CM4710 Biochemical Processes

An introduction to

1. Biochemical engineering as a subdiscipline
2. Microorganisms and biomolecules
3. Bioreactors and their analysis
4. Bioseparation unit operations
5. Genetic Engineering Basics / Applications

CM4710 Biochemical Processes

Instructors:	Dr. Shonnard
	Abraham Martin
Time:	12:05 - 12:55 MWF
Location:	room 102 CSEB

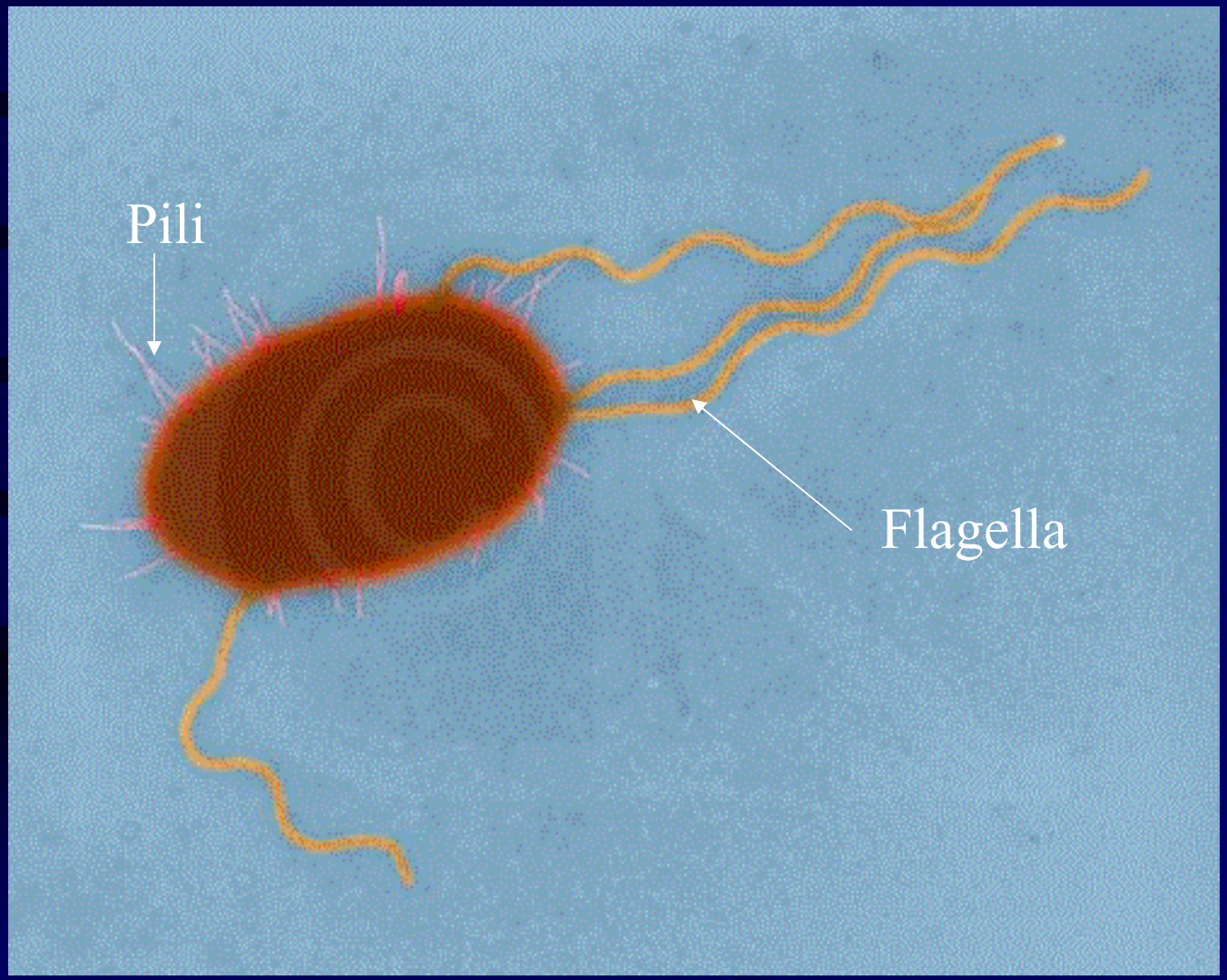
CM4710 Biochemical Processes

Advantages

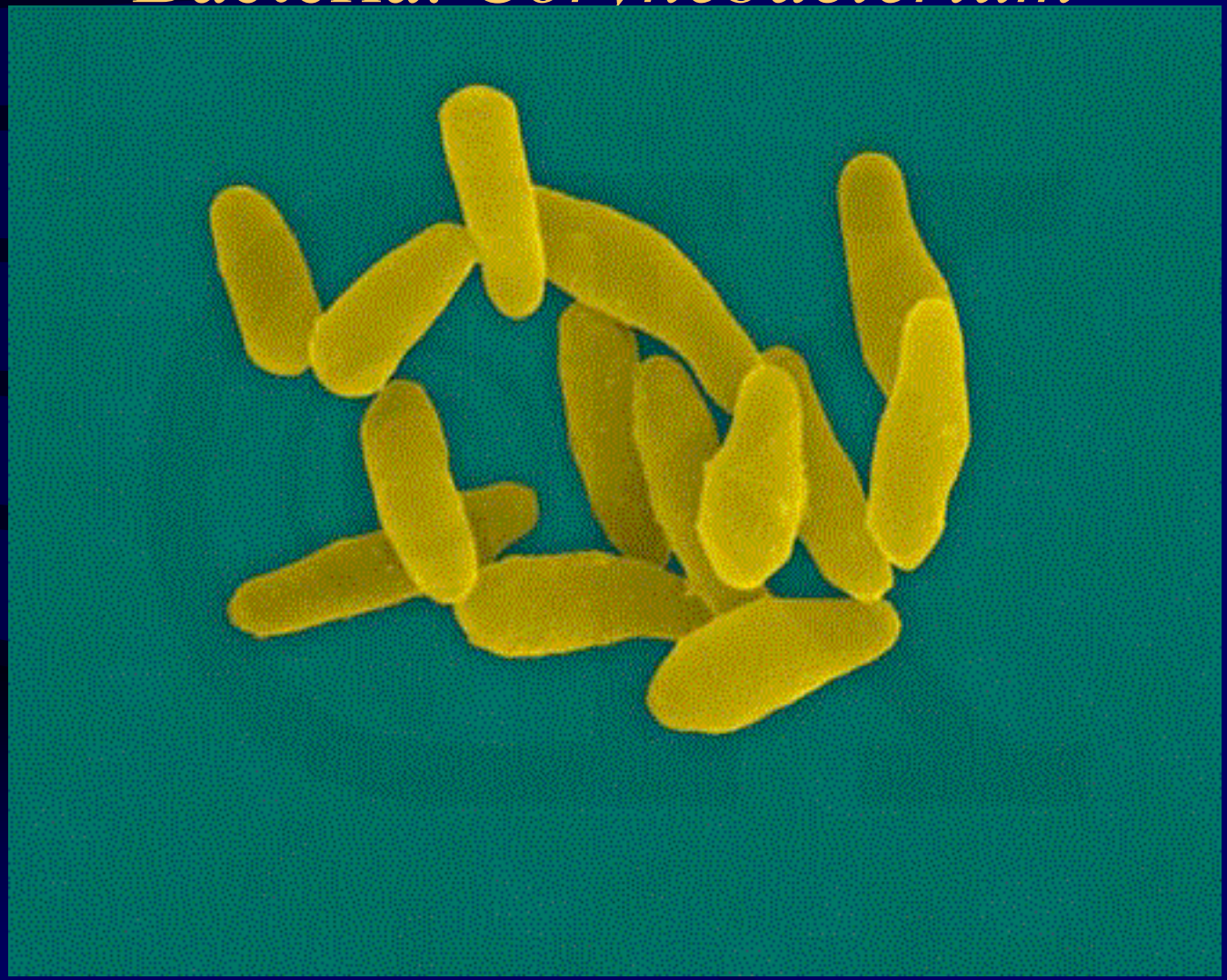
1. Become more specialized in an emerging high technology field

2. Open the door for positions in the pharmaceutical, biorenewables, and biomedical industries

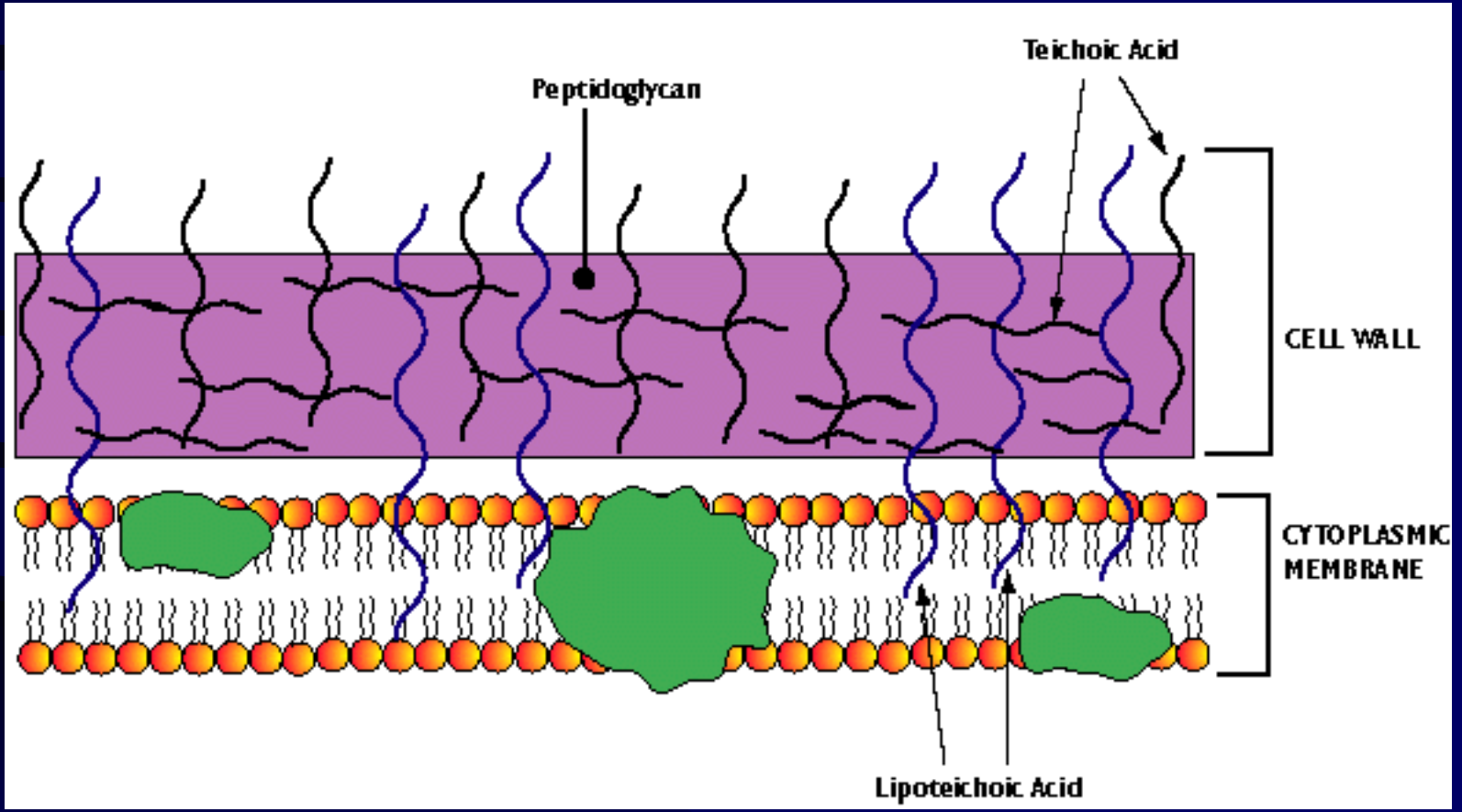
Bacteria: *E. coli*



Bacteria: *Corynebacterium*

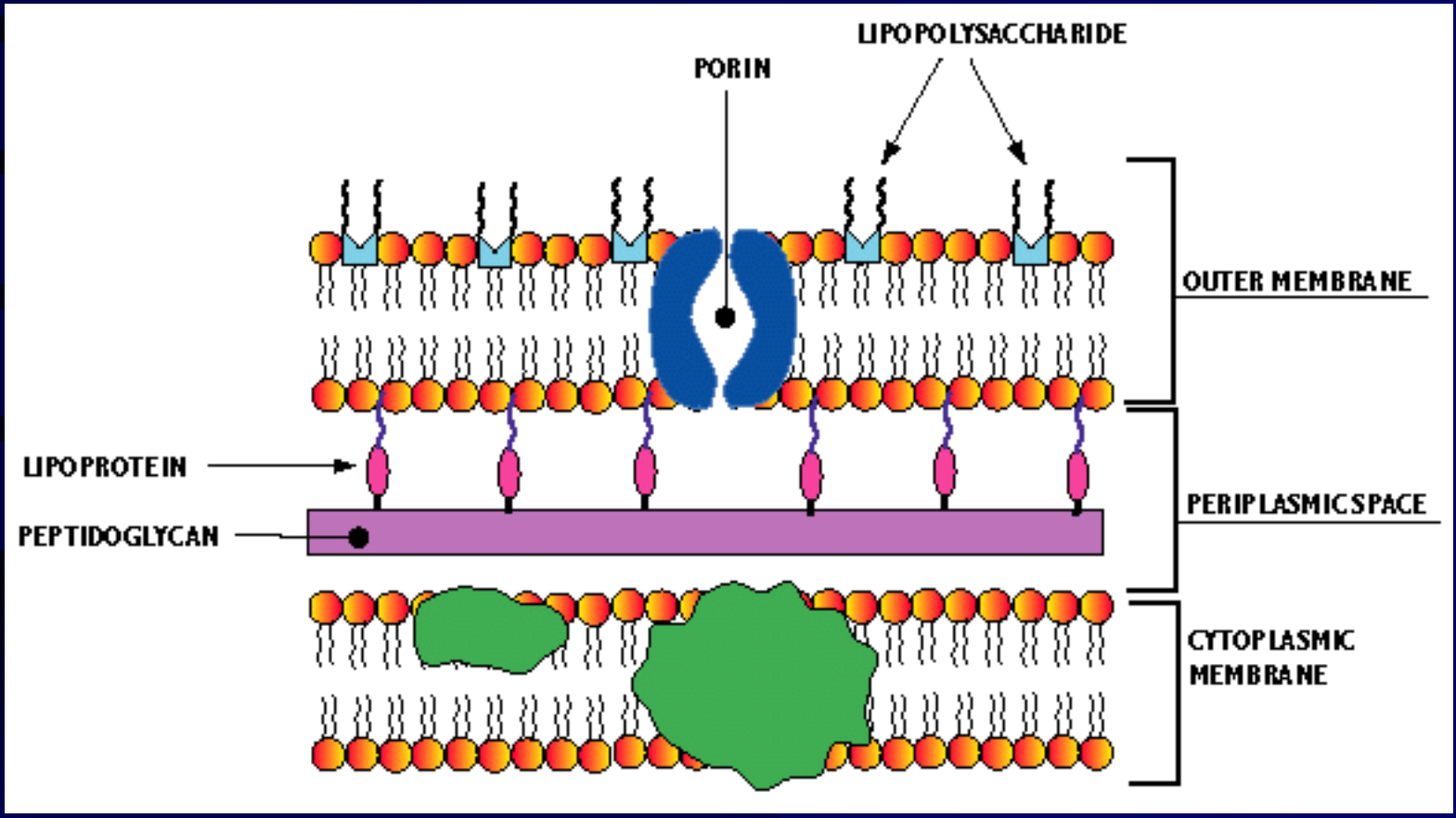


Bacteria: Gram + Cell Wall



Faculty Resource Center
Sylvester McKenna & Devabrata Mondal
Long Island University, Brooklyn Campus

Bacteria: Gram - Cell Wall



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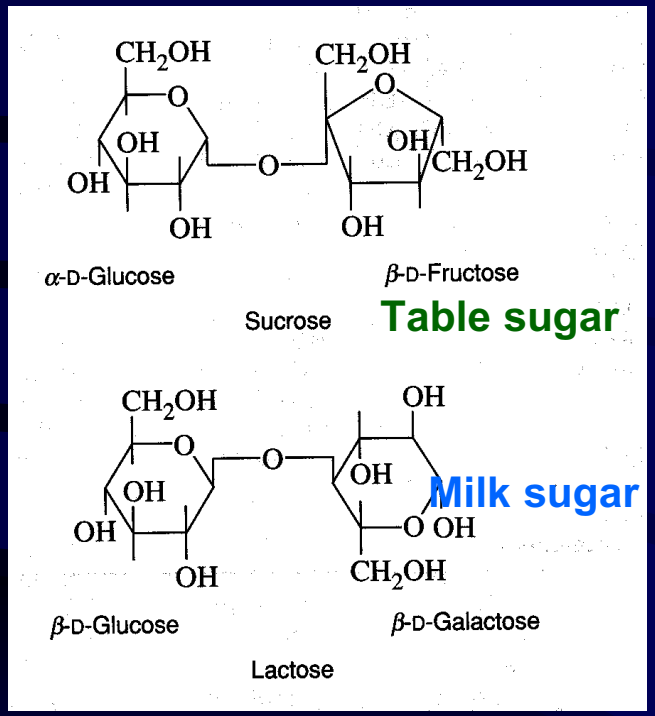
Long Island University, Brooklyn Campus

Disaccharides



Structure of Proteins

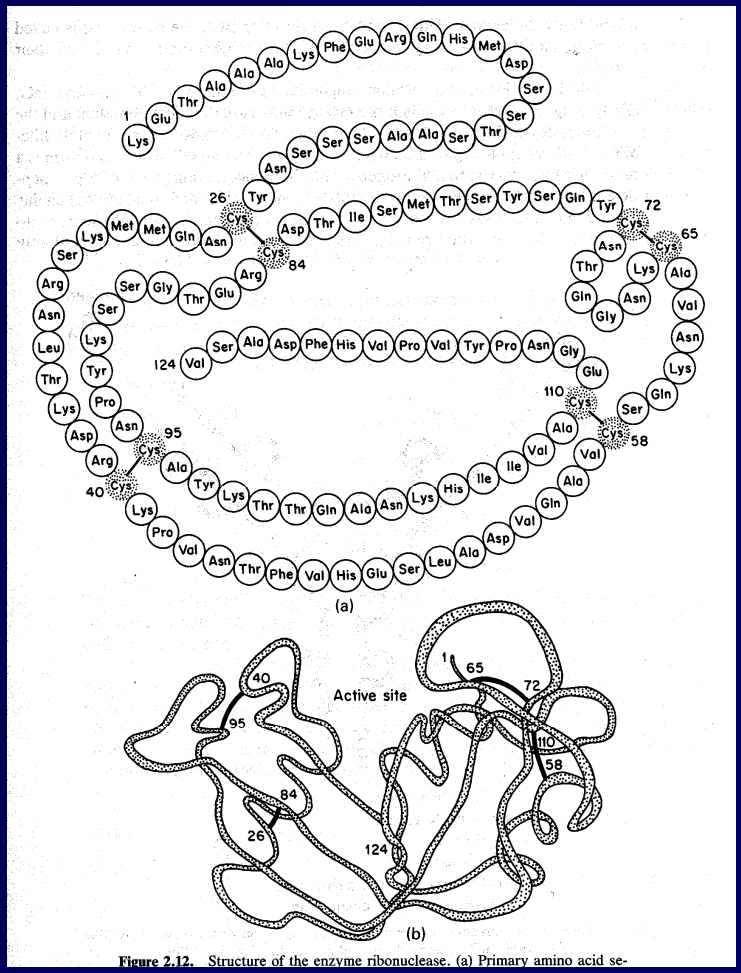


Figure 2.12. Structure of the enzyme ribonuclease. (a) Primary amino acid se-

Double Helix structure of DNA

DNA is always found in complimentary strands in a double helix having A matched with T and G matched with C. On *RNA*, U replaces T.

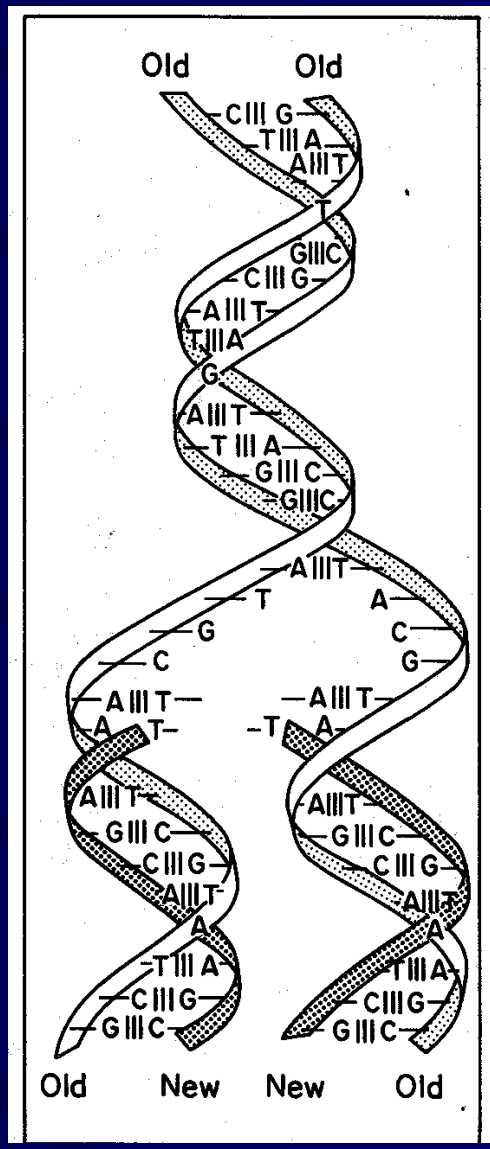


Figure 2.17. of DNA, sho replication by pairing. (Wit Brock, D. W gan, *Biology* ed., Prentice NJ, 1984, p.

Bioreactor Analysis

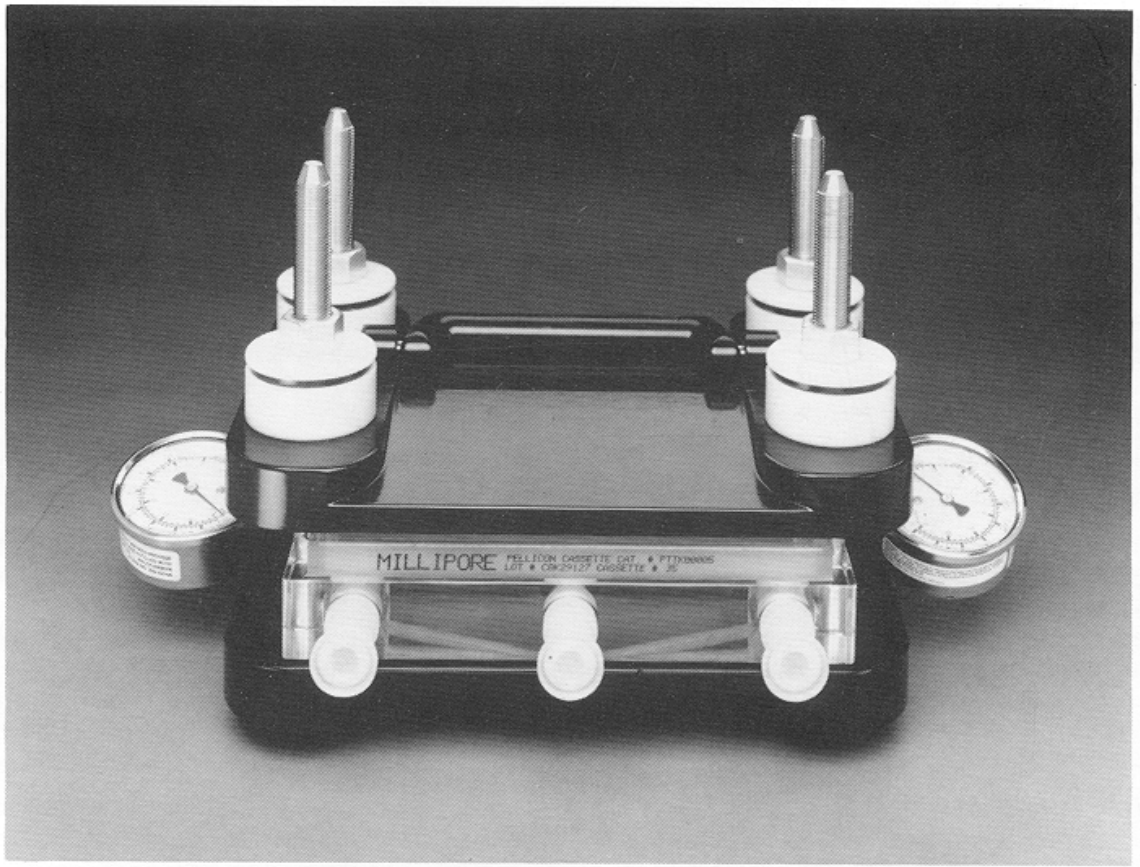
$$\frac{1}{X}\frac{dX}{dt} = \mu_{\max}\frac{S}{K_S + S}$$

$$\mu = D$$

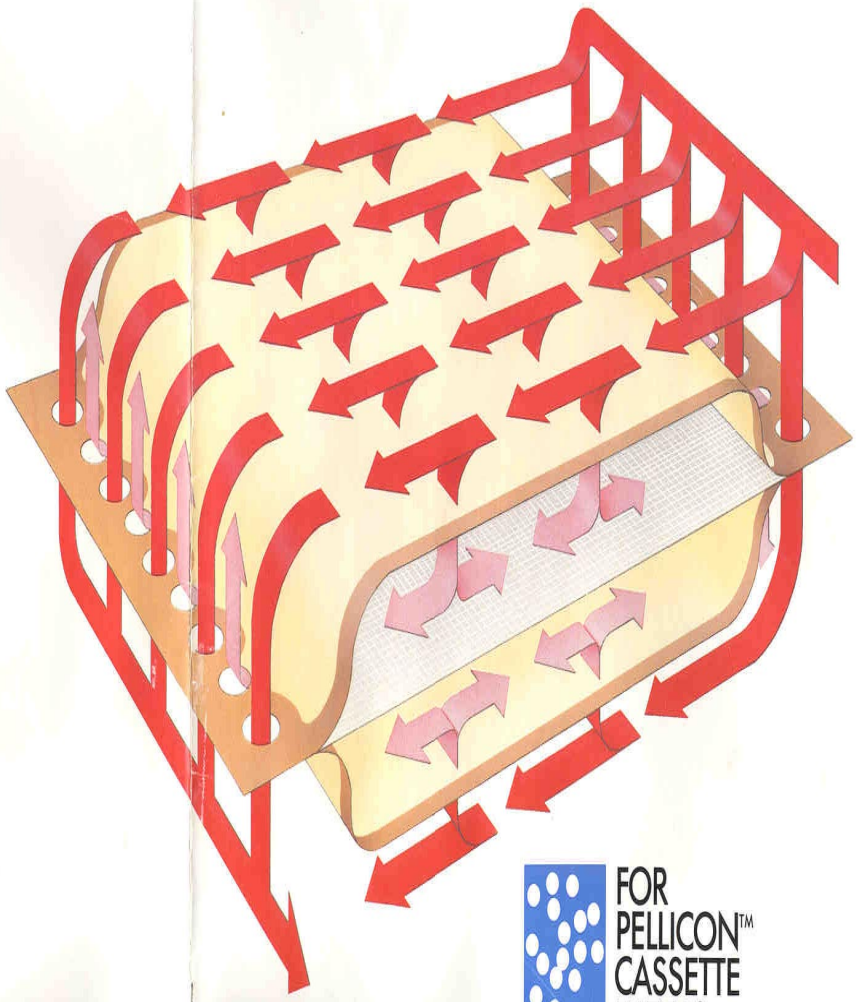
$$S = \frac{K_S D}{\mu_{\max} - D}$$

$$X = Y^M_{X/S}(S_o - \frac{K_S D}{\mu_{\max} - D})$$

Millipore Process Systems Division



MAINTENANCE PROCEDURES



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Recombinant DNA Cloning Procedure

1. Identify a cloning vector (Plasmid)
2. Identify a target DNA
3. Open up plasmid and target DNA using restriction endonuclease
4. Join target DNA with cloning vector
5. Introduce recombinant DNA construct into host cell
6. Isolate cells with cloned DNA

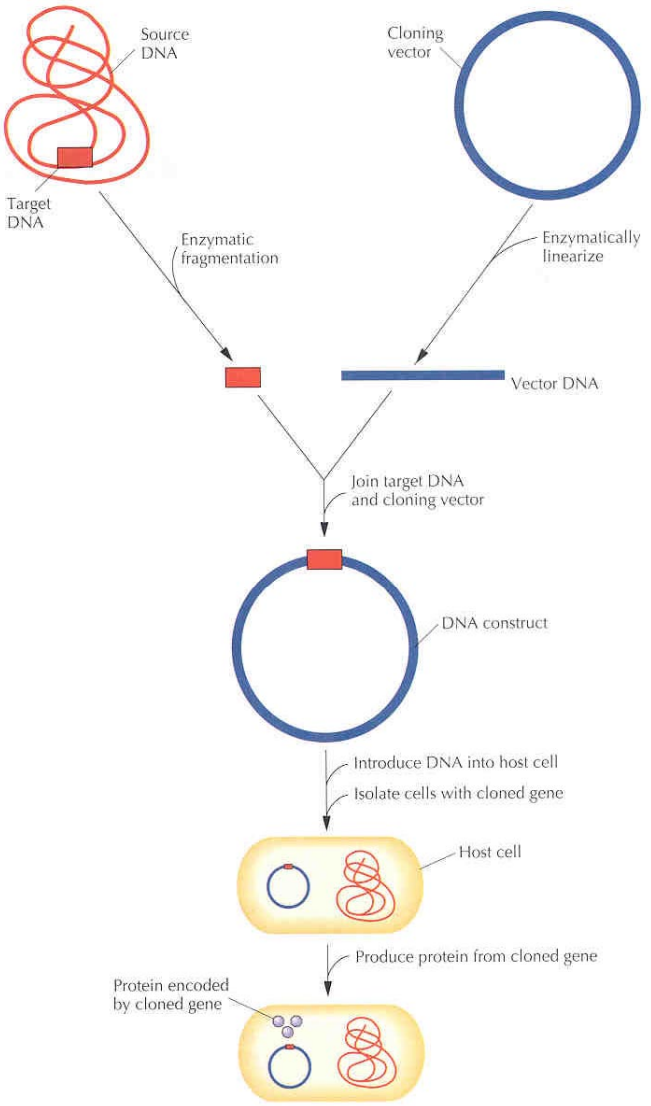

Figure 4.1 Recombinant DNA cloning procedure. DNA from a source organism is cleaved with a restriction endonuclease and inserted into a cloning vector. Then the cloning vector–insert DNA construct is introduced into a target host cell, and those cells that carry the construct are identified and grown. If required, the cloned gene can be expressed in the host cell and its protein can be produced and harvested.

Introduction to Biochemical Industry

Definition of Biochemical Processes

"A process that uses living cells or biomolecules to carry out a chemical transformation leading to the production and ultimate recovery of valuable products".

Short History of Biochemical Processes

- Ancient Uses of Microorganisms (Before 1800 A.D.)
  - Caveman to Earliest Recorded History --- aging of meats, cheeses, and alcoholic beverages.
  - Ancient Chinese and Japanese -- soy sauce from fermented beans.
  - Ancient Egyptians (2500 B.C.) -- malting of barley and beer fermentation.
  - Mesopotamian tablet records brewing of wine and beer are established professions in 2000 B.C.
  - Columbus lands in North America to find the native peoples drink beer made from corn.
  - Chinese use moldy soy bean curd to clear up skin infections (1000 B.C.)
  - Central American native peoples use fungi to treat infected wounds.
  - Middle Ages experimenters learn how to improve the taste of wine, bread, beer, and cheese.
- *Mankind did not know that these fermentation processes were being carried out by microscopic forms of life.*

Old Science (1800-1940)

- *From the discovery of the role of microscopic life in fermentations to the use of non-sterile fermentations in organic molecule synthesis.*

  - 1803 -- A French scientist, L.J. Thenard, announces that yeast used in wine making were alive and that they were responsible for the formation of alcohol. His findings were rejected by supporters of the conventional notion that fermentations were chemical processes only.

  - 1857 -- Louis Pasteur, another French Scientist, proves Thenard is correct. Showed that certain diseases are caused by microorganisms. Birth of modern Microbiology. Concludes that certain microorganisms are destroyed by other microorganisms and suggests that human disease could be cured by pitting microbe against microbe.

  - 1901 -- Rudolf Emmerich and Oscar Low, University of Munich, isolate a primitive antibiotic, pyocyanase, from *Pseudomonas aeruginosa*, a bacterium. Several hundred patients were successfully treated, but quality control was poor and pyocyanase was abandoned as too hazardous.

Old Science (1800-1940)

- 1900 - 1940
  - > Production of bakers yeast in deep, aerated tanks.
  - > World War I -- Chaim Weismann solves a serious British ammunition problem by converting corn maize mash into acetone, which is used in the manufacture of the explosive cordite.
  - > 1923 -- Pfizer opens the first commercial successful plant for citric acid production from sugar.
  - > 1928 -- Alexander Fleming discovers penicillin.
- > Simple organic molecules such as glycerol, lactic acid, and butanol are fermented on an industrial scale by fermentations

New Science (1940-late 1970s)

Fermentations of complex organic molecules requiring sterile conditions which protect the non-robust, highly selected microbial strains from competition by other microorganisms

- 1940 -- Drs. Howard Flory and Ernst Chain (England) and three American pharmaceutical companies (Merck, Pfizer, and Squibb) mass produce penicillin for WW II effort.

- Pioria Illinois -- 1940's, government worker discovers a new strain of *Penicillium* on a moldy cantaloupe which can produce 200 times more penicillin than Fleming's strain.

- Selman A. Waksman of Rutgers University discovers a new antibiotic, streptomycin, for the treatment of tuberculosis.

- Fermentive syntheses of amino acids, vitamins, cortisone, nucleic acids, polysaccharides, and enzymes.

Era of Molecular Biology (late 1970s-Present)

1973 Herbert Boyer (University of California, San Francisco) and Stanley Cohen (Stanford University) establish recombinant DNA technology

http://web.mit.edu/invent/iow/boyercohen.html

The discovery of recombinant DNA technology and the birth of genetic engineering allows for the efficient production of compounds not indigenous to the host microorganism.

Biochemical Engineering as a Discipline

Work in a team environment with chemists, biochemists, microbiologists, and chemical engineers.

- Steps in the development of a new biochemical process and roles professionals play.
  - 1. Identify a desired reaction or product (chemist, biochemist).
  - 2. Identify key enzyme(s) or microorganism (biochemist, microbiologist).
  - 3. Process development (chemist, biochemist, microbiologist, chemical engineer).
  - 4. Design of bioreactor and recovery unit operations (chemical engineer).
  - 5. Metabolic Engineering: application of engineering analysis to metabolic pathways within microorganisms to improve product yields.