Nucleotide Building Interactive Animation

Resource Type: Curriculum: Classroom

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Abstract

DNA and RNA are composed of nucleotides, which are combinations of nitrogenous bases, pentose sugars, and phosphate. This interaction provides students with practice in constructing these nucleotides and allows students to become familiar with the naming conventions of these molecules. The interaction may be used on a stand-alone web page or may be incorporated into the content of a website. It is a nongraded activity in which the student builds multiple, different nucleotides each time they access the activity. The interaction may be used in the classroom or may be provided to students as an online activity.

Activity

Invitation for User Feedback. If you have used the activity and would like to provide feedback, please send an e-mail to MicrobeLibrary@asmusa.org. Feedback can include ideas which complement the activity and new approaches for implementing the activity. Your comments will be added to the activity under a separate section labeled "Feedback." Comments may be edited.

Learning Objectives.

Upon completion of this activity, students should be able to match nucleotide structures to the appropriate molecule name.

Background.

Students should know the components of DNA and RNA and that nucleotides are the basic building blocks of nucleic acids.

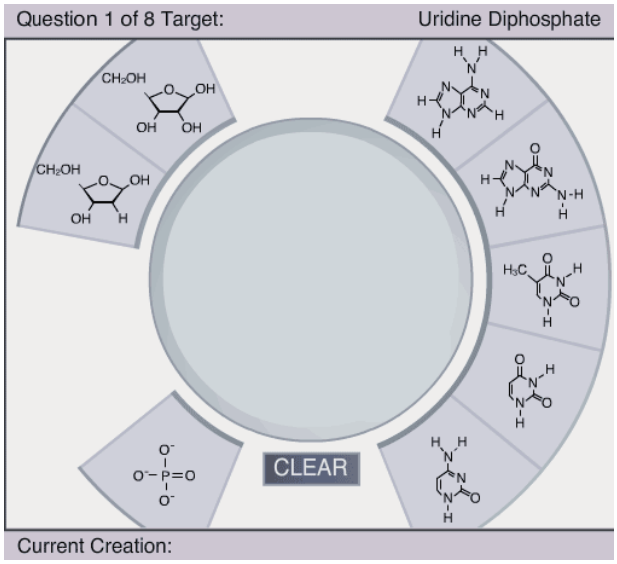
PROCEDURE

Materials.

Users need access to a computer with a current Flash program plug-in for Internet browsers. Flash is a cross-platform plug-in that is available for both PC and Macintosh computers. Flash is also compatible with most browsers, including Internet Explorer and Firefox. (Many current browsers come with a Flash plugin already installed. Flash Player is available at www.adobe.com.)

Introducing the Interaction to Students.

DNA and RNA are composed of nucleotides, which are combinations of nitrogenous bases, pentose sugars, and phosphate. Use the activity below to practice constructing various nucleotides that are precursors to the DNA or RNA macromolecules. The activity will define a "target," which is the molecule you are expected to construct. As you drag components to the center area, it will tell you what molecule you have constructed to that point. When the correct molecule has been created, it will tell you that you are ready to move on to the next example. If at any point you have constructed the incorrect molecule, you may "clear" the construction area and begin again on the particular example. When you have completed eight molecules, you are done with the exercise (Note: you can return to this interaction multiple times. Each time you will receive eight randomly selected molecules to build.)



View Animation

Instructor Version.

This interaction provides students with practice in constructing the nucleotide building blocks of DNA and RNA. Students also have the opportunity to become familiar with the naming conventions of these nucleotides. It is recommended that the instructor introduce students to nucleic acids and structures before students begin this reinforcing activity.

This nongraded activity allows the student to build multiple, different nucleotides each time they access the activity. The interaction may be used as an in-class activity if computers are available in the classroom or may be provided to students as an online activity. Due to the ability to repeat the interaction multiple times, online delivery would provide more opportunities for student practice. The interaction may be used on a stand-alone web page or may be incorporated into the content of a website. Instructions for inserting the animation into an HTML page are as follows:

1. Save the "nucleotide.swf" file to the same file folder as the web page on which it will appear.
2. The method for embedding the "nucleotide.swf" file in your HTML page will vary based on how you are creating your page.
   a. If you are using a program such as Macromedia's Dreamweaver, you can "Insert" a shockwave media object, and then select the "nucleotide.swf" file.
   b. If you are working with course management software such as Blackboard, the "nucleotide.swf" file can be attached in the same manner that image files are attached to pages.
   c. If you are working directly with the HTML coding, edit the HTML coding of the page to insert the following:

```
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width="550" height="500"
id="Nucleotide" align="middle">
<param name="allowScriptAccess" value="sameDomain" />
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<embed src="Nucleotide.swf" quality="high" bgcolor="#efeeed"
width="550" height="500" name="Nucleotide" align="middle" allowScriptAccess="sameDomain" type="application/x-shockwave-flash" pluginspage="http://www.macromedia.com/go/getflashplayer" />
</object>
```

In the activity, the students are given a "target" molecule that they are to construct; the molecule name is given in the upper-right corner of the interaction. Students must first click and drag into the central

construction area of the interaction a base structure from the right-hand side of the interaction. The name of the base will now appear in the lower-right corner of the interaction. Next, the student must select a pentose sugar from the upper-left side to click and drag into the construction area. The base-sugar combination name will now appear. The student should now select the appropriate number of phosphates to add in order to make the appropriate target molecule. This is done by repeating the drag-and-drop process of the phosphates until the desired number have been added. With each addition, the structure name will update. If the student should attempt any step out of order, such as placing a phosphate on the base before the sugar, the interaction will notify them of the correct addition order. If the wrong structure is created, the student may clear the center and begin constructing the target molecule again. Once the target molecule has been constructed, the interaction notifies the student that a correct target has been achieved. A "next" button appears that allows the student to proceed to the next target in a series of eight target molecules. Each time a student accesses the activity, they will receive a new set of eight target molecules.

The target molecules to be constructed will be chosen randomly from the following choices:

AMP, ADP, ATP, dAMP, dADP, dATP, CMP, CDP, CTP, dCMP, dCDP,dCTP, GMP, GDP, GTP, dGMP, dGDP, dGTP, dTMP, dTDP, dTTP, UMP, UDP, UTP

In addition to providing practice to students in building and recognizing these nucleotides, the activity can also serve as a springboard for addressing other aspects of nucleotide biochemistry and function. Some example thought questions that could accompany the activity include:

- Identify the structural feature that allows enzymes, such as DNA polymerase, to recognize the difference between ribonucleotides and deoxyribonucleotides. Once students are adept at recognizing the structural differences of the sugars, this could lead to further class discussion on how RNA primers are used in DNA replication, or how a dideoxynucleotide can be used in DNA sequencing.
- Discuss how a polymerase uses a nucleotide triphosphate as a substrate to add onto a growing nucleotide strand in DNA or RNA synthesis. Additionally, when an RNA or DNA strand is degraded, what form of nucleotide would be released and could that molecule be recycled in the cell for use in DNA or RNA synthesis.
- Identify the locations in the nucleotides that could contribute to hydrogen bonding in a DNA strand. Use that information to show why certain nucleotide pairs do not normally form base pairs in double-stranded DNA, as well as how this contributes to the ability of one DNA strand to serve as the template in DNA replication. Another aspect of this exploration could be to discuss why GC% content affects the stability of the bonding between complementary strands as evidenced by DNA melting points, for example.

Safety Issues.

None.

Suggestions for determining student learning.

Questions that require students to identify or match a name to a particular nucleotide structure are a method for assessing student learning from this activity.

Field Testing.

This interaction was used during the 2006-2007 academic year as a part of the online portion of a blended-format (face-to-face and online combination) course for freshman biology majors. A total of just over 200 students were enrolled during this time period, for which assessment of this activity is available for 145.

Assessment information is available from an online module quiz that the students take during the week that the DNA course module is available. Students may take this quiz as many times as they wish during a 1-week period, with their highest grade recorded in the gradebook. One question over nucleotide structure was included in each attempt (five different versions of this question were available, so students did not necessarily receive the same question during each attempt). These questions were in multiple-choice format in which students were given a graphic showing the structure of a particular nucleotide and asked to select the correct molecule name from a list of five choices.

For assessment of the Nucleotide Building Interactive Animation, data was obtained from the students' module quizzes to determine their answer on the nucleotide structure questions for their first attempt and last attempt at the quiz. The number of correct, incorrect, or no answer responses was tabulated for both first attempts and last attempts. Of the 145 students who took the quiz more than once, 17.2% (n = 25) gave a correct answer on the nucleotide structure question on their first attempt (essentially equivalent to a random guess). However, on their last quiz attempt, 60.7% (n = 88) selected a correct answer. Since the only method of presenting nucleotide structure in this course was through the Nucleotide Building Interactive Animation, it appears that this activity was successful in helping students to match nucleotide structure to the molecule names.

Sample questions

Student Data.

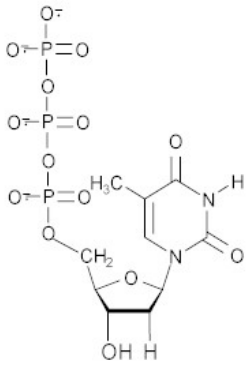
The only student data collected on this interaction is the assessment data presented previously. No student comments on this specific interaction were available.

Molecule graphics for use in construction of additional assessments

Nucleotide Building Interactive Flash Animation

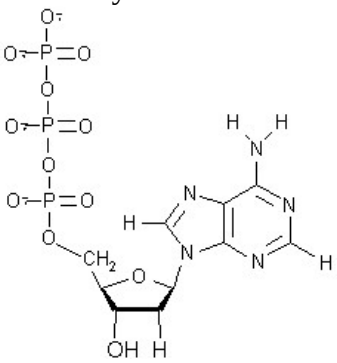
Sample questions:

1. Identify the molecule shown in the figure:



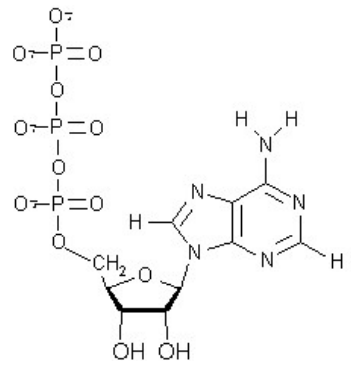
a. adenosine triphosphate
b. deoxyadenosine triphosphate
c. cytidine triphosphate
d. guanosine triphosphate
*e. deoxythymidine triphosphate

2. Identify the molecule shown in the figure:



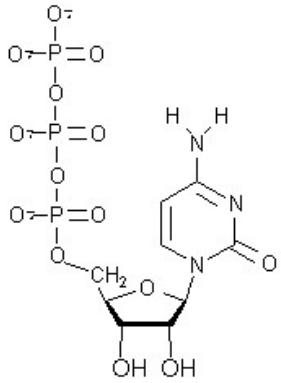
a. adenosine triphosphate
*b. deoxyadenosine triphosphate
c. cytidine triphosphate
d. guanosine triphosphate
e. deoxythymidine triphosphate

3. Identify the molecule shown in the figure:



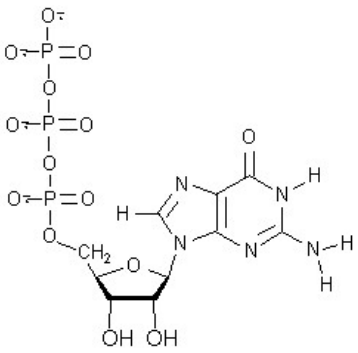
*a. adenosine triphosphate
b. deoxyadenosine triphosphate
c. cytidine triphosphate
d. guanosine triphosphate
e. deoxythymidine triphosphate

4. Identify the molecule shown in the figure:



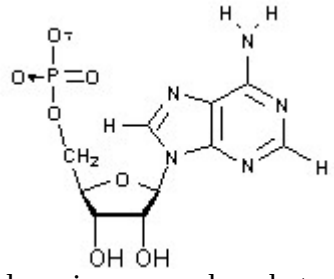
a. adenosine triphosphate
b. deoxyadenosine triphosphate
*c. cytidine triphosphate
d. guanosine triphosphate
e. deoxythymidine triphosphate

5. Identify the molecule shown in the figure:

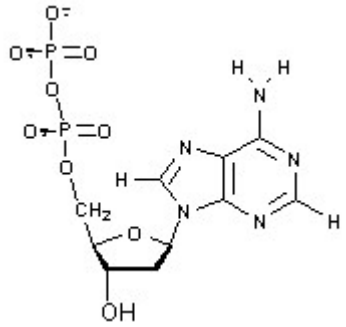


a. adenosine triphosphate
b. deoxyadenosine triphosphate
c. cytidine triphosphate
*d. guanosine triphosphate
e. deoxythymidine triphosphate

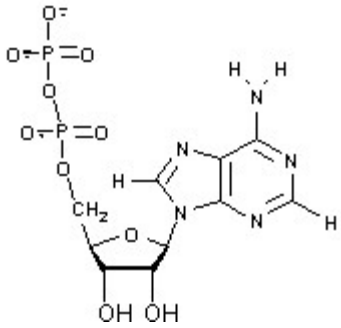
Molecule graphics for use in construction of additional assessments



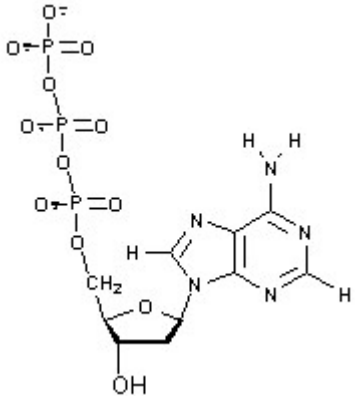
adenosine monophosphate



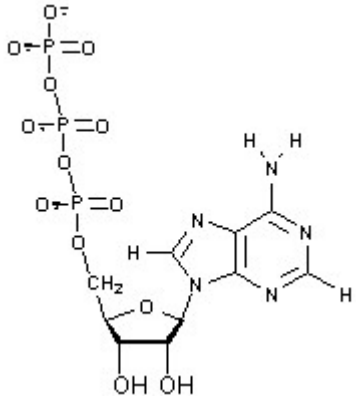
deoxyadenosine diphosphate



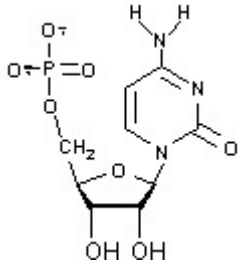
adenosine diphosphate



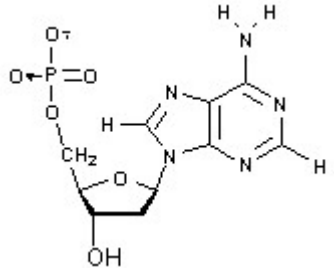
deoxyadenosine triphosphate



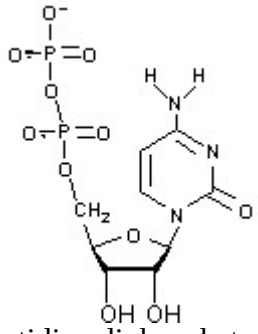
adenosine triphosphate



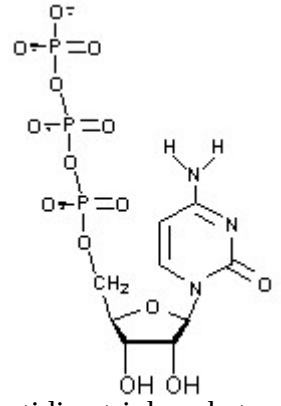
cytidine monophosphate

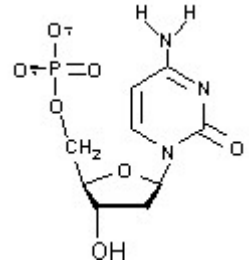


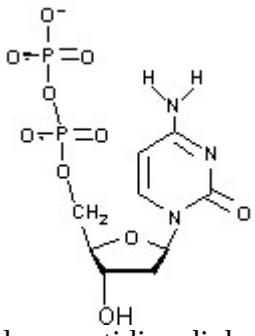
deoxyadenosine monophosphate

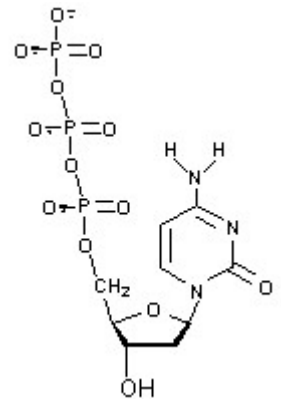


cytidine diphosphate


cytidine triphosphate


deoxycytidine monophosphate


deoxycytidine diphosphate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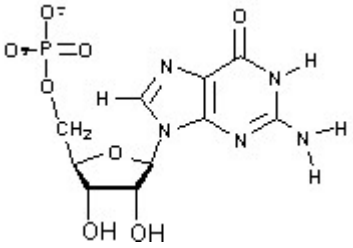
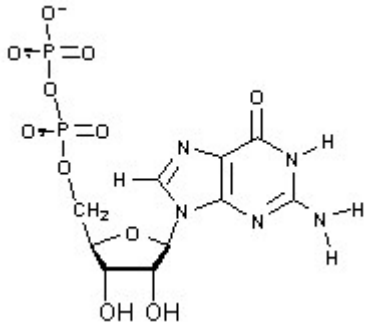
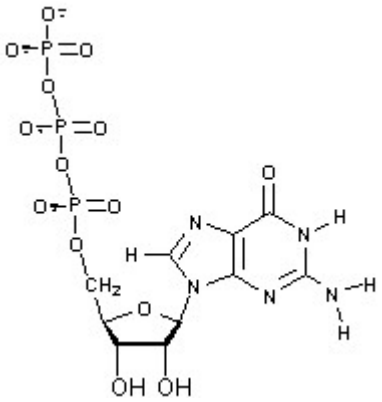
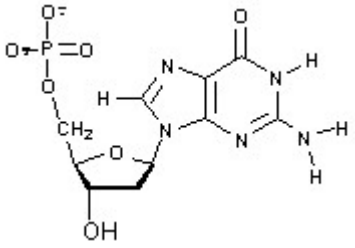
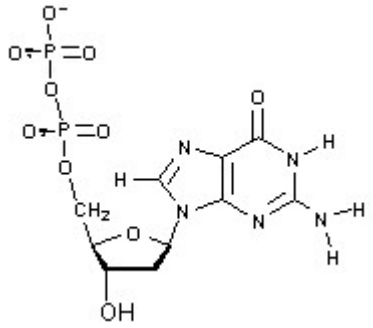

guanosine monophosphate

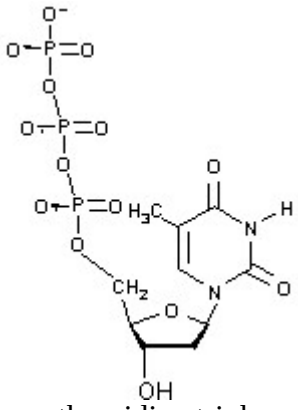

guanosine diphosphate


guanosine triphosphate

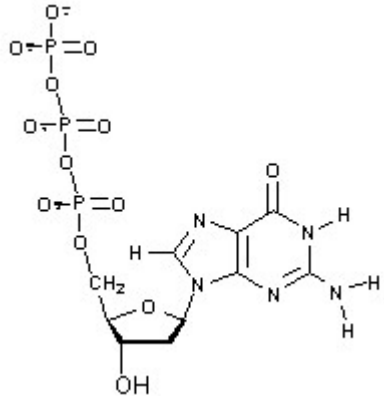

deoxyguanosine monophosphate



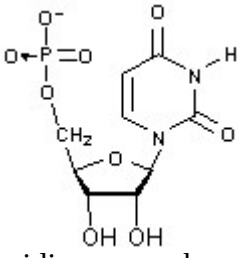
deoxyguanosine diphosphate



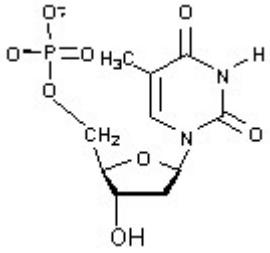
deoxythymidine triphosphate



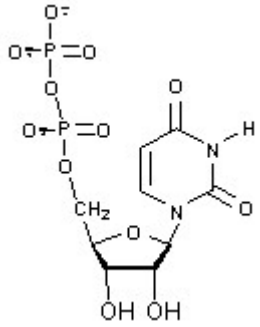
deoxyguanosine triphosphate



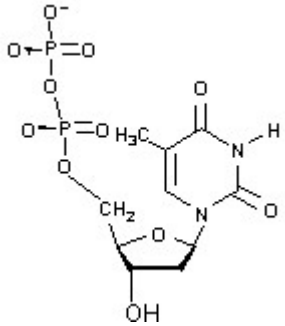
uridine monophosphate



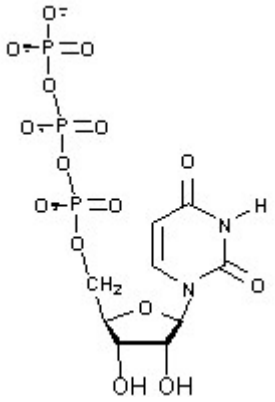
deoxythymidine monophosphate



uridine diphosphate



deoxythymidine diphosphate



uridine triphosphate