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Would you care for a sprinkle of nanotechnology with your biology?

Background

- 15th year teaching biology and computer graphic design (STEAM teacher), Kearny School of College Connections, San Diego, CA.
- Participated in the San Diego Nanotechnology Infrastructure's (SDNI) Research Education for Teachers (RET) program in 2018 & 2019. *Tasked with creating a lesson that integrates nanotechnology into my biology curriculum.*

Nanotechnology is Hard!

- Nanotechnology involves experience and knowledge in biology, chemistry, and physics.
- It also requires the use of “executive function” skills.

Know My Audience: Student and School Profile

- High school freshman (14 years old)
- Hispanic 54%
- Asian 22%
- White 10%
- African American 7%
- Two or more races 6%
- Other 1%
- 74% qualify for free or reduced lunch
- 50% Fluent in English
- CAASPP Math (11th grade 2019) – 34% met standards
- CAST Science (12th grade 2019) – 27% met standards

Know My Resources

- Funding for equipment.
- Finding time in an already packed curriculum.
- Support for me from a place like SDNI.

Would you care for a sprinkle of nanotechnology with your biology?

My Objectives

- Integrate an introduction to the nanoscale, nanoparticles, and the application of nanotechnology into the high school biology curriculum.
- Spark students' interest in nanotechnology by planting a "nano-seed" in their brain.

Student Objectives

- **Students will gain a basic understanding of…**
  - the nanoscale
  - emergent properties on the nanoscale (build on the relationship between structure and function)
  - the power of an SEM (build on the relationship between structure and function)
  - the use of nanotechnology in medicine
  - the use nanotechnology for environmental conservation

Sprinkle 1: Emergent Properties

- Within the first few days of school many biology teachers cover the concept of emergent properties within the context of the hierarchy of life.
- Last year I introduced the that topic by using the *phenomenon* of nanoparticles and their unique behavior with respect to color.

Sprinkle 1: Procedure

1. Present the gold solution demonstration (fake it with food coloring). Explain that all of the solutions contain gold nanoparticles and nothing else.
2. Present a blue morpho butterfly (not a living one) and tell them that it's not actually blue.
3. Ask students for possible explanations (write on board) but do not discuss their thoughts yet.

Sprinkle 1: Procedure Cont'd

4. Conduct my normal emergent property lesson which consists of an activity in which students module the concept using arts and crafts, as well as watch a video, and have a brief discussion.
5. Now go back and ask students about the gold demo & blue morpho for a revised explanation. *I am happy to report that they came up with some ideas about the relationship between size, shape, and behavior.*
6. Conduct a VERY brief presentation about pigment and light waves and the effect that *nanoparticles* and *nanostructures* have on light waves and color (color by shape and size – not pigment).

Sprinkle 2: The Scale of Things

- Many biology teachers cover the relationship between surface area and volume with respect to the movement of molecules through the cell membrane (why cells are so small?). *Again this builds on the relationship between structure and function.*
- This past year I added nanometers to this discussion and introduced the topic with an activity about their height in nanometers.

Sprinkle 2: Procedure

1. Introduce students to the nanoscale with a brief presentation in which I conduct a short math exercise to help illustrate the size of a nanometer using well know observable objects. For example, if a penny represents a nanometer, what object would represent a meter?
2. Then I gave them a fun fact -- Shaquille O'Neal is 2,160,000,000 nanometers tall! Have students figure out how tall they are in nanometers.

Sprinkle 2: Extension

Introduction to the SEM

Now that students have an idea of the nanoscale, this is a great time to set up a remote SEM session to observe examples of nanostructures using the “matching game”. I suggest emphasizing the relationship between form and function and wherever possible bring back emergent properties to go full circle.

Important notes:

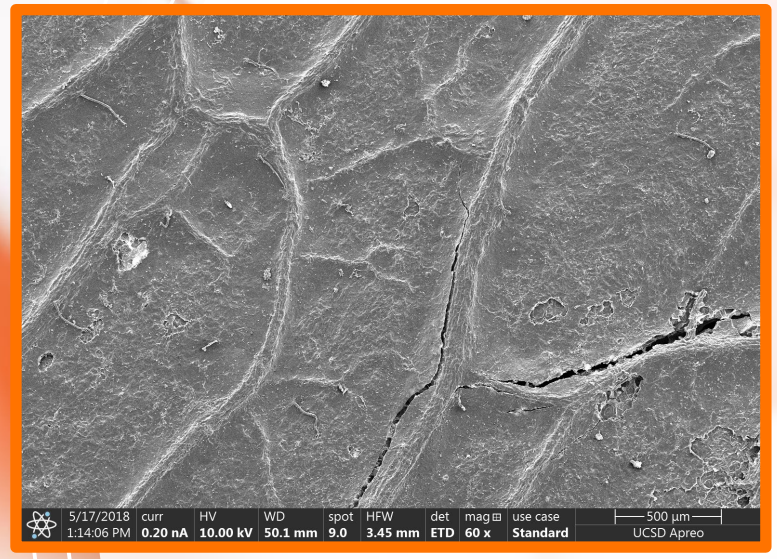
1. *Do not look at cells as we will do this in another “sprinkle”.*
2. *The same activity can easily be sprinkled into the evolution unit and adaptations*

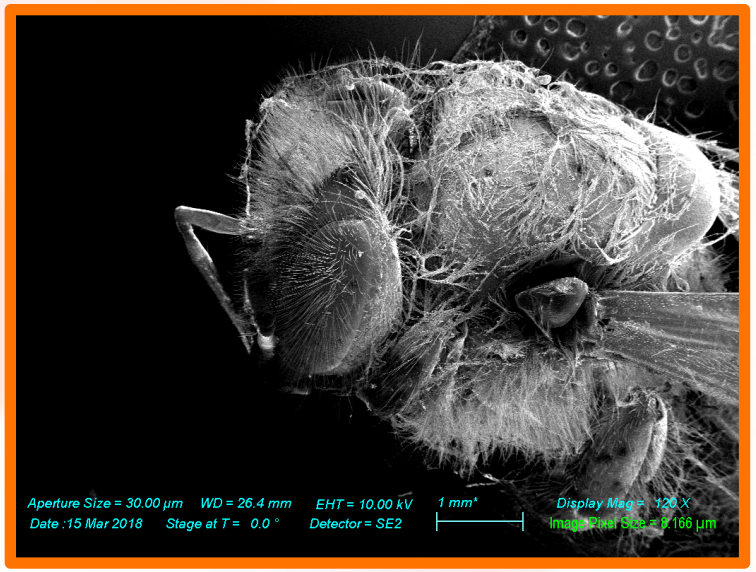
The SEM Matching Game

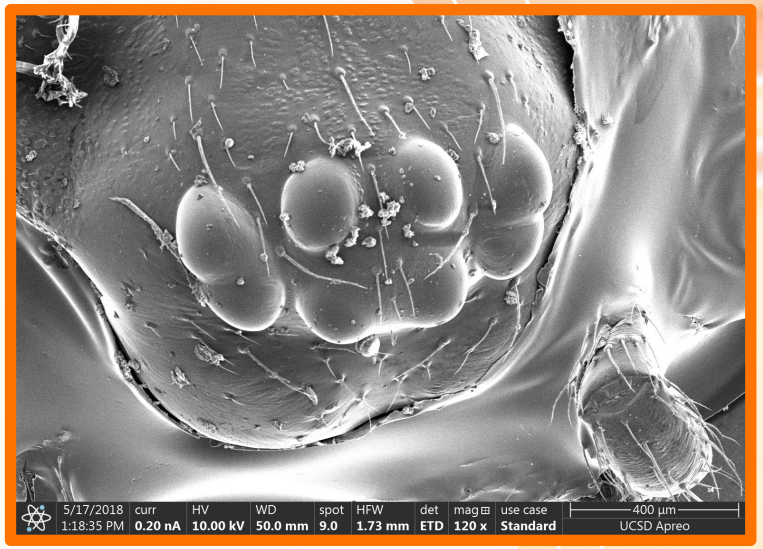
Show students photographs of the samples they are going to see in the SEM session.

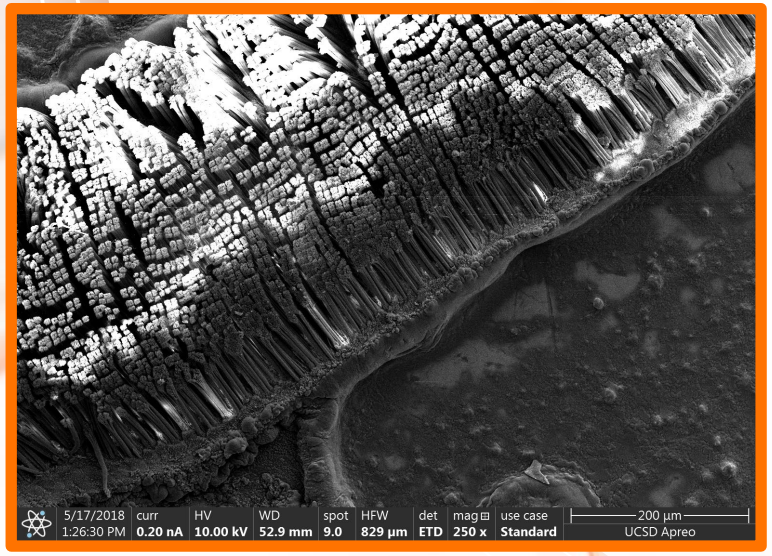
The SEM Matching Game

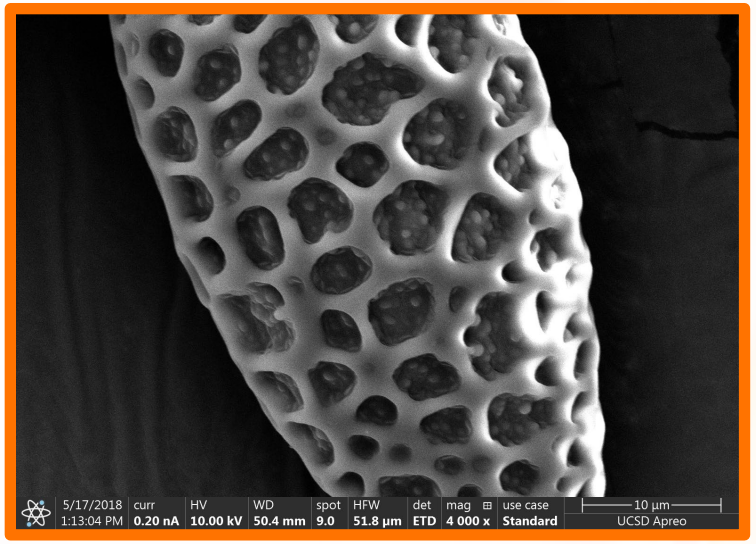
As students observe the images using the SEM, they try to guess which sample they are seeing. Then observe and discuss form & function.

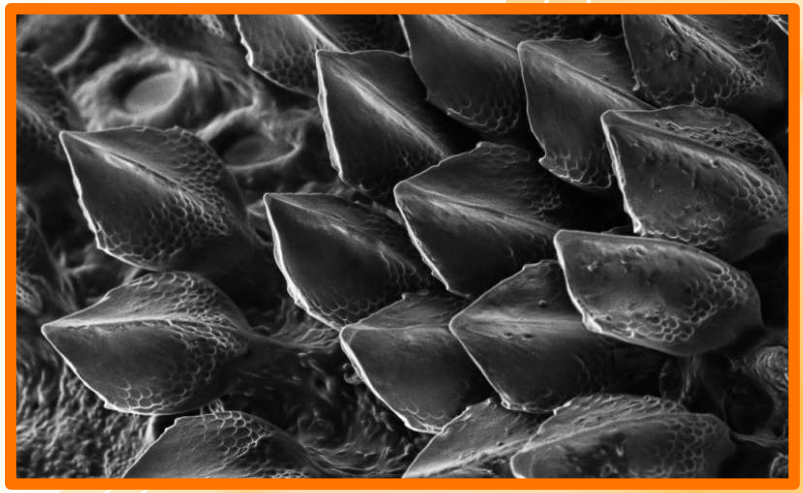












Sprinkle 3: Cell Structures

- As some point during the semester, biology teachers will address various cell structures, organelles and teach them how to use a compound light microscope.
- This is a great time for another SEM session.

Sprinkle 3: Procedure

1. Teach students how to use a compound light microscope by ideally observing ”the same” samples as they will with the SEM.
2. Have them draw what they observe.
3. Now use the remote SEM and once again play the “the matching game” as described in sprinkle 2.
4. Have students draw what they observe and try to identify the cell structures as they navigate the samples.
5. Have students compare their drawings between the 2 microscopes and then have them find relationships between form and function.

Sprinkle 4: In the News

I have started compiling a library of news articles and videos along with guiding questions that are *appropriate* for my students and hopefully of interest to them.

1. Smart Toilets
2. Biosensors
3. Nanosponges
4. Targeted Medicine (general)
5. Cancer & Nanotubes
6. Theranstatic particles in medicine
7. Quantum dots in medicine
8. Colloidal Silver
9. Nanotattoos (diabetes)
10. Nanopatch (vaccines)

Sprinkle 4: Example 1 – Smart Toilets

Vocabulary

Loo – toilet in England

Pounds – money (dollars in England)

GP – General Practitioner (your doctor)

Neurotransmitter – a method that messages are sent around the body

Questions

1. Describe the toilet and what is does:
2. List all of the advantages this toilet could have when compared to traditional methods (blood samples) of collecting a person's health data.
3. Describe how the data is collected from the urine:

Link: https://nano-magazine.com/news/2018/7/4/intelligent-toilet-to-flush-out-healthcare-issues?rq=toilet

Sprinkle 4: Example 2 – Cancer

Article Questions

1. Why is targeted cancer treatment better than traditional cancer treatment?
2. Describe what Professor Hongji Dai created and how it works step-by-step (a numbered list of the steps in the correct order).

Extensions

1. Show the video from Kerson about this treatment actually being applied and working
2. Have students illustrate the procedure it in a comic strip!

Article link: http://www.nanooze.org/carbon-nanotubes-and-cancer

Video link: https://phys.org/news/2018-12-video-nanoparticles-clinical-trials-prostate.html

NGSS

LS1.A: Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)
- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1-2)

HS-LS1-7.

- Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

HS-LS1-2.

- Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

NGSS

LS4.C: Adaptation

- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. (HS-LS4-6)
- Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2)

NGSS

LS3.B: Variation of Traits

- In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3-2)
- Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors. (HS-LS3-2),(HS-LS3-3)

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary to HSLS2-7),(secondary to HS-LS4-6)