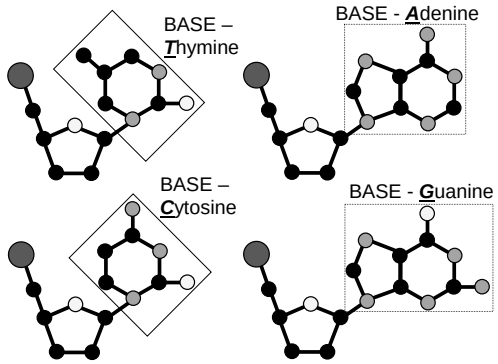
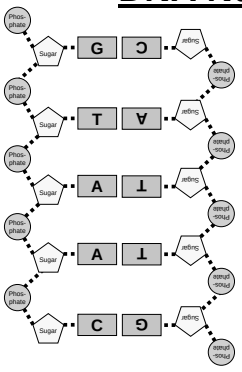
DNA

- **DNA** = deoxyribonucleic acid; formed by two strands of joined nucleotides.
- **Nucleotide** = a phosphate + a sugar (deoxyribose) + a nitrogen-containing base
- Nitrogen containing bases =
  - adenine (A)
  - guanine (G)
  - cytosine (C)
  - thymine (T)

Nucleotides

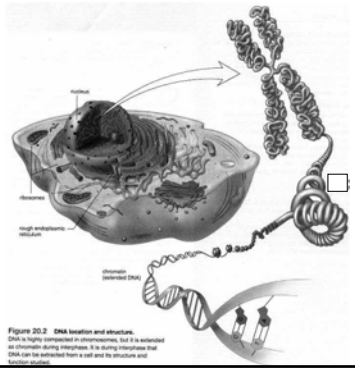


DNA Nucleotides



- Each base pairs with a complementary base.
  - G - C
  - A - T
- DNA = double stranded
- Each strand runs opposite to the other.
- Bases match up between strands.

DNA



DNA

- Double stranded DNA twists into a spiral called a **double helix**.
- The double helix wraps tightly around proteins to form the chromosomes.
- Genes are specific regions of the double helical strand.
- Information contained in the pattern of bases. (GGATTACACATATCG)

Complementarity

- DNA strands match up (G-C, A-T).
- If the base sequence of one strand is...

  G-A-T-T-A-C-A
- Then the base sequence of the complementary strand is...

  C-T-A-A-T-G-T
- When chromosomes duplicate the information of DNA is maintained.

DNA Replication

- **DNA Replication** = making a copy of the DNA molecule.
- When a cell divides all genes must be copied so each cell has a full set of genes.
- Problem...

  The information in the DNA must be maintained.

  (Info. = sequence of bases)

DNA Replication

- Each DNA strand (double stranded) forms a template for a *"new"* double stranded DNA molecule.

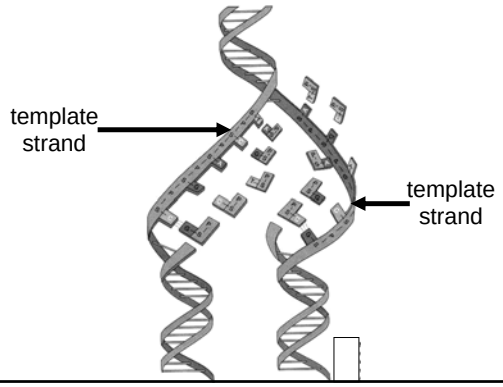
1. The strands separate
2. The enzyme **DNA polymerase** matches nucleotides to the existing nucleotides.
3. The matching nucleotides are then joined together.

DNA Replication

- Replication = one double stranded molecule becomes…

  two identical double stranded molecules.
- Each molecule contains ONE NEW strand and ONE "OLD" strand.

DNA Replication



What if there's a mistake?

- Replication is ***not*** foolproof.
- A nucleotide with the wrong base may be included in a new strand.
- Cells have mechanisms for fixing these mistakes….

  However, even this doesn't always work.
- **Mutation** = permanent change in a gene (causing a phenotype change)

Mutations

- A mutation in a somatic (non-sex) cell = not passed on to offspring

  Can cause a cell to malfunction.

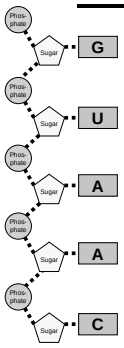
  Sometimes the malfunction causes cancer.
- A mutation in a sex cell = passed on to offspring

  This is how disorders like hemophilia and cystic fibrosis first arose.

RNA

- **RNA** = ribonucleic acid; ONE strand of joined nucleotides.
- **Nucleotide** = a phospate + a sugar (ribose) + a nitrogen-containing base
- Nitrogen containing bases =
  - adenine (A)
  - guanine (G)
  - cytosine (C)
  - uracil (U)
  - ("replaces" thymine)

RNA Nucleotides



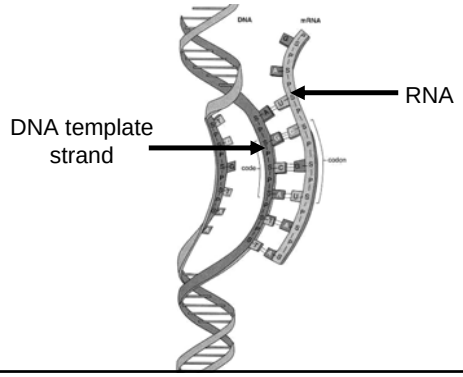
- Each base can pair with a complementary DNA base when the RNA is formed.
  - G - C
  - C - G
  - A - T
  - U - A
- RNA = single stranded

DNA Transcription

- **DNA Transcription** = making an RNA molecule based on DNA template.
- DNA information is transferred to RNA.

1. The DNA strands separate
2. The enzyme **RNA polymerase** matches RNA nucleotides to the existing DNA nucleotides.
3. The nucleotides are then joined.

DNA Transcription



Kinds of RNA

- **mRNA** = messenger RNA; Carries information for one gene from the DNA in the nucleus to the cytoplasm.
- **tRNA** = transfer RNA; Brings specific amino acids to the protein formation process.
- **rRNA** = ribosomal RNA; Forms part of ribosomes which are involved in the formation of proteins.

Translation

- **Translation** = the creation of a protein under the direction of an mRNA molecule.

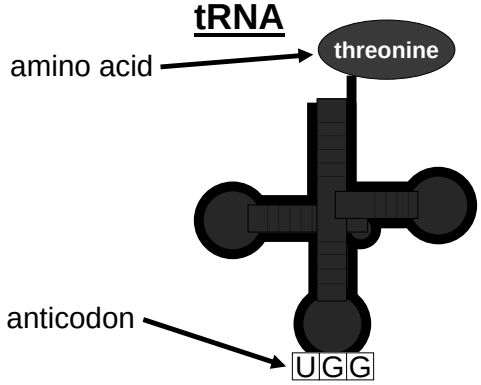
  Information on mRNA ⇒ protein
- **Triplet Code** = three **DNA** bases that are the basic units of information.
- **Codon** = three **mRNA** bases that correspond to a particular amino acid.

  triplet code ⇒ transcription ⇒ codons

Translation

- **mRNA** - contains the information (codons) for creating a protein.
- **tRNA** - cross-shaped section of RNA attached to a specific amino acid.
- **Anticodon** - 3 RNA bases on a tRNA that are complementary to a codon on the mRNA.
- **Ribosomes** - a 2 unit structure composed of rRNA & protein necessary for translation.

tRNA



Translation

1. mRNA attaches to a ribosome.
2. In a cleft of the ribosome, the anticodon of a tRNA molecule matches up with the codon of the mRNA.
3. In a 2nd cleft of the ribosome, the anticodon of a 2nd tRNA molecule matches up with the next codon of the mRNA.

Translation

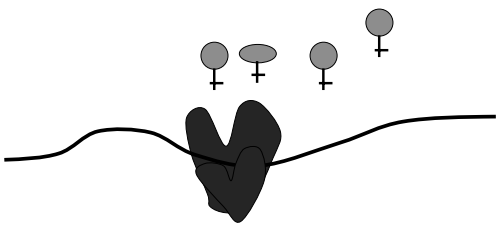
4. The amino acids of the two tRNA's are joined.
5. The 1st tRNA detaches from its amino acid and falls out of the ribosome.
6. The ribosome moves one codon up the mRNA.
7. A 3rd tRNA matching the new codon enters the ribosome with its amino acid.

Translation

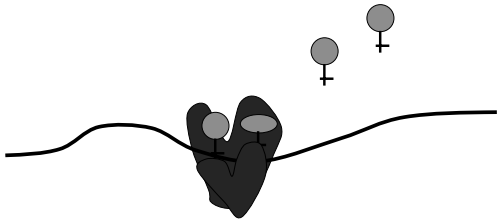
8. The ribosome moves along the mRNA forming a long amino acid chain (protein).
9. The ribosome falls off when it reaches a "stop codon."

   The two units fall apart and the protein "floats" free.

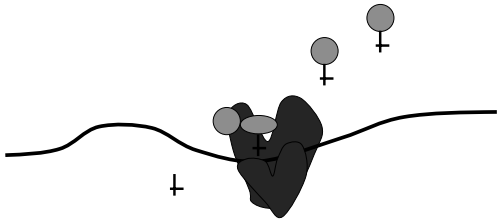
Translation



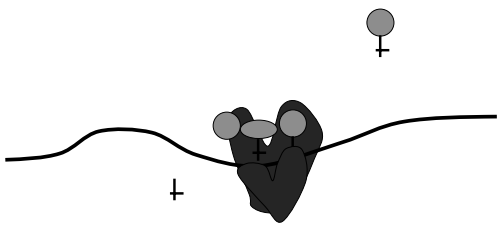
Translation



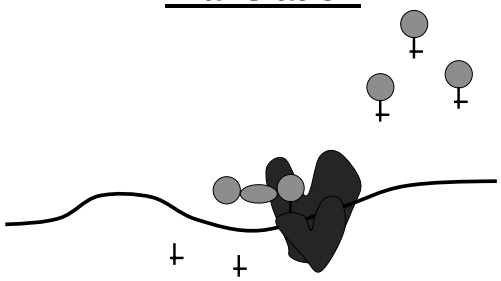
Translation



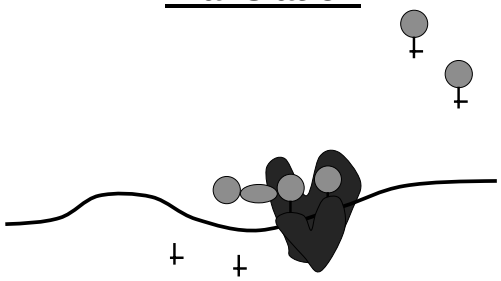
Translation



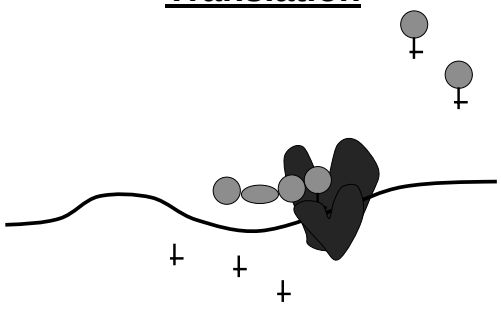
Translation



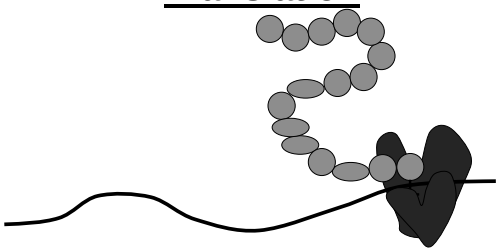
Translation



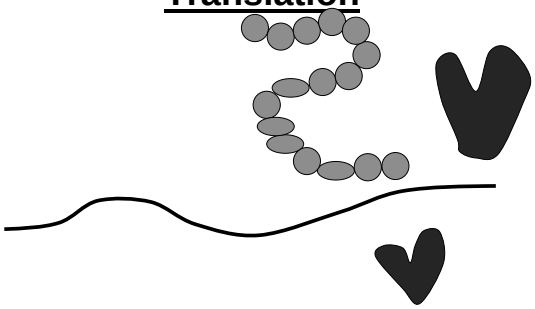
Translation



Translation



Translation



Translation

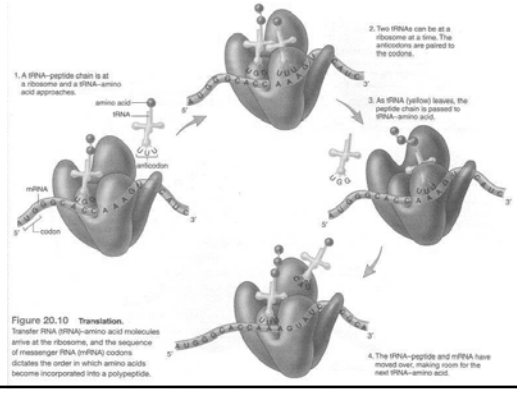
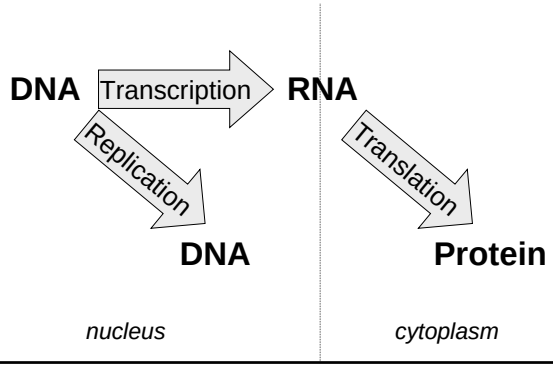
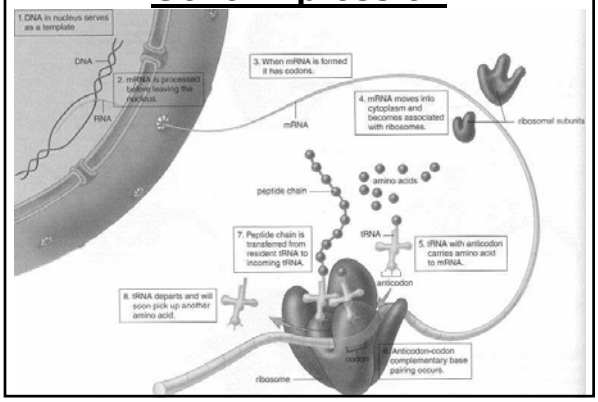


Figure 20.10 **Translation.** Transfer RNA (tRNA)–amino acid molecules arrive at the ribosome, and the sequence of messenger RNA (mRNA) codons dictates the order in which amino acids become incorporated into a polypeptide.

Gene Expression



Gene Expression



Gene Expression

- Not all genes are expressed at one time.
- Genes must be regulated.

  Some are only turned on in cells in certain places in the body.

  Some are only turned on at certain times in development.
- Misregulation of genes can result in serious disorders.

Gene Regulation

- **Transcriptional control** = control of the transcription of genes
- **Posttranscriptional control** = control of the processing of mRNA before translation
- **Translational control** = control of the translation of genes
- **Posttranslational control** = control of necessary modification of proteins

Biotechnology

- **Biotechnology** = application of biological techniques that result in a commercially valuable method or product.
- **Genetic engineering** = use of biological technology to alter the genetic composition of a living cell for medical or industrial use.

  Change the genotype.

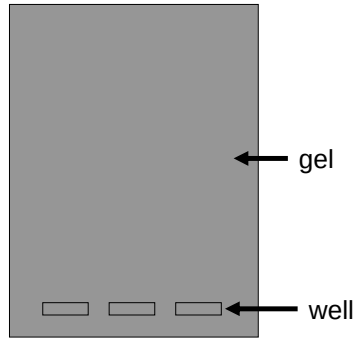
Biotech Techniques

- **Electrophoresis** = movement of molecules through a gel (Jello-like substance); using an electric current.

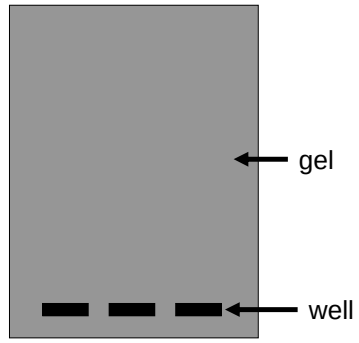
  Separates molecules based on charge and size.

  (Same charge repels, opposite charge attracts)
- Can differentiate proteins, RNA, and DNA of different sizes and charges.

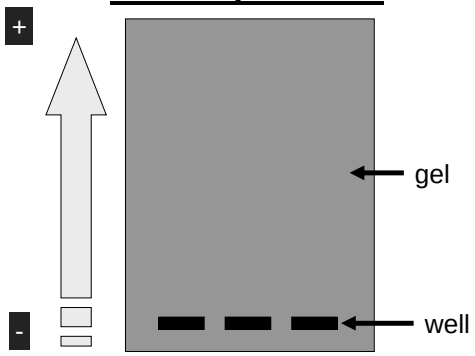
Electrophoresis

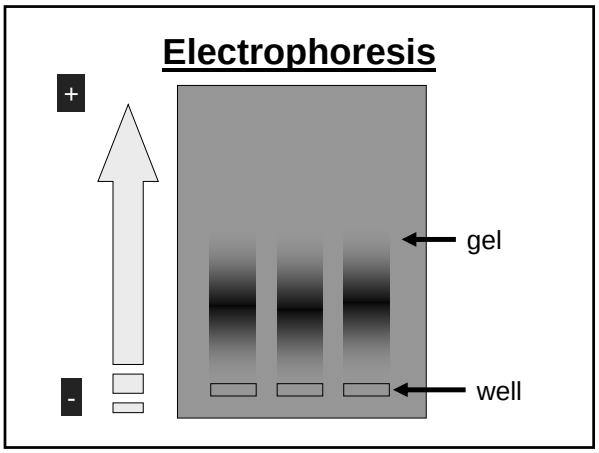


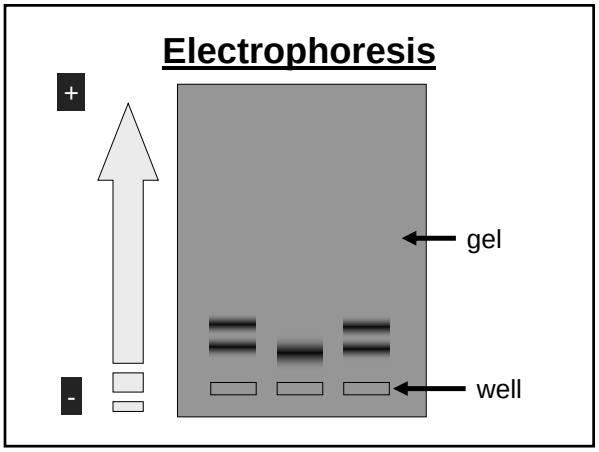
Electrophoresis

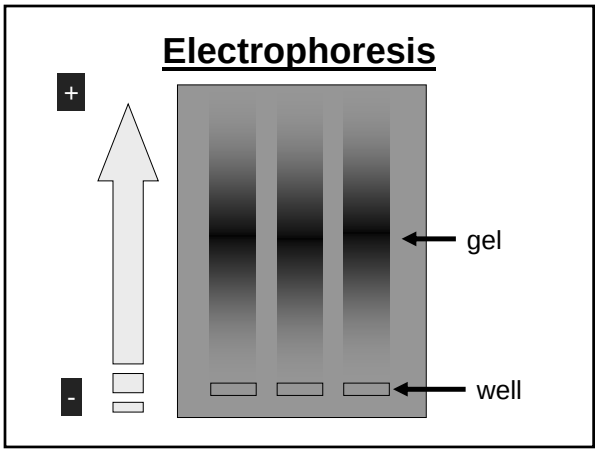


Electrophoresis

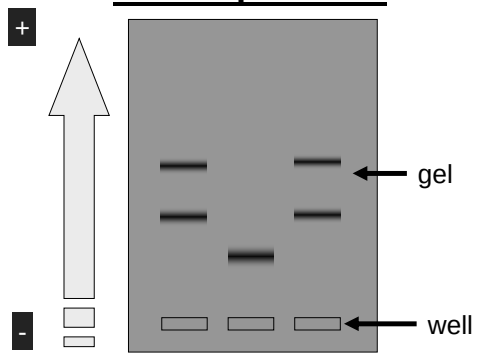



Electrophoresis
+
-
gel
well


Electrophoresis
+
-
gel
well


Electrophoresis
+
-
gel
well

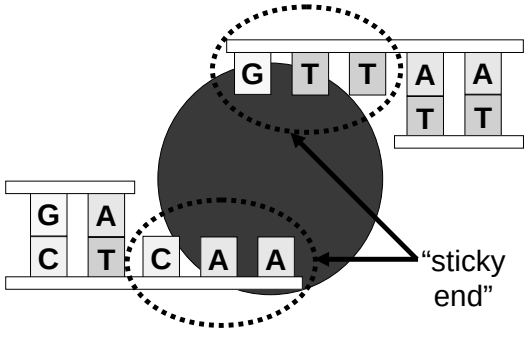
Electrophoresis



Restriction Enzymes

- **Restriction enzyme** = protein that cuts DNA at a certain base sequence leaving “sticky ends”. Bacteria use them to attack viruses.
- **“Sticky end”** = a single stranded end of a restriction enzyme cut (small region of uncomplemented bases).

Restriction Enzymes



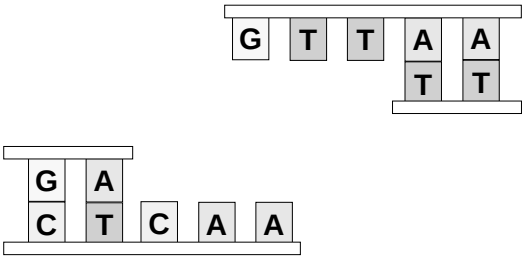
DNA Ligase

- **DNA ligase** = an enzyme that joins gaps in DNA.

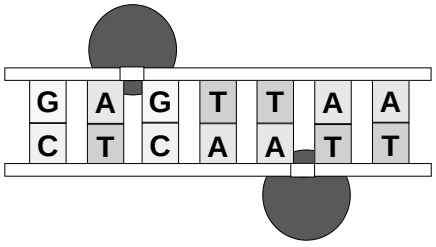
  Human cells use this enzyme to repair damaged DNA and in replication.
- **Reverse Transcriptase** = Makes a double stranded DNA copy from mRNA.

  Found in RNA viruses.

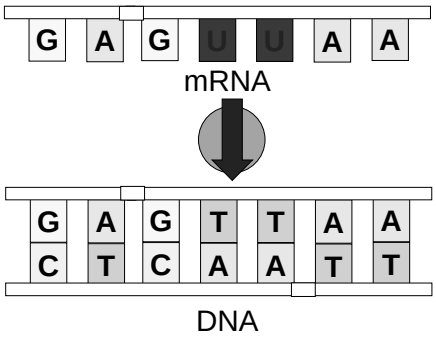
DNA Ligase



DNA Ligase



Reverse Transcriptase



Bacterial DNA

- **Plasmid** = small accessory rings of DNA found in bacterial cells.

  Circular

  Bacteria can be “forced” to pick up plasmids.
- Bacteria will make copies of plasmids and express plasmid genes.
- Plasmids are “easy” to work with.

Cloning a Gene

- **Cloning** = making many copies of a particular gene (using bacteria).

  (This is cloning in genetics. We’ll talk about “cloning” organisms later.)

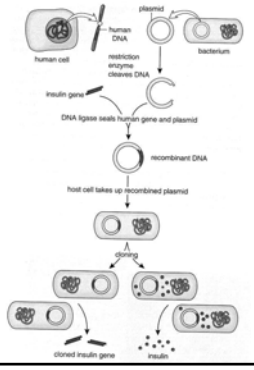
  1. Select the gene you would like to copy.

  2. Cut the gene out of its chromosome with a restriction enzyme.

Cloning a Gene

3. Use the same restriction enzyme to cut a known plasmid.
4. Combine the gene and the plasmid.
5. Use DNA ligase to seal together.
6. Put **recombinant** plasmid into bacteria.
7. Grow many bacteria.

Cloning a Gene



PCR

- **PCR** = polymerase chain reaction; using DNA polymerase and heating and cooling cycles to make ***many copies of a gene***.
- ***Taq*DNA Polymerase** = DNA polymerase that can tolerate being heated.

  SPECIAL - Discovered in bacteria living in hot springs in Yellowstone Natl. Park.

Biotechnology Products

- **Transgenic Organisms** = Organisms that have had a gene from another organism (or a constructed gene) inserted into them.
- Transgenic bacteria produce…

  insulin, human growth hormone, hepatitis B vaccine, "insecticides," phenylalanine for Nutra Sweet.

Biotechnology Products

- Transgenic plants can produce…

  human proteins, antibodies, & some biodegradable plastics.

  Transgenic plants can…

  be resistant to herbicides or produce their own insecticides.
- Transgenic animals can produce…

  human clotting factors, human growth hormone, & human proteins.

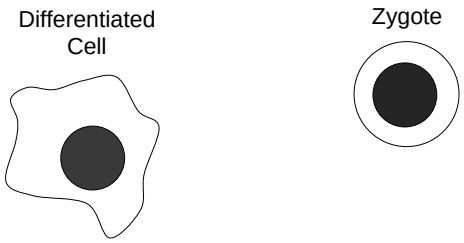
Organ Transplants

- **Xenotransplantation** = use of non-human organs in human transplant patients.
- Problem = human organs rare
- Problem = non-human organs rejected by the human immune system
- Genetically engineered pigs are being "made" to have non-rejectable organs.

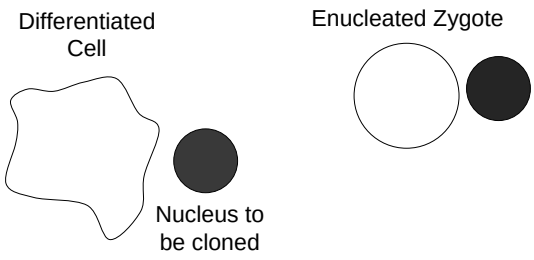
Cloning Organisms

- **Cloning Organisms** = producing genetically indentical multicellular individuals.
- Take the nucleus from one of an individual's cells.
- Remove the nucleus from a zygote.
- Insert the nucleus.
- Problem = getting the right genes to turn on.

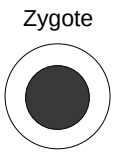
Cloning Organisms



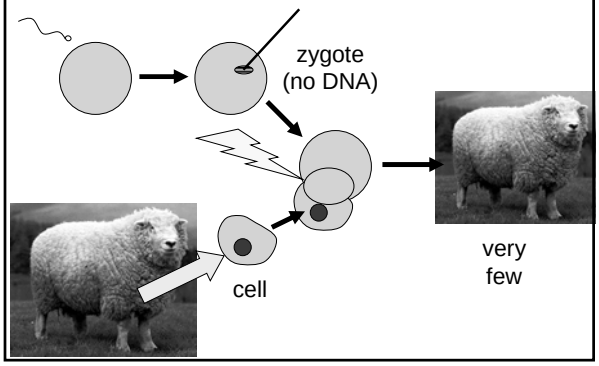
Cloning Organisms



Cloning Organisms



Mammalian Cloning



Cloning

- Offspring nuclei are genetically identical to nucleus donor.
- Fetal environment different than either donor.
- Time of development different than either donor.

Human Identical Twins

- Nuclei are genetically identical to each other.
- Fetal environment same.
- Time of development is the same.
- Environment usually similar due to being raised in the same family.
- Identical twins are MORE identical to each other than a clone would be to its nucleus donor.

Human Genome Project

- **Genome** = All the genes in a cell.
- **Human Genome Project** = effort to "map" all human chromosomes. (Obtain the base sequence for the human genome.)
- PCR
- better understand genetic diseases
- correlate drug to genes
- predict likelihoods of getting diseases

Gene Therapy

- **Gene Therapy** = adding genes to cells to "make up for" a faulty gene.
- ***Ex vivo* methods** = remove cells, add genes, then put cells back into patients
- ***In vivo* methods** = add genes directly to patients
- Gene therapy has had mixed success.