Biotechnology

This isn't a baaaaaaaaddd chapter!!! I'm funnier the 2nd time!!!

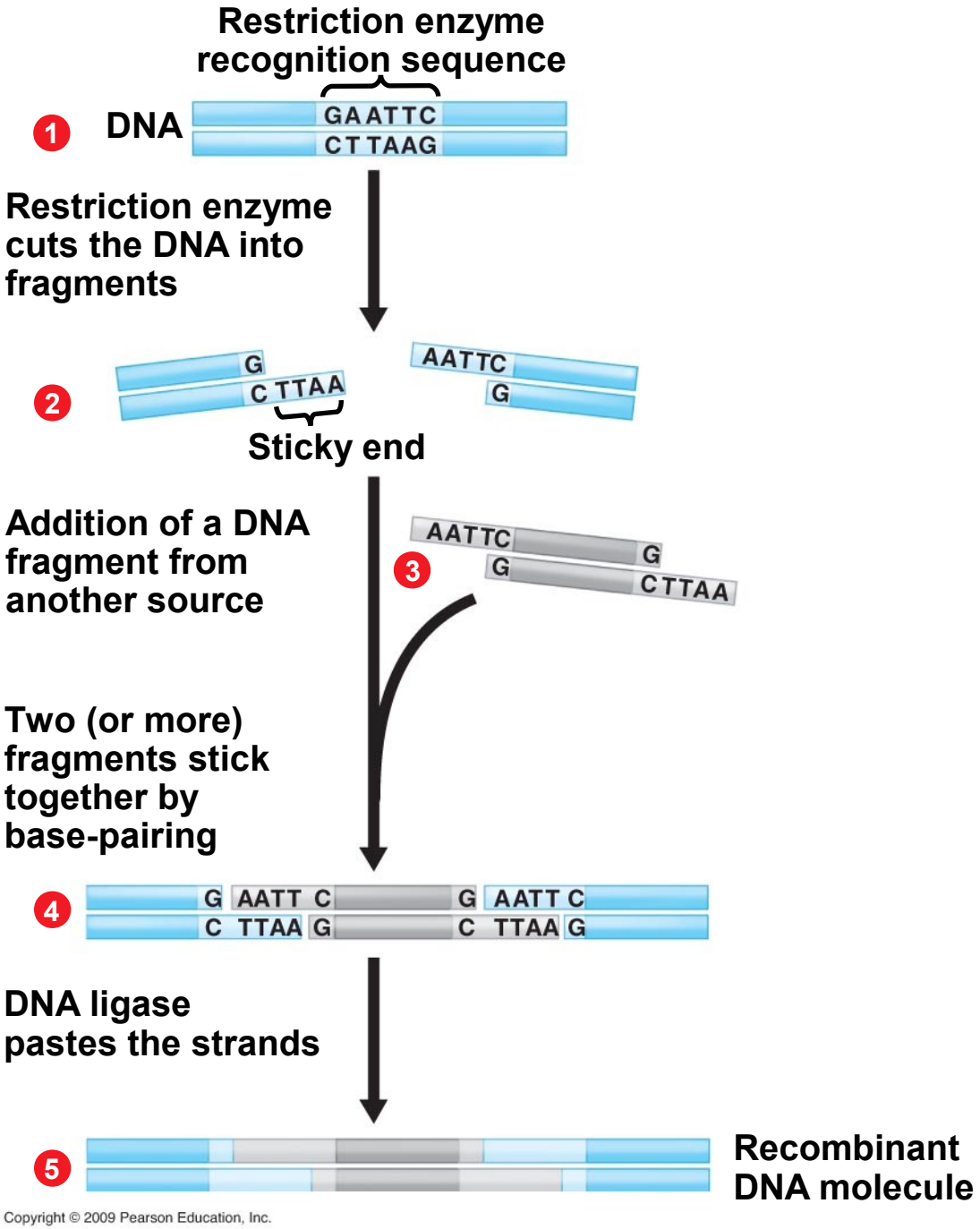
Genetic Engineering

- **Genetic engineering** involves manipulating genes for practical purposes
  - **Gene cloning** leads to the production of multiple identical copies of a gene-carrying piece of DNA
  - **Recombinant DNA** is formed by joining DNA sequences from two different sources

Enzymes are used to "cut and paste" DNA in order to recombine it!!!

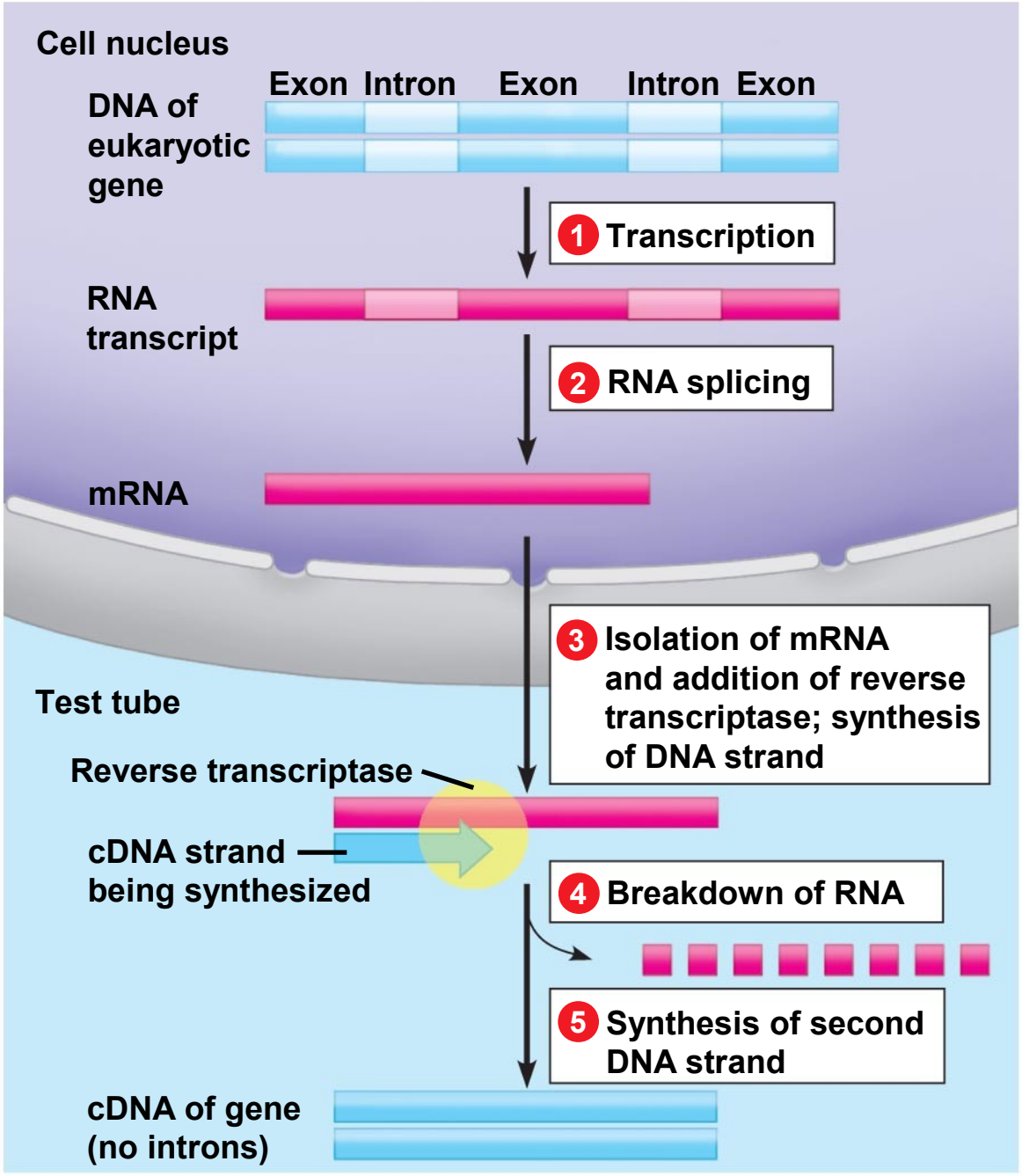
- **Restriction enzymes** cut DNA at specific sequences
  - Each enzyme binds to DNA at a different **restriction site**
  - Many restriction enzymes make staggered cuts that produce **restriction fragments** with single-stranded ends called "sticky ends"
  - Fragments with complementary sticky ends can associate with each other, forming recombinant DNA
- DNA ligase joins DNA fragments together

PLAY Animation: Restriction Enzymes



Reverse transcriptase can help make genes for cloning

- **Complementary DNA** (**cDNA**) is used to clone eukaryotic genes
  - mRNA from a specific cell type is the template
  - **Reverse transcriptase** produces a DNA strand from mRNA
  - DNA polymerase produces the second DNA strand



GENETICALLY MODIFIED ORGANISMS

Recombinant cells and organisms can mass produce gene products

- Cells and organisms containing cloned genes are used to manufacture large quantities of gene products

TABLE 12-6 SOME PROTEIN PRODUCTS OF RECOMBINANT DNA TECHNOLOGY

Product	Made In	Use
Human insulin	*E. coli*	Treatment for diabetes
Human growth hormone (HGH)	*E. coli*	Treatment for growth defects
Epidermal growth factor (EGF)	*E. coli*	Treatment for burns, ulcers
Interleukin-2 (IL-2)	*E. coli*	Possible treatment for cancer
Bovine growth hormone (BGH)	*E. coli*	Improving weight gain in cattle
Cellulase	*E. coli*	Breaking down cellulose for animal feeds
Taxol	*E. coli*	Treatment for ovarian cancer
Interferons (alpha and gamma)	*S. cerevisiae; E. coli*	Possible treatment for cancer and viral infections
Hepatitis B vaccine	*S. cerevisiae*	Prevention of viral hepatitis
Erythropoietin (EPO)	Mammalian cells	Treatment for anemia
Factor VIII	Mammalian cells	Treatment for hemophilia
Tissue plasminogen activator (TPA)	Mammalian cells	Treatment for heart attacks and some strokes

DNA technology has changed the pharmaceutical industry and medicine

- Products of DNA technology
  - Therapeutic hormones
    - Insulin to treat diabetes
    - Human growth hormone to treat dwarfism
  - Diagnosis and treatment of disease
    - Testing for inherited diseases
    - Detecting infectious agents such as HIV
  - Vaccines
    - Stimulate an immune response by injecting
      - Protein from the surface of an infectious agent
      - A harmless version of the infectious agent

CONNECTION
organisms a ure

- **Genetically mo** ntain one or more gen eans
- **Transgenic org** e gene from anoth
- GM plants
  - Resistance to
  - Resistance to
  - Improved nutr
- GM animals
  - Improved qua
  - Production of

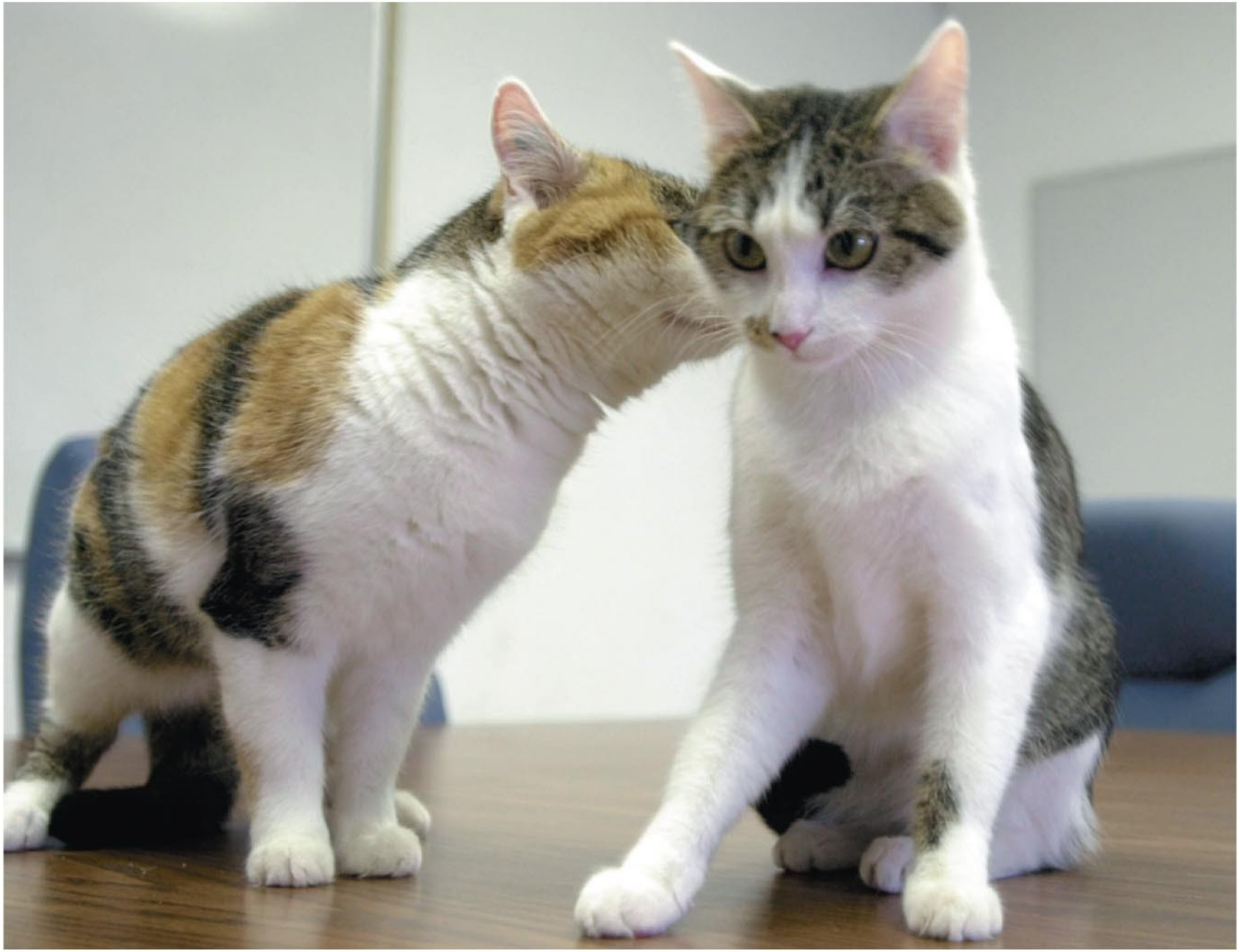
Cloning

- Clones
  - Exact copies of a molecule, cell, or individual
  - Occur in nature by asexual reproduction or embryo splitting (identical twins)

- **Reproductive cloning** technologies produce an exact copy (clone) of an individual

Reproductive cloning has valuable applications, but human reproductive cloning raises ethical issues

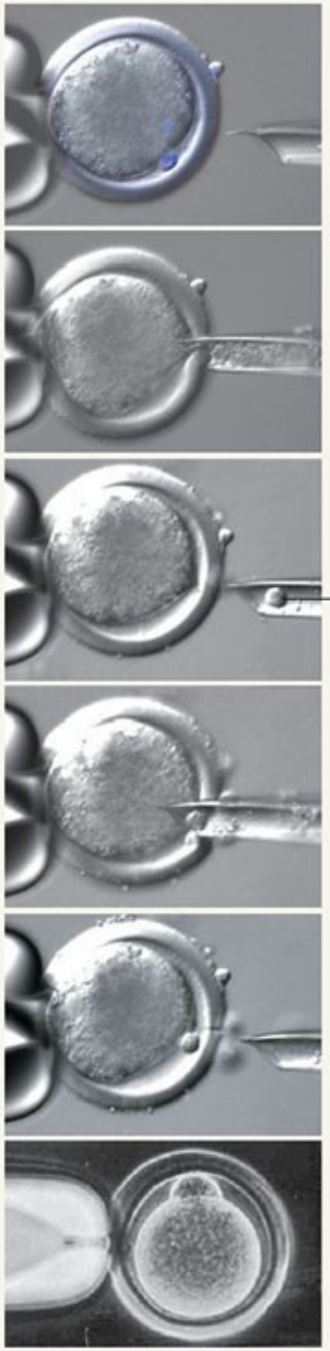
- Cloned animals can show differences from their parent due to a variety of influences during development
- Reproductive cloning is used to produce animals with desirable traits
  - Agricultural products
  - Therapeutic agents
  - Restoring endangered animals
- Human reproductive cloning raises ethical concerns



Reproductive Cloning Technologies

- **Somatic cell nuclear transfer (SCNT)**
  - Nuclear DNA of an adult is transferred to an enucleated egg
  - Egg cytoplasm reprograms differentiated (adult) DNA to act like undifferentiated (egg) DNA
  - The hybrid cell develops into an embryo that is genetically identical to the donor individual

Somatic Cell Nuclear Transfer (SCNT)



A A cow egg is held in place by suction through a hollow glass tube called a micropipette. The polar body (Section 10.5) and chromosomes are identified by a *purple* stain.

B A micropipette punctures the egg and sucks out the polar body and all of the chromosomes. All that remains inside the egg's plasma membrane is cytoplasm.

C A new micropipette prepares to enter the egg at the puncture site. The pipette contains a cell grown from the skin of a donor animal.

skin cell

D The micropipette enters the egg and delivers the skin cell to a region between the cytoplasm and the plasma membrane.

E After the pipette is withdrawn, the donor's skin cell is visible next to the cytoplasm of the egg. The transfer is complete.

F The egg is exposed to an electric current. This treatment causes the foreign cell to fuse with and empty its nucleus into the cytoplasm of the egg. The egg begins to divide, and an embryo forms. After a few days, the embryo may be transplanted into a surrogate mother.

A Clone Produced by SCNT

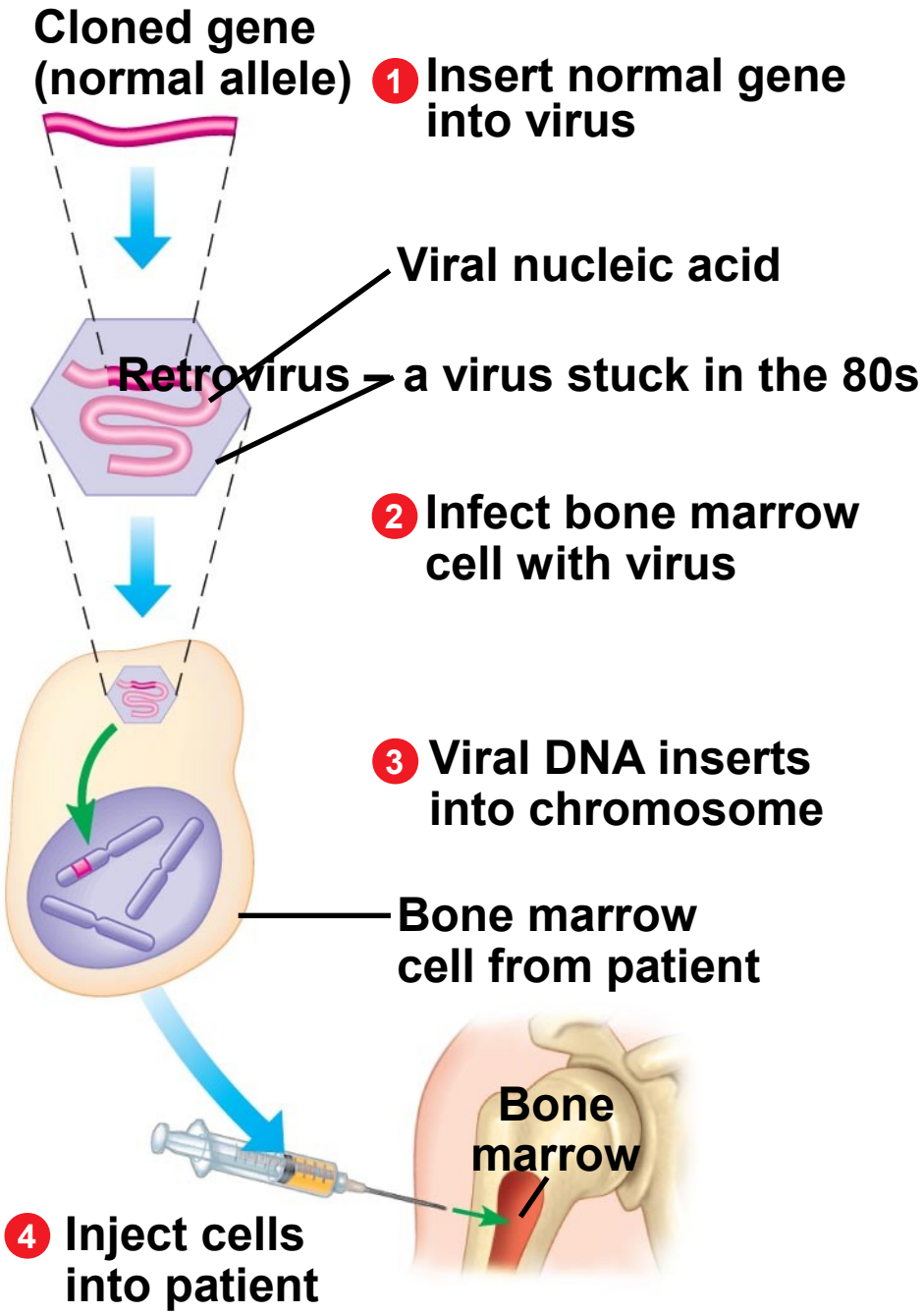
Therapeutic cloning can produce stem cells with great medical potential

- Stem cells can be induced to give rise to differentiated cells
  - Embryonic stem cells can differentiate into a variety of types
  - **Adult stem cells** can give rise to many but not all types of cells
- Therapeutic cloning can supply cells to treat human diseases
- Research continues into ways to use and produce stem cells

Gene Therapy & DNA Profiling

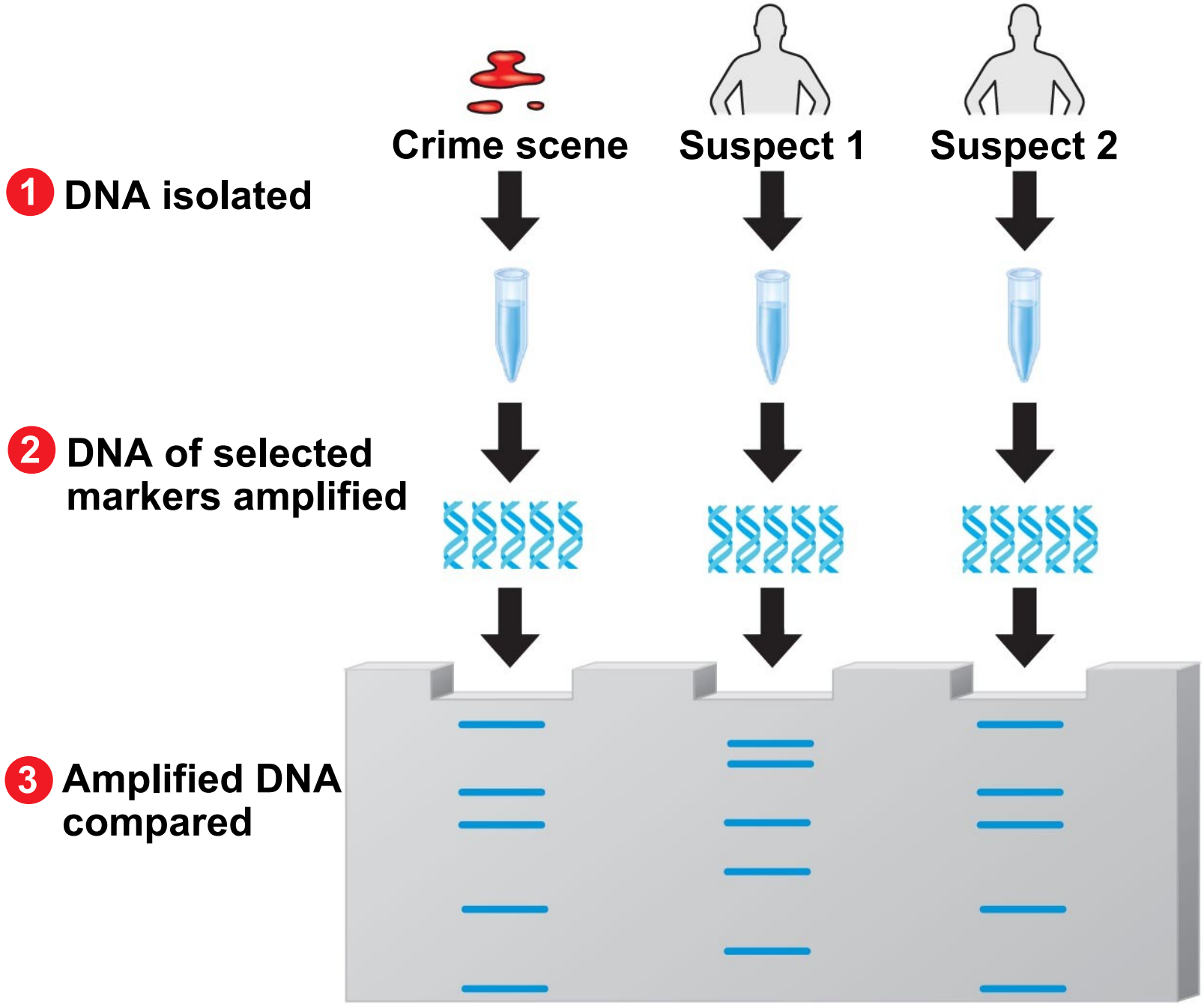
Gene therapy may someday help treat a variety of diseases

- **Gene therapy** aims to treat a disease by supplying a functional allele
- One possible procedure
  - Clone the functional allele and insert it into a virus
  - Use the virus to deliver the gene to an affected cell type from the patient, such as a bone marrow cell
  - Viral DNA and the functional allele will insert into the patient's chromosome
  - Return the cells to the patient for growth and division



The analysis of genetic markers can produce a DNA profile

- **DNA profiling** is the analysis of DNA fragments to determine whether they come from a particular individual
  - Compares genetic markers from noncoding regions that show variation between individuals
  - Involves amplification (copying) of markers for analysis – PCR!!!
  - Sizes of amplified fragments are compared



The PCR method is used to amplify DNA sequences

- **Polymerase chain reaction** (**PCR**) is a method of amplifying a specific segment of a DNA molecule. A way to make a DNA factory!!!
- Advantages of PCR
  - Can amplify DNA from a small sample
  - Results are obtained rapidly
  - Reaction is highly sensitive, copying only the target sequence

Gel electrophoresis sorts DNA molecules by size

- **Gel electrophoresis** separates DNA molecules based on size
  - DNA sample is placed at one end of a porous gel
  - Current is applied and DNA molecules move from the negative electrode toward the positive electrode
  - Shorter DNA fragments move through the gel pores more quickly and travel farther through the gel
  - DNA fragments appear as bands, visualized through staining or detecting radioactivity or fluorescence
  - Each band is a collection of DNA molecules of the same length

DNA profiling has provided evidence in many forensic investigations

- Forensics
  - Evidence to show guilt or innocence
- Establishing family relationships
  - Paternity analysis
- Identification of human remains
  - After tragedies such as the September 11, 2001, attack on the World Trade Center
- Species identification
  - Evidence for sale of products from endangered species

Genomics

Genomics is the scientific study of whole genomes

- **Genomics** is the study of an organism's complete set of genes and their interactions (the genome)
  - Initial studies focused on prokaryotic genomes
  - Many eukaryotic genomes have since been investigated
- Evolutionary relationships can be elucidated
  - Genomic studies showed a 96% similarity in DNA sequences between chimpanzees and humans

TABLE 12.17 SOME IMPORTANT COMPLETED GENOMES

Organism	Year Completed	Size of Genome (in Base Pairs)	Approximate Number of Genes
Haemophilus influenzae (bacterium)	1995	1.8 million	1,700
Saccharomyces cerevisiae (yeast)	1996	13 million	6,200
Escherichia coli (bacterium)	1997	4.6 million	4,400
Caenorhabditis elegans (nematode)	1998	97 million	19,000
Drosophila melanogaster (fruit fly)	2000	180 million	13,700
Arabidopsis thaliana (mustard plant)	2000	118 million	25,500
Mus musculus (mouse)	2001	2.6 billion	22,000
Oryza sativa (rice)	2002	430 million	60,000
Homo sapiens (humans)	2003	3.2 billion	21,000
Rattus norvegius (lab rat)	2004	2.8 billion	25,000
Pan troglodytes (chimpanzee)	2005	3.1 billion	22,000
Macaca mulatta (macaque)	2007	2.9 billion	22,000

The Human Genome Project revealed that most of the human genome does not consist of genes

- Goals of the **Human Genome Project** (**HGP**)
  - To determine the nucleotide sequence all DNA in the human genome
  - To identify the location and sequence of every human gene

The Human Genome Project revealed that most of the human genome does not consist of genes

- Results of the Human Genome Project
  - Humans have 21,000 genes in 3.2 billion nucleotide pairs
  - Only 1.5% of the DNA codes for proteins, tRNAs, or rRNAs
  - The remaining 98.5% of the DNA is "junk DNA"
    - If 98% of our genetic information (or "genome") isn't coding for protein, what is it for?
    - Intergenic DNA seems to play a key role in regulation, that is, controlling which genes are turned "on" or "off" at any given time.
    - Other functions of junk DNA? They are currently being explored!

Proteomics is the scientific study of the full set of proteins encoded by a genome

- **Proteomics**
  - Studies the proteome, the complete set of proteins specified by a genome
  - Investigates protein functions and interactions
- The human proteome may contain 100,000 proteins

EVOLUTION: Genomes hold clues to the evolutionary divergence of humans and chimps

- Comparisons of human and chimp genomes
  - Scientists have sequenced the genome of the chimpanzee and found that humans are 96 percent similar to the great ape species.
  - Genes showing rapid evolution in humans
    - Genes for defense against malaria and tuberculosis
    - Gene regulating brain size (The size of human brain tripled over a period of 2 million years)