BioMEMS Applications Activity: DNA Hybridization

Instructor Guide

Notes to Instructor

This activity provides the opportunity for exploration into biomedical applications of MicroElectroMechnical Systems (MEMS). It is one of three activities in the *BioMEMS Applications Overview Learning Module*. These three activities can be completed in any order or combination. You might have the participants complete one of the activities prior to the primary knowledge unit. This would provide an opportunity for inquiry.

The *BioMEMS Applications Overview Learning Module* consists of the following units:

- Knowledge Probe (KP or pre-test)
- BioMEMS Applications Overview PK
- BioMEMS Applications Overview Activity: Nanomachines
- BioMEMS Applications Overview Activity: ELISA
- **BioMEMS Applications Overview Activity: DNA Hybridization**
- BioMEMS Applications Overview Assessment

Description and Estimated Time to Complete

This activity provides the instructions for accessing an on-line tutorial on DNA Hybridization. DNA Hybridization is the process used to identify the degree of genetic similarity between pools of DNA. BioMEMS devices are being developed that can efficiently and accurately perform this task.

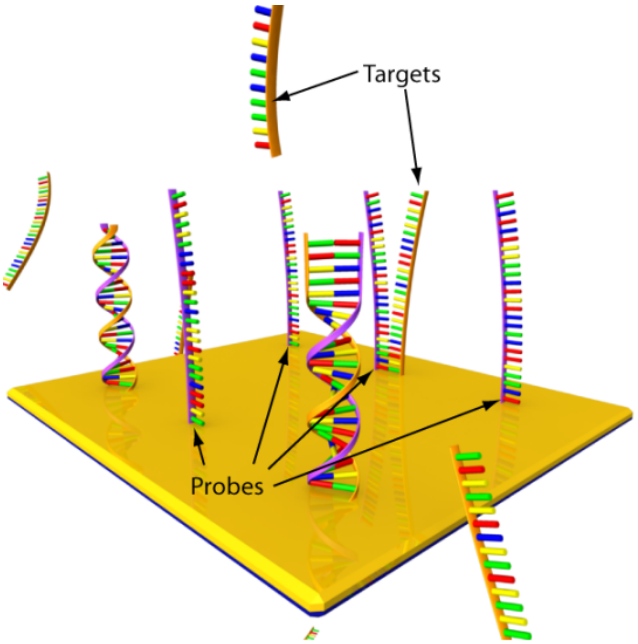
After completing the tutorial, this activity provides post-activity questions that allow you to demonstrate your understanding of the information presented in the tutorial.

Estimated Time to Complete
Allow at least 30 minutes to complete.

Introduction

The Human Genome Project introduced an era in which individualized approaches to medicine are possible through an analysis of a person's DNA. The 1997 movie "GATTACA", considered a world in which genetic engineering allowed parents to determine the complete genetic makeup of their children. With genetically perfect offspring, the film proposed a new brand of discrimination, one based on "science."

In 2007 the concept introduced in "GATTACA" became a possibility with the development and availability of DNA Lab-on-a-chip devices. These devices are used not only for basic genetics research, but also in the field of forensics and disease prediction. The DNA microarray in the graphic uses single-stranded DNA probes to bond with complementary single-stranded target DNA in a control sample and test sample, thus creating a "hybrid" DNA molecule. A "hybrid DNA" is a double-stranded DNA molecule with each strand being from a different source. The hybridization process occurs repeatedly in DNA microarray enabling the microarray to identify specific DNA, DNA mutations, or DNA activity.



Identifying target DNA through the hybridization process (Graphic illustrates what happens in a DNA Microarray: The target single strand DNA bonds with a matching complementary capture DNA probe.)

This activity helps you to better understand the process of DNA hybridization and how it applies to BioMEMS applications.

Activity Objectives and Outcomes

Activity Objectives

- Demonstrate your understanding of how probes made of nucleotide sequences can bind to complementary target DNA sequences.
- State at least two bioMEMS applications that study or utilize DNA hybridization.

Activity Outcomes

You will use the information gathered in this tutorial to explain how DNA hybridization occurs and its applications for bioMEMS.

Resources

Computer with high-speed Internet access.

Documentation

Your documentation should include all of the questions asked during each stage of this activity and your answer to each of these questions.

Documentation should also include the Post-Activity Questions and your answers.

Activity: DNA Hybridization

This activity will help you better understand the process of DNA hybridization and how it applies to BioMEMS applications. You will utilize the tutorial at The Molecular Workbench.

1. Go to The Molecular Workbench at http://workbench.concord.org/database
2. In the upper right corner "Jump to Activity" # 265. Select "Student". This should take you to an interactive called DNA Hybridization. (*NOTE: If you have a problem with the link, do a search within Molecular Workbench for DNA Hybridization.)*
3. Launch Activity (It may take a few minutes to download.)
4. Watch the modeling simulation.
5. When it stops and says "Probe Target Found", take a snapshot and describe the image you see. Record a sketch of the image and your description in this activity's documentation.
6. Resume simulation. Watch for a few more minutes and record what happens.
7. Select Southern Blot. During this activity, record all questions and your answers for the documentation.
8. Select Nucleotides. Follow the directions for an in-depth study of the five nucleotides
9. Select DNA double-helix. Follow the directions for an in-depth study of the DNA double-helix.
10. Select DNA molecule. Follow the directions for an in-depth study of the DNA molecule.
11. Answer the Post-Activity questions.

Post-Activity Questions

1. What is the Southern Blot?

2. What is a nucleotide?

3. DNA hybridization makes use of base pairing between
   _____

4. Where is DNA hybridization currently found in bioMEMS technology? (State at least two applications)

5. What is another *possible* application of bioMEMS and DNA Hybridization?

Post-Lab Questions / Answers

1. What is the Southern Blot?
   Answer: Southern Blot, named after Edward Southern, the man who invented this procedure in 1975, allows one to identify the presence of specific DNA sequences. It is used in many fields, from biotechnology and genetic engineering to forensics and DNA finger printing. The search for new drugs and cures for genetically based diseases also relies heavily on this technique.

2. What is a nucleotide?
   Answer: A nucleotide is a chemical compound that consists of 3 portions: a heterocyclic base (A,C,G,T) a sugar, and one or more phosphate groups.

3. DNA hybridization makes use of base pairing between ***nucleotides of short denatured DNA strands.***

4. Where is DNA hybridization found in bioMEMS technology? (State at least two applications)
   Answer: Southern Blot, DNA microarrays, GeneChip®, DNA sensors/transducers

5. What is another *possible* application of bioMEMS and DNA Hybridization? (Provide a source or reference for your answer.)
   Answers will vary.

Summary

Being able to see and study the DNA hybridization process has become a reality. BioMEMS devices are being designed to use this process for diagnostics and therapeutic applications.

References

[1] The Molecular Workbench at http://mw.concord.org/ (Program funded by the National Science Foundation)

[2] SCME's BioMEMS Applications Overview PK unit

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