Lesson 3: How does a CT scan help diagnose TBI?

I. Overview
In this lesson, students examine computed tomography (CT) scans of people with TBI and learn how to interpret these CT scans. Through readings, a TBI case puzzle, and a segment of The Golden Hour game, students learn to identify the structures of the brain on a normal CT scan and compare them with the CT scans of TBI victims. They identify types of injury such as open head injury, diffuse axonal injury, and hematomas, as well as the loci of injury in the brain. Having identified the loci of injury, students revisit what they learned about functional roles of the different areas of the brain in order to predict the type of impairment or disorder that might be caused by the injury.

In Scenes 2 and 3 of The Golden Hour, a Project NEURON interactive computer game, students conduct a CT scan to diagnose the patient’s brain injury and then perform brain surgery to remove the hematoma. At the end of each scene, students make a recommendation for what the medical team should do next (the claim), provide evidence from their findings to support this claim, and provide reasoning for how the evidence supports their claim.

Connections to the driving question
To understand the functional consequences of a traumatic brain injury, students need to be able to explain the close relationship between brain anatomy and physiology. In this lesson, students examine various CT scans and identify the structural changes to the brain after TBI. Students discuss the physiological and functional consequences of these structural changes making connections to The Golden Hour game. Students discuss the use of CT scan technologies for intervention to a traumatic brain injury and how quick identification of the location and the extent of the injury are critical during the golden hour.

Connections to previous lessons
In the previous lesson, students learned the basics of brain anatomy and physiology. In this lesson, they add another layer by discussing the importance of imaging technologies for diagnosis and intervention and by learning to read CT scans in order to distinguish between a normal brain and one that has been injured. Once they are able to identify the injury type and location, they can then apply what they learned in the previous lessons about TBI classification and brain structures to discuss potential effects of the injury on behavior and function.
II. Standards

National Science Education Standards
Content Standard F: Personal and Community Health

- Hazards and the potential for accidents exist. Regardless of the environment, the possibility of injury, illness, disability or death may be present. Humans have a variety of mechanisms—sensory, motor, emotional, social, and technological—that can reduce and modify hazards. (9–12 F: 1/1)

- The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease-producing organism. Many diseases can be prevented, controlled or cured. Some diseases, such as cancer result from specific body dysfunctions and cannot be transmitted. (9–12 F: 1/2)

- Personal choice concerning fitness and health involves multiple factors. Personal goals, peer and social pressures, ethnic and religious beliefs, and understanding of biological consequences can all influence decisions about health practices. (9–12 F: 1/3)

- Families serve basic health needs, especially for young children. Regardless of the family structure, individuals have families that involve a variety of physical, mental, and social relationships that influence the maintenance and improvement of health. (9-12 F: 1/6)

Benchmarks for Science Literacy
The Human Organism: Mental Health
- Biological abnormalities, such as brain injuries or chemical imbalances, can cause or increase susceptibility to psychological disturbances. (6F/H2)

The Human Organism: Physical Health
- New medical techniques, efficient health care delivery systems, improved diet and sanitation, and a fuller understanding of the nature of health and disease give today's human beings a better chance of staying healthy than their ancestors had. (6E/H3a*)

III. Learning Objectives

<table>
<thead>
<tr>
<th>Learning Goals</th>
<th>Assessment Criteria</th>
<th>Location in Lesson</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explain the diagnostic role of CT scans.</td>
<td>Students are able to explain the use of computed tomography (CT) as a diagnostic tool and how it is used to identify traumatic brain injuries.</td>
<td>Introduced in Activity 1 and explained throughout lesson</td>
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<tr>
<td>Identify certain structures and lobes of the brain on a normal CT scan.</td>
<td>Students locate and identify the structures and lobes of the brain on a normal CT scan.</td>
<td>Activities 1 &amp; 2</td>
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SEPA SCIENCE EDUCATION PARTNERSHIP AWARD

project NEURON
Compare a normal CT scan with a CT scan of a brain-damaged patient and explain the structural changes.

Students are able to make comparisons between normal and injured CT scans to identify irregularities in an injured brain.

Activities 1 & 2

Identify the different types and loci of brain injury on CT scans.

Using a variety of CT scans, students examine various types of injuries that result from TBI and practice identifying the types and loci of damage.

Activities 1 & 2

Explain the potential functional outcomes of the TBI based on location of injury.

Students see various types of traumatic brain injuries and they practice interpreting the functional outcomes of various types of injury by looking at the location of damage.

Activities 1 & 3

IV. Adaptations/Accommodations

Parts of the lesson require that students play a computer game. If access to computers is limited, 3-4 students can be assigned to each computer. If computers cannot be accessed the day of the lesson, the activities requiring The Golden Hour game can be revisited at a later time and used to review and further support learning of the concepts covered in this lesson. If students do not complete the game within class time, they can access and play the game online from home from the Project NEURON website: neuron.illinois.edu.

Safety

There are no additional safety concerns associated with this lesson.

V. Timeframe for lesson

Opening of Lesson

- Discussion to review previous lesson and introduce current lesson – 5 minutes

Main Part of Lesson

- Activity 1: How to read CT scans – 30 minutes
- Activity 2: The Golden Hour Scene 2: CT Scan – 25 minutes
- Activity 3: The Golden Hour Scene 3: Surgery – 25 minutes

Conclusion of Lesson

- Class discussion to review concepts – 5 minutes
VI. Advance prep and materials

Activity 1: How to read CT scans

Materials:
- Student Sheet: “How to Read a CT Scan”: U4_L3_StudentSheet_HowToReadCTscan
- Student Sheet: “How to Read an Abnormal CT Scan”: U4_L3_StudentSheet_HowToReadAnAbnormalCTscan
- Student Sheet: “TBI Case Puzzle”: U4_L3_StudentSheet_TBICasePuzzle

Preparation:
- Make enough copies of all three handouts (copies can be made 1 per student or per pair of students)
  - Note: The “TBI Case Puzzle” document needs to be printed using a good printer so that the CT images print clearly and students are able to identify the damage in each image.

Activity 2: The Golden Hour Scene 2: CT Scan

Materials:
- Computers (1 computer for 1–3 people, pairs is best)
- Student Sheet: “CT Report”: U4_L3_StudentSheet_Ctreport

Preparation:
- There are two ways to prepare the computers for students:
  - Option 1: Make certain all computers will have online access while students play the game. Open The Golden Hour game through the Project NEURON website (neuron.illinois.edu).
  - Option 2: Download The Golden Hour game from the Project NEURON website onto each computer prior to class. An internet connection will not be necessary to play the game once downloaded onto the machine.
- Conduct a trial run of Scene 2: CT Scan of The Golden Hour game on a computer before beginning the lesson to make sure it can be accessed and is running smoothly on the computers. Prepare all of the computers so students can quickly and easily begin the game.
- Make copies of “CT Report” (1 per student)

Activity 3: Golden Hour Scene 3: Surgery

Materials:
- Computers (1 computer for 1–3 people, pairs is best)
- Student Sheet: “Surgery Report”: U4_L3_StudentSheet_SurgeryReport

Preparation:
- There are two ways to prepare the computers for students:
Option 1: Make certain all computers will have online access while students play the game. Open The Golden Hour game through the Project NEURON website (neuron.illinois.edu).

Option 2: Download The Golden Hour game from the Project NEURON website onto each computer. An internet connection will not be necessary to play the game once downloaded onto the machine.

- Conduct a trial run of Scene 3: Surgery of The Golden Hour game on a computer before beginning the lesson to make sure it can be accessed and is running smoothly on the computers. Prepare all the computers so students can quickly and easily begin the game.
- Make copies of “Surgery Report” (1 per student)

**Homework**

**Materials:**
- Link to Project Neuron website (to access The Golden Hour): neuron.illinois.edu
- “Lesson Journal”: U4_L1_Homework_LessonJournal

**Preparation:**
- All students need to be able to access this link to The Golden Hour in order to complete the game or re-play it for review (or share with friends and family!) at home. For those students who are not be able to complete this task at home, computer lab time may need to be reserved to allow them access to the game outside of class time.
- Make sure students still have their Lesson Journals that were given to them in Lesson 1. Additional copies of Lesson 3 page of the Journal may need to be distributed.

**VII. Resources and references**

**Teacher resources**

Resources for additional information about brain anatomy and function:
- Harvard University Medical School, *The Whole Brain Atlas*:
  http://www.med.harvard.edu/AANLIB/home.html

Resources for additional information about CT Scan technology:
- Radiology Info: http://www.radiologyinfo.org/en/info.cfm?pg=headct#part_eight

Resources for additional information on brain trauma:
Resource for supporting students in constructing scientific explanations:


References

- Harvard University Medical School, The Whole Brain Atlas: http://www.med.harvard.edu/AANLIB/home.html

VIII. Lesson Implementation

Opening of Lesson:
Briefly review with students what they have learned in the unit so far. The following are some questions that can be used to guide the discussion. During the discussion, project an image or have some form of visual aid available of the brain to support students in thinking through and answering these questions. If students are having trouble remembering, direct them to refer to their Dissection of the Sheep Brain: Exploration Guide.

- What are the 4 main lobes of the cerebrum? (Or different parts of the brain – forebrain, midbrain, hindbrain...)
- What do you remember about the case of Phineas Gage?
- What comes to your mind when you hear the word ‘brain damage’?
- Which hemisphere of the brain is thought to host the two main speech and language areas?
- Visual information goes to which lobe of the cortex first?
- Which structure in the brain is mainly responsible for balance and precise movement?
- What are some major roles of a nervous system?
Teacher Pedagogical Content Knowledge

Additional details of the anatomy and function of the brain at various anatomical planes (coronal, sagittal, axial section) and levels can be accessed by downloading the Brain Voyager Brain Tutor free software (http://www.brainvoyager.com/downloads/downloads.html). This application allows the viewer to navigate through a 3D human brain model. It is user-friendly and easy to navigate once familiar with the program.

Brain Voyager can be used at the beginning of the lesson as a review of the material presented in Lesson 2. Because the program integrates the 3D and the 2D images of the human brain, it is a good transition between sheep brain dissections and reading the CT scan images. This software can be used as an extended practice of the material presented in Lesson 2 by showing students how brain structures look on a CT scan or an MRI by choosing the name of the structure from the drop-down menu and selecting the X, Y, Z plane.

This software can also be downloaded to smart phones and tablet computers for free.

Main Part of Lesson:

Activity 1: How to read CT scans

In this activity, students learn about computerized tomography (CT) scans. CT is a widely used imaging technique that is a valuable diagnostic tool in medical settings. Students learn how to read a normal CT scan and identify the basic structures of a brain.

To capture students’ interest in the activity, ask the following questions:

- Have you ever had an X-ray before? If so, which part of your body was X-rayed?
- Have you heard of MRI or CT scan? What do these words mean?
- Have you ever seen a CT scan or an MRI image? What do these look like?
- Have you seen an X-ray device, a CT scanner or an MRI device?
- What are these CT scans used for? Which structures of the body can be viewed using these tools?
- Have you seen these devices being used in popular medical TV shows (such as House M.D. or Grey’s Anatomy or other TV shows)? For what types of diseases or injuries do the TV doctors use these technologies?
Teacher Content Knowledge: Medical Technology

Medical imaging has a crucial role in diagnosis of diseases or disorders. Students may have familiarity with various medical imaging technologies such as X-rays, ultrasound, MRI or CT scans either by direct experience or by knowing someone who had a procedure using these technologies. Therefore, the use of medical imaging technology is very relevant to their lives. This lesson is a good opportunity to discuss the role of technology in medicine and how imaging techniques differ from each other and the relative strengths of each. After capturing students’ attention and interest in this activity, explain the use of technology in the medical settings. MRI and CT imaging are highly advanced diagnostic tools that can be used to see the 3D view of the internal structures of the body including the brain and other internal organs. One of the differences between an MRI and a CT scan is that the MRI has higher resolution; with the CT scan, it is hard to see the precise details of soft tissue. On the other hand, MRI is more expensive and requires much longer time to produce the image. Thus, the CT scan is often very useful in medical emergencies when time is a critical factor. Even though the CT scan emits more radiation than a regular chest X-ray, the benefits may outweigh the risks. Describe the strengths and weaknesses of each technology and ask students when they would recommend using one technology over another. For example, would they use a CT scan for dental work or braces? A head injury in a car accident?

For more information, refer to the following resources:

- http://www.radiologyinfo.org/en/info.cfm?pg=headct#part_eight

After the initial discussion, tell students that they will learn some of the basics on how to read a CT scan in today’s lesson.

Give students the “How to Read a CT Scan” (U4_L3_StudentSheet_HowToReadCTscan) handout. Allow students to read through the handout with a partner or in small groups and discuss some of the information that may be new to them or that they think is important.

Have students identify as many structures as possible on a normal CT scan of the brain. To help identify the structures on a CT scan, advise students to compare the CT scan to the drawings of the brain they have seen in previous activities. Students should be able to identify the following structures:

- Frontal lobe
- Occipital lobe
- Temporal lobe
- Parietal lobe
- Skull
- Cerebellum
- Right hemisphere
- Left hemisphere
Note that identifying the temporal and parietal lobes and cerebellum can be tricky since the appearance of these lobes in the CT scan depends on where in the brain the scan is taken. This can be used as a point of discussion for students to consider what needs to be taken into account when looking at a scan.

Go through the handout briefly with the students to cover the following main concepts:

- A Computer Tomography (or “CT”) Scan is a type of x-ray that is used to see the brain.
- Due to the way in which X-ray beams work, high density materials, such as the skull, appear very light on the CT scan and low density things, such as air or some tissues, appear dark on the CT scan.
- One of the main things to remember when looking at a CT scan is that, you are looking from the bottom of the brain towards the top. Therefore, the structures that you see on the right side of the CT image are actually in the LEFT hemisphere of the patient and vice versa. For example, in most people, Broca’s Area (the part of the brain responsible for certain elements of language production) is located in their left hemisphere—on which side of a CT image would Broca’s Area appear?
- As the CT scan moves from the bottom of the brain to the top, you are seeing slices of the brain (almost like slices of a loaf of bread).

As students become familiar with how a CT scan works and how to read the brain scans, ask them the following questions:

- In what way are CT scans important for patients with TBI?
- Have you ever seen the X-ray image of a broken limb? Is it clear to identify the damage on the X-ray image?
- How do you think the CT scan of a TBI patient looks?

Now that students are familiar with some of the main ideas of a CT scan, hand out the “How to Read an Abnormal CT Scan” (U4_L3_StudentSheet_HowToReadAnAbnormalCTscan) to them. This is a brief guide to learn about different types of TBIs and how to identify them on CT scans.

Ask students to work in their partners or groups to look through this handout to familiarize themselves with the four TBI types and how they appear on a CT scan. They will need to use this guide to complete the “TBI Case Puzzle”. This TBI Case Puzzle will simulate the medical setting, giving students a chance to see the effect of a trauma in the brain at a macroscopic level. Students look at a number of TBI CT scans and identify the affected structures and interpret the functional impact of the injury.

Hand out one “TBI Case Puzzle” (U4_L3_StudentSheet_TBICasePuzzle) to each student. In this puzzle, students are given 4 different patients and their CT scan images of different types of brain injury. For each patient case, students need to: 1) decide which brain injury type they have, 2) select whether the
injury is in the patient’s left or right hemisphere, 3) identify the areas of the brain affected by the injury, and 4) based on the location, describe what functions of the patient may be affected/impaired.

Encourage students to refer back to the materials presented in Lessons 1 and 2 as well as resources from Lesson 3 and use their knowledge of neuroanatomy and physiology as they complete the case puzzle.

When students complete this activity, bring the class together to share and discuss responses. Begin the discussion by first asking which brain injury type each patient was diagnosed with. This will help to make sure all students are on the same page for the remainder of the discussion.

While answers to the first three sections of each report should be the same for everyone, responses to the last two questions will likely vary slightly from group to group. In some cases there are multiple possible correct answers to brain areas and cognitive functions affected by injury. This is a good opportunity to remind students that although certain areas of the brain are specialized for certain functions, all brain areas are very closely interconnected and lines between areas are not as rigid as they might appear in the illustrations.

The following are some questions that should be considered for each case.

- What is the location of injury in each case?
- What signs did you use to figure out which injury each CT scan was showing?
- Predict which patient might have a speech disorder following TBI.
- Predict which patient might experience partial/temporary or permanent visual loss following TBI.
- Predict which patient might have severe memory problems.
- Predict which patient might have moderate to severe paralysis on the right side of his body.
- Predict which patient’s prognosis for recovery is lowest.

**Teacher Pedagogical Content Knowledge**

The questions about location of injury, affected brain areas, and possible functional outcomes require students to draw on knowledge they have been developing throughout the unit. The questions about location are fairly straightforward but the later questions, which ask for affected areas and possible outcomes, require students to synthesize some of the material they have learned. Therefore, student responses can be collected as a formative assessment of their understanding of the material thus far or the entire TBI Case Puzzle can be given as a formal in-class assessment at the end of the lesson or unit.
Activity 2: Golden Hour Scene 2: CT Scan
Tell students that now that they have learned about different types of brain injuries and how to read CT scans, they are ready to assess what type of TBI their patient in The Golden Hour game has suffered.

Before beginning the game, remind students what they have already done in the game. As the medical student, they are working on an emergency case in which a patient was brought into the hospital after a bike accident where he fell and suffered a head injury.

Explain that, in this second scene of the game, they will use their knowledge to identify the type of injury the patient has suffered. They can refer back to their handouts on CT scans while they play through the game.

Hand out the “CT Report” (U4_L3_StudentSheet_CTreport) and ask students to fill it out as they gather information throughout the CT scene of the game. The game will prompt them for this information at the end of the scene.

To begin, ask students to open “The Golden Hour”. (This can be done by clicking the link in the games section of the Project NEURON website or by an icon on the computer if the game has been downloaded to the computer prior to class). When the menu screen appears, ask students to click on the “Scenes” button and then on “Scene 2.0 CT Scan”. An image of a woman will appear at the opening of Scene 2—this is the CT technician who will help players through this scene of the game.

- The character will introduce herself in a dialogue box saying “Hi, my name’s Allana. I’m excited that you have the chance to help us with this patient! I hope you’ll do well and can be a part of our team.”

From this point on, students can progress through the game by clicking the right pointing (next) arrow in each dialogue box or by clicking as directed by the dialogue.

- If a player does not respond within a certain amount of time, an object in the game will flash yellow, to further direct the player about what to do next.

Note: The Golden Hour game will continue to be updated. Therefore, some of the details provided here (i.e. quoted dialogue) may change. However, overall, the content covered in each section of the game will remain the same.

Allow students to play through Scene 2 (CT Scan) of the game.

In the beginning of this scene, students first briefly review how a CT scan works. Students then explore the anatomical landmarks of a healthy brain while comparing an illustrated brain with a CT scan image of the brain. Encourage students to take their time examining each landmark in both the CT scan and the illustrated image. They should also carefully read the descriptions of each landmark’s function. They will review the following anatomical landmarks of the brain and their functions:
• Frontal Lobe
• Temporal Lobe
• Occipital Lobe
• Skull
• Cerebellum
• Lateral Ventricle
• Thalamus

As students review the landmarks, ask them to compare how the structures look on a CT scan vs. the real brain (from the illustration shown in the game as well as the material they covered doing the dissection in lesson 2).

After students review the anatomical landmarks of the brain, the game takes them through a short quiz where they identify the parts they just learned on a CT scan image.

By the end of the CT scan Quiz, students should be fairly familiar with how the brain structures look on a CT scan. Have the students pause playing after this quiz to have a discussion about the following questions before moving on to the next section on brain injury types:

- In what way are CT scans important for patients with TBI?
- Will it always be easy to identify parts of the brain or damage on a CT scan?
- What do you think the CT scan of the patient’s brain injury might look like?
- Why do you think it is important to know the brain’s anatomy and function when diagnosing a brain injury?
- Do you think the location of the injury in the brain would be a factor in how severe the injury is? Why?

Ask students to continue playing the game. They will review four kinds of brain injuries: 1) open or penetrating head injury; 2) epidural hematoma, 3) subdural hematoma, and 4) diffuse axonal brain injury.

After viewing these brain injuries, students come to a dialogue box that states, “Now that you are familiar with the CT imaging system, let’s take a look at the patient’s scans.” Students then study the CT scan to identify the patient’s injury and decide which type of TBI it is.

Finally, at the end of the scene, students are prompted to complete a CT Report (or CT Assessment) of their findings. They are led through a dialogue with the lead physician in charge of this case (Dr. Picotte) where they need to decide the most appropriate next step for treatment and support their decision.

- This dialogue is designed within the claim, evidence, reasoning (CER) framework and encourages students to think critically about the information they have gathered. Through the dialogue and multiple-choice questions, students are guided to select their claim, evidence, and reasoning for recommending next steps.
As students complete the report and answer questions in the CER-style dialogue, remind students that they can use their student sheets and the tablet within the game for help. The tablet records the information they have collected thus far in the game and makes it available for the students’ reference.

Students can use the back of the “CT Report” student sheet to construct their recommendation. Students can first use the C, E, and R, columns to organize their thoughts about the three different components of a scientific explanation. Then, at the bottom of the page, in the “Medical Recommendation” section, they should synthesize these ideas into a coherent explanation written in paragraph form. As students work, scaffold them to write their recommendation for what the next step should be (their claim), add evidence they collected that supports that claim, and provide reasoning that explains how the evidence supports the claim.

**IMPORTANT:** Medical recommendation responses submitted within the game will not be saved once students exit the game. Students should have their medical recommendation written on their student sheet or copied into a word document on the computer before exiting the scene.

This explanation completed by the students in a CER-style format can be collected and evaluated as an assessment of what they have learned thus far in the game.

The following is one example of the type of information a recommendation summary (CER explanation) for the CT Scan scene of the game may contain.

**Example Recommendation Summary**

I recommend that the patient receive emergency surgery. Analysis of the CT scans of the patient’s head show a gray, crescent-shaped appearance just under the skull on five adjacent scans. This indicates that there is a subdural hematoma on the right side of the head near the temporal lobe. Surgery should be performed because if the blood remains or continues to collect in the head, the hematoma will increase pressure within the skull and cause additional brain damage.

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**Scientific Practices: Constructing explanations and engaging in argument from evidence**

Scientists must constantly exercise the ability to defend their claims, incorporate evidence, and work with peers to develop the best explanations of scientific phenomena. An important goal of science teaching is to encourage students to use their understanding of the science and the evidence available to them to construct logical and coherent explanations.

At the end of each segment of the game, students are asked to answer the question “What should be done next for the patient?” by providing a claim, evidence, and reasoning (CER). If students have not yet learned about the CER framework (McNeill & Krajcik, 2012) for constructing scientific explanations, instruct them in this approach before they complete their report for The Golden Hour game. Explain to students that
all good scientific explanations must have these three components. For any scientific explanation, you must first make a sound claim, provide evidence that supports that claim, and explain the reasoning that connects the evidence to the claim. Encourage students to think explicitly about these three components and why each one is an important part of a sound scientific explanation.

In The Golden Hour game, students are given the opportunity and appropriate scaffolds to practice these important skills. Situated in the format of a conversation with the lead physician at the end of each segment, students are guided to make and defend a claim based on the evidence and knowledge they have accumulated. The claim, evidence, and reasoning framework used to develop this scene supports students and further structures the process as they practice constructing scientific explanations and engaging in argument from evidence.

Activity 3: Golden Hour Scene 3: Surgery
After completing Scene 2 and 2.5, students can continue on to Scene 3 (surgery) of the game. Students should navigate through the scene in the same way as they did in Scenes 1 and 2. Remind students to complete the Surgery Report student sheet (U4_L3_StudentSheet_SurgeryReport) to record the surgical procedure and findings as they play through the game.

In this scene, students will prep the patient for surgery and then cut through the layers of tissue and bone to remove the hematoma from the right temporal lobe of the patient’s brain. A neurosurgeon, Dr. Charles Drew, will guide them through the surgical procedures.

Following the surgery, students will need to complete and submit the Surgery Report within the game. Students will then have a conversation with Dr. Picotte and be prompted to write a medical recommendation in response to the question “Based on what we know about the brain injury, what kinds of difficulties might we expect the patient to have during recovery?” In response to this question, students will need to write an explanation which includes a claim, evidence, and reasoning.

Similar to the reports completed for Scenes 1 and 2, students can use the back of the Surgery Report student sheet to scaffold the construction of their medical recommendation summary.

**IMPORTANT:** Medical recommendation responses submitted within the game will not be saved once students exit the game. Students should have their medical recommendation written on their student sheet or copied into a word document on the computer before exiting the scene.

The following is one example of what a recommendation summary (CER explanation) for the Surgery scene of The Golden Hour game may look like.

**Example Recommendation Summary**
For post-surgery, I expect that the patient may have difficulties with language processing and face recognition during recovery. These predictions can be made because the brain is made up of certain
regions and neuronal circuits, each of which is associated with certain functions. In this case, a hemATOMa was found pressing on the patient’s right temporal lobe; this is an area of the brain that is associated with language processing and face recognition. Therefore, damage to the right temporal lobe may cause the patient to have problems with these functions.

Conclusion of Lesson:
After students have finished the final report and recommendation in The Golden Hour game, review some of the main ideas from this lesson. Facilitate a discussion to help them review and to think about these concepts by asking questions such as the following:

- How much and what kind of information can doctors gather by looking at CT scans?
- To what extent do you think the CT scans can help predict functional outcomes?
- What are the four different traumatic brain injury types you learned about?
- How can you make some predictions of impairment based on location of injury?

For homework, ask students to complete their Lesson Journal for Lesson 3 found in the document U4_L1_Homework_LessonJournal. Students can also access and play The Golden Hour from home (as a review or as homework if time runs out to complete it in class). Have students write down the link to be able to find the game online.

- Link to Project NEURON “Games & Videos” page: neuron.illinois.edu/media

Teacher Pedagogical Knowledge
The Lesson Journals are completed for each lesson in the TBI unit, and they are used together as a review and assessment tool in the final lesson. Students will review material from the unit and will contribute to a class ‘zine’ that integrates ideas and content from the unit. A zine (pronounced ZEEN) is a form self-publication with original text and images. Similar to a magazine, the topics are usually of a particular interest and the method of reproduction is via photocopiers.

Assessment
There are several ways in which learning can be assessed for this lesson. The first is to collect the “TBI Case Puzzle” document where students were asked to identify brain injury types and explain possible effects of the injury. Also, if preferred, the “TBI Case Puzzle” worksheet can be used instead as an in-class assessment. Another assessment opportunity for this lesson are the medical recommendation summaries (CER explanations) in which students use evidence from the game and reasoning to make claims regarding next steps in the medical procedure. These CER explanations can be collected and evaluated as an assessment of what students have learned about CT scans, brain anatomy and function, and the potential functional consequences of a TBI based on its location in the brain.