Science Assessment System
Through Course Task

EMR Don't Damage My DNA

Grade Level:
9, 10, 11, 12

Phenomena:
High Energy EMR Can Damage DNA

Science & Engineering Practices:
Using Mathematics and Computational Thinking
Engaging in Argument from Evidence

Crosscutting Concepts:
Patterns
Cause and Effect

Designed and revised by Kentucky Department of Education staff
in collaboration with teachers from Kentucky schools and districts.

Preparing to implement Through Course Tasks in the Classroom

What is a TCT?

- TCTs are 3-dimensional tasks specifically designed to get evidence of student competency in two dimensions, Science and Engineering Processes (SEPs) and Crosscutting Concepts (CCC), untethered from Performance Expectations (PEs)/standards. Tasks are sense-making experiences.
- Tasks are to be used formatively. The goal is for both students and teachers to understand areas of strength and improvement for the SEP(s) and CCC assessed within the task.

How do I facilitate a Through Course Task (TCT)?

- TCT facilitation is a collaborative process in which teacher teams calibrate understanding of the expectations of the task and refine strategies to be used during task facilitation.

Before the task:

1. Complete the TCT as a learner – compare understanding of task through the lens of success criteria (identified in the task) in order to understand expectations.
   Success criteria include:
   - What is this task designed to get evidence of?
   - What is the task asking the students to do?
   - What might a student response look like?
2. Identify the phenomenon within the task. Consult resources to assure teacher teams have a deep understanding of associated science concepts.
3. Collaborate to generate, review and refine feedback questions during facilitation.
4. Identify potential “trouble spots” and plan for possible misconceptions.

During the task:

5. Collect defensible evidence of each student’s competencies in 3-dimensional sense-making for the task.
6. Ask appropriate feedback questions to support student access and engagement with the task in order to elicit accurate evidence of student capacities.

After the task:

7. Reflect on the task as a collaborative team.
8. Review student work samples to identify areas of strength and areas of need.
9. Determine/plan next steps to move 3-D sense making forward through the strengthening of the use of SEPs and CCCs.

Using the materials included in this packet:

- **Task Annotation:**
  - The task annotation is a teacher guide for using the task in the classroom. Additionally, the annotation gives insight into the thinking of developers and the task overall.

    - Each task has science and engineering practices, disciplinary core ideas, and crosscutting concepts designated with both color and text style:
        - **Science and Engineering Practices**
        - *Disciplinary Core Ideas*
        - <u>Crosscutting Concepts</u>
- **Student Task:** The materials to be used by students to complete the TCT.

EMR Don't Damage My DNA Task Annotation

After **using mathematical representations** for *the energy of different types of electromagnetic radiation*, **make a valid scientific claim** to predict the effect of *radiation exposure on living organisms* using patterns in the data as evidence **to support your claim.**
Phenomenon within the task: High-energy (or short wavelength) electromagnetic radiation interacts with the DNA in living organisms to cause tissue damage.

Possible struggles
Electromagnetic radiation (and in some cases, its interaction with matter) is an abstract concept that cannot be seen. Typical students will struggle with handling numbers in scientific notation, understanding comparative values in scientific notation (especially those having negative exponents) and the energy calculations (especially the use of constants).

Possible misconceptions
The term "radiation" in everyday life usually has negative connotations (cancer, nuclear weapons, etc.) for most students, but students need to know that not all types of electromagnetic radiation damage living organisms.

How the phenomenon relates to DCI

- **HS-PS4.A Disciplinary Core Idea:** The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave.
- **HS-PS4.B Disciplinary Core Idea:** Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.
- **MS-PS4.A Disciplinary Core Idea:** A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. A sound wave needs a medium through which it is transmitted.

What information/data will students use within this task?
Students will use various sources of information in the task to evaluate the effect of electromagnetic radiation on living organisms including:

- a figure of a wave that helps students visualize wavelength
- a model that shows how types of electromagnetic radiation may damage the structure of DNA
- a form of the Planck equation, $E = hc/\lambda$, including constants in scientific notation
- a table that gives the type of radiation and its corresponding wavelength range
- a blank table for organization of data based on a criterion decided upon by student

Students may also use **prior knowledge** about possible effects of and prevention against radiation exposure such as sunburns/sunscreen and x-rays/lead cape. However, students should focus on their data (calculated energy values) to support their claim.

Ideas for setting up the task with students

- It is suggested that this task be completed as part of the atomic structure unit before discussing how light is emitted when electrons in atoms are excited. This is necessary for students to develop their own reasoning about the relationship between energy and damage to the DNA in living organisms. Please keep in mind the suggestions below are based on our teacher team's collaboration process to ensure that all of our students could access the task. These are only suggestions; you do not have to implement the task in the same way.
- Practice use of calculator with scientific notation. Review scientific notation, especially the meaning of positive and negative exponents.
- Practice solving for variables in scientific equations that involve constants and/or data in scientific notation. For example, use $c = \nu \lambda$ or $PV = nRT$ to practice solving for one of the missing variables.
- https://www.youtube.com/watch?v=cfXzwh3KadE Pause video at **2:13 and skip to 2:30** to skip energy and wavelength discussion which is the intent of this TCT. Some students were exposed to this portion of the video due to the teacher forgetting to pause it during that portion and we found that it did not affect the range or average quality of the responses.
- Have students read the introduction and annotate. Ask students to write down two main ideas from the introduction. Then do Think, Pair, Share with a partner to come to a consensus of the two main ideas in the introduction. Each student writes down one of the consensus ideas on the whiteboard. Share main ideas as a class.
- Students read Part A and identify the important information from the passage. In partners, students choose a wavelength in the range for visible light. Discuss the chosen wavelengths as a class to ensure that students understood how to correctly choose the wavelength.

- In order to scaffold for time or lower-level math students, teachers can include chosen wavelengths for all types of radiation in Table 2.
- Student pairs complete the chosen wavelength column. An option for scaffolding for lower-level students is to have the teacher verify that the chosen wavelength is within the range, especially for ultraviolet and gamma radiation.
- Student pairs calculate the energy of their chosen visible wavelength. Teacher verifies that their first calculation is accurate. Then student pairs calculate the energies for the remaining chosen wavelengths. To scaffold for lower-level students, it may be a good idea for the teacher to check all energy calculation results before proceeding.
- Once all students have completed their energy calculations, Table 2 is completed in pairs. Make additional copies of Table 2 available in case students need to rework their organization of the data.
- Parts B & C are intended to be completed by students individually. As a scaffolding idea, have students independently read Part B of the task, restate it in their own words, and share with the class. Same for Part C.
- Another scaffolding idea for the argumentation portion of the task is for students to use the space available below Part C to write down their claim and jot down notes about each of the pieces of evidence they will utilize in their argument. Also, they can be given a CER rubric.
- Some optional “lined” response sheets for the argument are provided as resources, including one that has the claim, evidence, and reasoning separated from each other for lower-level students.

Intent of the Task for Assessment

This task was designed to meaningfully engage students in the idea that electromagnetic radiation exists essentially everywhere on Earth in many different forms, and that some forms of electromagnetic radiation can damage human tissue because these forms can disrupt cellular DNA. Some natural questions are, “What types of electromagnetic radiation can damage DNA?” and “Why do these types cause damage (and not others)?” In the storyline about “electrosmog,” students are provided text that prompts thinking about cancer-causing radiation they are likely to have heard about in their lives. A figure is included that shows two waves interacting with DNA in a way that one disrupts the sequence while another does not. These two waves were chosen deliberately because they occur sequentially in the electromagnetic spectrum. This allows students to determine (later in the task) that radiation with energies greater than and including ultraviolet will cause damage to the DNA. Wavelength ranges are given for the different radiation types. Students select a single wavelength to be used in the equation to calculate the energy. In order to make sense of the energy levels for each type of electromagnetic radiation, students have to do calculations, arrange the data in a way to reveal a pattern or trend in the data and then identify a relationship between wavelength and energy. This part of the task involves messy calculations that high school students may struggle with, so allowing students to complete this part of the task in pairs or groups to catch errors and make the work less tedious may be a reasonable approach. It could also be considered, for the sake of time, that teachers provide the "chosen wavelength" in the range for each type of radiation. However, students performing the energy calculations (Using Mathematical and Computational Thinking) is part of the original intent of the task. Prior to performing the actual energy calculations, teachers should stress the importance of estimating these values (using law of exponents) so students consider the reasonableness of answers. This should eliminate some of the common mistakes involving scientific notation in calculations, especially with a calculator. Teachers should circulate to identify student success and struggles, and scaffold appropriately.

Part C of the task is intended to be completed independently, and is intended to provide evidence about a student's ability to develop an argument: make a claim, support it with evidence from their calculations, information from the text and DNA figure (possibly including background knowledge) and provide reasoning as to why their evidence supports their claim.

Claim, Evidence, Reasoning Information

At the beginning of the year, this website was used to make a general outline (occurs right before the Bozeman video) for students regarding what should be included in the claim, evidence and reasoning (CER) of a scientific argument. If students are not familiar with CER (or continue to struggle with it), a general outline, such as the one on this website, may be helpful to handout or discuss during the task.

Pre-task Activities

As a teacher team, we developed many pre-task activities which included practice worksheets involving:

- converting quantities between numerical and scientific notation
- comparing values in scientific notation to determine larger or smaller numbers
- doing calculations in scientific notation using law of exponents, estimation and calculator
- solving scientific equations (using unfamiliar quantities and units) for a variable

Success Criteria

Evidence of Learning Desired based on Progression from Appendices

Using Mathematical and Computational Thinking

- Use mathematical, computational, and/or algorithmic representations of phenomena to support claims.
- Organize data sets to reveal patterns that suggest relationships. (This is from the 3-5 grade band but this is an essential skill and the nature of the data in scientific notation makes the level of rigor appropriate for high school).

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
- Mathematical representations are needed to identify some patterns.

Engaging in Argument from Evidence

- Make and defend a claim based on evidence about the natural world that reflects scientific knowledge and student-generated evidence.

Cause and Effect

- Cause and effect relationships can be suggested and predicted for complex natural systems by examining what is known about smaller scale mechanisms within the systems

Success Criteria

- Student chooses representative wavelength for each type of electromagnetic radiation and accurately calculates the energy associated with this wavelength. (This is done collaboratively.)
- Student organizes their data in a way to show a pattern or trend (increasing or decreasing wavelength, increasing or decreasing energy) and describes the relationship between wavelength and energy.
- Students make a claim about the types of radiation that are likely to damage living organisms and provide evidence to support their claim. (Evidence should come from their data analysis and page 1 of the task.)
- Students provide reasoning for why the evidence they provided supports their claim

Possible Student Responses

Using Mathematical and Computational Thinking

- Students successfully choose representative wavelengths within the range for each type of radiation and record it into Table 1. (This can be completed by the teacher if time does not allow.)
- Students show their work and successfully calculate the energy of their chosen wavelength for each type of radiation using the speed of light and Planck’s constant. They record their results into Table 1.

- Students successfully organize their data in Table 2 to show a trend or pattern.
- See completed Data Table KEY for Tables 1 and 2 (in resources).
- Students identify the criterion used in organizing their data (either increasing or decreasing wavelength OR increasing or decreasing energy) in Part B.
- Possible Student Responses to Relationship:
    - As the wavelength increases, the energy of the wave decreases (or vice versa).
    - As the energy of the wave increases, the wavelength decreases (or vice versa).

Engaging in Argument from Evidence

Expectation of Student Response:

Claim:

- Ultraviolet, X-rays and gamma rays are likely to damage DNA in living organisms.

Evidence:

- Students reference a few of the ACTUAL student-generated energy values in Table 2 for different types of radiation that are likely to damage DNA in living organisms.
- Students use the model on Page 1 as evidence: In the DNA model from Page 1, visible light did not disrupt the DNA chain, whereas ultraviolet light did.

Reasoning:

- The model shows that ultraviolet radiation with a shorter wavelength can damage the DNA whereas visible light with a longer wavelength does not. According to the organization of the data by wavelength (or energy) in Table 2, only gamma rays and X-rays have shorter wavelengths than ultraviolet rays. Since shorter wavelength radiation has higher energy, the higher energy radiation (ultraviolet light, X-rays, and gamma rays) will damage the DNA. The energy from the radiation can be transferred to the DNA chain. The more energy associated with the type of radiation, the more damage it will tend to do (for example, earthquakes and hurricanes).

Other information teacher teams might find useful when preparing to use this task in the TCT process
Articles:

- Penetrating Ability of EMR
- How Does Radiation Affect Humans
- Teachers may wish to search for other articles that provide information about the effect of cell phones and sunscreen on the human body.

Videos:

- TED Talk: Is Radiation Dangerous
- How Radiation Damages Your DNA

Other Resources not noted above:

- NASA Unit Plan-Space Faring the Radiation Challenge-Radiation Damage in Living Organisms

Teacher Insight:

- Since we planned and included this task as part of a unit, it took a lot of time but we feel that it was worth the time spent because we were able to evaluate where our students were regarding all three dimensions of our KAS for Science. If you are using the task after your students have already mastered scientific notation and solving scientific equations for a variable, you will not need to complete the suggested pre-activities. If your students have not mastered these skills, they will need practice beforehand or you will need to do more of the task collaboratively to ensure they can access the task. If short on time, teachers can have students do the calculations together as a class or in pairs and share/check results before proceeding to the organization and argumentation portion of the task. We do think that using the mathematical and computational thinking involved in the energy calculations helps teachers evaluate where their students are regarding that particular science and engineering practice (SEP) so it should not be completely omitted.
- Some students struggled in choosing a wavelength within each range, especially for the ultraviolet and gamma ranges. For example, the range of ultraviolet radiation given is 1.0×10^{-8} to 3.8×10^{-7}m. A few students chose a wavelength of $1.0 \times 10^{-7.5}$. When probed about the meaning of scientific notation, they recognized that it is impossible to move the decimal place 7.5 place values. Gamma radiation has a wavelength range less than 1.0×10^{-11} m. Initially, several students chose a negative

coefficient instead of concentrating on the exponent. The teacher needs to be actively roaming the classroom to catch these errors.

- For evidence and reasoning in their scientific argument, some students focused more on their own background knowledge of radiation exposure rather than including evidence from their calculations and figures. While appropriately using background knowledge is acceptable, they must also cite evidence from the tables, DNA figure and passage for a strong argument.

Extensions and/or other uses after the task is implemented

- Consider reading article(s) or watching videos to extend student learning regarding damage from electromagnetic radiation. Refer to KAS Science Standards related to DCI PS4.A and PS4.B regarding wave properties and electromagnetic radiation. In particular, the Performance Expectation HS-PS4-4 is to evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
- Consider using ACT passages in which students must analyze data for patterns, especially when the data is not organized.
- This task can be followed by a Process Oriented Guided Inquiry Learning (POGIL) called “Electron Energy and Light” as well as a flame test lab and emission spectra activities. This task provides an introduction to the electromagnetic spectrum which leads into early experiments that developed the current model of the atom.

Don't Damage My DNA -- Example of Daily Schedule Teacher Implementation of Task

Please keep in mind that this is a general timeline and example narrative which was developed by the high school teachers on our team during the pre-TCT collaborative process. It is not required to complete the task, but is being provided as a possible tool to help teachers with task facilitation. This was used to implement the task based on what we felt our students needed at the time in our curriculum to access the task. Please adjust and scaffold based on your time constraints and the level of your students. In our curriculum, we no longer do a huge (and boring) measurement unit at the beginning of the year but instead include content at the time it is needed by bundling NGSS standards. Therefore, we had not gone over scientific notation yet and decided to teach it right before students engaged in this task. Another possible scaffold or time saver is to do the calculations in Table 2 of the task collaboratively (without previous instruction) which will allow teachers to show students how to solve scientific equations with constants and numbers in scientific notation using their calculators.

Pre-Task Lessons

Day 1

- Review Scientific Notation Powerpoint of basic scientific notation principles.
- Do example problems converting from scientific notation to numerical form and vice versa in class using white boards.
- Hand out Scientific Notation Reference Sheet to go into binder. (Just hand out but do not go over.)
- Complete Scientific Notation Practice Worksheet Part 1 (or for homework if you run out of time).

Day 2

- Go over answers to Scientific Notation Practice Worksheet Part 1.
- Begin Scientific Notation Practice Worksheet Part 2 Parts B and C without a calculator. Students use their knowledge of the laws of exponents to determine the answer to the problem in scientific notation.
- Provide instruction on how to use calculator to solve problems in scientific notation, especially division problems due to "operator error" (not using EE or EXP button or parentheses for value in denominator).
- Complete Part E using calculator, students first estimate the answer to each scientific notation problem (multiplication/addition/subtraction/division). Then using their calculator, students perform the calculations and write their final answer in scientific notation.
- Station Worksheets can be homework or may not be necessary.

Day 3

- If necessary, review homework assignments or anything students are struggling with from Day 2.
- Give a short quiz on scientific notation.
- Begin **Practice Solving Scientific Equations Worksheet(s)**. We find that students are intimidated by strange symbols for scientific quantities or units. This type of practice also prepares them for strange symbols on ACT. These worksheets help them identify the variables and constants (including their units), determine where to plug them into the equation, and solve for the identified variable. For lower-level students, color coding the variables in the equation along with the corresponding numerical quantities in the word problem helped them focus only on the information needed to solve the equation.

- Recommendation: Have students go over a problem as a class (showing color coding technique) and then allow them to work with a partner to complete the rest. If time allows, go over answers.

Don't Damage My DNA task (teacher narrative and schedule)

Day 1

1. Pass out ONLY first two pages of task (Introduction and Table 1 as back–to-back copy).

   Instructions to students: Today we are going to do a task that will help each of us assess where you are in terms of your ability to make sense of things using scientific concepts and processes.

2. Read ONLY the Storyline to the students, then play the YouTube video referenced in the task. (If you do not want your students to hear about the energy and wavelength relationship pause video a 2:13 and restart at 2:30.)

   Instructions to students: Individually, read the introduction to the task-FIRST PAGE ONLY, but do not go any further. As you read, annotate by marking up the text and write down two main ideas in the introduction. I will give five minutes for you to complete this.

3. Students do a "think, pair, share" of main ideas. Students have already thought about two main ideas while annotating. Then, students work with a partner and agree on two main ideas from the introduction.

   Instructions to students: Move your desks so you can share with a partner. If there is anything that you did not understand in the introduction, see if your partner can help you make sense of it. If as a pair you need help with any terminology or concepts, ask me as I roam around the room. Then, with your partner, come up with two main ideas from the article and rank them as #1 and #2. One partner write the #1 main idea on one whiteboard and then the other partner write the #2 idea on their whiteboard. I will give you five minutes to complete this.

4. Share out main ideas.

   Instructions to students: Is there a student willing to record the main ideas from the class on the board? (Call on a student to share their main idea from their whiteboard.) Can you please share your main idea? (Record on board.) With a show of hands, how many of you have the same or similar main idea on your whiteboard? If yes, flip your whiteboard over face down on your desk. (Call on another student that does not have whiteboard flipped to share their main idea, record and continue until all main ideas are shared and whiteboards are flipped.)

   Instructions to students: Read Part A. Mark, circle, or highlight equations given, constants, and any other important information.

   Instructions to students: Consider the first type of radiation - VISIBLE. With a partner, using your mental math sense and scientific notation skills we have been practicing in previous activities, determine a wavelength in meters that fits within the wavelength range of wavelength given for VISIBLE light. Do not move on to next type of radiation yet.

5. Share out values to ensure students can find a correct wavelength in the visible range.

   Instructions to students: WITH YOUR PARTNER, complete the rest of the chosen wavelength column in Table 1. Roam the room as students work on this to address any errors or misconceptions.

6. Have students work in pairs to complete the rest of the chosen wavelength column in Table 1. For lower-level students, it is helpful to check all chosen wavelengths before moving on.

Day 2

1. Make sure all students chosen wavelength columns are correct. (particularly lower-level students)
2. Instructions to students: **Using the information given in Part A, calculate the energy of the radiation for that wavelength and record in Table 1 ON YOUR OWN. Then check your answer with your partner. If your answers agree, move on to the next type of radiation. Continue through the rest of the types of radiation.** NOTE: Students only have the introduction and Table 1 at this point so they cannot work ahead on the task. If students are lower-level, you should check their energy calculations using the KEY provided before moving on.
3. Once all students have completed Table 1, pass out Table 2 (copied as single front page-have extra copies available). DO NOT HAND OUT PARTS B AND C YET!! Read instructions to students above Table 2 on the task. Students complete organization with their partner. Roam the room to check on student progress.
4. Once all students have completed Table 2, hand out Parts B and C-the scientific argument (copied as single front page).
5. IMPORTANT: **Parts B & C are intended to be completed by students individually**. As a scaffolding idea, have students independently read Part B of the task, restate it in their own words, and share with the class. Same for Part C. Another scaffolding idea for the argumentation portion of the task is for students to use the space available below Part C to write down their claim and jot down notes about each of the pieces of evidence FROM THE TASK they will utilize in their argument. Also, they can be given a CER rubric (see resources) In addition, some optional "lined" response sheets for the argument are provided as resources, including one that has the claim, evidence, and reasoning separated from each other (with descriptions) for lower-level students.

NICE JOB-TASK COMPLETE!!

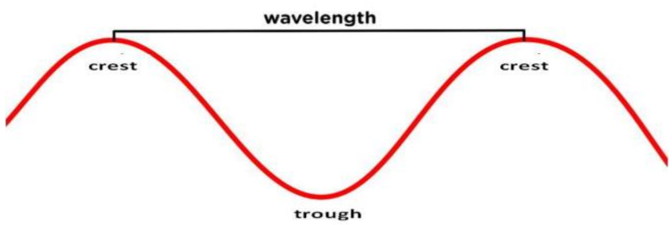
Through Course Task – EMR Don't Damage My DNA

Jason approaches his chemistry teacher, Mrs. Atomos, and says, "I watched on the news last night that electrosmog, the electromagnetic waves surrounding us in our environment, is harming our health because it damages our DNA and causes cancer. Is this true? I watched a video on YouTube from NASA and it showed that we are exposed to many types of electromagnetic waves every single day. It looked kind of scary. Does this mean that our cell phones, microwaves, computers, televisions and radios can cause cancer by damaging our DNA?"

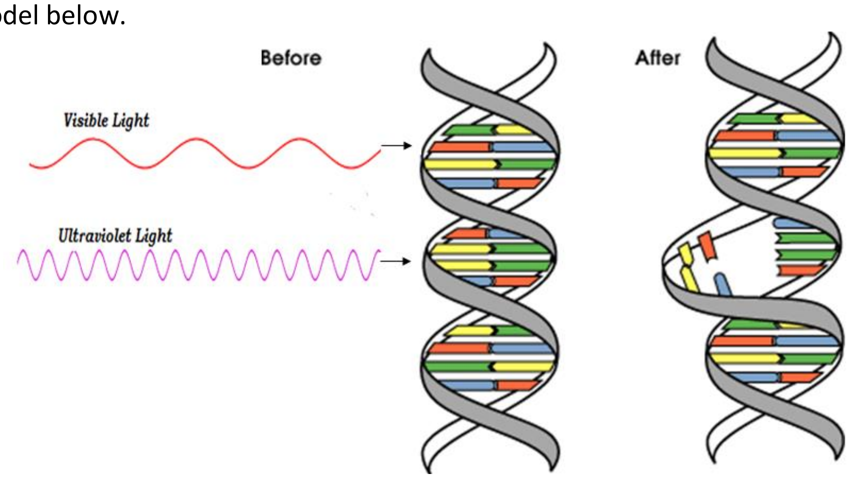
Mrs. Atomos says, "Let's watch the video (https://www.youtube.com/watch?v=cfXzwh3KadE) in chemistry class and investigate whether all types of electromagnetic radiation affect our DNA."

Background

The electromagnetic spectrum consists of all of the wavelengths for the different types of electromagnetic waves, including gamma rays, X-rays, ultraviolet light, visible light, infrared light, microwaves and radio waves. Generally, scientists classify types of electromagnetic waves based on the wavelength, which is defined as the distance between successive crests (peaks) or troughs (valleys) on a wave as shown in the figure below. The wavelengths in the electromagnetic spectrum can range from 10^{-12} to 10^{7} meters (m).



All living organisms are exposed to radiation on a daily basis. More commonly, we think about exposure from man-made radiation, such as X-rays, tanning beds and cancer therapy. We are also exposed to background radiation from cosmic rays in space, sunlight, radioactive waste, radon decay, nuclear tests and nuclear accidents. When electromagnetic radiation interacts with living organisms, the energy of the radiation may cause changes in the DNA helix as demonstrated in the model below.



Look closely at the model above, which indicates how damage to the cell by the direct action of certain types of radiation on the DNA molecules might occur. A structural change, caused by a breakage in the DNA sequence, can lead to the damage or death of a cell. Even if a damaged cell survives the radiation exposure, cancer or other abnormalities can eventually occur. It might be helpful to examine the different wavelengths and energies associated with the types of radiation represented in the model above to determine which ones are more harmful to DNA.

Part A: When waves interact with matter, they transfer energy. If we examine the relationship between the wavelength and the amount of energy that can be transferred by electromagnetic waves, it can give us insight into which types of radiation can do damage to DNA. If we understand the relationship between the amount of energy and the wavelength associated with different types of electromagnetic radiation, it might explain why it causes the damage it does to cells. To help us analyze this relationship, we need to take into account that **all** electromagnetic radiation travels at a constant speed, the speed of light (c = 3.00×10^8 m/s). Then it is possible to calculate the amount of energy associated with any wavelength (λ) using this equation:

$$E = \frac{hc}{\lambda} \quad \text{where } h = 6.63 \times 10^{-34}\ \text{J·s (Planck's constant)}$$

For each type of radiation given in the table below, choose a wavelength (λ) within the range **<u>(not at the boundaries)</u>** and record in Table 1. Calculate the energy of that particular wavelength using the equation above. Record in Table 1. Remember to include the units.

Table 1:

Electromagnetic radiation	Speed of Light (c)	Wavelength (λ) range	Your chosen wavelength (λ)	Energy (E) of your chosen wavelength
Visible	3.00×10^8 m/s	3.8×10^{-7} m – 7.5×10^{-7} m		
Gamma	3.00×10^8 m/s	< $1. \times 10^{-11}$ m		
X-Rays	3.00×10^8 m/s	1×10^{-11} m – 1×10^{-8} m		
Ultraviolet	3.00×10^8 m/s	1.0×10^{-8} m – 3.8×10^{-7} m		
Microwave	3.00×10^8 m/s	1.00×10^{-3} m – 1.87×10^{-1} m		
Radio	3.00×10^8 m/s	1.87×10^{-1} m – 1×10^7 m		
Infrared	3.00×10^8 m/s	7.5×10^{-7} m – 1×10^{-3} m		

Show your work here:

Using the information in Table 1, organize the data in Table 2 below in a way that reveals a pattern or trend. You may request an additional copy of this table from your teacher if you need more than one attempt at organizing the data in a useful way.

Table 2:

Electromagnetic radiation	Speed of Light (c)	Your chosen wavelength (λ)	Energy (E) of your chosen wavelength
	3.00×10^8 m/s		
	3.00×10^8 m/s		
	3.00×10^8 m/s		
	3.00×10^8 m/s		
	3.00×10^8 m/s		
	3.00×10^8 m/s		
	3.00×10^8 m/s		

Part B: 1) In the space below, identify the criterion you used to organize your data in the table.
2) Describe a relationship (how the values are connected) based on the patterns or trends you observe in the data.

Part C: People talk about the dangers associated with exposure to certain types of electromagnetic radiation. Consider the relationship you identified in your data analysis and the models in the task introduction to think about the question, **"What type(s) of radiation are more likely to cause damage to DNA in living organisms?"**

Develop an argument to answer the guiding question above by using the data organized in Table 2, the models, and/or the relationship you identified in Part B as evidence of support.

Your argument must include:

1) a claim.
2) evidence to support your claim.
3) reasoning to connect your evidence with your claim.

Name:____Date:____________Period:____

Don’t Damage My DNA-Effect of Electromagnetic Radiation on Living Organisms Argument

Guiding Question: What type(s) of radiation are more likely to cause damage to DNA in living organisms?

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Name:____Date:____________Period:____

<u>Don't Damage My DNA-Effect of Electromagnetic Radiation on Living Organisms Argument</u>

Guiding Question: What type(s) of radiation are more likely to cause damage to DNA in living organisms?

Claim: Write a one sentence statement that answers the guiding question.

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Evidence: Provide scientific data that supports your claim. Your evidence should be relevant and sufficient.

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Reasoning: Explain how or why your evidence supports your claim using scientific principles.

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Effect of Electromagnetic Radiation on Living Organisms-Don't Damage My DNA-KEY

Table 1 KEY: Your students' responses should be within the range indicated. Note that each energy range in the tables is given as the smaller value → larger value.

Electromagnetic radiation	Speed of Light (c)	Wavelength (λ) range	Your chosen wavelength (λ)	Energy (E) of your chosen wavelength
Visible	3.00×10^{8} m/s	3.8×10^{-7} m – 7.5×10^{-7} m		2.65×10^{-19} J → 5.23×10^{-19} J
Gamma	3.00×10^{8} m/s	< $1. \times 10^{-11}$ m		> 1.99×10^{-14} J
X-Rays	3.00×10^{8} m/s	1×10^{-11} m – 1×10^{-8} m		1.99×10^{-17} J → 1.99×10^{-14} J
Ultraviolet	3.00×10^{8} m/s	1.0×10^{-8} m – 3.8×10^{-7} m		5.23×10^{-19} J → 1.99×10^{-17} J
Microwave	3.00×10^{8} m/s	1.00×10^{-3} m – 1.87×10^{-1} m		1.06×10^{-24} J → 1.99×10^{-22} J
Radio	3.00×10^{8} m/s	1.87×10^{-1} m – 1×10^{7} m		1.99×10^{-32} J → 1.06×10^{-24} J
Infrared	3.00×10^{8} m/s	7.5×10^{-7} m – 1×10^{-3} m		1.99×10^{-22} J → 2.65×10^{-19} J

Table 2 KEY: Your students' responses should be the same or reversed. This table is organized by increasing wavelength and decreasing energy.

Electromagnetic radiation	Speed of Light (c)	Your chosen wavelength (λ)	Energy (E) of your chosen wavelength
Gamma	3.00×10^{8} m/s		> 1.99×10^{-14} J
X-Rays	3.00×10^{8} m/s		1.99×10^{-17} J → 1.99×10^{-14} J
Ultraviolet	3.00×10^{8} m/s		5.23×10^{-19} J → 1.99×10^{-17} J
Visible	3.00×10^{8} m/s		2.65×10^{-19} J → 5.23×10^{-19} J
Infrared	3.00×10^{8} m/s		1.99×10^{-22} J → 2.65×10^{-19} J
Microwave	3.00×10^{8} m/s		1.06×10^{-24} J → 1.99×10^{-22} J
Radio	3.00×10^{8} m/s		1.99×10^{-32} J → 1.06×10^{-24} J