Lesson 11: How can we use EM radiation to create and store digital images?

Previous Lesson *We sorted cards and identified the wave properties that characterize harmful EM radiation. We used various data sources to identify the pattern of increased frequency and increased cancer risk. We found the water wave analogy model insufficient and then analyzed a photon model. We determined that in this case, the photon model better explains our evidence.*

This Lesson

Investigation

1 day

We wonder how EM radiation is used to create and store digital images. We read about how the interactions of X-rays with matter can be harnessed to create images of the internal structure of our body, and the advantages and disadvantages of digital and conventional radiography to achieve this. We wonder how EM radiation is used in wireless communication to transmit information.

Next Lesson *We will develop different ways to send messages with EM waves using a simulation. We will develop a model for this system and compare it to digital communication systems. We will gather information from multiple sources in various formats. We will integrate this information to summarize how our wireless electronic devices use EM waves to reliably communicate information.*

BUILDING TOWARD NGSS

HS-PS2-5, HS-PS4-1, HS-PS4-2, HS-PS4-3, HS-PS4-4, HS-PS4-5, HS-ESS2-4

What students will do

11.A Critically read scientific literature adapted for classroom use to determine the advantages and disadvantages of creating X-ray images using digital transmission and storage of information. (SEP: 8.1; CCC: 6.1; DCI: PS4.A.2, PS4.C.1)

What students will figure out

- Sensors that respond to EM radiation are very sensitive and can trigger electric currents that can be used to create digital images.
- Digital images can be reliably stored in our computers.

- Digital technologies can reduce the time of exposure to the ionizing radiation necessary in medical applications.

Lesson 11 • Learning Plan Snapshot

Part	Duration		Summary	Slide	Materials
1	4 min		**NAVIGATE** Share ideas about the types of information we can communicate with our devices.	A-B	*Unknown material with identifier: pr.l9.ref*
2	2 min		**IDENTIFY RELEVANT INTERACTIONS BETWEEN X-RAYS AND MATTER** Discuss the interactions between X-rays and matter that can be used for creating images of the internal structure of our bodies.	C	*Unknown material with identifier: pr.l9.ref*
3	3 min		**IDENTIFY AREAS OF UNCERTAINTY ABOUT IMAGING USING X-RAYS** Notice and wonder about how X-ray technologies work to create images.	D	
4	20 min		**OBTAIN INFORMATION ABOUT X-RAY TECHNOLOGIES** Read about X-ray technologies to gather information about the advantages and disadvantages of digital and conventional radiography.	E-F	*Radiography: Conventional versus Digital*
5	11 min		**DISCUSS ADVANTAGES AND DISADVANTAGES OF CREATING AND STORING DIGITAL IMAGES** Discuss the main ideas from the reading about the pros and cons of digital radiography. Create a consensus model about Conventional versus Digital Radiography.	G-I	chart paper, markers
6	5 min		**NAVIGATE** Update the *Progress Tracker* and add a definition for *digital information* to Personal Glossaries. Discuss the uses of EM radiation that we cannot yet explain.	J-K	*Progress Tracker*

End of day 1

Lesson 11 • Materials List

	per student	per group	per class
Lesson materials	• *Radiography: Conventional versus Digital* • science notebook • *Progress Tracker*	• *Unknown material with identifier: pr.l9.ref*	• chart paper • markers

Materials preparation (15 minutes)

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Have enough copies of the *Unknown material with identifier: pr.l9.ref* for every pair of students.

Lesson 11 • Where We Are Going and NOT Going

Where We Are Going

This lesson is designed to coherently build ideas related to the following disciplinary core ideas (DCIs):

- **PS4.A: Wave Properties.** Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory ~~and sent over long distances as a series of wave pulses~~.
- **PS4.C: Information Technologies and Instrumentation.** Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging~~, communications, scanners~~) ~~and in scientific research~~. They are essential tools for producing~~, transmitting,~~ and capturing signals and for storing ~~and interpreting~~ the information contained in them. (HS-PS4)

In this lesson, students are introduced to the creation of digital information by exploring how digital and conventional radiography work. They use ideas about EM radiation and its interactions with matter to explain how information can be digitized and how the design of X-ray technologies can reduce the inherent risks of using ionizing radiation.

Students encounter or co-develop a definition for *digital information.* **Do not** post any words or ask students to add them to their Personal Glossaries until after the class has developed a shared understanding of their meaning.

Where We Are NOT Going

This lesson is focused on the creation and storage of digital information. The transmission of digital information will be explored in the next lesson.

LEARNING PLAN for LESSON 11

1 · NAVIGATE

4 min

MATERIALS: *Unknown material with identifier: pr.l9.ref*

Share ideas about the types of information we can communicate with our devices. Present **slide A**. Say, *I saw some questions in the DQB about the connection between the Bluetooth speaker and the cellphone, and how our devices shared music with each other. But we know that our devices can communicate more than music*. Elicit 1-2 ideas with the slide's prompt:

- *What types of information can we communicate with our current devices?*

Accept all responses, but listen for students to mention music, videos, and/or images. Say, *We saw that several EM radiation types and technologies are used for creating images, so let's investigate how we can create and share images using EM radiation.*

Motivate a closer look at EM radiation used for imaging. Present **slide B**. Distribute the *Unknown material with identifier: pr.l9.ref* to each pair of students. Ask them to use the information on the cards to consider the slide's prompts:

- *Which types of EM radiation are used to create images?*
- *Which types of EM radiation are used to send images?*
- *Which of these EM radiation types are we more familiar with?*

After a couple of minutes, ask students to share out. Accept all responses for the first two prompts.

For the third prompt, listen for students to mention X-rays. Suggest that we use X-rays for our investigation, as we have some ideas from our everyday life experiences and from Lesson 10, when we looked at ionizing radiation. Say, *Although there are many technologies that we may want to explore, X-rays will help us understand how other technologies might create images.*

2 · IDENTIFY RELEVANT INTERACTIONS BETWEEN X-RAYS AND MATTER

2 min

MATERIALS: *Unknown material with identifier: pr.l9.ref*

Identify relevant interactions with matter. Present **slide C**. Ask students to look at the information on the X-ray card or read the slide's text for this discussion. Have them turn and talk about the prompt:

- *What interactions with matter do we think can help us use X-rays to create images of a fractured bone?*

After a minute in partners, invite students to share with the class. Listen for these suggestions:

- X-rays can pass through different materials.
- The density of the material affects how much energy is absorbed, reflected, or transmitted.

3 · IDENTIFY AREAS OF UNCERTAINTY ABOUT IMAGING USING X-RAYS

3 min

MATERIALS: None

Identify areas of uncertainty in the system. Present **slide D**. Mention that the diagram on the slide shows a person getting an X-ray. Some students might not have had the same experience with X-rays, which is OK. Explain that there are various types of X-ray technologies but the principles they use are similar. Use the diagram on the slide to elicit noticings and wonderings.

Listen for the following noticings:

- The X-ray detector is under the person.
- The X-rays go through the arm and then reach the detector.
- The image is stored in the computer.
- The patient has a broken arm.

Listen for the following wonderings:

- What is the X-ray detector?
- What is a digital image?
- How do computers store information?
- Is it dangerous to get X-rays?

Say, *We should explore some of these wonderings.*

4 · OBTAIN INFORMATION ABOUT X-RAY TECHNOLOGIES

20 min

MATERIALS: *Radiography: Conventional versus Digital*

Motivate reading about X-ray technologies. Present **slide E**. Read the text and prompt aloud:
X-rays are a form of ionizing radiation.

- *How could we safely learn more about X-rays?*

As students share ideas, ask the rest of the class: *Is the suggestion that _____ is proposing safe for all of us?* Listen for students to suggest searching on the internet or reading more about it. Say, *We cannot study X-rays directly, but I have a reading that might help us answer some of these questions.*

✱ SUPPORTING STUDENTS IN ENGAGING IN OBTAINING, EVALUATING, AND COMMUNICATING INFORMATION

To support students in identifying the main ideas from a scientific text, encourage them to paraphrase the text in simplified terms.

Gather information from a text. Present **slide F**. Distribute *Radiography: Conventional versus Digital* to each student. Describe the task by reading the slide's instructions aloud:

Use the reading to gather information to help us explain:

- *What happens at the X-ray detector?*
- *How is the computer (digital) image created and stored?*

Give students 20 minutes to complete the reading and write answers to the questions on their handout. ✱

Consider using prompts such as, *What is the main idea?* or, *How could you say that in your own words?* as you walk around the classroom and monitor their progress on the handout.

ADDITIONAL GUIDANCE

Make sure to mention that the information presented in this reading is based on the following scientific article: Bansal, G. J. (2006). Digital radiography. A comparison with modern conventional imaging. *Postgraduate Medical Journal, 82*(969), 425-428.

In addition to adapting the information in the original text for classroom use, we added text about digital information.

ASSESSMENT OPPORTUNITY

What to look for/listen for in the moment: Look for students to:

- Use information from the reading to describe in their own words how the patterns of absorption and transmission of X-rays are used to create images of the internal structure of our body. (SEP: 8.1; CCC: 6.1; DCI: PS4.C.1)
- Use information from the reading to describe how electronic detectors can be used to absorb X-ray radiation and create digital images. (SEP: 8.1; CCC: 6.1; DCI: PS4.A.2, PS4.C.1)
- Use information from the reading to identify the advantages of digital radiography over conventional radiography based on the interactions of different components to reduce the time of radiation exposure, image processing, and image storage. (SEP: 8.1; CCC: 6.1; DCI: PS4.A.2, PS4.C.1)
- Use information from the reading to identify the disadvantages of digital information, such as data loss or security risks. (SEP: 8.1; DCI: PS4.C.1)

What to do: If some students finish early, encourage them to think about how other digital imaging technologies work. For instance, you can say, *The cameras in our smartphones work similarly to digital radiography. Behind the camera lens, there's a sensor that detects EM radiation. How do you think it works? What kind of EM radiation do you think it uses?*

Building toward: 11.A Critically read scientific literature adapted for classroom use to determine the advantages and disadvantages of creating X-ray images using digital transmission and storage of information. (SEP: 8.1; CCC: 6.1; DCI: PS4.A.2, PS4.C.1)

5 · DISCUSS ADVANTAGES AND DISADVANTAGES OF CREATING AND STORING DIGITAL IMAGES

11 min

MATERIALS: chart paper, markers

Debrief the main ideas from the reading. Present **slide G**. Guide a class discussion using the prompts:

- *How does the exposure time of digital radiography and conventional radiography compare?*
- *What explains the difference in exposure time between these technologies?*
- *What are the benefits of decreasing exposure time?*

Listen for students to suggest:

- The exposure time in digital radiography is much shorter.
- The difference is due to the sensitivity of the detector.
- The film used in conventional radiography needs to absorb more X-rays to create the image.
- The detector in digital radiography is very sensitive and can create the image after absorbing very little radiation.
- X-rays are a type of ionizing radiation, so less exposure time means less risk of ionizing molecules in our cells, which can be harmful.

Evaluate merits and limitations of the photon and wave models. Present **slide H**. Ask students to turn and talk about the prompts:

- *Which model of light, the photon model or the wave model, was more helpful to explain why digital radiography requires less exposure than conventional radiography?*
- *How can we use this model to identify strategies that reduce harm from exposure to high-frequency EM radiation?*

After a minute or two, ask for a few volunteers to share out. As students express their ideas, title a piece of chart paper "Conventional versus Digital Radiography" and create a consensus model that captures the way they are thinking about imaging. ✱

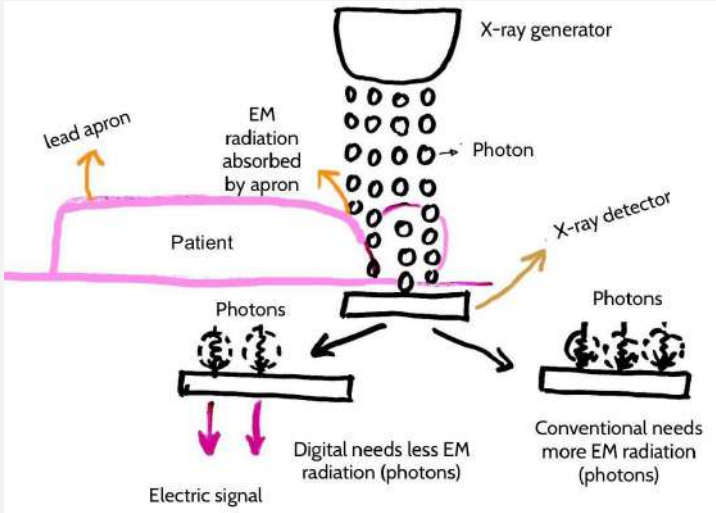
At the end of this discussion, your model may look something like the image below.

✱ SUPPORTING STUDENTS IN ENGAGING IN DEVELOPING AND USING MODELS

The purpose of this discussion is to build a class consensus model to explain why digital radiography is safer than conventional radiography. The teacher's role is to prompt students to share what needs to be in the model, evidence to support it, and how to represent it. The students' role is to propose ideas to include in the model and how to represent them, to support or challenge peers' proposed ideas, and to come to a consensus about what should be included in the model.

Through this discussion, make sure the following elements are part of the class consensus model:

- the source of X-rays
- the interactions of X-rays (absorption or transmission) with different materials (apron, patient, X-ray detector)



Discuss advantages and disadvantages of creating digital images. Present **slide I**. Ask students to turn and talk about the text and prompt: *Digital radiography stores images digitally in computers, whereas conventional radiography uses film.*

- *What are the advantages and disadvantages of creating X-ray images digitally rather than using conventional film?*

After a minute or two, ask a few pairs to share with the class. Listen for them to suggest these advantages:

- Digital images are faster to create.
- Digital images are cheaper.
- Digital images can be stored in a computer.

Listen for them to suggest these disadvantages:

- Digital images can be accessed by many people other than the patient, which could raise privacy issues.
- If the system is not well protected, hackers could steal that information.
- Some people might not have a computer or smartphone and wouldn't be able to view the file.

ADDITIONAL GUIDANCE	One of the goals of this discussion is to help students recognize how we can modify technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

- the difference in the amount of X-ray exposure between digital and conventional radiography

ALTERNATE ACTIVITY	As an extension opportunity for students interested in learning about the use of other ionizing radiation technologies, provide them with *Ionizing Radiation Technologies*.

6 · NAVIGATE

5 min

MATERIALS: science notebook, *Progress Tracker*

Update the *Progress Tracker* and Personal Glossaries. Present **slide J**. Give students 3 minutes to follow the directions:

- *Make a record of your ideas right now in your Progress Tracker to explain how we can use EM radiation to create and store digital images.*
- *Record a definition of digital information in your Personal Glossary.*

Motivate the next exploration. Present **slide K**. Navigate into Lesson 12 using the prompts:

- *What uses of EM radiation can we explain?*
- *What are some uses of EM radiation that we cannot fully explain yet?*

For the first prompt, listen for students to mention creating digital images (imaging). For the second prompt, listen for them to mention communication, space observations, and some industrial applications. Suggest that we try to make progress along the line of communication-related technologies next time.

Additional Lesson 11 Teacher Guidance

SUPPORTING STUDENTS IN MAKING CONNECTIONS IN ELA

This is the CCSS for the ELA/Literacy-related idea that is used to support sensemaking in this lesson:

CCSS.ELA-LITERACY.RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

As students read about how digital and conventional radiography work, they need to synthesize the process through which EM radiation is used to create images of the internal structure of the body.