

UCF RET Site: Research Experiences in Computer Vision and Bio-Medical Imaging Lesson/Unit Plan

2000340: AP Biology

2019

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READ THIS FIRST

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- Remember to do your 3R reflection include and updated copy of your lesson plan, developed assessment tools, presentation materials, to the evaluator. See implementation plan instructions developed by the evaluator. Send within a week after completing the lesson to bonnie.swan@ucf.edu

RET Site: Research Experiences in Computer Vision and Bio-Medical Imaging Lesson/Unit Plan

Course(s): AP Biology
Grade Level: 9-12
Suggested Length of Lesson: 315 minutes (7 periods x 45 mins)

Materials/Technology Needed

- **Student Laptops**
- **3D Slicer Download**
- **LDCT Images/Transparencies**
- **Rulers**
- **Research Articles**
- **Edvotek DNA Microarray Kit**
- **Large Poster Paper**
- **Markers**
- **3-d Printer (optional)**

Where this Fits

- **Big Idea 3: Information:** Living systems store, retrieve, transmit and respond to information essential to life processes
- 3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.
- 3.A.3: The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring
  3.A.4: The inheritance pattern of many traits cannot be explained by simple Mendelian genetics.
- 3.C.1: Changes in genotype can result in changes in phenotype.
  3.C.2: Biological systems have multiple processes that increase genetic variation

Lesson Objective(s)/Learning Goal(s)

- Students will be able to stage lung cancer LDCT images and understand the potential for human error when staging.
- Students will be able to identify and evaluate current methods of detecting cancer.
- Students will be able to propose ways of detecting cancer utilizing available technologies.
- Students will understand the importance of data collection and evidence gathering and its implication on cancer patients' survival.
- LO 3.7 The student can make predictions about natural phenomena occurring during the cell cycle.
- LO 3.13 The student is able to pose questions about ethical, social or medical issues surrounding human genetic disorders.

Standard(s)/Benchmark(s) Addressed

- *Next Generation Sunshine State Standards:*
  - *N/A*
- *Common Core Standards for Mathematics:*
  - N/A

Standards for Mathematical Practice

- CCSS.MATH.PRACTICE.MP3 Construct viable arguments and critique the reasoning of others.

Instructional Strategies

- Card Sort
- Guided Practice
- Individual Exploration
- Inquiry-Based Activity

Evidence of Learning (Assessment Plan) ▪ **Mini-Poster Presentation (Summative)** ▪ **Cancer Mythbusters Activity (Formative)** ▪ **3d Slicer segmentation (Formative)** ▪ **Edvotek DNA Microarray (Formative)**	▪ CER Posters

Description of Lesson Activity/Experiences:

The lesson(s) are intended to have follow the 5E Model Framework. This is a series of lessons that will be taught at the end of Big Idea 3 in AP Biology. Each lesson will address at least one component of the 5E model with embedded opportunities for formative assessment.

1. **Engage:** The primary purpose of this component is to elicit student interest in the topic. For this unit, students will explore the field of radiology. The engage component will take two 45-minute class periods.
2. **Explain**: The explain component is one 45-minute lesson that will have students connect the research taking place at UCF CRCV to its application in radiology. This is a primarily teacher-led lesson with an emphasis on how the 3-d slicer program can be utilized to segment lung cancer nodules
3. **Explore**: The explore component will provide students with an opportunity to use 3-d slicer on their own. In a follow up lesson, students will use perform a DNA microarray utilizing a laboratory kit made by Edvotek.
4. **Elaborate:** Once students have familiarized themselves with the various technologies that can be utilized to detect cancer, students will conduct further research to brainstorm ways to improve this technology as they will be tasked with a challenge to design their detection and future prevention plan.
5. **Evaluate:** Students will now communicate their findings from their research in the form of a mini-poster. This will be a formal evaluation of their understanding of the concept thus far.

The integration of Computer Vision into the Advanced Placement Biology course is primarily accomplished by the incorporation of the following guiding question:

"How Low-Dosage Computed Tomography (LDCT) Scans and Computer-Assisted Detection (CAD) systems aid in early identification of potentially life threatening lung cancer nodules."

Day One (45 Minutes) - Engage

1. ***Introduction to Lung Cancer Statistics***: Students will receive the "Cancer Myth-busters" card sort. Students will be asked to categorize the cards as true or false. Once student groups have categorically agreed, students can share their results by taking a picture and posting it on Padlet (or similar digital tool). After teacher-guided discussion, students will re-arrange their card sorts. This also serves as a formative tool to assess student misconceptions prior to beginning this unit. This portion of the lesson should take approximately 15-20 mins.
2. The next portion of the lesson is primarily teacher-led in which students are shown how lung cancer is staged and categorized. The students will also be familiarized with the various forms of technology available to detect cancer and the pro's and con's related to the technology. The outcome of this teacher-led discussion is for students to understand the effect on patient-outcome the later a cancer is diagnosed. Students do not need to become proficient at staging. This portion of the lesson should take the remainder of the lesson.

Day Two (45 Minutes) - Engage

3. ***Staging in Neon:*** Students receive images of lung scans and asked to circle areas that they suspect are cancer. The students can use Neon expo markers on laminated images which can be wiped off for future use. The students will be asked to measure the size of the nodules (if any detected) and asked to record measurements and estimates as they relate to size, volume, and density. This activity should take the entire class period. The outcome of this activity is for students to realize the potential for human error and the implications of false-positives or false-negatives.

Day Three (45 Minutes) - Explain

4. ***3d Slicer Guided Tutorial:*** Students will be guided through the 3d slicer program utilizing images found at The Cancer Imaging Archive (TCIA). For the sake of simplicity, everyone will segment the same patient and follow along with the teacher. This lesson serves as a connection between computer science and its application in biomedical science. The students will leave the lesson with an introduction to UCF CRCV and their research. The purpose of this lesson is for students to become familiar with the program so that they are able to segment a nodule on their own.

Day Four (45 Minutes) – Explore

5. ***3d Slicer Individual Exploration***: Students will use the 3d slicer program to segment a lung cancer nodule. They will be tasked with accuracy and precision. They will then record their measurements and the class will vote for which 4 students had the best segmentation. As an additional engagement element, the students' work will be sent to be 3d printed. This component also serves as a great opportunity to discuss the nuances between student groups even though everyone is segmenting the same patient.

Day Five (45 Minutes) – Explore

6. ***Edvotek DNA Microarray Exploration:*** The students will read through the Edvotek instructions and diagram their experimental overview for approval. Students will conduct an experiment using the Edvotek kit with teacher supervision after being approved. This serves as an additional explore task in which students connect the concept of DNA to cancer and how advances in computer science can aid in this process.

Day Six (45 Minutes) – Elaborate

7. ***Student Research Experience***: Students will be review current cancer research that is taking place utilizing a teacher-created list of resources. The students will then extend their research while working in groups to design an effective early cancer detection protocol utilizing the knowledge they have gained throughout this unit. The students will have to fulfill criteria provided by a guiding rubric. The purpose of this lesson is to become familiar with the various challenges and improvements that can be made in the field of cancer-detection.

Day Seven (45 Minutes) – Evaluate

8. ***Mini-Poster Presentations:*** Students will make a mini-poster outline their cancer detection protocol utilizing the available technologies. They must include their reasoning and have evidence to support their protocol. In addition, students will be tasked with presenting viable solutions that to improve current detection options. Students will present these posters to visiting faculty members in a semi-formal setting. The purpose of this lesson is to evaluate student's understanding of the overall connections between the field of computer science and biomedical sciences and to strengthen their understanding of how a multitude of scientists work together to solve problems plaguing humankind.

Recommended Assessment(s) and Steps

- **Day One (45 Minutes): Introduction to Lung Cancer Statistics & Staging Overview**
  - **5E Embedded Elements**
    - Students organize cancer cards and categorize them as true or false. Students will then take a picture with their digital device and upload to Padlet. This serves as an engaging introduction and an opportunity to assess previous understandings and misconceptions (Engage/Evaluate).
    - Students should find some of the statistics to be particularly shocking especially the sharp decline is survival rates as each stage increases.
    - Students will be introduced to the field of radiology with a specific emphasis on cancer detection (Explain).
    - Students will be guided through a teacher-led discussion on various imaging technologies and how they are used to stage cancer with a final overview on staging cancer (Explain).

- **Day Two (45 Minutes): Staging Cancer in Neon**
  - **5E Embedded Elements**
    - The students are assigned a set of laminated images that they will be tasked with staging using neon markers (Engage).
    - Students are given an opportunity to stage a set of images and compare their findings with other groups. Students will be tasked with collecting/predicting measurements as they relate to size, volume, density, and determine if the growth is cancerous or not (Explore/Elaborate).
    - The teacher will guide a discussion on each group had the same set of images but potentially varied in their results or diagnosis. (Explain/Elaborate)
    - Students will also compare their data and understand the potential for human error (Elaborate/Evaluate).

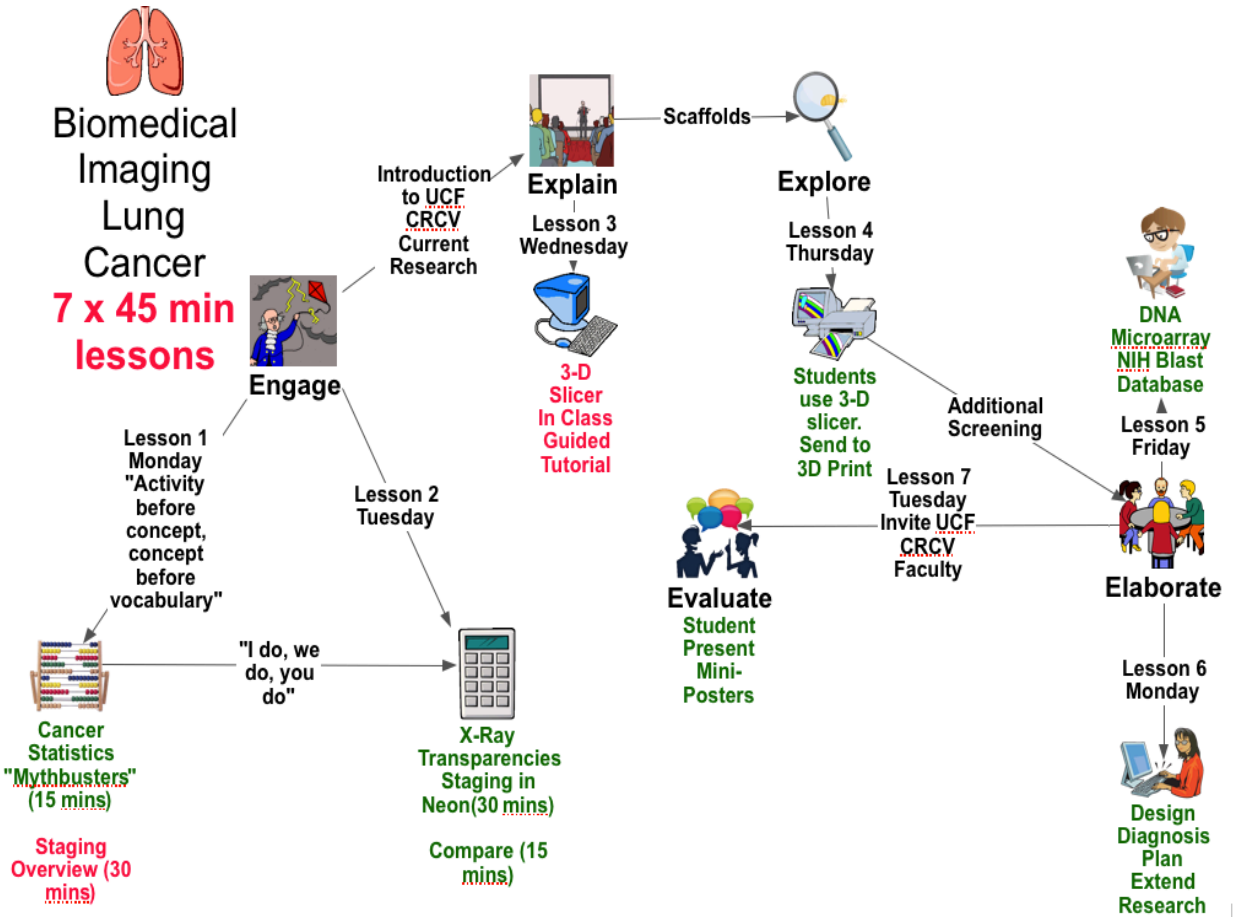
- **Day Three (45 Minutes): 3d Slicer Guided Tutorial**
  - **5E Embedded Elements**
    - The students will be guided through a teacher-led tutorial on how to segment using patient data from TCIA (Engage).
    - The students will follow the teacher as the teacher explains the features of the program related to the task(Explain).
    - The students will each have their own digital device to follow along (Explore).
    - The students will be given an additional self-guided tutorial for additional practice (Elaborate).
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- **Day Four (45 Minutes): 3d Slicer Exploration**
  - **5E Embedded Elements**

        - The students are assigned the same patient data from TCIA (Engage).
        - The students will use 3d slicer and the knowledge obtained the previous lesson to segment lung nodules (Explore).
        - The students will collect data using the program comparing these data points to their previous staging by hand data collection protocol (Elaborate).
        - The students will then vote on the best segmentation from their table to submit for 3d printing (Evaluate)
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- **Day Five (45 Minutes): Edvotek DNA Microarray Exploration**
    - **5E Embedded Elements**
        - The students are introduced to the concept of DNA Microarrays by watching a short YouTube video explaining the concept. (Engage)
        - The students will read the background information related to the Edvotek Microarray Experiment they will perform (Explain).
        - The students will diagram their lab flow on their lab tables for teacher approval to demonstrate understanding of their intended task(Elaborate).
        - The students will conduct the experiment adhering to the protocol recommended by Edvotek (Explore).
        - The students will compare and analyze results between groups to make evidence-based claims that are supported by their lab results (Evaluate).
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- **Day Six (45 Minutes): Student Research Experience**
    - **5E Embedded Elements**
        - The students are introduced to a teacher-complied list of relevant research that identifies the areas of growth and potential concerns (Engage).
        - The students will be grouped and assigned an exploration task; Design a plausible research based early cancer detection protocol(Explain).
        - The students will also have a guiding rubric to ensure they are extending and elaborating on existing research and taking into consideration multiple perspectives (Elaborate).
        - The students will present their research in the form of a poster that must have their "Claim, Evidence, and Reasoning." (Evaluate)
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- **Day Seven(45 Minutes): Mini Poster Presentation**
    - **5E Embedded Elements**
        - The students will be presenting to other staff members (admin, teachers, counselors, and UCF faculty) (Engage).
        - The students will follow a presentation rubric to ensure that each group is able to present within the 45-minute time period (Explain/Evaluate).
        - The students will have an opportunity to engage in conversation with UCF faculty to discuss their research (Elaborate).

List of Materials/Resources Used

- Cancer Mythbuster Card Sort Activity
- Cancer Images (to be printed and laminated) – Screenshots from TCIA
- Cancer Image Data from TCIA – Teacher Tutorial
- Cancer Image Data from TCIA – Student Exploration
- Edvotek DNA Microarray Kit
- Teacher Research Resource List
- Poster Rubric
- Presentation Rubric



Important Vocabulary

Term	Definition
Cancer	Uncontrolled growth of cells
Calcification	The deposit or accumulation of Calcium deposits
Cavitation	The development of an opening within a lung nodule
Cell Cycle	The series of stages associated with the replication and division of a cell.
Characterization	The evaluation of a specific visual and quantitative factors to determine malignancy.
Chromosome	A structure made up by the coiling of DNA around proteins that contains the genetic information for a cell.
Computed Tomography (CT) Scan	An imaging procedure that produces detailed black and white images (slices) of internal tissue and organs.
DNA	A molecule known as Deoxyribose Nucleic Acid, that contains the genetic information of a cell.
Genes	Segments of a hereditary information of a chromosome that is utilized by the cell to determine certain physical traits.
Lung Nodule	Small masses of tissue developed in the lungs
Metastasis	The development of abnormal cell growth originating from a primary tumor
Mitosis	The division of the nucleus of a cell
Mutation	A change in the gene sequence of DNA
Tumor	Abnormal growth of tissue within an organism
Spiculated	Irregularly shaped margins of a lung nodule.

Troubleshooting Tips

It is recommended that students download 3d slicer prior to the teacher guided tutorial. The school's technology specialist should be able to assist in pushing/approving the download to the student computers. The Edvotek laboratory experiment instructions are freely available and it is highly recommended that students read the instructions and draw a concept map on the their lab tables using neon markers to demonstrate understanding. The files that are related to the TCIA activity are very large. It is helpful to pick the patients in advance and download the files as zip files and put them on to a removable USB drive.

Other Helpful Information

Due to the nature of guided inquiry and inquiry based lessons in general, plenty of time is afforded to the instructor to be able to circulate and monitor for formative understanding. In addition, this is also an opportunity to further clarify and elaborate for struggling students.

Attachments

List here any lesson or activity attachments not included within this document, such as the following:

- Mythbusters Cancer Card Sort Activity
- DNA Microarray Experiment Protocol
- Teacher Research Resource List
- Mini Poster Rubric
- Mini Poster Presentation Rubric

References

DNA Microarray
https://www.youtube.com/watch?v=6ZzFihESjp0

Edvotek Edvo-kit #235 – 2018:
http://www.edvotek.com/site/pdf/235.pdf

Low-dose CT for lung cancer screening: opportunities and challenges.
Front Med. 2018 Feb;12(1):116-121. doi: 10.1007/s11684-017-0600-1. Epub 2017 Dec 7.
https://www.ncbi.nlm.nih.gov/pubmed/29218678
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Lung Cancer Fact Sheet
http://www.lung.org/lung-health-and-diseases/lung-disease-lookup/lung-cancer/resource-library/lung-cancer-fact-sheet.html
American Lung Association – 2018

Lung Cancer Staging
http://cancerstaging.org/references-tools/quickreferences/documents/lungmedium.pdf
American Joint Committee on Cancer - 2018

Lung Cancer Statistics
https://www.cancer.org/cancer/non-small-cell-lung-cancer/about/key-statistics.html
American Lung Cancer Society – 2018

Risk Stratification of Lung Nodules Using 3D CNN-Based Multi-task Learning
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Supervised and Unsupervised Tumor Characterization in the Deep Learning Era
Sarfaraz Hussein, Maria M. Chuquicusma, Pujan Kandel, Candice W. Bolan, Michael B. Wallace, Ulas Bagci
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Yearly Lung Cancer Screening: Is It Right for Me?
Dr. Pamela Samson, Washington University in St. Louis, Department of Surgery Dr. Mary Politi, Washington University in St. Louis, Department of Surgery and the Institute for Public Health Dr. David Gierada, Washington University in St. Louis, Division of Cardiothoracic Imaging Dr. Sanjeev Bhalla, Washington University in St. Louis, Division of Cardiothoracic Imaging Dr. Bryan Meyers, Washington University in St. Louis, Division of Cardiothoracic Surgery
https://siteman.wustl.edu/wp-content/uploads/2016/04/Lung-Cancer-Screening-20160427_rev.pdf

Acknowledgements

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