

# Information

## Formative Assessment Exemplar - Phys.4.3

### Introduction:

The following formative assessment exemplar was created by a team of Utah educators to be used as a resource in the classroom. It was reviewed for appropriateness by a Bias and Sensitivity/Special Education team and by state science leaders. While no assessment is perfect, it is intended to be used as a formative tool that enables teachers to obtain evidence of student learning, identify gaps in that learning, and adjust instruction for all three dimensions (i.e., Science and Engineering Practices, Crosscutting Concepts, Disciplinary Core Ideas) included in a specific Science and Engineering Education (SEEd) Standard.

In order to fully assess students' understanding of all three dimensions of a SEEd standard, the assessment is written in a format called a cluster. Each cluster starts with a phenomenon, provides a task statement, necessary supporting information, and a sequenced list of questions using the gather, reason, and communicate model (Moulding et al., 2021) as a way to scaffold student sensemaking. The phenomenon used in an assessment exemplar is an analogous phenomenon (one that should not have been taught during instruction) to assess how well students can transfer and apply their learning in a novel situation. The cluster provides an example of the expected rigor of student learning for all three dimensions of a specific standard. In order to serve this purpose, this assessment is NOT INTENDED TO BE USED AS A LESSON FOR STUDENTS.

Because this assessment exemplar is a resource, teachers can choose to use it however they want for formative assessment purposes. It can be adjusted and formatted to fit a teacher's instructional needs. For example, teachers can choose to delete questions, add questions, edit questions, or break the tasks into smaller segments to be given to students over multiple days.

Of note: All formative assessment clusters were revised based on feedback from educators after being utilized in the classroom. During the revision process, each cluster was specifically checked to make sure the phenomena was authentic to the DCI, supporting information was provided for the phenomena, the SEPs, CCCs, and DCIs were appropriate for the learning progressions, the cluster supported student sensemaking through the Gather, Reason, and Communicate instructional model, and the final communication prompt aligned with the cluster phenomena. As inconsistencies were found, revisions were made to support student sensemaking. If other inconsistencies exist that need to be addressed, please email the current Utah State Science Education Specialists with feedback.

### General Format:

Each formative assessment exemplar contains the following components:

1. Teacher Facing Information: This provides teachers with the full cluster as well as additional information including the question types, alignment to three dimensions, and answer key. Additionally, an example of a proficient student answer and a proficiency scale for all three dimensions are included to support the evaluation of the last item of the assessment.
2. Students Facing Assessment: This is what the student may see. It is in a form that can be printed or uploaded to a learning platform. (Exception: Questions including simulations will need technology to utilize during assessment.)

### Accommodation Considerations:

Teachers should consider possible common ways to provide accommodations for students with disabilities, English language learners, students with diverse needs or students from different cultural backgrounds. For example, these accommodations may include: Providing academic language supports, presenting sentence stems, or reading aloud to students. All students should be allowed access to a dictionary.

### References:

Moulding, B., Huff, K., & Van der Veen, W. (2021). *Engaging Students in Science Investigation Using GRC*. Ogden, UT: ELM Tree Publishing.

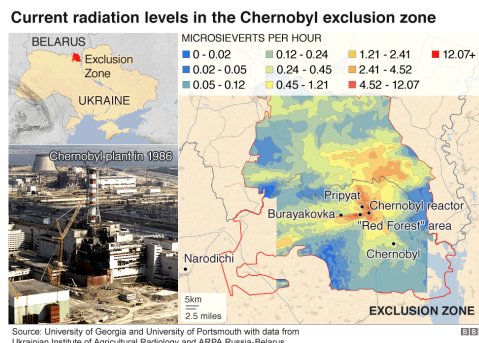
# Teacher Facing Info

## Teacher Facing Information

**Standard:** Phys.4.3

**Assessment Format:** Printable or Online Format (Does not require students to have online access)

| Phenomenon                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>The <b>Chernobyl Nuclear Power Plant</b> is a closed nuclear power plant . The <b>Chernobyl disaster</b> was a nuclear accident that occurred on Saturday 26 April 1986, at the No. 4 reactor in the Chernobyl Nuclear Power Plant, near the city of Pripjat in the north of the Ukrainian SSR in the Soviet Union. It is considered the worst nuclear disaster in history. What happened in Chernobyl caused a release of <b>gamma radiation</b> which is an <b>electromagnetic wave</b>. This type of radiation is extremely dangerous for living organisms.</p>                                                                                                               | <p>Proficient Student Explanation of Phenomenon:</p> <p>Electromagnetic radiation interacts with biological systems, but not all electromagnetic radiation is dangerous or damaging to biological systems. Damaging interactions of electromagnetic radiation occur when a high energy electromagnetic wave causes ionization to sub-cellular systems (e.g. DNA). Electromagnetic radiation with shorter wavelength/higher frequency has higher energy.</p> <p>High energy electromagnetic waves, in the form of gamma radiation or gamma rays were released (and continue to be released) as a result of the Chernobyl disaster. The resulting release of gamma radiation has caused changes to living organisms in the area surrounding the reactor.</p> |
| Cluster Task Statement                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <p>In the questions below, you will evaluate scientific information to determine why Chernobyl caused so many health effects while cell phones do not, despite near constant exposure.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Supporting Information                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <div> <div> <p><b>Chernobyl</b></p> <p>Chernobyl was a nuclear reactor that melted down and released many types of radiation, including gamma radiation, into the surrounding areas. Thirty-one people died, but many more suffered health effects due to the exposure. The gamma radiation released is part of the electromagnetic spectrum.</p> </div> <div> <p><b>Cell Phones</b></p> <p>Cell phones use radio waves to send and receive information through the air. These waves are all around us and we are exposed to them constantly. Radio waves are also part of the electromagnetic spectrum, yet do not cause the health effects seen with Chernobyl.</p> </div> </div> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

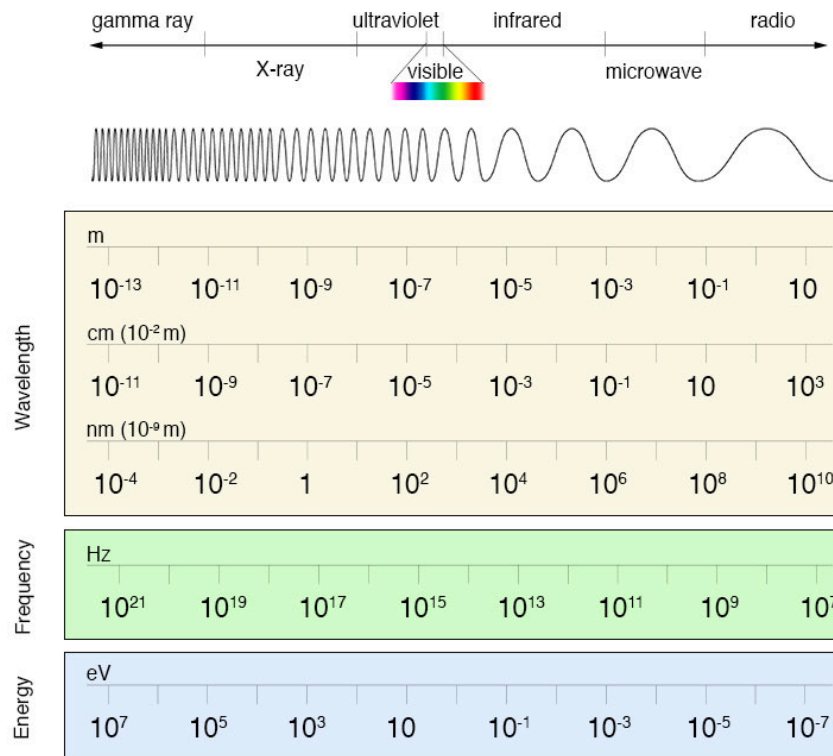


## Supporting Information:

### The Electromagnetic Spectrum (EMS)

However, not all electromagnetic radiation damages cells. Different wavelengths of radiation have different energies. The electromagnetic spectrum is the range of all types of electromagnetic radiation. The electromagnetic spectrum incorporates the full range of electromagnetic waves: from low energy radio waves, with low frequency, and long wavelength, all the way up to high energy gamma waves (or gamma rays), with high frequency and short wavelength.

**Figure 1: Energies, Frequencies, and Wavelengths of Electromagnetic Spectrum**

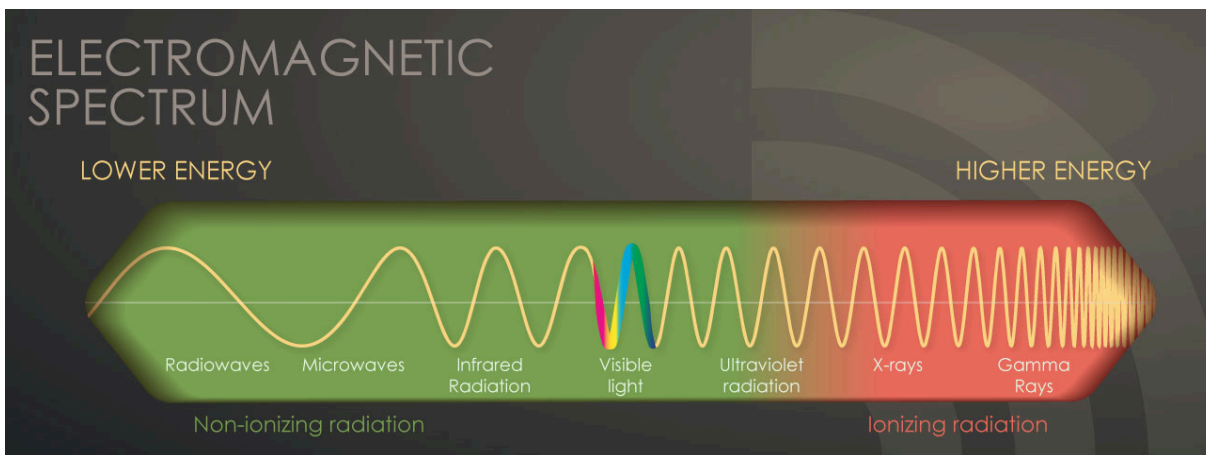


### Biological Effects

The electromagnetic spectrum can be divided into **non-ionizing** and **ionizing radiation**.

Electronic devices that send information through the air are everywhere. Between Wi-Fi, cell phones and other networks, people are in a nearly constant cloud of wireless signals. These devices use radio waves to send and receive information.

**Figure 2: Non-Ionizing vs. Ionizing Radiation**



**Ionizing radiation** is what causes biological changes such as mutations. Radiation surrounds us but large dosages can have dramatic and life changing effects. This form of radiation can cause damage to living tissue at high level doses. **Ionizing radiation** is radiation consisting of particles, X-rays, or gamma rays with sufficient energy to cause ionization (creating charged atoms or particles) in the medium through which it passes.

Exposure to high levels of ionizing radiation can result in mutation, radiation sickness, cancer, and death. The energy from radiation can damage or break DNA molecules. Sometimes DNA can't be repaired, producing a **mutation**, resulting in tumors and affecting an animal's ability to reproduce. If a mutation occurs in sex cells, it can result in an embryo with birth defects. Due to the **short wavelength** of gamma Rays, they have a **high frequency**, and therefore a high **amount of energy**. This means that the amount of energy they transfer to materials they interact with can be intense enough to cause damage to the structure of the material.

Radio waves are a type of **non-ionizing radiation**. Radio waves have a **long wavelength, low frequency** and **low energy**. Non-ionizing radiation is not strong enough to directly affect the structure of atoms or damage DNA; however, it can somewhat increase the heat of tissues.

Text and information in this cluster are referenced from the following:

[Electromagnetic Spectrum Imagine the Universe! | NASA](#)

[What is Radiation? The Electromagnetic Spectrum | CDC](#)

[Non-ionizing Radiation from Wireless Technology | EPA](#)

### Cluster Questions

Gather:

Cluster Question #1

Question Type: Fill in the blank

Addresses:

\_\_\_\_ DCI (PS4.B)

\_\_\_\_ SEP Obtaining, Evaluating,  
and Communicating Information

Item:

When Chernobyl melted down, it released large amounts of Gamma Radiation. Gamma Radiation is a type of \_\_\_\_\_.

Word options

- electromagnetic wave
- visible light

| <p>____ CCC</p> <p>Answer:</p> <p>Electromagnetic Wave</p>                                                                                                                                                                                                                                                                                                                                          | <ul style="list-style-type: none"> <li>- neutron radiation</li> <li>- microwave</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                    |                        |  |  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|------------------------|--|--|
| <p>Gather:</p> <p>Cluster Question #2</p> <p>Question Type: fill in the blank (with drag-and-drop)</p> <p>Addresses:</p> <p>____ DCI (PS4.B)</p> <p>____ SEP SEP Obtaining, Evaluating, and Communicating Information</p> <p>____ CCC Cause and effect</p> <p>Answer:</p> <p>Correct order:</p> <p>frequencies/energies</p> <p>energies/frequencies</p> <p>ionizing radiation</p> <p>mutations</p>  | <p>Item:</p> <p>Using the provided word bank, fill in the blanks to correctly complete the statement.</p> <p>Not all electromagnetic radiation is ionizing radiation. Different _____ have different _____. _____ is radiation consisting of particles, X-rays, or gamma rays with sufficient energy to cause ionization. Ionizing radiation is what causes biological changes, such as _____.</p> <p>Word Bank:</p> <ul style="list-style-type: none"> <li>• frequencies</li> <li>• energies</li> <li>• mutations</li> <li>• ionizing radiation</li> </ul>                   |                    |                        |  |  |
| <p>Gather:</p> <p>Cluster Question #3</p> <p>Question Type: Multiple Choice</p> <p>Addresses:</p> <p>____ DCI (PS4.B)</p> <p>____ SSEP SEP Obtaining, Evaluating, and Communicating Information</p> <p>____ CCC</p> <p>Answer:</p> <p>Ionizing– UV, X-Ray, Gamma</p> <p>Non-Ionizing– Radio, Micro, Infrared, Visible Light, UV</p> <p>(The dividing line is in the middle of the UV spectrum.)</p> | <p>Item:</p> <p>Complete the T-chart below by listing the seven types of electromagnetic radiation from the spectrum as either ionizing or non-ionizing. If the section of the EMS is at the break point, you may include it on both charts.</p> <table border="1" data-bbox="618 1211 1414 1524"> <thead> <tr> <th data-bbox="618 1211 1016 1278">Ionizing Radiation</th><th data-bbox="1016 1211 1414 1278">Non-Ionizing Radiation</th></tr> </thead> <tbody> <tr> <td data-bbox="618 1278 1016 1524"></td><td data-bbox="1016 1278 1414 1524"></td></tr> </tbody> </table> | Ionizing Radiation | Non-Ionizing Radiation |  |  |
| Ionizing Radiation                                                                                                                                                                                                                                                                                                                                                                                  | Non-Ionizing Radiation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                    |                        |  |  |
|                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                    |                        |  |  |
| <p>Reason:</p> <p>Cluster Question #4</p> <p>Question Type: multiple choice</p> <p>Addresses:</p> <p>____ DCI(PS4.B)</p> <p>____ SEP SEP Obtaining, Evaluating, and Communicating Information</p>                                                                                                                                                                                                   | <p>Item:</p> <p>What is the relationship between energy and frequency?</p> <ul style="list-style-type: none"> <li>A. AA/Exponential</li> <li>B. Inversely Proportional</li> <li>C. Directly Proportional</li> <li>D. Inverse Square</li> </ul>                                                                                                                                                                                                                                                                                                                                |                    |                        |  |  |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>____ CCC Cause and effect</p> <p>Answer:</p> <p>C</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <p>Reason:</p> <p>Cluster Question #5</p> <p>Question Type: short answer</p> <p>Addresses:</p> <p>____ DCI (PS4.B)</p> <p>____ SEP SEP Obtaining, Evaluating, and Communicating Information</p> <p>____ CCC Cause and effect</p> <p>Answer:</p> <p>Ionizing radiation can damage DNA, which can lead to mutations and birth defects.</p> <p>Non-ionizing radiation does not have enough energy to damage DNA.</p>                                                                                                                                                                                                                                                                                  | <p>Item:</p> <p>How does ionizing radiation affect cells, which leads to negative health effects? Why does non-ionizing energy not have these same effects?</p>                                                                                                                                                                                                                                                                                                                  |
| <p>Communicate:</p> <p>Cluster Question #6</p> <p>Question Type: long answer</p> <p>Addresses:</p> <p>____ DCI (PS4.B)</p> <p>____ SEP SEP Obtaining, Evaluating, and Communicating Information</p> <p>____ CCC Cause and effect</p> <p>Answer:</p> <p>Student answers should contain the following in order to demonstrate mastery of standard:</p> <ul style="list-style-type: none"> <li>- References data from the charts</li> <li>- uses 3 Direct textual quotes directly tied to supporting their evaluation</li> </ul> <p>DCI/concepts:</p> <ul style="list-style-type: none"> <li>- Gamma rays are ionizing radiation</li> <li>- ionizing radiation causes damage to biological</li> </ul> | <p>Item:</p> <p>Evaluate all the presented information to answer the question, "Why did Chernobyl cause so many health effects while using a cell phone does not, even though they both involved radiation from the electromagnetic spectrum?"</p> <ul style="list-style-type: none"> <li>- Reference data from the two charts provided</li> <li>- Use 3 direct textual citations from the provided reading</li> <li>- Thoroughly and completely answer the question.</li> </ul> |



|                                                                                                                                                                                       |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| materials <ul style="list-style-type: none"> <li>- Radio waves are non-ionizing radiation</li> <li>- Non-ionizing radiation does not cause damage to biological materials.</li> </ul> |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|

### Proficiency Scale

**Proficient Student Explanation:** Chernobyl involved gamma radiation, which is a form of ionizing radiation. It was able to damage DNA and cause significant health issues, including death. However, cell phones use radio waves which are the lowest frequency/energy and are non-ionizing. This type of radiation does not have enough energy to cause damage to cells.

| Level 1<br>Emerging                                               | Level 2<br>Partially Proficient                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Level 3<br>Proficient                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Level 4<br>Extending                                 |
|-------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|
| <b>SEP:</b><br>Does not meet the minimum standard to receive a 2. | <b>SEP:</b><br>Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).<br><br>Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.<br><br>Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral | <b>SEP:</b><br>Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.<br><br>Compare, integrate, and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.<br><br>Communicate | <b>SEP:</b><br>Extends beyond proficient in any way. |

|                                                                   |                                                                                                                                                                                         |                                                                                                                                                                                                                                                              |                                                      |
|-------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|
|                                                                   | presentations.                                                                                                                                                                          | scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). |                                                      |
| <b>CCC:</b><br>Does not meet the minimum standard to receive a 2. | <b>CCC:</b><br>Cause and effect relationships may be used to predict phenomena in natural or designed systems.                                                                          | <b>CCC:</b><br>Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.                                                     | <b>CCC:</b><br>Extends beyond proficient in any way. |
| <b>DCI:</b><br>Does not meet the minimum standard to receive a 2. | <b>DCI:</b><br>When Light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. | <b>DCI:</b><br>Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons.                                                                                  | <b>DCI:</b><br>Extends beyond proficient in any way. |

(Student Facing Format on following page)

# Student Assessment

Name: \_\_\_\_\_ Date: \_\_\_\_\_

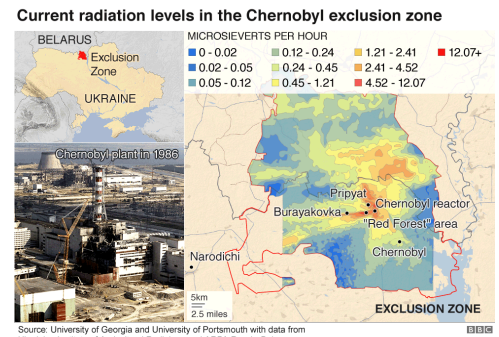
## Stimulus

### Chernobyl

Chernobyl was a nuclear reactor that melted down and released many types of radiation, including gamma radiation, into the surrounding areas. Thirty-one people died, but many more suffered health effects due to the exposure. The gamma radiation released is part of the electromagnetic spectrum.

### Cell Phones

Cell phones use radio waves to send and receive information through the air. These waves are all around us and we are exposed to them constantly. Radio waves are also part of the electromagnetic spectrum, yet do not cause the health effects seen with Chernobyl.

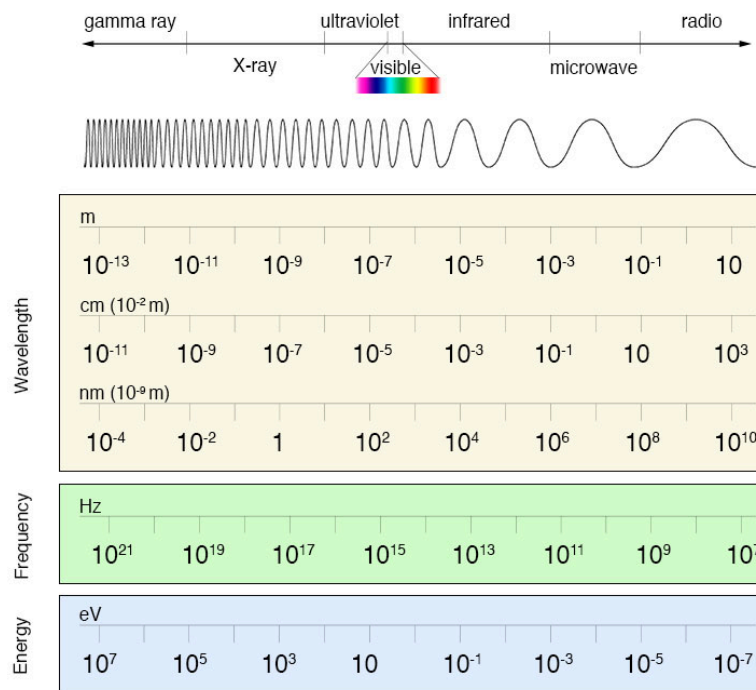


## Supporting Information:

### The Electromagnetic Spectrum (EMS)

However, not all electromagnetic radiation damages cells. Different wavelengths of radiation have different energies. The electromagnetic spectrum is the range of all types of electromagnetic radiation. The electromagnetic spectrum incorporates the full range of electromagnetic waves: from low energy radio waves, with low frequency, and long wavelength, all the way up to high energy gamma waves (or gamma rays), with high frequency and short wavelength.

Figure 1: Energies, Frequencies, and Wavelengths of Electromagnetic Spectrum

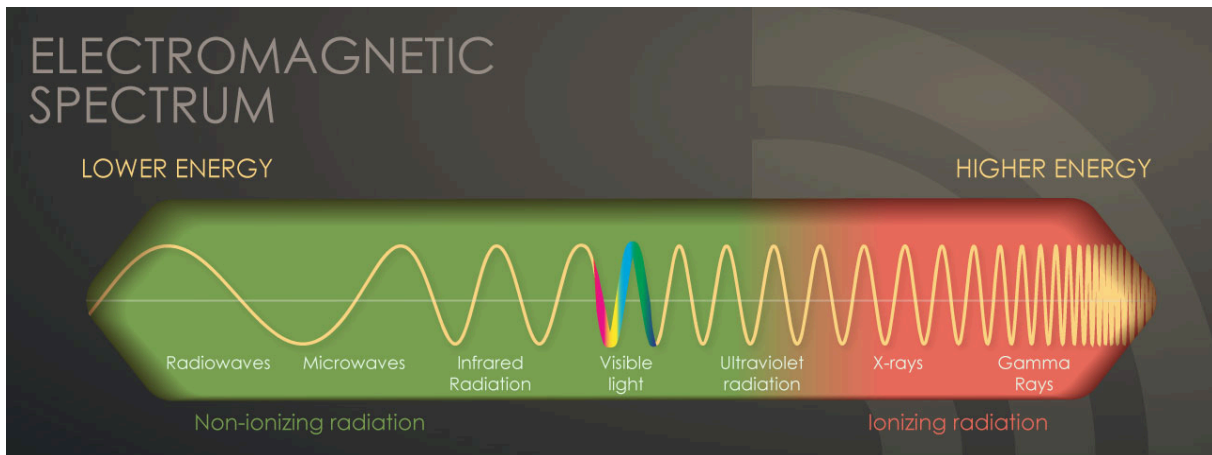


### Biological Effects

The electromagnetic spectrum can be divided into **non-ionizing** and **ionizing radiation**.

Electronic devices that send information through the air are everywhere. Between Wi-Fi, cell phones and other networks, people are in a nearly constant cloud of wireless signals. These devices use radio waves to send and receive information.

Figure 2: Non-Ionizing vs. Ionizing Radiation



**Ionizing radiation** is what causes biological changes such as mutations. Radiation surrounds us but large dosages can have dramatic and life changing effects. This form of radiation can cause damage to living tissue at high level doses. **Ionizing radiation** is radiation consisting of particles, X-rays, or gamma rays with sufficient energy to cause ionization (creating charged atoms or particles) in the medium through which it passes.

Exposure to high levels of ionizing radiation can result in mutation, radiation sickness, cancer, and death. The energy from radiation can damage or break DNA molecules. Sometimes DNA can't be repaired, producing a **mutation**, resulting in tumors and affecting an animal's ability to reproduce. If a mutation occurs in sex cells, it can result in an embryo with birth defects. Due to the **short wavelength** of gamma Rays, they have a **high frequency**, and therefore a **high amount of energy**. This means that the amount of energy they transfer to materials they interact with can be intense enough to cause damage to the structure of the material.

Radio waves are a type of **non-ionizing radiation**. Radio waves have a **long wavelength**, **low frequency** and **low energy**. Non-ionizing radiation is not strong enough to directly affect the structure of atoms or damage DNA; however, it can somewhat increase the heat of tissues.

### Your Task

In the questions below, you will evaluate scientific information to determine why Chernobyl caused so many health effects while cell phones do not, despite near constant exposure.

### Question 1

When Chernobyl melted down, it released large amounts of Gamma Radiation. Gamma Radiation is a type of \_\_\_\_\_.

Word options

- electromagnetic wave
- visible light
- neutron radiation
- microwave

### Question 2

Using the provided word bank, fill in the blanks to correctly complete the statement.

Not all electromagnetic radiation is ionizing radiation. Different \_\_\_\_\_ have different \_\_\_\_\_. \_\_\_\_\_ is radiation consisting of particles, X-rays, or gamma rays with sufficient energy to cause ionization. Ionizing radiation is what causes biological changes, such as \_\_\_\_\_.

Word Bank:

- frequencies
- energies
- mutations
- ionizing radiation

### Question 3

Complete the T-chart below by listing the seven types of electromagnetic radiation from the spectrum as either ionizing or non-ionizing. If the section of the EMS is at the break point, you may include it on both charts.

| Ionizing Radiation | Non-Ionizing Radiation |
|--------------------|------------------------|
|                    |                        |

### Question 4

What is the relationship between energy and frequency?

- A. Exponential
- B. Inversely Proportional
- C. Directly Proportional
- D. Inverse Square

### Question 5

How does ionizing radiation affect cells, which leads to negative health effects? Why does non-ionizing energy not have these same effects?

### Question 6

Evaluate all the presented information to answer the question, “Why did Chernobyl cause so many health effects while using a cell phone does not, even though they both involved radiation from the electromagnetic spectrum?”

- Reference data from the two charts provided
- Use 3 direct textual citations from the provided reading
- Thoroughly and completely answer the question.