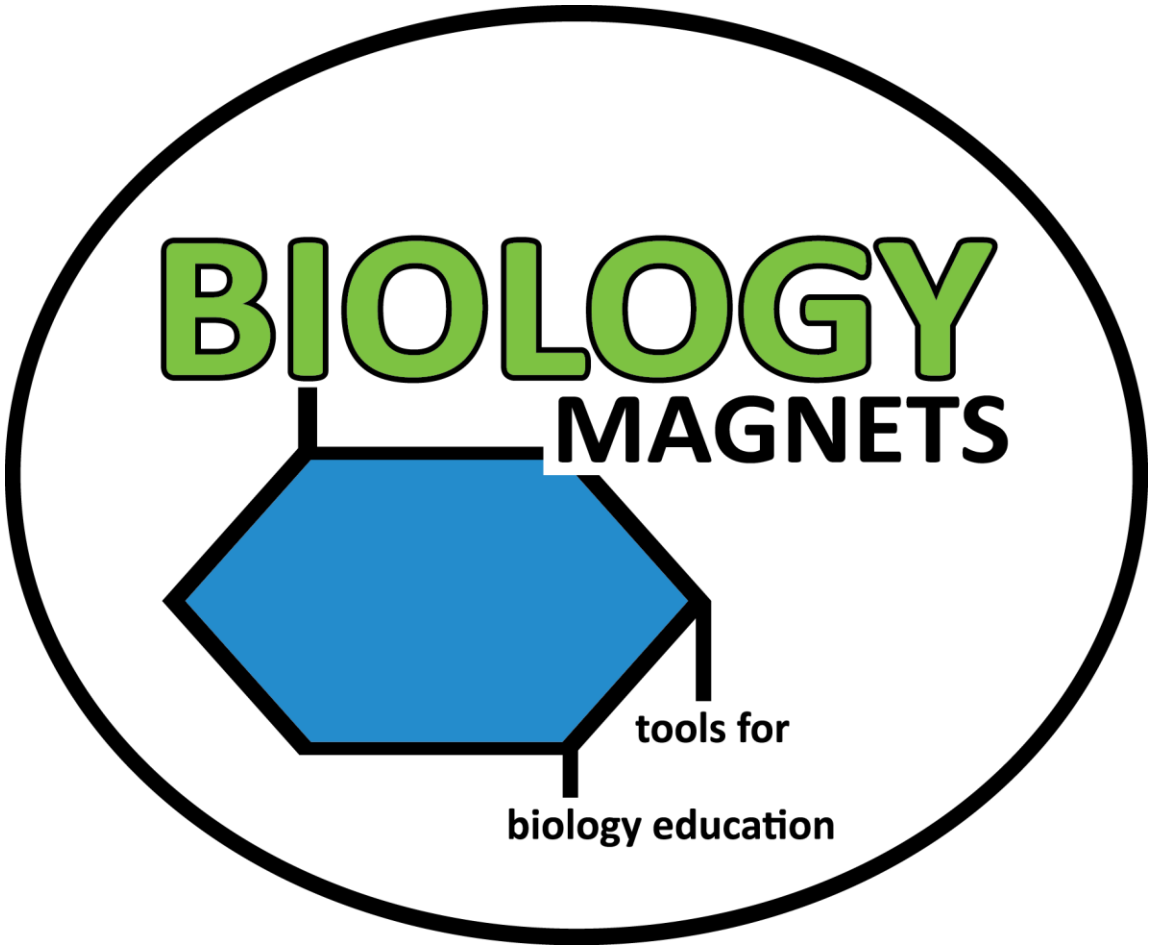
Biology Magnets Module 7: Biotechnology - Teacher and Student Guides



Teacher Information

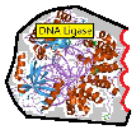
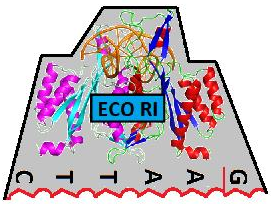
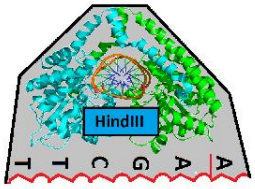
This module uses magnets designed for teacher and student interaction to guide learning the processes involving restriction enzymes. Contained in this guide are lesson ideas that can last from 10 minutes each to an entire class period, depending upon teacher preference. Each lesson has both teacher-centered and student-centered activities. The student-centered activities are most effective if students are in small groups. It may be necessary to have multiple magnet sets for large classes. A student handout is provided which can be printed out and given to each student group to help guide their progress as they work with the Biology Magnets. If budget or white board space is limited, groups can alternate between using a set of Biology Magnets and doing other activities. Teachers can refer to the videos posted at the Biology Magnet web site at BiologyMagnets.com for guided teaching instructions. The guides presented here are written to supplement, not replace, textbooks and lessons and thus do not fully elaborate on all processes and terms.

Magnet Care and Maintenance

Biology magnets are made to last for years. Periodically magnets will fall off or are knocked off the plastic. A piece of magnetic tape is included with each module, which should be able to replace around 10-12 magnets if necessary. Simply cut a new magnet and peel off the back to replace. Magnetic tape can be purchased from a hobby store to replace magnets lost over time. Laminate may peel off, especially on small pieces. Transparent tape can be used as a replacement or to re-attach laminate that comes loose by curling the tape over the back of the magnet. The machines used to cut Biology Magnets are not always perfectly accurate. Sometimes a bit of white or black outline on the edges occurs or a cut might be slightly off center. Use scissors to remove extra outline that is unnecessary if desired. Store magnets in the clasp envelopes in which they arrived for easy organization.

Copyright Information – Module 7 – Biotechnology

Biology Magnets Module 7 Materials List

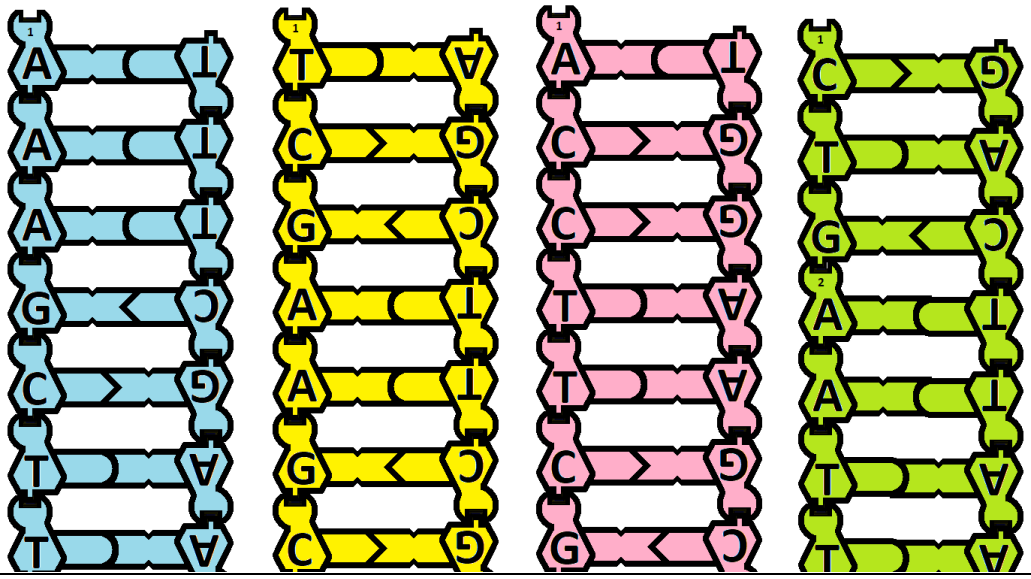
Magnet Name	Quantity	Picture
Blue DNA Strand	3 (3 taped together)	
Yellow DNA Strand	4 (4 taped together in two strands)	
Pink DNA Strand	4 (2 taped together)	
Green DNA Strand	5 (2 taped together)	
DNA Ligase	2	
EcoRI Restriction Enzyme	2	
HindIII Restriction Enzyme	1	
3” Magnetic Tape Strip	1	
Total Quantity	**22**	

Lesson 7A – Biotechnology – DNA Fingerprinting (10-50 minutes)

Teacher Centered Activity (10-20 minutes): This lesson utilizes the Biology Magnets to model restriction and DNA fingerprinting. Start with the four strands of DNA Biology Magnets on the board, put together to make complete strands joined end to end. Use the numbers printed on the tips of the nucleotides to put the pieces in the correct order, with 1 at the top and 2-5 sequentially below (**Figure 7.A.1**). The DNA represents samples taken from four different individuals. Each DNA strand is 33 base pairs long (66 nucleotides) and contains from 0 to 4 GAATTC recognition sequences (**Figure 7.A.2**).

Figure 7.A.1 – Numerical designation on DNA

Figure 7.A.2 – Four DNA strands from different individuals (extends downward to 33 nucleotides in length)



Move EcoRI along the DNA until it encounters a GAATTC recognition sequence. The enzyme cuts between the G and A on both sides of the DNA to form "sticky ends" (**Figure 7.A.3**). When GAATTC is encountered, make a staggered cut by separating the DNA on each side (**Figure 7.A.4**). Do this for all four strands. Depending upon where cuts are made, each strand will have different lengths of DNA fragments (**Figure 7.A.5**). The number of cuts, fragments, and fragment size in nucleotides is shown below (**Table 7.A.1**). This table is left blank in the student guide for students to fill in.

Table 7.A.1 – EcoRI Restriction Digest Results

DNA Color	Cuts Made By EcoRI	EcoRI digest fragments	Fragment size(s) in nucleotides
Blue	0	1	66
Yellow	1	2	36,30
Pink	2	3	34,18,14
Green	3	4	30,14,12,10

To make a DNA fingerprint, the cut DNA will be put into a gel and moved with an electric current. The small fragments move faster than the large fragments in proportion to the inverse logarithm of the number of nucleotides. Have the students draw a DNA fingerprint by drawing a sample gel on the board or on graph paper and marking where the bands would be produced after the restriction digest. Have the students use a logarithmic scale for more accurate fingerprints (**Figure 7.A.6**).

Figure 7.A.3 – EcoRI scanning for the GAATTC sequence from 5'->3'

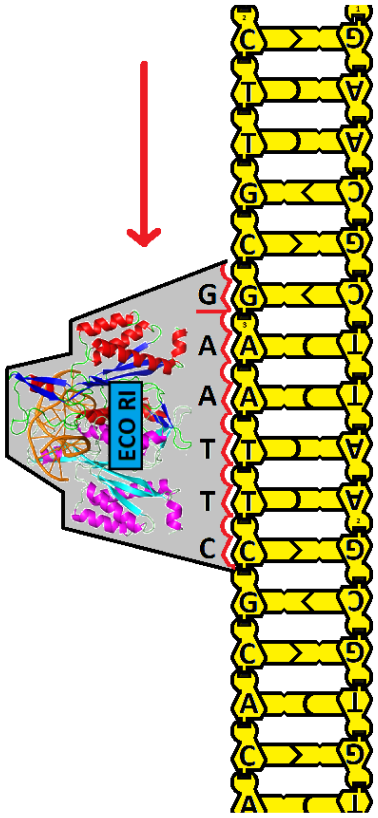


Figure 7.A.4 – EcoRI cutting the DNA at GAATTC sequence

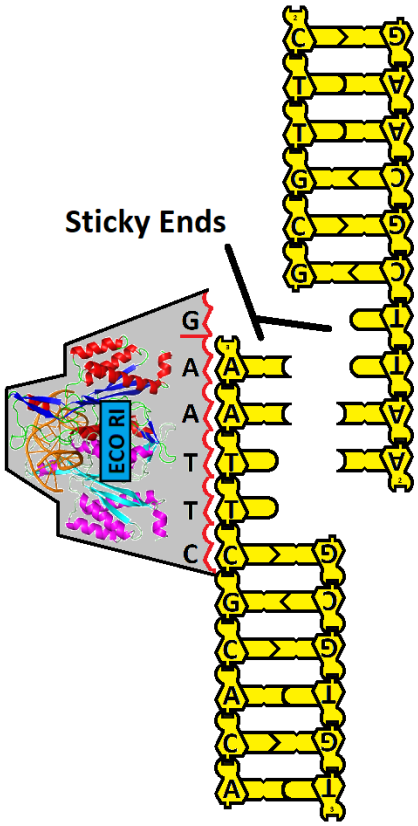


Figure 7.A.5 – Results of restriction digest of DNA using EcoRI (blue DNA has no cuts)

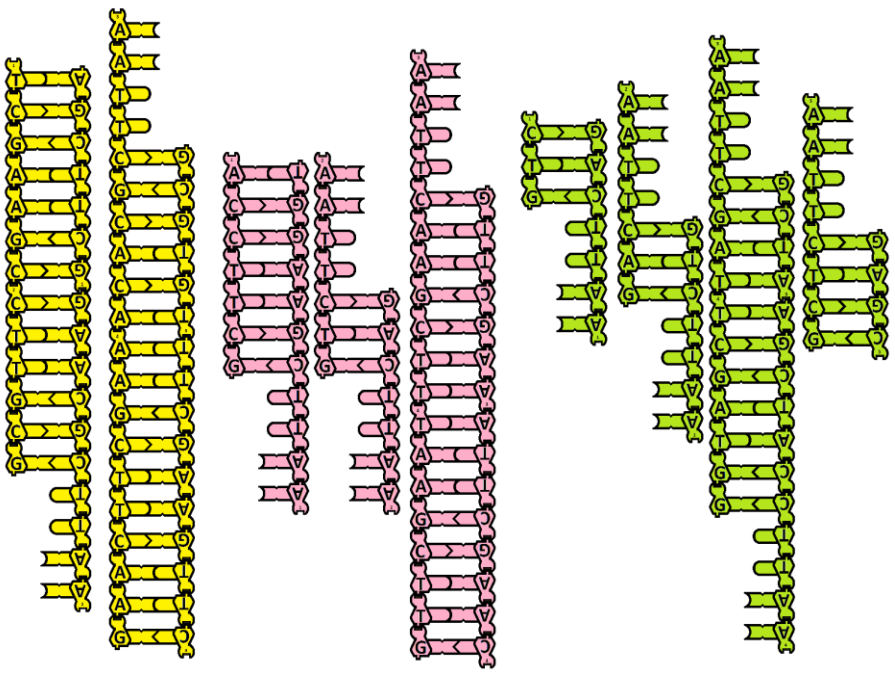
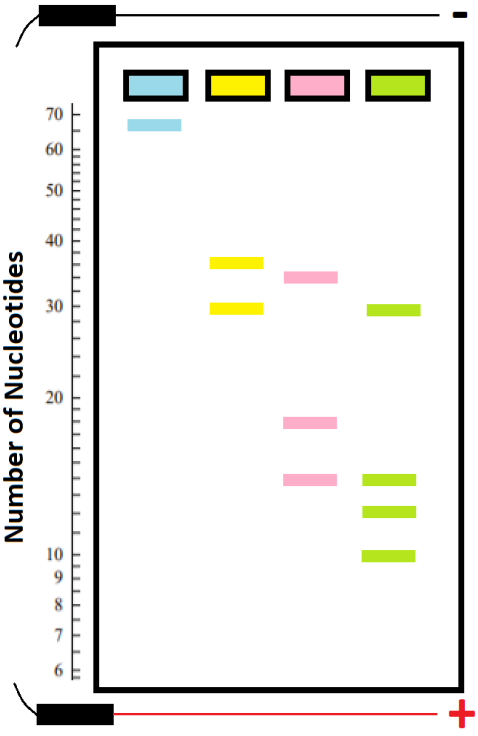


Figure 7.A.6 – DNA fingerprint with gel electrophoresis for EcoRI digest



Student centered activity (10-30 minutes): After teaching restriction enzymes and DNA fingerprinting, put students into small groups. A copy of the student guide for the lesson may be given to each group if necessary. Have the students take turns moving the Biology Magnets to accurately model the restriction digests. Allow the students to correct and help one another. Continue to practice until each student can model the digests without looking at the guide.

Extra Exercises:

HindIII: The strands also have embedded HindIII cut sequences. HindIII is a restriction enzyme that cuts at the recognition sequence AAGCTT. Have students use the HindIII magnet to move down each DNA strand and make imaginary "cuts" at each site between the AA forming sticky ends as EcoRI cut. Students can use a dry erase marker to mark where the cut would be on the strand (**Figure 7.A.7**). Have the students draw a sample DNA fingerprint on the board, on a piece of graph paper, or on the student guide handout to show what the gel electrophoresis might look like. Students should use a logarithmic scale for a more accurate representation (**Table 7.A.2)** (**Figure 7.A.8**).

EcoRI and HindIII: Have the students figure out what fragments would result if both EcoRI and HindIII restriction enzymes were used to digest the DNA strands. Have students draw sample DNA fingerprints and use logarithmic scales as above (**Table 7.A.2)** (**Figure 7.A.9**).

Table 7.A.2 – Restriction Digest Results for Hind III and EcoRI/HindIII

DNA Color	Hind III digest fragments number	Hind III digest fragments nucleotide number	EcoRI and HindIII digest fragments number	EcoRI and HindIII digest nucleotide number
Blue	3	42, 16, 8	3	42, 16, 8
Yellow	2	52,14	3	30,22,14
Pink	3	44,14,8	5	18,14,14,12,8
Green	1	66	4	30,14,12,10

Figure 7.A.7 – Marking the HindIII digest location

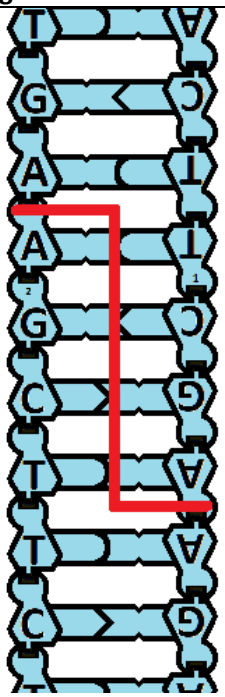


Figure 7.A.8 – DNA fingerprint with gel electrophoresis for HindIII digest with semi-log axis

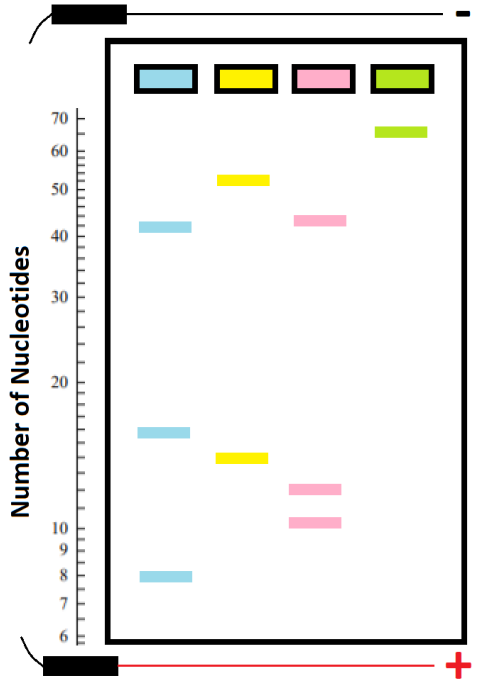
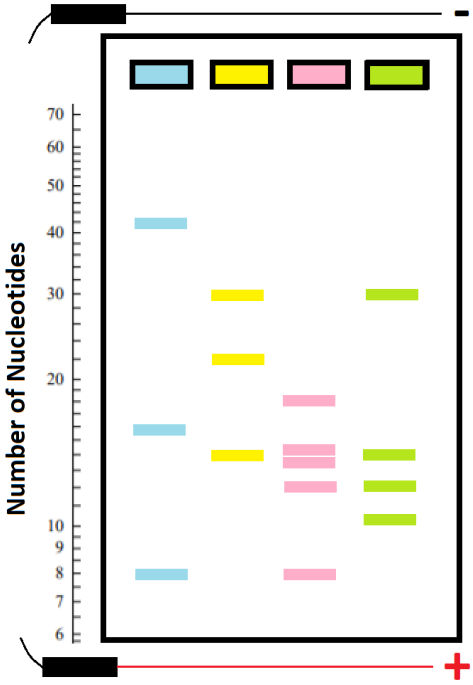


Figure 7.A.9 – DNA fingerprint with gel electrophoresis for EcoRI and HindIII digest with semi-log axis



Lesson 7B – Biotechnology - Genetic Engineering (10-50 minutes)

Teacher Centered Activity (10-20 minutes): This lesson utilizes the Biology Magnets to teach how restriction enzymes can be used in genetic engineering. Start with the pink and yellow DNA strands assembled completely side by side on the board. Use a marker to draw extensions from either end of the pink strand that will represent a segment of a human chromosome. Use a marker to draw the ends of the yellow DNA strand continuing on either end in a circle to form a looped bacterial plasmid. Use the EcoRI restriction enzyme magnet to cut the human DNA and free up a fragment for transfer to the plasmid. Also, use the EcoRI enzyme to cut the plasmid open to receive the human DNA segment (**Figure 7.B.1**). Note that the EcoRI cuts leave "sticky ends" on the DNA strands that will allow splicing of the human fragment into the plasmid (**Figure 7.B.2**). Move the short pink DNA fragment across to the plasmid, and place the fragment into the opening in the plasmid (**Figure 7.B.3**). Finally, use the DNA ligase enzymes splice the gene into the plasmid (**Figure 7.B.4**). What results is a recombinant plasmid that has both bacterial and human DNA.

Figure 7.B.1 – Human and bacterial DNA cut with EcoRI restriction enzymes

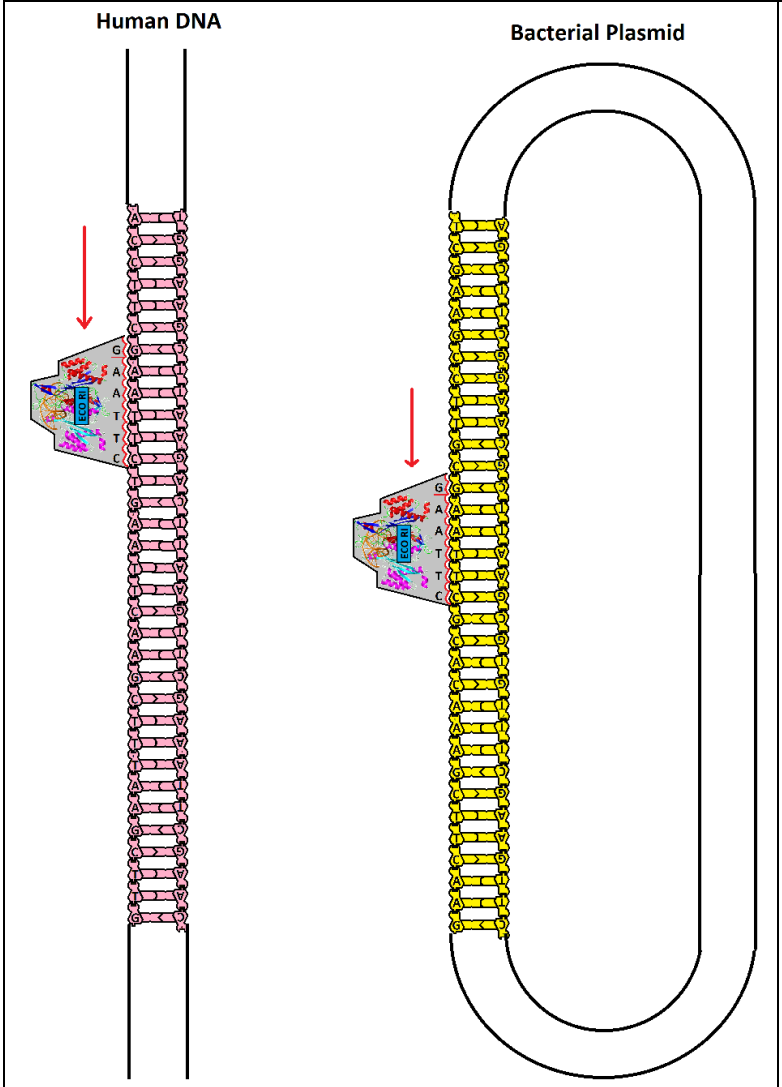


Figure 7.B.2 – Cut fragments with sticky ends

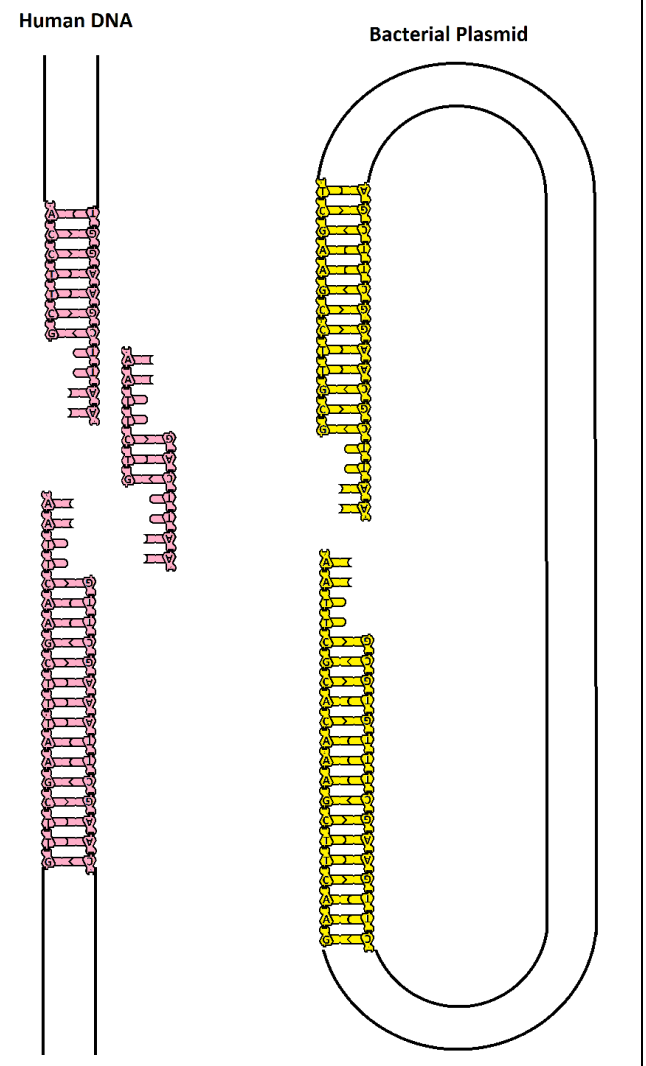
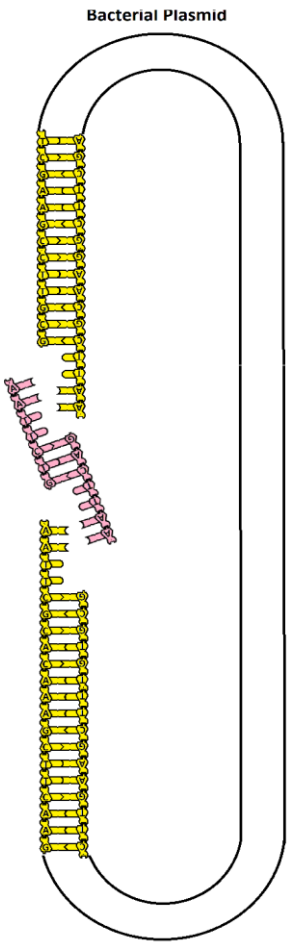
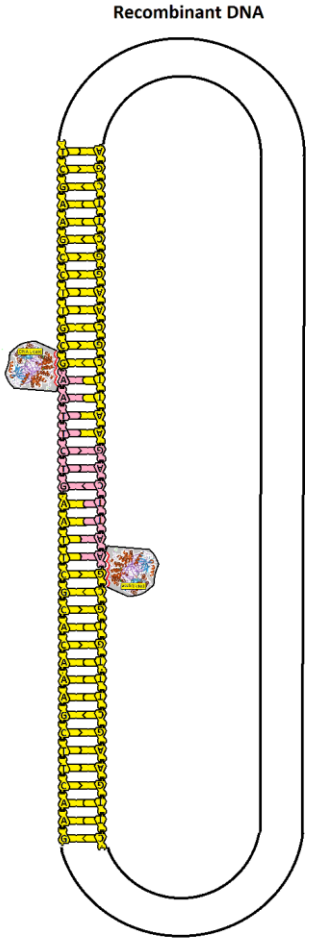


Figure 7.B.3 – Positioning of human DNA	Figure 7.B.4 – Splicing in human DNA with DNA ligase
	

Student centered activity (10-30 minutes): After teaching biotechnology and genetic engineering, put students into small groups. A copy of the student guide for the lesson may be given to each group if necessary. Have the students take turns moving the Biology Magnets to accurately model genetic engineering. Allow the students to correct and help one another. Continue to practice until each student can model the process without looking at the guide.

Extra exercises:

Other DNA strands: Have the students use the other DNA strands (blue and green) as the human DNA or as the bacterial plasmid. Have them determine what problems may arise if these strands are used in the process instead of the pink and yellow DNA strands. *Possible Answers*: Blue has no digest site, therefore will not be cut by EcoRI. Green has many cut sites, so different genes could be introduced to the plasmid rather than the desired gene.

HindIII restriction enzyme: Have the students determine what strands would work best for gene transfer if the HindIII restriction enzyme, which cuts at AAGCTT, were used instead of EcoRI. *Possible answers*: The blue and pink strands both have two cut sites so could be used as the human DNA. The yellow strand has one cut site so would be good for the plasmid.

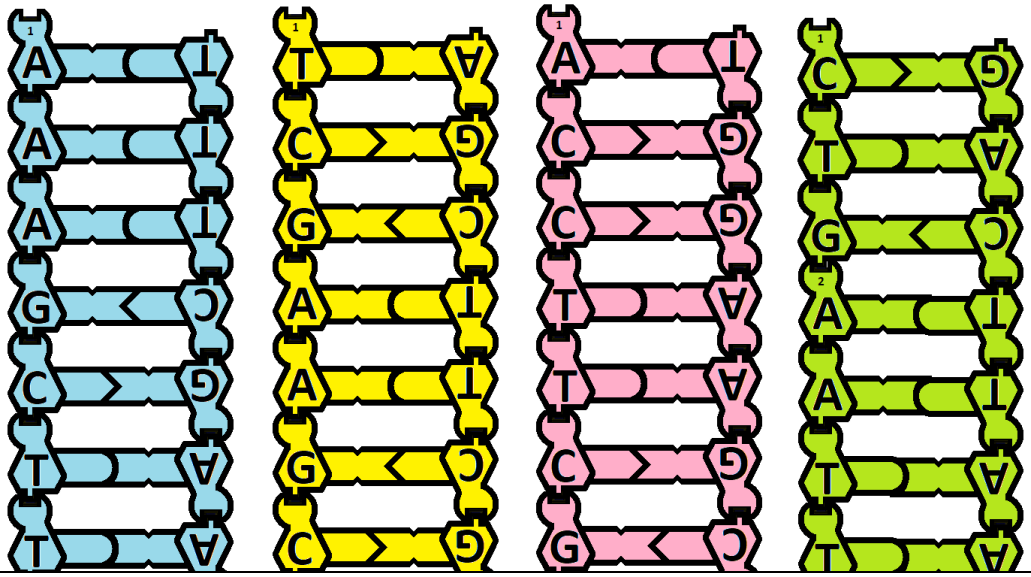
Research restriction enzymes: Have students research restriction enzymes and recognition sequences online. Have the students determine if enzymes researched would cut the various strands and how many cuts would result. Some restriction enzyme leave blunt ends instead of sticky ends. Have students discuss how this would affect the genetic engineering activity. *Answer*: Blunt end cuts do not leave sticky ends so do not allow splicing of the cut segments.

Lesson 7A – Biotechnology – DNA Fingerprinting - Student Guide

Student Centered Activity: After learning about DNA fingerprinting, use the Biology Magnets to simulate the processes involved. Start with the four strands of DNA Biology Magnets on the board, put together to make complete strands joined end to end. Use the numbers printed on the tips of the nucleotides to put the pieces in the correct order, with 1 at the top and 2-5 sequentially below (**Figure 7.A.1**). The DNA represents samples taken from four different individuals. Each DNA strand is 33 base pairs long (66 nucleotides) and contains from 0 to 4 GAATTC sequences (**Figure 7.A.2**).

Figure 7.A.1 – Numerical designation on DNA

Figure 7.A.2 – Four DNA strands from different individuals (extends downward to 33 nucleotides in length)



The restriction enzyme EcoRI moves down the DNA in the 5'->3' direction and cuts DNA at GAATTC recognition sequences between the AA to form "sticky ends". Move EcoRI along the DNA until it encounters a GAATTC sequence (**Figure 7.A.3**). When GAATTC is encountered, make a staggered cut by separating the DNA between the G and A on each side (**Figure 7.A.4**). Do this for all four strands. Depending upon where cuts are made, each strand will have different lengths of DNA fragments. Determine the number of cuts, fragments, and fragment sizes in nucleotides and fill in the table below (**Table 7.A.1**).

Table 7.A.1 – EcoRI Restriction Digest Results

DNA Color	Cuts Made By EcoRI	EcoRI digest fragments	Fragment size(s) in nucleotides
Blue			
Yellow			
Pink			
Green			

To make a DNA fingerprint, the cut DNA will be put into a gel and moved with an electric current. The small fragments move faster than the large fragments in proportion to the inverse logarithm of the number of nucleotides. Draw a DNA fingerprint by drawing a sample gel on the board, graph paper, or the student handout and marking where the bands would be produced after the restriction digest. Use a logarithmic scale for more accurate fingerprints (**Figure 7.A.6**).

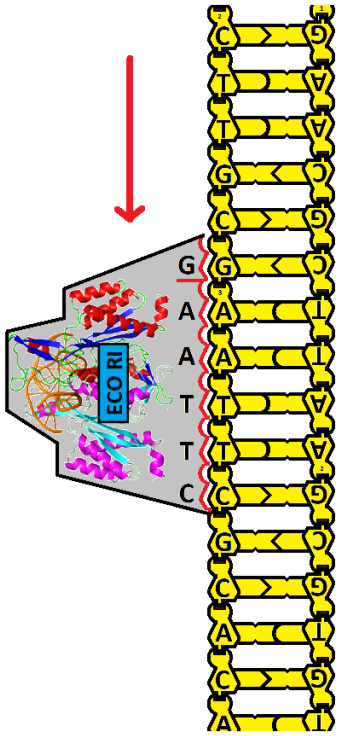
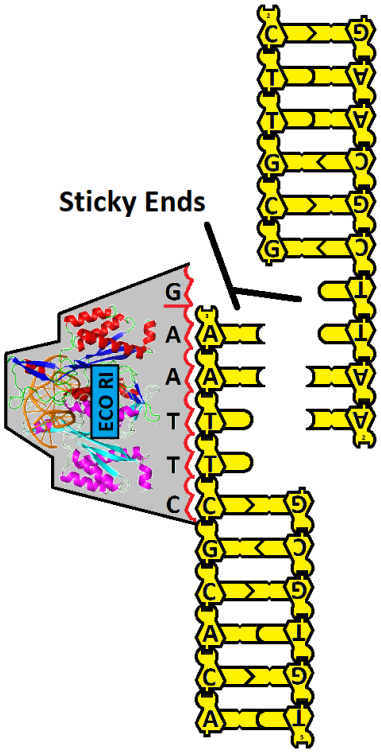
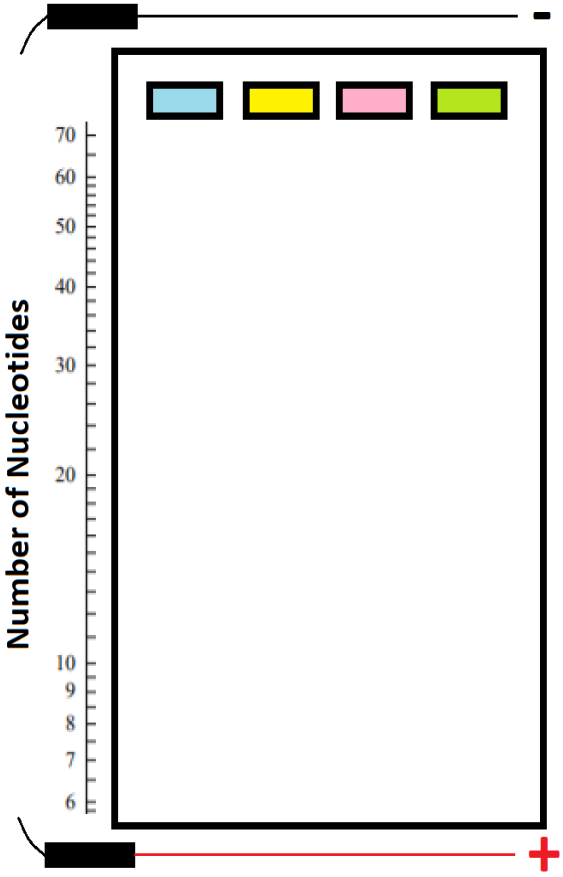
Figure 7.A.3 – EcoRI scanning for the GAATTC sequence from 5'->3'	Figure 7.A.4 – EcoRI cutting the DNA at GAATTC sequence
	

Figure 7.A.6 – DNA fingerprint with gel electrophoresis for EcoRI digest



Extra Exercises:

HindIII: The strands also have embedded HindIII cut sequences. HindIII is a restriction enzyme that cuts at the recognition sequence AAGCTT. Use the HindIII magnet to move down the DNA strand and make imaginary "cuts" at each site between the AA forming sticky ends, similar to how EcoRI cut. Use a dry erase marker to mark where the cut would be on the strand (**Figure 7.A.7**). Figure out the number of cuts and the size of each fragment in nucleotides after the cuts. Fill out that information in the table (**Table 7.A.2)**. Draw a sample DNA fingerprint on the board, on a piece of graph paper, or on the student guide handout to show what the DNA fingerprint might look like. Use a logarithmic scale for a more accurate representation (**Figure 7.A.8**).

EcoRI and HindIII: Have the students figure out what fragments would result if both EcoRI and HindIII restriction enzymes were used to digest the DNA strands. Have students draw sample DNA fingerprints and use logarithmic scales as above (**Table 7.A.2)** (**Figure 7.A.9**).

Table 7.A.2 – Restriction Digest Results for Hind III and EcoRI/HindIII

DNA Color	Hind III digest fragments number	Hind III digest fragments nucleotide number	EcoRI and HindIII fragments number	EcoRI and HindIII nucleotide number
Blue				
Yellow				
Pink				
Green				

Figure 7.A.7 – Marking the HindIII digest location

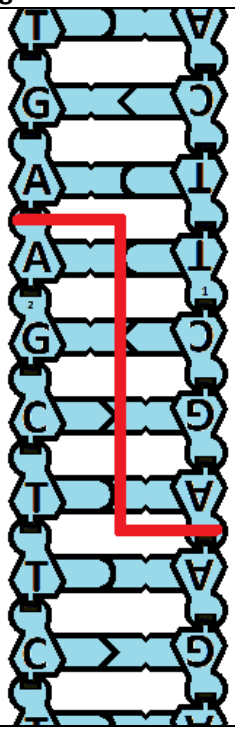


Figure 7.A.8 – DNA fingerprint with gel electrophoresis for HindIII digest with semi-log axis

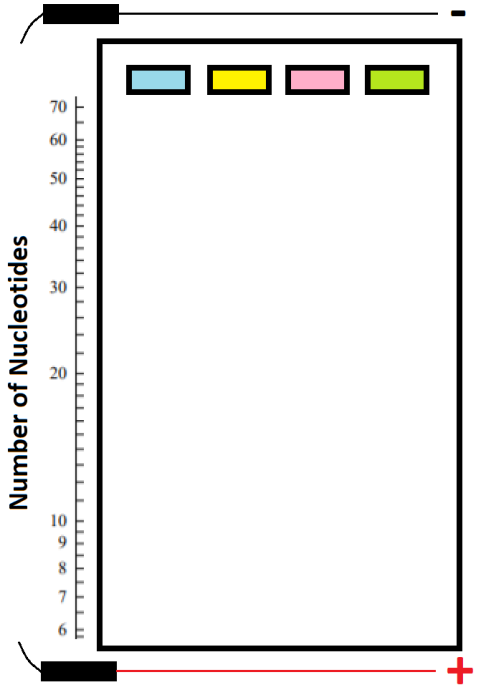
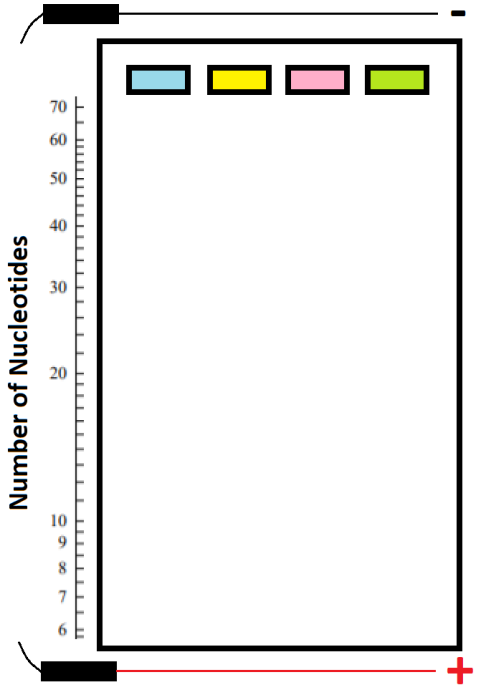


Figure 7.A.9 – DNA fingerprint with gel electrophoresis for EcoRI and HindIII digest with semi-log axis



Lesson 7B – Biotechnology - Genetic Engineering – Student Guide

Student Centered Activity: After learning about genetic engineering, use the Biology Magnets to simulate the processes involved. Start with the pink and yellow DNA strands assembled completely side by side on the board. Use a marker to draw extensions from either end of the pink strand that will represent a segment of a human chromosome. Use a marker to draw the ends of the yellow DNA strand continuing on either end in a circle to form a looped bacterial plasmid. Use the EcoRI restriction enzyme magnet to cut the human DNA and free up a fragment for transfer to the plasmid. Also, use the EcoRI enzyme to cut the plasmid open to receive the human DNA segment (**Figure 7.B.1**). Note that the EcoRI cuts leave "sticky ends" on the DNA strands that will allow splicing of the human fragment into the plasmid (**Figure 7.B.2**). Move the short pink DNA fragment across to the plasmid, and place the fragment into the opening in the plasmid (**Figure 7.B.3**). Finally, use the DNA ligase enzymes splice the gene into the plasmid (**Figure 7.B.4**). What results is a recombinant plasmid that has both bacterial and human DNA. Continue to practice until each student can model the process without looking at the guide.

Figure 7.B.1 – Human and bacterial DNA cut with EcoRI restriction enzymes

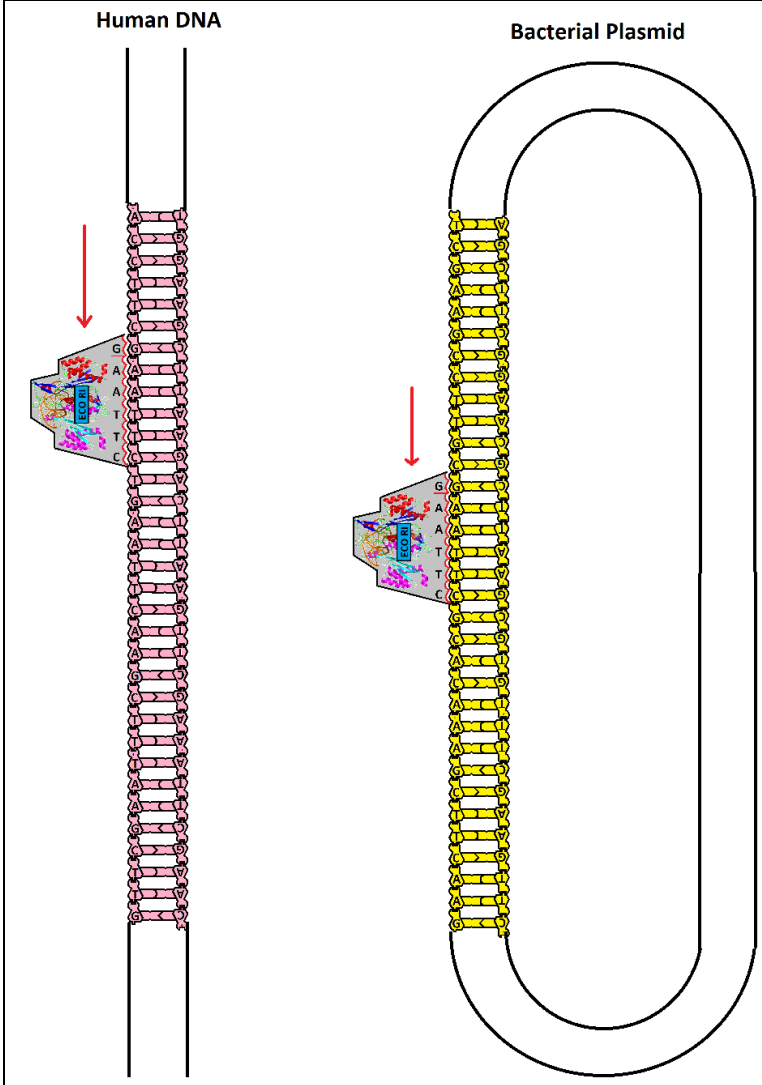


Figure 7.B.2 – Cut fragments with sticky ends

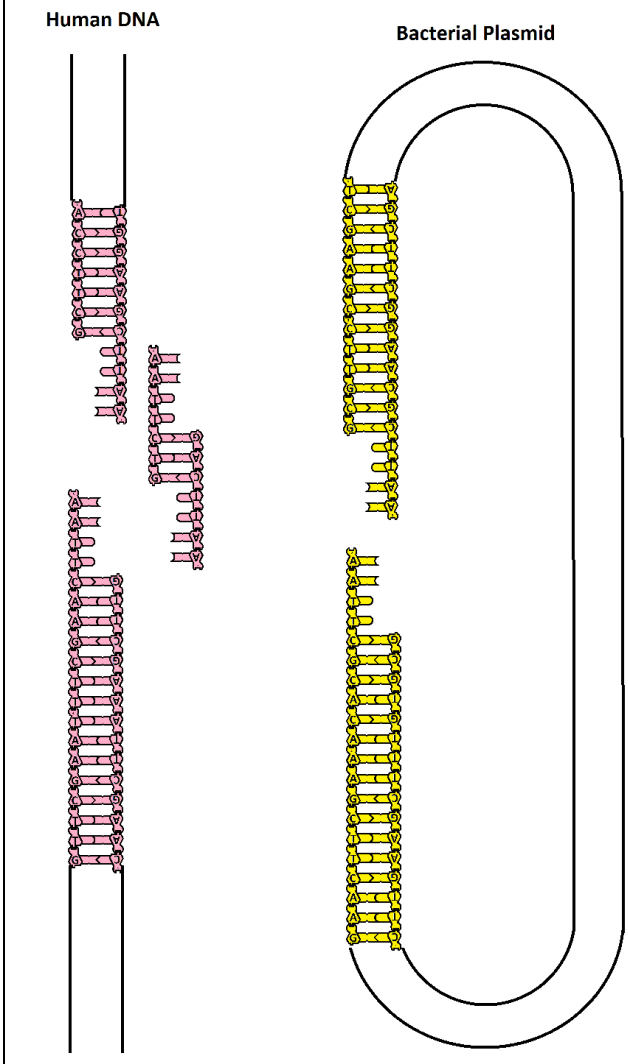
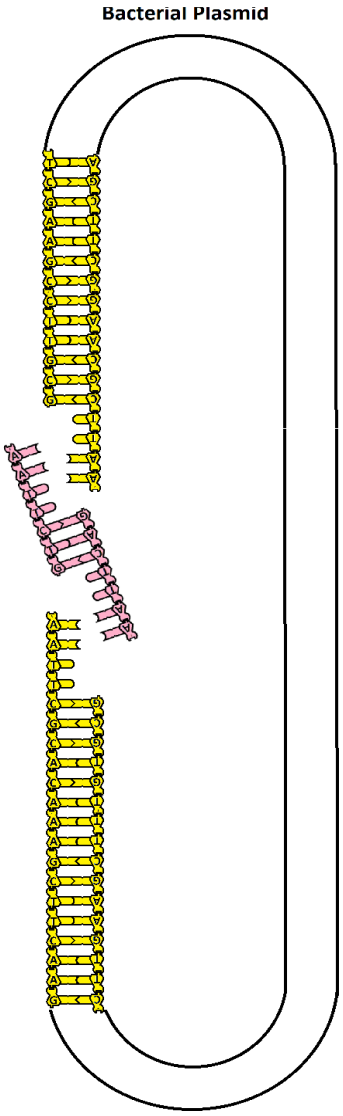
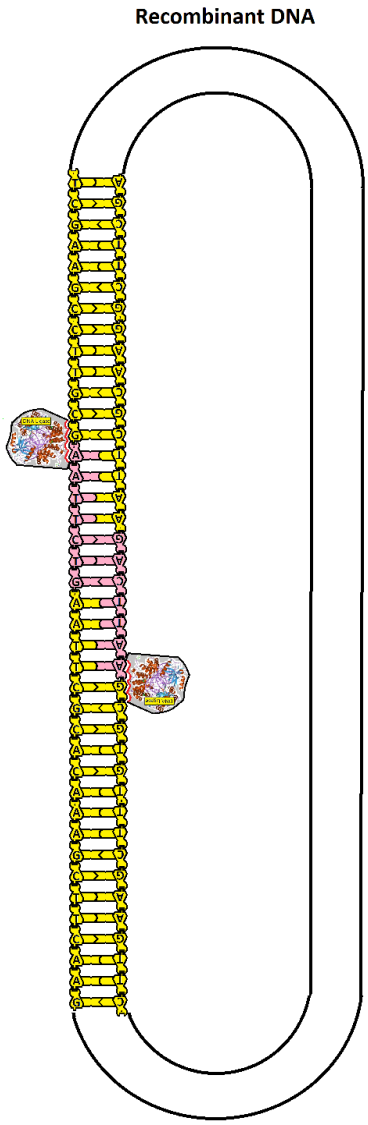


Figure 7.B.3 – Positioning of human DNA	Figure 7.B.4 – Splicing in human DNA with DNA ligase
	

Extra exercises:

Other DNA strands: Use the other DNA strands (blue and green) as the human DNA or as the bacterial plasmid. Determine what problems may arise if these strands are used in the process instead of the pink and yellow DNA strands. Write down your ideas or report them to the teacher or other groups.

HindIII restriction enzyme: Determine what strands would work best for gene transfer if the HindIII restriction enzyme, which cuts at the recognition site AAGCTT, were used instead of EcoRI. Write down your ideas or report them to the teacher or other groups.

Research restriction enzymes: Research restriction enzymes and their recognition sequences online. Determine if enzymes researched would cut the various strands and how many cuts would result. Some restriction enzyme leave blunt ends instead of sticky ends. Discuss how this would affect the genetic engineering activity. Write down your ideas or report them to the teacher or other groups.