A Chest X-Ray Is Equal to 10 Days of Natural Radiation. Is Radiation Bad?

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Major Sections	Content
Project Overview	**Overall Purpose** Students will make connections between biological responses, radiosensitivity among different organs, and implementation of safe exposure practices to minimize radiation dose to the patient. **Project Length** Approximately three class periods **Appropriate Courses for Implementation** RAD 111/112 (Procedures 1 and 2), RAD 241 (Radiobiology), Anatomy and Physiology (BIO 163, 168, 169) **Key Terms** Human anatomy, cellular structure, organ systems, analysis, writing, drawing, interpretation, types of radiation, radiation theories, radiation sensitivity, radiation damage, radiation calculations, organ sensitivity, dose limits, charting, prediction, critical thinking, communication, collaboration. **Student Learning Objectives** Upon completion of this activity, the student should be able to: • Calculate organ radiosensitivity. • Make clear connections between biological responses and radiosensitivity among different organs. • Understand the reasons for minimizing radiation dose to the patient. • Provide simple, yet clear explanations to the patients on how many doses they received.
Equipment/Materials	**List of Materials and Equipment** • Course notes • Calculator • Computer • Internet access • Microsoft Office/Word • Textbook • Handouts

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Discussion	**Industry/Real-world Scenario** A patient comes into the Radiology Department to get a routine series of chest x-rays. As the student is asking personal health history, the patient indicates a history of breast cancer and is concerned about the level of radiation already received and the amount that these exposures will give them. The patient asks if the radiation will affect all the organs in the chest area the same and relatively how much dosage will be received. **Proposed Teaching Strategies—going above and beyond lecture and problem sets** • Teamwork • Data gathering • Calculation • Simulation • Analysis • Research
Activities	**Activity Preparation for Instructor** • Review previously learned concepts about via links provided in the faculty resource area below: o Radiosensitivity o Cellular structure and division **Activity Steps** <u>Lab period 1:</u> • To allow a better understanding of the foundation of cells and radiation sensitivity, students should review the links provided. • Students should partner up to review the videos and links and collaborate on the findings to make sure each student has a good understanding of the material. • Students should refer to their lecture PowerPoint, notes, and textbook for reinforcement and clarification. • Once complete with review, the students should gather in larger groups to discuss their outcomes and get feedback on questions. • Students should take good notes in preparation for the next lab period. <u>Lab period 2:</u> • Students should pair up with a partner and find a place where they can have access to the computer, textbook, and their notes. Students should bring their calculator. • Students will be given several worksheets to complete for reinforcement of the applied concepts. o Calculations for Tissue Weighing o Cell Replication and the Law of B & G o BERT Worksheet

Major Sections	Content

	• After completing the worksheets:
	  o The students should use the cellular structure and replication notes and compare to the outcomes on the worksheets as a basis to analyze and predict how the organs will react to exposure to radiation.
	  o This will allow students to understand which parts of the body are more sensitive from exposure to x-rays and be able to give a better explanation to their patients in the healthcare setting.
	  o Take the calculations and write them in order of greatest to least sensitive to radiation.
	  o Interpret the results and compare them to the concept of Law of Bergonie and Tribondeau which identifies how cells replicate compared to their sensitivity to radiation.
	  o The students should take the information concerning the chest area (lungs) and refer to the information from lecture concerning background equivalent radiation. This will allow the student to come up with a real-life comparison to how much natural radiation is equal to one chest x-ray.
	• After all worksheets are completed, students should get into larger groups to compare and interpret the data collected.
	• Discussions should be centered on the difference of radiosensitivity of the tissues and why. Refer to all resources in lab (notes, worksheets, internet searches, and instructor).
	• Students should return to their individual desks and work on a simulation response to the scenario:
	  o A patient comes into the Radiology Department to get a routine series of chest x-rays. As the student is asking personal health history, the patient indicates they have a history of Breast Cancer and is concerned about the level of radiation they have already received and the amount that these exposures will give them. They ask if the radiation will affect all the organs in the chest area the same and relatively how much dose they will receive.
	• Students should be prepared to practice this in the next lab period with their classmates.
	
	<u>Lab period 3:</u>
	• Students should practice how to communicate their answers to the scenario to a patient in a mock simulation with classmates.
	  o Maintain good eye contact, have good voice inflections to engage the patient, and have good body language when interacting with the patient.
	• Immediate verbal feedback will offer improvements on how to clearly and effectively communicate to the patient without causing undue worry about the amount of radiation received.
	• Students should be prepared to answer additional questions.
	• Students should construct a simple chart to post in the x-ray departments about their findings to educate the technologists and help provide a dialogue between the staff and students on practicing safe radiation standards with patients by using lead shields whenever possible.
	• Take home: students will write a two-page summary to make connections between the Law of Bergonie and Tribondeau, chest exam radiation exposure, and radiation protection for the patient. There should be at least

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	two sources to document your findings and should be in APA style format. **Expected Results** (Include observations and data collection, calculations, and wrap-up/conclusions) • Students will use this chart to calculate the dose of radiation to the specific organ. The radiation dose comes from the readout off the control panel in the x-ray room. For simulation purposes, the numbers can be estimated.

Organ	Tissue weighting factor $_T$
Gonads	0.20
Colon	0.12
Bone marrow (red)	0.12
Lung	0.12
Stomach	0.12
Bladder	0.05
Chest	0.05
Liver	0.05
Thyroid gland	0.05
Oesophagus	0.05
Skin	0.01
Bone surface	0.01
Adrenals, brain, small intestine, kidney, muscle, pancreas, spleen, thymus, uterus (the weighting factor 0.05 is applied to the average dose of these organs)	0.05

• Students should understand the difference and sensitivity of different types of cells. This supports the Law of Bergonie and Tribondeau that states the faster a cell replicates, the more sensitive it will be to radiation.

Radiosensitivity Cell type

Low
- Nerve cells
- Muscle cells

Intermediate
- Osteoblasts
- Endothelial cells
- Fibroblasts
- Spermatids

High
- Spermatogonia
- Lymphocytes
- Stem cells
- intestinal mucosa cells
- Erythroblasts

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Students will conclude that the gonads are the most sensitive to radiation based on cellular replication
The colon, stomach, bone marrow, and lungs are considered moderately sensitive to radiation compared to other organs
The thyroid, bone surface, skin, and bladder will be the lowest in sensitivity to radiation exposure.
Students will refer to the following chart from their lecture notes to help determine how much natural radiation is equivalent to a chest x-ray exam. This is something understandable to the average patient. However, anything past the first row would cause alarm to the patients and should be avoided. Radiation is safe in low numbers, but not in high replicated areas concerning the bone marrow or digestive system.

BERT based on background estimate of ~ 3 msv or 300 mrems p/yr
<table>
<tr><td>Chest radiograph</td><td>6 mrem (.06 msv)</td><td>1.5 wk (10 days) to receive same dose in nature</td></tr>
<tr><td>Thoracic Spine</td><td>150 mrem</td><td>6 mo. to receive the same dose in nature</td></tr>
<tr><td>Lumbar Spine</td><td>300 mrem</td><td>1 yr. to receive the same dose in nature</td></tr>
<tr><td>Upper Gi series</td><td>450 mrem</td><td>1.5 yrs to receive the same dose in nature</td></tr>
<tr><td>BE*****</td><td>600 mrem (6 msv)</td><td>2 yrs. To receive the same dose in nature</td></tr>
</table>
Extension Options
(Options for expanding project, modifying it to meet local interests, deepening its complexity.)

Students could use patient exam data for their lifetime and calculate the predicted cumulative dose. This would take written permission from the patient. Clinical sites are teaching hospitals or facilities and permission may be received if proper steps are followed to gain access to the patient’s history.
Students could do an in-service with the technologists at their clinical sites during the department meetings to help close the gap on excessive radiation exposure.

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<tr><td>Faculty Resources</td><td>
Background Material

Firm understanding of the human anatomy and physiology, especially cell structure and replication processes

Suggested Website Links
NRC - Dose in our daily lives
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	Radiation – what is the risk? National Science Foundation – Radiation sensitivity National Science Foundation – Interaction with matter **Videos** CDC Radiation overview video Slideplayer video for Law of Bergonie and Tribondeau Mitosis Video – Khan Academy Cellular Radiation Sensitivity Video Effects on Organ Tissues slides **Handouts** Calculation Worksheet for Tissue Sensitivity Cellular Replication and the Law of Bergonie and Tribondeau Worksheet Background Equivalent Radiation Time (BERT) Worksheet Project Activity Worksheet for Students Project Activity Worksheet for Faculty Grading Rubric Student Self-Evaluation **Other Resources** Lecture PowerPoint Textbook **Answer Keys** Answer Key Calculation Worksheet for Tissue Sensitivity Answer Key Cellular Replication and the Law of Bergonie and Tribondeau Worksheet
Assessment	**How will students demonstrate what they have learned?** (Determine the criteria by which you will evaluate student achievement of the project's learning objectives.) • Give scenarios of different combinations of calculations to complete and ask for predictions for biological effects – graded on content and theories used and facilitated in collaboration with other students for discussions. • Assignment for student to summarize and interpret their findings in a two-page paper. This would give a gauge level of understanding and ensure students made the connections and applied the knowledge learned. • Students will simulate with a "patient" to promote reinforcement of activity **Assessment Tools** Create the following assessment tools, as appropriate:

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	• Rubrics • Observations • Discussion participation • Writing prompts