GENESIS
SEARCH FOR ORIGINS

Education

Dynamic Design: The Cleanroom

Keep It Clean

TEACHER GUIDE

BACKGROUND INFORMATION

Once a cleanroom has been certified at a particular level of clean, it is up to the personnel that work in the cleanroom on a daily basis to constantly monitor the conditions and correct the problem if contamination occurs. There are two primary ways in which contamination is monitored in the Genesis cleanroom. The first is a witness plate. This is a wafer that is placed near the area where the assembly is done. This plate can be tested periodically to determine if the amount of contamination is above the specifications for that class of cleanroom. The second is an air particle counter that is used to count the number of particles in a sample of the air space.

In this activity students will investigate different methods of sampling in a simulated cleanroom environment. The Student Text, "Maintaining Clean" is used to introduce students to convenient, systematic and random samples.

The NCTM *Principles and Standards for School Mathematics* states that systematic observations, such as random testing of manufacturing parts taken from an assembly line, can be used for purposes of quality control. The mathematics standards go on to say that the relationship between the characteristics of a sample and the population from which it is drawn lies behind the use of sampling for monitoring process control and quality in the workplace. (NCTM, 2000) The Genesis cleanroom provides the real life context for which the standards can be applied. The activity continues by having the students sample simulated air from the cleanroom in three different ways, thus obtaining three different results. Once students have discovered the results, they will be able to compare the three methods and determine which is the most generalizable to the population from which it was obtained.

Johnson Space Center

NATIONAL SCIENCE STANDARDS ADDRESSED

Grades 5-8
Science As Inquiry
    Abilities necessary to do scientific inquiry
    Understandings about scientific inquiry
Science and Technology
    Understandings about science and technology
Science in Personal and Social Perspectives
    Risks and benefits

Grades 9-12
Science As Inquiry
    Abilities necessary to do scientific inquiry
    Understandings about scientific inquiry
Science and Technology
    Understandings about science and technology

(View a full text of the National Science Education Standards.)

PRINCIPLES AND STANDARDS FOR SCHOOL MATHEMATICS ADDRESSED

Data Analysis and Probability Standard for Grades 9–12
Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them

Know the characteristics of well-designed studies, including the role of randomization in surveys and experiments

Develop and evaluate inferences and predictions that are based on data
Use simulations to explore the variability of sample statistics from a known population and to construct sampling distributions

Understand how sample statistics reflect the values of population parameters and use sampling distributions as the basis for informal inference

(View a full text of the Principles and Standards for School Mathematics.)

MATERIALS

For the class:
- 30 film canisters (labeled 1-30 on the lids and canisters)
- 30 cotton balls
- Vanilla extract (or perfume or other scent)

For each group of four to five students:
- Colored pencils or markers
- Student Activity, "Keep it Clean"
- Student Text, "Maintaining Clean"

Safety Tip

Teachers should survey the class prior to this activity to determine if anyone is allergic to vanilla extract or other scents that might be used.

PROCEDURE

1. Before class, duplicate the student activity sheet and the student text. Prepare the film canisters in the following way. First decide which canister(s) you want to have contamination. We recommend having one canister with contamination with two or three surrounding it with a little bit of contamination. To each of the three or more canisters add one cotton ball. To the canister that is to represent a sample of contaminated air, add drops of vanilla extract or other scent. To the surrounding canisters add just a "hint" of the scent, perhaps 1-2 drops. Place the lids on the film canisters so that the number on the lid matches the number on the canister base. Place the canisters on a table according to the following diagram.
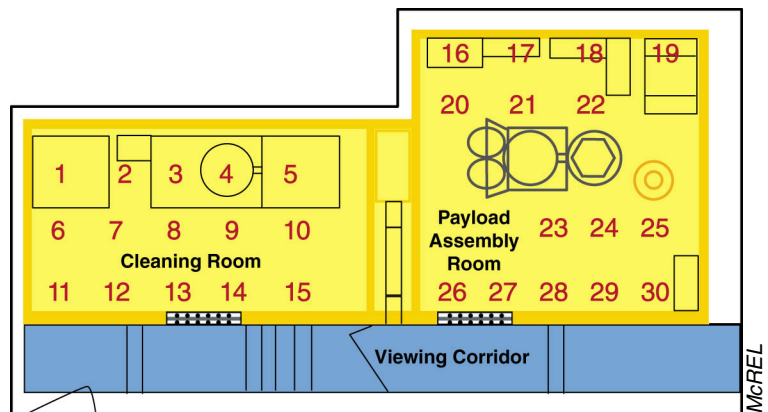
2. Distribute the student activity sheets to the student groups. Assess the students' understanding of sampling by asking the following questions.

   a)   What is the purpose of a survey? (Answers will vary but students may suggest that surveys are given to find out about a question about the general public.)
   b)   What is sampling? (Investigating or looking at part of something.)
   c)   What is representative sampling? (Taking enough samples or parts of samples so that you get a picture of the whole.)
   d)   Why is sampling necessary? (It is sometimes difficult or impossible to obtain information from the entire population.)
   e)   When taking a survey, how are participants chosen? (Some students may note that sometimes it is whoever is willing. Often times at a shopping mall, survey takers try to obtain respondents by asking everyone who passes

by. Other students may note that at the airport, after people go through the metal detector, bags are searched every so often. Students who have completed surveys may say that a random survey is the best.)

 f) What are some examples of sampling that you have seen from everyday life?(Answers will vary)

3. Based on the class discussion from procedure 2, you may want to distribute the Student Text, "Maintaining Clean" to the student groups. Students should read the text and generate a list of questions about sampling techniques in general before continuing on with the activity.

4. If the students have viewed the *Cleanroom Technology: NASA Genesis Mission*, ask students to recall the purpose of the air particle counter. If the students need a refresher you may want to show the last minute or two of this video. Explain to students that the air particle counter is used to sample the air inside the cleanroom and indicate whether the conditions are clean enough to continue work in this environment. If the air particle counter indicates that the air sample does not meet specifications, then work stops until the conditions have been corrected. Explain to students that they will act as air particle counters to take measurements of samples of air inside the cleanroom. Explain that they will be sampling the air and making qualitative observations instead of quantitative observations, since they will not be able to indicate the size and number of contaminants in their sample.

5. Explain that they will be taking convenient, systematic and random samples in the simulation. Show students the floor plan of the Cleaning Room and the Assembly Room. Tell them that the numbers represent areas in the cleanroom in which air samples may be taken. Tell them to follow the directions on the student activity sheet to indicate the samples that will be taken. Tell students that all sample numbers need to be indicated on their sheet before they can perform any tests.

6. Allow students time to write how they will take each of the samples. Students should then take five samples using each method. Once students have their sample numbers in the first data table, allow them access to the film canisters that they will use for sampling. Encourage students to record their observations by constructing a data table and filling it in to best represent the results.

7. Students should use the results in their data table to answer the first two questions of the conclusion.

> **Safety Tip**
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> Explain to students the correct way to smell substances in the laboratory is wafting. Demonstrate this to the class by waving your hand across the canister toward your nose. How does wafting help control variables?

 a) Based on your data, did the method of sampling affect your number of contaminated canisters you were able to detect? If so, how? (Answers may vary, though you should point out that the random sample would give results that are the most generalizable to the population. Students may state that with the random sample, every canister would have a chance to get chosen.)

 b) If you were going to sample a population, which method would you choose and why? (Answers will vary, but they should have an explanation. Some may say convenient because they know where the most contamination would be. Others may say systematic, since the entire lab would eventually be tested. Most might say random for the same reasons mentioned in question a).

 c) Based on what you know about the air particle counter, in the Genesis cleanroom, in what way(s) was this a good model and what way(s) was this a poor model for simulating the air particle counter? (Answers will vary. Possible answers may include the fact that the sense of smell yields qualitative observations, while the air particle counter provides quantitative data in the form of size and number of contaminants. The air particle counters take samples from different parts of the cleanroom air and analyzes them separately, as they did.)

TEACHER RESOURCES

http://www.pmeasuring.com/alasair.html
One of the air particle counters mentioned in the student text