“Model Conjugation: The Construction of Model Dendrimers”
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Summary
This lesson has students learning about dendrimers and their application in the medical world. Students will create models of dendrimers with surface groups of magnets, tape, and Velcro to see how different items can attach to different dendrimers and how well these items attach. This task and lesson will also introduce students to problem solving, forming hypotheses and nanoscience.

Learning Objectives
Following this lesson, students will be able to:
- Discuss the challenges in drug delivery systems
- Form a hypothesis on the functionality of surface groups
- Identify what a dendrimer is and its use in the medical field
- Interact in teams to work through the scientific method

Lesson Plan
This lesson is split up into two sixty minute session. The first describes dendrimers and their use, and gives students time to create their dendrimer and form a plan to execute for the second lesson. In the second lesson, students will be given materials and asked to find out which materials work best with the dendrimers they created.

Lesson1- Introduction to dendrimer science
Lesson pre-requisites: Students should have a basic understanding of the steps to the scientific method and how to form hypotheses. For more advanced students, the concepts behind chemical bonding and how two molecules can bond to each other would be helpful in creating and forming conclusions. This lesson should be run in a biology sciences or general chemistry class.

Activity 1: What is “Nano”?
Time Allotted: 20 Minutes
Materials: Computer/projector (http://www.youtube.com/watch?v=wV0t6smYm8M “e.d.Films: Do You Know what Nano Means?)
Instructions: Begin by asking students what they think “nano” means and how small is “nano” exactly. Ask them what they think is measured on the nanoscale. This should start a discussion on what is nano, how small is the nanoscale, and finally what is measured in the nano-world. Once this discussion is coming to a close show the video from youtube about the nano-world and how big it really is.

Activity 2: Lecture portion- Introduction to dendrimers and nanoparticles
Time Allotted: 20 Minutes
During this lecture portion, students will be introduced to different types of nanoparticles and their general uses. Specifically, students will learn about dendrimers and their use in the
medicinal field. Both encapsulation of drugs and attaching drugs will be discussed, and what sort of drugs are more common to be used—anti-cancer drugs, anti-clotting, etc. This discussion will be an easy transition once the idea of nano is maintained from activity 1, and how large the nanoparticles are.

Further, a discussion of pros and cons should be discussed for encapsulating vs attaching the drugs to the dendrimers, as the students will be attempting both in lesson 2. This will help students formulate their hypotheses about which method should be easier and more efficient.

Activity 3: Creation of Dendrimers
Time Allotted: 20 Minutes
Materials: Styrofoam balls, thin dowel rods, tape, magnets, Velcro, glue
Preparation: Split of class into groups of about 4 students per group, separate material into group stations.
Instructions: Once students get into the groups and stations assigned, tell them their task.

“Your task is to create and test a dendrimer. You can trap the drug inside the surface groups, entwining them or you can attach the drugs to the end of the surface groups. The material you have in front of you is what you can use for the dendrimer, and for the drugs, you will have paper clips, more magnets, pieces of felt, buttons, pipe cleaner, and pompons.”

Have them form a hypothesis. This hypothesis should be what type of dendrimer material do they think would be easiest to deal with, and would encapsulation be easier or attaching the drug to the end of the surface groups? Next, have them write out the steps they plan on taking before they start building anything. Have them check with you before they move on to building.

Discussion questions
- How did you form a hypothesis? What was your hypothesis, and how do you plan to test it? Is there any way to disprove you hypothesis?
- For those who decided encapsulation would be easiest, how many surface groups did you plan on using? Are you attaching anything to the dowel rods? For those that chose attaching to the end of the surface groups, how many surface groups would one drug molecule take up? What materials are going to be the easiest to work with?

Lesson 2- Testing the hypothesis and discussion
Lesson Pre-Requisites: Lesson 1

Activity 1: Testing of Dendrimers
Time Allotted: 35 Minutes
Materials: paper clips, magnets, pieces of felt, buttons, pipe cleaner, and pompons.
Instructions: Have students, if necessary, complete building their dendrimers or change their steps on how to test their dendrimers. After they have checked off the dendrimer with you, have them follow their methodology and chart any differences they made and observations they had throughout the testing process in their composition lab notebooks.
Throughout the 45 minutes of testing, walk around and talk with each group individually about their progress and what changes they are making, how the hypothesis seems to be holding up, etc.

Group Presentations and Discussion
Time Allotted: 20 Minutes
Instructions: Take this time to come together as a class and have them discuss their results to the class as groups in short 3-5 minute presentations. Have the student groups show what their dendrimers look like with (and without if possible) the drugs attached. If fitting ask each group a set of discussion questions, otherwise, ask the class as a whole.

Discussion Questions:
- Did your hypothesis work? If so, how did you come to the hypothesis? If not, what was not correct about your hypothesis?
- Did you stick to your methodology fully, or were some things done differently? If you did some things different, what did you change, and why did you change them? If you stuck to your methods, how did you come up with such a good methodology?
- What challenges do you think scientists have while working with dendrimers on the nanoscale? What would you do to overcome these challenges? What was the most difficult thing you had to do?
- If you could choose any material to work with instead of the things I gave you, what would you use to create your dendrimer?

Wrap up
Time Allotted: 5 Minutes
Instructions: Discuss the challenges scientists face while working on the nanoscale, and reflect on what they said and the students experience was like.