Chemistry Cavalcade

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Tips About This Curriculum

Lesson Plan Format: All lessons in this curriculum unit are formatted in the same manner. In each lesson you will find the following components:

KEY QUESTION(S): Identifies key questions the lesson will explore.
OVERALL TIME ESTIMATE: Indicates total amount of time needed for the lesson, including advanced preparation.
LEARNING STYLES: Visual, auditory, and/or kinesthetic.
VOCABULARY: Lists key vocabulary terms used and defined in the lesson. Also collected in master vocabulary list.
LESSON SUMMARY: Provides a 1-2 sentence summary of what the lesson will cover and how this content will be covered. Also collected in one list.
STUDENT LEARNING OBJECTIVES: Focuses on what students will know, feel, or be able to do at the conclusion of the lesson.
STANDARDS: Specific state benchmarks addressed in the lesson. Also collected in one list.
MATERIALS: Items needed to complete the lesson. Number required for different types of grouping formats (Per class, Per group of 3-4 students, Per pair, Per student) is also indicated.
BACKGROUND INFORMATION: Provides accurate, up-to-date information from reliable sources about the lesson topic.
ADVANCE PREPARATION: This section explains what needs to be done to get ready for the lesson.
PROCEDURE WITH TIME ESTIMATES: The procedure details the steps of implementation with suggested time estimates. The times will likely vary depending on the class.
ASSESSMENT SUGGESTIONS: Formative assessment suggestions have been given. Additionally, there is a brief summative assessment (pre/post-test) that can be given. Teachers should feel free to create additional formative and summative assessment pieces.
EXTENSIONS: (ACTIVITIES/LITERATURE): There are many activities and reading sources available to augment and enhance the curriculum. They have been included. If you find additional ones that should be added, please let us know.
RESOURCES/REFERENCES: This curriculum is based heavily on primary sources. As resources and references have been used in a lesson, their complete citation is included as well as a web link if available. All references and resources are also collected in one list.
STUDENT PAGES: Worksheets and handouts to be copied and distributed to the students.
TEACHER PAGES: Versions of the student pages with answers or the activity materials for preparation.

Collaborative Learning: The lessons in this curriculum have been developed to include many collaborative learning opportunities. Rather than presenting information in lecture format and teacher driven, the activities involve the students in a more engaged manner. For classrooms not accustomed to using collaborative learning strategies, have patience. It can be difficult to communicate instructions, particularly for students who are visual learners. For these students, use of visual clues such as flowcharts and graphics can help them understand how they are to move to different groups.
Groups: Most of the lessons are carried out in groups. While it isn’t necessary for students to remain in the same groups the entire unit, if they work well together, it may foster students to think deeper as they are comfortable with their teammates and willing to ask questions of each other.

Inquiry-based: The lessons in the curriculum invite students to be engaged and ask questions. They work through background information in a guided fashion, but are challenged to think beyond what they have read or done. The teacher serves as the facilitator in these activities, not the deliverer of information.

Technology: Lessons have been written to be mindful of varying availability of technology in schools and homes. Some of the lessons would be very well suited to online environments and if your students are able, you might wish to engage in some of the technology modifications.

Content: Often we teach in a manner that is very content heavy. With high-stakes testing the norm, students are pushed to memorize and regurgitate numerous isolated facts. There is so much content that must be covered in a biology class, for example, that often it is difficult to synthesize those discrete facts into a compelling context or a story. This unit provides that opportunity: to take concepts learned such as muscles have a lot of glycogen or DNA codes for RNA, and put them in the context of disease. The lessons aren’t designed to teach students what lysosomes do or transcription is, but rather why these ideas are important and how they can be used by researchers.

Implementation notes: This curriculum should be modified and adapted to suit the needs of the teacher and students. To help make implementation easier in this first draft, notes have been included in lessons as needed.

Extensions: Possible/recommended extension activities that can be completed in addition to the written curriculum.

Science Subject: Chemistry, Biology

Grade and ability: 9-12 grade regular or honors.

Science concepts: The overarching concepts within a unit.
Lesson Summaries

**LESSON ONE:** “The Random Walk”
In this activity, students will see that, when a small particle is surrounded by water molecules (or by other atoms/molecules), the resulting motion looks random. The particle appears not to move in straight lines. However, this apparently random movement is due to collisions with many other atoms or molecules, all moving in straight lines until they collide.

**LESSON TWO:** “Tiny but Mighty!”
Nanoparticles have many properties that their larger counterparts do not. One property of silver nanoparticles is its ability to kill bacteria. It is because of their small size that they can cross the cell membrane; larger pieces of silver have absolutely no effect on bacterial functions. Students will learn this through the lab activity and discussion.

**LESSON THREE:** “Nanoparticle Cookout”
Nanoparticles have many properties that their larger counterparts do not. One property of silver nanoparticles is its ability to kill bacteria. It is because of their small size that they can cross the cell membrane; larger pieces of silver have absolutely no effect on bacterial functions. Students will learn this through the lab activity and discussion.
Vocabulary

**Agar** - a gelatinous colloidal extractive of a red alga (as of the genera *Gelidium*, *Gracilaria*, and *Eucheuma*) used especially in culture media or as a gelling and stabilizing agent in food

**Antimicrobial** – a substance that inhibits microbial growth or kills microbes

**Brownian Motion** - The random movement of microscopic particles suspended in a liquid or gas, caused by collisions with molecules of the surrounding medium.

**Colloidal mixture** - a small solid suspended in liquid; ex: paint, milk or sunscreen

**E. coli** – a straight rod-shaped gram-negative bacterium (*Escherichia coli* of the family Enterobacteriaceae) that is used in public health as an indicator of fecal pollution (as of water or food) and in medicine and genetics as a research organism and that occurs in various strains that may live as harmless inhabitants of the human lower intestine or may produce a toxin causing intestinal illness

**Electromagnetic Field** - a field of force that consists of both electric and magnetic components, resulting from the motion of an electric charge and containing a definite amount of electromagnetic energy.

**Friction** - the resistance that one surface or object encounters when moving over another.

**Hyperthermia** - Hyperthermia is the condition of having excessive heat.

**Hypothermia** - a condition of having too little heat

**Hypothesis** - A tentative explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation.

**Kinetic Energy** - The energy possessed by a body because of its motion, equal to one half the mass of the body times the square of its speed

**Magnetic rotation** – movement of polarities in which opposite poles rotate about a central point or axis.

**Molecule** - The smallest particle of a substance that retains the chemical and physical properties of the substance and is composed of two or more atoms; a group of like or different atoms held together by chemical forces.

**Microscope** - An optical instrument that uses a lens or a combination of lenses to produce magnified images of small objects, especially of objects too small to be seen by the unaided eye.
**MSDS** - MSDS is an acronym for Material Safety Data Sheet. A MSDS is a written document that outlines information and procedures for handling and working with chemicals. Current MSDS documents contain physical and chemical property information, potential hazard information, emergency procedures, and manufacturer contact information.

**Nanoparticles** – a particle measuring between 1 – 100 nm

**Particle** - A very small piece or part; a tiny portion or speck.

**Theory** - A set of statements or principles devised to explain a group of facts or phenomena, especially one that has been repeatedly tested or is widely accepted and can be used to make predictions about natural phenomena.

**Rotational Motion** - constant rotation around the center of mass.

**Vibrational Motion** - the movement of covalently linked atoms vibrating through their bonds

**Viscosity** - the state of being thick, sticky, and semifluid in consistency, due to internal friction.
### Next Generation State Standards

<table>
<thead>
<tr>
<th>NEXT GENERATION STATE STANDARDS - SCIENCE</th>
<th>1</th>
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<th>3</th>
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<tbody>
<tr>
<td>HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.</td>
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### Common Core Standards

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Lesson 1: The Random Walk

KEY QUESTION(S): How is it possible for non-living components to move in our bodies?

SCIENCE SUBJECT: Biology, Chemistry, and Physics

GRADE AND ABILITY LEVEL: This lesson is designed for regular and honors curriculum


SCIENCE CONCEPTS: In this activity, students will see that, when a small particle is surrounded by water molecules (or by other atoms/molecules), the resulting motion looks random. The particle appears not to move in straight lines. However, this apparently random movement is due to collisions with many other atoms or molecules, all moving in straight lines until they collide.

OVERALL TIME ESTIMATE: 1 block (90 minutes) or 2 half blocks (45 minutes)

LEARNING STYLES: Visual, auditory, and kinesthetic learners will benefit from the lesson

VOCABULARY:

Brownian Motion - The random movement of microscopic particles suspended in a liquid or gas, caused by collisions with molecules of the surrounding medium.

Molecule - The smallest particle of a substance that retains the chemical and physical properties of the substance and is composed of two or more atoms; a group of like or different atoms held together by chemical forces.

Particle - A very small piece or part; a tiny portion or speck.

Microscope - An optical instrument that uses a lens or a combination of lenses to produce magnified images of small objects, especially of objects too small to be seen by the unaided eye.

Hypothesis - A tentative explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation.

Theory - A set of statements or principles devised to explain a group of facts or phenomena, especially one that has been repeatedly tested or is widely accepted and can be used to make predictions about natural phenomena.

Kinetic Energy - The energy possessed by a body because of its motion, equal to one half the mass of the body times the square of its speed.
Hyperthermia - Hyperthermia is the condition of having excessive heat.

Hypothermia - a condition of having too little heat

Vibrational Motion - the movement of covalently linked atoms vibrating through their bonds

Rotational Motion - a constant rotation around the center of mass.

LESSON SUMMARY: In this activity, students will see that, when a small particle is surrounded by water molecules (or by other atoms/molecules), the resulting motion looks random. The particle appears not to move in straight lines. However, this apparently random movement is due to collisions with many other atoms or molecules, all moving in straight lines until they collide.

STUDENT LEARNING OBJECTIVES WITH STANDARDS: Students will be able to: replicate Brown’s experiment in which he discovered Brownian motion; explain that the apparent random motion of atoms and molecules is responsible for many cellular processes; analyze how temperature influences the motion of particles.

NEXT GENERATION SCIENCE STANDARDS (http://www.nextgenscience.org/next-generation-science-standards)

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

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

COMMON CORE STANDARDS (http://www.corestandards.org/)

CCSS.Math.Content.HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

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CCSS.ELA-Literacy.RL.11-12.2 Determine two or more themes or central ideas of a text and analyze their development over the course of the text, including how they interact and build on one another to produce a complex account; provide an objective summary of the text.

**MATERIALS:**

Introductory/Hook
- Balloons and paper (to make fans) OR
- Bottle of bubbles

Brownian Motion Microscope Lab
- Basic student compound microscope with an objective of at least 20x, preferably 40x and an eyepiece ca. 10x.
• A few drops of whole milk
• Microscope slides and coverslips
• A piece of fine wire or small needle
• Distilled water or use boiled water
• Refrigeration (a cooler)
• Vaseline®, petroleum jelly or similar (optional)

Brownian Motion Virtual Lab
• Computers that students can print from
• Internet connection; this program is also downloadable if you do not have internet. You will need to install on every computer prior to starting the virtual lab
• If you do not have the ability for the students to print their work I have included a printable worksheet that students can write on

Concept Map
• Print one for each student

BACKGROUND INFORMATION:

Students will need to understand what defines a living being. It would be ideal for students to have learned how heat translates into kinetic energy on the molecular level. PhET has a wonderful simulation that demonstrates this concept well. http://phet.colorado.edu/en/simulation/states-of-matter-basics

MISCONCEPTIONS: Students may think that non-living particles move through the body via osmosis alone or they may think that living components actively transport the particles (like a cellular postal worker).

ADVANCE PREPARATION: Depending on whether you choose to use the computer for the virtual activity or microscopes for the hands-on activity will change in how you prepare.
**PROCEDURE AND DISCUSSION QUESTIONS WITH TIME ESTIMATES:**

<table>
<thead>
<tr>
<th>Agenda: Block (90 minutes) or two ½ blocks (45 minutes)</th>
<th>Estimated Time:</th>
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</thead>
<tbody>
<tr>
<td>Introduction/Hook: Crowd Surfing Balloon or Bubble Blowing</td>
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<tr>
<td>Materials: Balloon and paper to make fans with OR jars of bubbles.</td>
<td>15 minutes</td>
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<tr>
<td>Microscope Activity OR Virtual Brownian Activity located at <a href="http://molit.concord.org/database/activities/40.html#practice">http://molit.concord.org/database/activities/40.html#practice</a></td>
<td>45 minutes</td>
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<tr>
<td>Concept mapping – you have the option of</td>
<td>20 minutes</td>
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<tr>
<td>Assessment</td>
<td>10 minutes</td>
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</tbody>
</table>

**ASSESSMENT SUGGESTIONS:**

The concept of Brownian Motion is relevant when teaching about nanoparticles but it really is a simple concept. I would revisit the hook and discuss with the students if they revised any of their answers or thoughts since doing the lab and map. An excellent way to begin and end with this hook is to make it into an activity like “TableTop Twitter” or even writing it into a probe.

**EXTENSIONS:**

**ACTIVITIES:**

1. You can modify the lab so that students can design experiments to test other factors (such as temperature) that may affect the particle movement.

2. Einstein derived a formula for Brownian Motion; the Physics Department of the University of Utah has some excellent tutorials ([http://www.google.com/url?q=http://www.physics.utah.edu/~gernot/elemlabs/AAAPowerpoint/2025%2520powerpoint/Physics%2520Brownian%2520Motion.pptx&sa=U&ei=yBfxUcmgB4nA9QSFr4GoCQ&ved=0CCEQFjAC&sig2=FavknogCMKFCy2Ed8_SeLA&usg=AFQjCNGT_Quq5ax2ws6hVd3NzBZZ8rCWew](http://www.google.com/url?q=http://www.physics.utah.edu/~gernot/elemlabs/AAAPowerpoint/2025%2520powerpoint/Physics%2520Brownian%2520Motion.pptx&sa=U&ei=yBfxUcmgB4nA9QSFr4GoCQ&ved=0CCEQFjAC&sig2=FavknogCMKFCy2Ed8_SeLA&usg=AFQjCNGT_Quq5ax2ws6hVd3NzBZZ8rCWew)). While this lesson is a basic understanding of Brownian Motion and does not introduce the math portion, a worthy extension would be to teach your students how the formula was derived and used.
3. Have your students research and present what extreme cold and extreme heat do to the body down to the molecular level. Why is it necessary to be in a certain temperature range?

LITERATURE:
1. *Brownian movement in Clarkia pollen: a reprise of the first observations* by Brian J. Ford. *The Microscope*, 1992, 40 (4), pp. 235-241. This fascinating paper describes how Robert Brown's observations were repeated using one of Brown's original microscopes. This demonstration was carried out to dispel the suggestion that Brown's microscopes were not good enough to show the motion. The paper also discusses many aspects of Brown's life and work.

2. 2) *The Single Lens - The Story of the Simple Microscope* by Brian J Ford (Heinemann, London, 1985). Robert Brown used a so-called simple microscope for his studies i.e. a microscope with a single lens. This book includes a discussion of various aspects of the life and work of Brown as well as his microscopes.

3. 3) Encyclopaedia Britannica (Micropaedia) or other large encyclopaedias, entry under 'Brownian motion' and 'Robert Brown'. (The former entry in the 15th edition, 1993 printing, incorrectly states Brown observed the motion in the pollen grain themselves rather than particles suspended within the fluid of pollen grains).


5) Microsoft Encarta entry under 'Brownian motion' and 'Robert Brown'

RESOURCES/REFERENCES:

CPALMS prepared by Florida State University  http://www.cpalms.org/Homepage/index.aspx

Orange County Public Schools – Order of Instruction
https://www.ocps.net/cs/services/cs/currareas/sci/Curriculum/TA/Pages/High.aspx


PhET prepared by University of Colorado http://phet.colorado.edu/en/simulation/states-of-matter-basics

Molecular Literacy for biotechnology and nanotechnology careers http://molit.concord.org/

University of Utah, Department of Physics and Astronomy, Brownian Motion
http://www.google.com/url?q=http://www.physics.utah.edu/~gernot/elem_labs/AAAPowerpoint/2025%2520powerpoint/Physics%25202025%2520Fall%25202012%2520Brownian%2520Motion.pptx&sa=U&ei=yBfxUcmdB4nA9QSFr4GoCQ&ved=0CCEQFjAC&sig2=FavknogCMKFCy2Ed8SeLA&usg=AFQjCNGT_Qquqax2ws6hVd3NzBZZ8rCWew
Introduction/Hook – Crowd Surfing Balloon or Bubble Blowing

Materials: Balloon and fans (you can have students make their own) OR bottles of bubbles

Blow up a balloon and allow the students to fan it around the room or blow bubbles

Pose the questions:
Is the balloon alive? Are the bubbles alive?
Students will most likely answer no, that balloons or bubbles are not alive.

Ask students what defines life or being alive.
Possible answers: breathing, moving, replicating, thinking, growing, eating, etc. Any answer they share will give insight into their background knowledge and also give an opportunity to clarify what defines living.

Make the statement that the balloon/bubbles are moving…doesn’t that mean they are alive?
Students will most likely attribute the movement to something living, you or themselves.

When they attribute the movement to something living make sure they understand that no one pushed the balloon or bubbles…. They should reach the conclusion that the air (stirred up by your or their kinetic energy) pushed the balloon.
Brownian Motion Lab Activity using a Microscope

In 1827, Robert Brown was a botanist studying a sample of pollen using a wet slide and a microscope when he noticed that the pollen appeared to be moving by itself. He wasn’t sure why; the pollen wasn’t supposed to be able to move voluntarily as it wasn’t alive...so why were they moving? Years later, in 1905, Albert Einstein hypothesized that the observations were movement from the constant bombardment of water molecules. At the time, the molecular model was still under debate; after all, no one could see molecules! Was the movement that Brown witnessed proof that molecules were real?

**Purpose:**

Students will replicate Brown’s observations using milk. Students will determine whether

**Materials:**

- Basic student compound microscope with an objective of at least 20x, preferably 40x and an eyepiece ca. 10x.
- A few drops of whole milk
- Microscope slides and coverslips
- A piece of fine wire or small needle
- Distilled water or use boiled water
- Refrigeration (a cooler)
- Vaseline®, petroleum jelly or similar (optional)

**Procedure:**

1. Prepare the slide by placing a small drop of distilled water in the center of the slide and then spreading it out with the needle.

2. Dip the needle in the milk and then dip and stir the needle in the water on the slide. This inures that a very dilute amount of milk is used.
**Optional step: to make a slide that lasts longer, spread a thin line of petroleum jelly along the edges of the coverslip before placing it on your droplet. Using this step “seals” the slide so that droplet motion caused by currents created by evaporation is minimized. This will give an optimal view and is a good laboratory procedure when viewing wet slides.

3. Place the coverslip over the water-milk mixture on the slide. If liquid creeps past the edge of the coverslip, carefully wipe it up. You don’t want the droplet to be so large that it flows past the edges of the coverslip.

4. View the slide under your microscope. Magnify until the tiny fat droplets in the milk come into focus. Magnify again until you obtain an optimal view.

What to look for: Initially the droplets may be moving across the field of view in the same direction. This is not Brownian motion; you are observing currents in the liquid before the liquid has reached a steady state under the coverslip. When the slide has settled for a few minutes, the fat droplets should no longer be moving across the field but should be noticeably jiggling, but not in any specific direction. This is Brownian motion.

Study the motion of the droplets on your own slide and answer the following questions

Questions: Be clear and concise.
1. Are the milk fat droplets alive? Why or why not?______________________________________________

2. On your slide you saw the milk fat droplets moving; why do you think this is?__________________________

3. Do you think that what you observed is good proof that molecules exist? Why or why not?__________________________

4. What do you think would happen to the motion of the particles if the milk was suspended in warm water instead of room temperature water? In cold water?__________________________

__________________________
In 1827, using a microscope, the botanist Robert Brown observed that pieces of pollen grains suspended in water moved in random directions. Initially, people thought Brown had discovered the essence of life. However, after several other experiments, it was apparent that any tiny particles floating in water would move in this way, even microscopic pieces of dust.

To the right is a virtual microscope which is focused on a tiny particle floating in water. When you run that model, you will see the behavior that Brown observed and what is now known as Brownian Motion.

Describe the movement of the tiny particle in the microscope:

_____________________________________________________________________

_____________________________________________________________________

Brown's observation of a tiny particle moving in a random pattern when floating in water was considered to be a historic event. For 2000 years people speculated that atoms existed. Until Brown, nobody had any visual evidence that everything was made of atoms (and molecules, which are groups of bonded atoms). To understand why Brown's observations helped give us insight into the atomic nature of all matter, we need to understand how an individual atom behaves.

Describe the motion of a single atom. How is this different from the motion that Brown observed of a particle in water?

_____________________________________________________________________

_____________________________________________________________________

Brown found the strange movement of tiny particles so fascinating that he stared at them for hours. They never stopped bouncing around. Assuming the motion of the particles he saw was due to water being made from atoms (or molecules), what do you notice about the atom above that would help to explain his continual observation of particle movement?

_____________________________________________________________________

_____________________________________________________________________

_____________________________________________________________________

Brownian Motion: Introduction, Page 1

Brownian Motion: Discovering the Cause of Brownian Motion, Page 2
Observing the Motion of One Atom
Brownian Motion: Discovering the Cause of Brownian Motion, Page 3
Observing the Motion of Multiple Atoms

Click the buttons to add more atoms. Observe the motions.

In the previous page you observed one single atom moving. How is the movement of an individual atom different when there are other atoms around?

_________________________________________________________________________
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Another factor which affects Brownian motion is temperature. Use the slider below the model to change the temperature. How does temperature affect the motion of atoms and molecules?

_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________

The motion of one of your atoms above is not quite the same as the Brownian Motion you observed on the first page. There are parts of an atom’s path in your experiment where the atom travels straight for a while. This was not seen by Brown. His particles continually changed direction, appearing to move randomly. See if you can make this atom behave in a similar way as the particle Brown observed.

As you have seen, a single atom, alone, tends to be very predictable. It doesn't change directions randomly. However, Brown observed what appeared to him as random unpredictable movement. Why do you think the particle he saw appeared to move in random directions?

_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
Living things are made of cells, and these cells are made from smaller structures, which are, in turn, made from atoms and molecules. Every life-sustaining function, from digesting food to fighting disease, relies on the ability of atoms and molecules to find each other, so they can interact. Sometimes this interaction activates a gene, sometimes it breaks down larger molecules for food and energy, and sometimes it involves sending impulses up to your brain to let you sense the world around you.

The only way atoms and molecules can move around is through Brownian motion. It's amazing that the random motion of atoms and molecules can accomplish so much, but it's true. One important factor which affects Brownian motion is temperature.

**Why Refrigeration Prevents Food from Rotting**

The rotting of food is actually a chemical/biological process. As mentioned above, certain atoms and molecules need to find each other through random Brownian motion in order for something to happen. Experiment with the temperature slider to see how this affects the ability of the two molecules to come in contact via Brownian motion. The more often the two molecules touch each other, the more quickly the food can spoil.

**Explain why putting food in a refrigerator delays the decaying process.**

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
Molecules are in Constant Motion

<table>
<thead>
<tr>
<th>Translational Motion</th>
<th>Rotational Motion</th>
<th>Vibrational Motion</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="http://images.tutorvista.com" alt="Translational Motion" /></td>
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<td><img src="http://molit.concord.org/database/activities/40.html#practice" alt="Vibrational Motion" /></td>
</tr>
</tbody>
</table>

All molecular motion increases and decreases with temperature in a reciprocal manner. As temperature increases so does molecular motion. Alternately, as temperature decreases molecular motion will also decrease. This explains why all chemical reactions take place within a certain temperature range. This also explains why living organisms can only survive within a certain temperature range as biochemistry is affected by heat and cold. Too cold and your body’s chemistry will not be active enough to react; too hot and your body’s proteins start to denature as molecules break from their bonds.

<table>
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<tr>
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</table>
All molecules in living cells, from small molecules of water to large biopolymers such as DNA or proteins, are involved in three kinds of molecular motion; moving constantly from one place to another, rotating around the center of mass and vibrating from the vibrations of every covalently bound atom. It is due to this movement that any biological processes can happen.

*Continuous random molecular movements in living cells help to:*
Molecules are in Constant Motion – Teacher Copy

<table>
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<tr>
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<td><img src="http://molit.concord.org/database/activities/40.html#practice" alt="Vibrational Motion" /></td>
</tr>
<tr>
<td>Translational motion is also called Brownian Motion. It is the motion resulting from molecules bouncing into each other.</td>
<td>Rotational motion is a constant rotation around the center of mass.</td>
<td>Vibrational motion is the movement of covalently linked atoms.</td>
</tr>
</tbody>
</table>

**All molecular motion increases and decreases with temperature in a reciprocal manner.** As temperature increases so does molecular motion. Alternately, as temperature decreases molecular motion will also decrease. This explains why all chemical reactions take place within a certain temperature range. This also explains why living organisms can only survive within a certain temperature range as biochemistry is affected by heat and cold. Too cold and your body’s chemistry will not be active enough to react; too hot and your body’s proteins start to denature as molecules break from their bonds.

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<tr>
<td>a condition of having too little heat. Lack of heat results in low kinetic energy causing molecules to slow down.</td>
<td>an optimal amount of heat; a range of temperature in which a molecule, or any system for that matter, functions well.</td>
<td>the condition of having excessive heat. Excessive heat results in a great amount of kinetic energy causing molecules to speed up.</td>
</tr>
</tbody>
</table>
All molecules in living cells, from small molecules of water to large biopolymers such as DNA or proteins, are involved in three kinds of molecular motion; moving constantly from one place to another, rotating around the center of mass and vibrating from the vibrations of every covalently bound atom. It is due to this movement that any biological processes can happen.

*Continuous random molecular movements in living cells help to:*

**MOVES ENZYMES AND OTHER CHEMICALS INSIDE CELLS**

- This allows enzymes to connect with their substrates, activators, or inhibitors so enzymatic reactions can occur.

**BRINGING PROTEIN BINDING SITES CLOSE TO EACH OTHER FOR SELF-ASSEMBLY**

- This allows for the assembly of antibodies and other structures.

**UNWINDS DNA DURING REPLICATION**

- Enzymes help to separate the DNA strands but it is the kinetic energy of molecular motion that completes the work.
FACILITATES EFFECTIVE COLLISIONS BETWEEN MOLECULES LEADING TO BIOCHEMICAL REACTIONS

As with any chemical process, the more frequently molecules collide with each other the more likely reactions will occur.

BE SAFE IN THE LAB!!
LESSON 2: Tiny but Mighty!

KEY QUESTION(S): How are the properties of nanoparticles different then their larger counterparts?

SCIENCE SUBJECT: Biology and Chemistry

GRADE AND ABILITY LEVEL: 9th-12th grade, regular or honors

SCIENCE CONCEPTS: Nanoparticles, Antimicrobials

OVERALL TIME ESTIMATE: 2 (90 minute) blocks or 4 (45 minute) ½ blocks

LEARNING STYLES: Visual, auditory, and kinesthetic learners will benefit

VOCABULARY:
Nanoparticles – a particle measuring between 1 – 100 nm

Antimicrobial – a substance that inhibits microbial growth or kills microbes

E. coli – a straight rod-shaped gram-negative bacterium (Escherichia coli of the family Enterobacteriaceae) that is used in public health as an indicator of fecal pollution (as of water or food) and in medicine and genetics as a research organism and that occurs in various strains that may live as harmless inhabitants of the human lower intestine or may produce a toxin causing intestinal illness

Agar- a gelatinous colloidal extractive of a red alga (as of the genera Gelidium, Gracilaria, and Eucheuma) used especially in culture media or as a gelling and stabilizing agent in food

Colloidal mixture - a small solid suspended in liquid; ex: paint, milk or sunscreen

MSDS - MSDS is an acronym for Material Safety Data Sheet. A MSDS is a written document that outlines information and procedures for handling and working with chemicals. Current MSDS documents contain physical and chemical property information, potential hazard information, emergency procedures, and manufacturer contact information.
LESSON SUMMARY:

Nanoparticles have many properties that their larger counterparts do not. One property of silver nanoparticles is its ability to kill bacteria. It is because of their small size that they can cross the cell membrane; larger pieces of silver have absolutely no effect on bacterial functions. Students will learn this through the lab activity and discussion.

STUDENT LEARNING OBJECTIVES WITH NEXT GENERATION SUNSHINE STATE STANDARDS:

The student will be able to...
1. Know that the cell membrane is a permeable matrix
2. Know that the cell has central functions that can be disrupted
3. Know that nanoparticles have different properties than their larger counterparts

Number your objectives for easy reference. Focus on what students will KNOW, FEEL, or be able to DO at the conclusion of the lesson, not what they are doing during the lesson. Use specific, measurable, observable verbs. Avoid general terms like “know,” “understand,” or “appreciate.” Include at least ONE objective for EACH subject area addressed. Remember that each objective will require at least one specific assessment. Correlate lesson objectives to state or national standards.

NEXT GENERATION SCIENCE STANDARDS (http://www.nextgenscience.org/next-generation-science-standards)

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

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

COMMON CORE STANDARDS (http://www.corestandards.org/)

CCSS.Math.Content.HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

CCSS.Math.Content.HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

CCSS.Math.Content.HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities
CCSS.ELA-Literacy.RI.9-10.1 Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

CCSS.ELA-Literacy.RI.9-10.2 Determine a central idea of a text and analyze its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text.

CCSS.ELA-Literacy.RI.9-10.3 Analyze how the author unfolds an analysis or series of ideas or events, including the order in which the points are made, how they are introduced and developed, and the connections that are drawn between them.

CCSS.ELA-Literacy.RI.9-10.4 Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze the cumulative impact of specific word choices on meaning and tone (e.g., how the language of a court opinion differs from that of a newspaper).

CCSS.ELA-Literacy.RI.9-10.5 Analyze in detail how an author’s ideas or claims are developed and refined by particular sentences, paragraphs, or larger portions of a text (e.g., a section or chapter).

CCSS.ELA-Literacy.RI.9-10.6 Determine an author’s point of view or purpose in a text and analyze how an author uses rhetoric to advance that point of view or purpose.

CCSS.ELA-Literacy.RL.11-12.1 Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.

CCSS.ELA-Literacy.RL.11-12.2 Determine two or more themes or central ideas of a text and analyze their development over the course of the text, including how they interact and build on one another to produce a complex account; provide an objective summary of the text.

BACKGROUND INFORMATION:

Nanotechnology is an emerging industry which is bringing us exciting new products and promises to change the way we live and work in the future. Several new products are using silver nanoparticles to generate antimicrobial surfaces. Silver nanoparticles are integrated into fabrics to prevent clothes from developing foul odors, doorknobs have silver nanoparticles embedded in their surfaces—even silver nanoparticle-treated pacifiers are on the market. For a
Scientists are very interested in nanoparticles as it pertains to nanotechnology. Nanoparticles are often defined as having dispersed particles in the size range 1-100 nm. Gold nanoparticles are finding applications in cancer treatment, and silver nanoparticles are found to have antimicrobial properties. (Source: http://nano-cemms.illinois.edu)

ADVANCE PREPARATION:

You must prepare agar plates 2-3 days before lab and liquid bacteria culture 1-2 days before lab

Antimicrobial Lab sheet: per student or station (your preference)

Power point – slides provided

- 1 mM silver nitrate
- 1% sodium citrate
- small test tube
- 250 mL beaker
- 1 mL disposable transfer pipets
- Sterile agar plates (2-3 days before lab)
- *E. coli* bacterial culture (1-2 days before lab)
- filter paper
- cotton swab
- small containers for soaking filter paper
- incubator
- hot plate
- Lab Journal (or worksheet)

Aluminum Foil for hook (or video)
PROCEDURE AND DISCUSSION QUESTIONS WITH TIME ESTIMATES:

<table>
<thead>
<tr>
<th>Agenda: Block #1 (90 minutes)</th>
<th>Estimated Time:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction/Hook: Aluminum Foil</td>
<td>10-15 minutes</td>
</tr>
<tr>
<td>Power point and lab activity— students will view a power point that will give them safety and general information about the lab. I encourage students to use research journals as this closely mimics procedure in a research lab. They are required to write out the calculations as well as anticipate any problems prior to beginning the lab. I usually have a basic procedure posted at each station and a power point running concurrently. Students can use these if they forget what they are supposed to do but they soon learn to work out issues beforehand. There is no penalty for a failed experiment; they are just required to write the errors in their lab report. There are penalties for failed experiments that result from unsafe practices.</td>
<td>65-75 minutes</td>
</tr>
<tr>
<td>Students are required to stand at their stations while I review the cleanliness and order; I sign off in their journals if the station is satisfactory. Because I usually teach all periods students know that they must set up for the next class. This is also good procedure for students to learn.</td>
<td></td>
</tr>
<tr>
<td>Homework – none</td>
<td></td>
</tr>
</tbody>
</table>


## Agenda: Block #1 (90 minutes)

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>Students will review the remainder of the power point and reminded of safety. They will then find their plates and make their observations; answer questions. Clean up stations.</td>
<td>25 - 30 minutes</td>
</tr>
<tr>
<td>Product Proposal – students now see the benefits of silver nanoparticles, what are some products that could be made with silver nanoparticles. This can be as small or as big as you want it. You can have the students do full on product development; brainstorm today and continue to the next class with presentation or just a product idea with rationale. **Fun fact – when a baby was born it was customary to give them a silver spoon; hence the saying “born with a silver spoon in his mouth”. It was known that infants fed with silver spoons seemed healthier; go figure!</td>
<td>45 minutes</td>
</tr>
<tr>
<td>Wrap up – review Spend time repeating the key concepts of the lab as well as the expectations of the lab report</td>
<td>10-15 minutes</td>
</tr>
<tr>
<td>Homework – Lab Report</td>
<td></td>
</tr>
</tbody>
</table>

## ASSESSMENT SUGGESTIONS:

The assessment will be their lab report and their notebooks.
Plating bacteria is a testable procedure for Biology Students Semester and Final Lab practical
Making molar concentrations is a testable procedure for Chemistry Students Semester and Final Lab Practical

## EXTENSIONS:

**ACTIVITIES:** Students are encouraged to research the modern uses of nanoparticles. If you have a great deal more time you can use this product testing pdf and have students test products that incorporate silver nanoparticles

**LITERATURE:** Silver Nanoparticles: Antimicrobial Fact, Fiction, or Pandora’s Box?
Developed by: Jon Pazol

How silver nanoparticles kill bacteria, NANOS Nanotechnology

RESOURCES/REFERENCES:

Silver Nanoparticles: Properties and Applications, Steven J. Oldenburg, Ph.D.

How silver nanoparticles kill bacteria, NANOS Nanotechnology


Silver Nanoparticles: Antimicrobial Fact, Fiction, or Pandora’s Box? Developed by: Jon Pazol

About.com, Chemistry http://chemistry.about.com

Inspiration – Bill Nye “Cutting the Cheese” http://www.youtube.com/watch?v=cnXV7Ph3WPk
Introduction/Hook

Inspiration – Bill Nye “Cutting the Cheese” [http://www.youtube.com/watch?v=cnXV7Ph3WPk](http://www.youtube.com/watch?v=cnXV7Ph3WPk)

Take a piece of aluminum foil and tear it in half. Keep tearing while asking your students

“How small can I go?” Students will tell you various answers.

Once you have gotten to the smallest piece ask the “can I get smaller than this?” Students will tell you yes, they will tell you that you can cut all the way to the atom.

Once you hear this you ask them “How? How can I cut I make it smaller?” Students will give you various ideas

Ask the students if the know what a nanoparticle is. The general student has heard of nanoparticles but is not quite sure what it is.

Explain to them that nanoparticles are bigger than atoms but are still very small – nanosized and they are not made by cutting. The world is very different when you are nanosized and environmental factors don’t affect these particles like it affects us.

Ask the students what factors do they think would change.

Answers to look for:

- Gravity – gravity has zero effect on nanoparticles
- Light – nanoparticles of silver will be yellow – light is refracted differently because of their small size
- Magnetism – nanoparticles can have different magnetic properties
- Strength – nanoparticles are too small to bend easily

Lead into lab; let them know that they are making nanoparticles!
Silver Nanoparticle Lab

It will be your preference whether or not you want your students to work from a worksheet; this lab was made to be used with a journal. The sooner students become comfortable thinking for themselves in the research process, the better. The following pages contain the lab cheat sheet (I usually place one at each station with the MSDS sheets in page protectors so the students have a reference), the power point slides that they will use to start their research notebook and the format that I expect to see in their research books.

MSDS sheets are provided with every chemical order; it is ideal for students to see them and understand what they mean. If you cannot locate the MSDS for your order you are able to find them online through www.sciencelab.com, www.fishersci.com, or www.sigmaaldrich.com.
Silver Nanoparticle Lab

Purpose: To synthesize silver nanoparticles and research their effect on bacterial cells

Safety: Gloves, goggles and apron/lab coat are required the entire duration of this lab. Tongs have been provided and must be used to handle glassware that is too hot to touch.

Materials:

- 1 mM silver nitrate
- 1% sodium citrate
- small test tube
- 250 mL beaker
- 1 mL disposable transfer pipets
- agar plate
- E. coli bacterial culture
- filter paper
- cotton swab
- small containers for soaking filter paper
- incubator
- hot plate
- 10% bleach solution in marked plastic bottles

Procedures:

Day 1

1. Begin by heating 100 ml of water in a 250 ml beaker on the hot plate.

2. Add 2 mL of 1mM silver nitrate to a small test tube and then place the test tube in the boiling water bath for 5 minutes.

3. After 5 minutes add 7 drops of 1% sodium citrate to the test tube containing hot silver nitrate and continue to heat until the silver nitrate solution turns color (yellowish).

4. Carefully remove test tube and set in a test tube rack to cool.

5. While waiting for your silver nanoparticles to form you should cut up some filter paper into squares.

6. Pour the silver solution into petri dishes and soak up the solution with cut up pieces of filter paper.
7. Mark the bottom of your agar plate into four zones (make sure you put your initials!).

8. Using a disposable pipette place 1 to 2 drops of the bacterial broth on the agar. Use a cotton swab to completely cover the entire agar plate with the broth.

9. Place your plates in the incubator FACING DOWN and leave for 24-48 hours. Make your observations in your journal.

Day 2

1. Locate your petri plate and observe the zones of clearing around your filter papers. Make your observations in your journal.

2. Locate the bleach solution bottles provided; rinse the petri dishes over the sink and dispose of them in the designated container.

3. Answer the questions from the powerpoint in your notebook using complete sentences.
Silver Nanoparticle Lab
Silver as an antimicrobial

What are Nanoparticles?

Nanoparticles are any particles that are 1nm – 100 nm in size.
Nanoparticles have been used for thousands of years for many different reasons. Recently, new and novel applications have been discovered. We are going to use one of those applications in this lab; silver acts as an antimicrobial when it is a nanoparticle!
Objectives

To synthesize silver nanoparticles and research their effect on bacterial cells

Safety!!!

Because of their small size, nanoparticles and may become hazardous. As with all chemical use in a laboratory, appropriate gloves, lab coats or aprons and chemical-splash safety goggles should be worn at all times; even when cleaning!
Safety!!!

Because of their small size, nanoparticles and may become hazardous. As with all chemical use in a laboratory, appropriate gloves, lab coats or aprons and chemical-splash safety goggles should be worn at all times; even when cleaning!

Safety!!!

Hot water baths should be handled with care. Use appropriate equipment when handling hot items; latex gloves will not protect you from high temperatures!
Safety!!!

This lab uses *Escherichia coli*. The *E.coli* used in this lab is nonpathogenic and will not likely live in a human intestine even if ingested in large amounts, HOWEVER all plates with *E. coli* in them must be disposed of properly! This will be accomplished by rinsing the plates with a bleach solution before disposing. Remember: gloves, apron and goggles must be worn at all times!

Materials List – verify!

- 1% sodium citrate
- small test tube
- 250 mL beaker
- 1 mL disposable transfer pipets
- agar plate
- *E. coli* bacterial culture
- filter paper
- cotton swab
- small containers for soaking filter paper
- incubator
- hot plate
Procedure - 1st day

We will first make a silver colloidal mixture. A colloidal mixture is a small solid suspended in liquid. Some examples are paint, milk, or sunscreen.

Begin by heating 100 ml of water in a 250 ml beaker on the hot plate. Add 2 mL of 1mM silver nitrate to a small test tube and then place the test tube in the boiling water bath for 5 minutes.

Image Source: http://nano-cemma.illinois.edu

Procedure - 1st day

After 5 minutes add 7 drops of 1% sodium citrate to the test tube containing hot silver nitrate and continue to heat until the silver nitrate solution turns color (yellowish). Carefully remove test tube and set in a test tube rack to cool.

Image Source: http://nano-cemma.illinois.edu
Procedure - 1st day

While waiting for your silver nanoparticles to form you should cut up some filter paper into squares.
Pour the silver solution into petri dishes and soak up the solution with cut up pieces of filter paper.
Procedure - 1st day

Mark the bottom of your agar plate into four zones (make sure you put your initials!). Using a disposable pipette place 1 to 2 drops of the bacterial broth on the agar. Use a cotton swab to completely cover the entire agar plate with the broth.

Procedure - 1st day

Using tweezers, place two squares of silver soaked filter paper on two zones and unsoaked filter paper squares on the other two (these are your controls). Make sure you *push* the filter paper into the agar but be careful not pierce the agar.
Procedure - 1st day

Place your plates in the incubator FACING DOWN and leave for 24–48 hours. Make your observations in your journal.

Questions - 1st day

1. What is a nanoparticle?

2. Did the color of your silver nanoparticles match the color of silver as you know it? Why do you think this is?

3. What do you think you will see when you look at your plate next class?
Procedure – 2\textsuperscript{nd} day

Locate your petri plate and observe the zones of clearing around your filter papers. Make your observations in your journal.

![Image](http://nano-cemms.illinois.edu)

Images Source: http://nano-cemms.illinois.edu

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Procedure – 2\textsuperscript{nd} day

This lab uses \textit{Escherichia coli}. The \textit{E.coli} used in this lab is nonpathogenic and will not likely live in a human intestine even if ingested in large amounts, HOWEVER all plates with \textit{E. coli} in them must be disposed of properly! This will be accomplished by rinsing the plates with a bleach solution before disposing. There are bleach solution bottles provided; rinse the petri dishes over the sink and dispose of them in the designated container.
Questions

1. From your observations, what conclusion can you draw about silver nanoparticles and their effect on *E. coli*?

2. Propose a mechanism as to how silver nanoparticles could kill bacteria.

3. What are some ideas of further research?
**Expected Student Notebook Format**

1	extsuperscript{st} day  
Date: Students must date the DAY they wrote in their notebook! Even though this is a two day lab they must be accurate in their date of work

Purpose/Objective: the student must put this in their own words, they are not permitted to copy the ppt or lab sheet

Safety: Student must write what safety precautions they need to take. This is not a typical entry in a researcher’s journal as most research students complete a rigorous safety course before working in the lab. However, I require it of my students.

Materials: Students can copy the ppt for the materials list. They are advised that they check off the list in their notebook when they get to their stations.

1	extsuperscript{st} day Procedure: students must write down what they intend to do in the lab, they are allowed to loosely copy from the protocol but I encourage them to put it in their own words. Students must write down whether they deviated from the procedure or if there were any issues while trying to conduct the lab after the procedure.

1	extsuperscript{st} day Observations: students must write or draw their observations.

Teacher signature – showing I approved of the care of the work station

2	extsuperscript{nd} day  
Date: Students must date the DAY they wrote in their notebook! Even though this is a two day lab they must be accurate in their date of work

2	extsuperscript{nd} day Procedure: students must write down what they intend to do in the lab, they are allowed to loosely copy from the protocol but I encourage them to put it in their own words. Students must write down whether they deviated from the procedure or if there were any issues while trying to conduct the lab after the procedure.

2	extsuperscript{nd} day Observations: students must write or draw their observations.

Q&A

Conclusion – I do not expect a lengthy conclusion, just general first thoughts. I will see a better conclusion when they write their lab reports.

Teacher signature – showing I approved of the care of the work station


”The amazing thing is that every atom in your body came from a star that exploded. And, the atoms in your left hand probably came from a different star than your right hand. It really is the most poetic thing I know about physics: You are all stardust.” – Lawrence Krauss
Lesson 3: Nanoparticle Cookout!

KEY QUESTION(S): How do magnetic nanoparticles create heat?

SCIENCE SUBJECT: Physics, Biology and Chemistry

GRADE AND ABILITY LEVEL: 9th-12th grade, regular or honors

SCIENCE CONCEPTS: Nanoparticles
Magnetic rotation
Electromagnetic Field
Friction
Viscosity

OVERALL TIME ESTIMATE: 1 (90 minute) blocks or 2 (45 minute) ½ blocks

LEARNING STYLES: Visual, auditory, and kinesthetic learners will benefit

VOCABULARY:

Nanoparticles – a particle measuring between 1 – 100 nm

Magnetic rotation – movement of polarities in which opposite poles rotate about a central point or axis.

Electromagnetic Field - a field of force that consists of both electric and magnetic components, resulting from the motion of an electric charge and containing a definite amount of electromagnetic energy.

Friction - the resistance that one surface or object encounters when moving over another.

Viscosity - the state of being thick, sticky, and semifluid in consistency, due to internal friction.

LESSON SUMMARY:

Nanoparticles have many properties that their larger counterparts do not. One property of silver nanoparticles is its ability to kill bacteria. It is because of their small size that they can cross the cell membrane; larger pieces of silver have absolutely no effect on bacterial functions. Students will learn this through the lab activity and discussion.

Both Electric & Magnetic fields are inter-dependent (i.e.) One field requires another (or) one field produces another. The phenomenon is called Electromagnetism. For example, consider an
electric charge at rest (static). It produces an electric field. But when the charge is in motion (current), a magnetic field is produced perpendicular to its direction of propagation.

Say, If you pass current through a straight wire, magnetic field is formed around the wire in the form of circular rings (could affect compass or metal fillings nearby). On the other hand, you’re passing current through a circular spring-like thing (commonly, a coil) called solenoid, magnetic field is produced along its axis. Simply you could keep in mind that Magnetic field is produced by moving charges (current). This is an observed phenomena and it's explained by Maxwell.

STUDENT LEARNING OBJECTIVES WITH NEXT GENERATION SUNSHINE STATE STANDARDS:

The student will be able to...
4. Know that the cell membrane is a permeable matrix
5. Know that the cell has central functions that can be disrupted
6. Know that nanoparticles have different properties than their larger counterparts

Number your objectives for easy reference. Focus on what students will KNOW, FEEL, or be able to DO at the conclusion of the lesson, not what they are doing during the lesson. Use specific, measurable, observable verbs. Avoid general terms like “know,” “understand,” or “appreciate.” Include at least ONE objective for EACH subject area addressed. Remember that each objective will require at least one specific assessment. Correlate lesson objectives to state or national standards.

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

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

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CCSS.Math.Content.HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
CCSS.Math.Content.HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities

CCSS.ELA-Literacy.RI.9-10.1 Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

CCSS.ELA-Literacy.RI.9-10.2 Determine a central idea of a text and analyze its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text.

CCSS.ELA-Literacy.RI.9-10.3 Analyze how the author unfolds an analysis or series of ideas or events, including the order in which the points are made, how they are introduced and developed, and the connections that are drawn between them.

CCSS.ELA-Literacy.RI.9-10.4 Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze the cumulative impact of specific word choices on meaning and tone (e.g., how the language of a court opinion differs from that of a newspaper).

CCSS.ELA-Literacy.RI.9-10.5 Analyze in detail how an author’s ideas or claims are developed and refined by particular sentences, paragraphs, or larger portions of a text (e.g., a section or chapter).

CCSS.ELA-Literacy.RI.9-10.6 Determine an author’s point of view or purpose in a text and analyze how an author uses rhetoric to advance that point of view or purpose.

CCSS.ELA-Literacy.RI.9-10.8 Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is valid and the evidence is relevant and sufficient; identify false statements and fallacious reasoning.

CCSS.ELA-Literacy.RL.11-12.1 Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.

CCSS.ELA-Literacy.RL.11-12.2 Determine two or more themes or central ideas of a text and analyze their development over the course of the text, including how they interact and build on one another to produce a complex account; provide an objective summary of the text.

BACKGROUND INFORMATION:

Physics Animations – The magnetic field [http://www.youtube.com/watch?v=-NeF7u_9_Sw]
ADVANCE PREPARATION:

Lab:

Prepare one day or less in advance - makes 50 batches
1. Prepare 2 M FeCl2 by dissolving 19.9 g of the salt in 50 mL of 2 M HCl. It should be prepared fresh as it reacts with oxygen. Each group will need 1 mL.

2. Prepare 1.0 M FeCl3• 4H2O by slowly dissolving 54.1 g of FeCl3• 4H2O in 200 mL of 2 M HCl. This quantity will serve 50 students group. Each group will need 4 mL.

3. Prepare 1.0 M NH4OH by dissolving 200 mL of concentrated ammonia solution in 3.0 L of water. Each group will need 50 mL.

4. The 25% TMAH is ready to use as purchased. Each group will need 2 mL.

Power point – slides provided

- Copper coil
- Power source
- Hot dogs
- Syringe
- Lab Journal (or worksheet)

Aluminum Foil for hook or video)
PROCEDURE AND DISCUSSION QUESTIONS WITH TIME ESTIMATES:

<table>
<thead>
<tr>
<th>Agenda: Block #1 (90 minutes)</th>
<th>Estimated Time:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction/Hook:</td>
<td>10-15 minutes</td>
</tr>
<tr>
<td></td>
<td>65-75 minutes</td>
</tr>
</tbody>
</table>

Power point and lab activity— students will view a power point that will give them safety and general information about the lab. I encourage students to use research journals as this closely mimics procedure in a research lab. They are required to write out the calculations as well as anticipate any problems prior to beginning the lab. I usually have a basic procedure posted at each station and a power point running concurrently. Students can use these if they forget what they are supposed to do but they soon learn to work out issues beforehand. There is no penalty for a failed experiment; they are just required to write the errors in their lab report. There are penalties for failed experiments that result from unsafe practices.

Students are required to stand at their stations while I review the cleanliness and order; I sign off in their journals if the station is satisfactory. Because I usually teach all periods students know that they must set up for the next class. This is also good procedure for students to learn.

Homework – none
ASSESSMENT SUGGESTIONS:

The assessment will be their lab report and their notebooks.

Understanding how hyperthermia leads to cell destruction is a testable procedure for Biology Students

Making molar concentrations is a testable procedure for Chemistry Students Semester and Final Lab Practical

Understanding the electromagnetic field and how it affects magnets is a Physics testable concept.

EXTENSIONS:

ACTIVITIES:  Researching nanoparticles and hyperthermia is a good activity

A project where students build the electromagnetic device and attempt to devise a cooling system (to draw heat away produced from the coil) is an excellent engineering activity.

Students present on how magnetic nanoparticles produce heat, the reason for cell lysis, how electricity produces magnetism or how the electromagnetic field affects the nanoparticle are all excellent group projects to extend the lesson.

LITERATURE:

RESOURCES/REFERENCES:

Physics Stack Exchange  http://physics.stackexchange.com


Success with a German Hyperthermia Cancer Treatment  http://www.youtube.com/watch?v=HT2UHDw1NFQ

UF researchers develop ‘nanotrain’ for targeted cancer drug transport  http://news.ufl.edu/2013/04/29/nanotrain/
Nanoparticle Cookout!!
Lab Activity

Purpose:
To explore some of the properties of magnetic nanoparticles.

Materials:
- 4 mL of FeCl3
- mL of 2 M FeCl2
- 50 mL of ammonia solution
- 3 mL of tetramethylammonium hydroxide
- magnetic stirrer and magnetic bar
- 1 100mL beaker
- gloves
- goggles
- Petri dish
- 1 wash bottle with distilled water
- Hot dog
- Syringe
- Electromagnetic Field Device
- Temperature probe

Procedure:
1. Add 4.0 mL of 1 M FeCl3 and 1.0 mL of 2 M FeCl2 to a 100 mL beaker. Stir with magnetic stirring bar.
2. Add 50 mL of aqueous ammonia drop-by-drop while stirring (should take about 5 min).
3. The color will darken as you add the ammonia and will form a black precipitate. Remove the stir bar and transfer to a Petri dish.
4. Use a strong magnet to attract the magnetic nanoparticles to the bottom of the dish.
5. Decant and rinse three times with water.
6. Continue using a strong magnet to attract the magnetic nanoparticles to the bottom of the dish.
7. Add 1.5 mL of 25% tetramethylammonium hydroxide and discard any excess liquid.
8. Hold a strong magnet under the dish and move slowly.
9. Record your observations.

10. Syringe the nanoparticles; use the magnet to help you “localize” the nanoparticles to make it easier to syringe.

11. Take your hot dog and carefully inject the contents of your syringe into one end of the hot dog. You want to keep it one spot as well as possible

12. Insert the end of the hot dog containing nanoparticles into the copper coil (the electromagnetic field).

13. Wait two minutes then immediately take the temperature of the nanoparticle end of the hot dog with the temperature probe. Record the temperature in your journal.

14. Using the probe, take the temperature of the opposite end of the hot dog and record it.

15. Record your observations.

Questions:

When you held the magnet under the petri dish you saw spikes form. What do you think the spikes represent?

Write the balanced chemical equation

From the balanced chemical equation in this method, calculate the number of moles of ferrofluid (Fe3O4) that will be formed from 1 mole of FeCl3.
UF researchers develop ‘nanotrain’ for targeted cancer drug transport
Filed under Health, Research, Sciences on Monday, April 29, 2013.

GAINESVILLE, Fla. — University of Florida researchers have developed a “DNA nanotrain” that fast-tracks its payload of cancer-fighting drugs and bioimaging agents to tumor cells deep within the body. The nanotrain’s ability to cost-effectively deliver high doses of drugs to precisely targeted cancers and other medical maladies without leaving behind toxic nano-clutter has been the elusive Holy Grail for scientists studying the teeny-tiny world of DNA nanotechnology.

DNA nanotechnology holds great promise as a new way to deliver chemotherapy directly to cancer cells, but until now, scientists have not been able to direct nanotherapies to consistently differentiate cancer cells from healthy ones. Other limiting factors include high costs, too-small amounts of drugs delivered and potential toxic side effects.

“Most nanotechnology relies on a nanoparticle approach, and the particles are made of inorganic materials; after they’ve been used as a carrier for the drug, they’ll be left inside the body,” said the study’s lead investigator, Weihong Tan, a UF distinguished professor of chemistry, professor of physiology and functional genomics, and a member of the UF Shands Cancer Center and the UF Genetics Institute. “Compared to existing nanostructures, our nanotrain is easier and cheaper to make, is highly specific to cancer cells, has a lot of drug-loading power and is very much biocompatible.”

Described in today’s issue of the Proceedings of the National Academy of Sciences, Tan’s DNA nanotrain is a three-dimensional structure composed of short strands of DNA tethered together into one long train. On the end of the nanotrain is an aptamer, a tiny piece of nucleic acid serving as the train’s “locomotive” on biochemical autopilot to home in on and bind to specific cancer cells. Trailing behind are tethered DNA structures that serve as side-by-side, high-capacity “box cars,” transporting bioimaging agents or drug cargos to their targets.

“The beauty of the nanotrain is that by using different disease biomarkers you can hitch different types of DNA probes as the train’s ‘locomotive’ to recognize and target different types of cancers,” Tan said. “We’ve precisely targeted leukemia, lung and liver cancer cells, and because the DNA probes are so precise in targeting only specific types of cancer cells we’ve seen dramatic reduction in drug toxicity in comparison to standard chemotherapies, which don’t discriminate well between cancerous and healthy cells.”

Tan and his colleagues report that the DNA nanotrains can be cost-effectively made by mixing bits of DNA in a liquid medium. The mixture is then exposed to a compound that stimulates the pieces of DNA to seek each other out and self-assemble into the DNA nanotrains. The type of
cancer cell the DNA nanotrain will seek out and destroy is determined by the specific compound added to the mixture as the trigger.

The study demonstrated in vitro and in mice that the DNA nanotrains exclusively target the cancer cells for which their probes were programmed. The DNA probes go straight to the cancer cells, leading the nanotrains to dock on the cell membranes and gain entry into the cells. Once inside, the drug payloads disperse, killing the cancer cells, a process Tan and his team monitored in real time by measuring the amount of fluorescent light emitted. The biodegradable components of the DNA nanotrains decay with the dead cancer cells and are removed by the body’s normal housekeeping mechanisms.

“Our study found that when loaded with anticancer drugs, these nanotrains inhibited tumor growth in mice more than in those that received drugs injected freely into the bloodstream. What’s more exciting is that the mice treated with these nanotrains suffered dramatically fewer side effects than those treated with free drugs,” said Guizhi Zhu, a UF doctoral student who was instrumental in the study. “This is what we aim to achieve for future clinical health care of cancer patients.”

In addition to longer survival and inhibited tumor growth, the mice that were treated with nanotrain drug delivery experienced less weight loss and are in better condition physically than both the mice that received injected therapy and the mouse control group that received no treatment. Tan and his team attribute these improved outcomes to greatly reduced toxicity achieved by the targeted nanotrain drug delivery.

“We think we have demonstrated that these DNA nanotrains are a promising targeted drug transport platform for delivery of cancer chemotherapeutics with very low toxicity to healthy tissues, and that the platform has wide application for many different cancer types,” Tan said. “Moving forward, we are working to identify optimum dosage using mouse models for T-cell leukemia, lung and liver cancers and triple negative breast cancer.

“It’s very exciting, but we still have a long way to go before human trials,” he said.

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Credits

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I talked about the survival of the fittest

Before the Hunger Games