Chapter 13: **DNA Structure & Function**

Structure of the Hereditary Material

- Experiments in the 1950s showed that DNA is the hereditary material
- Scientists raced to determine the structure of DNA
- 1953 - Watson and Crick proposed that DNA is a double helix

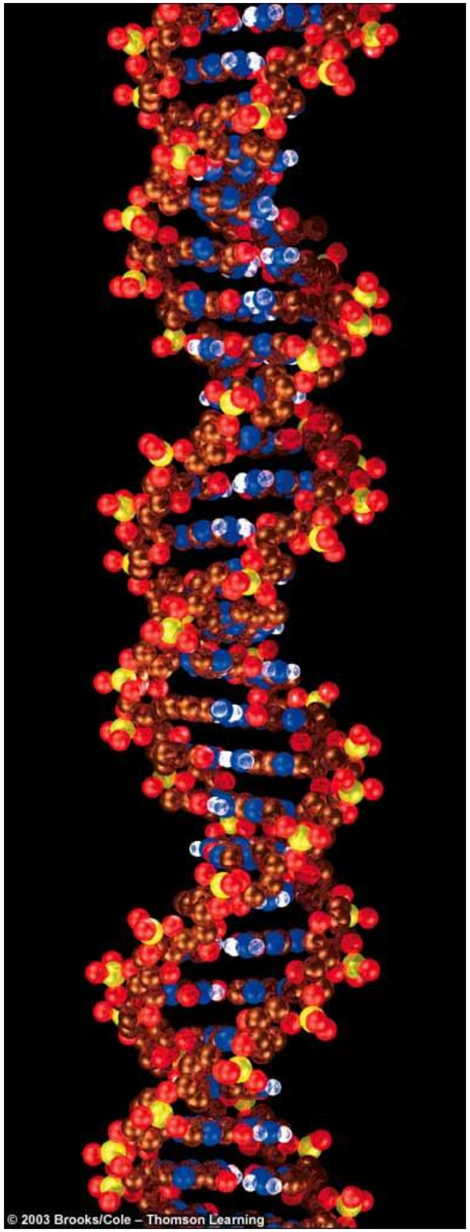

Figure 13.6

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Griffith Discovers Transformation

- 1928
- Attempting to develop a vaccine
- Isolated two strains of *Streptococcus pneumoniae*
  - Rough strain was harmless
  - Smooth strain was pathogenic

Mice injected with live cells of harmless strain R.

Mice injected with live cells of killer strain S.

Mice injected with heat-killed S cells.

Mice injected with live R cells *plus* heat-killed S cells.

Mice live. No live R cells in their blood.

Mice die. Live S cells in their blood.

Mice live. No live S cells in their blood.

Mice die. Live S cells in their blood.

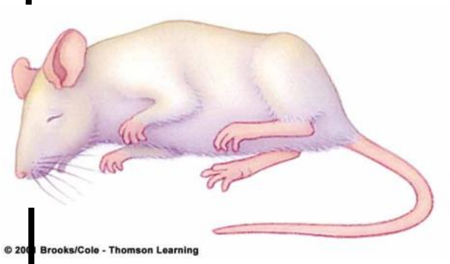
Stepped Art

Fig. 13-3, p.208

Transformation

- What happened in the fourth experiment?
- The harmless R cells had been *transformed* by material from the dead S cells
- Descendents of the transformed cells were also pathogenic

Mice injected with live R cells *plus* heat-killed S cells.



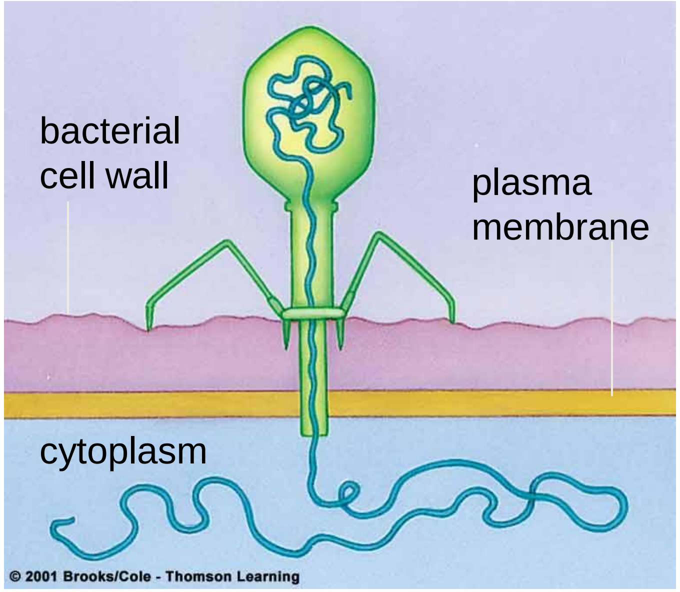
Mice die. Live S cells in their blood.

Oswald & Avery

- What is the transforming material?
- Cell extracts treated with protein-digesting enzymes could still transform bacteria
- Cell extracts treated with DNA-digesting enzymes lost their transforming ability
- Concluded that DNA, not protein, transforms bacteria

Bacteriophages

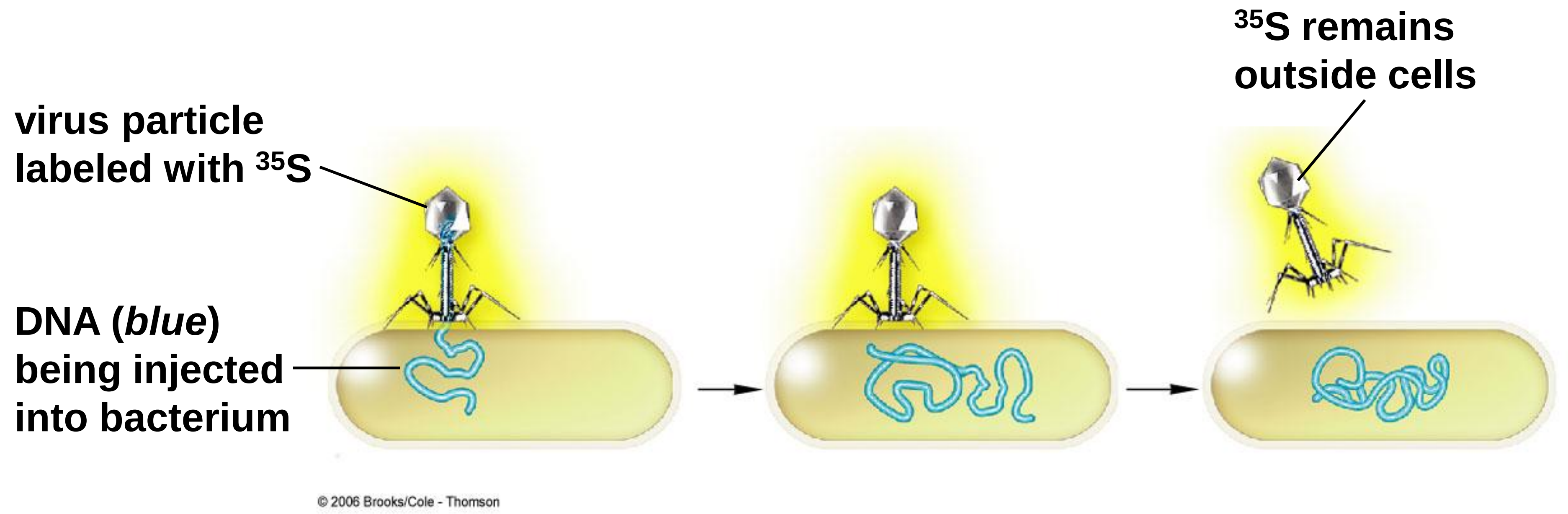
- **Viruses are NOT living,** they do not satisfy all the characteristics of life.
- **Viruses that infect bacteria**
- **Consist of protein coat and DNA**



Hershey & Chase's Experiments

- Created labeled bacteriophages
  - Radioactive sulfur
  - Radioactive phosphorus
- Allowed labeled viruses to infect bacteria
- Asked: Where are the radioactive labels after infection?

Hershey and Chase Results



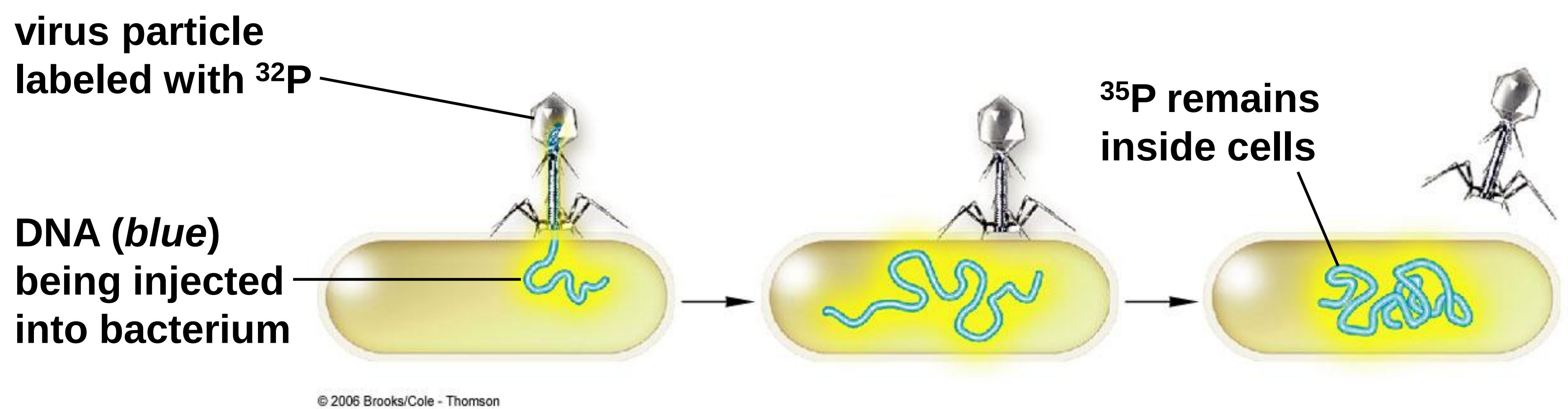
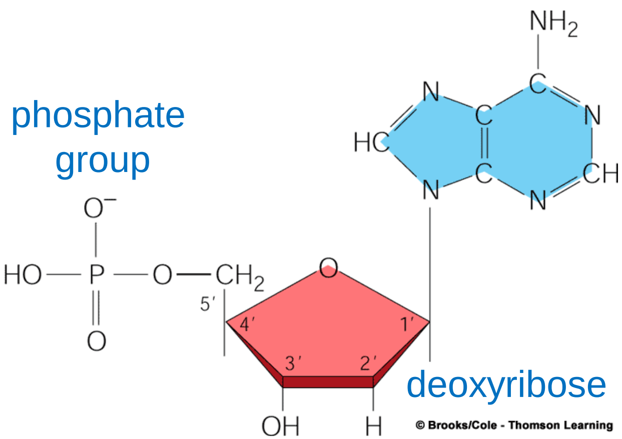


Fig. 13-4ab, p.209

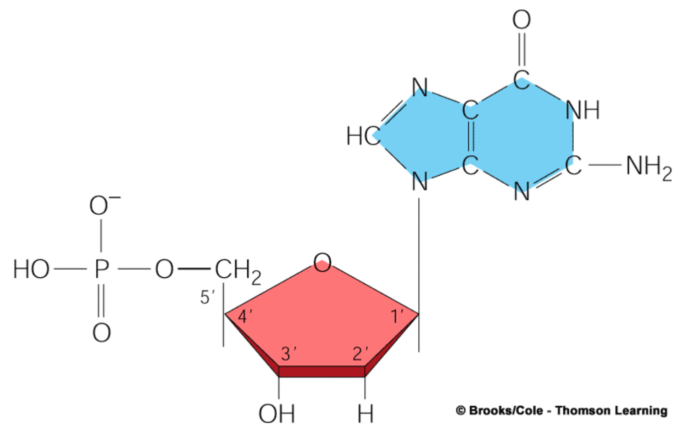
Structure of Nucleotides in DNA

- Remember WAAAAY back from Ch 2 that nucleotides are the building blocks of nucleic acids
- **Each nucleotide consists of**
  - **Sugar**
  - **Phosphate group**
  - **Base**
- **Four bases of DNA**
  - **Adenine, Guanine, Thymine, Cytosine**

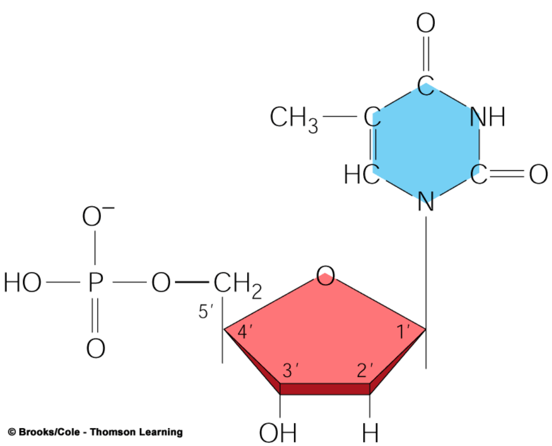
Nucleotide Bases



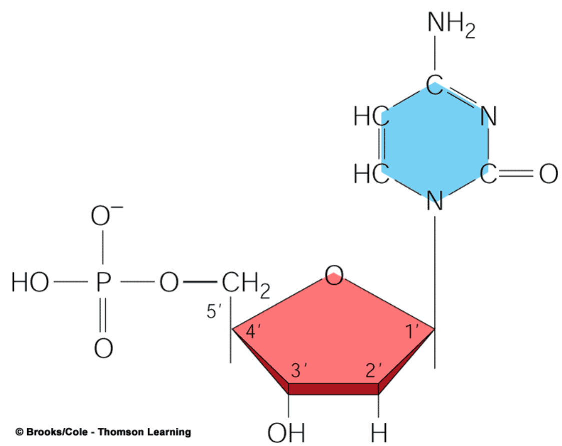
ADENINE (A)



GUANINE (G)

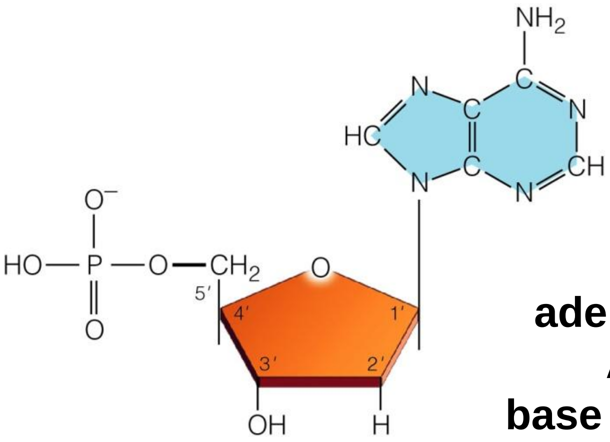


THYMINE (T)

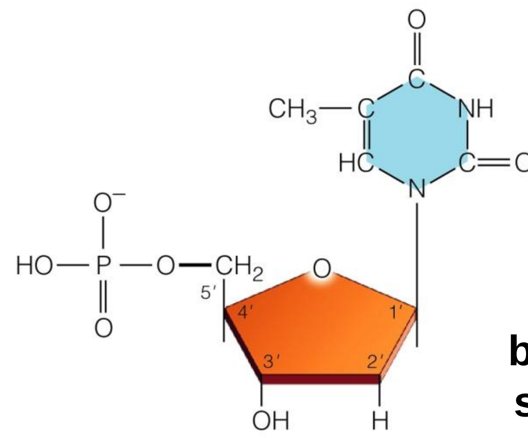


CYTOSINE (C)

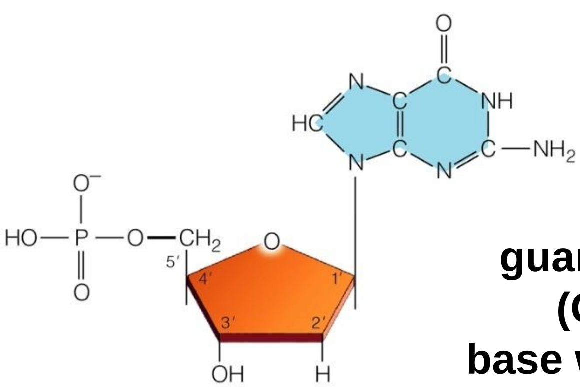
Nucleotide Bases



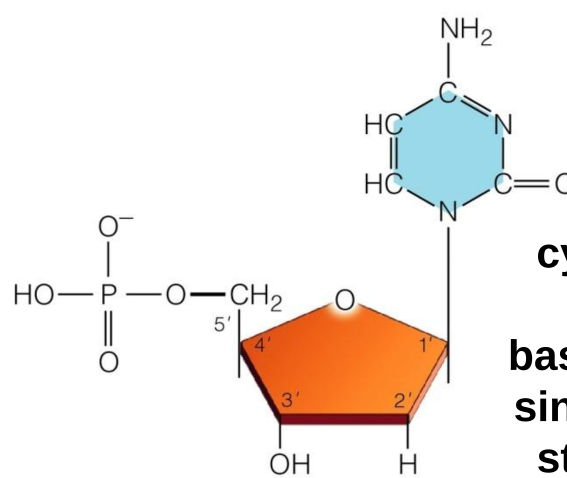
adenine
A
base with a double-ring structure



thymine
(T)
base with a single-ring structure



guanine
(G)
base with a double-ring structure

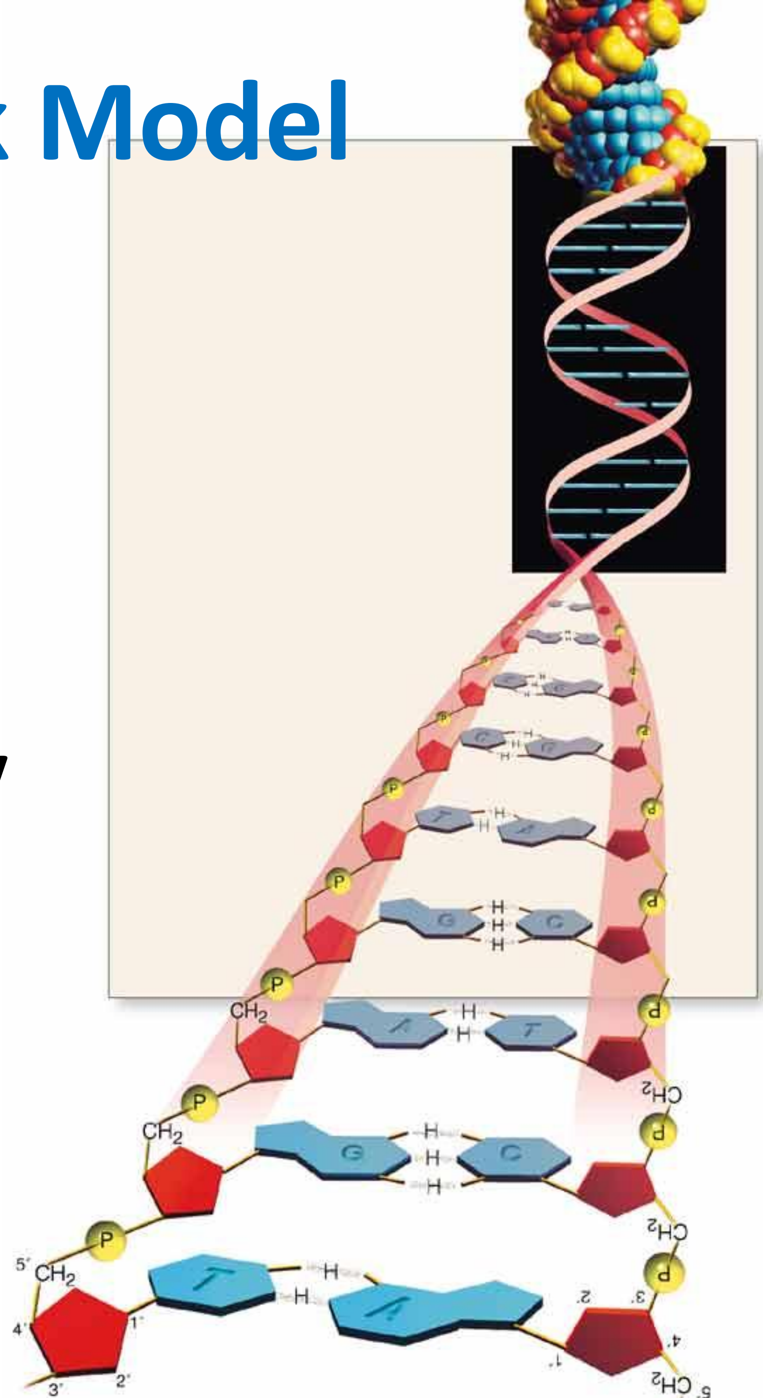


cytosine
(C)
base with a single-ring structure

Fig. 13-5, p.210

Watson-Crick Model

- DNA consists of two nucleotide strands
- Strands run in opposite directions
- Strands are held together by hydrogen bonds between bases
- A binds with T and C with G
- Molecule is a double helix



DNA Structure Helps Explain How It Duplicates

- DNA is two nucleotide strands held together by hydrogen bonds
- **Hydrogen bonds between two strands are easily broken**
- **Each single strand can serve as template for a new strand**

DNA Replication

- Each parent strand remains intact
- Every DNA molecule is half “old” and half “new”

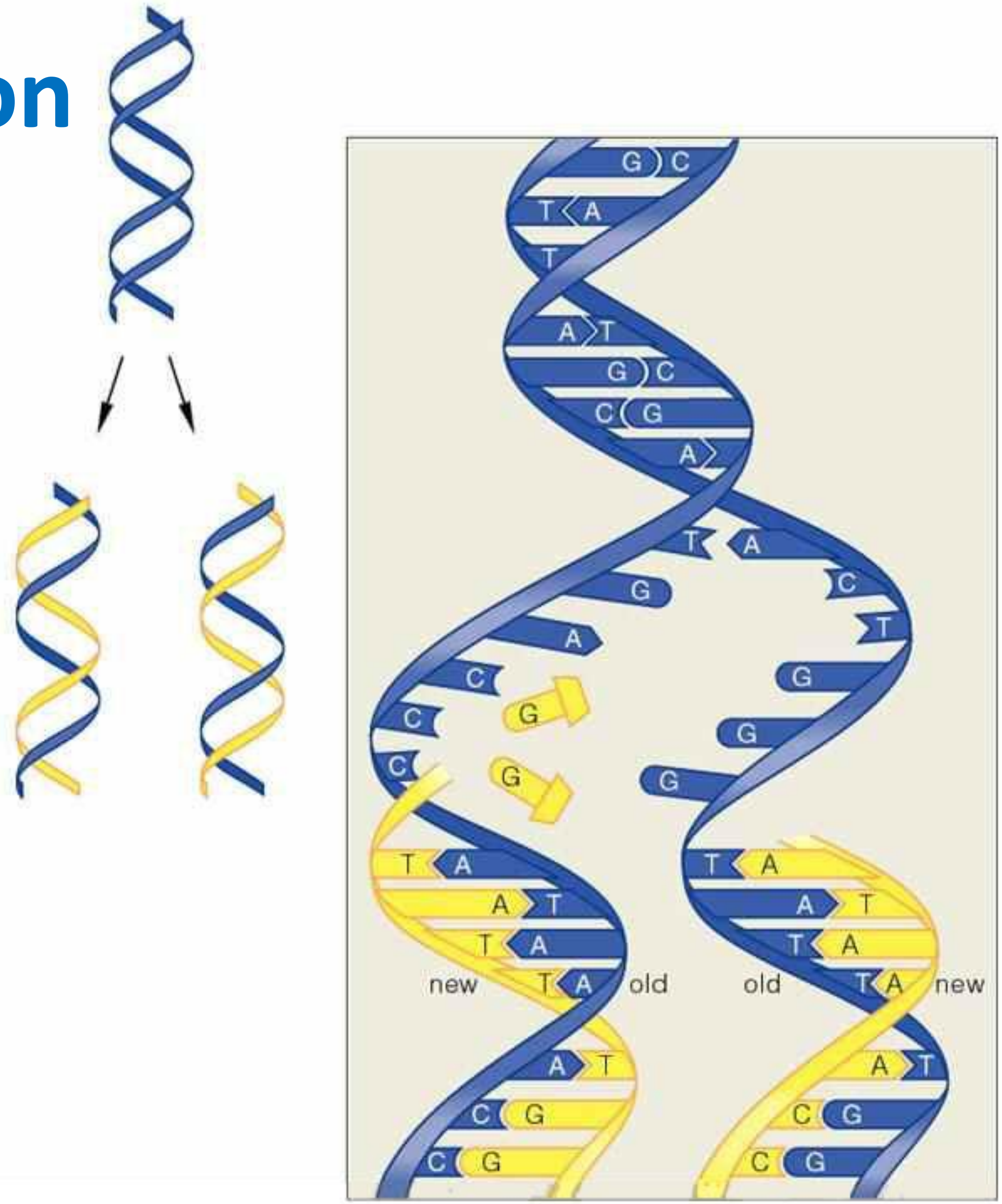


Fig. 13-7, p.212

Base Pairing during Replication

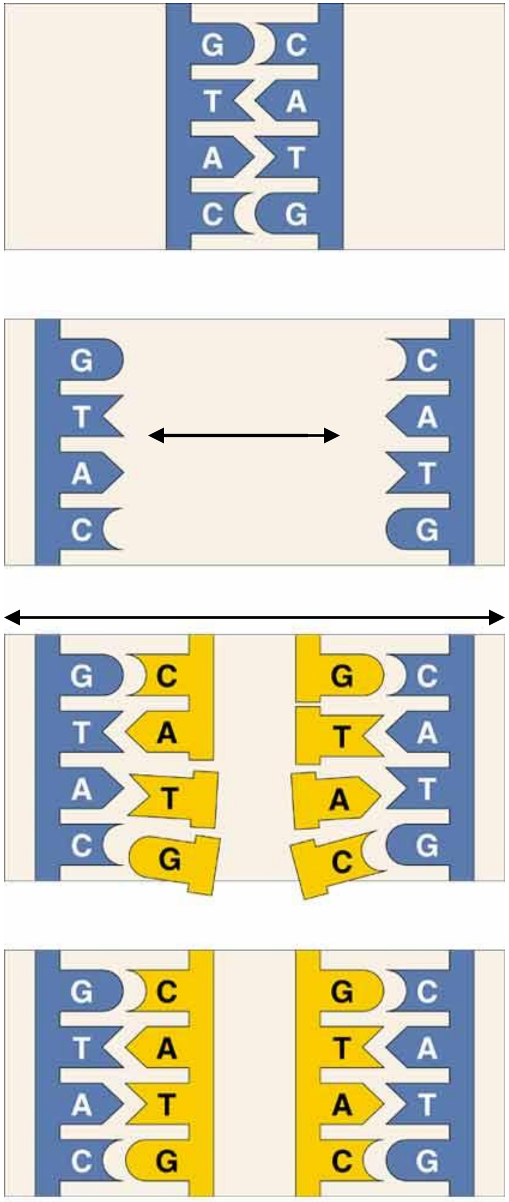
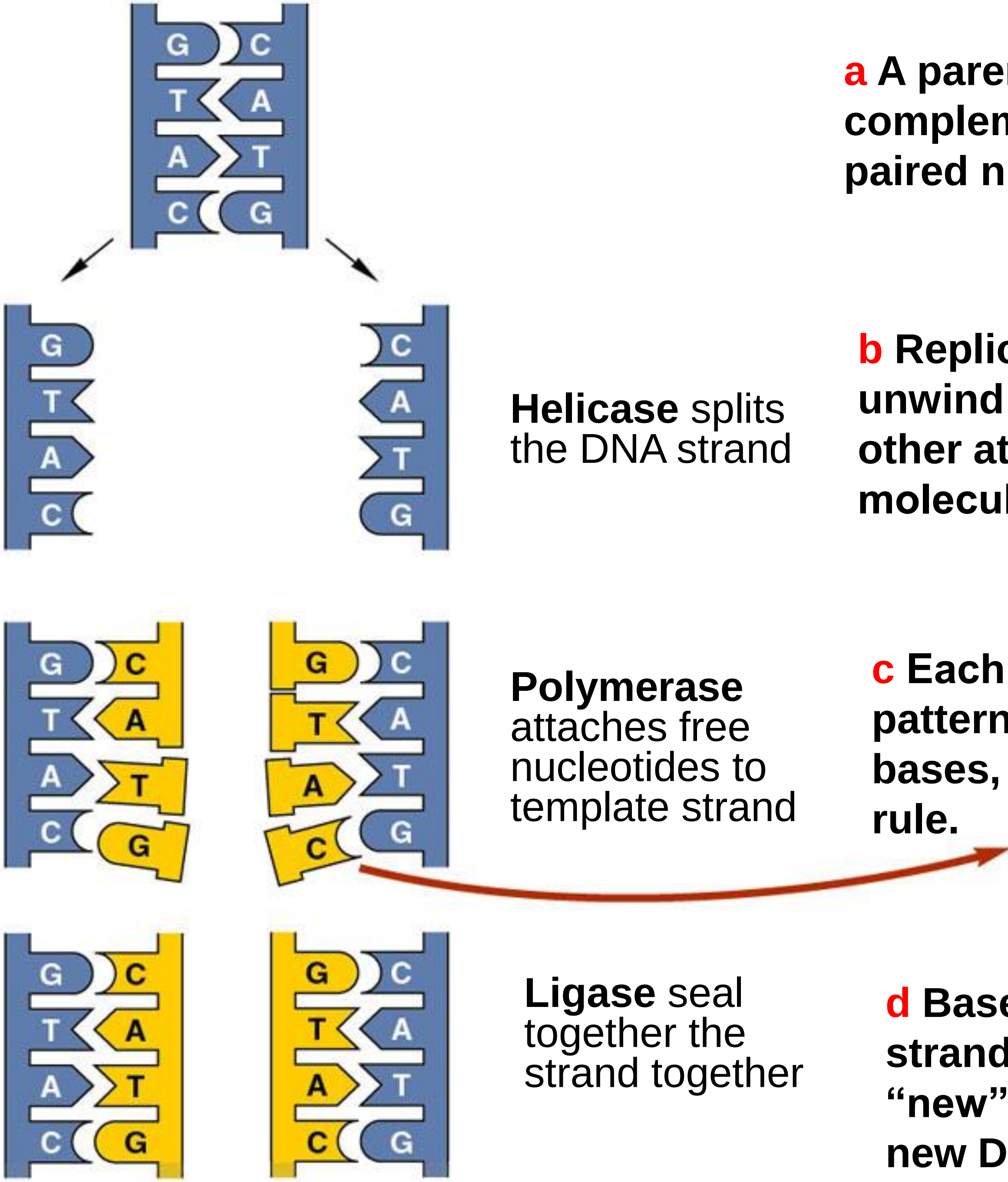


Fig. 13-8, p. 213



a **A parent DNA molecule with two complementary strands of base-paired nucleotides.**

Helicase splits the DNA strand

b **Replication starts; the strands unwind and move apart from each other at specific sites along the molecule's length.**

Polymerase attaches free nucleotides to template strand

c **Each "old" strand is a structural pattern (template) for attaching new bases, according to the base-pairing rule.**

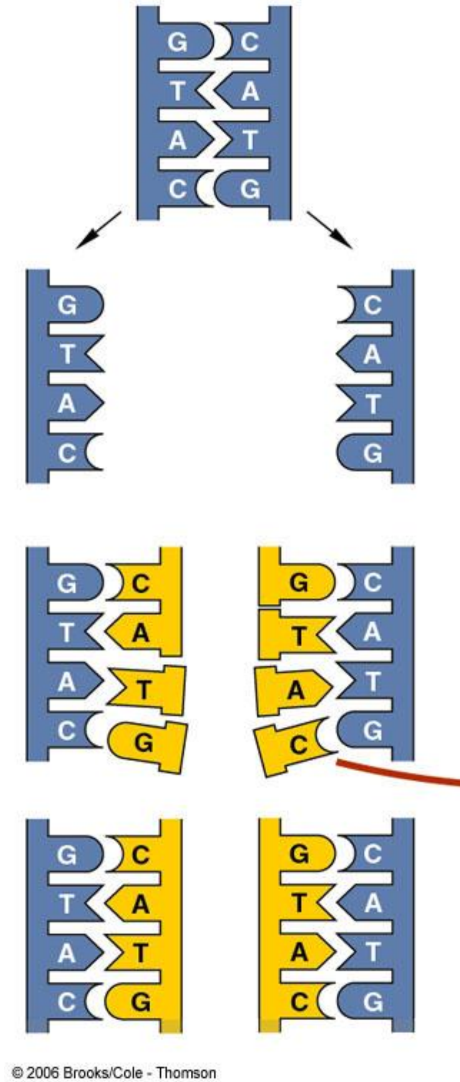
Ligase seal together the strand together

d **Bases positioned on each old strand are joined together as a "new" strand. Each half-old, half-new DNA molecule is like the parent molecule.**

Fig. 13-8a, p.213

Enzymes in Replication

- Enzymes unwind the two strands
- DNA polymerase attaches complementary nucleotides
- DNA ligase fills in gaps
- Enzymes wind two strands together



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- http://www.mcb.harvard.edu/losick/images/trombonefinald.swf

Enzymes in Replication

Table 13.1 Three of the Enzymes With Roles in DNA Replication and Repair

Helicases

Catalyze the breaking of hydrogen bonds between base pairs in the DNA molecule, which unzips in two directions from double-stranded to single-stranded form. Protein factors work with helicases to keep the two parent strands unwound. The helicases are ATP-driven motors, similar to ATP synthases.

DNA polymerases

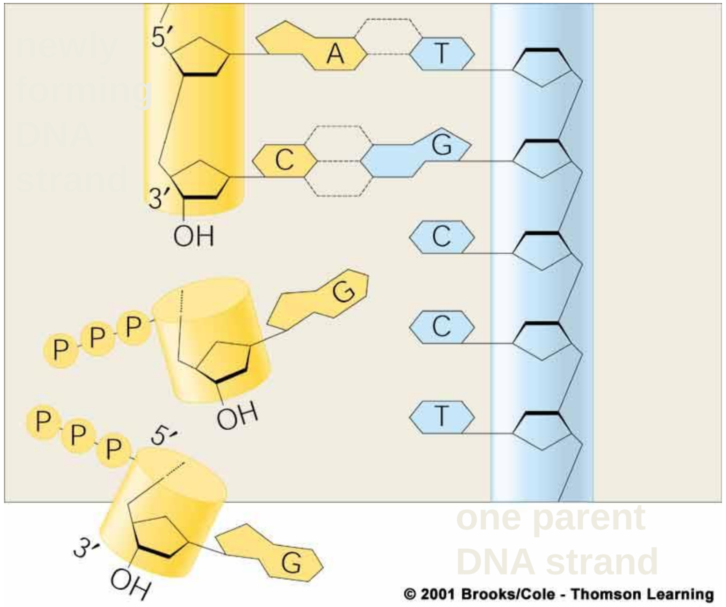
Catalyze the additions of free nucleotides to each new strand of deoxyribonucleases on a parent DNA template. Also proofread; some DNA polymerases can reverse direction by one base pair and correct mismatches, which occur once in every thousand or so additions.

DNA ligases

Catalyze the sealing-together of short stretches of new nucleotides, which are assembled discontinuously on one of the parent DNA strands. Also can seal strand breaks.

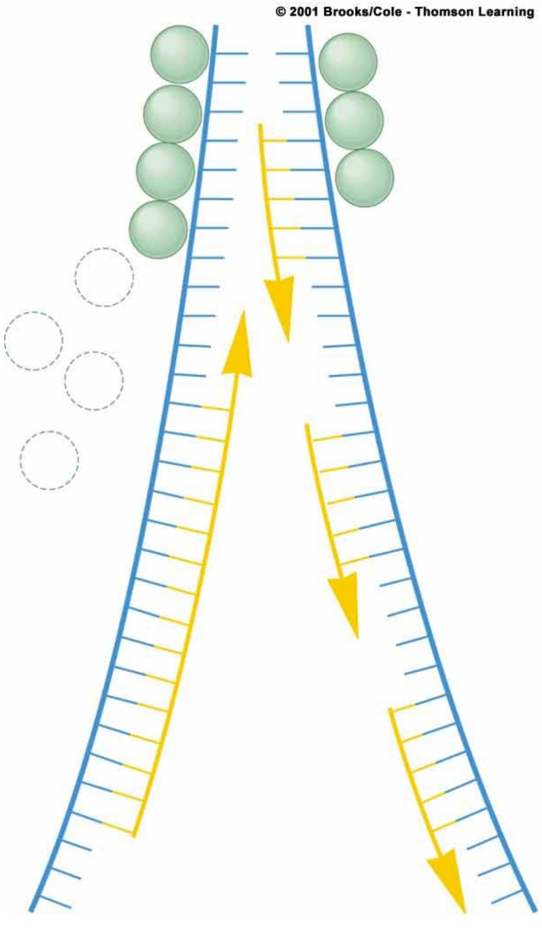
A Closer Look at Strand Assembly

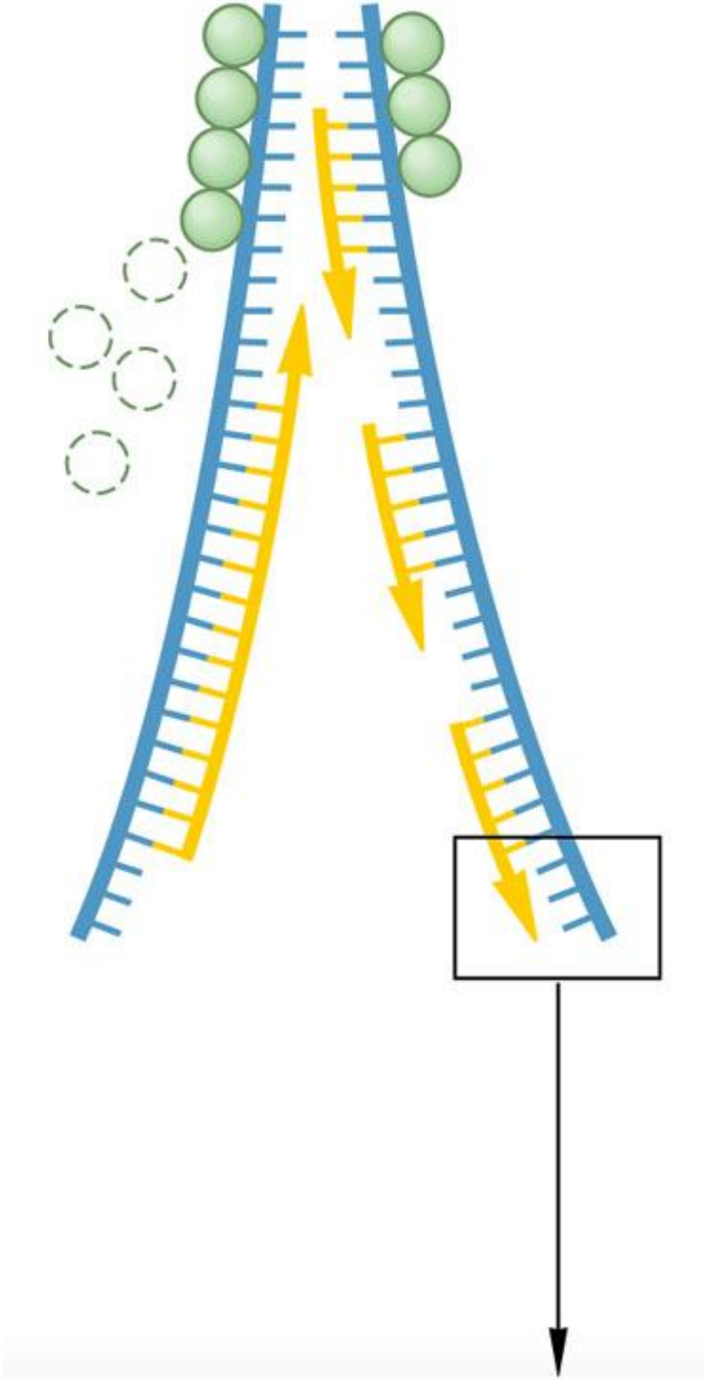
Energy for strand assembly is provided by removal of two phosphate groups from free nucleotides



Continuous and Discontinuous Assembly

Strands can only be assembled in the 5’ to 3’ direction





Continuous and Discontinuous Assembly

As Reiji Okazaki discovered, strand assembly is *continuous* on just one parent strand. This is because DNA synthesis occurs only in the 5´ to 3´ direction. On the other strand, assembly is *discontinuous*: short, separate stretches of nucleotides are added to the template, and then enzymes fill in the gaps between them.

Fig. 13-8b, p.213

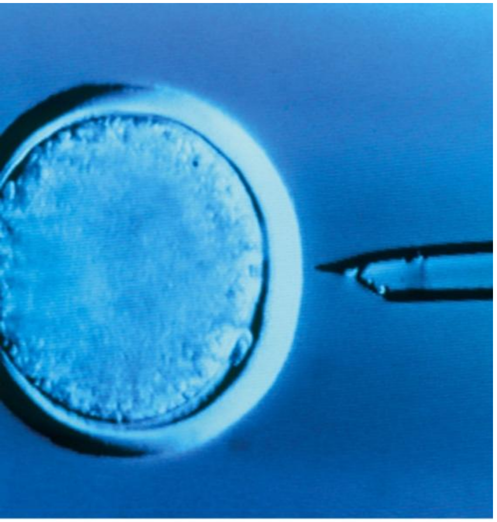
DNA Repair

- **Mistakes can occur during replication**
- DNA polymerase can read correct sequence from complementary strand and, together with DNA ligase, can repair mistakes in incorrect strand

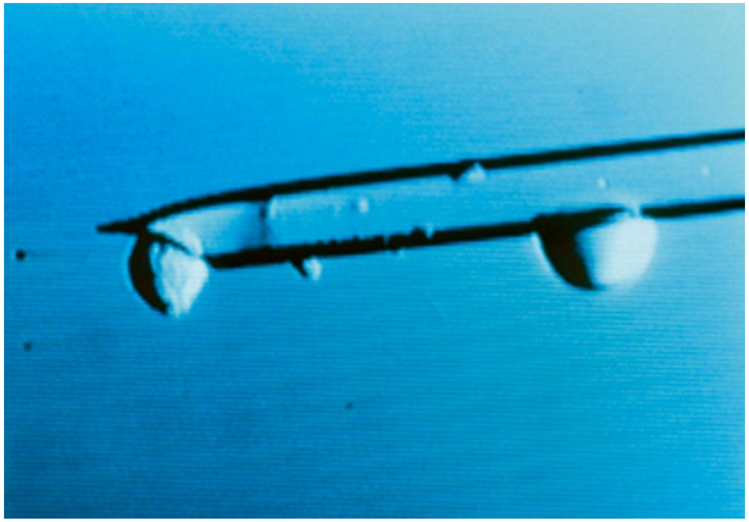
Cloning

- Making a genetically identical copy of an individual
- Researchers have been creating clones for decades
- These clones were created by embryo splitting

Cloning



1 A microneedle



2 The microneedle has emptied the sheep egg of its own nucleus.

3 DNA from a donor cell is about to be deposited in the enucleated egg.

4 An electric spark will stimulate the egg to enter mitotic cell division.

the first cloned sheep

Fig. 13-9, p.214

Cloning vs. Sexual Reproduction

Table 13.2 How Cloning Procedures Compare With Sexual Reproduction

Procedure	Starting material	Intermediate	Early stage	Result
Sexual Reproduction	Maternal DNA; Paternal DNA	fertilized egg	early embryo	Individual with mix of parental traits
Embryo Cloning	Maternal DNA; Paternal DNA	fertilized egg	artificial splitting of early embryo	Identical twins with same mix of parental traits
Adult Cloning (reproductive cloning)	Nucleus of cell from an adult	ball of cytoplasm (unfertilized egg stripped of nucleus)	early embryo	Genetically identical individual (clone of parent)
Therapeutic Cloning	Cell nucleus from adult organ (e.g., nerve, heart, muscle)	ball of cytoplasm (stem cell stripped of nucleus)		New, replacement tissue for nerves, heart, muscles, other organs