SPACE BUGS

TI-Nspire™ Lab Activity

Background

From the beginning of the human spaceflight era, NASA has been mindful of the need to monitor the health and well-being of its astronauts. As such, specialists from the Immunology Laboratory at the NASA Johnson Space Center are investigating the effects of spaceflight on various aspects of human physiology, primarily the responses of the human immune system. The goal of this laboratory is to investigate the mechanisms responsible for physiological changes of the immune system, so that appropriate countermeasures or interventions can be developed for future human space exploration missions.

Another important aspect of human immunology is the study of infection by different pathogens. As part of this investigation, lab scientists from the Microbiology Laboratory at NASA Johnson Space Center routinely analyze infectious agents (bacteria, viruses, and fungi) which co-exist with astronauts on the space shuttle and on the International Space Station (ISS).

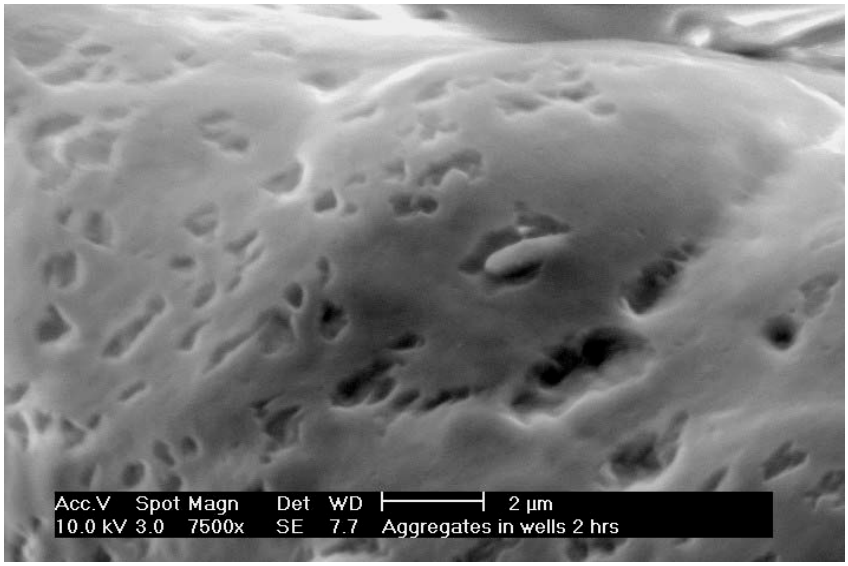

Figure 1: Environmental Scanning Electron Microscopy (ESEM) image of Salmonella enterica Typhimurium invading intestinal cell aggregates grown in vitro

Multiple spaceflight experiments have demonstrated that microorganisms change the way they grow and respond when cultured in the spaceflight environment. One change which concerns NASA scientists is evidence that microorganisms may change their virulence (disease-causing potential)

during spaceflight. If microbes do cause disease at a higher rate in space, the astronauts are at greater risk, and it may be necessary for more protective measures to be put in place during a mission.

To better understand the potential risk, samples of microorganisms are collected from surfaces, air, and water located in the spacecraft. When these samples are returned to Earth, the DNA of these "space bugs" is evaluated to determine the presence of infectious agents which might infect the crew. While these “space bugs” are similar to microorganisms found on Earth, the microgravity environment may cause these microbes to behave differently than on Earth. Therefore, scientists continue to investigate how these microorganisms may change in space in order to better protect the crew.

Some microbial changes during spaceflight are the results of the way microbes respond to their environment. These are temporary changes. Other changes can occur that are permanent. These are DNA mutations, which can occur due to radiation. Changes can also occur when pieces of DNA (often in the form of circular DNA called plasmids) are shared with one another. Mutations caused by both radiation and exchange of plasmids can cause a number of changes in microorganisms, including changes in the virulence of organisms.

A variety of techniques are used to measure changes in DNA. A common way is through a process called DNA gel electrophoresis. This technique separates DNA based on its length and ability to move through a gel.

Lab Procedure

On your TI-Nspire handheld open the file, *Space_Bugs*. Work through the entire activity and answer the questions embedded throughout the document.

Mission

In this activity, you will be asked to analyze the basic composition of DNA. You will then look at how DNA is "cut up" with special molecular scissors (called *restriction enzymes*) so it can be analyzed. Finally, you will observe and evaluate the results of some simulated *DNA gel electrophoresis* trials.

Questions (embedded within the TI-Nspire document)

1.6 The DNA of S. aureus consists of 32.78% G-C base pairs. What percentage of the S. aureus DNA consists of A-T base pairs?

1.7 What percentage of the S. aureus DNA nucleotides is guanine?

1.8 What percentage of the S. aureus DNA nucleotides is cytosine?

1.9 What percentage of the S. aureus DNA nucleotides is adenine?

1.10 What percentage of the S. aureus DNA nucleotides is thymine?

1.11 The entire, circular chromosome of S. aureus consists of 29,585 base pairs. How many nucleotides comprise this chromosome?

1.12 How many of the S. aureus base pairs are A-T?

1.13 How many of the S. aureus base pairs are C-G?

1.14 How many thymine nucleotides are there in the S. aureus genome?

1.15 How many cytosine nucleotides are there in the S. aureus genome?

1.16 The human genome consists of about 3.15×10^9 base pairs, and 61.2% of these base pairs are A-T. How many of each of the four DNA nucleotides are in the human genome?

2.5 If the NasAI plasmid is digested with the restriction enzyme EcoRI, how many DNA fragments will be produced per plasmid?

2.6 If the NasAI plasmid is exposed to EcoRI, what will be the sizes of the fragments produced?

2.9 Why is the well into which the DNA is placed near the negative electrode?

3.7 Using the information from the XBaI gel on page 3.2, draw a possible plasmid restriction map on your student handout for the NasAI plasmid when it is exposed to the restriction enzyme, XBaI, or insert a geometry page and draw it there.

*To insert a geometry page, press **ctrl** and **doc**, then select **Add Geometry**. To create a circle, press **menu** and select **Shapes > Circle**. To create segments, press **menu** and select **Points & Lines > Segment**. To add text, press **menu** and select **Actions > Text**.*

4.2 If the plasmid is digested with both EcoRI and XBaI, how many DNA fragments will be produced per plasmid?

4.8 If the plasmid is exposed to both restriction enzymes, what will be the sizes of the fragments produced?

4.9 Not counting the uncut DNA, the gel only has seven bands of DNA instead of eight. Explain.

4.10 Explain why many of the DNA fragments in this gel are much smaller (migrated further) than in the other two gels.

4.11 Explain why the smaller DNA fragments end up furthest from the well.