DYNAMIC DNA: EXPLORING DNA STRUCTURE AND FUNCTION WITH PHYSICAL MODELS

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Learning objectives

- Demonstrate how learning through models deepens student learning about DNA structure and reveals student thinking.

What are YOUR learning objectives regarding DNA?

- What do you want your students to KNOW?
- What do you want your students to UNDERSTAND?
DNA UNDER A MICROSCOPE...


DOESN'T LOOK LIKE THIS!

https://upload.wikimedia.org/wikipedia/commons/8/81/ADN_animation.gif
MODELS!

If models are designed to tell stories.. What stories were these models designed to tell?
TEACHING THROUGH MODELING

All models are wrong, but some are useful.

— George E. P. Box —
MODELS ARE USEFUL IN LEARNING... BUT WHAT STORIES DO THEY TELL? WHAT MISCONCEPTIONS CAN THEY CREATE?

One of the goals of NGSS is to “discuss the limitations and precision of a model as a representation of a system”.

- What is the model representing?
- Identify what the model did well.
- Identify the limitations of this model.
- How could the model be improved?
“Based on this model, I see that DNA...”
“Using this model as a guide, I wonder...”
"Based on this model, I see that DNA..."
LEARNING DNA STRUCTURE THROUGH MODELING

“Using this model as a guide, I wonder…”
What I see...
“Based on this model, I see that DNA…”
LEARNING DNA STRUCTURE THROUGH MODELING

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What I see...
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Student Assessment Ideas...

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DNA Structure Assessment

Scientists often use models in order to test or further understand their ideas. In fact, Francis Crick and James Watson “discovered” the structure of DNA by building various models of nucleotides and trying to figure out how they would best fit together. Their models helped them solve their question of basic structure, but they weren’t perfect representations of every detail of DNA. Like their models, the models we have used to learn about DNA have some strengths in helping us understand DNA. However, they may also be lacking some details or might promote misconceptions if you only use one such model to learn about DNA. The scientists educators who designed these models did so for a purpose, and chose to highlight various details of the structure of DNA in order to teach students about them.

This leads us to the statement by George Box: “All models are wrong. Some are useful.”

For this assessment, you have been given a copy of a 2D model of DNA that, like all models, has some useful details illustrating the structure of DNA. However, as with all models, some details of the molecule may be missing, and other details of the model may actually be wrong (causing misconceptions).

Please address the prompts below by annotating the model you are given. Annotate means to add notes giving explanations or comments. Your annotations should be on the paper that contains the model.

What is useful about this model? To be completed with a blue pencil.

⇒ Include all important concepts you think this model is designed to communicate about DNA structure.
⇒ Be sure to label or draw arrows to any portions of the model your comments refer to.
⇒ Be CLEAR in your written/drawn communication to your teacher.

How can this model be improved? To be completed with a red pencil.

⇒ Include all important concepts you know about DNA structure that are not communicated in this model.
⇒ Be CLEAR in your written/drawn communication to your teacher.
⇒ Use RED to draw/label/indicate features of the model that are missing or wrong.
⇒ You may add details to your model in any color, as long as you label any features of the model that you in RED.
The diagram illustrates the structure of DNA. The bases (A, T, C, G) are shown in a double helix, with complementary base pairing (A with T, C with G) indicated by dashed lines. The text annotations include:

- "Bases should touch" near the bottom of the diagram.
- "Doesn't show 3 weak bonds" near the bottom right.
- "Doesn't show 2 weak bonds" near the bottom left.
- "Phosphodiester is less small (less molecule) than sugar" near the top right.
- "Sugar bond to phosphates" near the top left.
- "Sugar bond to phosphates" near the top center.
- "Shows that adenine and guanine, cytosine and thymine are similar in size and structure" near the bottom middle.
- "Deoxyribose sugar forms a pentagon" with an arrow pointing to the left.
- "The same thing" written in a box at the bottom left.
Due to the lack of composition, we can’t tell that a nucleoside consists of sugar, phosphate, and a nitrogen base.

Nitrogen bases and pairing properties are well represented.

Overall double-helix structure is shown.

Direction of sugar-phosphate backbone is not clearly shown.

End of arrow = direction of phosphate backbone.

The nitrogen bases are not well represented – some seem to be larger than others.

It is hard to infer that the DNA could continue with the same structure.

The backbone doesn’t show the composition of sugar and phosphate.

Phosphate renders it more rigid. It doesn’t have to have the same order in every base pair being.
Your ideas?

- How might you use an approach like this in your classroom?
- What are some advantages to introducing the structure of DNA through student evaluation of models?
DNA STARTER KIT – Replication!
DNA STARTER KIT – Transcription!
DYNAMIC DNA! One model, so many learning objectives!
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• There is a wide major groove...

• And a narrow minor groove...
THE MAJOR GROOVE...

• Large enough to fit an alpha helix of a protein.

• Protein sidechains can interact with atoms in nucleotides.

• Sequence-specific interactions
  • DNA binding proteins
  • Transcription factors
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THANK YOU!

Please check out our **LENDING LIBRARY**!

Please come visit us for a **WORKSHOP** at the **CBM**!

Check out our resources to help you find funding

Use **STEM2019** for a 20% discount on 3D Molecular Design products

For more molecular stories... . . .

Come visit us at booth **501**.

We hope to see you soon!

**contactus@3DMolecularDesigns.com**
DYNAMIC DNA! One model, so many learning objectives!

What Students Can Discover with the Dynamic DNA Kit®

Feel the inherent flexibility of DNA
Unfurl your gene map for beta hemoglobin!
What do you observe?
What do you infer?
Student Map
The first methionine amino acid is cleaved from the β-Globin protein soon after its synthesis. This negatively charged glutamic acid (E) is replaced by a hydrophobic valine (V) in sickle cell anemia.
Using the 3 possible reading frames, find the amino acid sequence:

```
MVHLT  PEEKS  AVTAL  WGKV  NVDEV  GGEAL  GRLLV  VYPWT
QRFFE  SFGDL  STPDA  VMGNP  KVKAH  GKKVL  GAFSD  GLAHL
DNLKG  TFATL  SELHC  DKLH  VDPEN  FRLLG  NVLVC  VLAHH
FGKEF
```

TPRVO  AAYOK  WAGV  ANALA  HKYH
Exons and Introns!

Group 1
Group 2
Group 3
Group 4
Group 5
Group 6
What can be done with this and other gene maps?

- model introns and exons and other features of a gene.
What can be done with this and other gene maps?

- model introns and exons
- find mutations that lead to particular phenotypes

https://evolution.berkeley.edu/evolutionlibrary/article/mutations_06
What can be done with this and other gene maps?

• model introns and exons
• find mutations that lead to particular phenotypes
• review the flow of genetic information