Lesson overview: This lesson is an introduction to the history of elements and the periodic table. The students investigate the evolution of the periodic table and the people who made discoveries leading up to it including John Dalton, Antoine Lavoisier, Johann Döbereiner, and Jacob Berzelius as well as the creator of the table itself; Dimitri Mendeleev. Students also create original periodic table’s in groups. Students will present their findings to their peers.

Performance objectives (Kiah) - students will be able to:

1. Organize a periodic table of elements
2. Explain method of organization
3. Compare periodic tables among different groups
4. Distinguish between different scientists credited to the creation of the periodic table including Dimitri Mendeleev, John Dalton, Antoine Lavoisier, Johann Döbereiner, and Jacob Berzelius.

Standards Addressed: (Kiah)

STANDARD 1: SCIENCE AS INQUIRY
Grades 8-12

SCIENCE AS INQUIRY – The student will develop the abilities necessary to do scientific inquiry and develop an understanding of scientific inquiry.
Benchmark 1: The student will demonstrate the abilities necessary to do scientific inquiry.

The student...

1. actively engages in asking and evaluating research questions.
2. actively engages in investigations, including developing questions, gathering and analyzing data, and designing and conducting research.
3. actively engages in using technological tools and mathematics in their own scientific investigations.
4. actively engages in conducting an inquiry, formulating and revising his or her scientific explanations and models (physical, conceptual, or mathematical) using logic and evidence, and recognizing that potential alternative explanations and models should be considered.
5. actively engages in communicating and defending the design, results, and conclusion of his/her investigation.

STANDARD 2A: CHEMISTRY

Grades 8-12

CHEMISTRY – The student will develop an understanding of the structure of atoms, compounds, chemical reactions, and the interactions of energy and matter.

Benchmark 2: The students will understand the states and properties of matter.

2. understands the periodic table lists elements according to increasing atomic number. This table organizes physical and chemical trends by groups, periods, and sub-categories.

STANDARD 7: HISTORY AND NATURE OF SCIENCE

Grades 8-12

HISTORY AND NATURE OF SCIENCE – The student will develop understanding of science as a human endeavor, the nature of scientific knowledge, and historical perspectives.

Benchmark 2: The student will develop an understanding of the nature of scientific knowledge.

2. understands scientific knowledge begins with empirical observations, which are the data (also called facts or evidence) upon which further scientific knowledge is built.

Benchmark 3: The student will understand science from historical perspectives.

Lesson Bibliography:

Britannica, Encyclopedia. Johann Dobereiner.
http://www.britannica.com/EBchecked/topic/167249/Johann-Wolfgang-Dobereiner


Materials:
60 cards with different “elements”—20 elements per group
5 laptops—1 per group
Poster board
Glue
Markers, crayons, colored pencils etc.

Safety considerations: All classroom rules shall be followed. There should be enough room for students to work comfortably.
<table>
<thead>
<tr>
<th>What the teacher will do</th>
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<th>Specific possible student responses</th>
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<tbody>
<tr>
<td>The teacher will bring in or show pictures of three very common elements: gold, silver, and copper.</td>
<td>Today we are going to discuss the history of the periodic table, but before we do that, I want to first talk about these three items that I have here with me.</td>
<td>What are the items that I have here? Are you familiar with these items? If so, how? Other than being found in jewelry and coins, do you know where all of these things can be found? What is an element? Who can tell me something they know about the periodic table or the discovery of the elements?</td>
<td>Gold, silver, and copper Yes, gold and silver are in jewelry; copper is in pennies Periodic Table of Elements. No.</td>
</tr>
<tr>
<td>The teacher shows the periodic table of elements and highlights where copper, silver, and gold are.</td>
<td>They are found on the Periodic Table of elements, which means that they all elements.</td>
<td></td>
<td>An element is the purest substance. It is a list of all the elements that are known. It is made up of rows and columns.</td>
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Today, we will discuss some of the questions and how the periodic table came into being. We will also begin to understand the order of the periodic table.

### Exploration

**Time: 20 minutes**

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<tr>
<td>The class will need to be divided into groups. In order to do this efficiently, the teacher should come to class knowing how they are going to split the groups up. For this lesson plan, we are saying there are 20 students in the class. The instructor will divide the class into eight groups. Four of the groups (organizers) will</td>
<td>We want to know a little more about the history of the elements so today you will be working in groups to discover important concepts about the history. Half of you will be working on discovering how to create a periodic table of &quot;elements&quot; and the other half will be researching the history of the periodic table and its elements.</td>
<td>Questions for periodic table groups; What are the characteristics of your elements? How will you group them? Why? How are your elements related? How did Mendeleev organize his elements?</td>
<td>They have atomic weight, density, and color. We will group them in atomic weight, or density, or charge etc. He organized them by increasing atomic weight and by similar reactivity and</td>
</tr>
</tbody>
</table>
consist of 3 people per group. The other four groups (researchers) will consist of 2 people.

Put a list of groups on the projector to make the transition into groups smooth. Also, the projector will tell them where they need to go in the classroom. Then hand out an instruction sheet to each group and give them 1 minute to look over it before they begin. The division scheme can be seen in an attached page.

The teacher proceeds to show the overhead that allows the students to see which scientist they are researching. The teacher should proceed to hand out the reading excerpt about Dmitri Mendeleev from The Dissappearing Spoon (pg 50-52).

After 20 minutes, we will get back together as a class and you will present to the class what you found or learned.

I will post your groups on the board and the person whose name is first in your group will come up and get your instruction sheet. Once you get your instruction sheet, take one minute to read it and think of any questions you have about it.

Questions for research groups:

Who organized the first periodic table?

How did they go about this?

Why is the periodic table organized the way it is?

What were some of the first elements discovered?

Who discovered certain elements and how?

Those of you doing research, you will be provided with an article about your scientist. After reading this, if time permits, you may use computers or any other resource you may find useful. The person that you are researching is written on the overhead so you may come up and get your articles.

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| properties. |
The teacher distributes the worksheet.

The students should then begin working. The teacher shall walk around the room monitoring the students’ work and make sure they are aware of their time.

The groups of students that are organizing the elements should read a short article on Dmitri Mendeleev. After doing this, you can arrange the elements that you have in any way you like.

Make sure that you work through the worksheet. This will provide you with a good basis for what to discuss in your presentations.

Ask the students if they have questions.

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<tr>
<td>The teacher will have the students present their project to each</td>
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</table>
other in small groups. This will take the form of mini presentations.

Therefore, one of the organizing groups will present to one of the researching groups (see Explanation Organization Scheme in the attached pages).

Researchers and scientists! The time has come to join your colleagues in a discussion on the periodic table and the history of the elements. The group that designed the periodic table will actually get to meet a scientist that contributed much to your ability to create such a table. They will tell you many things about themselves, especially what exactly they contributed to the progression of the elements that we know today. The researchers will actually get to see how the elements that we know today can be organized. The worksheets that were provided for you should do a great job of providing you with a list of things to presents to the other group.

Specific questions for the researchers to think about:
1) Did the periodic table group incorporate any information that was contributed by the scientist I researched?
2) Do you think that they could have used the scientists help?

Specific questions for the periodic table group:
1) What was the basis for the other groups organization of the elements?
2) Do you think that their historian could have made improvements to your periodic table?

<table>
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<th>Elaboration (Dana)</th>
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<td>Time: 8–10 minutes</td>
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<tr>
<td>The teacher will then build off what they have been discussing and move through a powerpoint presentation.</td>
<td>As you all have probably figured out by now, there are many contributors to how the periodic table of elements came into being.</td>
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<td></td>
<td>Antoine Lavoisier was really the first person to come up with an extensive list of elements. His list consisted of 33 elements and was organized in one dimensional space,</td>
<td></td>
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</tbody>
</table>
John Dalton, in the early 1800’s, believed that all elements were made up of atoms and had a particular atomic weight associated with them. He created a system to determine atomic weights, using the assumption that the atomic weight of hydrogen was 1. About 50 years later Jacob Berzelius built on Dalton’s work by compiling a list of relative atomic weights. In this, Berzelius increased the number of atomic weights (because more elements were discovered) and made those weights more accurate.

Do you think that this would be a good way to organize the elements?

No, because it does not organize them in any particular way. It is difficult to navigate through.

What importance could atomic mass play in

It could provide a quantifiable way to organize them.
The work of Johann Döbereiner was also instrumental in the way that people organized the elements. He discovered that certain elements could be grouped into categories of three. For instance, lithium, sodium, and potassium could be grouped into what he called a triad because they all reacted violently with water.

Through all of this work that had been done before him, the Russian chemist Dmitri Mendeleev was able to design his periodic table. He was influenced by all the people that we have discussed because he organized the elements by increasing atomic weights and based on their physical/chemical properties.

Mendeleev left gaps because he was predicting the existence of new elements that
The teacher shows the slide of Mendeleev’s revised table.

Mendeleev’s table was not without scrutiny, however. Many people did not like it because it did not follow any practical reasons why the elements should be arranged like this. However, the advent of the Bohr model and quantum theory in the early 1900’s provided an answer to this question. Mendeleev’s table could be explained in terms of electrons in the outermost shell.

<table>
<thead>
<tr>
<th>had not yet been discovered. He predicted accurately several elements, including gallium and germanium. He not only predicted their existence, but also their density and atomic mass! His table changed a little over the course of the next 30 years because more elements were being discovered. This table does include the noble gases and the columns and rows are switched.</th>
<th>first periodic table?</th>
<th>gaps. There are no noble gases.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very efficient because it organizes them in logical sense.</td>
<td>How efficient do you think his table is?</td>
<td></td>
</tr>
</tbody>
</table>
Move to powerpoint slide about evolutionary factors contributing to our current periodic table.

This explained why certain elements in a column react in similar ways. Also, Mendeleev received considerable criticism from 20th century chemist Henry Mosley, who argued that the table should be organized by nuclear charge instead of atomic mass. Therefore, he altered Mendeleev’s table by basing it on increasing atomic numbers, like we see in our own periodic table today. The other major contribution to the modern day periodic table is the discovery of new elements. These elements have seemed to fit into the table quite perfectly.

Despite all of these things, there is even scrutiny about Mendeleev’s table as we see it today. For example, the retired chemist Fernando Dufour argues that we should use a three dimensional periodic table because it takes into account the natural symmetry that the elements tend to offer.
The teacher moves to the slide with the 3-D periodic table on it.

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Can you think of any reason why Mendeleev’s table should not be used in today’s society?

Would you think a three dimensional version of the periodic table would be good?

It does not pay attention to physical states of the elements. It can be confusing. No.

Yes, it would be more fun to look at.

No, it would be more difficult to understand.

Evaluation
Time: 3–5 minutes
The teacher will hand out the form to be filled out by the student. The student will then complete the form. This will effectively measure what the students learned from the lesson.

Instructions

Periodic Arrangements:

You will be playing the role of creators of a periodic table. You will first read an article on Dmitri Mendeleev. The year is 1868 and there are only 15 elements that have been discovered. You will be given a set of these 15 made up elements. Your group is to arrange these elements in a way that makes sense to you. The properties of each element are listed on the cards and may be useful to you.

Remember: Be creative!

Each member of your group will explain your table and your reasoning for arrangement to a scientist of the time. (Your peers).

You have 20 minutes to complete your table so plan accordingly.
Researchers:

You will research a person who made great contributions to the study of elements either by discovering properties of elements, elements themselves, or arranging elements. You will be provided with an article about your scientist in which you are to read. You want to make sure you answer the questions: Who? What? Where? When? Why? The most important thing that you need to address is what these scientists main contribution to chemistry was. Try to understand what his theory was and why it is applicable.

You will be presenting your findings to the periodic table groups. You will be presenting as if you are the scientist themselves. Each of you will present so make sure you both know your person!

The following articles will be provided to the students for research:


Johann Dobereiner: http://www.britannica.com/EBchecked/topic/167249/Johann-Wolfgang-Dobereiner

Post lesson evaluation
Instructions: Put your name and whether you were in a periodic table group or a research group at the top of this page. Answer both questions below.

1) Name and describe one scientist that contributed to the periodic table that we know today. What did that person do to further the development of the elements and the periodic table?

2) Briefly describe one periodic table you observed. List 3 things you found interesting and how the table was organized.

ORGANIZATION SCHEME

There will be 4 groups of 3 Organizers and 4 groups of 2 Researchers. The overhead that will show students what groups they are in is seen below.

ORGANIZER 1 -- STUDENT 1, STUDENT 2, STUDENT 3
ORGANIZER 2 – 3 students
ORGANIZER 3 – 3 students
ORGANIZER 4 – 3 students
RESEARCHER 1 – 2 students
RESEARCHER 2 – 2 students
RESEARCHER 3 – 2 students
RESEARCHER 4 – 2 students

RESEARCHER 1 – JOHN DALTON
RESEARCHER 2 – ANTOINE LAVOISIER
RESEARCHER 3 – JOHANN DOBEREINER
RESEARCHER 4 – JACOB BERZELIUS

Explanation Organization scheme
ORGANIZER 1 presents to RESEARCHER 1
ORGANIZER 2 presents to RESEARCHER 2
ORGANIZER 3 presents to RESEARCHER 3
ORGANIZER 4 presents to RESEARCHER 4