Name: **Date:**

HANDS-ON ACTIVITY

Modeling Genetic Engineering

Some people are unable to produce certain essential hormones. For example, a small percentage of children produce too little human growth hormone (hGH). Thus, they fail to reach normal height as adults.

Genetic engineering has made it possible to synthesize hGH and other hormones. In this investigation, you will simulate the techniques used by genetic engineers to produce recombinant DNA that codes for the production of hGH.

MATERIALS

- cup, paper (to hold paper clips)
- paper clip, black (36)
- paper clip, blue (32)
- paper clip, silver (4)
- paper clip, white (36)
- paper clip, yellow (32)

PREDICT

How do you think recombinant DNA technology can be used to synthesize hGH?

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PROCEDURE

Part A: The *hGH* gene

1. Obtain the different paper clips. Throughout this investigation, use the following key:

   black clip = adenine (A) white clip = thymine (T)

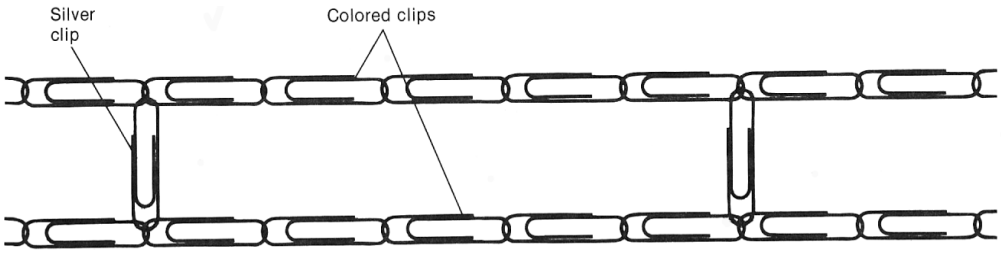
   blue clip = cytosine (C) yellow clip = guanine (G)

2. Link the appropriate paper clips to form a single strand of DNA that has the following sequence:

   A-A-G-C-T-T-A-T-G-G-T-C-C-C-G-G-A-C-G-A-A-G-C-T-T-C

3. Use additional paper clips to make the complementary DNA strand. Place the two strands side by side on your desk. Be sure the complementary base pairs line up. The strand that begins with the sequence A-A-G-C-T should be on top, and the complementary strand should be on the bottom.

4. Use two silver paper clips to link the two DNA strands as shown in the diagram.



5. The model you made in steps 2–4 represents the *hGH* gene. Your model contains 26 DNA base pairs, but the actual gene contains 573 DNA base pairs.

Part B: Genetic engineering

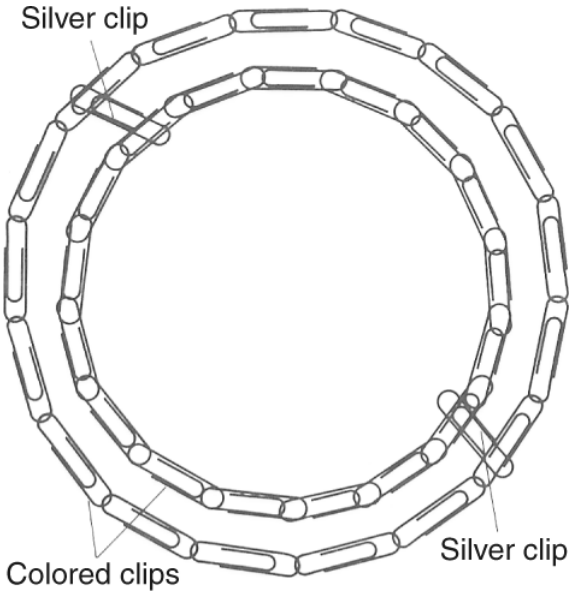
1. In this part of the investigation, you will simulate the procedures used to produce recombinant DNA. First, make a model of a bacterial plasmid. Recall that plasmids are small loops of DNA found in certain types of bacteria.

2. Use colored paper clips to construct a double-stranded DNA molecule with the following sequence:

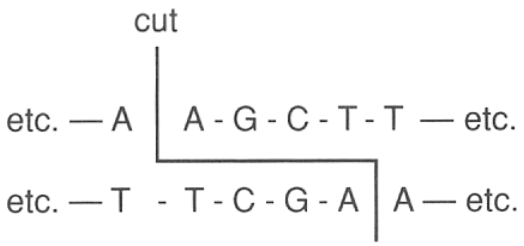
   G-G-A-T-C-C-T-G-A-C-A-C-C-G-G-C-G-C-G-T-C-A-A-G-C-T-T-C-C-C

   C-C-T-A-G-G-A-C-T-G-T-G-G-C-C-G-C-G-C-A-G-T-T-C-G-A-A-G-G-G

3. Connect the ends of the two strands so that they form a double circle, as shown below. Be sure complementary bases are next to each other. Use silver paper clips to connect the two circles and keep the base pairs in line.



4. You now have a plasmid and an *hGH* gene. To insert the gene into the plasmid, you must produce "sticky ends." In the DNA sticky ends are unpaired bases at the ends of DNA molecules that have been cut apart. Genetic engineers use enzymes called *restriction enzymes* to cut DNA molecules. There are a variety of restriction enzymes. You will simulate the use of the enzyme called HindIII, which cuts DNA strands between adjacent A's in the base sequence, as shown.



5. In your plasmid, find the base sequence shown in Step 4. Then separate the double-stranded DNA ring just as HindIII would. Which bases make up the sticky ends on the plasmid after treatment with HindIII?

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6. Find the base sequence shown above on your *hGH* gene. You should be able to find two such sequences—one at each end of the molecule. Separate the two DNA strands just as HindIII would. Set aside the few leftover clips. Which bases make up the sticky ends on your *hGH* gene after treatment with HindIII?

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7. Compare the sticky ends of the plasmid with those of the *hGH* gene. What do you observe?

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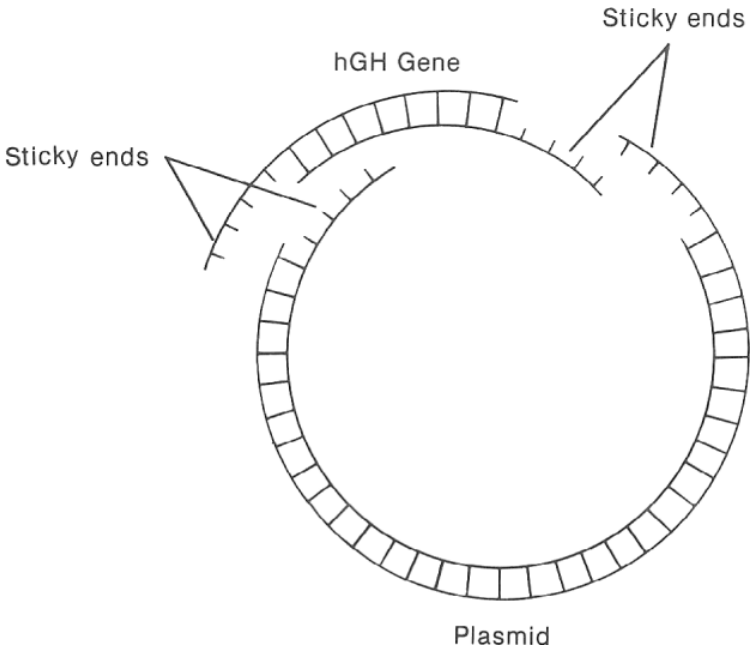
8. Move the *hGH* gene to the open ends of the plasmid. Fit the *hGH* gene into the ring so the complementary bases line up, as shown below. When you are sure that the base pairing is correct, connect the clips to form one new, closed ring.



ANALYZE

1. How did you determine that your insertion of the *hGH* gene into the plasmid was correct?

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2. The restriction enzyme HpaII cuts DNA between adjacent C's in the following base pair sequence:

C-C-G-G

G-G-C-C

What sticky ends would have resulted if you had used this enzyme to cut your plasmid and the *hGH* gene?

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3. Could you have used HpaII to make a recombinant DNA with the *hGH* gene? Explain.

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4. The restriction enzyme BamHI cuts DNA between adjacent C's in the following base pair sequence:

G-G-A-T-C-C

C-C-T-A-G-G

What sticky ends would have resulted if you had used this enzyme to cut your plasmid and the *hGH* gene?

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5. Could you have used BamHI to make a recombinant DNA with the *hGH* gene? Explain.

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6. When scientists cut DNA molecules, they must avoid cutting codons. Why do you think this is so?

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7. How do you think genetic engineers would determine whether the desired recombinant DNA is produced?

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