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| **Title** | **Biotechnology Applications: Freeze Drying to Limit Organism Growth in Samples** |
| **Introduction** | Students will dry freeze food samples to understand the advantages of removing water from samples for preservation purposes. While using simplistic techniques during class, students will also learn about how industrial dry freezers work and learn about the advantages for using this technology with food as well as other industrial products such as medicines. Students will familiarize themselves with the history and development of dry freezing products. Water is essential for substances to incubate life – the goal is for students to connect that removing water from different substances, whether it is food or medicines, to begin growing microorganisms which cause spoiling. |
| **Learning Outcomes** | Students will be able to…   * Explain the importance of freeze drying products for preservation. * Use simplistic techniques to dry food samples but state the difference between drying these products and using freeze drying techniques to preserve the product. * Connect the importance of using freeze drying to prevent degradation of the product from microorganisms using the substance for metabolism. |
| **Time Required and Location** | This lesson will require 105 minutes to set up and then “check ins” for approximately 5 minutes a day for a week to make observations of the samples that are freeze drying. Once the samples have freeze dried, if you are interested in also having students observe the difference in degradation of a freeze dried product versus a fresh one – it will take 30 minutes to set up and then 5 minutes a day for another week to allow for degradation. Both “set up” days can be reduced if the teacher does some of the work for the students (slicing apples, freeze drying for them, etc) – although, it’s a more valuable experience if students are able to do a little of the preparation work for themselves! |
| **Materials Needed** | * Freeze dried food – camping or space food. * Freezer * Cookie Sheet OR cooling rack (preferred) * Material to freeze dry (apples work well) * Cutting boards * Knives for cutting fruits/vegetables * Gloves * Digital scales/balances   **Technology Resources:** If you would like to extend this activity, students could complete their own research to deepen their understanding of how a freeze dryer works. |
| **Participant Prior Knowledge** | It is easily possible to link this lab activity to creating diets for fruit flies. Students can use their food samples and then discuss ways to preserve the samples for selling. It may be useful to start off with a more simplistic food sample, such as thinly sliced apples or potatoes, but then use the food samples to make it more clearly applicable to industry. Additionally, it would be essential for students to understand phase change diagrams. As freeze drying works through sublimation, students should be familiar with how substances move from one phase to another particularly from solid directly to gas. |
| **Activities** | 1. Show students “space food” or “camping food”. If you do not have access to this, you can bring in cereals (like Special K with berries) and show them the berries that have been freeze dried to preserve the berries into the cereal. Have students look at the samples and discuss why these foods have been developed for each of these purposes. Ask students questions such as: Why don’t we leave fresh strawberries in the cereal box? Why do we need to dry food samples before sending it to space? Why do you think campers buy these special types of food before going on longer trips out into the wilderness? Students should state things like “the strawberries would go bad” or “it wouldn’t stay fresh”. Main idea being students will be aware that the dried food lasts longer than fresh food. [15 minutes] 2. Show students the PowerPoint that provides information on the history of freeze drying and how freeze drying works. Skeleton note sheets may be provided for students to assist them with note taking. [30 minutes] 3. Following the PowerPoint, instruct students they are going to create their own freeze dried food samples. Provide students with fruit or vegetables that have high water content AND that can be sliced thinly. It is suggested that students use apples (because you can then eat them!). Students should take their sample and slice it very thinly (the thinner the slice the more effectively all the water can sublimate from the sample. [25 minutes] 4. In their lab notebooks, or on a lab worksheet provided for the students, students should write down initial observations of their samples. If scales are available, students could weigh their apple samples. They should also include qualitative data describing the samples as they will change over time. [15 minutes] 5. Once students have made their observation, they should place their samples on a cooling rack or cookie sheet. The cooling rack will allow water to escape from both sides of the sample so will be more effective in the freezer for freeze drying. Put the samples in a freezer. [5 minutes] 6. Over the course of 1 week, students should be given 10 minutes per class period to take more observations of their samples. Have students record in their lab notebook or on the worksheet provided the changes they see in their samples. [5-6 minutes/class period] 7. To test to see if food samples have been fully dried, remove one apple slice from the freeze and allow thawing at room temperature. If the sample is fully dry, it should maintain the same appearance once thawed as when frozen. If the sample is still wet, it will turn colors (darker brown/black) if there is still water in the sample. Students can test this OR you can test it for them. [Time to thaw] 8. Once your samples are dry, you want students to compare the degradation of a freeze dried apple to a fresh apple. Have students (or you, to save time) slice an apple just as thinly as when we went to prepare the freeze dried samples. Leave freeze dried apple slices in a controlled environment with fresh apple slices that are sliced just as thinly. You can have students leave their own samples out, or you can create one lab set up for the entire class. [20 minutes] 9. Have students record initial observations for the freeze dried apples and the freshly sliced apples [10 minutes]. In this case, students may record weight; however, it is important to remember that both samples may absorb water from the atmosphere and then will be growing organisms – so it will be difficult to figure out what is causing the weight of the samples to change. Mostly, you would like your students to have a record of how the physical state of the samples is changing over time. 10. Leave the samples in the same place for one week. At the beginning of each class period, have students check in on their samples. Students should notice the faster degradation of the fresh apple samples compared to the freeze dried samples. [5 min/day] 11. At the conclusion of the week, have students write a final conclusion as to how freeze drying impacted their apple samples. In their essay, they should connect that without water – microorganisms are unable to go through metabolic processes and therefore dried products cannot incubate life [30 minutes, can be assigned as homework]. |
| **Assessment** | Assessments for this assignment may vary. Some suggestions include:     * Students will provide a written summary of how freeze drying apple samples allow them to stay in a preserved state longer than the fresh apple samples. * Ask students to explain how a freeze drying machine forces samples to go into sublimation (addition of higher pressure and lower temperatures). |
| **Critical Vocabulary** | Freeze drying  Sublimation  Phase Change Diagrams  Evaporation  Preservation  Water Activity  Microorganisms |
| **Extension Activities** | * Have students research the positive impacts of freeze drying on preserving medicines that can be useful for areas without developed medical care systems. * What makes substances good candidates for freeze drying? Have students brainstorm a list of different materials in groups of 3-4 that are poor candidates for freeze drying and argue why they came up their list. Since freeze drying is the removal of water from a substance, hopefully they will recognize substances that are highly aqueous will not freeze dry well (iceberg lettuce is a good example). Have students present their thoughts to the class and discuss. Then, realizing high water foods are harder to freeze dry – think (as a whole class) of foods that would be good to freeze dry (low water concentrations - coffee beans, carrots). |
| **Modifications** | * If access to a freeze dryer IS available, students should use the apparatus to freeze dry their sample. Local universities or industries would be a good place to check for access to this. * Skeleton note work sheets may be provided for students to assist them with taking notes on the PowerPoint. * You can pre-slice vegetables/fruits for the students to save time within the class period. I think it is essential, though, for students to check in on their own samples throughout the freeze drying process so they can see the changes of the samples. * If you don’t have time within the class to create your own freeze dried samples, you can use a freeze dried fruit with a sliced piece of the same fruit (apple slices) and leave them in places and watch their changes over time. Obviously with moisture in the atmosphere, the freeze dried sample will also develop the growth of microorganisms – but it should be much more slowly than the fresh sample. |
| **References** | Gasteiger, Daniel (2010). *Yes, You Can! And Freeze and Dry It, Too: The Modern Step-by-Step Guide to Preserving Food.* Franklin, Tennessee: Cool Spring Press.  Jennings, Thomas (2002). Lyophilization: Introduction and Basic Principles. Boca Raton, Florida: Interpharm/CRC. |
| **Comments** | Freeze drying was an essential technique in the biotechnology industry in order to reduce water activity in both foods and medicines to preserve for shipping. This allows industry to create products and then ship longer distances or to store for longer periods of time before use. |
| **Author Info** | Sarah Kaneko is a biology and earth science teacher at CE Jordan High School in Durham, North Carolina. She began working at Jordan after completion of her M.A.T. at Duke University in the fall of 2007. She was drawn to the school because of the Freshman Academy program which activity works to support the transition and growth of ninth graders to high school through modes such as increased communication between each students core teachers, increased parent contact, academic skill building through a freshman seminar, and a structured study hall program to assist students with reviewing course material and working on homework assignments. She currently serves as team leader in this program.  Prior to pursuit of her MAT degree, Ms. Kaneko worked for two years at Durham Nativity School in Durham, North Carolina as a science and math teacher. Her interest at DNS began as a volunteer while she was a senior in college; she assisted with the after school homework and tutorial program as well as worked with the headmaster of the school with student recruitment. She began working at DNS following the completion of her B.S. in Biological Anthropology and Anatomy at Duke University. It was at DNS, her love of teaching became evident and returned to Duke to pursue a master’s degree in teaching and certification in teaching high school science.  Sarah Kaneko was supported during her Kenan Fellowship summer research by Dr. Allen Cohen, Director of Insect Diet and Rearing Research, LLC (IDRR). Prior to opening IDRR, Dr. Cohen worked for the USDA at Mississippi State University as a research entomologist and research leader for the ARS Biological Control and Mass Rearing Research Unit. In addition to his work in industry, Dr. Cohen also has an extensive history in teaching biology and entomology at the collegiate level and has been supporter and mentor for teachers in science education. This Kenan Fellowship was funded by NC BioTechnolgy Education Center (NC BTEC) |