本講座內容主要介紹現代生物技術及人類基因體計畫。所謂DNA技術，包括基因工程（也稱之為遺傳工程、重組DNA技術等）及其他用於研究及操作DNA分子的方法，譬如DNA分子的選殖、分析、擴增和個體細胞整體基因表現的分析。DNA技術可應用在許多方面，包括農業、醫學及法學之刑事案件等各種領域，但最令人興奮的莫過於人類基因體計畫。人類基因體計畫的目標是繪製整個人類基因體DNA的核苷酸序列圖譜，核苷酸序列的解碼不但可以讓我們在基因層次去了解各種遺傳疾病，進而設計預防及治療方法。期望經由這一主題的介紹，能使同學更深入了解現代生物技術能被譽為第二工業革命。
• The transferred DNA is then integrated into the recipient cell's chromosome

![Image](12.1D)

12.2 Bacterial plasmids can serve as carriers for gene transfer

• An F factor is a DNA segment in bacteria that enables conjugation and contains an origin of replication

![Image](12.2A)

12.3 Plasmids are used to customize bacteria: An overview

• Plasmids are key tools for DNA technology
  – Researchers use plasmids to insert genes into bacteria

![Image](12.2B, C)

12.4 Enzymes are used to “cut and paste” DNA

• Restriction enzymes cut DNA at specific points
• DNA ligase “pastes” the DNA fragments together
• The result is recombinant DNA

![Image](12.4)

Figure 12.3

1. Bacterium
2. Bacterial chromosome
3. Plasmid
4. Cell containing gene of interest
5. DNA isolated

Figure 12.4

1. DNA
2. Restriction enzyme recognition sequence
3. Restriction enzyme cuts the DNA into fragments
4. DNA ligase
5. DNA ligase joins the DNA fragments

Figure 12.5

1. Gene for pest resistance inserted into plants
2. Clones of cell
3. Gene inserted into bacteria
4. Recombinant bacterium
5. Recombinant DNA molecule

Figure 12.6
12.5 Genes can be cloned in recombinant plasmids: A closer look

- Bacteria take the recombinant plasmids and reproduce
- This clones the plasmids and the genes they carry
  - Products of the gene can then be harvested

12.6 Cloned genes can be stored in genomic libraries

- Recombinant DNA technology allows the construction of genomic libraries
  - Genomic libraries are sets of DNA fragments containing all of an organism’s genes
- Copies of DNA fragments can be stored in a cloned bacterial plasmid or phage

12.8 Nucleic acid probes identify clones carrying specific genes

- A nucleic acid probe can tag a desired gene in a library

OTHER TOOLS OF DNA TECHNOLOGY

12.7 Reverse transcriptase helps make genes for cloning

- Reverse transcriptase can be used to make smaller cDNA libraries
  - These contain only the genes that are transcribed by a particular type of cell
• DNA probes can identify a bacterial clone carrying a specific gene

12.9 Connection: DNA microarrays test for the expression of many genes at once

• A labeled probe can reveal patterns of gene expression in different kinds of cells
• This technique may revolutionize the diagnosis and treatment of cancer

• DNA microarray

12.10 Gel electrophoresis sorts DNA molecules by size

• Restriction fragments of DNA can be sorted by size

12.11 Restriction fragment analysis is a powerful method that detects differences in DNA sequences

• Scientists can compare DNA sequences of different individuals based on the size of the fragments
• Radioactive probes are also used to make comparisons

1. Restriction fragment preparation
2. Gel electrophoresis
3. Blotting
4. Radioactive probe
5. Detection of radioactivity (autoradiography)

Figure 12.11C

12.12 The PCR method is used to amplify DNA sequences

• The polymerase chain reaction (PCR) can quickly clone a small sample of DNA in a test tube

1 2 3 4
Figure 12.12

12.13 Most of the human genome does not consist of genes

• The 23 chromosomes in the haploid human genome contain about 3 billion nucleotide pairs
  – This DNA is believed to include about 35,000 genes and a huge amount of noncoding DNA

1 2 3 4 5

12.14 The challenge of the human genome

• Much of the noncoding DNA consists of repetitive nucleotide sequences
  – One example includes telomeres at the end of the chromosomes

Figure 12.14A

• Barbara McClintock discovered that segments of DNA called transposons can move about within a cell’s genome

Figure 12.14B, C

• Corn transposons, detail

Figure 12.14D
• Transposon flower

12.14 Connection: The Human Genome Project is unlocking the secrets of our genes

• The Human Genome Project involves:
  – genetic and physical mapping of chromosomes
  – DNA sequencing
  – comparison of human genes with those of other species

12.15 Connection: DNA technology is used in courts of law

• DNA fingerprinting can help solve crimes

12.16 Connection: Recombinant cells and organisms can mass-produce gene products

• Recombinant cells and organisms are used to manufacture useful proteins

12.17 Connection: DNA technology is changing the pharmaceutical industry and medicine

• Hormones, cancer-fighting drugs, and new vaccines are being produced using DNA technology
  – This lab equipment is used to produce a vaccine against hepatitis B

• These sheep carry a gene for a human blood protein that is a potential treatment for cystic fibrosis

12.18 Connection: Recombinant cells and organisms can mass-produce gene products

• Recombinant cells and organisms are used to manufacture useful proteins

Table 12.16

• Recombinant cells and organisms are used to manufacture useful proteins

12.17 Connection: DNA technology is changing the pharmaceutical industry and medicine

• Hormones, cancer-fighting drugs, and new vaccines are being produced using DNA technology
  – This lab equipment is used to produce a vaccine against hepatitis B

Figure 12.16

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Figure 12.17
New genetic varieties of animals and plants are being produced

- A plant with a new trait can be created using the Ti plasmid

“Golden rice” has been genetically modified to contain beta-carotene

- This rice could help prevent vitamin A deficiency

Genetic engineering involves some risks

- Possible ecological damage from pollen transfer between GM and wild crops
- Pollen from a transgenic variety of corn that contains a pesticide may stunt or kill monarch caterpillars

Techniques for manipulating DNA have potential for treating disease by altering an afflicted individual’s genes

- Progress is slow, however
- There are also ethical questions related to gene therapy

Our new genetic knowledge will affect our lives in many ways

- The deciphering of the human genome, in particular, raises profound ethical issues
- Many scientists have counseled that we must use the information wisely
Major concerns:
I. Safety – risk for man and environment
   [ex. Genetic modified organism (GMO)]
II. Ethical considerations –
   1. Individual genetic information – human genome project
   2. Gene therapy – somatic cells vs germ cells
   3. Genetic manipulation
   4. Animal and human clone
   5. Stem cell therapy
   6. Military or terrorist use