nano gold for cancer therapy

GOAL:

Visitors will understand how the radiation-absorbing properties of nano-gold can be used to destroy tumors in cancer patients.

MATERIALS:

- Vial of red nano-gold suspension (spheres, 12 nm diameter)
- Vial of pink nano-gold suspension (spheres, 80 nm diameter)
- Vial of blue nano-gold suspension (rods, 25 nm axis x 47 nm length)
- Vial of water with yellow food coloring
- Flask of red colored water
- Flask of pink colored water
- Flask of blue colored water
- Red, green, and blue LED flashlights
- Magnet board (from Seeing Scale)
- Red theatrical gel
- Graphic of cancer therapy process

PROCEDURE:

Set-up:

1. Lay the magnet board flat and set up the four different vials on top (a white surface helps to distinguish the different colors). Make sure the nano-gold in each vial has not fallen out of solution.

2. Lay out all other supplies. Attach flashlights to key ring for convenience.

Doing the demonstration:

1. Ask visitors to guess which vial contains gold particles (many will guess the vial with yellow liquid). Tell them that in fact the vial with yellow liquid is the only one that does **not** contain gold particles – when gold particles are made at the nano-scale, small differences in size can cause them to absorb different wavelengths of light and appear different colors. Small spheres appear red, medium spheres appear pink, and large spheres appear blue.

2. Explain that nano-gold can be used to treat cancer. Show visitors the graphic of how cancer therapy using nano-gold works. Ask what visitors know about cancer to introduce tumors. Nanoparticles of gold can be injected into a tumor. The patient is then exposed to a specific wavelength of light that harmlessly passes through the skin and body tissue but gets absorbed by the nano-gold, which heats up and destroys the surrounding tumor cells.

3. Tell visitors that they will need to experiment to figure out the right wavelength of light and the right size of nano-gold to determine how to do this kind of therapy. The first step is to determine which wavelength of light can pass through body tissue. Have a visitor stick out their thumb and hold each flashlight against the tip of the thumb to see which colored light will pass through (do red light last). The red light will pass through, while green and blue lights will be blocked, indicating that red is the correct wavelength of light.

4. The second step is to determine the right size of nano-gold to inject. Bring out the flasks and explain that they contain water colored to simulate different sizes of nano-gold because the actual material can be very sensitive. Prop up the magnet board as a target for the light. Have a visitor shine the red light through the side of each flask so they can see whether the beam of light can pass through the liquid and hit the magnet board. The red light will pass through the red ("small nano-gold") and pink ("medium") solutions, but will be absorbed by the blue ("large") solution, indicating that blue nano-gold is the correct size to use.

5. Reinforce the idea by holding the red theatrical gel (representing body tissue) against the flask of blue nano-gold and show how red light passes through tissue but gets absorbed by the nano-gold in the tumor.

Clean-up:

1. Gather all materials and return to storage.

EXPLANATION:

Macro-scale gold is the shiny yellow color that is familiar to everyone. At the nano-scale, however, gold takes on a number of very different properties, including changes in optical absorption that result in a spectrum of colors based on particle size. The exact relationship between particle diameter and light absorption is complicated and nonlinear(it is predicted by the Rayleigh theory of light scattering), but in general, the smaller the particle, the closer the color is to orange. This property of gold has long been recognized – gold was used to make many different colors of stained glass found in the windows of medieval churches.

The gold particles used for this cancer therapy are called "nanoshells" because they are actually spherical nanoparticles of silica that are covered in a coating of gold. The thickness of the gold coating is tuned to absorb the correct wavelength of light (the actual treatment uses near-infrared lasers). **The samples used in this activity are not**

nanoshells; they are appropriately sized particles of colloidal gold along with a few other chemicals that keep the gold from dropping out of suspension. Because the blue nano-gold is comprised of rod-shaped particles, whose scattering properties differ from spheres, the sizes of the samples do not correlate exactly with the size/color relationship of spherical nanoshells. You may want to simplify these details when talking to most visitors and assume spherical shape.

When nanoshells are injected into the bloodstream, they infiltrate tumors but not normal tissue. One reason for this specificity is that tumors are inherently "leakier" than normal tissue because the junctions between tumor cells are not as tight. The specificity can be further enhanced by attaching antibodies to the nanoshells that match proteins expressed by tumor cells but not healthy cells. Pure gold is nontoxic to the human body (think of gold dental fillings in the past). Eventually, the nanoshells will be filtered out by the kidneys and naturally removed from the body.

This technology was developed by Dr. Naomi Halas and Dr. Jennifer West at Rice University. They have established a private company called Nanospectra Biosciences (http://www.nanospectra.com) to develop the technology for clinical applications. They have shown that nano-gold cancer therapy is effective in animal studies. Long-term studies did not indicate any toxicity or effect on the immune system, and it avoids the toxic side effects (e.g. hair loss, nausea) of traditional chemotherapy and ionizing radiation. Clinical trials in patients with head and neck cancers began in summer 2007; this treatment may become more widely available in the next 5-10 years.

WHAT COULD GO WRONG?

Visitors can get distracted by the different colors of the gold suspensions and forget about the importance of particle size. Refer to the suspensions as small, medium, and large rather than red, pink, and blue to reinforce the size concept.

GENERAL MAINTENANCE:

Keep the flashlights in "signal mode" to preserve battery life (read flashlight instructions on how to switch between modes).

In order to minimize evaporation and contamination, do not open flasks unless necessary.

Keep the flasks containing stocks of real nano-gold suspensions wrapped in aluminum foil and in a refrigerator to minimize the gold falling out of solution. If a solution precipitates, dispose of the old solution down the drain and refill the vial with 10 ml (about half full) of the appropriate stock solution.