The Alien Periodic Table

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Target Grade: 9th–12th Grade Chemistry/Physical Science

Time Required: 120 minutes (2 class periods)

Standards

NGSS HS-PS1-1: Develop and use models to explain the relationship of the structure of atoms to patterns and properties observed within the Periodic Table and describe how these models are revised with new evidence.

Lesson Objectives

Students will:

- Construct a logical organizational table (the "Alien Periodic Table") based on observable patterns in the provided properties.
- Defend their organizational choices (rows and columns) using specific property patterns, correlating them to the concepts of groups and periods.
- Correlate the "Alien Profiles" properties (ID number, eyes, shape, arms) with the real parts of the periodic table (atomic number, period, group, valence electrons).
- Explain the key difference between Dmitri Mendeleev's historical organization (based on properties and atomic mass) and the modern periodic table's structure (based on Atomic Number).

Central Focus

In this lesson, students will explore how patterns in atomic structure relate to the organization of the periodic table. By analyzing fictional "alien" elements with unique properties, students will model their own version of a periodic table and compare it to the real one. This activity encourages critical thinking, pattern recognition, and a deeper understanding of how scientific models evolve with new evidence. Students will also learn about the historical development of the periodic table and how it has changed over time.

Key terms: Atomic Number, Periodic Table, Valence Electrons, Groups, Periods, Mendeleev, Chemical Properties, Scientific Models

Background Information

Teacher Background Information

Before teaching this lesson, ensure you are familiar with the following concepts, resources, and preparation steps:

Scientific Concepts:

- Understand the structure and organization of the modern periodic table, including groups (columns), periods (rows), and valence electrons. The modern periodic table is organized based on atomic number, which represents the number of protons in an atom's nucleus. This arrangement reveals repeating patterns in chemical properties, known as periodicity. Understanding the following structural features is essential:
    - Groups (columns): Vertical columns in the periodic table are called groups. Elements in the same group share similar chemical properties because they have the same number of valence electrons (electrons in the outermost shell). For example, group 1 elements (alkali metals) all have one valence electron, making them highly reactive.
    - Periods (Rows): Horizontal rows are called periods. Each period represents a new principal energy level (electron shell). As you move across a period from left to right, atomic number increases, and properties gradually change (e.g., metals on the left, nonmetals on the right).
    - Valence Electrons: Valence electrons determine an element's chemical reactivity and bonding behavior. The number of valence electrons corresponds to the group number for main-group elements (e.g., Group 17 elements have 7 valence electrons).
    - Key Organizational Principle: The periodic table is structured so that elements with similar properties align vertically in groups, while trends such as increasing atomic number and changing metallic character occur horizontally across periods.
- Know the historical development of the periodic table:
    - Mendeleev's approach: Organized elements by atomic mass and chemical properties, leaving gaps for undiscovered elements.
    - Moseley's revision: Organized elements by atomic number, which corrected inconsistencies and became the modern standard.
    - Be prepared to explain why scientific models change with new evidence.

Activity Logic:

- The Alien Periodic Table activity mirrors the logic of the real periodic table:
    - ID Number → Atomic Number
    - Number of Eyes → Period (row)
    - Body Shape → Group (column)
    - Number of Arms → Valence Electrons
    - The most logical organization for the alien table is rows by Number of Eyes and columns by Body Shape.

Preparation Steps:

- Print and pre-cut Alien Profile Cards for each group. Laminating cards is recommended for durability.
- Prepare 18 blank rectangles for alien drawings, chart paper, and markers for group work.
- Gather everyday objects (paperclips, rubber bands, sticky notes, coins) for the hook activity.
- Ensure access to the video *The Genius of Mendeleev's Periodic Table* If unavailable, have an alternative resource ready (Crash Course Chemistry, Khan Academy, or similar).
- Print student handouts, reflection worksheets, and blank periodic table templates.

Technology Contingency:

- If video streaming is not possible, summarize key points verbally or provide a printed transcript.

Potential Areas of Confusion:

- Students may confuse atomic mass with atomic number. Emphasize that the modern table is organized by atomic number (protons), not mass. Clarify that alien properties are analogies for real periodic table features.

Student Background Information

Before beginning this lesson, students should have the following foundational knowledge and skills:

Basic Understanding of Atoms and Elements: Students should know that matter is made up of atoms and that elements are pure substances composed of one type of atom.

Familiarity with the Periodic Table Concepts: Students should recognize that the periodic table organizes elements based on patterns in their properties. They do not need to know all details yet, but they should understand that elements are arranged in rows and columns for a reason.

Observable Properties and Categorization Skills: Students should be comfortable identifying and grouping objects based on shared characteristics (e.g., size, color, shape). This skill will help them organize the alien cards during the activity.

Basic Vocabulary: Students should know or be introduced to these terms:

- Property: A characteristic used to describe or classify something.
- Pattern: A repeated or predictable arrangement.
- Group: A column in the periodic table where elements share similar properties.
- Period: A row in the periodic table that shows a progression of properties.
- Valence Electrons: Electrons in the outermost shell that influence chemical behavior.

Collaboration Skills: Students should be prepared to work in small groups, share ideas, and explain their reasoning during discussions and presentations.

Materials

- Everyday Objects for Hook Activity:
  - ~50 paperclips
  - ~25 rubber bands
  - ~50 sticky notes
  - ~50 coins (enough for 5 groups of 4 students)
- Alien Profile Cards: One complete set of 18 cards per group (printed and pre-cut; laminating recommended for durability)
- Blank Rectangles for Alien Drawings: 18 per group
- Chart Paper and Markers: One large sheet per group for organizing aliens into a table
- Student Handouts: Includes reflection questions, activity instructions, and video notes
- Blank Periodic Table Template: Printable version for labeling groups, periods, and classifications
- Video: *The Genius of Mendeleev's Periodic Table* https://ed.ted.com/lessons/the-genius-of-mendeleev-s-periodic-table-lou-serico *(Alternative: Crash Course Chemistry or Khan Academy videos on the periodic table)*
- Interactive Periodic Table (Optional): https://ptable.com/?lang=en#Properties

Instruction

Before class, gather about 50 paperclips, 25 rubber bands, 50 sticky notes, and 50 coins (enough for 5 groups of 4 students).

Introduction (10 minutes) Activity 1: Organizing the World

- Divide students into small groups, distribute the student handout, and give each group a mix of paperclips, rubber bands, sticky notes, and coins.
- Have groups sort the objects into categories based on properties like size, color, material, or use. They should record their categories in the table on the handout and answer the reflection questions.

Activity 1: Organizing the World

Instructions: Work with your group to sort out the random objects provided.

Object	Category 1:	Category 2:	Category 3:
Paperclips			
Rubber Bands			
Sticky Notes			
Coins			

Reflection:

1. Why is it helpful to organize a collection of items?

2. What criteria (properties) did your group use to create the categories above?

- After sorting, discuss as a class the reflection questions:

  - What categories did you use?
  - Why is it helpful to organize a collection of items?
  - What properties did you use?
- Explain that scientists organize elements in the periodic table using similar strategies. Today, students will look for patterns just like Mendeleev did.

Activity 2: The Alien Periodic Table (75 minutes)

- Divide the class into small groups of 3–4 students and give each group a set of pre-cut Alien Profile cards.
- Following along with their handout, students review the properties on each card (e.g., ID Number, Number of Eyes, Body Shape, Number of Arms).

- Instruct groups to draw all 18 aliens based on the properties listed on the cards. Each drawing should go on a small rectangle piece of paper.
- On a large sheet of chart paper, students arrange their 18 aliens into a grid (table). They must decide which property will organize the rows and which will organize the columns.

- Encourage groups to use only the alien properties to determine their arrangement and look for patterns as they work.
- Circulate between groups to observe and guide with questions like:
  - “What patterns are you noticing?”
  - “How are you deciding what goes in each row or column?”

- Once tables are complete, have each group answer the reflection questions on their worksheet before presenting their alien periodic table to the class.
    - What property did you use to organize the rows of your table?
    - What do the aliens in each row have in common?
    - What property did you use to organize the columns of your table?
    - What do the aliens in each column have in common?
    - Did your organizational system help you predict the properties of any missing or unseen alien? Explain how.
- After completing the reflection, have each group present their alien periodic table to the class.
    - During presentations, prompt students to explain their organizational choices and describe how their system helped them identify patterns or predict missing information.
    - Use the presentation rubric to assess clarity, logic, and connection to periodic table concepts.

Connecting to the Periodic Table (25 minutes)

- Bring all groups back together and explain the true relationships between the alien properties and the periodic table. Students will fill in their worksheet as you provide the answers:
    - ID Number → Atomic Number
    - Number of Eyes → Period
    - Body Shape → Group
    - Number of Arms → Valence Electrons

Core Content: History & Structure

Instructions: As your teacher reveals the "key" to the alien table, fill in the blanks to connect the alien properties to the real parts of the periodic table. Choose your answer from the box.

Group (or **Family**)	**Atomic Number**
Period	**Valence Electrons**

Alien Property	Corresponds to (Periodic Table Feature)	Definition/Function
Body Shape		The vertical columns; elements in the same column have similar chemical properties and the same number of valence electrons.
Number of Eyes		The horizontal rows; represents the number of electron shells (or energy levels).
Number of Arms		The electrons in the outermost shell that participate in chemical bonding.
ID Number		The number of protons in the nucleus of an atom; determines the element's identity and is the basis for the modern periodic table.

- Show the video The Genius of Mendeleev's Periodic Table. During the video, students should complete the notes on their handout.
    - Mendeleev's brilliance was in recognizing patterns among elements and using those patterns to predict properties of undiscovered ones, like gallium. His approach shows

how organizing information logically can reveal relationships and even allow scientists to make accurate predictions.

Watch the video and take brief notes: The Genius of Mendeleev's Periodic Table **Dmitri Mendeleev's Key Idea:** 1. What did Mendeleev successfully do with his table? 2. What key element property was missing from Mendeleev's organization that led to the modern table?

- After the video, lead a discussion on:
    - How Mendeleev organized elements by chemical properties and atomic mass.
        - Mendeleev arranged elements in a table so that those with similar chemical properties were grouped together, and he ordered them by increasing atomic mass. This organization revealed patterns that allowed him to predict the existence and properties of elements that had not yet been discovered.
    - How Moseley revised the model by organizing elements by atomic number.
        - Later, Moseley discovered that the true organizing principle was atomic number (the number of protons), not atomic mass. His revision corrected inconsistencies in Mendeleev's table and became the basis for the modern periodic table.
    - Why scientific models change with new evidence.
        - Scientific models change because they are based on the best available evidence at the time. As new discoveries and data emerge, like Moseley's work on atomic number, models are updated to better explain and predict natural phenomena.
- Distribute a blank periodic table handout to each student.
    - Example: https://0.tqn.com/z/g/chemistry/library/BlankPeriodicTable.pdf
- Define and label groups, periods, and major element classifications (metals, nonmetals, metalloids) on the handout.
- Check for understanding by asking students to identify examples of groups and periods on their handout.

Closure (10 minutes)

- Instruct students to answer the reflection question on their handout:
    - Explain one key difference between how Mendeleev organized his periodic table and how the modern periodic table is organized. Which alien property corresponds to the modern organizing principle?
- Collect the handout to assess student understanding.

Differentiation

Materials:

- Provide laminated Alien Profile Cards for durability and ease of handling.
- Pre-cut cards for groups that may struggle with fine motor skills or time management.

Sorting Task:

- Pre-label one axis on the chart paper (e.g., rows labeled by Number of Eyes → Period) to give students a starting point. Allow them to discover the remaining axis (columns) independently.
- For students with low literacy or English Language Learners (ELLs):
    - Use heterogeneous grouping so they can receive peer support.
    - Permit visual matching of properties (e.g., pointing to body shape images) instead of relying solely on text descriptions during presentations.

Advanced Learner Challenge: The Missing Alien

- After completing and presenting their alien periodic table, inform the group that two aliens are missing: Alien ID 19 and Alien ID 20.
- Instruct students to use their completed organizational table (based on Body Shape and Number of Eyes) to predict and draw the properties of the missing aliens.
- Students must provide a written prediction and justification for the following properties:
    - Body Shape (Group)
    - Number of Eyes (Period)
    - Number of Arms (Valence Electrons)
    - Color/Size (Non-correlated property)
- Challenge students to briefly explain their reasoning to the class or teacher, explicitly stating how the patterns in their table allowed them to predict the properties of unseen organisms.

Assessment

Formative Assessment

- Activity 1 Reflection Questions (Introduction): Review student responses on the handout after the object-sorting activity. Check for understanding of why organizing by properties is useful and how categories were chosen.
- Teacher Observation During Group Work: Circulate during the Alien Periodic Table activity to listen for reasoning and pattern recognition. Use guiding questions to assess whether students are identifying relationships among properties.
- Video Notes and Discussion: Monitor student notes during *The Genius of Mendeleev's Periodic Table* video and participation in the discussion. Look for accurate identification of Mendeleev's and Moseley's organizing principles.

- Exit Ticket (Closure): Collect student responses to the question:
  "Explain one key difference between how Mendeleev organized his periodic table and how the modern periodic table is organized. Which alien property corresponds to the modern organizing principle?"
    - Expected answer:
        - Mendeleev organized by atomic mass and chemical properties; modern table is organized by atomic number.
        - Alien property corresponding to atomic number: ID Number.

Summative Assessment

- Group Presentation Rubric (Alien Periodic Table): Use the following rubric to evaluate each group's presentation:

Score	Criteria
4 – Exemplary	Table is logically organized (preferably by Eyes/Shape). Justification for rows and columns is clear, compelling, and well-defended using specific properties.
3 – Proficient	Table has clear organization (even if not by Eyes/Shape). Justification is clear and uses property names.
2 – Developing	Table shows an attempt at organization but is inconsistent or unclear. Justification is weak and lacks specific reference to properties.
1 – Needs Support	Aliens are placed randomly or no coherent organizational principle can be identified or defended.

- **Student Handout Completion:** Review completed handouts for accuracy in mapping alien properties to periodic table features and labeling Groups, Periods, and major classifications.
- **Advanced Learner Challenge (Optional Extension):** Evaluate predictions for Alien ID 19 and 20 based on:
    - Correct identification of patterns
    - Logical justification for predicted properties
    - Clarity of explanation during brief presentation

Name:

Activity 1: Organizing the World

Instructions: Work with your group to sort out the random objects provided.

Object	Category 1:	Category 2:	Category 3:
Paperclips			
Rubber Bands			
Sticky Notes			
Coins			

Reflection:

1. Why is it helpful to organize a collection of items?

2. What criteria (properties) did your group use to create the categories above?

Activity 2: The Alien Periodic Table

Goal: Your group will act as scientists discovering a new civilization. You have been given "Alien Profile" cards containing different properties. Your task is to draw and organize all 18 aliens into a logical, useful table based only on the information provided on the cards.

Instructions:

1. Draw the 18 Aliens based on their property describe on the Alien Card.
2. On the large sheet of chart paper, arrange the 18 Aliens you draw into a grid (a table).
3. Decide which alien property will be the main organizing principle for your rows and which will be the main organizing principle for your columns.
4. Once the table is done, answer the questions below.

Questions:

1. Row Label & Property:

    a. What property did you use to organize the rows of your table?
    b. What do the aliens in each row have in common?

2. Column Label & Property:

    a. What property did you use to organize the columns of your table?
    b. What do the aliens in each column have in common?

3. Predictive Power: Did your organizational system help you predict the properties of any missing or unseen alien? Explain how.

Core Content: History & Structure

Instructions: As your teacher reveals the "key" to the alien table, fill in the blanks to connect the alien properties to the real parts of the periodic table. Choose your answer from the box.

Group (or **Family**)	**Atomic Number**
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Watch the video and take brief notes: The Genius of Mendeleev's Periodic Table

Dmitri Mendeleev's Key Idea:

1. What did Mendeleev successfully do with his table?

2. What key element property was missing from Mendeleev's organization that led to the modern table?

Closure/Assessment: Exit Ticket

Explain one key difference between how Dmitri Mendeleev organized his periodic table and how the modern periodic table is organized. Which alien property corresponds to the modern organizing principle?

Alien Profile Cards

Tombstone High School

Alien ID : 1

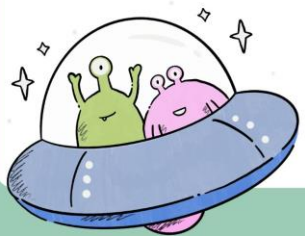
Body Shape: Sphere

Number of Eyes: 1

Number of Arms: 1

Size: Small

Color: Red



Tombstone High School

Alien ID : 2

Body Shape: Fortified Circle

Number of Eyes: 1

Number of Arms: 8 (Full Ring)

Size: Tiny

Color: Colorless

Tombstone High School

Alien ID : 3

Body Shape: Sphere

Number of Eyes: 2

Number of Arms: 1

Size: Medium

Color: Orange

Tombstone High School

Alien ID : 4

Body Shape: Cube

Number of Eyes: 2

Number of Arms: 2

Size: Small

Color: Yellow

Tombstone High School

Alien ID : 5

Body Shape: Triangle

Number of Eyes: 2

Number of Arms: 3

Size: Small

Color: Light Green

Tombstone High School

Alien ID : 6

Body Shape: Diamond

Number of Eyes: 2

Number of Arms: 4

Size: Tiny

Color: Green

Tombstone High School

Alien ID : 7

Body Shape: Pentagon

Number of Eyes: 2

Number of Arms: 5

Size: Tiny

Color: Teal

Tombstone High School

Alien ID : 8

Body Shape: Hexagon

Number of Eyes: 2

Number of Arms: 6

Size: Tiny

Color: Blue

Tombstone High School

Alien ID : 9

Body Shape: Star

Number of Eyes: 2

Number of Arms: 7

Size: Tiny

Color: Indigo

Tombstone High School

Alien ID : 10

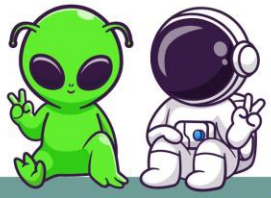
Body Shape: Fortified Circle

Number of Eyes: 2

Number of Arms: 8 (Full Ring)

Size: Tiny

Color: Colorless



Tombstone High School

Alien ID : 11

Body Shape: Sphere

Number of Eyes: 3

Number of Arms: 1

Size: Large

Color: Orange

Tombstone High School

Alien ID : 12

Body Shape: Cube

Number of Eyes: 3

Number of Arms: 2

Size: Medium

Color: Yellow

Tombstone High School

Alien ID : 13

Body Shape: Triangle

Number of Eyes: 3

Number of Arms: 3

Size: Medium

Color: Light Green

Tombstone High School

Alien ID : 14

Body Shape: Diamond

Number of Eyes: 3

Number of Arms: 4

Size: Small

Color: Green

Tombstone High School

Alien ID : 15

Body Shape: Pentagon

Number of Eyes: 3

Number of Arms: 5

Size: Small

Color: Teal

Tombstone High School

Alien ID : 16

Body Shape: Hexagon

Number of Eyes: 3

Number of Arms: 6

Size: Small

Color: Blue

Tombstone High School

Alien ID : 17

Body Shape: Star

Number of Eyes: 3

Number of Arms: 7

Size: Small

Color: Indigo

Tombstone High School

Alien ID : 18

Body Shape: Fortified Circle

Number of Eyes: 3

Number of Arms: 8 (Full Ring)

Size: Tiny

Color: Colorless

Periodic Table of the Elements