Students can work alone or in pairs.

4. While students are writing, monitor their learning experience and ask them questions about why they are choosing particular activities for their particles to do (ex: ***"I see that you are having Ned the Neutron take a nap. Is this because we wrote on the board that he is grumpy and stays still a lot?"***) It is important to ensure that students are not choosing activities at random and are instead making a conscious effort to incorporate the information they have to work with from the board.

5. When students are done, ask for volunteers to share one of the activities that they had their character do and why. Return to the Teacher's Guide and go over the Discussion section.

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**Note that prior to the beginning of the activity, the printout copies of the book pages should be hung in a very visible location in which students can see them and refer to them while completing the activity. Choose pages that best document the particles' facial expressions and behaviors to give students inspiration.

Discussion

The main point of this activity is to help students acquire a basic understanding of the way the smaller particles behave by thinking about them as characters. The creativity that students employ to write their characters' daily schedules should be tied back to the basic information about particles that is discussed in the books. When students have finished sharing, explain the above background information to them through the particle characters, incorporating the observations students have made (ex: ***"Many of you said that you had Pete the Proton and Ned the Neutron do everything together because they seem like best friends. That was a great observation to make—neutrons and protons like Ned and Pete are always in the center of the atom, packed tightly together."***)

Activity: Sketching the Elements

Grades
1–4

Subjects
Elements, periodic table, atoms

Skills
Identifying, reading comprehension, applying abstract concepts, critical thinking

Materials
My First Science Textbook: Atoms, printouts of element labels (page 27 & 28), paper, pencils

NGSS
K-2-ETS1-2: Engineering Design

Common Core English Language Arts
CCSS.ELA-LITERACY. SL.2.5

Background
An element is a type of chemical substance that is made of the same types of atoms, all of which have the same number of protons and neutrons. The **periodic table** classifies each of these elements by ascribing them a label with the following components:

> **Atomic number**: the number of protons in each of an element's atoms, located in the top left corner of the label.
>
> **Chemical symbol**: a one or two-letter abbreviation for the name of the element, located in the center of the label (above the fully written out name.)
>
> **Atomic mass**: the number of protons and neutrons in each of an element's atoms, located below the element's full name.

The elements are grouped in terms of their atomic numbers, starting with the smallest atomic number on the left and the largest atomic number on the right.

The number of neutrons in an atom can be determined by subtracting the atomic number (number of protons) from the atomic mass (number of protons plus number of neutrons).

Activity
1. Show students pages 20 and 21 in *Atoms* and explain what all of the different parts of the label are. Hang up one of the labels as an example.

2. Place the printed element labels (page 27 & 28 of the Guide) in a hat and have each student pick one. There are 32 labels. Form groups if you have more than 32 students.

3. Help them pronounce the name of their element. Is it a familiar word or a new one for them? Do they have any association with the word?

4. Instruct the students to draw one of the atoms that would be in the element, using the clues provided on the label. They should sketch out the protons and neutrons in the center and a few electrons on the outside. If students are struggling, go over the different numbers on the element label with them. ***Which number shows the number of protons plus neutrons? Which number shows the number of protons? Can you subtract one from the other?*****

5. Return to the Teacher's Guide and go over the Discussion section.

Discussion
Use the example label on the board to draw an atom, explaining your rationale for including the number of protons, neutrons, and electrons that you chose to include in the drawing. Seeing you complete the process yourself will help students check their answers and solidify their understanding of the relationship between the element labels on the periodic table and the atoms that comprise elements. Ask students: ***why is it so important to draw out the atoms in different elements?***

**The atomic mass is never a whole number. To make subtraction easier, students can round the atomic mass either up or down before subtracting. This will give them a chance to practice their math skills as well.

8 **O** Oxygen 15.999	11 **Na** Sodium 29.990	3 **Li** Lithium 6.941	7 **N** Nitrogen 14.007
9 **F** Flourine 18.998	10 **Ne** Neon 20.180	26 **Fe** Iron 55.845	14 **Si** Silicon 20.086
16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.453	4 **Be** Beryllium 9.0122	19 **K** Potassium 39.098
6 **C** Carbon 12.011	5 **B** Boron 10.81	13 **Al** Aluminium 26.982	12 **Mg** Magnesium 24.305

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1 **H** Hydrogen 1.008	20 **Ca** Calcium 40.078	2 **He** Helium 4.0026	8 **O** Oxygen 15.999
15 **P** Phosphorus 30.974	18 **Ar** Argon 39.948	34 **Se** Selenium 78.971	30 **Zn** Zinc 65.38
29 **Cu** Copper 63.546	28 **Ni** Nickel 58.693	27 **Co** Cobalt 58.933	25 **Mn** Manganese 54.938
24 **Cr** Chromium 12.011	22 **Ti** Titanium 47.867	21 **Sc** Scandium 44.956	23 **V** Vanadium 50.942

Activity: Element Matching Game

Grades
K–4

Subjects
Elements, periodic table

Skills
Reading comprehension, critical thinking, sorting, identifying

Materials
My First Science Textbook: Atoms, Element Matching Worksheet (page 30)

NGSS
2-PS1-1: Matter and Its Interactions

Common Core English Language Arts
CCSS.ELA-LITERACY.W.2.7
CCSS.ELA-LITERACY.W.2.8

Background
There are 118 elements on the periodic table, and some are more common in everyday life than others. The most abundant elements on earth are **oxygen**, **hydrogen**, **carbon**, and **nitrogen**. These elements make up most of our mass and the mass of every other living creature on earth. Other elements are incredibly important because they are used in everything from coins to table salt to balloons.

Activity
1. Go over the background information with students. Ask for volunteers to give you the names of elements they have heard of. ***Are all of these elements similar, or are they different? Are some elements more likely to show up in the world than others? Why do they think elements are important?***

2. Hand out the Element Matching Worksheet (page 30).

3. Ask students to match the elements to their intended use in everyday life. With younger students, this activity can be modified so that the teacher is reading the descriptions and the students are guessing out loud which purpose the element serves.

4. Come together as a class and review the answers.

5. Return to the Teacher's Guide and go over the Discussion section.

Fun Fact
The elements that can be found on Earth—such as silicon, which makes up some of Earth's composition—can also be found on Mars!

Discussion
Certain elements can be seen with the naked eye, while others cannot. Ask students which elements they found easiest and hardest to identify and why. For the elements that they cannot see or touch (such as oxygen and helium), what might these elements have in common? The goal is to ultimately steer students toward the idea that some elements exist in a solid state, like metals, and others are more like air because they are gases.

—
Information for this activity came from interestingengineering.com and the American Chemical Society, acs.org.

Name:____________________________ **Date:**_____________

Worksheet: Element Matching

Draw a line connecting each element to its description.

Neon	Humans need me to survive because I make up the air you breathe.
Chlorine	I show up all the time in advertising signs. I am what makes them glow at night and get your attention.
Gold	I am used in the salt that seasons your food.
Helium	Whenever you go swimming at the pool, I am there to clean the water! I am the reason why your eyes might hurt when you open them underwater.
Copper	You can find me in a penny. I am also a great conductor of electricity, which means that electrons can flow through me very easily.
Silver	I can be found in all kinds of jewelry and kitchen utensils. I reflect light very well, so people think I am beautiful, but I also get stains and smudges a lot.
Sodium	I am used in toothpaste to help protect your teeth. There are all kinds of bacteria living in your mouth that create acid, and I make it harder for the acids to damage your teeth.
Oxygen	Out of all of the metals in the world, I am the one that people want most. I am perfect for using in art, such as sculptures, and I never get stains.
Flourine	I am used to fill balloons because I am lighter than air. This is why balloons filled with me float!

Answers: Element Matching

Neon

Chlorine

Gold

Helium

Copper

Silver

Sodium

Oxygen

Flourine

Humans need me to survive because I make up the air you breathe.

I show up all the time in advertising signs. I am what makes them glow at night and get your attention.

I am used in the salt that seasons your food.

Whenever you go swimming at the pool, I am there to clean the water! I am the reason why your eyes might hurt when you open them underwater.

You can find me in a penny. I am also a great conductor of electricity, which means that electricity can flow through me very easily.

I can be found in all kinds of jewelry and kitchen utensils. I reflect light very well, so people think I am beautiful, but I also get stains and smudges a lot.

I am used in toothpaste to help protect your teeth. There are all kinds of bacteria living in your mouth that create acid, and I make it harder for the acids to damage your teeth.

Out of all of the metals in the world, I am the one that people want most. I am perfect for using in art, such as sculptures, and I never get stains.

I am used to fill balloons because I am lighter than air. This is why balloons filled with me float!

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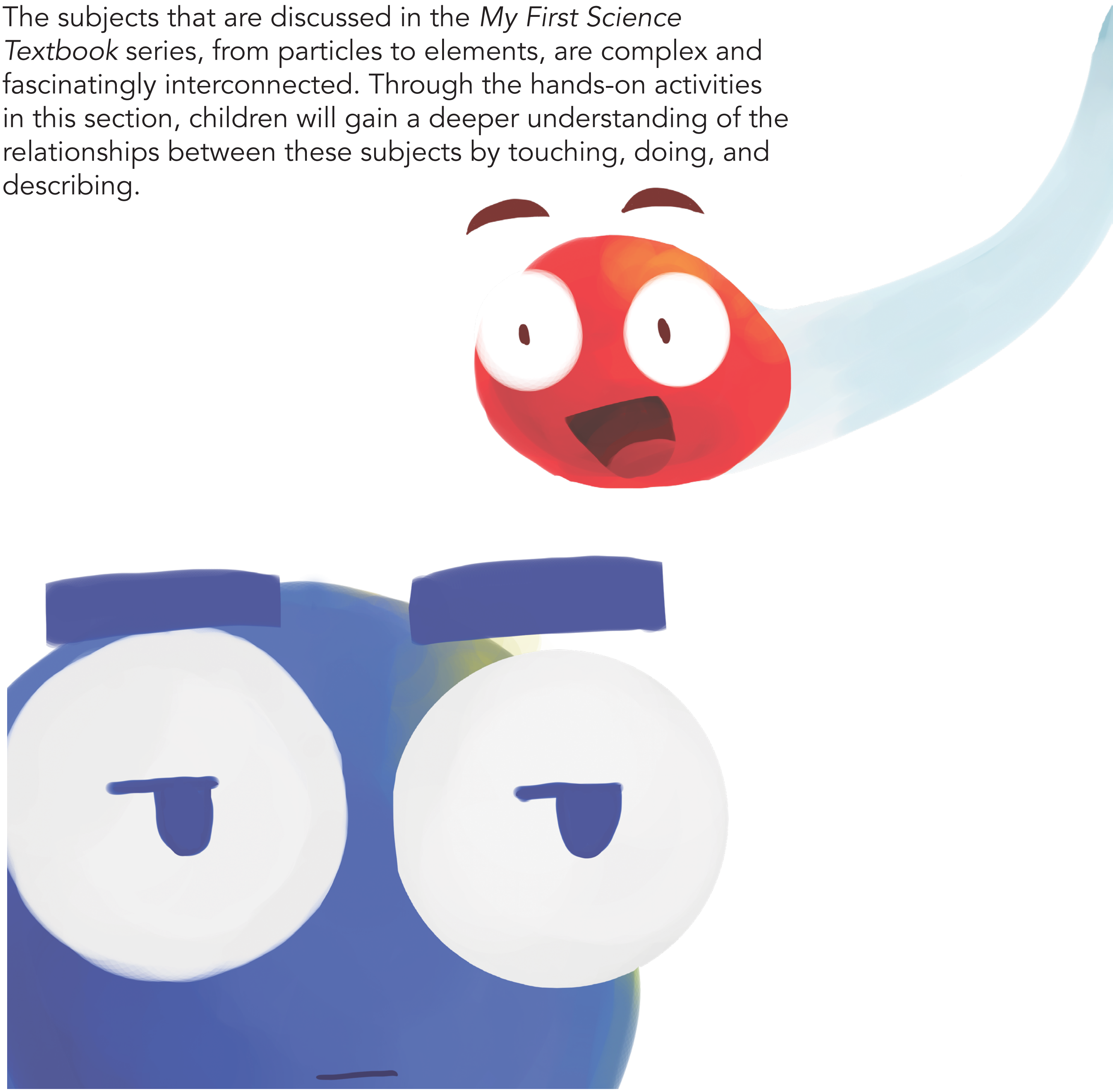
Section 3: Hands-On Activities

The subjects that are discussed in the *My First Science Textbook* series, from particles to elements, are complex and fascinatingly interconnected. Through the hands-on activities in this section, children will gain a deeper understanding of the relationships between these subjects by touching, doing, and describing.



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Activity: States of Matter

Grades
Pre-K–3

Subjects
Structure and properties of matter, chemical changes

Skills
Constructing an argument with evidence, recalling past information, understanding cause and effect

Materials
My First Science Textbook: Protons and Neutrons, ice cubes, cups, rulers

NGSS
2-PS1-4: Matter and its Interactions
2-ESS2-3: Earth's Processes

Common Core English Language Arts
CCSS.ELA-LITERACY.RI.2.1
CCSS.ELA-LITERACY.RI.2.3
CCSS.ELA-LITERACY.RI.2.8
CCSS.ELA-LITERACY.W.2.1

Background
While there are three distinctly recognizable states of matter in the world, the phase of matter is not always consistent. Students who have studied the Water Cycle should be familiar with this. The easiest way to discuss states of matter is by using liquid water/water vapor/ice as an example.

Changes in state depend upon the temperature in the surrounding environment. When solids are exposed to heat, they may change to liquids. When liquids are heated, they may change to gases. Usually, solids can become gases if they are first melted down into liquids and then heated. Solids can also become gases without the intermediate liquid stage through a process called sublimation. Lastly, when liquids are exposed to freezing temperatures, they may turn to solids.

When a solid turns into a liquid, it is because increased temperature makes the molecules in the solid that would ordinarily be moving slowly start to move faster and spread out. The reverse is true for a liquid turning into a solid: decreased temperature makes the molecules in the liquid slow down and move closer together. When a liquid turns into a gas, the molecules fly apart and become too spaced out for the matter to hold any form.

Activity
1. Divide students into pairs and hand each pair an ice cube. Tell students that you would like for them to find the fastest way to melt an ice cube, and hint that temperature has something to do with it.

2. Once the ice cubes are melted and students have wiped their hands/spaces, hand each pair of students a cup. Have students fill the cups halfway with water, then use a ruler to measure the water level.

3. Head outside as a class and place the cups of water in a sunny spot.

4. Return to the cups later in the day (or in class the next day) and have students measure the water level again.

5. Return to the Teacher's Guide and go over the Discussion section.

Discussion

Request observations from students about how much time it took them to melt their ice cube and what they or their partner did to make it melt faster. ***What strategies worked and did not work? Was this change reversible or irreversible, and why?*** From there, circle back around to the idea that temperature can cause the state of matter to change. Explain that the ice cubes melted because heat can make a solid turn into a liquid, and add that the students just made the molecules in the ice cubes spread further apart and move faster to melt them down. You can then introduce the reverse process of a liquid turning into a solid by asking them to tell you what could happen when a liquid is exposed to freezing temperatures.

Either later in the day or in class the next day, have students return to check their cups and measure the water level—there may be none left. Ask students whether the change was observable or not. This will prompt them to recall the previous class, when they were able to see the ice cubes melting in real time. ***What do the students think happened? What is the scientific name for the process of the water disappearing (evaporation)? Ask them to tell you in terms of molecules, and direct them toward the correct answer. Was this a reversible or irreversible change? What are some examples of changes to matter that are observable or unobservable? What are some other examples of changes to matter that are reversible or irreversible?***

Activity: Acting Out Atoms

Grades
Pre-K–4

Subjects
Atoms, ions, positive and negative charges

Skills
Collaboration, active listening, abstract thinking

Materials
My First Science Textbook series, construction paper in three different colors, ample floor space

NGSS
K-2-ETS1-2: Engineering Design

Common Core English Language Arts
CCSS.ELA-LITERACY.SL.2.5

Background
Positively charged protons and neutral neutrons sit in the center of the atom and make up its nucleus, while negatively charged electrons race around the outside of the atom. Because protons are positively charged and electrons are negatively charged, they are constantly attracted to each other. Neutrons stabilize this attraction. In its default state, when an atom is neutral, it has the same number of protons and electrons, and the charge is balanced. However, this is not always the case—an atom that gains or loses an electron is called an **ion**. In some instances, an atom might gain an electron and become a **negative ion**. In other cases, an atom might lose an electron and become a **positive ion**.

Warm-up
To provide context for this activity, show students photos of atoms from the book. Point out the protons and neutrons in the middle, then the rings on which the electrons are orbiting. Students should be able to understand that electrons orbit the nucleus with the protons and neutrons like planets orbit the sun.

Activity
1. Divide students into protons, neutrons, and electrons. The number of protons and electrons depends on the number of students in the class, but there should be an even number of protons and electrons.

2. Have students take a piece of construction paper (with each color corresponding to a particular subatomic particle) and write down which particle they are in big, bold letters. Students who are protons and electrons should put a plus (+) or minus (–) symbol on their signs as well. Advise them to hold the signs clearly in front of them during the activity.

3. Students who are assigned to proton and neutron groups will cluster together in the center of the classroom. Tell the class that the proton and neutrons make up the atom's nucleus.

4. Have the students who are assigned to the electron group spread out in a circle and begin walking around the proton and neutron students. Inform the class that these students represent the electrons that race around the nucleus.

5. Instruct the proton and electron students to pause and face each other. This pause presents a moment to explain that protons and electrons are always attracted to each other because of their opposite charges.

Bonus Activity
For older students who are able to more firmly grasp the structure of an atom and the atoms' charges, the following steps can be added to explain what may happen when atoms gain or lose electrons.

1. Ask one of the students who is in the electron group to step out of the circle. Explain the process of creating a positive ion to students.

2. Join the electron circle with a sign. Explain the process of creating a negative ion to students.

Discussion
Refer back to the books in order to aid students in conceptualizing what they learned about the structure of atoms through physical movement. Ask students to think about and verbalize points in the books in which they first saw the structure of atoms, the subatomic particles' charges, and the ways in which atoms change when they gain or lose electrons. If students seem stuck, turn to specific points in the book to jog their memories. ***Was it easier or harder to learn about the behavior of subatomic particles by acting it out rather than reading about it? What do they still not understand about particles and their role in the atom after doing the activity, and what further questions have come up?***

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Activity adapted from study.com

Activity: Gumdrop Molecules

Grades
K–4

Subjects
Atoms, molecules, compounds, bonds, elements

Skills
Abstract thinking, identifying, reading comprehension

Materials
Gumdrops in different colors, toothpicks, flashcards with molecules and compounds on page 40

NGSS
2-PS1-1: Matter and its Interactions
K-2-ETS1-2: Engineering Design

Common Core English Language Arts
CCSS.ELA-LITERACY.W.2.7
CCSS.ELA-LITERACY.W.2.8
CCSS-ELA.LITERACY.SL.2.5

Background
When two or more atoms bond together, a molecule is formed. When a molecule contains two or more atoms from different elements, it is called a **compound**. An example of a molecule is O_3. Some common examples of molecules that are compounds include H_2O (water) and NaCl (table salt).

Activity
1. Distribute a molecule flash card to each student found on page 40 of this Guide. Ask students to examine their flash cards carefully and find out how many elements (oxygen, hydrogen, etc.) are represented in their assigned flashcard. Based on this information, is their molecule a compound or not?

2. Distribute gumdrops and toothpicks by asking each student individually to identify the elements in their compounds. Each element needs a different gumdrop color.

3. Have students create their own molecules or compounds by following the instructions on the flash cards. The gumdrops are the atoms of different elements, and the toothpicks are used to connect them. Once they have finished creating their first gumdrop compounds, students can swap flashcards with another students and repeat the process.

Discussion
Some molecules and compounds are familiar, and some might compose things that appear frequently in everyday life. Ask students if they have ever heard of compounds such as H_2O or NaCl and where these compounds can be found. Based on the association between the gumdrop colors and the types of atoms they represent, students should be able to determine which molecules are compounds. Molecules are also responsible for the differences in the three types of matter.

Flashcard Identification

O3: Ozone	NH3: Ammonia	Cl2: Chlorine
H2O: Water	CO2: Carbon Dioxide	CO: Carbon Monoxide

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Activity from "Playdough to Plato" blog.

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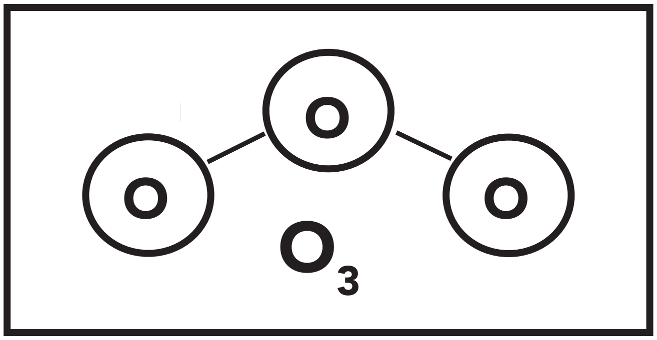
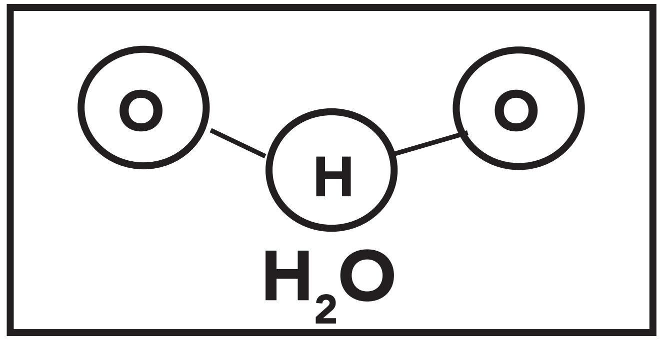
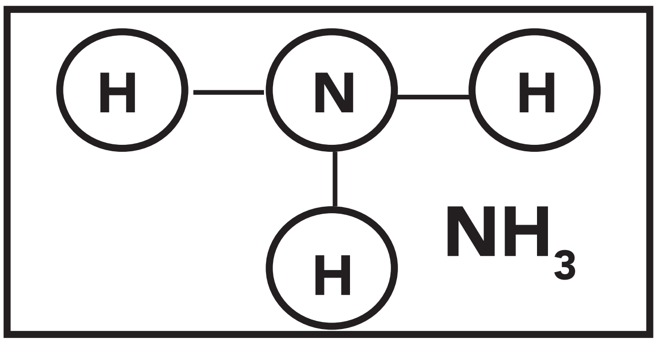
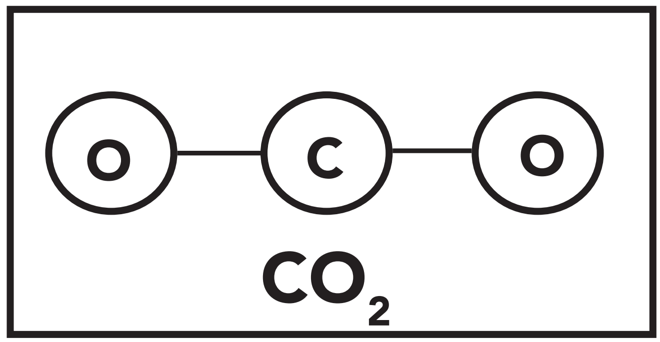
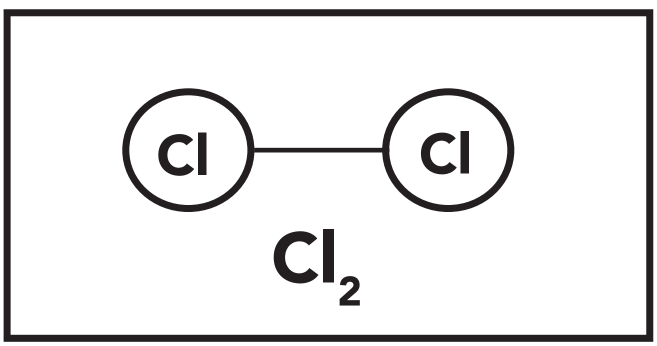
Gumdrop Molecules Flashcards

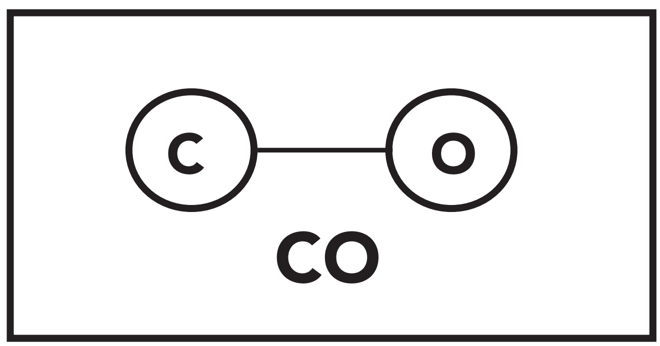












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Activity: Opposites Attract

Grades
Pre-K–3

Subjects
Atoms, subatomic particles, positive and negative charges

Skills
Active listening, inference, critical thinking

Materials
My First Science Textbook: Electrons, magnets (should have a clearly labeled North and South Pole in different colors)

NGSS
3-PS2-3: Forces and Interactions

Common Core English Language Arts
CCSS.ELA-LITERACY.RI.3.3
CCSS.ELA-LITERACY.RI.3.8
CCSS-ELA.LITERACY.SL.3.3

Background
Because protons are positively charged and electrons are negatively charged, these two subatomic particles are constantly attracted to each other. Opposites attract and two forces that are the same repel each other, so protons and electrons would not be attracted to each other and the atom would not have the structure it has if both protons and electrons had the same charge. This phenomenon can be explained using standard magnets, which have a positively charged "North Pole" and a negatively charged "South Pole."

Activity
1. For context, show students pages 8 and 9 of *Electrons*. Explain that you are going to investigate why Ellie the Electron is so drawn to Pete the Proton by using magnets.

2. Hand each student a magnet. Ask for a "thumbs up" if anyone has seen a magnet before and if anyone knows what the two different ends of the magnets represent.

3. Instruct students to hold the "North Pole" of one magnet and the "South Pole" of another magnet near each other. What do they think is happening with the magnets? Can they use adjectives to describe the sensations in their hands?

4. Instruct students to point the "North Pole" end of one magnet to the "North Pole" end of another magnet. What sensations are they experiencing now?

5. Return to the Teacher's Guide and go over the Discussion section.

Discussion
Now that students have an idea of what happens when different types of charges are pointed toward each other, it is time to compare the attraction and repulsion they experienced in the magnets to protons and electrons. Why do students think that they could sometimes make the magnets stick together and sometimes could not? Explain that the "North Pole" of a magnet is negatively charged and the "South Pole" of a magnet is positively charged. How can this observation be related back to Ellie the Electron and Pete the Proton? Through conversation, help students arrive at the conclusion that protons and electrons must have opposite charges for the atom to be held together—"opposites attract."

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Activity: Paper Plate Isotopes

Grades
Pre-K–4

Subjects
Isotopes, mass

Skills
Identifying, listening comprehension, organizing, observation

Materials
My First Science Textbook: Protons and Neutrons, paper plates, pom-poms, markers

NGSS
K-2-ETS1-2: Engineering Design

Common Core English Language Arts
CCSS.ELA-LITERACY.SL.2.5

Background
The atoms in each element always have the same number of protons, but the number of neutrons do not always stay the same. An **isotope** is a variant of an atom with a different number of neutrons. When the number of neutrons is different, the atom's atomic mass changes. An atom's atomic mass can be found by adding the number of protons to the number of neutrons. Atomic mass is the weight of the atom in units that happen to be the same weight as one proton/neutron, as electrons are too light to affect the weight. On the periodic table, the atomic mass of the atoms in a particular element can always be found by looking at the number underneath the element's full name.

Warm-up
1. Show students pages 5, 6, 7, 12, and 13 in *Protons and Neutrons*, which introduce Pete the Proton and reveal how many protons are in carbon and oxygen. Remind students that protons are always the "defining trait" of the atom. Next, show students page 20 in *Protons and Neutrons,* which introduces isotopes.

2. Show students the pages in *Protons and Neutrons* that introduce Ned the Neutron. Ask them to describe Ned the Neutron, paying special attention to the role he plays in the atom. ***Why are neutrons so important to the atom? What does it mean that neutrons like Ned make up half the atom's mass? What might happen if the number of neutrons in an atom changes? Would that make the atom different?***

3. Introduce the activity by defining an isotope for students. Tell them that you will be using paper plates to make the regular atom in an oxygen element and its isotope. ***Why is oxygen such an important element?***

Activity
1. Distribute two paper plates, pom-poms, and markers to each student. Instruct them to draw two rings, one on the outside of the plate and another one toward the center. Tell students that one pom-pom color will represent positively-charged protons, one will represent neutrons, and one will represent negatively-charged neutrons. The plate on the left will be the regular atom in an oxygen element, and the plate on the right will be an isotope of an oxygen element.

Activity continued on the following page.

2. For the atom on the left, students will count out eight protons, eight neutrons, and eight electrons. To aid in retention, frame this in the form of a question first—why are they adding this many of each particle? Instruct students to build up the atoms as they have seen in the books, with the protons and neutrons in the middle, two electrons on the inside ring, and six electrons on the outside ring.

3. For the atom of the right, tell students that the number of neutrons will be changing. Ask questions that enable students to think back on the warm-up discussion. ***What is an atom with a different number of neutrons called?***

4. Return to the Teacher's Guide and go over the Discussion section.

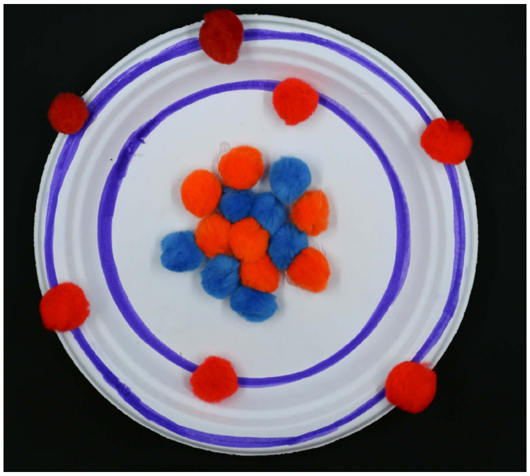
Discussion

Isotopes are a bit like apples. Apples look similar on the outside, but when you cut them open, they might all have different numbers of seeds. Like neutrons, the seeds in an apple change the apple's weight if you add or subtract them—seeds weigh half a gram each! Still, apples are the same kind of apple regardless of how many seeds there are, just as oxygen atoms are all oxygen atoms regardless of how many neutrons there are.

Before students glue down their pom-poms on the plates, have them pause for a discussion on the ways in which an isotope changes an atom. This is when the concept of atomic mass should be introduced. Ask students to add the number of protons and neutrons that they see on each plate. Are the numbers different? Finish by defining the term "atomic mass" for students and asking them which atom they think is heavier: the regular atom or the isotope. The primary objective is for students to understand that a) elements can have atoms with different numbers of neutrons, and b) the number of neutrons in an atom changes its atomic mass.

Bonus Activity

Older students who have stronger abstraction capabilities can be introduced to the connection between isotopes and the periodic table. Once you have completed the discussion on isotopes and atomic mass, project an image of the periodic table. Ask students to think back on what they have learned about the periodic table and where they can find the number of protons and neutrons for an element. This question will enable you to determine how well they are able to link their paper plate visual of isotopes to the periodic table. After reviewing where to find the atomic number (number of protons) and the atomic mass (number of protons plus number of neutrons) on the periodic table, instruct students to pick any element on the periodic table and practice making their own atoms and isotopes.



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Activity and image from "Playdough to Plato" blog.

Activity: Element Reports

Grades
2–4

Subjects
Isotopes, mass

Skills
reading, researching, presenting, organizing

Materials
My First Science Textbook: Atoms

NGSS Practices
8: Obtaining, Evaluating, and Communicating Information

Common Core English Language Arts
CCSS.ELA-LITERACY.SL.3.4
CCSS.ELA-LITERACY.RI.3.5

Background
Once students have received an introduction to the periodic table and have a basic understanding of what an element is, they are ready to do some more in-depth exploring of specific elements on their own. In addition to being grouped from smallest to largest atomic number on the periodic table, elements tend to be grouped together into three main categories: **metals**, **semimetals**, and **nonmetals**.

Activity
1. Read *Atoms* and review the above background with students. Inform them that they will each be choosing an element from the periodic table to research and present in class (older students may be given more leeway in choosing their elements. Younger students will likely need to choose from a pre-selected group of elements that are easier to understand, such as sodium and silver).

2. Once students have chosen an element, have them research their elements at home, answering the questions on the accompanying sheet.

3. When students have completed their research, have them present on their element to the class.

Discussion
While students are presenting, ask them questions about their research process. ***Why did they choose this element? What resources did they use to conduct their research (Books? The Internet? The periodic table?) Why did they choose to include certain information and not other information? Do they think that there would be a better way of describing an element to someone besides a presentation (drawing, diagram, etc.)?***

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Name:_______________ Date:_____________

Worksheet: Element Reports

Picture that describes your element

Name: ____________________

Element: ____________________

Why I picked this element:

____

____

____

What is this element's symbol? ____________________

What category is this element in? ____________________

What are three words to describe this element?

__________ __________ __________

Where is this element used?

____

If this element can be found in everyday life, where can you find it?

____

What is something that really surprised you about this element?

____

____

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Activity: Covalent and Ionic Bonds

Grades
Pre-K–3

Subjects
Atomic bonds, divisibility, indivisibility

Skills
Critical thinking, abstract thinking, active listening

Materials
My First Science Textbook: Atoms, markers in two different colors

NGSS
2-PS1-3: Structure and Properties of Matter

Common Core English Language Arts
CCSS.ELA-LITERACY.W.2.7
CCSS-ELA-LITERACY.W.2.8

Background
At times, two or more atoms from different elements will get together and share or swap electrons. When they do this, a compound made up of the different elements will form. There are two types of bonds that create compounds: **covalent bonds**, when atoms merge and share an electron pair between them, and **ionic bonds**, when one atom gives an electron to another atom. When an ionic bond happens, the atom that gave away an electron becomes positively charged, and the atom that received an electron becomes negatively charged.

Activity
1. Show students pages 14, 15, 16, and 17 in *Atoms*, which demonstrate covalent and ionic bonds in the making. Ask students: ***What do you think is going on here? Why is it important?***

2. Divide students into pairs. One student in each pair should have two markers. Tell students that they are atoms, and the markers represent electrons.

3. Ask the students with two markers what they would do if they saw that their friend had no markers. Would they keep the markers to themselves, or let their friend share with them? Instruct the students without markers to grab onto one end of each marker so that both students in a pair are holding onto a marker. Explain that the students are now sharing markers, just as atoms in a covalent bond share electrons with each other.

4. Ask the students with the markers: ***what would happen if your friend only needed one color of marker?*** Instruct them to hand their partner one of the markers. They have now lost a marker, but their partner has gained one. Explain to students that in an ionic bond, one atom gives an electron to another atom in the same way that they just gave a marker away to their friend.

5. Return to the Teacher's Guide and go over the Discussion section.

Fun Fact
"Atom" comes from the Greek word for "**indivisible**," because it was once thought that atoms were the smallest units of matter in the universe and could not be divided. However, we now know that atoms are indeed **divisible** because they are comprised of subatomic particles and because they can share these particles with each other in the form of (covalent and ionic) bonds.

Discussion

Now that students understand that ionic and covalent bonds mean "sharing" between atoms, it is time to link the activity to the broader idea of creating compounds (for younger students, it is fine to stop after covalent and ionic bonds in order to avoid overloading them with information). Ask students whether they think some atoms can share with each other while others can't. ***If you did not have the specific marker colors that your friend wants, would you be able to share both markers with your friend or give one marker to your friend to borrow?*** In the same way, some types of atoms cannot form covalent or ionic bonds with each other.

Return to *Atoms* and show students pages 14 and 15. Ask them to say out loud what kind of atoms are pictured sharing with each other. Next, draw a couple of similar examples of atoms sharing electrons (covalent bonds) and atoms transferring electrons (ionic bonds) on the board (for example, two hydrogen atoms and one oxygen atom form a covalent bond to create water, while a sodium atom gives an electron to a chlorine atom to form sodium chloride). Remind students that these atoms are sharing electrons with each other because one of them needed electrons, just as the students shared markers with each other because one of them needed markers.

Close the activity by asking students about the "divisibility" of compounds and atoms. ***Can compounds be divided?*** (the answer is "yes"—compounds are made up of atoms.) ***What about atoms—can they be divided?*** Students should be able to see that atoms can be divided because they are able to share and swap electrons with each other in covalent and ionic bonds, meaning that atoms are dividing themselves in order to create new bonds.

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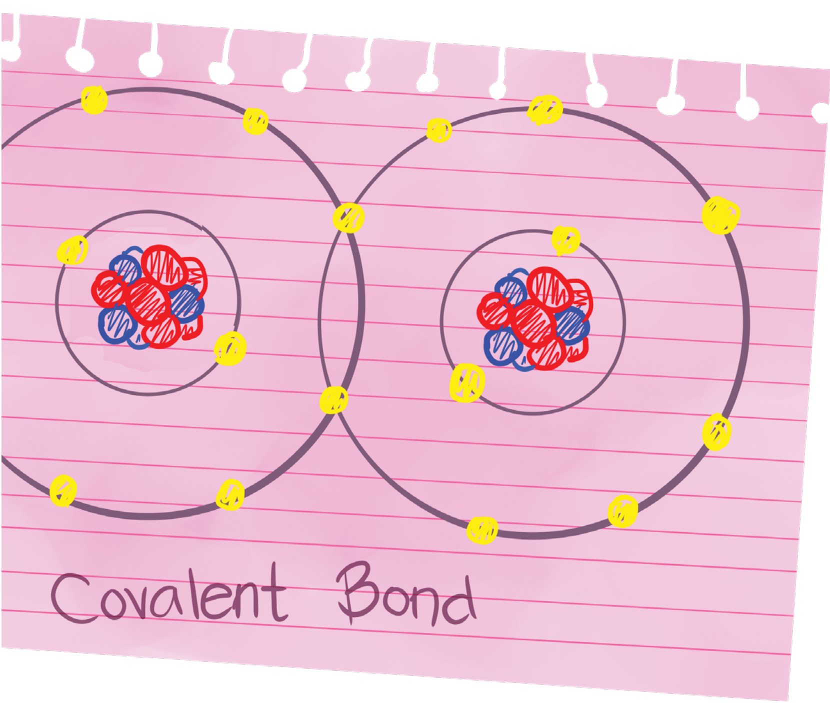
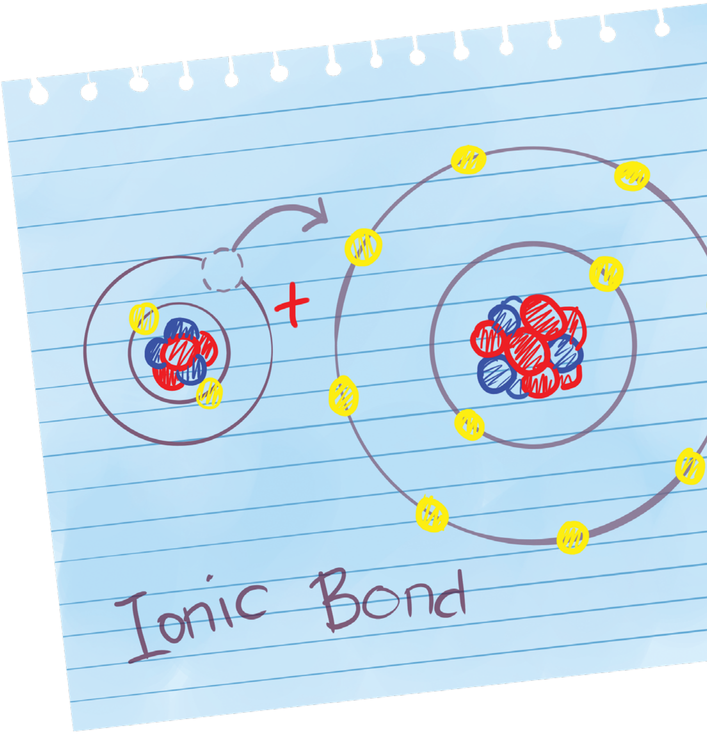
Activity adapted from study.com





Glossary

Atomic mass
The combined number of protons and neutrons in an atom. On the periodic table, it is shown as the number under each element's full name.

Atomic number
The number of protons in an atom determines an element's atomic number, which is used to categorize elements. On the periodic table, the atomic number is shown in the top left-hand corner of each element label.

Atoms
The building blocks for all matter in our universe. They are so small that you can't see them, and are made up of even smaller particles called protons, neutrons, and electrons.

Big Bang
The explanation that astronomers use to explain how the universe began. According to our understanding, all of the energy in the universe was once contained within a single point, and a massive explosion caused this energy to turn into matter that has been expanding ever since.

Carbon
An element containing atoms with six protons. It is one of the most abundant elements in the universe.

Chemical symbol
The abbreviation for the name of an element. The chemical symbol for each element is listed on the periodic table.

Compound
A group of atoms from two or more different elements that are bonded together.

Covalent bond
A chemical bond that forms between two atoms when they share electrons.

Divisible
Something that can be broken up into different parts. Atoms have been found to be divisible because they share and swap electrons.

Electric current
An electric charge in motion, caused by the electrons within an atom.

Electricity
The flow of electrical power associated with the presence and motion of electrically charged matter.

Electrons
Very teeny particles with a negative electric charge. Electrons travel around the nucleus of every atom.

Element
A pure substance made of one type of atom.

Force
The push or pull on something when it interacts with something else. A force can cause an object to move faster, slow down, stay in place, or change shape.

Gas
Air-like substances that have no set shape or volume because the molecules in them are spread very far apart and move very quickly. A gas can expand to fill a whole space.

Helium
An element containing atoms with two protons. It is an odorless and colorless gas that is lighter than air.

Hydrogen
An element containing atoms with one proton. It is the lightest element on the periodic table and the most abundant chemical substance in the universe.

Indivisible
Something that cannot be broken up or divided.

Ion
An atom or molecule that carries a positive or negative electric charge as a result of having gained or lost electrons.

Ionic bond
A chemical bond that forms when one atom gives away electrons to another atom. The atom that loses electrons becomes positively charged, and the atom that gains electrons becomes negatively charged.

Isotopes
Two or more atoms of the same element with the same number of protons but a different number of neutrons.

Liquid
A substance that flows freely and has volume but no set shape, such as water or oil. The molecules in liquids stay close together, but they can move freely.

Mass
A measure of how much matter is in an object.

Matter
Anything in the universe that takes up space and has mass.

Metals
Minerals, like iron or copper, that are found underground in rocks. About 75% of the elements in the periodic table are metals. They can be very strong, and are particularly good at conducting electricity.

Molecule
A group of atoms that are bonded together to form the smallest unit of a substance that has all the properties of that substance. For example, a water molecule is the smallest unit that is still water.

Negative ion
An atom that has gained one or more electrons and is negatively charged.

Nucleus
The center of an atom, made up of protons and neutrons.

Neutrons
Very teeny particles with no electric charge, found in the nucleus of most atoms.

Nitrogen
An element containing atoms with seven protons. Nitrogen gas makes up 78% of the Earth's atmosphere and is essential to life on Earth.

Nonmetals
Elements on the far right of the periodic table that are not solid, like chlorine or oxygen. There are 17 elements that are nonmetals, most of which are gases.

Oxygen
An element containing atoms with eight protons. Oxygen constitutes 21% of the Earth's atmosphere. Plants and animals require oxygen to breathe.

Particles
Tiny, singular bits of matter that can range in size from subatomic particles, such as electrons, to ones large enough to be seen, such as particles of dust floating in sunlight.

Periodic table
A chart that arranges chemical elements, organized by atomic number.

Positive ion
An atom that has lost one or more electrons and is positively charged.

Protons
Very teeny particles with a positive electric charge. Protons are in the nucleus of every atom.

Semimetals
Elements on the center–right of the periodic table that are a bit like metals and a bit like gases—they can change their shape easily. Examples are silicon and arsenic.

Solid
A form of matter that has a set shape and volume because the molecules in it are packed close together and do not move much. The shape of a solid only changes when a force is applied.

Static shock
When an object or person has a negative charge from extra electrons, and they touch an object that has a positive charge from too few electrons, electricity jumps between the two. You might feel a static shock when you touch something made of metal.

Subatomic Particle
A particle that is smaller than an atom and exists within it, like protons, neutrons, or electrons.

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