**Table 1. Probing questions, by grade level.** Possible questions that can be used to assess in various ways: written out and given as a formal, written assessment; given as a series of 1-2 question entry or exit slips; informally used as small or large group discussion questions; used as a guide for a performance assessment using models.

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| **Step or Section of Modeling** | **Grade/Level** | | |
| **Beginner (Grade 6-8; grade 9 & 10 ELL, SPED)** | **Intermediate (Introductory biology, grade 9 & 10)** | **Advanced (TAG students; AP & IB classes)** |
| **Replication: writing the original DNA sequence** | What do the letters represent? Why are we copying the letters from the board (what process are you simulating)? Do you think the sequence of letters you wrote is complete? What should we add to it if not? Why do you think it is important that the sequence is finished? Or, why do you think it would be bad if the sequence was *not* finished? | What do the letters represent? How do you predict they will pair up? Is the strand you see/the strand you wrote DNA or RNA? How do you know? Is this strand complete? If not, why not? How would you finish it? Why do you think it is important that the sequence is finished? Or, why do you think it would be bad if the sequence was *not* finished and left as it is? | What are the names of the four DNA bases? How do they pair up, and which ones are purines and which are pyrimidines? What direction should you have written your original strand—5 to 3”, or 3 to 5”? What direction was the template strand? The same or different from the daughter strand? How is this model not a complete representation of replication? What would we need to add to make it more complete? |
| **Replication: creating the complementary strand** | Match up the letters in this sequence (use your DNA model if you need): A T C… Summarize the steps you just followed. What did you create? How did you create the second strand of DNA? Do you see any patterns between the strand written on the board and the two strands you created? Do they all use the same letters? Do they all have the same pattern of letters or are they different? Predict why you think this might be important. | How should the complementary strand be drawn? Should it match your original strand or be different? Do both sides use the same letters? Why is it important the letters pair in this way? What type of bond holds DNA bases together? Explain why you think this type of bond is helpful for a molecule like DNA that often unzips and then zips back up. What process have you just simulated with your model? | What enzyme(s) play a role in replication? Thinking about the structure of the double helix, why is it important that the nitrogenous bases air up in the way they do? Do purines go with other purines, or with pyrimidines? What type of bond holds bases together? Why is this type of bond in particular essential for DNA’s structure *and function?* What do you notice about the complementary strand? Does it match either or both of the strands in the original sequence? If so, why do you think that is? |
| **Transcription** | What bases/letters do DNA and RNA have in them? The same or different? Which bases pair together in transcription? Using your model, show me which strand(s) are DNA and which are RNA; explain how you know which is which. Compare and contrast replication and transcription. Show me how you would transcribe this sequence: T A G T C A G A  When we turn DNA into RNA in transcription, does the structure of the backbone change? If so, how? | List similarities and differences between DNA and RNA. Does RNA have the same bases? If not, how does it differ? Identify the DNA and RNA strands in your model and explain how you know which is which. Compare and contrast replication and transcription. Hypothesize why the steps of transcription would be different from replication. Show me how you would transcribe this sequence: T A G T C A G A C G C T A  During transcription, does the structure of the backbone change? If so, how? | Which strand(s) will be used for translation? 5 to 3” or 3 to 5”? How do you know? Why is this important, and why do you think it works this way in particular? What enzyme(s) are critical for beginning transcription? Where does transcription occur, and why? Explain (or predict) why it *doesn’t* occur outside of the nucleus. What type of RNA have you created during transcription (tRNA, mRNA, rRNA, snRNA)? Which strand does your RNA strand most closely match: the sense strand or antisense strand? Which strand does your RNA strand use as a template? |
| **Building ribosome** | Why would we make our window 3 letters/bases wide? Or, how many letters are read at a time during translation? Use your model to show. How many letters will our strand shift down each time? What does a “codon” code for? What do you think we will use our envelope for? DNA or RNA? What do you predict are reasons why DNA or RNA should be used? Use your model as evidence to help you explain what the ribosome is used for. | Why would we make our window 3 bases wide? Or, how many letters are read at a time during translation? Use your model to show. How many letters will our strand shift down each time? What does a codon code for? What is an anticodon? Considering your model so far, what do you think the envelope will be used for? DNA or RNA? Provide evidence—including your model—for why this particular molecule would be used. | Why would we make our window 3 bases wide? What is this series of bases called? What does it code for? Summarize the steps that occur between a codon being read and an amino acid being added to a polypeptide. What is an anticodon? How will this be important during translation? Show me on your model which sites would be the A, P and E sites, and explain what happens at each. Which direction (left to right, or right to left) will your RNA strand feed through? |
| **Translation** | Looking at your model, can you guess where translation occurs? Why do you think it happens here (and *not* in the nucleus)? This is different from transcription…why do you think they happen in different places? What is different about DNA and RNA? Why does this matter for where these steps happen? What is needed for translation? Can it be found in the nucleus? Use your codon chart to show how you know which codon(s) signal the start of translation? What codon(s) signals the end? Use your model to show how you slide the RNA through to make a polypeptide. What are you adding, and how do you know which one to add each time? Show me how you use your codon chart. Why do you think there are so many codons (combinations of letters), but only 20 main amino acids? Look at your codon chart for a hint! What happens when the stop codon is reached? What product have we created at the end of translation? | Where does translation occur and why? Does it happen in the same place as transcription? Why or why not? Think of *one* critical difference between DNA and RNA that accounts for the difference in location, and explain why you think it matters. What is needed for translation? Can it be found in the nucleus? Which codon(s) signals the start of translation? What codon(s) signals the end? What is meant by “redundancy” of amino acids? Do all codons code for an amino acid? How many possible codons are there, and how many amino acids are there? Explain why this is. Using your model, show and explain in detail how a polypeptide is built: for example, what in particular is being read, where does the process begin, and how are amino acids added? Be specific! What do the staples represent when you build your polypeptide? Which *type* of bond specifically do they represent? What happens when the stop codon is reached? What product have we created at the end of translation? | Where does translation occur and why? Think of *one* critical difference between the structure of DNA and RNA, and identify *one* critical component needed for translation. Explain how this accounts for the location of transcription versus translation. Or, compare and contrast the structures of DNA and RNA, and what components are needed for transcription and translation, then explain why these differences account for the location of each. Which codon(s) signals the start of translation? What codon(s) signals the end? What is meant by “redundancy” of amino acids? Do all codons code for an amino acid? How many possible codons are there, and how many amino acids are there? Explain why this is. What is the role of tRNA in translation? Show me how tRNA and mRNA add the correct amino acid, and explain which one(s) dictate(s) what is added. Using your model, show and explain in detail how a polypeptide is built: for example, what in particular is being read, which sites are used for what, in what order, and how is the polypeptide growing and bound together? What type of bond do the staples represent? |
| **Folding polypeptide** | What does your strand of amino acids represent? A polypeptide can be folded or bundled up. When it has been bundled, what is it called? What is one possible role of the protein you created? Can one protein be used for more than one job in a cell? | What does your strand of amino acids represent? If you fold up your polypeptide, is it called something different? If so, what is it called? How do polypeptides fold up, and what type(s) of bonds hold them together? List the possible roles this protein could have in the cell. Can it carry out more than one role? | Before the chain of amino acids is modified, what is it called? After you fold it, then what is it considered? What bonds hold amino acid *chains* together? How, specifically, is a polypeptide folded? How do different types of amino acids interact? Show me on your model how a nonpolar amino acid would be aligned. Show where a basic amino acid would be found in the protein. Which level(s) of protein structure are represented by your model? What other modification(s) need to occur in order to form a functional protein? List the possible roles this protein could have in the cell. Can you predict anything about a protein’s function based upon its structure? |
| **Critical thinking/ reflection questions** | What is the purpose of creating a polypeptide or protein? Why is turning DNA into RNA into protein so important in biology? Summarize the steps of replication, transcription and translation, using your model as a guide. | What is the purpose of creating a polypeptide or protein? Why is turning DNA into RNA into protein so important in biology? Summarize the steps of replication, transcription and translation, using your model as a guide. Be specific! | What is the purpose of creating a polypeptide or protein? Why is turning DNA into RNA into protein considered the “central dogma” of biology? Summarize the steps of replication, transcription and translation, using your model as a guide. Be specific about each step, key components, and include details such as types of bonds. |
| **NOTE:** *Offering sentence stems or fill-in-the-blanks can be useful for students of all grades and all levels, particularly on complex and/or difficult questions; this could include offering sentence starters to open-ended free-response type questions, and/or including a word bank or “key words” for students to pull from. Probing questions from the “intermediate” category could be used in a formal assessment for* all *students in an introductory biology class if these supports are offered to ELL and SPED students.* | | | |