Biology

Prokaryotes:
The First Life on Earth

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Vocabulary

Click on each word below to go to the definition.

- antibiotic resistance
- archaea
- bacilli
- bacteria
- binary fission
- capsule
- cell wall
- chromosome
- cocci
- colonies
- conjugation
- co-repressor
- cytoplasm
- deletion
- domain
- extremophile
- fimbriae
- flagella
- F plasmid
- gel electrophoresis
- genetic recombination
- host cell
- host range
- inducer
- inducible operon
- insertion
- lac operon
- locus
- lysogenic cycle
- lytic cycle
Vocabulary

Click on each word below to go to the definition.

- nucleoid
- obligate intracellular parasite
- operon
- origin of replication
- peptidoglycan
- pili
- phage
- plasmid
- prokaryote
- promoter
- recombinant DNA
- replication bubble
- repressible operon
- repressor
- restriction enzyme
- R plasmid
- R strain
- sex pili
- S strain
- substitution
- taxes
- temperate phage
- transduction
- transformation
- trp operon
- unicellular
- virus

Prokaryotes Unit Topics

- Types of Prokaryotes
- Structure & Function
- Reproduction & Gene Expression
- Genetic Variation
- Biotech: Recombinant DNA

Types of Prokaryotes
**Prokaryotes**

Prokaryotes are the simplest organisms that adhere to biology's definition of life.

Remember the 7 characteristics of life are:
- Organization/Order
- Adaptation
- Response to the Environment
- Regulation
- Energy Processing
- Growth and Development
- Reproduction

**Prokaryotes are everywhere!**

Prokaryotes are microscopic, but what they lack in size they make up for in numbers.

There are more prokaryotes in a handful of fertile soil than the number of people who have ever lived on Earth.

They thrive almost everywhere, including places too acidic, too salty, too cold, or too hot for most other organisms.

They have astonishing diversity.

**Prokaryotes: 2 Types**

- **Bacteria**
- **Archaea**
We Rely on Bacteria!

Often we think of bacteria as being primarily harmful organisms. While there are harmful bacteria, most are beneficial; we depend on them. Bacteria cover all the external surfaces of our bodies. This includes our digestive tracts since that is also considered to be external.

Bacteria live in cooperation with you; they protect you against harmful bacteria and help you digest food. Without these bacteria, which have evolved with us, as we evolved, we could not live healthy lives.

In fact, the number of bacterial cells living on us is greater than the number of our own cells. Those bacteria have more unique genetic material than do our own genes. That bacterial genetic material allows them to create enzymes or products that are essential to us.

Newborn babies get inoculations of these bacteria from their mothers, so that their digestive systems can function. There are also bacteria in many food sources, like yogurt and cheese.
**Antibiotics**

When we take antibiotics to fight a harmful bacteria, it's usually recommended to consume probiotics, such as yogurt, to replace any of our helpful bacteria that might be accidentally harmed.

In fact, most antibiotics themselves are derived from bacteria. They are created in nature by bacteria to fight other bacteria.

When then use them in the form of antibiotic pills or injections to fight harmful bacteria.

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**Archaea**

Archaea were classified as bacteria until very recently. In 1977, they were separated from bacteria into their own domain, or grouping.

Many archaea are extremophiles, organisms that live in environments where life had been considered impossible. They have been found living in areas of extreme temperature (such as hydrothermal vents), pH solutions of lower than 3 and higher than 9, and solutions with high salt, methane, or heavy metal concentrations.

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**Archaea**

While archaea have many cell structures and metabolic pathways in common with bacteria, research has shown that their genes and factors involved in their gene expression are more like those of eukaryotes (the class of organisms that include animals, plants, and fungi).

This has led scientists to believe that archaea developed after bacteria.
1. The earliest living organisms were:
   - A. animals
   - B. archaea
   - C. bacteria
   - D. plants

2. All bacteria are harmful.
   - True
   - False

3. Prokaryotes can live in which of the following environments?
   - A. the ocean
   - B. acidic lakes
   - C. hydrothermal vents
   - D. under the Arctic ice
   - E. all of the above
All prokaryotes are unicellular, meaning a single cell is considered an entire organism.

They can live on their own, but most form colonies, large groups (millions, billions or more) live in a tightly packed area.

They have a variety of shapes and functions.
Structures

Prokaryotes have many different structures, each having a specific job or function. These structures within the cell operate like small molecular machines. They are used for various functions that help maintain the life of the overall organism.

Cell Surface

Most prokaryotes have a cell wall.

The cell wall is outside the cell’s plasma membrane and maintains the cell’s shape, provides physical protection, and prevents the cell from bursting in a hypotonic environment.

In bacteria, this cell wall is made of a strong carbohydrate fiber called peptidoglycan. In Archaea, various cell wall types exist.

Cell Surface

The cell wall of some prokaryotes is covered by a capsule, a sticky layer of polysaccharide or protein.

The cell wall and capsule are in addition to the plasma membrane, and are found covering it. They do not replace it.
**Flagella**

Most motile prokaryotes propel themselves by flagella, a tail-like protein structure.

This allows these prokaryotes to exhibit taxis, the ability to move toward or away from certain stimuli.

Chemotaxis is movement in response to chemicals in the environment. Phototaxis is movement in response to light.

*Interesting note: Flagellum is the Latin word for whip.*

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**Pili**

Pili are thin, protein tubes originating from the prokaryotic cell membrane.

There are two basic types of pili:

- short attachment pili, also known as fimbriae, that are usually quite numerous - fimbriae allow cells to attach to other cells or to inanimate objects.
- long conjugation pili, also called "F" or sex pili that are few in number - sex pili allow bacteria to transfer genetic information from one cell to another

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**4 What structure allows a prokaryote to adhere to environmental surfaces?**

- A cell wall
- B sex pili
- C flagellum
- D fimbriae
5. What structure allows a prokaryote to exhibit taxis?
   - A. cell wall
   - B. sex pili
   - C. flagellum
   - D. fimbriae

6. In bacteria, the ________ is made of a substance called peptidoglycan.
   - A. capsule
   - B. pili
   - C. flagellum
   - D. cell wall

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**Inside the Cell**

The fluid which fills the cell is called the **cytoplasm**.

Floating in the cytoplasm are the **ribosomes** and the **bacterial chromosome**, a double-stranded, circular structure containing the prokaryote's DNA.

Prokaryotes usually only have one chromosome and the area where it is located is known as the **nucleoid**.
Many prokaryotes also have plasmids, smaller circular DNA molecules that are independent of the bacterial chromosome.

Plasmids contain genes for adaptations like resistance against antibiotics, making a sex-pilus (F-pilus), making toxins, and guarding against heavy metal toxicity.

**F Plasmids**

The presence of an F plasmid gives the prokaryotic cell the ability to have fertility, by forming a sex pilus. This allows the prokaryote to donate DNA to other prokaryotes in its colony, increasing their genetic variability.

*Note: Fertility can also be present if the "F" factor are located in the bacterial chromosome.*

**R Plasmids**

R plasmids give a bacterium cell antibiotic resistance. Antibiotic resistance gives the bacterial cell immunity to certain types of antibiotics.

When a bacterial population is exposed to an antibiotic, individuals with the R plasmid will survive and increase in the overall population.
7. Which is the shape of a bacterial chromosome?
   - A. spiral
   - B. rod
   - C. spherical
   - D. circular

8. How many chromosomes do most prokaryotes have?

9. The area where a bacterial chromosome is located is called:
   - A. capsule
   - B. flagella
   - C. nucleoid
   - D. ribosome
10. A sex pilus is coded for by genes on the R plasmid.
   - True
   - False

11. Bacteria that have R plasmids can cause medical problems in animals because they _____.
   - A control conjugation in bacteria
   - B are used as vectors to transfer genes
   - C make bacteria resistant to antibiotics
   - D code for DNA polymerase
   - E protect bacteria against mutations
Genes are the units of heredity. They are segments of DNA. Each gene has a specific locus, or location, on a certain chromosome.
12. What does DNA stand for?
   - A Denitrogenous Acid
   - B Dinitric Acid
   - C Disaccharide Nucleic Acid
   - D Deoxyribonucleic Acid

13. What type of organic compound is DNA?
   - A Protein
   - B Lipid
   - C Nucleic Acid
   - D Carbohydrate

14. The twisted ladder or spiral staircase structure of DNA is referred to as a "________" shape.
   - A Nucleic Acid
   - B Double Helix
   - C Nucleotide
   - D Cyclic
15 DNA is made of chains of _________.
- A Amino Acids
- B Sugars
- C Nucleotides
- D Proteins

16 In DNA, adenine pairs with ________.
- A guanine
- B cytosine
- C adenine
- D thymine

17 A ________ is a segment of DNA three nucleotides long that codes for the formation of a specific amino acid.
- A gene
- B nucleotide
- C protein
- D codon
Prokaryotic Reproduction

Prokaryotic cells divide and reproduce by binary fission, the splitting of one cell into two.

In order for each cell to have a complete copy of the DNA, the bacterial chromosome must be replicated prior to cell division.

Replication of the Chromosome

Every bacterial chromosome has an origin of replication where it will begin to self-replicate.

The DNA double helix unwinds in both directions from the origin forming a replication bubble. This bubble consists of 2 replication forks.

The DNA code in the bubble is the template strand and new strands are formed using both template strands.

The bubble keeps expanding until the two sides meet at the other end of the bacterial chromosome.

![Image of replication process](image-url)
Binary Fission

After the chromosome is replicated, the cell divides in half with one copy in each new cell.

18. The location on a bacterial chromosome where replication begins is known as the
   - A starting point
   - B 5' end
   - C replication bubble
   - D origin of replication

19. At the end of binary fission, there are two prokaryotic cells
   - A one has all the parent DNA
   - B both have only parent DNA
   - C both have only daughter DNA
   - D both have half parent and half daughter DNA
20. Transcription is a chemical reaction that builds an mRNA molecule.
   - True
   - False

21. Translation is the reaction that builds a lipid.
   - True
   - False
22 How many amino acids are there?

23 _________ is a three nucleotide sequence that codes for a specific amino acid.

- A mRNA
- B codon
- C replicator
- D protein
24 RNA polymerase is an enzyme responsible for catalyzing the reaction of transcribing DNA into mRNA.

- True
- False

Transcription is the making of RNA from the code in the DNA.

Once the RNA is made, then the RNA is translated into the protein.

Transcription and Translation

Transcription and translation are the two reactions that allow a prokaryote to create proteins.

The code for the proteins is located in the DNA of the bacterial chromosome.

Ribosomes are utilized to read codons in transcribed mRNA to create the polypeptide.
Prokaryotic Transcription and Translation

Transcription and translation occur simultaneously in the cytoplasm of a prokaryotic cell.

Prokaryotic Gene Expression

Individual prokaryotes respond to environmental change by regulating their gene expression.

A prokaryote can adapt to the changing environment and varying food sources.

Remember: one of the properties of life is "response to the environment"

Examples of Bacterial Gene Expression

The following are 2 examples of the regulation of gene expression in prokaryotes:

- Lac Operon
- Trp Operon
In prokaryotes, genes are often clustered into **operons** within the chromosome.

Operons consist of 3 parts...

- An **operator** - essentially an “on-off” switch
- A **promoter** - an area that attracts RNA polymerase
- The **genes** - which code for the protein needed by the cell

### Repressors

An operon can be switched off by a protein called a **repressor**.

The repressor can be controlled through allosteric regulation with **co-repressors** and **inducers**.

- A **co-repressor** is a small molecule that cooperates with a repressor to help switch an operon off.
- An **inducer** is small molecule that inhibits a repressor to help switch an operon on.

### Inducible Operons

An **inducible operon** is one that is usually off; a molecule called an inducer inactivates the repressor and turns on transcription.

An example of an inducible operon is the **lac operon**, which contains genes coding for enzymes that break down lactose into glucose so the bacteria can use it for energy.

If no lactose is present then no enzyme needs to be made. The bacteria saves energy this way.

In this operon, the lactose molecule is the inducer.

**Click here to see an animation of the Lac Operon**
A repressible operon is one that is usually on. When a repressor binds to an operator, transcription is shut off.

The trp operon is a repressible operon. The trp operon codes for a number of genes responsible for the production of the amino acid tryptophan. If tryptophan is present in the environment, the trp operon is not used. Tryptophan acts as the co-repressor in this operon.

25 The lac operon is an example of an _____.
   ○ A inducible operon
   ○ B repressible operon

26 In the presence of Trp _____.
   ○ A the repressor is activated
   ○ B the cell makes metabolites
   ○ C the operon is turned on
27 In the presence of lactose ______.
   ○ A the lac operon is turned off
   ○ B the lac operon is turned on
   ○ C the repressor becomes active

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**Prokaryotic Symbiosis**

*Symbiosis* is used to describe the relationship between organisms from different species that interact together to provide benefit to one or both organisms.

*Symbiosis is from the Greek word for "living together"

**Three Types**

1. **Mutualism** - both organisms benefit
2. **Commensalism** - one organism benefits with no harm or help to the other organism
3. **Parasitism** - one organism benefits with harm to the other

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**Prokaryotic Symbiosis**

Prokaryotes have a small amount of DNA compared to other living organisms. They have a limited number of genes so they can only make a limited number of products from their proteins.

If 2 different types of bacterial cells are living very close together, each can use the others products to enhance their chances of survival.

This would be an example of mutualism.
**Prokaryotic Symbiosis**

In this photo, the green bacteria makes the enzyme lactase.

The pink bacteria makes the amino acid tryptophan.

They live in close proximity so each can obtain the others product and have a better chance at survival than if they were alone.

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**Natural Selection and Prokaryotes**

Bacterial cells that live in close contact with many other kinds of bacterial cells have a better chance of survival than those who don't.

**Natural selection** will favor those species of bacteria that have the best symbiotic relationships.

Having many species working together for survival leads to an increase in complexity of the biological system.

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**Genetic Variation**
Variation

Mutation and Genetic Recombination are sources of genetic variation for bacterial cells.

- Since bacteria can reproduce rapidly, new mutations quickly increase genetic diversity.
- More genetic diversity arises by recombination of DNA from two different bacterial cells.

Mechanisms of Genetic Recombination

Three processes bring prokaryotic DNA from different individuals together:

- Transformation
- Conjugation
- Transduction

These mechanisms of gene transfer and genetic recombination in prokaryotes lead to great diversity.

Transformation

Transformation is the alteration of a prokaryotic cell’s genes by the uptake of foreign DNA from the surrounding environment.

For example: harmless Streptococcus pneumoniae bacteria can be transformed into pneumonia-causing cells.
Evidence that DNA can Transform Bacteria

The discovery of the genetic role of DNA began with research by Frederick Griffith in 1928.

Griffith worked with two strains of a bacterium:
- a pathogenic “S” (smooth) strain and
- a harmless “R” (rough) strain.

When he mixed heat-killed remains of the pathogenic strain with living cells of the harmless strain, some living cells became pathogenic.

He called this phenomenon transformation, now defined as a change in genotype and phenotype due to assimilation of foreign DNA.

The Griffith Experiment

Conclusion:

The dangerous, mouse-killing gene (DNA) that was in the S strain was "absorbed" by the R strain.

The S strain was then TRANSFORMED into a killer bacteria

In other words, prokaryotes can take pieces of DNA and make them part of their genes.
Conjugation

Conjugation is the direct transfer of genetic material between prokaryotic cells that are temporarily joined.

The transfer is one-way:

One cell donates DNA via a sex pilus and the other receives the genes.

Gene Transfer

The ability of a prokaryote to act as a donor during conjugation is usually due to a piece of DNA called

- A a probe
- B a plasmid
- C a transfer
- D an F factor
- E an R factor
29 Transformation is

- A a mutation that causes a bacterium to become pathogenic
- B a change in DNA due to the uptake of foreign DNA from the environment
- C the passage of DNA via a sex pilus
- D only possible in prokaryotes that have the R plasmid

30 Initially, in Griffith's experiment, the ____ strain was ______, and the ____ strain was ______.

- A S, pathogenic; R, pathogenic
- B S, pathogenic; R, harmless
- C S, harmless; R, harmless
- D S, harmless; R, pathogenic

**What is a Virus?**

Viruses are small, non-living particles that infect living organisms. They are not considered to be living for 3 reasons.

**Viruses:**
- lack order and are not comprised of cells.
- cannot reproduce on their own. They must infect a **host cell** to reproduce.
- cannot metabolize food or process energy.
Transduction

Transduction is the process by which DNA is transferred from one prokaryote to another by virus.

Viruses

The small dots surrounding this bacterial cell are viruses infecting their host cell.

Phages

Bacteriophages, also called phages, are viruses that infect bacteria.

A protein tailpiece attaches the phage to the host and injects a small amount of DNA or RNA into their host cell. The phage essentially "hijacks" the gene expression and DNA replication systems.

The virus then uses the host cell to make more viruses and kills the cell by causing it to burst open.

Phage is from the Greek work meaning "to eat".
Viruses are *obligate intracellular parasites*, which means they can reproduce only within a host cell.

Each virus has a *host range*; it is limited by type of host cells that it can infect.

Viruses use enzymes, ribosomes, and other parts of the host cell to synthesize new viruses.

**Lytic Cycle**

The *lytic cycle* is a phage reproductive cycle that causes the death of the host cell.

The lytic cycle produces new phages and digests the host’s cell wall, thereby releasing the new viruses.
31 Viruses that infect bacteria are called ______.

- A  bacterioviruses
- B  bacteriophages
- C  capsomeres
- D  proviruses
- E  retroviruses
When a virus infects an E. coli cell, what part of the virus enters the bacterial cytoplasm?

- A the entire virus
- B only the nucleic acid
- C the protein capsid and enclosed nucleic acid
- D the tail fibers
- E the protein capsid only

Lysogenic Cycle

Unlike the lytic cycle which is detrimental to the host cell, the lysogenic cycle does not cause the cell to die.

In the lysogenic cycle, the virus's DNA is incorporated into the host's DNA. Then the bacteria cell continues to replicate through binary fission, copying the virus's DNA and its own together.

Temperate Phages

Many viruses are only able to utilize the lytic cycle.

Some viruses, called temperate phages, can utilize both the lytic and lysogenic cycles.

When a temperate phage switches from the lysogenic cycle to the lytic cycle, it separates its phage DNA from the host DNA and then proceeds through the steps of the lytic cycle as usual.

However, sometimes when the virus DNA separate it takes with it some of the bacteria's DNA.
**Transduction**

Even though the lytic cycle is a detriment to the individual host cell, sometimes it can be beneficial to the colony of cells. When viruses infect prokaryotic cells there is a possibility of increasing the genetic variation of the population of prokaryotes. When a part of the prokaryotic DNA is separated with the virus DNA, a beneficial transduction process happens in six steps...

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**Steps of Transduction**

Step 1: A virus infects a bacteria cell.

Step 2: Once infected, the viral DNA and associated enzymes destroy the bacterial chromosome.

Step 3: The bacterial cell is destroyed and new viruses are released.

Step 4: The new viruses (containing a mix of viral DNA and the host DNA) seek out new host cells.

Step 5: When they infect other cells, they inject both the viral and bacterial DNA.

Step 6: The new host cells take the bacterial DNA from the previous host and inserts it into its own genes.

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**Steps of Transduction**

1. ![Image](image1.png)
2. ![Image](image2.png)
3. ![Image](image3.png)
4. ![Image](image4.png)
5. ![Image](image5.png)
6. ![Image](image6.png)

- Bacterial DNA
- Viral DNA
33 In the lytic life cycle of phages _____.
   - A  the cell typically dies, releasing many copies of the virus
   - B  the entire phage is taken into the bacterium
   - C  DNA replication is not part of the life cycle
   - D  phage DNA is incorporated into the host cell's chromosome

34 The host cell dies in the
   - A  lytic cycle
   - B  lysogenic cycle
   - C  Neither
   - D  Both lytic and lysogenic cycles

35 Which cycle can be utilized by temperate phages but not by most other viruses?
   - A  lytic cycle
   - B  lysogenic cycle
36. Which cycle results in the production of full virus molecules?
   - A. lytic cycle
   - B. lysogenic cycle
   - C. Neither
   - D. Both the lytic and lysogenic cycles

37. Which cycle makes it possible for transduction to occur?
   - A. lytic cycle
   - B. lysogenic cycle
   - C. Neither
   - D. Both the lytic and lysogenic cycle

38. The end result of transduction is
   - A. the uptake of viral DNA by the new host cell
   - B. the uptake of the previous host's DNA by the new host
   - C. binary fission producing bacteria cells that contain both bacteria and virus DNA
   - D. many phages containing both bacteria and virus DNA
Biotech: Recombinant DNA

Biotechnology Tools
Case study: Diabetes

Diabetes is a disease that affects approximately 200 million people worldwide. This number is predicted to rise at a continued exponential rate.

Blood glucose monitoring is a daily necessity for diabetics.

A person with diabetes lacks the ability to effectively control the level of glucose in the bloodstream. This results in many problems including heart disease, kidney failure and blindness.

Diabetes

In 1921 it was discovered that many people with diabetes lack the proper amount of a protein hormone called insulin.

At first, doctors treated this ailment by injecting insulin harvested from cows, but this cow protein is not exactly the same as human insulin. The human immune system began to reject the cow hormone substitute and cause complications for the patient.
Recombinant DNA Technology

In the late 1970s, scientists began to look for a way to make human insulin in a laboratory. This resulted in the first product ever produced by Recombinant DNA Technology.

In this case, the gene for human insulin was found and isolated. It was then put into the bacterial chromosome of E. Coli.

The bacteria then was able to produce human insulin and the hormone, now known as Humulin, could be harvested.

Recombinant DNA Technology

In recombinant DNA technology, DNA pieces can be recombined to make unique, sequences. When new genes are inserted, organisms can express different proteins.

This salmon was given a gene for eel growth hormone which is more potent than its own and causes it to grow 3x bigger in half the time.

These tomatoes have been given a gene found in fish so they can survive frost, meaning a longer growing season and more yield.

Why can DNA sequences from different organisms be combined together?

Recombinant DNA Technology

Step 1: Find the piece of DNA in the genome, the gene of interest.

Today this step is done by computers attached to robotic DNA sequencers that fragment, analyze and find a gene based on user input.
Recombinant DNA Technology

If the sequence of the gene of interest, say the insulin gene, is known and the sequences in the surrounding DNA are known, then restriction enzyme cut sites that are on opposite sides of the gene can be utilized to cut the gene out.

**Diagram:**
- EcoRI cut site
- Insulin Gene (gene of interest)
- DNA fragment

**Step 3: Isolate the gene of interest**

Restriction enzymes mixed with DNA is called a digest because the enzymes breaks down the fragments of DNA into many smaller pieces.

It is important to remember that we are working with molecules. We cannot simply "grab" the piece of DNA we want. We must separate the unique pieces of DNA in the digest and select the fragment we want.
Recombinant DNA Technology

If we look at the insulin gene again we can see that the sequence between the two EcoRI cut sites has a unique length.

So in this digest there are DNA fragments that are 5k, 10k, and 15k nucleotides long. The gene of interest here is the 5k piece.

Recombinant DNA Technology

Gel Electrophoresis is one way to separate DNA fragments based on length.

The digest is loaded by pipetting into a gel, that resembles Jello. The gel is a network of fibers called collagen.

Small pieces of DNA can move through the gel quicker than the longer pieces that get tangled in the collagen fibers.

Recombinant DNA Technology

DNA has a slightly negative charge.

An electrical current is passed through the gel and the DNA fragments move to the positive charge. Small fragments move faster, larger fragments are slowed down by the matrix.

The result is that the small pieces can travel farther than the larger ones. The DNA is separated by size in what is known as a banding pattern.
Recombinant DNA Technology

**Step 4:** Make more of the gene of interest (amplification).

Once the gene of interest is isolated in the gel, the band that contains the gene can be cut from the gel, but this is a very small sample. More DNA must be made in order to be able to work with it in the lab.

Polymerase Chain Reaction (PCR) is used to increase the amount of the sample.

Recombinant DNA Technology

**Step 5:** "Paste" the gene of interest into the host's DNA

Sticking to the insulin example, the technique utilized to get the insulin gene into the *E. Coli* bacteria involved using a plasmid, the small circular pieces of DNA that bacteria use to trade pieces of genetic information.

A plasmid with an EcoRI cut site is "digested" using the same restriction enzyme that was used to cut out the insulin gene.

Recombinant DNA Technology

Mix the cut plasmid with the gene of interest to create a recombinant DNA plasmid that contains a human insulin gene
Recombinant DNA Technology

Step 6: Put the recombined piece of DNA into the host organism

Now that the gene of interest is in a plasmid, it can be mixed with bacterial cells and be taken up into the bacterial chromosome.

Remember, all living things use the universal genetic code. The bacterial cells will read the newly acquired gene, transcribe it into mRNA and its ribosomes will translate the mRNA into a protein.

The bacterial cells will reproduce and express the gene. Each time a recombinant bacterial cell divides by binary fission it will make a new copy of the gene.

Recombinant DNA Technology

Step 7: Collect the protein product

The protein can be extracted from bacterial cultures using various techniques. It can then be delivered to the patient.

Currently there is no cure for diabetes, but with advancements in insulin therapy patients can now avoid many of the life threatening complication.
Gene Therapy

Gene therapy is a technique for correcting defective genes responsible for disease development.

It is a unique procedure because it can cure ailments at the genetic level, rather than just treat the symptoms of the ailment.

In gene therapy, therapeutic DNA is placed inside a body via a vector. Once inside, the DNA is expressed by the body, producing proteins that treat the targeted disease.

Back to the diabetes example...

Instead of getting bacteria to make the insulin, it would be better to give a patient the gene so they could make their own.

39 In recombinant DNA technology, how are genes of interest "cut" from DNA?

- A cycles of heat and acid
- B restriction enzymes
- C gel electrophoresis
- D polymerase chain reaction
40 In gel electrophoresis, if there are DNA segments that are 5, 10 and 15 base units long, which segment will be found closest to the negative end of the chamber?

- A 5
- B 10
- C 15

41 In recombinant DNA technology, how is a DNA molecule amplified?

- A polymerase chain reaction
- B restriction enzymes
- C gel electrophoresis
- D computer analysis