Unit Title: Unit 2: Atomic Structure and Bonding

## Chapter Title: Chapter 3: Unlocking the Atom

# Lesson Title: Lesson 1: The Evolution of Atomic Models and Structure

1. Big Idea:  
The understanding of atomic structure has evolved over time through the contributions of several key scientists. Each new discovery has added to our knowledge of the atom, leading to the modern quantum mechanical model.  
  
  
  
 2. Essential Questions  
- How have discoveries over time influenced our current understanding of atomic structure?  
  
  
  
 3. Phenomenon-Based Learning  
  
- **Unit Phenomenon**:   
In northern countries, during icy winters, road salt is spread to melt ice and snow. However, metal street signs and lampposts do not melt. Why does salt only affect the ice and snow? To understand this, we must explore the atomic structure of salt, water, and metal.  
  
- **Chapter Phenomenon**:   
When salt is added to ice, the ice seems to disappear. Is this a magic trick? What does the structure of salt and water have to do with this reaction? To answer this, we need to investigate the basic structure of all matter: the atom. But what exactly is an atom, and how have scientists developed our understanding of atoms over time?  
  
  
  
 4. Vocabulary  
  
- **Bohr**: A scientist who proposed that electrons orbit the nucleus in fixed paths.  
**- Dalton**: Proposed that atoms are indivisible and the smallest unit of matter.  
- **Democritus**: An ancient philosopher who first suggested that matter is made of small, indestructible particles called atoms.  
- **Electrons:** Negatively charged particles that orbit the nucleus of an atom.  
- **Nuclear Model:** A model of the atom with a dense central nucleus and electrons orbiting around it.  
- **Neutrons:** Neutral particles found in the nucleus of an atom.  
- **Plum-Pudding Model:** Thomson’s model of the atom, where electrons were scattered throughout a positively charged "pudding."  
- **Protons:** Positively charged particles found in the nucleus of an atom.  
- **Rutherford**: Discovered that atoms have a small, dense nucleus.  
- **Schrodinger:** Developed the quantum mechanical model of the atom.  
- **Thomson:** Discovered the electron and proposed the plum-pudding model.  
- **Quantum Mechanical Model:** The modern model of the atom, where electrons exist in probability clouds around the nucleus.  
  
  
 5. SMART Objectives  
  
By the end of this lesson, students will be able to:  
  
1. Name key scientists who contributed to the development of atomic theory.  
2. Trace the evolution of atomic models from early ideas to the modern quantum mechanical model.  
3. Compare and contrast the contributions of different scientists to the understanding of atomic structure.  
  
  
  
 6. Engage (Ignite)  
  
Phenomenon-Related Question:   
Is salting the road a magic trick? What makes the ice disappear when salt is added?  
  
**Hands-on Experiment**:  
  
**Materials Needed:**  
- Two small bowls  
- Ice cubes  
- Table salt  
- Timer  
- Thermometer  
  
**Procedure:**  
1. Place an equal number of ice cubes in each bowl.  
2. Sprinkle salt on one of the bowls of ice.  
3. Leave the other bowl as is.  
4. Observe the two bowls over time, recording any changes in the ice in each bowl.  
5. Measure the temperature of each bowl every 5 minutes.  
  
**Follow-up Questions:**  
1. What happened to the ice in the bowl with salt? How did it compare to the bowl without salt?  
2. How does this experiment relate to our understanding of atomic structure?  
3. Can you think of what’s happening at the atomic level when the salt interacts with the ice?  
  
  
  
 7. Pre-Explore (Direct Instruction)  
  
**Background Information:**  
  
Atoms are the basic building blocks of all matter. But what exactly is an atom? For over 2,000 years, humans have been exploring this question. Early ideas about atoms were quite simple, but as science progressed, so did our understanding. Let's explore how key scientists have contributed to our knowledge of atomic structure.  
  
- **Democritus (460-370 BCE):**   
 One of the first to suggest that everything is made of tiny, indivisible particles called "atoms." Though his idea was not based on experiments, it laid the groundwork for future scientists.  
  
- **John Dalton (1808):**   
 Proposed that atoms were solid spheres and that each element was made of a different type of atom. This was known as the "Billiard Ball Model."  
  
- **J.J. Thomson (1897):**   
 Discovered the electron and proposed the "Plum-Pudding Model," where negatively charged electrons were embedded in a positively charged "pudding."  
  
- **Ernest Rutherford (1911)**:   
 Conducted the famous Gold Foil Experiment, which showed that atoms have a dense, positively charged nucleus surrounded by electrons. This led to the Nuclear Model.  
  
- **Niels Bohr (1913):**   
 Suggested that electrons orbit the nucleus in specific energy levels, much like planets orbit the sun. This model is known as the Bohr Model.  
  
- **Erwin Schrödinger (1926)**:   
 Developed the Quantum Mechanical Model. This model suggests that electrons do not travel in fixed orbits but exist in "clouds" of probability, where they are likely to be found.  
  
  
  
 8. Evaluate (Progress Check) - Pre-Explore  
  
- Question 1: What was the main idea of Democritus's atomic theory?  
- Question 2: How did J.J. Thomson's discovery of the electron challenge Dalton's model?  
- Question 3: Why was Rutherford's Gold Foil Experiment so important?  
  
  
  
 9. Explore (Pathfinder)  
  
**Activity: Atomic Models Timeline**  
  
Students will work in groups to create a timeline of the evolution of atomic models. Each group will be assigned a key scientist and their model of the atom.   
  
**Instructions:**  
1. Research your assigned scientist and the atomic model they proposed.  
2. Create a visual representation of the model (e.g., a poster or 3D model).  
3. Present your model to the class and explain how it contributed to our understanding of atomic structure.  
  
**Data Collection**:  
- Name of the scientist  
- Date of discovery  
- Key features of the atomic model  
- How this model improved upon previous ideas  
  
  
  
 10. Explain (Lightbulb)  
  
Atoms are the tiny building blocks of matter, but understanding their structure has been a long journey. Let's break down the major steps in this journey and see how each scientist contributed to our current understanding.  
  
 **Democritus - The Idea of the Atom**  
  
Democritus, an ancient Greek philosopher, was one of the first to suggest that everything is made of tiny, indivisible particles called "atoms." While his idea was purely theoretical and lacked experimental evidence, it introduced the concept that matter is made up of fundamental units.  
  
Think of it this way: If you keep cutting a piece of paper in half, there would eventually be a point where you can’t cut it anymore. For Democritus, this smallest possible piece was the atom.  
  
 Dalton - The Solid Sphere Model  
  
Many centuries later, John Dalton advanced the atomic theory by proposing that atoms were solid spheres, like little billiard balls, and that different elements were made of different types of atoms. Dalton’s theory was based on experimental evidence from chemical reactions, which showed that elements combine in specific ratios to form compounds.  
  
Dalton’s model was simple but didn’t explain how atoms of different elements could interact or what atoms were made of.  
  
 Thomson - The Plum-Pudding Model  
  
In 1897, J.J. Thomson discovered the electron, a small particle with a negative charge. This meant that Dalton’s idea of a solid sphere was incorrect. Thomson proposed the Plum-Pudding Model, where negatively charged electrons were scattered throughout a positively charged "pudding." Imagine a chocolate chip cookie, where the chips represent the electrons, and the dough is the positive charge.  
  
While this model was a step forward, it didn’t explain where the positive charge came from or how it was distributed.  
  
 Rutherford - The Nuclear Model  
  
In 1911, Ernest Rutherford conducted the famous Gold Foil Experiment. He fired tiny positively charged particles at a thin sheet of gold foil. Most of the particles passed straight through, but some were deflected at large angles, which suggested that the positive charge in an atom was concentrated in a small, dense nucleus at the center, with electrons orbiting around it.  
  
This was a significant breakthrough because it showed that atoms were mostly empty space, with a dense nucleus at the center.  
  
 Bohr - The Planetary Model  
  
Niels Bohr built on Rutherford’s model by suggesting that electrons orbit the nucleus in specific energy levels, much like planets orbit the sun. This Bohr Model explained why electrons don’t just spiral into the nucleus and why atoms emit light in specific colors (called emission spectra).  
  
While the Bohr Model worked well for simple atoms like hydrogen, it couldn’t explain the behavior of more complex atoms.  
  
 **Schrödinger - The Quantum Mechanical Model**  
  
The current model of the atom, known as the Quantum Mechanical Model, was developed by Erwin Schrödinger and other scientists in the 1920s. Instead of electrons moving in fixed orbits, this model suggests that electrons exist in "clouds" of probability, where they are likely to be found. This model accounts for the strange behavior of electrons, which can behave both like particles and waves.  
  
  
  
 11. Evaluate (Progress Check) - Explain  
  
- Question 1: How did Rutherford’s Gold Foil Experiment change our understanding of atomic structure?  
- Question 2: What is the main difference between the Bohr Model and the Quantum Mechanical Model?  
- Question 3: Why is the discovery of the electron so important to atomic theory?  
  
  
  
 12. Elaborate (Power Up)  
  
**Mini Task**:   
Research how the discovery of neutrons by James Chadwick in 1932 further completed the atomic model. How do neutrons contribute to the stability of the nucleus?  
  
**Open-Ended Question**:   
How do you think our understanding of the atom might change in the future? What new discoveries could be made?  
  
  
  
 13. Final Evaluation  
  
**Debate Question**:   
Was the Plum-Pudding Model a necessary step in the development of atomic theory, or did it slow down scientific progress? Defend your position with evidence.  
  
**Multiple Choice Questions:**  
1. Who discovered the electron?  
 - a) Niels Bohr   
 - b) John Dalton   
 - c) J.J. Thomson   
 - d) Ernest Rutherford   
 Answer: c) J.J. Thomson  
  
2. Which scientist proposed that electrons orbit the nucleus in specific energy levels?  
 - a) Democritus   
 - b) Erwin Schrödinger   
 - c) Ernest Rutherford   
 - d) Niels Bohr   
 Answer: d) Niels Bohr  
  
3. What did Rutherford’s Gold Foil Experiment demonstrate?  
 - a) Atoms are solid spheres   
 - b) Electrons are spread throughout the atom   
 - c) The nucleus is dense and positively charged   
 - d) Electrons orbit in specific energy levels   
 Answer: c) The nucleus is dense and positively charged  
  
4. In the Quantum Mechanical Model, electrons are described as:  
 - a) Moving in fixed orbits   
 - b) Existing in clouds of probability   
 - c) Always located at a fixed distance from the nucleus   
 - d) Particles that cannot be detected   
 Answer: b) Existing in clouds of probability  
  
**Long Answer Questions:**  
1. Explain how Thomson’s discovery of the electron led to the development of the Plum-Pudding Model. What were the limitations of this model?  
2. Describe Rutherford’s Gold Foil Experiment. What were its results and how did it lead to the Nuclear Model of the atom?  
3. Compare and contrast the Bohr Model and the Quantum Mechanical Model of the atom.  
4. How did the discovery of neutrons help complete the atomic model? Why are neutrons important for atomic stability?  
  
  
  
 14. Extend (Beyond the Lesson)   
  
**Further Reading**:   
Research how quantum mechanics is being used today in modern technology, such as quantum computers. How does our understanding of electrons in the Quantum Mechanical Model help advance these technologies?  
  
**Spaced Practice**:   
Create flashcards of each key scientist and their atomic model. Review these over several days to reinforce your understanding of how our knowledge of the atom has evolved over time.  
  
  
  
This lesson plan provides a structured approach to teaching the evolution of atomic models and the contributions of key scientists. It encourages critical thinking, hands-on learning, and connections to real-world phenomena, ensuring that students grasp the foundational concepts of atomic structure.