Chapter 11: Biotechnology

Important Concepts

- Recombinant DNA technology has changed the way medicines are made
- Genetically modified organisms (GMOs) are made using DNA technologies
- New genomic technologies (bioinformatics) are changing our society (personalized medicine)
- Organismal cloning possibilities? Human cloning?

Biotechnology

- the use of biological organisms to produce useful products/processes
- modern biotech: genetic changes are known and specific

Advantages

- increase food yield, decrease cost, decrease spoilage
- less pesticide use, less soil erosion
- potentially increase nutritional value
- increase medical treatment (edible cholera/malaria vaccine)

Disadvantages

- long term ecological effects on natural plant populations
- potential long term human health effects (none so far after 25 years of testing)

Recombinant DNA technology

- human and pig insulin are different by one amino acid
- pig insulin injection causes body to produce antibodies against insulin (severe side effects)
- 1980s: discovery of recombinant DNA tech revolutionized human medicine and disease treatment

Key Discoveries

- bacterial enzymes that cut DNA (*restriction* enzymes at specific sequences) (eg. EcoRV)
- bacterial enzymes that glue (ligate) DNA back together (eg. DNA ligase)
- small bacterial circular DNA molecules (eg. plasmids)

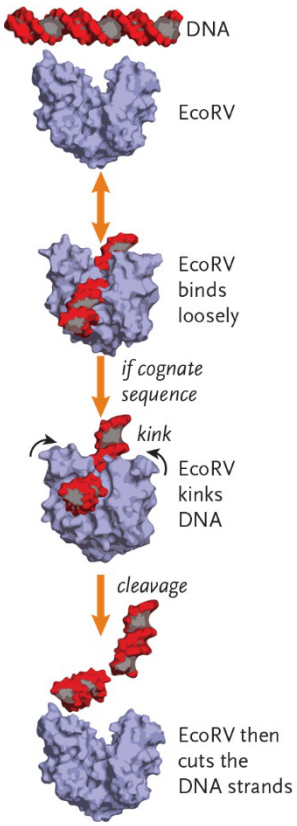

FIGURE 11.8 The restriction enzyme EcoRV, cutting DNA. Restriction endonucleases recognize the three-dimensional shape of short DNA sequences and cut the sequence in a predictable way. Like all enzymes, they follow the lock-and-key mechanism with their substrate.

SOURCE: I, Thomas Splettstoesser, http://commons.wikimedia.org/wiki/File:EcoRV_cleaving_DNA.png. This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license, http://creativecommons.org/licenses/by-sa/3.0/deed.en

FIGURE 11.7 **(a)** Plasmids can be isolated from many types of microbes. **(b)** Engineered plasmids are designed for use in molecular biology labs. The map of the plasmid shown in (b) highlights the multiple cloning site on the right.

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Professor Stanley N. Cohen / Science Source

Key Points

- DNA is DNA, regardless of what organism it comes from
- can put human DNA (genes) into bacteria and bacteria will produce gene product

Key Experiment

- isolate human insulin gene
- insert human insulin gene into bacterial plasmid
- have bacteria make human insulin
- purify human insulin from bacteria and inject into patients

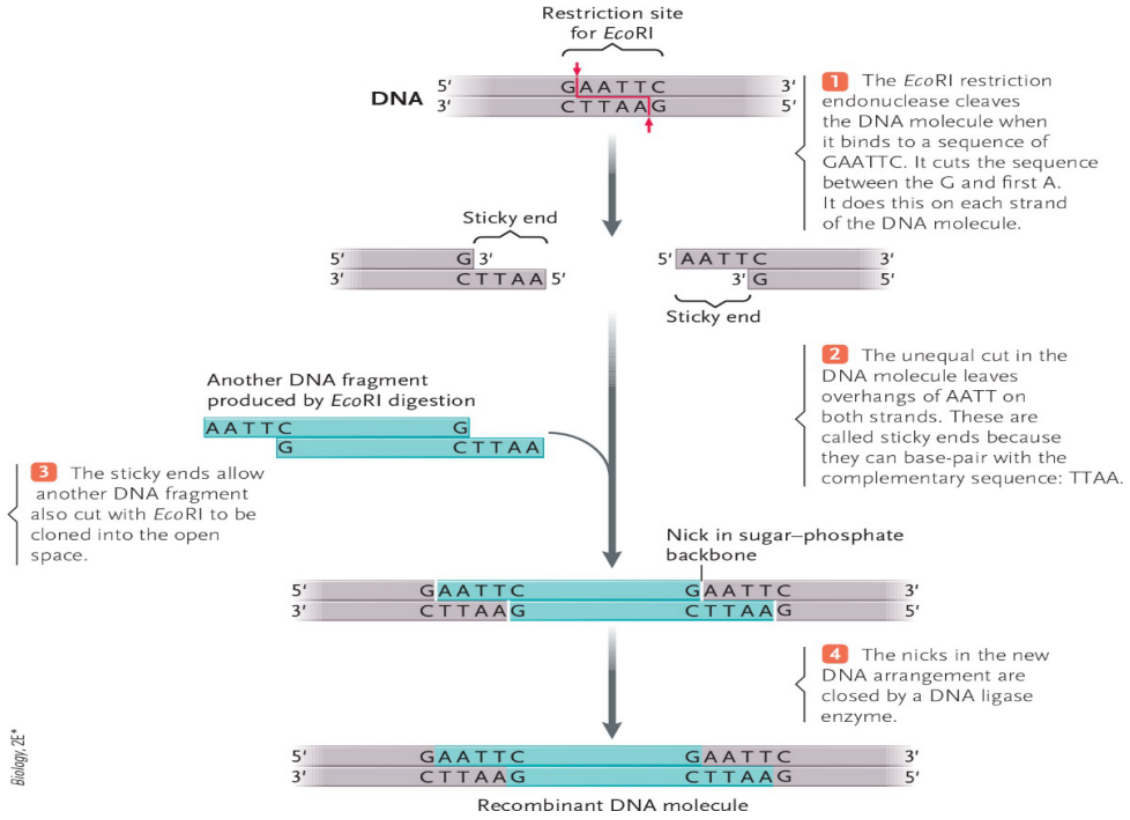

FIGURE 11.9 Restriction endonucleases can be used to open one DNA molecule so that a second fragment can be cloned into the gap.

Genetically Modified Organisms (GMOs)

- similar processes done for all organisms *Isolate gene* ⇒ *Inject gene into organism* (*transgenic*) ⇒ *Grow transgenic organism*

Traditional biotechnology	Modern biotechnology
• genetic changes are unkown • takes long time • limited applications apart from food	• genetic changes are known • takes shorter time • unlimited applications

Genomic Technologies (personalized medicine)

- DNA sequencing of many organisms has allowed for better understanding on role of genes in human disease (bioinformatics)
- obtaining individual DNA sequences will allow for better diagnosis and treatment/prevention of disease
- whole individual genome sequencing (all 6billion DNA bp) costs ~$5k today, ~1k in a few years

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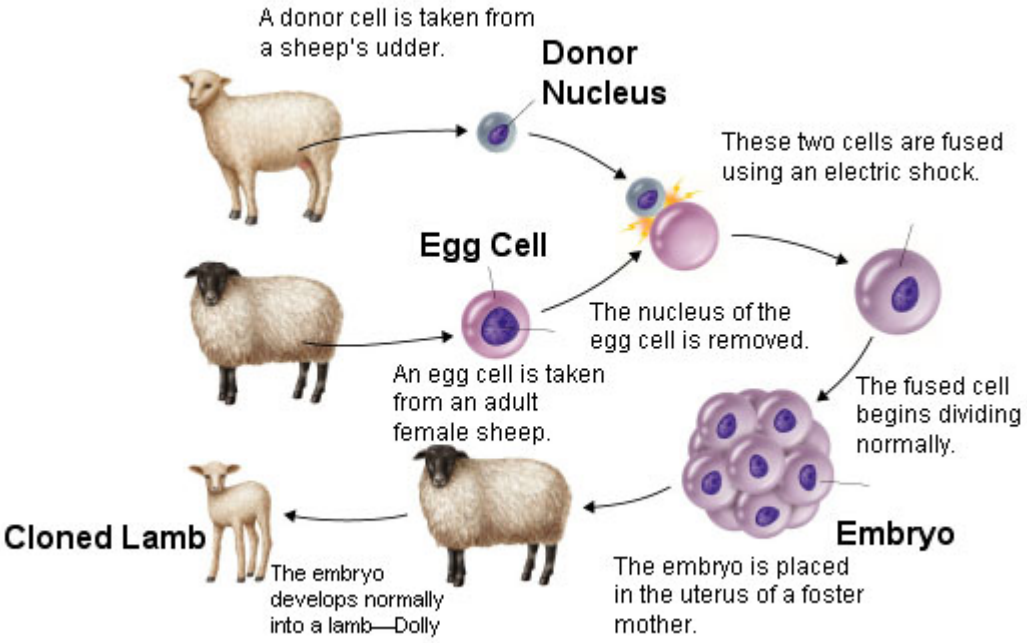
Organism Cloning

- plants can regenerate themselves from a cutting/twig (clone)
- genetically indentical as parent

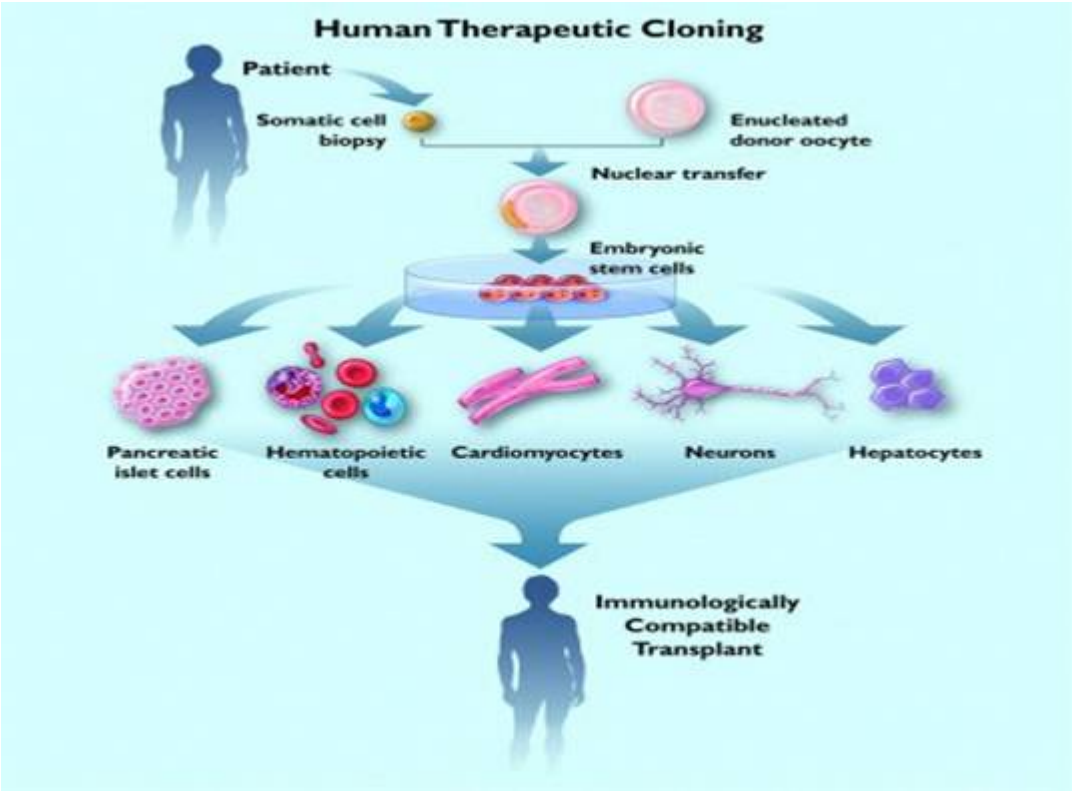
Animal Cloning?

- need DNA (nucleus) from individual you want to clone
- need a fetilized egg to develop
- need to replace DNA (nucleus) in egg with DNA from individual
- need to grow up embryo in surrogate female



Therapeutic Human Cloning

- **Stem cells** can give rise to many different tissues


Human Therapeutic Cloning
Patient
Somatic cell biopsy
Enucleated donor oocyte
Nuclear transfer
Embryonic stem cells
Pancreatic islet cells
Hematopoietic cells
Cardiomyocytes
Neurons
Hepatocytes
Immunologically Compatible Transplant