Name: _____

T-Shirt Station

Directions: You are given 2 shirts. Play around with the shirts and the liquids provided. Please play over the buckets provided. Make observations.

Try to develop an explanation for your observations. What is different between the shirts? What is causing this difference?

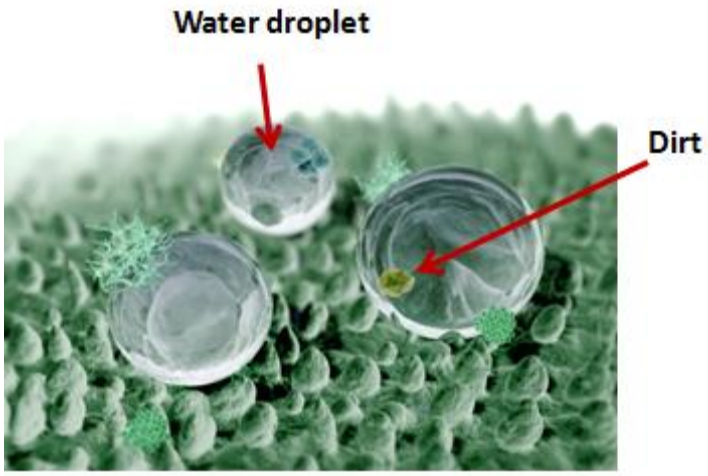
1. Write down a hypothesized explanation for why there is a difference between the materials.
2. Share your written explanation with your teacher.
3. You can then receive the Explanation Page that explains the difference.
4. Answer and turn in the questions provided on the Explanation page afterwards.

Hypothesized Explanation

Name: _____

Nano Shirt Explanation:

Most clothing gets wet when water is spilled on it like one of the shirts provides but the other shirt has nano-sized compounds on it make of silica. These nanoparticles are hydrophobic, meaning they repel water causing the shirt to be water resistant. The angle and texture/roughness of the silica coating cause the liquid to form beads and roll off of the shirt as shown in the figure to the right. This is called the "lotus effect" since it acts similarly to how water rolls off of some plant leaves.



Other examples:

- Silver nanoparticles have also been added to clothing, like socks, due to its antimicrobial properties (ability to kill bacteria). These nanoparticles stop bacteria cells from functioning through the release of positively charged ions.
- Titanium dioxide and zinc oxide have been added to clothing to protect from UV radiation. These particles work by scattering the ultraviolet light from the Sun.
- Sprays including zinc oxide, titanium dioxide and antimony-doped tin oxide nanoparticles can be used to reduce the static charge fabrics like polyster and nylon tend to gather. These particles conduct electricity which works to disperse the charge.

Questions:

1. What is a revised explanation for why the shirts were different?

References:

http://www.nisenet.org/catalog/programs/exploring_products_-_nano_fabrics_nanodays_10_11

http://silicshirts.com/about-silic-waterproof-shirts/

http://www.theguardian.com/science/small-world/2014/feb/14/nanotechnology-clothes-nanoparticles

https://www.teachengineering.org/view_lesson.php?url=collection/duk_/lessons/duk_surfacetensionunit_lessons/duk_surfacetensionunit_less4.xml

http://nanoyou.eu/en/component/content/article/87-hands-on-activities/502-experiment-with-superhydrophobic-materials.html?directory=4&Itemid=4 (handouts and worksheets)

Name: _____

Plant Station

Directions: You are given lettuce leaves, kale leaves and broccoli. Examine these three different plants and use the water provided to explore their properties. Make observations.

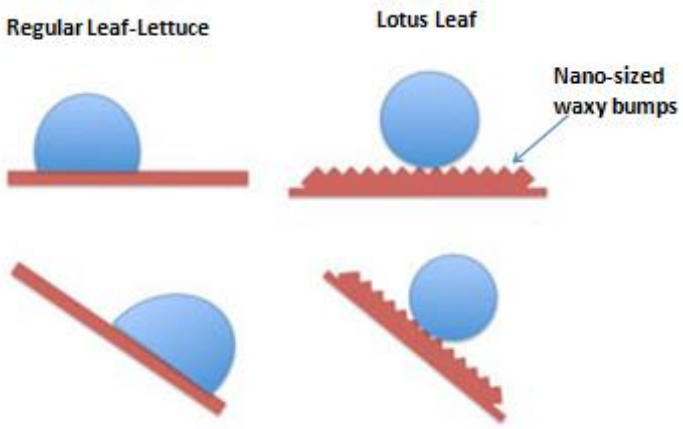
Develop an explanation for how the vegetables are different.

1. Write down a hypothesized explanation for why there is a difference between the materials.
2. Share your written explanation with your teacher.
3. You can then receive the Explanation Page that explains the difference.
4. Answer and turn in the questions provided on the Explanation page afterwards.

Hypothesized Explanation

Name: _____

Vegetable Explanation:



As you can see, the water does not wet the surface of the kale or broccoli but rolls right off. On the other hand, the lettuce remains wet. This is due to the "lotus effect". Plants like the lotus, kale and broccoli have a superhydrophobic surface, meaning water repelling. The leaves of these plants have nano-sized waxy bumps on their leaves. The water and dirt say on top of the bumps. This causes a lot of surface tension which causes the water to bead up. Not only does the water roll off, but it picks up and carries away materials like dirt and dust on the leaf. This is shown in the figure above.

Scientists have been working on mimicking this property on a variety of materials, such as clothing, house paint with silicon nanoparticles, ceramic roof tiles and architectural glass. All of these have display hydrophobic and self-cleaning properties.

Questions to Consider:

1. What is your revised explanation for why the vegetables are different?

References:

https://www.teachengineering.org/view_lesson.php?url=collection/duk_/lessons/duk_surfacetensionunit_lessons/duk_surfacetensionunit_less4.xml

http://www.nisenet.org/catalog/programs/exploring_products_-_nano_fabrics_nanodays_10_11

https://www.teachengineering.org/view_lesson.php?url=collection/duk_/lessons/duk_surfacetensionunit_lessons/duk_surfacetensionunit_less4.xml

http://www.nanowerk.com/spotlight/spotid=19644.php

Name: _____

Sand Station

Directions: Make observations about how the regular sand and magic sand interact with water and oil provided.

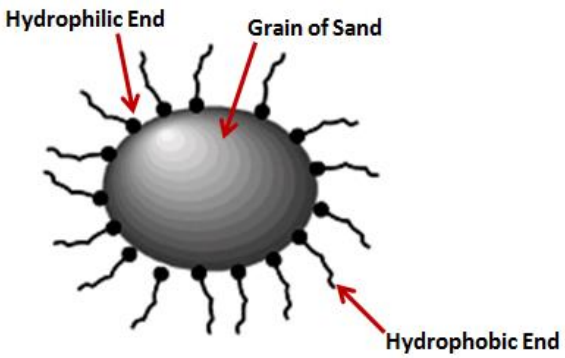
Develop an explanation for why the regular sand and magic sand are different.

1. Write down a hypothesized explanation for why there is a difference between the materials.
2. Share your written explanation with your teacher.
3. You can then receive the Explanation Page that explains the difference.
4. Answer and turn in the questions provided on the Explanation page afterwards.

Hypothesized Explanation

Name: _____

Explanation:



In magic sand, individual grains of sand are coated with an oil-like substance. Because of this, the water becomes hydrophobic. Since water is polar, it does not mix with non-polar compounds like oils, fats, tar or vegetable oil. This occurs because the interactions between water molecules are so strong, it does not mix with non-polar compounds so it can continue to interact with other water molecules. These nonpolar substances are said to be hydrophobic, or repel water. Substances that mix with water, polar substances, are said to be hydrophilic, or attract water. Naturally sand is hydrophilic but since this sand has been coated with an oil-like substance, it has become hydrophobic and repels the water.

The coating of each sand grain is a silicon-based compound with one end that attracts to the sand particle and the other end, which sticks out away from the sand, is hydrophobic. This creates a hydrophobic surface around each grain of sand.

Magic sand was originally created to clean up oil spills. It is currently being used by utilities companies in the artic so they can repair buried equipment. With the magic sand buried around the equipment, it repels water and does not allow the ground to freeze there. It is also used to hold water near plant roots in desert climates.

Questions:

1. How do you think the magic sand would help to clean up oil spills?

2. What is your revised explanation for why the two types of sands are different?

References:

http://www.nisenet.org/catalog/programs/magic_sand_nanosurfaces

http://ice.chem.wisc.edu/Oil/On_The_Surface,_Its_All_About_Nano/Magic_Sand.html

http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-97332005000400018 (picture)

Name: _____

Gold

Directions: You are given 2 test tubes with gold nanoparticles. Use the light provided to explore its properties. (Do not spill). Add a little salt to one of the test tubes and a little sugar to the other test tube. Make observations.

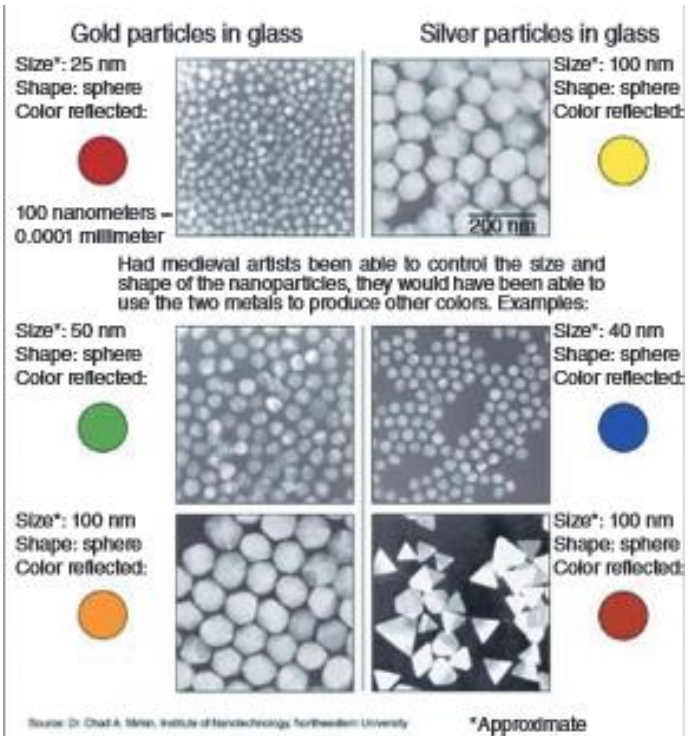
Develop an explanation for why the gold nanoparticles react differently.

1. Write down a hypothesized explanation for why there is a difference between the materials.
2. Share your written explanation with your teacher.
3. You can then receive the Explanation Page that explains the difference.
4. Answer and turn in the questions provided on the Explanation page afterwards.

Hypothesized Explanation

Name: _____

Explanation:



The use of nanoparticles in materials dates back to the ancient and medieval times. For example, Romans used nanoparticles in the fourth and fifth century in the Lycurgus cup. The Lycurgus cup is a Roman cup that had gold and silver nanoparticles between 50 and 100 nm within the glass part of the cup. These particles allow the glass to appear green when lit from the outside and appear red when lit from the inside.

Differing sizes of the same element or compound can display different properties such as color. The image to the left shows how the differing sizes of gold and silver nanoparticles reflect different colors.

The gold nanoparticle solution given to you is made adding sodium citrate ($Na_3C_6H_5O_7$) to a gold chloride solution ($HAuCl_4$). The citrate anions to adsorb, attach to the surface of the nanoparticle, causes the nanoparticles to repel each other. Adding the salt (NaCl) to the nanoparticle solution has an effect since salt is a strong electrolyte. This means that the salt breaks into its sodium (Na^{+1}) and chloride (Cl^{-1}) ions. The ions reduce the electrostatic repulsion between the nanoparticles decreases and the nanoparticles aggregate, or combine. As the space between nanoparticles decreases, the color changes. If enough salt is added, the nanoparticles will precipitate or solidify. The sugar ($C_{12}H_{22}O_{11}$) is not an electrolyte so it has no effect on the nanoparticle solution.

Other Example: Macroscale silver is non-toxic but silver nanoparticles kill viruses upon contact. Nanosilver socks have been developed which contain silver nanoparticles used because of its antibacterial properties.

Questions:

1. What is your revised explanation for why the gold reacts differently with salt and sugar?

References:

http://nanosense.sri.com/activities/sizematters/properties/SM_Lesson3Student.pdf

http://www.nanosilver.eu/Tema/Why-Nanosilver/Magical-Socks-Nanosilver-with-Silver-Nanoparticles

http://www.ifsc.usp.br/eng2/index.php?option=com_content&view=article&id=21&Itemid=15&rowid=390 (gold synthesis picture)

http://mathinscience.info/public/does_all_gold_glitter/synthesis_of_gold_nanoparticles_old.doc (gold nanoparticle synthesis activity)

Name: _____

http://nanoyou.eu/en/component/content/article/87-hands-on-activities/501-experiment-with-colorimetric-gold-nanosensor.html?directory=4&Itemid=4 (background info and synthesis procedure)

Sunscreen Station

Directions: Use the pieces of black construction paper and Q-tips to observe how the 2 different sunblocks absorb.

(You can rub a small amount on your arm as well.)

Develop an explanation for why the two sunblocks react differently.

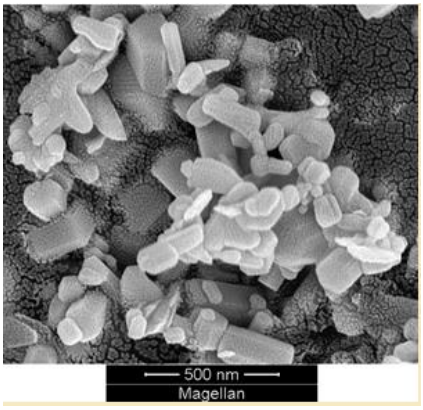
1. Write down a hypothesized explanation for why there is a difference between the materials.
2. Share your written explanation with your teacher.
3. You can then receive the Explanation Page that explains the difference.
4. Answer and turn in the questions provided on the Explanation page afterwards.

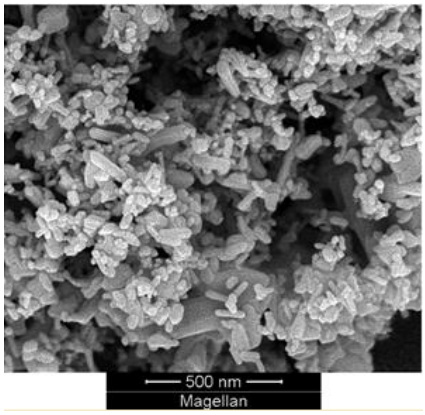
Hypothesized Explanation

Name: _____

Explanation:

The sunscreen lotions both contain zinc oxide but one contains zinc oxide nanoparticles. The regular zinc oxide leaves a visible film since the particles are large enough to reflect visible light. The nano-sunblock appears transparent since the nanoparticles are too small to reflect visible light (400-780 nm) but still large enough to absorb UV radiation (400-100 nm). Zinc oxide nanoparticle in sunscreen typically range from 10-100nm in diameter where their chemical and physical properties stay the same but optical properties differ. A scanning electron microscope image of the non-nano zinc oxide is shown on the left and one of nano zinc oxide is shown on the right.





Questions:

1. What is your revised explanation for why the two sunscreens apply differently?
2. What are the pros and cons of each type of sunscreen?

References:

http://www.nisenet.org/catalog/programs/invisible_sunblock

http://www.badgerbalm.com/s-33-zinc-oxide-sunscreen-nanoparticles.aspx

Stevens, S. Y., Sutherland, L. M., & Krajcik, J. S. (2009). *The big ideas of nanoscience and engineering: A guidebook for secondary teachers*. Arlington, VA: National Science Teachers Association Press. (pg.41)