

# ScienceNews

EDUCATOR GUIDE



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**Radioactive Cloud Linked to Russia**



SOCIETY FOR SCIENCE & THE PUBLIC

# Radioactive Cloud Linked to Russia

## About this Guide

This guide, based on the *Science News* article "[Radioactive cloud traced to Russia](#)," asks students to evaluate evidence, explore global monitoring networks and use an interactive simulation to learn about elements, ions and isotopes.

### This Guide includes:

**Article-Based Comprehension Q&A** — These questions, based on the *Science News* article "[Radioactive cloud traced to Russia](#)," Readability: 13.1, ask students to identify a series of events and list and evaluate evidence. Related standards include NGSS-DCI: HS-PS1; HS-PS2; HS-ESS3 and HS-ETS1.

**Student Comprehension Worksheet** — These questions are formatted so it's easy to print them out as a worksheet.

**Cross-curricular Discussion Q&A** — Students will learn about three global monitoring networks and the types of scientific data collected by each. Additional prompts encourage students to consider the purposes of these networks. Related standards include NGSS-DCI: HS-ESS2; HS-ESS3 and HS-PS4.

**Student Discussion Worksheet** — These questions are formatted so it's easy to print them out as a worksheet.

### Activity: Atoms, Ions and Isotopes, Oh Why?

**Summary:** Students will use a PhET Interactive Simulation to understand the definitions, similarities and differences of elements, ions and isotopes. Then students will explore the *Science News* journalism archive to find current science research examples that apply these concepts. Related standards include NGSS-DCI: HS-PS1 and HS-PS3.

**Approximate class time:** One class period.

**Article-Based Comprehension, Q&A**

**Directions:** After students read the *Science News* article "[Radioactive cloud traced to Russia](#)," ask them to answer the questions that follow.

**1. The article describes "a nuclear whodunit." What is the mystery that researchers are trying to solve?**

A radioactive cloud appeared over Europe in September and October 2017, but no one knows for sure where the cloud came from or what caused it.

**2. What data alerted scientists to the mystery and what about that data causes concern?**

A network of sensors that monitor the atmosphere across Europe detected small amounts of ruthenium-106 in the skies. This isotope is not found naturally on Earth.

**3. Some scientists believe they have solved the mystery. What is their conclusion about the origin and cause of the mystery?**

Some scientists believe the Mayak Production Association, a nuclear facility near Ozersk in Russia, was the source. These scientists argue that the cloud was released when the facility attempted to make a material for an experiment looking for subatomic particles called neutrinos.

**4. Name the three most important pieces of evidence that support the conclusion.**

Students answers will vary, but should come from this list:

- The cloud shape suggested it didn't originate in Romania
- The cloud was moving west as it passed over Romania, and simulations suggest it could have traveled from Mayak
- The type and ratio of radioactive material detected matched what might be expected from fuel processing at Mayak related to the neutrino experiment
- An e-mail between experiment leaders referred to "unexpected problems"
- Concentrations of ruthenium across the cloud were not consistent with another possible explanation, that a satellite with a radionuclide battery burned up when it entered Earth's atmosphere

**5. If the scientists' conclusion is correct, the events below preceded the cloud's detection. Number the events according to their chronological order.**

- Ruthenium-106 was released into the atmosphere. (3)
- The Mayak facility in Russia attempted to create that source from recently spent fuel. (2)

- Scientists working on a neutrino experiment in Italy needed a radioactive source that produced neutrinos. (1)
- The neutrino experiment was canceled. (5)
- The cloud of ruthenium was carried over parts of Europe. (4)

**6. Look at the graphic titled “European traveler” in the online version of the story ([www.sciencenews.org/article/2017-radioactive-plume-europe-russia-plant-neutrino-experiment](http://www.sciencenews.org/article/2017-radioactive-plume-europe-russia-plant-neutrino-experiment)). What pattern is shown in the animated graphic? (Include what the circles and colors indicate in your answer.)**

The graphic shows where detectors in Romania picked up ruthenium-106 from September 28 through October 5. Circles show detector locations. Red circles indicate that ruthenium-106 was spotted by the detector; white shows where no ruthenium-106 was measured. Red circles appear to be generally moving from an east to west direction as the days pass.

**7. What conclusions can and cannot be drawn from the graphic?**

Since there detectors shown are only in Romania, we cannot determine the origin or final destination of the cloud. Within Romania, the cloud of ruthenium-106 first appeared over the eastern side of the country and then spread to the west. It either moved over other countries or dissipated in northwest Romania.

**8. According to the article, does everyone agree that the mystery is solved? Why or why not?**

No. The Russian state atomic energy corporation says that there was no accident at Mayak that would have led to the radioactive cloud.

**9. Do you think the evidence is strong enough to say the mystery is solved? If yes, why? If not, what additional evidence could help solve the mystery?**

Student answers will vary. If students answer yes, they should explain why the evidence outweighs the Russian denial. If students answer no, they might suggest new forms of data, including interviews with Russian officials or nuclear workers, or with the leaders of the neutrino experiment. Students might brainstorm other ways to gain environmental data, such as through satellites, or suggest further simulations.

# Radioactive Cloud Linked to Russia

## Student Comprehension Worksheet

**Directions:** After reading the *Science News* article "[Radioactive cloud traced to Russia](#)," answer the questions that follow.

- 1. The article describes "a nuclear whodunit." What is the mystery that researchers are trying to solve?**
- 2. What data alerted scientists to the mystery and what about that data causes concern?**
- 3. Some scientists believe they have solved the mystery. What is their conclusion about the origin and cause of the mystery?**
- 4. Name the three most important pieces of evidence that support the conclusion.**
- 5. If the scientists' conclusion is correct, the events below preceded the cloud's detection. Number the events according to their chronological order.**
  - Ruthenium-106 was released into the atmosphere.
  - The Mayak facility in Russia attempted to create that source from recently spent fuel.
  - Scientists working on a neutrino experiment in Italy needed a radioactive source that produced neutrinos.
  - The neutrino experiment was canceled.
  - The cloud of ruthenium was carried over parts of Europe.
- 6. Look at the graphic titled "European traveler" in the online version of the story ([www.sciencenews.org/article/2017-radioactive-plume-europe-russia-plant-neutrino-experiment](http://www.sciencenews.org/article/2017-radioactive-plume-europe-russia-plant-neutrino-experiment)). What pattern is shown in the animated graphic? (Include what the circles and colors indicate in your answer.)**

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**9. Do you think the evidence is strong enough to say the mystery is solved? If yes, why? If not, what additional evidence could help solve the mystery?**

# Radioactive Cloud Linked to Russia

## Cross-curricular Discussion, Q&A

**Directions for teachers:** By collecting and analyzing a variety of data from distant sites, global monitoring networks can watch for potential threats around the world. The *Science News* article "[Radioactive cloud traced to Russia](#)" summarizes how a "network of atmospheric monitoring sites across Europe" detected and tracked a radioactive plume.

This discussion will focus on three global monitoring networks. Either for homework or in class, ask students to read the brief background provided below on the three networks and split students into groups, assigning one of the networks to each group. Have students go to the link provided to learn more about the network's data-collection process and answer the data questions below. Come together as a class to share observations and answer the three summarizing questions.

For more educator resources on climate change data, check out the February 18, 2017 educator guide, "[2016 shattered Earth's heat record.](#)"

### Brief overviews of three global monitoring networks

The **Global Seismographic Network** formed in 1986 as a partnership between the United States Geological Survey, the National Science Foundation and the Incorporated Research Institutions for Seismology (a consortium of universities). The network has 150 stations across the globe that detect and record seismic vibrations. Data are collected by seismometers and accessible through the IRIS's Station Monitor app. Learn more about the IRIS's data at [www.iris.edu/app/station\\_monitor/#2019-08-06/LD-SDMD/help-section/](http://www.iris.edu/app/station_monitor/#2019-08-06/LD-SDMD/help-section/)

The **Global Ocean Observing System**, or GOOS, was established in 1991 by the Intergovernmental Oceanographic Commission of UNESCO, the United Nations Educational, Scientific and Cultural Organization. The network collects data that impact three main areas: monitoring climate, operational services such as weather forecasts and hazard warnings, and marine ecosystem health. An array of floats with various sensors, called Argo, is one of the sources of data. Learn more about Argo data at [www.argo.ucsd.edu/Argo\\_date\\_guide.html#gtsusers](http://www.argo.ucsd.edu/Argo_date_guide.html#gtsusers)

The **Global Environment Monitoring System** for freshwater, known as GEMS/Water, began in 1978 as a collaboration between the United Nations Environment Programme, the World Health Organization, the World Meteorological Organization and UNESCO, the United Nations Educational, Scientific and Cultural Organization. In 2014, the United Nations Environment Assembly deemed the GEMS/Water data as integral to achieving the United Nations' Sustainable Development Goals. The system monitors surface water and groundwater quality. Learn more about GEMS/Water data at [gemstat.org/about](http://gemstat.org/about)

## Data questions for small groups

*Answers are included for the Global Seismographic Network example and can be used as a reference for the depth of answers students should be providing.*

1. Explore the website provided in the brief overview and give an example of a type of data collected. Don't forget to include the appropriate unit(s) of measurement and how the data is displayed.

*The network collects data from seismometers that measure the speed of the motion of the ground in nanometers per second. This data is displayed on a seismogram.*

2. How do you think this type of data is collected? Is there a physical device in the location or is data collected by a satellite or other remote device?

*The data is collected by seismometers, which are physical devices that measure ground motions at the location where they are installed.*

3. What general information could be gained from analyzing trends in the data? What types of issues could the monitoring system prevent or warn against?

*By analyzing trends in the data, scientists may be able to predict and warn against potentially catastrophic volcanic eruptions or earthquake aftershocks, for example.*

4. What type of science background would be needed to monitor the data?

*A seismologist is a scientist who studies the motion within the Earth by monitoring seismic waves, but anyone with a background in earth science and who knows how to read and interpret a seismogram would be able to monitor the data.*

5. Describe how the data could be used on an international scale.

*Student answers will vary. Data from one area could be used to argue for the evacuation of a different area due to signs that a volcanic eruption is imminent. Data could also be used to predict the impact of seismic events in different areas around the world, which could allow governments and international organizations to mobilize and send relief if necessary.*

## Summarizing questions for the class

*Student answers will vary for the questions that follow. Try to encourage students from each group to participate in the group discussion.*

1. What is the purpose of any global network?



2. Why is the international nature of these networks important? How might geopolitical relations or cultural differences affect these types of efforts?
  
3. Brainstorm a monitoring network that would be useful that isn't included in this list. Do you know if it currently exists? What would be the purpose and benefits of this type of monitoring network?

**Student Discussion Worksheet**

**Directions for students:** By collecting and analyzing a variety of data from distant sites, global monitoring networks can watch for potential threats around the world. The *Science News* article "[Radioactive cloud traced to Russia](#)" summarizes how a "network of atmospheric monitoring sites across Europe" detected and tracked a radioactive plume.

This discussion will focus on three global monitoring networks. Read the brief background provided on the three networks and split into groups, with each group focused on one of the networks. Go to the link provided to learn more about the data collection process and answer the data questions with your group. Come together with your class to share observations and answer the three summarizing questions.

**Brief overviews of three global monitoring networks**

The **Global Seismographic Network** formed in 1986 as a partnership between the United States Geological Survey, the National Science Foundation and the Incorporated Research Institutions for Seismology (a consortium of universities). The network has 150 stations across the globe that detect and record seismic vibrations. Data are collected by seismometers and accessible through the IRIS's Station Monitor app. Learn more about the IRIS's data at [www.iris.edu/app/station\\_monitor/#2019-08-06/LD-SDMD/help-section/](http://www.iris.edu/app/station_monitor/#2019-08-06/LD-SDMD/help-section/)

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The **Global Environment Monitoring System** for freshwater, known as GEMS/Water, began in 1978 as a collaboration between the United Nations Environment Programme, the World Health Organization, the World Meteorological Organization and UNESCO, the United Nations Educational, Scientific and Cultural Organization. In 2014, the United Nations Environment Assembly deemed the GEMS/Water data as integral to achieving the United Nations' Sustainable Development Goals. The system monitors surface water and groundwater quality. Learn more about GEMS/Water data at [gemstat.org/about](http://gemstat.org/about)

**Data questions for small groups**

1. Explore the website provided in the brief overview and give an example of a type of data collected. Don't forget to include the appropriate unit(s) of measurement and how the data is displayed.

2. How do you think this type of data is collected? Is there a physical device in the location or is data collected by a satellite or other remote device?

3. What general information could be gained from analyzing trends in the data? What types of issues could the monitoring system prevent or warn against?

4. What type of science background would be needed to monitor the data?

5. Describe how the data could be used on an international scale.

### **Summarizing questions for the class**

1. What is the purpose of any global network?

2. Why is the international nature of these networks important? How might geopolitical relations or cultural differences affect these types of efforts?

3. Brainstorm a monitoring network that would be useful that isn't included in this list. Do you know if it currently exists? What would be the purpose and benefits of this type of monitoring network?

**Activity Guide for Teachers: Atoms, Ions and Isotopes, Oh Why?**

**Purpose:** Use a PhET Interactive Simulation and the *Science News* journalism archive to understand the definitions, similarities, differences and applications of elements, ions and isotopes.

**Procedural overview:** In this activity, students will explore a simple simulation to define and understand elements, ions and isotopes. Students will then find recent STEM research examples from the *Science News* archive that connect to that knowledge.

**Approximate class time:** One class period.

**Supplies:** A computer with internet access per group.

**Directions for students:**

A popular chemistry joke asks, “Why can you never trust an atom?” The answer, “Because they make up everything.” To understand almost any natural phenomena, scientists must start with the basic knowledge of the building blocks of matter, atoms. Atoms with a specific number of protons are known by an element name, like “oxygen” or “hydrogen.” Atoms exist in nature as either neutral elements or as ions, depending on the surrounding atoms and other physical conditions. There are also multiple versions of atoms of the same element that exist in nature in varying abundances, called isotopes.

In this activity, you’re going to explore a simple simulation to define and understand elements, ions and isotopes. You will then explore the *Science News* journalism archive to find current science research examples that apply these concepts.

**Read and watch**

Before you begin to explore the simulation, check out a *Science News* article about microwaving grapes and the related video: [www.sciencenews.org/article/grapes-spark-microwave-plasma](http://www.sciencenews.org/article/grapes-spark-microwave-plasma). Scientists have recently gained insights into why microwaved grapes make plasma fireballs. While there are many concepts involved, at the most basic level, scientists have to understand atoms and ions to understand plasma formation. And, so we start with learning the basics of atoms, ions and isotopes.

**Now explore the simulation**

1. Download and open the PhET Interactive Simulation titled [Build an Atom](#). Next click on “Atom,” and allow the simulation to load. Now click on the “+” sign for both “Net Charge” and “Mass Number” to open those windows.

2. Atoms make up everything, but first we'll explore what makes up an atom. Before you start adding subatomic particles to create an atom, name those particles using the table below. Note that the "x" in the middle of the Bohr atomic model onscreen in the simulation represents the nucleus. The dashed lines represent electron orbitals. Move the subatomic particles into and out of the atomic model and watch how it changes the values in the "Net Charge" and "Mass Number" windows. Fill in the table below based on what you learn, then answer the question that follows.

Subatomic particle name	Charge (include the magnitude of the charge per subatomic particle and whether it is a + or - charge)	Location in atom	Mass (amu)
<i>proton</i>	<i>1+</i>	<i>nucleus</i>	<i>1</i>
<i>neutron</i>	<i>0</i>	<i>nucleus</i>	<i>1</i>
<i>electron</i>	<i>1-</i>	<i>electron orbits</i>	<i>0</i>

**How would you define an atom?**

*An atom is made up of subatomic particles including, protons, neutrons and/or electrons.*

3. Atoms of different elements are different. We're going to use lithium (Li) and carbon (C) to explore how. Use the simulation to build a Li atom and then a C atom. Figure out which subatomic particle you need to manipulate to create the atoms, then write the correct number of that subatomic particle in the table below. Note the following abbreviations: proton ( $p^+$ ), neutron ( $n^0$ ) and electron ( $e^-$ ). If you did not need to manipulate a subatomic particle to create the atom, write an "X" in the table. Finally, answer the questions below the table before moving on.

Element	Li	C
# of $p^+$	<i>3</i>	<i>6</i>
# of $n^0$	<i>X</i>	<i>X</i>
# of $e^-$	<i>X</i>	<i>X</i>

**You created a Li atom and a C atom, two different elements. How are the atoms of these two elements different?**

*Li and C atoms have different numbers of protons.*

**Based on this exercise, how would you define an element?**

*Elements are atoms with a specific number of protons.*

4. Using the “Net Charge” window as a guide, figure out which subatomic particle you need to manipulate to create a neutral Li atom and then a neutral C atom, then write the correct number in the table below. If you did not need to manipulate other subatomic particles, write an “X” in the table. Answer the questions below the table before moving on.

Element	Li	C
# of p <sup>+</sup>	3	6
# of n <sup>0</sup>	X	X
# of e <sup>-</sup>	3	6

**What does it mean for an atom to be neutral? How do the number of subatomic particles compare?**

*An atom is neutral when the net charge is 0. This occurs when the number of positively charged protons equals the number of negatively charged electrons.*

**What does it mean if an atom is not neutral? How do the number of subatomic particles compare?**

*If atoms are not neutral, they have a charge. The number of protons will not equal the number of electrons.*

**These types of atoms are called ions. How would you define an ion?**

*Ions are atoms with a charge.*

5. Next we will explore what gives ions a specific charge. Create the ions listed below by manipulating the necessary subatomic particles, and write the number of each particle in the table. If you did not need to manipulate a subatomic particle, write an “X” in the table. Write a formula, described below the table, before moving on. Note that the charge on an atom is always written to the upper right of an element’s symbol.

Element	Li <sup>+</sup> (same as Li <sup>1+</sup> )	C <sup>4-</sup>
# of p <sup>+</sup>	3	6
# of n <sup>0</sup>	X	X
# of e <sup>-</sup>	2	10

**Write a general formula for determining the charge from the number of subatomic particles.**

*Charge on an ion = the number of protons minus the number of electrons*

5. Check the box in the simulation that says “Stable/Unstable” so your atom’s stability appears onscreen. Figure out which subatomic particle you need to manipulate to create a stable, neutral Li atom and then a stable, neutral C atom, and write the correct number of that subatomic particle in the table below. Use the “Mass Number” window to write down the mass of each stable, neutral element. Write a formula, described below the table, before moving on.

Element	Li	C
# of p <sup>+</sup>	3	6
# of n <sup>0</sup>	3 or 4	6 or 7
# of e <sup>-</sup>	3	6
Mass number	6 or 7	12 or 13

**Write a general formula for determining an atom’s mass from the number of subatomic particles.**

Atomic mass (or mass number) = *the number of protons plus the number of neutrons*

6. Atomic symbols are often used to clarify an atom’s mass number. The symbols use the format below, where “X” is the element symbol (as shown on the periodic table), “A” is the atomic mass (or mass number) and “Z” is the number of protons (or the atomic number). Note that the “Z” is not always written, because the element symbol defines the number of protons that an atom has.

General format of an atomic symbol:



**Write an atomic symbol for the stable, neutral Li atom.**

*<sup>6</sup>Li or <sup>7</sup>Li*

**Write an atomic symbol for the stable, neutral C atom.**

*<sup>12</sup>C or <sup>13</sup>C*

7. Use the simulation to fill out the table below. Then answer the related questions below the table.

Atomic symbol	$^{12}\text{C}$	$^{13}\text{C}$	$^{14}\text{C}$
Atomic mass	12	13	14
# of $\text{p}^+$	6	6	6
# of $\text{n}^0$	6	7	8
# of $\text{e}^-$	6	6	6
Stable or unstable?	Stable	Stable	Unstable

**Do atoms have to have the same number of protons and neutron to be stable? Why do you say that?**

*No.  $^{13}\text{C}$  does not have the same number of protons and neutrons, and it is stable.*

**What do all of the atoms listed in the table have in common? How are they different?**

*All of these atoms are the same element, carbon, and therefore all have the same number of protons, 6. They all have a different number of neutrons, and therefore a different overall atomic mass/mass number.*

8. These atoms are examples of isotopes. Most elements exist in nature as multiple types of isotopes. For example,  $^{12}\text{C}$  and  $^{13}\text{C}$  are the most abundant isotopes in nature, but  $^{14}\text{C}$  also exists. Because  $^{14}\text{C}$  isn't stable, it breaks down or decays very slowly over time.

**Define an isotope.**

*Isotopes are atoms of the same element with different atomic masses, or number of neutrons.*

9. Think back to the [grape plasma article and video](#) that you watched at the beginning of the lesson, rereading and rewatching if necessary.

**How does a concept you learned today explain something about the grape plasma production?**

*The Science News article mentions that salts within the grape skin are ionized and released, which produces a plasma flare. This must mean that salts have lost or gained electrons to become ions, which must be what happens to produce a plasma flare.*

10. Now that you've created your general definitions, let's take a little time to explore how current research applies the concepts of atoms, ions and isotopes. In your groups, choose one of the articles listed below that interests you (most relate to lithium or carbon atoms, ions or isotopes), or do your [own search in the Science News](#) journalism archive to find an article related to the concepts learned today. Answer the prompts below.



Environmental science: "[As ice retreats, frozen mosses emerge to tell climate change tale](#)"  
View the [related educator guide](#) for additional information.

Chemistry: "[The search for new geologic sources of lithium could power a clean future](#)"

Physics: "[Scientists seek materials that defy friction at the atomic level](#)"

Astronomy: "[Competing ideas abound for how Earth got its moon](#)"  
View the [related educator guide](#) for additional information.

Biology/health: "[Small intestine is the first stop for fructose](#)"  
View the [related educator guide](#) for additional information.

**Summarize which concept is applied in the current research described in the article and explain how a scientist or technology mentioned in the article applies the concept.**

*Student answers will vary and can be related to the field of their choice.*

# Radioactive Cloud Linked to Russia

## Activity Guide for Students: Atoms, Ions and Isotopes, Oh Why?

**Directions for students:** A popular chemistry joke asks, “Why can you never trust an atom?” The answer, “Because they make up everything.” To understand almost any natural phenomena, scientists must start with the basic knowledge of the building blocks of matter, atoms. Atoms with a specific number of protons are known by an element name, like “oxygen” or “hydrogen.” Atoms exist in nature as either neutral elements or as ions, depending on the surrounding atoms and other physical conditions. There are also multiple versions of atoms of the same element that exist in nature in varying abundances, called isotopes.

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2. Atoms make up everything, but first we’ll explore what makes up an atom. Before you start adding subatomic particles to create an atom, name those particles using the table below. Note that the “x” in the middle of the Bohr atomic model onscreen in the simulation represents the nucleus. The dashed lines represent electron orbitals. Move the subatomic particles into and out of the atomic model and watch how it changes the values in the “Net Charge” and “Mass Number” windows. Fill in the table below based on what you learn, then answer the question that follows.

Subatomic particle name	Charge (include the magnitude of the charge per subatomic particle and whether it is a + or - charge)	Location in atom	Mass (amu)


**How would you define an atom?**

3. Atoms of different elements are different. We're going to use lithium (Li) and carbon (C) to explore how. Use the simulation to build a Li atom and then a C atom. Figure out which subatomic particle you need to manipulate to create the atoms, then write the correct number of that subatomic particle in the table below. Note the following abbreviations: proton ( $p^+$ ), neutron ( $n^0$ ) and electron ( $e^-$ ). If you did not need to manipulate a subatomic particle to create the atom, write an "X" in the table. Finally, answer the questions below the table before moving on.

<b>Element</b>	<b>Li</b>	<b>C</b>
<b># of <math>p^+</math></b>		
<b># of <math>n^0</math></b>		
<b># of <math>e^-</math></b>		

**You created a Li atom and a C atom, two different elements. How are the atoms of these two elements different?**

**Based on this exercise, how would you define an element?**

4. Using the "Net Charge" window as a guide, figure out which subatomic particle you need to manipulate to create a neutral Li atom and then a neutral C atom, then write the correct number in the table below. If you did not need to manipulate other subatomic particles, write an "X" in the table. Answer the questions below the table before moving on.

<b>Element</b>	<b>Li</b>	<b>C</b>
<b># of <math>p^+</math></b>		
<b># of <math>n^0</math></b>		
<b># of <math>e^-</math></b>		

**What does it mean for an atom to be neutral? How do the number of subatomic particles compare?**

**What does it mean if an atom is not neutral? How do the number of subatomic particles compare?**

**These types of atoms are called ions. How would you define an ion?**

5. Next we will explore what gives ions a specific charge. Create the ions listed below by manipulating the necessary subatomic particles, and write the number of each particle in the table. If you did not need to manipulate a subatomic particle, write an "X" in the table. Write a formula, described below the table, before moving on. Note that the charge on an atom is always written to the upper right of an element's symbol.

<b>Element</b>	<b>Li<sup>+</sup> (same as Li<sup>1+</sup>)</b>	<b>C<sup>4-</sup></b>
<b># of p<sup>+</sup></b>		
<b># of n<sup>0</sup></b>		
<b># of e<sup>-</sup></b>		

**Write a general formula for determining the charge from the number of subatomic particles.**

Charge on an ion =

5. Check the box in the simulation that says "Stable/Unstable" so your atom's stability appears onscreen. Figure out which subatomic particle you need to manipulate to create a stable, neutral Li atom and then a stable, neutral C atom, and write the correct number of that subatomic particle in the table below. Use the "Mass Number" window to write down the mass of each stable, neutral element. Write a formula, described below the table, before moving on.

<b>Element</b>	<b>Li</b>	<b>C</b>
<b># of p<sup>+</sup></b>		
<b># of n<sup>0</sup></b>		
<b># of e<sup>-</sup></b>		

<b>Mass number</b>		
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**Write a general formula for determining an atom's mass from the number of subatomic particles.**

Atomic mass (or mass number) =

6. Atomic symbols are often used to clarify an atom's mass number. The symbols use the format below, where "X" is the element symbol (as shown on the periodic table), "A" is the atomic mass (or mass number) and "Z" is the number of protons (or the atomic number). Note that the "Z" is not always written, because the element symbol defines the number of protons that an atom has.

General format of an atomic symbol:



**Write an atomic symbol for the stable, neutral Li atom.**

**Write an atomic symbol for the stable, neutral C atom.**

7. Use the simulation to fill out the table below. Then answer the related questions below the table.

<b>Atomic symbol</b>	<sup>12</sup> C	<sup>13</sup> C	<sup>14</sup> C
<b>Atomic mass</b>			
<b># of p<sup>+</sup></b>			
<b># of n<sup>0</sup></b>			
<b># of e<sup>-</sup></b>			
<b>Stable or unstable?</b>			

**Do atoms have to have the same number of protons and neutron to be stable? Why do you say that?**

**What do all of the atoms listed in the table have in common? How are they different?**

8. These atoms are examples of isotopes. Most elements exist in nature as multiple types of isotopes. For example,  $^{12}\text{C}$  and  $^{13}\text{C}$  are the most abundant isotopes in nature, but  $^{14}\text{C}$  also exists. Because  $^{14}\text{C}$  isn't stable, it breaks down or decays very slowly over time.

**Define an isotope.**

9. Think back to the [grape plasma article and video](#) that you watched at the beginning of the lesson, rereading and rewatching if necessary.

**How does a concept you learned today explain something about the grape plasma production?**

10. Now that you've created your general definitions, let's take a little time to explore how current research applies the concepts of atoms, ions and isotopes. In your groups, choose one of the articles listed below that interests you (most relate to lithium or carbon atoms, ions or isotopes), or do your [own search in the Science News](#) journalism archive to find an article related to the concepts learned today. Answer the prompts below.

Environmental science: "[As ice retreats, frozen mosses emerge to tell climate change tale](#)"

Chemistry: "[The search for new geologic sources of lithium could power a clean future](#)"

Physics: "[Scientists seek materials that defy friction at the atomic level](#)"

Astronomy: "[Competing ideas abound for how Earth got its moon](#)"

Biology/health: "[Small intestine is the first stop for fructose](#)"

**Summarize which concept is applied in the current research described in the article and explain how a scientist or technology mentioned in the article applies the concept.**

