DNA = *deoxyribonucleic acid*

1. It’s the genetic material
   - inherited from cell to cell
   - inherited from parent to offspring

2. It’s the “blueprint” for life
   - instructions for protein synthesis
   - genes encode proteins
Definitions

- **Nucleotide** = building blocks of DNA
- **Gene** = group of nucleotides (DNA) that encode a protein
- **Chromosome** = strand of genes + other DNA
- **Genome** = all DNA information contained in 46 chromosomes
  = 3 billion nucleotides
Genes regulate the human life cycle

Egg + sperm = embryo

Fetus

Newborn
Some people have identical DNA sequence

Identical twins (monozygotic)
Fraternal Twins are dizygotic

• Mother releases 2 eggs, each is fertilized by a separate sperm
• DNA?
(a) Monozygotic (identical) twins

Egg → Sperm → Zygote → Embryo → Embryo splits → Two embryos
100% genetically identical

(b) Dizygotic (fraternal) twins

Egg → Sperm → Egg → Sperm → Zygote → Embryo → Embryo
=50% identical (no more similar than siblings born at different times)
Double helix structure
Watson and Crick 1950's
X-ray diffraction shows helical structure
Nucleotides building blocks of DNA

- nucleotide bases G,A,T,C
- Sugar/phosphate backbone
Chargaff’s complementary base pair rule

G and C pair
A and T pair

The sequence of G,A,T,C is the genetic code
• If one strand of the DNA double helix is:

TCT TAC TCT ATG GAA

What is the complementary strand sequence?
Gene Expression

• When the cell uses the DNA code to make a particular protein
Gene Expression depends on:

- Tissue type – liver, heart, brain etc…
- Developmental stage/age – embryo, elderly
- Metabolic needs – making energy, taking in nutrients
- Disease – cancer, infection, diabetes etc…

*All of your cells have the same DNA, but use genes differently*
Gene mutation
Example: Sickle cell disease

- Single base change from __ to ___
DNA fingerprinting

paternity, forensics, evolution, conservation, hunt for disease genes

Routine in US military, prisons
1. Isolate DNA from?

2. Perform technique that is DNA sequence specific
3. **Gel electrophoresis** to separate sizes

**DNA fingerprint** = Different people show different sized DNA pieces depending on their unique DNA sequence of G,A,T,C
•*Remember – one chromosome is inherited from mom, one from dad

•M is the mother

•C is her newborn baby

Who could the father be?
Rape case
1. **Transgenic bacteria** = cloning genes into bacteria = recombinant DNA

Example: Human Growth Hormone
Human Growth Hormone (\textit{hGH}) cloned into bacteria (1980s)

- Pre-1980s
  Pituitary dwarfs received hGH purified from cadaver brains
  Drawbacks?

- Today
  - receive hGH that has been \textit{cloned}

26 inches tall
Cloning a gene into bacteria

Isolate DNA and cut out gene

....ggattgcgtacgcttt|gatcgtagtaatagg|acctagtgtgtacgtaagcggccacacagtgtaccacatt............

|gatcgtagtaatagg|
Introduce hGH gene into bacteria

Bacteria make hGH protein

Bottle, sell, and inject into child
Advantages of recombinant DNA

• Bacteria can supply world’s need
• Clean, disease free, easy to produce
• 2. Transgenic plants (GM plants)
A few genetically modified plants
<table>
<thead>
<tr>
<th>Benefits</th>
<th>Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Increased crop yield</td>
<td>increased seed costs</td>
</tr>
<tr>
<td>• Resistance to drought, freezing</td>
<td>pesticide resistant bugs</td>
</tr>
<tr>
<td>• Decreased use of pesticides</td>
<td>resistant weeds</td>
</tr>
<tr>
<td>• Decreased use of herbicides</td>
<td>new allergens</td>
</tr>
<tr>
<td>• Increased nutrition</td>
<td>may spread to other plants</td>
</tr>
<tr>
<td>• Increased shelf life</td>
<td>harmful to insects?</td>
</tr>
</tbody>
</table>
Example: Golden Rice

• Many in world are deficient in Vitamin A
  – Leading cause of childhood blindness (500,000 new cases per year)

• Rice engineered to produce vitamin A!

Controversial…….
• Do we need legislation for labeling of GM foods?

• Should GM genes, plants, animals, be patented?
3. Transgenic animals

These goats produce human TPA (blood clot buster) in their milk (pharming)
How are transgenic animals made?

• Inject the gene (DNA) into the animal embryo
• Implant embryo in mother
• If the drug is made in milk, then…..
Mouse model organism

• These mice are models for human disease (Alzheimer)

• This mouse is genetically modified to be diabetic
• This pig is genetically engineered to be able to digest more and produce less manure

• Other pigs produce meat high in omega 3 fatty acids
• This pig is genetically engineered to have an immune system similar to humans’
• genetically engineered salmon grow faster
Cloning and stem cell research
Ch 12 pg 180
Animals that have been cloned
To clone an animal (reproductive cloning)

End product = animal that is a genetic copy of the cloned individual
Reproductive Cloning

1. Take nucleus (with DNA) from a somatic cell

2. Add to “empty” donated egg

This egg has a full set of chromosomes
Pipetting DNA into an egg

Animal embryo

Human reproductive cloning is illegal
End product = cloned cells to treat disease
Therapeutic Cloning – making stem cells

1. Take nucleus (with DNA) from a somatic cell

2. Add to “empty” donated egg

This egg has a full set of chromosomes
3. Grow (in lab dish) for ~ 2 weeks

4. Remove cells from embryo and grow in lab dish
Therapeutic Cloning – making stem cells

Continue to grow cells in lab dish

• Can grow large quantities of cells – brain cells, liver cells, etc..

• No rejection of tissue
Reproductive vs therapeutic cloning

a. Reproductive cloning

G₀ cells from animal to be cloned

nucleus removed

fuse egg with G₀ nucleus

culture

embryo

implant embryo into surrogate mother.

Clone is born.

b. Therapeutic cloning

G₀ somatic cells removed

fuse egg with G₀ nucleus

culture

embryo

Specialized tissue cells are produced.

nervous

blood

muscle
Uses of ES cells

tissue transplants – new liver cells, pancreas cells

- Alzheimer disease, spinal cord injury, Parkinson’s disease, multiple sclerosis, diabetes, burned tissue, stroke, lung disease, heart disease, arthritis
Other advantages of stem cells

Not limited by organ donation

- 80,000 people in the US are waiting for a transplant
- Over 5,000 people die each year waiting
- organ a perfect match
- recipients must take immunosuppressants for life
Sources of ES cells

- In-vitro fertilization
  - 800,000 unused embryos currently frozen
  - What happens to these?
  - Should people be able to donate them?
• donated sperm and eggs

Should people be able to donate for stem cell research?
• therapeutic cloning
• there are also fetal stem cells in umbilical cord blood and adult stem cells in bone marrow