Macromolecules to nanofibrous biomaterial: An outreach module developed for middle school science teachers

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Statement of Purpose: Introducing middle to high school-aged students to STEM based education can be very challenging for teachers in today's classrooms. Finding ways to bridge the gaps in knowledge between science, technology, engineering, and math is a desire most teachers have. Using unique ways to introduce information to their students through labs, and demonstrations, is a task providing teachers the opportunity to utilize their creativity. We developed a simple module which can assist and motivate school students to learn about role of macromolecules to create complex biomaterials that assist doctors in repairing damaged tissue of human body. One particular macromolecule selected for our demonstration, which grabs the eyes of youth and adults everywhere, is sugar, also known as glucose. When this particular macromolecule is transformed into a fiber-like material, called "cotton candy", there is a twinkle in the eyes of the students. How is this macromolecule transformed into a stringy fibrous material that appears like a well spun spider web? Furthermore what does this have to do with engineers, scientists, and students from grades 6th-12th? For these fibers to be used in the real world application in the human body, they must be transformed into very small building blocks that cannot be seen by the naked eye or even using a light microscope. These fibers must be transformed into nano (10^{-9} m) scale sized architectures in order for live cells to use them to communicate. This demonstration is an example of ways in which teachers assists their students in making connections between advances in STEM and everyday life activities. This demonstration will also help students understand the importance of the collaboration between different disciplines.

Methods: Cotton candy is made in the classroom to demonstrate this module. Recipe is taken from the Food Network website (http://www.foodnetwork.com). A mixture containing sugar, corn syrup, and water in a 2-quart heavy-bottomed saucepan is heated at 320°F for 10 minutes. A whisk (one with the round ends cut off) is dipped into hot sugar. The excess sugar is allowed to drain off for 1 to 2 seconds until the draining sugar strands are relatively the same consistency. The whisk is then waved over the extended wooden spoons and the sugar strands allowed to gently drift until they are resting on top of the spoons. The cotton candy is gathered and rolled onto any shape. Cotton candy can be stored for a few hours by placing it in an airtight container because the delicate sugar can melt in a humid environment.

Results: This procedure takes approximately 10-15 minutes. Using sugar, light corn syrup, water, vanilla flavoring, food coloring, vegetable baking spray, and a few classroom and kitchen items, students are amazed how easy it is to go from macromolecule to fibrous materials in minutes all the while enjoying a wonderful treat. This simple concept is used to explain how a more complex process called electrospinning can be used to turn these macromolecules into nanofibers. Electrospinning is a highly versatile method used to process polymers into continuous fibers with diameters ranging from micrometers to a few nanometers. To assess how well students understand the fiber spinning technique and the potential benefits for medical practitioners and patients, a vocabulary questionnaire is given at the end of the demonstration. Students can also write a brief statement explaining how science, technology, engineering, and math play a role to solve complex problems in human organs.

Conclusion: Hands-on involvement of students in the actual making of cotton candy during a science class is an excellent way for students to understand the concept of turning macromolecules into fibers.