Shedding a "Little" Light on Cancer Surgery

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Date Created: 8/9/2016

Subject: Physics

Grade Level: 10th -12th grade

Standards: Next Generation Science Standards (www.nextgenscience.org)

HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

HS-PS4-4 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

HS-PS4-5 Communicate technical information about about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Schedule:
2-3 45 minute class periods

CCMR Lending Library Connected Activities:

Objectives:	**Vocabulary:**
Develop and understanding of the interaction between nanotechnology and biological systems. Explain light absorption and fluorescence in materials.	Fluorescence Nanoscale Optical imaging Nanoparticles Melanoma C-Dots
Students Will: - Students participate in primer activity as "surgeons" or observers in primer activity. - Students remove "malignant" tissue from jello mold brain. One with jello of different rigidity but no fluorescent marker and one with fluorescent marker. Both equal mass. - Students evaluate which removal method was most effective, based on percent deviation from mass of tissue implanted. - Students investigate methods of marking cancerous tissue using nanoparticles and chemical markers. Groups will be assigned to support each method during a debate. - Students participate in a two round class debate answering the question of which method to fund, from the perspective of a grant committee. One prechosen group will be for funding C-Dot work the other will be against it. - Students will complete a post-debate survey choosing which method to fund by evaluating what they learned in the debate.	**Materials:** Brain surgery primer activity sheet Jello brain mold Two packets clear Knox Gelatine Mix 1 liter tonic water 1 ml pipet Scalpel Tweezers UV light source (black light) Mass scale Debate activity sheet Article 1: "New Imaging Method Lights Up Cancer Cells during Surgery" Article 2: "Fluorescent Cancer-Selective Alkylphosphocholine Analogs for Intraoperative Glioma Detection" Computer for access to YouTube videos on each procedure type. Post-debate survey sheet
Safety	Sharp instruments such as scalpels can puncture skin, all necessary precautions should be taken while students perform the mock surgery.

Science Content for the Teacher:

Primer Activity:

Tonic water is a carbonated beverage that has a chemical called quinine dissolved in it. Quinine is made from the bark of a tree and has been used for centuries as a treatment for malaria. Quinine not only gives tonic water a characteristic bitter taste (which is offset today by the addition of sweeteners to bottled tonic water) but this chemical can also be very fluorescent under the right conditions.

Under an ultraviolet "black light," the quinine in tonic water makes the water fluoresce a brilliant, bright blue (even though only a relatively small amount of quinine is dissolved in the water). In general, something fluoresces because it has absorbed light energy, which makes it excited, and then it releases (or emits) light as it returns to its normal, unexcited state. Part of why we find things that glow under ultraviolet lights—such as some minerals, fish and tonic water—to be fascinating is because we cannot see the (ultraviolet) light they absorb but can see the visible light they emit (which is blue in the case of quinine).

Nanotechnology:

Nanotechnology is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers.
Nanoscience and nanotechnology are the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering.
One nanometer is a billionth of a meter, or 10^{-9} of a meter. Here are a few illustrative examples:

- There are 25,400,000 nanometers in an inch
- A sheet of newspaper is about 100,000 nanometers thick
- On a comparative scale, if a marble were a nanometer, then one meter would be the size of the Earth

C-dots:

Carbon quantum dots (CQDs, C-dots or CDs) are small carbon nanoparticles (less than 10 nm in size) with some form of surface passivation.

CQDs were first discovered by Xu et al. in 2004 accidentally during the purification of single-walled carbon nanotubes. This discovery triggered extensive studies to exploit the fluorescence properties of CQDs. Much progress has been achieved in the synthesis, properties and applications of CQDs.

As a new class of fluorescent carbon nanomaterials, CQDs possess the attractive


properties of high stability, good conductivity, low toxicity, environmental friendliness, simple synthetic routes as well as comparable optical properties to quantum dots. Carbon quantum dots have been extensively investigated especially due to their strong and tunable fluorescence emission properties, which enable their applications in biomedicine, optronics, catalysis, and sensing.

Classroom Procedure:

1. Setup lab stations for 2-3 students each with the materials listed.
2. Present the lesson objectives to the class.
3. Allow time for students to conduct primer activity.
4. Conduct a brief (5-10 minute) discussion on the results of the activity.
5. As a whole class watch introductory videos on both processes, one from the University of Wisconsin, the other from MSKCC.
6. Divide students into debate groups and hand out background material.
7. Discuss group expectations and research preparation for debate.
8. Allow research and preparation time (outside of class)
9. Conduct debate using the fomat:
    - Round One (10 min each)
        a. Group One: Presentation of argument for C-Dots
        b. Group Two: Presentation of arguments against C-Dots
    - Team Discussion Period (5 min)
        Groups prepare responses to arguments based on text evidence and research
    - Round Two (10 min)
        a. Group One: Response or rebuttal
        b. Group Two: Response or rebuttal
10. Allow time for students to complete the post-debate survey.

Assessment:

1. Completion of Primer Activity Sheet
2. Research Preparation and Participation in Class Debate
3. Completions of post-debate survey

Resources:

Article from Memorial Sloan Kettering Cancer Center. 2014. April 24

https://www.mskcc.org/blog/new-imaging-method-lights-cells-during-surgery

Article from Neurosurgery: The Register of Neurosurgical Meme. 2015. February. Volume 76 - Issue 2 - p 115–124
http://journals.lww.com/neurosurgery/Fulltext/2015/02000/Fluorescent_Cancer_Selective_Alkylphosphocholine.11.aspx

Video from University of Wisconsin School of Medicine and Public Health. 2015. February 10
http://journals.lww.com/neurosurgery/pages/videogallery.aspx?videoId=372&autoPlay=false

Video from Wiesner Group at Cornell University. 2014. February.
MSKCC: C-dots in the operating room
https://wiesner.mse.cornell.edu/videos.html

Acknowledgements:

I would like to acknowledge the National Science Foundation, Cornell University, the Wiesner Group at the Cornell Department of Material Science & Engineering, and the Cornell Center for Materials Research for sharing resources, personnel, and inspiration. A special thanks to Teresa Kao, Nev Singhota and Mark Walsh for their support and time.