The atomic dating game

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*****Note: Figures may be missing from this format of the document**

Atoms are lonely hearts that are constantly in search of partners to bring stability to their lives—at Least that's the premise of our Atomic Dating Game, a chemistry activity that helps students visualize and understand how and why atoms combine.

With the exception of the Noble Gases, atoms are unstable on their own. They must combine with atoms of other elements to become stable. When an atom of one element enters into chemical combination with another element, both atoms usually attain a stable outer shell consisting of eight electrons. As a science teacher, 1 realize that this concept is critical to a student's understanding of chemistry. We can see chemicals bubble, change colors, or give off smoke, but unless we examine what is happening on the atomic level, we are presenting chemistry as a magical experience rather than a scientific reality. The Atomic Dating Game was created to help students visualize atoms combining, and to increase student understanding of how, and why, combinations occur.

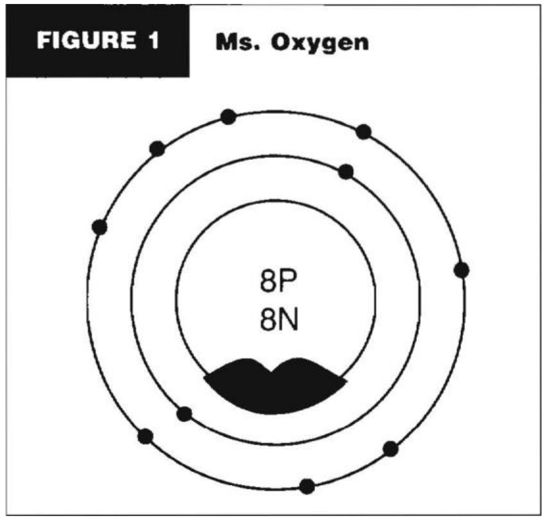
Prior to the activity, students must have already learned how to draw electron shells. I always remind my students that we are not drawing atoms, but rather we are drawing models of atoms that are realistic in some ways and unrealistic in others. The Atomic Dating Game, among other things, provides students with opportunities to practice drawing atomic models. If the game is successful, students will discover logical pairings of whole families on the periodic table.

When students finish playing, they understand the logic inherent in the shape of the periodic table. The first period (row) contains two elements to match the two electrons on the first shell; the second period contains eight elements (to match the eight electrons on the second shell), and so on. Atoms in the same family (column) on the table have the same number of valence, or outer shell, electrons. For example, in family two, Beryllium (Be) has two valence electrons; Magnesium (Mg) has two valence electrons; Calcium (Ca) has two valence electrons; and Strontium (Sr) has two valence electrons. Valence refers to the combining capacity of an element. In the formation of a chemical compound, valence electrons are either transferred from the outer shell of one atom to the outer shell of another atom (ionic bonds) or shared among the outer shells of the combining atoms (covalent bonds). The Atomic Dating Game focuses only on ionic compounds.

Let the game begin

The game requires very few materials: an overhead projector, paper or notebooks, and periodic tables for each of the students. I begin by choosing a "lonely bachelorette," or any unstable element on the periodic table—Ms. Oxygen, for example. I ask the students to help me draw the oxygen atom. How many protons does she have? How many electrons are on her first shell? How many electrons are on her next shell? While I draw and label Ms. Oxygen (0), they draw and label her in their notebooks (See Figure 1). I then ask, "Is she stable?" They tell me, no, and I ask why not. Once they've explained that she needs two more electrons to complete her outer shell, we set about the task of finding her a suitable mate.

Following the format of the TV game show, The Dating Game, I give my students three "eligible bachelors" to choose from: Mr. Carbon (C), Mr. Sodium (Na), and Mr. Magnesium (Mg), fol.- example. With their help, I draw and label all three bachelor atoms on the projector and they draw them in their notebooks. Then, one by one, we eliminate the bachelors. I'll ask, "How many outer shell electrons does Mr. Carbon have?...Four? Nope, not a match..."



Together, we discover that Mr. Magnesium has two electrons to offer, and since Ms. Oxygen needs two electrons, we've made a match! We draw our new compound with a big heart around it, choose a destination for the pair (like Cancun or the Bahamas), and then send them off with a big Dating Game Kiss! Now we're ready for our next round, this time with a bachelor and three bachelorettes.

As the game goes on, the students become skilled at picking eligible bachelors or bachelorettes because they discover the patterns on the periodic table. Until they have all caught on, however, I continue to suggest a few unlikely elements; for example, Ms. Neon (Ne). Once we draw her, we realize she is stable and doesn't require a match, and so we kick her out of the game.

The big discovery

For the final round, 1 pick a bachelor for them and then we draw him together. The students are given several minutes to work in cooperative pairs using their periodic tables to find a good bachelorette atom for him. When they are done, I call on each group to tell the class which bachelorette they chose. While double-checking each one, we discover that there are several possible atoms that successfully pair with the bachelor, all of which fall in the same group, or family, on the periodic table. When we look inure closely at the table, we discover that any element in the "bachelorette" family could form a stable compound with any of the elements in the "bachelor" family.

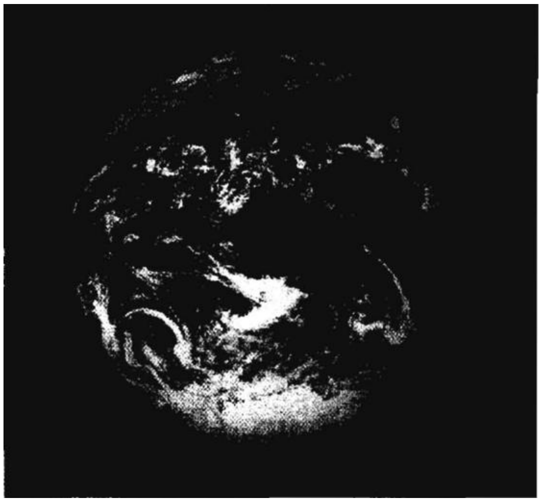
Following up

The next day, I find it is important to explain to students that The Atomic Dating Game only works far one-to-one pairings because it is a game show that creates one-to-one pairs. However, if I ask students to give me examples of molecules that are not one-to-one pairs such as water (H2O) or carbon dioxide (CO)), we discover that there are several possible combinations of atoms that can form stable compounds.

Wrapping it up

This game is enjoyed more than almost any other activity that 1 do during the year. First of all, it is great fun, both for the students and for me. The more drama I add to hosting the game show— such as making side comments about the atoms or by portraying Ms. Neon as a modem woman who doesn't need a man to fill her outer shell—the more fun we all have. It is a day when the kids are so involved in the fun of the game, they don't realize they are learning. The second reason I love to play this game is for the wealth of information that can be taught or reviewed while playing. It can he used to review concepts as broad as physical and chemical changes, or as specific as finding neutron numbers and drawing atom models.

While drawing each bachelor or bachelorette, I have the students talk me through the drawing so their review is ongoing. Also, the discovery we make at the end of the lesson is priceless. Kids often wonder about the shape of the periodic table, and when we discover that our bachelors can pair with several different bachelorettes from the same family, the kids construct their own understanding of the periodic table. Have fun with the game, but be sensitive to the cultural issues in your school. Issues such as dating, relationships, and television game shows can he sensitive topics. With that in mind, if you have any unstable atoms hanging around your classroom let your students find them a match!



Using inquiry allows students to have a part in designing their own investigations and to create their own questions and hypotheses. Their curiosity is engaged and they have a freedom to explore where their interests lie. Earth system science is just the right instrument for engaging middle school students in the learning process because they are quick to make the connection of a healthy Earth to their own real life needs. With their keen interest in human biology, they have acquired the knowledge that humans must have fresh water in order to live and have developed an understanding that Earth's environment needs to he protected.

The National Science Education Standards state that "Inquiry into authentic questions generated from student experiences is the central strategy for teaching science" (NRC 1996). The following activity uses student-generated questions to investigate the interrelatedness of Earth systems. This lesson is based on the Suchman Inquiry Model. This model of instruction is different from the standard intellectual strategy that scientists use because it provides the framework for teaching this method of problem solving to learners in middle school (Gunter 1999). The problem statement used for the activity was taken from a poster, Blast from the Past, produced by the Joint Oceanographic Institutions (see Resources).

I will admit that using inquiry with middle school students requires that a teacher take some risks because she will not know the specific path students may choose in their investigation. It is also a challenge to find material that requires students to create their own questions. However, if we are to teach young adolescents to design effective investigations of their environment and to be critical thinkers, we must take this hazardous first step toward using true inquiry in our classrooms. Enthusiasm, waving hands, smiling faces, competition among groups, as well as increased student knowledge of the structure of the Earth system, are just some of the payoffs you will reap from using this activity.

Guiding the inquiry

To begin, review the teacher fact sheet (Figure 1) to familiarize yourself with the background material related to the problem statement students will be addressing. Next, divide the class into small groups and provide each student with an activity sheet. This sheet includes background information, the problem statement, and the rules for inquiry. Students work in small groups to facilitate discussion during caucuses, the time students spend reviewing what they have learned and developing a hypotheses based on this new information.

Ask a volunteer to read the problem statement aloud and encourage students to discuss it and ask questions to clarify any concepts. Once they have considered the statement, students work together to develop a hypothesis that addresses it. Remind them that the hypothesis should he written as an "if/then" statement. For example, "If reindeer meat is contaminated 2000 miles from Chemoble, then it was because the wind carried radioactive material through the air."

Now the inquiry questioning can begin. As the students ask questions, make sure that you only provide them with a :yes or no answer.

Spheres of influence

Problem statement

Why do events happening in one place on this huge Earth have such far-reaching effects all over the planet?

Background information

Sixty-five million years ago, an asteroid hit Mexico's Yucatan Peninsula ejecting ashes and fragments of Earth into the atmosphere. Wildfires brought about by burning pieces of Earth falling from the sky literally set the whole planet aflame, causing the skies to become dark.
Little or no sunlight penetrated the blanket of ash and soot and temperatures below zero resulted. Fifty to eighty percent of plant and animal life in the ocean and on land all over the Earth became extinct.

In 1982, a volcano in Mexico, El Chichon, ejected sulfur dioxide gas into the atmosphere. This gas converted fo drops of sulfuric acid that disturbed global climate for a year or more. El Nino, a natural disruption of the ocean-atmosphere in the tropical Pacific, caused floods, droughts, fires, hurricanes, tornadoes, and mudslides all over the world in 1997-98. In 1986, a Russian reactor at Chernobyl power plant was destroyed by a core meltdown. Two thousand miles away in Sweden, meat from about 50,000 reindeer had to be thrown away because if was contaminated from the accident.

Rules for inquiry

- Only one person can speak at a time and must wait to be recognized by the teacher.
- You may ask only yes or no questions. If you ask a question that cannot be answered by yes or no, the teacher will ask you to restate it.
- As long as you receive a yes answer you can keep asking questions.
- You may call for a caucus to discuss ideas with your group. This is the only time discussion among students can take place.
- If a group states a hypothesis at fhe conclusion of a caucus it will be written on the board and the class will decide if it is a possible answer to the problem. The process will continue until the class is satisfied that the problem has been solved.

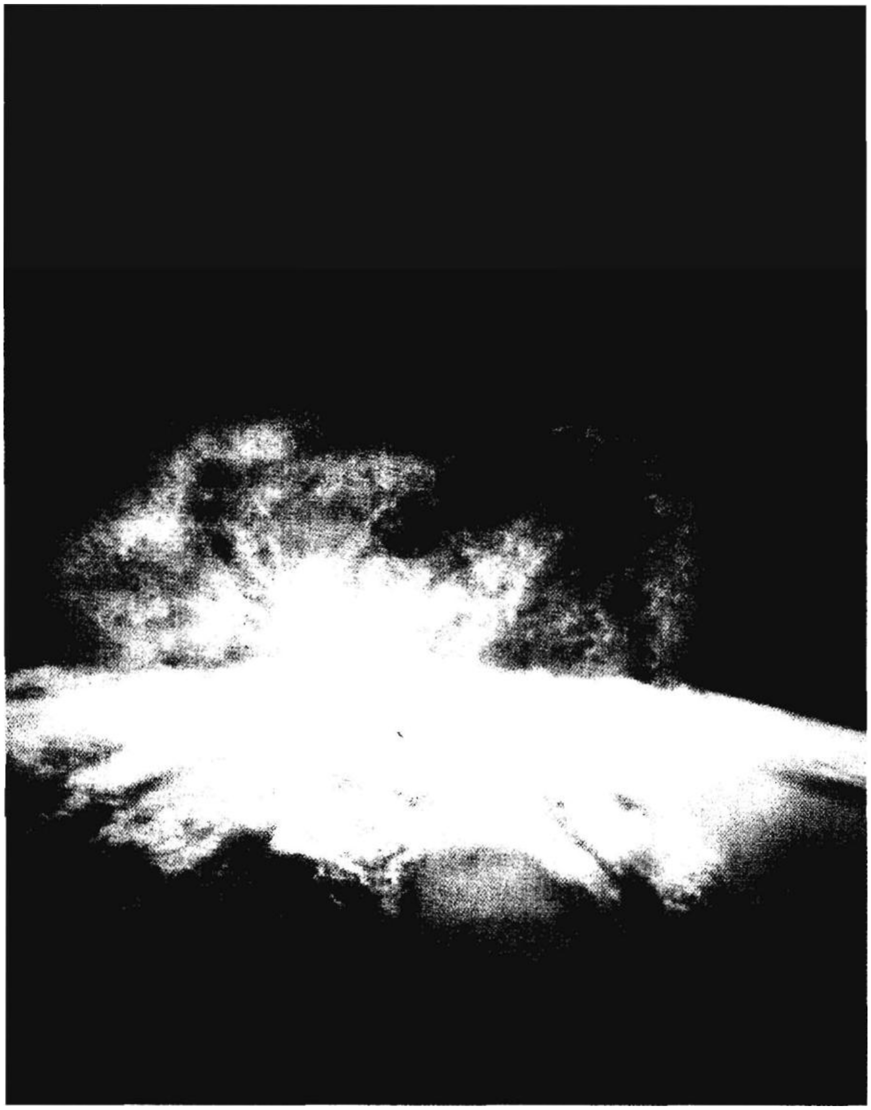


FIGURE 1 **Teacher inquiry fact sheet about Earth systems**

Sixty-five million years ago an asteroid hit the Yucatan Peninsula ejecting ashes and fragments of earth into the atmosphere. Wildfires brought about by burning fragments falling from the sky literally set the whole Earth aflame, causing the skies to become dark. Little or no sunlight reached the surface of the Earth and temperatures below zero resulted for weeks after the asteroid impacted. Fifty to eighty percent of plant and animal life became extinct on land and in the ocean.

In 1982, in southern Mexico El Chichon, a volcano, ejected volcanic debris into the stratosphere. The cloud from El Chichon contained sulfur dioxide gas, which was converted to drops of sulfuric acid that disturbed global climate for a year or more.

In 1986, a Russian reactor at Chernobyl power plant was destroyed by a core meltdown. Two thousand miles away in Sweden, meat from about 50,000 reindeer had to be thrown away because it was contaminated by radionuclides from the accident.

The 1997–98, El Niño, a natural disruption of the ocean-atmosphere in the tropical Pacific, caused worldwide damage and was partly responsible for the deaths of more than 2,000 people. On the other side of the globe it caused a shifting of rainfall that produced floods in eastern Africa and drought and fires in western Africa.

Rain forests recycle enormous amounts of water back to the atmosphere. This adds rainfall and clouds to large areas of the globe. Satellite data recently proved that, in general, clouds are powerful cooling agents for Earth. As rain forests are cut, less water is returned to the Earth's atmosphere, fewer clouds are formed, and global warming becomes more of a problem.

There is an "ocean conveyor belt" on Earth that causes circulation of ocean waters all over the globe. It is fueled by cold water (which is more salty than warm water) sinking to the bottom; this helps trigger an upwelling on the other side of Earth into a surface current which is warmed by the Sun. If natural events or human intervention should cause this conveyor belt to shut down or be disrupted, several billion people in northern Europe could be without enough food to survive, causing a global catastrophe. Some scientists sum this up by saying that the Earth acts like an incredible living organism. The currents in its oceans are like its circulation system and the forests, which produce vast amounts of oxygen for the atmosphere, are like its lungs. They call this organism Gaia.

Geophysiology or Earth system science regards the Earth as a living system controlled by complicated operations in the geosphere, atmosphere, hydrosphere, and biosphere. In other words, the land, water, air, and life on this planet are so connected that the proper functioning of any one of them depends on the interactions of the four spheres of the Earth system.

Remember, if the answer is yes, the student may continue to ask questions. Record vocabulary related to the questions on the board. For example, if a student should ask, "Does the wind have anything to do with the fact that an event in one place has effects on the other side of the Earth?" you would answer yes and write wind in the Yes column. This continues until the teacher or students call for a caucus to allow students to discuss what they have learned and to develop a hypothesis based on their newfound knowledge.

Both of my classes generated a first hypothesis about the atmosphere. I wrote on the hoard, If these events have global effects, then it is because the atmosphere covers the Earth." This hypothesis was a result of yes answers on the board to questions about the wind, air pressure, clouds, rain, solar heat, and oxygen. You may further guide the inquiry by drawing a box around all the words that pertain to one of the four spheres of the Earth system. [n order to elicit a hypothesis about the hydrosphere, for example, you would draw a box around words such as plankton, oceans, water cycle, lakes, and ocean currents. You may wish to list the major parts of the Earth system—atmosphere, hydrosphere, geosphere, and biosphere--and list vocabulary and concepts brought up by students below the related system.

As the teacher, you will decide how much direction is needed to stimulate the inquiry process and keep the frustration at a level appropriate to the experience of your students. Some in the class may feel that they have arrived at the answer with the first hypothesis. Inform them that they have one-fourth of the whole answer for this inquiry. Be prepared for comments like, "She took my answer!" or "That's exactly what I was going to say!" Refer students to the rules and continue the inquiry.

Solution

Once they presented a hypothesis about all four parts of the Earth System (hydrosphere, atmosphere, geosphere, and biosphere), I asked if the four parts working together as a whole could he identified by a concept we had been recently studying. A student offered the word system. (Our seventh grade thematic unit for the first grading period was "systems," so my students were familiar with the idea that a system has parts that work together to function as a whole. You may want to review the concept of systems before using this problem statement.) The class agreed a solution to the question had been found. A student said, "The Earth is a system!" At that point, one girl did a victory dance because her group came up with geosphere, which was the hypothesis that took the most time to identify. Several hooting cheers such as those appropriate for sporting events sounded from the hack! Like 1 said, smiling faces and lots of enthusiasm will reward the teacher brave enough to use inquiry in the middle school science classroom!

Summary activity

At the end of the questioning period, ask student groups to explain why system is the solution to the problem statement. Also, students could design an experiment on paper to prove or disprove their group,s hypothesis.

References

National Research Council. 1996. The *National Science Education Standards. Washington,* D.C.: National Academy Press.
Gunter, M.A., T.H. Estes, and J. Schwab. 1999. Instruction: A models *approach.* Boston: Allyn and Bacon.

Internet resources

- Educators can receive a free copy of the Blast from the Past poster by sending their requests to *ses@agiweb.org.*
- Earth Science World: *www.earthscienceworld.org/ week/wrapper. html?page=; standardsgeneral. ht ml*
- Volcano World: *volcano.und.nodak.edu/twdacs/ frequent_questions/grp6/question3752. hnnl*
- Worldwide Effects: Rest`of the World: *ultras v. thinkquest. org/3426/data/wrrrldwide-ef fects/rcst. html*

The Effects of El Nino on Marine Life: *www.csa.com/hottopicsleluinoIoview.hrml*

- Report to the Nation on Our Changing Planet: The Climate System: www.ogp.mxta.gov/lihrary/rmw9 t . *htr*
- Geophysiology: The Science of Gaia: www.bio.vu.nl/ vakgroepen/thh/userskdberglherg-gaia.html

Standards

The structure of the Earth system is a content standard for Earth and Space Science for grades five through eight in The National Science Standards.