An Exploration of DNA Concepts Activity
Instructor Guide

Note to Instructor

This activity provides the participants with the opportunity to explore DNA concepts. It is one of two activities within the *Overview of DNA Learning Module*. This activity can be presented as an inquiry activity prior to presenting the primary knowledge material.

This activity is part of the *Overview of DNA Learning Module*.
- Knowledge Probe (pre-test)
- Overview of DNA Primary Knowledge (PK)
- **DNA Activity: Exploration of DNA Concepts**
- DNA Activity: Exploring DNA Applications
- Overview of DNA Assessment

Description and Estimated Time to Complete

This activity is one of two activities in the *Overview of DNA Learning Module*. This activity provides further exploration into DNA concepts and DNA's significance as the genetic material. This information should help you to better understand how microsystems are used in the exploration of DNA and how this information is used in the design of new microsystems for the medical fields.

If you have not review the Overview of DNA primary knowledge unit, you should consider reading it prior to starting this activity.

Estimated Time to Complete
Allow approximately 1 hour

Introduction

Deoxyribonucleic acid (DNA) is a long polymeric molecule found in most cells that functions as the carrier of genetic information. The information carried in the linear sequence of bases in DNA defines an organism. Changes in the linear sequence, sometimes called mutations or polymorphisms, can be used to explain differences between individuals and diagnose diseases such as cancer.
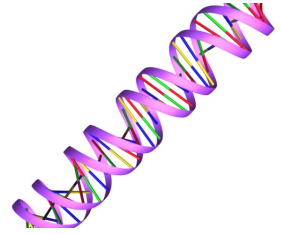
Past and current studies of DNA identify how DNA can be used in biomedical applications. Such applications include the following:
• Improve diagnosis of a disease
• Test the best treatment options for a disease
• Execute rational drug design
• Create custom drugs
• Utilizing DNA in gene therapy

Activity Objectives and Outcomes

Activity Objectives
• Describe the structure and function of DNA

Activity Outcomes
Upon completion of this activity, you will be able to describe the DNA double helix, how it is copied, and to understand its significance as genetic material.

Activity – An Exploration of DNA Concepts

1. Go to http://www.dnai.org
   Complete the "Code" tutorial

2. Go to http://www.dnai.org
   Complete the "Manipulation" tutorial

3. Go to http://www.dnai.org
   Complete the "Genome" tutorial

4. Go to http://www.dnai.org
   Complete the "Applications" tutorial

5. Answer the Post-Activity Questions.

Post-Activity Questions / Answers

"Code"
1. How do the 4 bases (A, T, C, G) fit together in the DNA double helix?
    Answer: A binds to T with the formation of 2 hydrogen bonds, and C binds to G with the formation of 3 hydrogen bonds.

2. Watch the video on "Copying the Code". What is helicase?
    Answer: A protein that unwinds the DNA double helix during replication. It spins the DNA as fast as a jet engine.

3. Watch the video on Translation with the "Reading the Code" section. Why is the ribosome referred to as a molecular machine?
    Answer: The ribosome locks around the mRNA to translate the genetic information in the mRNA into a string of amino acids.

4. What are histones and what is their function within the cell?
    Answer: Histones are small proteins that interact with DNA to aid in condensing or packaging the DNA.

5. What is an operon?
    Answer: A set of genes subject to common regulation. An operon is a functional unit of transcription and genetic regulation. Operons are found in prokaryotic organisms.

"Manipulation"
1. What is transformation?
    Answer: The uptake and expression of recombinant DNA in a bacterium.

2. What is a restriction enzyme?
    Answer: A protein that cuts at specific sites on a DNA molecule.

3. How are pieces of DNA that have been cut with a restriction enzyme pasted back together?
    Answer: Arthur Kornberg characterized an enzyme, DNA ligase, that pastes the pieces together by re-working the sugar-phosphate bonds.

4. What methods of large scale analysis of DNA are described?
    Answer: DNA microarrays and GeneChips™

5. View the descriptions of DNA microarrays and GeneChips™. Are these large scale analysis methods examples of BioMEMS?
    Answer: Yes

"Genome"

1. What is a consensus sequence?
   Answer: Nucleotide sequences that are common to, or similar in regulatory regions of DNA. For example, promoter regions contain the TATA box consensus sequence.

2. How are gene density and GC content of DNA related?
   Answer: Gene density increases with GC content of DNA.

3. What is a chromosome?
   Answer: One continuous piece of DNA that is tightly packed around and with proteins. Chromosomes are only visible during certain stages of cell division.

4. How much DNA is inside every nucleus in our cells?
   Answer: ~6 ft of DNA.

5. Who headed the private Human Genome Sequencing Project?
   Answer: Craig Venter at his company, Celera Genomics.

"Applications"

1. What is the technique of DNA fingerprinting?
   Answer: A technique that analyzes the unique attributes of an individual's DNA.

2. What DNA variation did Alec Jeffreys examine in his initial DNA fingerprints?
   Answer: VNTRs (Variable Numbers of Tandem Repeats)

3. What DNA source has been used to construct a maternal lineage map?
   Answer: mitochondrial DNA (mtDNA)

4. What technique does the FBI currently use for DNA profiling?
   Answer: The FBI uses 13 different STRs (Short Tandem Repeats) plus a sex marker.

5. How are DNA segments separated for analysis of STRs?
   Answer: The DNA segments are loaded onto a polyacrylamide gel, and separated by electrophoresis. The smaller segments move more rapidly through the gel than the larger segments.

Matching Activity *(Note to Instructor: This activity can be used in place of the above questions or in conjunction with. The questions and answers are a repeat of the above open-ended questions.)*

Answer	Description		Match
F	Small proteins that interact with DNA to aid in packaging the DNA		**A.** 6 feet
J	Devices used to detect DNA presence and activity		**B.** hydrogen
A	The amount of DNA inside every nucleus in our cells		**C.** Gene density
H	The DNA variation that Alec Jeffreys examined in his initial DNA fingerprints		**D.** chromosome
B	The types of bonds that bind together nitrogenous bases		**E.** Transformation
K	A protein that cuts at specific sites on a DNA molecule		**F.** Histones
D	The thread-like packaging of DNA molecules		**G.** Operon
O	Technique used by the FBI for DNA profiling		**H.** VNTRs
M	A protein that unwinds the DNA double helix during replication.		**I.** mtDNA
E	The genetic alteration of a bacterial cell by introduction of DNA from another cell		**J.** DNA microarrays
N	The percentage of nitrogenous bases in a DNA molecule that are either guanine or cytosine		**K.** Restriction enzyme
I	DNA source used to construct a maternal lineage map		**L.** Ribosome
P	Nucleotide sequences that are common to or similar in regulatory regions of DNA		**M.** helicase
G	A functional unit of transcription and genetic regulation found in prokaryotic organisms		**N.** GC content
C	Increases the GC content of DNA		**O.** STRs
L	Locks around the mRNA during replication to translate the genetic information in the mRNA into a string of amino acids		**P.** Consensus sequences

Summary

DNA is the genetic material with the genetic information stored in the linear array of nitrogenous bases. The DNA molecule is composed of the sugar deoxyribose, phosphate groups, and the nitrogenous bases. The molecular structure is a double-stranded helix with the sugar and phosphate groups forming the ladder and the nitrogenous bases forming the steps of the ladder. DNA replication is a complex process that requires many enzymes and proteins, and follows a semiconservative model for replication.

References

1. DNA Interactive: Dolan DNA Learning Center. Cold Spring Harbor Laboratory. http://www.dnai.org
2. Overview of DNA: SCME Primary Knowledge Unit

Disclaimer

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