# Unit: Unit 2: Atomic Structure and Bonding

## Chapter: Chapter 3: Unlocking the Atom

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

## Unit Title: Atomic Structure and Bonding   
## Chapter Title: Unlocking the Atom   
# Lesson Title: The Evolution of Atomic Models and Structure   
  
---  
  
### Essential Questions:  
- How have discoveries over time influenced our current understanding of atomic structure?   
  
---  
  
### 1. Big Idea:  
The atomic model has evolved over time through the contributions of many scientists, leading to our current understanding of atomic structure.  
  
---  
  
### 2. Essential Questions:  
- How have discoveries over time influenced our current understanding of atomic structure?  
  
---  
  
### 3. Phenomenon-Based Learning:  
- Phenomenon: How do we know what atoms look like, even though they are invisible to the naked eye?  
- This lesson will explore how our understanding of atomic structure has changed over time, focusing on the discoveries and models proposed by key scientists such as Democritus, Dalton, Thomson, Rutherford, Bohr, and Schrodinger. Students will investigate how these models were developed and how they shaped our current view of the atom.  
  
---  
  
### 4. Vocabulary:   
- \*\*Bohr\*\*: Proposed a model of the atom where electrons orbit the nucleus in distinct energy levels.   
- \*\*Dalton\*\*: Introduced the atomic theory, stating that atoms are indivisible and indestructible particles.   
- \*\*Democritus\*\*: An ancient Greek philosopher who first proposed the idea of the atom, calling them "atomos," meaning indivisible.   
- \*\*Electrons\*\*: Negatively charged particles found outside the nucleus of an atom.   
- \*\*Nuclear model\*\*: Rutherford's model of the atom, which introduced the concept of a dense nucleus surrounded by electrons.   
- \*\*Neutrons\*\*: Neutral particles found in the nucleus of an atom.   
- \*\*Plum-pudding model\*\*: Thomson's model of the atom, where electrons were scattered within a positively charged sphere.   
- \*\*Protons\*\*: Positively charged particles found in the nucleus of an atom.   
- \*\*Rutherford\*\*: Discovered the nucleus of the atom and proposed the nuclear model.   
- \*\*Schrodinger\*\*: Developed the quantum mechanical model of the atom, where the position of electrons is described probabilistically.   
- \*\*Thomson\*\*: Discovered the electron and proposed the plum-pudding model.   
- \*\*Quantum mechanical model\*\*: The modern model of the atom, which describes the behavior of electrons in terms of probabilities rather than definite paths.   
  
---  
  
### 5. SMART Objectives:  
1. \*\*Name key scientists\*\* who contributed to the development of atomic theory.  
2. \*\*Trace the evolution\*\* of atomic models over time from Democritus to the quantum mechanical model.  
3. \*\*Compare and contrast\*\* the contributions of different scientists to our understanding of atomic structure.  
4. \*\*Explain how each atomic model\*\* built upon or challenged previous models based on new discoveries.  
  
---  
  
### 6. Engage (Ignite):  
- \*\*Activity\*\*: "Model the Invisible"   
 - \*\*Materials\*\*: Opaque container, small objects (coins, marbles, etc.), paper, and pencil.  
 - \*\*Procedure\*\*:   
 1. Place the small objects inside the opaque container without showing the students.   
 2. Ask students to shake the container and use the sound, feel, and weight to guess what is inside.   
 3. Students will draw a "model" of what they think the inside looks like, based on the evidence they gathered.   
 4. Once models are drawn, reveal the contents of the container and compare the students' guesses to the actual objects.  
  
- \*\*Follow-up Questions\*\*:   
 1. How did you use the clues (sound, weight, etc.) to make your model?   
 2. How did your model change after seeing the contents of the container?   
 3. How is this activity similar to how scientists developed models of the atom?   
  
---  
  
### 7. Pre-Explore (Direct Instruction):  
- \*\*Background Information\*\*:   
 - Begin by discussing how atoms are too small to see, so scientists had to use indirect evidence to create models of them.   
 - Introduce the idea that atomic models have changed over time as new evidence came to light.   
 - Give a brief overview of each scientist and their atomic model, laying the foundation for the hands-on activities that will follow.  
  
- \*\*Interactive Element\*\*:   
 - Use a timeline on the board to show when each scientist made their discovery.   
 - Encourage students to ask questions or add comments as you discuss each model.   
 - Scaffolded questions such as, "Why do you think Dalton thought atoms were indivisible?" or "What might have led Rutherford to think the atom had a nucleus?" will help students connect with the content.  
  
---  
  
### 8. Evaluate (Progress Check) - Pre-Explore:  
- \*\*Scaffolded Questions\*\*:   
 1. What was Democritus’s idea about atoms?   
 2. How did Dalton build on Democritus’s idea?   
 3. What is the main difference between Thomson’s plum-pudding model and Rutherford’s nuclear model?  
  
---  
  
### 9. Explore (Pathfinder):   
- \*\*Activity\*\*: "Tracing Atomic Models"   
 - \*\*Materials\*\*: Notebooks, pencils, chart paper, markers, and atom model cut-outs (representing different models).   
 - \*\*Instructions\*\*:   
 1. Break students into small groups.   
 2. Assign each group a different atomic model (e.g., Dalton, Thomson, Rutherford, Bohr, Schrodinger).   
 3. Each group will create a poster explaining their assigned model, including how it was developed and its key features.   
 4. Groups will present their findings to the class.  
  
- \*\*Group Discussion\*\*:   
 - After the presentations, lead a discussion on how each model built upon or refuted the previous one.   
 - Ask retrieval practice questions like, "How did Rutherford’s experiment prove Thomson's model wrong?"  
  
---  
  
### 10. Explain (Lightbulb):  
This section will provide a detailed explanation of the main ideas related to the lesson and expand on the concepts introduced in the explore section. It will also break down complex concepts and provide prompts for students to connect their hands-on activity with the theory.  
  
---  
  
\*\*The Evolution of Atomic Models:\*\*  
  
Atoms are the building blocks of matter, but our understanding of what they look like and how they behave has changed significantly over the centuries. Let’s dive into how different scientists, using evidence gathered from experiments, shaped our current understanding of atomic structure.  
  
---  
  
\*\*1. Democritus and the First Idea of the Atom:\*\*  
  
Over 2,400 years ago, a Greek philosopher named Democritus proposed a radical idea. He believed that if you kept cutting a piece of matter into smaller and smaller pieces, you would eventually reach a point where it could not be divided any further. He called these indivisible particles “atomos,” meaning "uncuttable." This was the first recorded idea of the atom. However, because Democritus had no experimental evidence, his idea was largely ignored for centuries.  
  
---  
  
\*\*2. Dalton’s Atomic Theory:\*\*  
  
In the early 1800s, John Dalton, a British scientist, revisited Democritus’s idea of the atom. Dalton proposed that:  
- All matter is made of tiny, indivisible atoms.   
- Atoms of the same element are identical.   
- Atoms of different elements are different.   
- Atoms combine in fixed ratios to form compounds.  
  
Dalton’s theory was based on experimental evidence, which made it much more accepted than Democritus’s idea. Although we now know that atoms can be divided into even smaller particles (protons, neutrons, and electrons), Dalton’s work laid the foundation for modern atomic theory.  
  
---  
  
\*\*3. Thomson’s Plum-Pudding Model:\*\*  
  
In 1897, J.J. Thomson discovered the electron, a tiny particle with a negative charge. This discovery led him to propose a new model of the atom, known as the \*\*plum-pudding model\*\*. In this model, the atom was thought to be a sphere of positive charge, with negatively charged electrons scattered throughout, like plums in a pudding.  
  
This model was the first to suggest that atoms were not indivisible, as Dalton had thought. However, it was soon replaced by an even more accurate model.  
  
---  
  
\*\*4. Rutherford’s Nuclear Model:\*\*  
  
In 1911, Ernest Rutherford conducted his famous \*\*gold foil experiment\*\*, where he shot positively charged particles at a thin sheet of gold foil. Most of the particles passed through the foil, but some were deflected at large angles. This led Rutherford to conclude that the atom must have a small, dense, positively charged center, which he called the \*\*nucleus\*\*. The electrons, he proposed, orbited this central nucleus, much like planets orbit the Sun.  
  
Rutherford’s model was a major breakthrough in understanding atomic structure, but it still had some flaws. For example, it couldn’t explain why the negatively charged electrons didn’t spiral into the positively charged nucleus.  
  
---  
  
\*\*5. Bohr’s Model:\*\*  
  
In 1913, Niels Bohr improved upon Rutherford’s model. Bohr proposed that electrons orbit the nucleus in fixed energy levels, or shells. Electrons could move between these shells by absorbing or releasing energy, which explained why they didn’t fall into the nucleus.  
  
Bohr’s model worked well for simple atoms like hydrogen, but it couldn’t explain the behavior of more complex atoms.  
  
---  
  
\*\*6. Schrodinger and the Quantum Mechanical Model:\*\*  
  
The final major breakthrough came in the 1920s with the work of Erwin Schrodinger and others. Schrodinger proposed the \*\*quantum mechanical model\*\*, which is still used today. In this model, electrons don’t orbit the nucleus in fixed paths, as Bohr suggested. Instead, their positions are described probabilistically – we can only predict where an electron is likely to be at any given time, not its exact location. This model is based on complex mathematics and explains the behavior of electrons in all atoms, not just hydrogen.  
  
---  
  
### Sample Solved Problem:  
  
\*\*Problem\*\*: If an electron in a hydrogen atom jumps from the second energy level to the first energy level, what happens to the energy of the atom?   
\*\*Solution\*\*: When an electron moves from a higher energy level to a lower one (such as from the second to the first energy level), it releases energy in the form of light. This is why we see the hydrogen emission spectrum.   
  
\*\*Progress Check\*\*:   
If an electron moves from the third energy level to the first, will it release more or less energy than when moving from the second to the first? Explain your reasoning.  
  
---  
  
### 11. Evaluate (Progress Check) – Explain:  
- \*\*Scaffolded Questions\*\*:   
 1. How did Rutherford’s gold foil experiment change our understanding of atomic structure?   
 2. Why was Bohr’s model an improvement over Rutherford’s model?   
 3. What is the key difference between Bohr’s model and the quantum mechanical model?  
  
---  
  
### 12. Elaborate (Power Up):  
- \*\*Mini-Task\*\*:   
 - Research an experiment that led to a major discovery in atomic theory. Write a short explanation of the experiment and how it changed our understanding of the atom.  
- \*\*Open-Ended Question\*\*:   
 - Why do you think each scientist’s model was accepted for a time, but then replaced by a new model?  
  
---  
  
### 13. Final Evaluation:  
- \*\*Debate Question\*\*:   
 - Should we consider the current quantum mechanical model the final answer to atomic structure, or could future discoveries change it again? Defend your position with evidence.  
  
- \*\*Assessment Questions\*\*:  
 1. \*\*Multiple-choice\*\*:   
 - Which scientist proposed the plum-pudding model of the atom?   
 a) Dalton   
 b) Rutherford   
 c) Thomson   
 d) Bohr   
 \*\*Answer\*\*: c) Thomson  
  
 2. \*\*Multiple-choice\*\*:   
 - What did Rutherford’s gold foil experiment demonstrate?   
 a) Electrons are spread evenly throughout an atom.   
 b) Atoms have a dense nucleus.   
 c) Electrons orbit the nucleus in fixed paths.   
 d) Atoms are indivisible.   
 \*\*Answer\*\*: b) Atoms have a dense nucleus.  
  
 3. \*\*Multiple-choice\*\*:   
 - Which model of the atom describes electron positions as probabilities rather than fixed orbits?   
 a) Bohr model   
 b) Plum-pudding model   
 c) Nuclear model   
 d) Quantum mechanical model   
 \*\*Answer\*\*: d) Quantum mechanical model  
  
 4. \*\*Multiple-choice\*\*:   
 - Who first proposed that matter is made of indivisible particles called "atomos"?   
 a) Democritus   
 b) Dalton   
 c) Thomson   
 d) Rutherford   
 \*\*Answer\*\*: a) Democritus  
  
- \*\*Long-answer Questions\*\*:   
 1. Explain how Rutherford's gold foil experiment led to the discovery of the nucleus.   
 2. Compare and contrast the Bohr model and the quantum mechanical model of the atom.   
 3. How did the discovery of the electron by Thomson change the atomic theory proposed by Dalton?   
 4. Describe how the quantum mechanical model helps explain the behavior of electrons in all atoms, not just hydrogen.  
  
---  
  
### 14. Extend (Beyond the Lesson) [Optional]:  
- \*\*Suggested Reading\*\*:   
 - “The Quantum World” by Kenneth Ford for students interested in how quantum mechanics explains atomic behavior.  
   
- \*\*Challenge\*\*:   
 - Research an application of atomic theory in modern technology (e.g., MRI machines, semiconductors) and write a short report on how our understanding of the atom enables this technology.  
  
- \*\*Spaced Practice\*\*:   
 - Review the key features of each atomic model over the next week to reinforce understanding.  
   
---  
  
This lesson sets the stage for future lessons on atomic interactions and bonding, and how our understanding of atomic structure applies to chemical reactions and material properties.