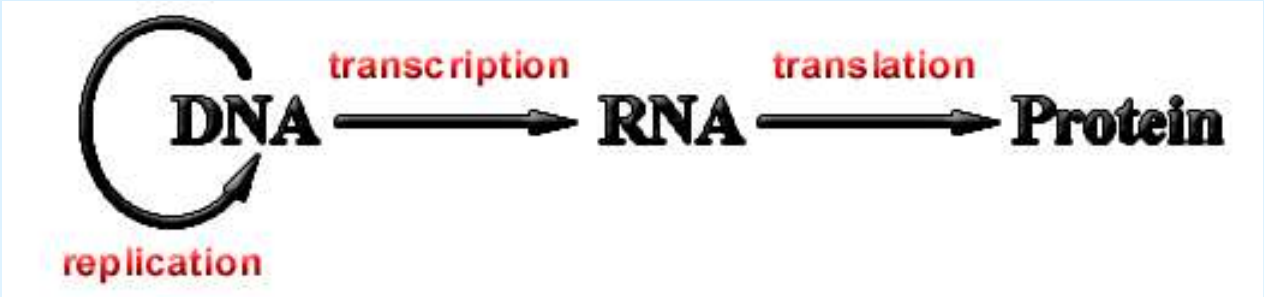
Review of DNA, RNA, protein synthesis; structure and growth of bacteria

March 30, 2004

“Central Dogma”



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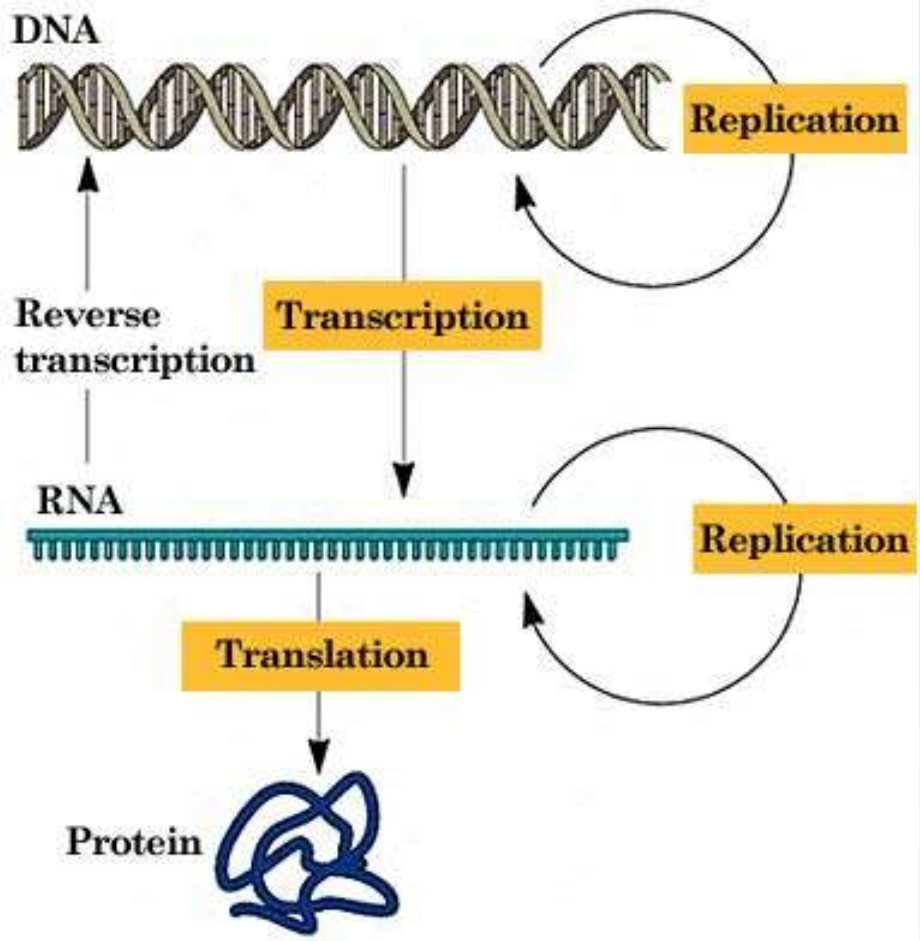
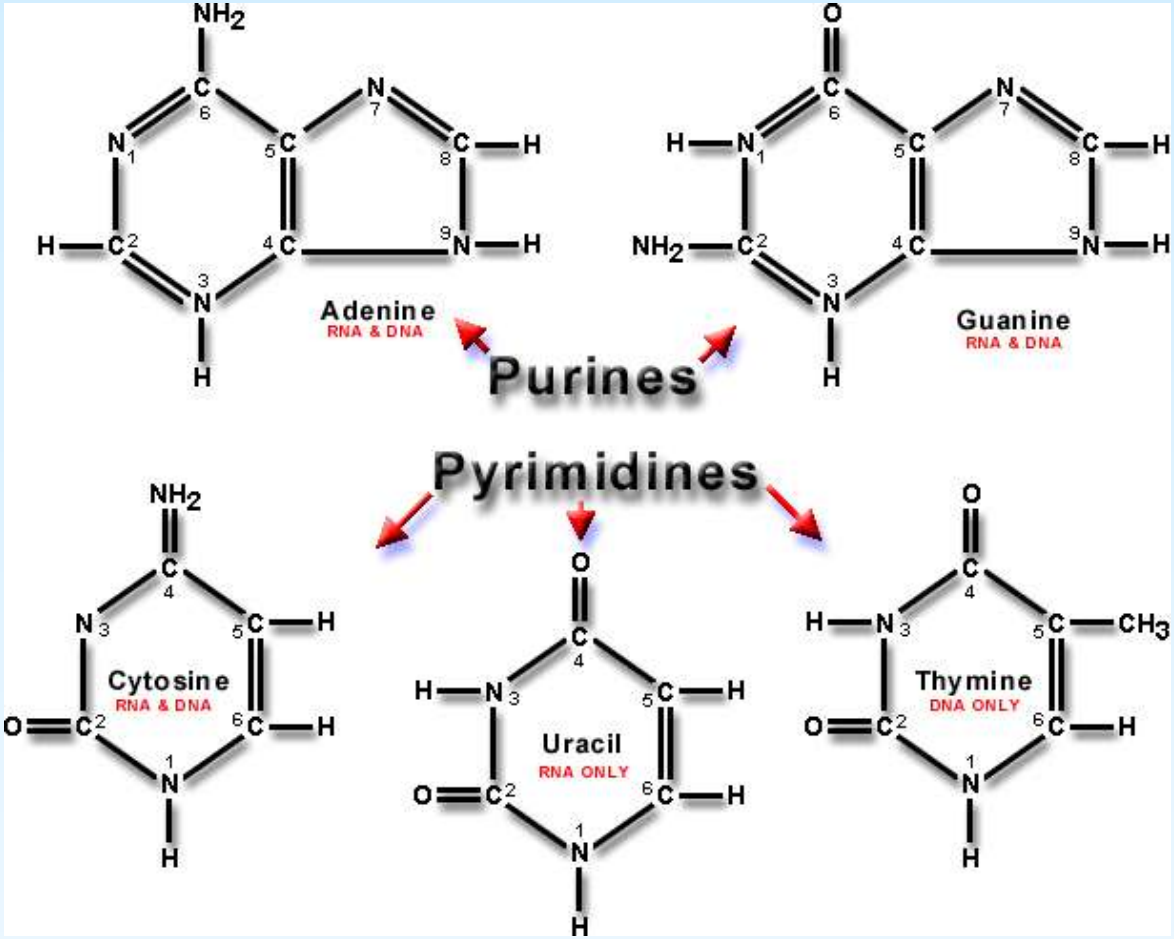
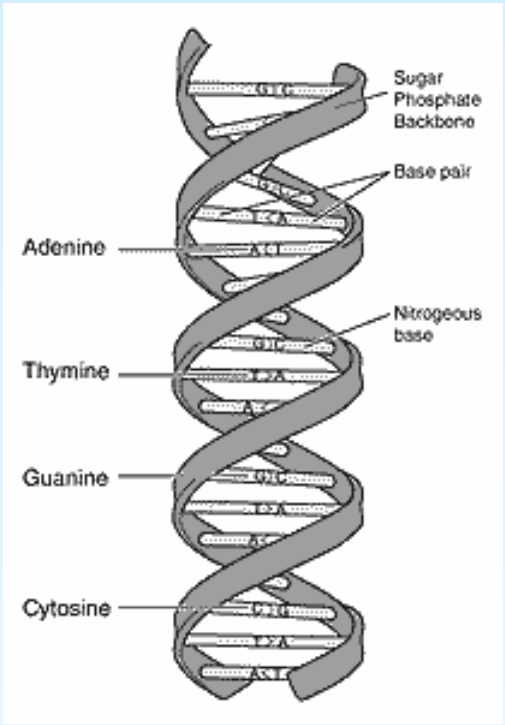
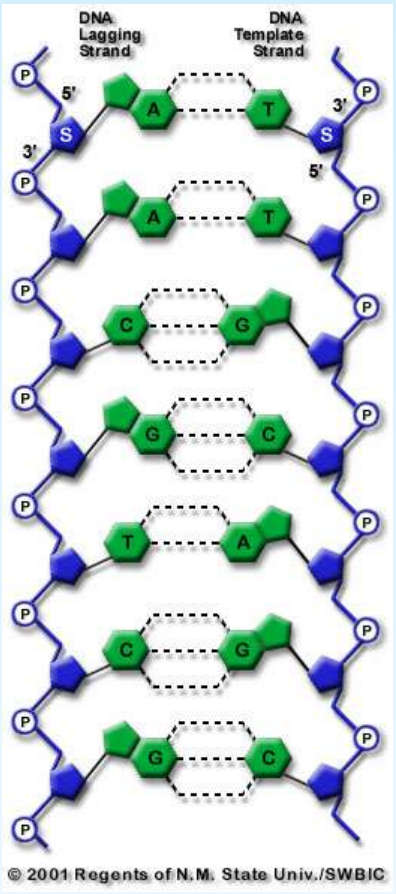


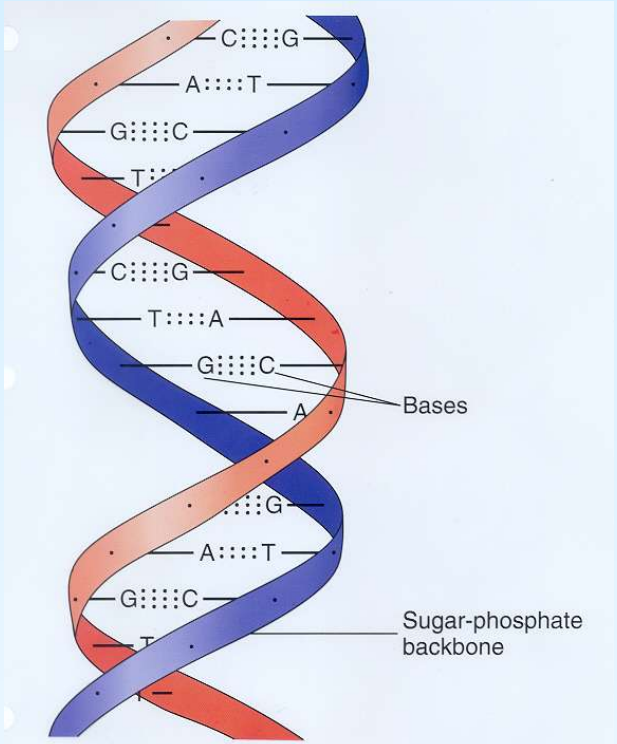
Nucleotide Bases



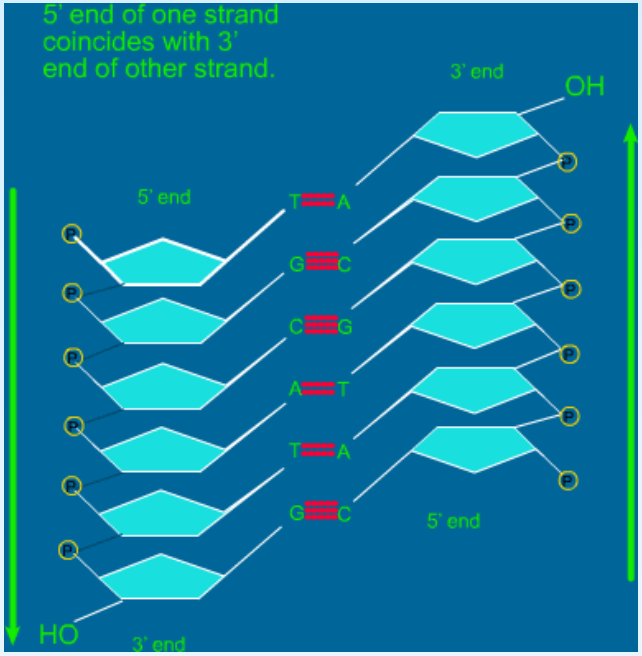
DNA Structure

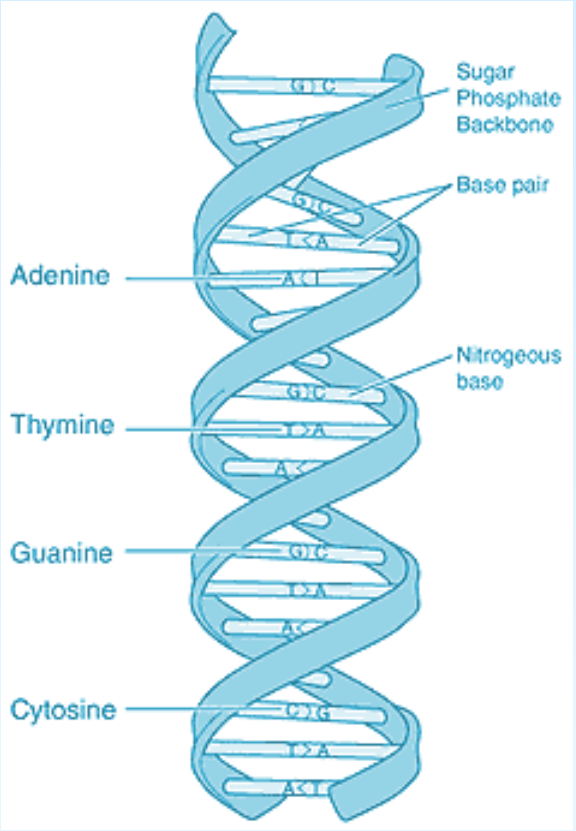




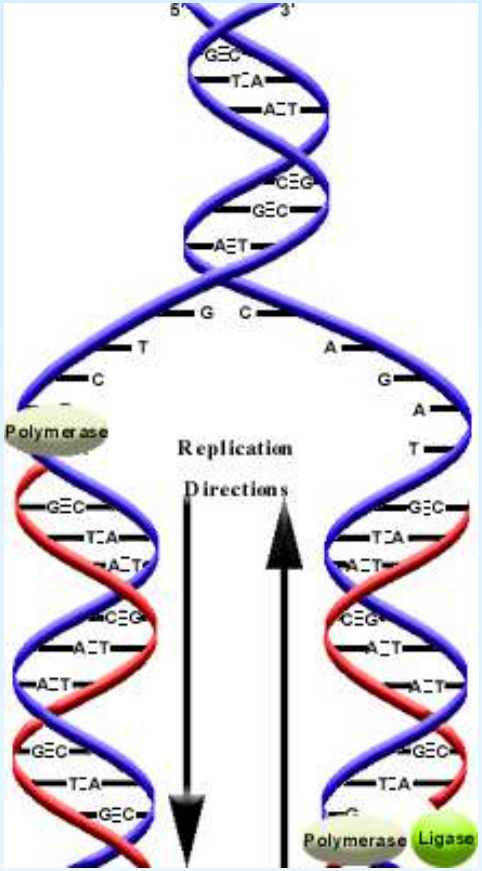


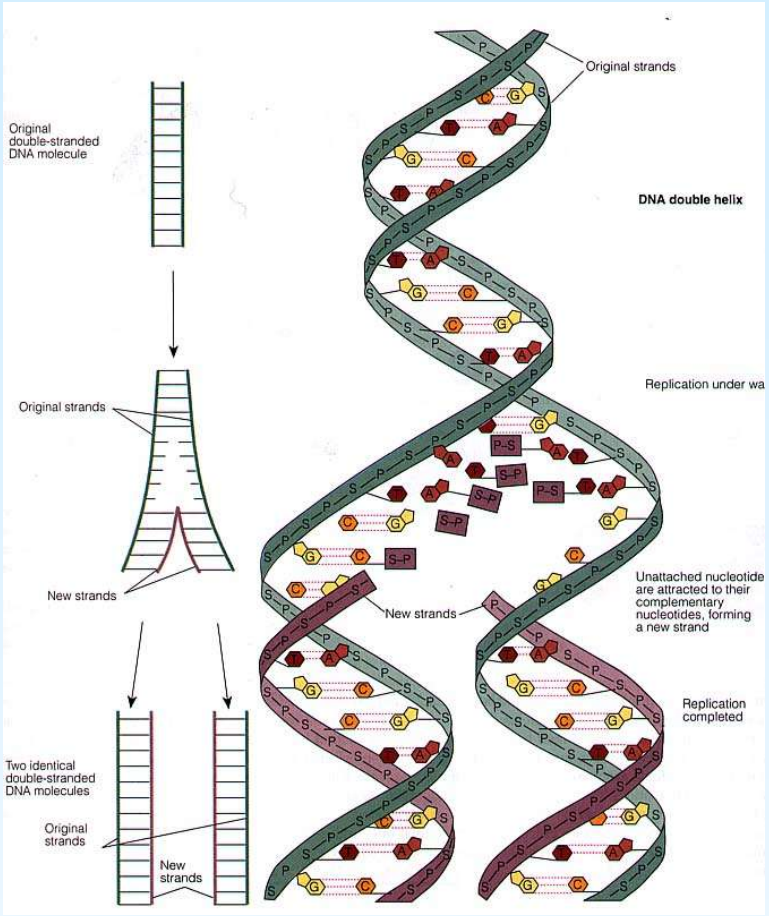
DNA Structure (2)





DNA Replication





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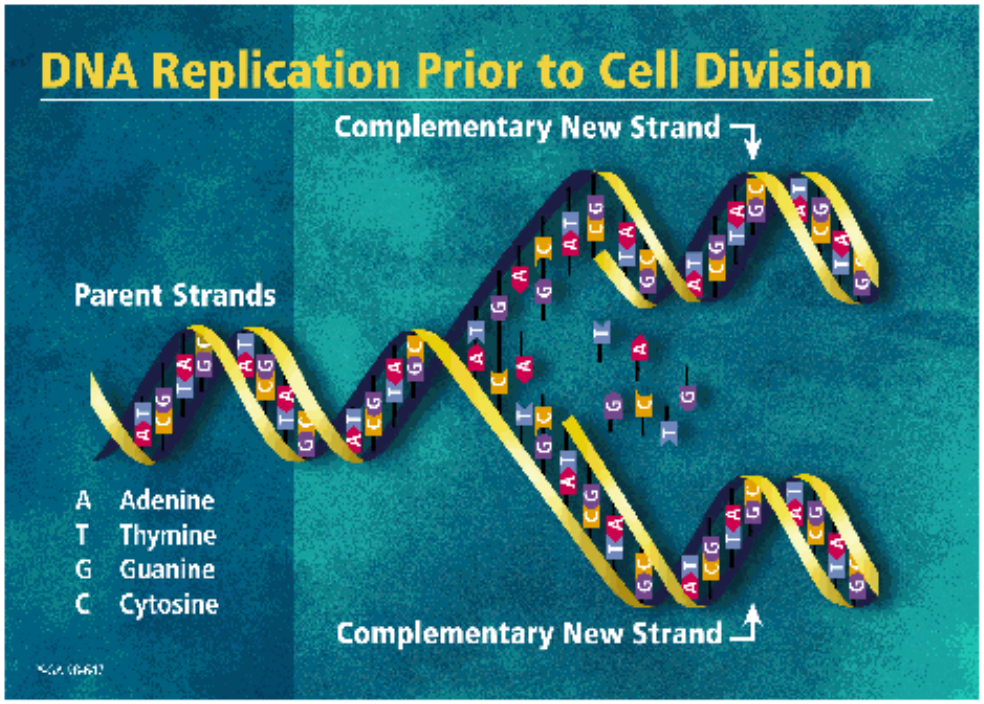
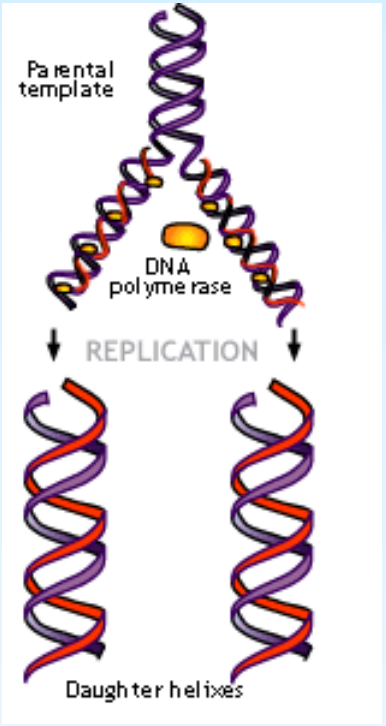
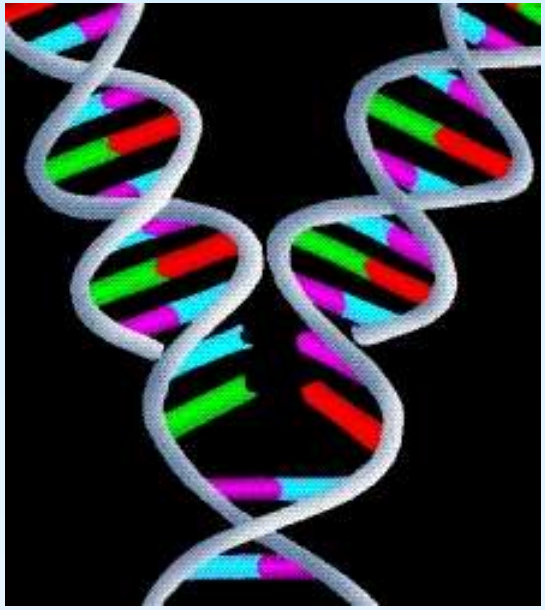
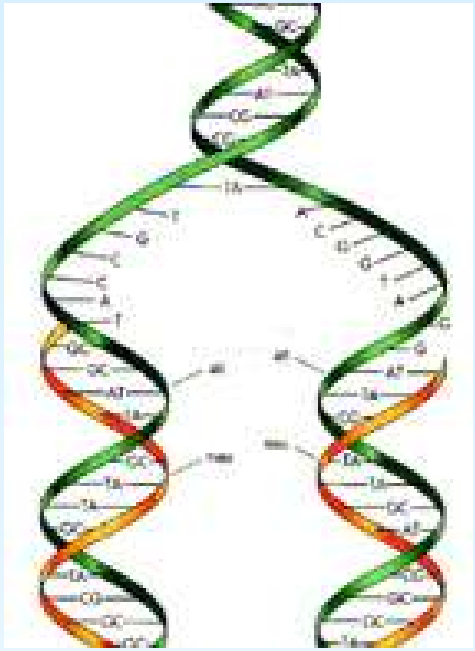


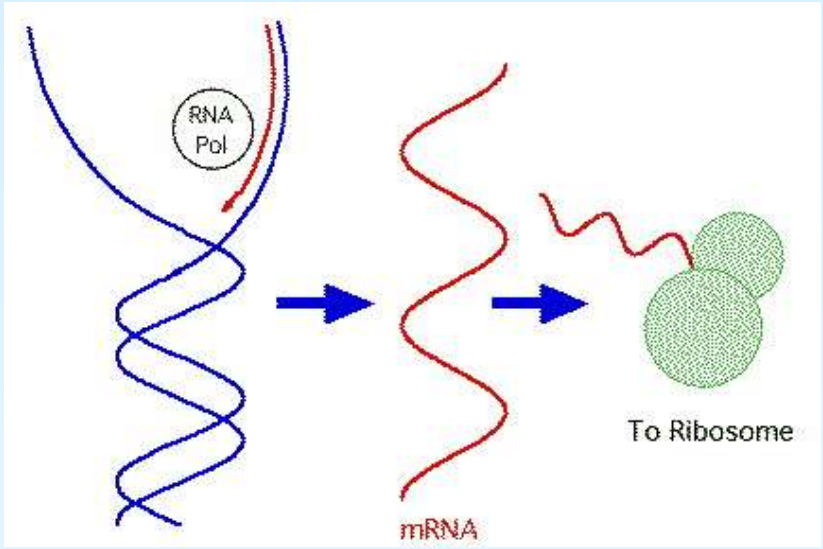


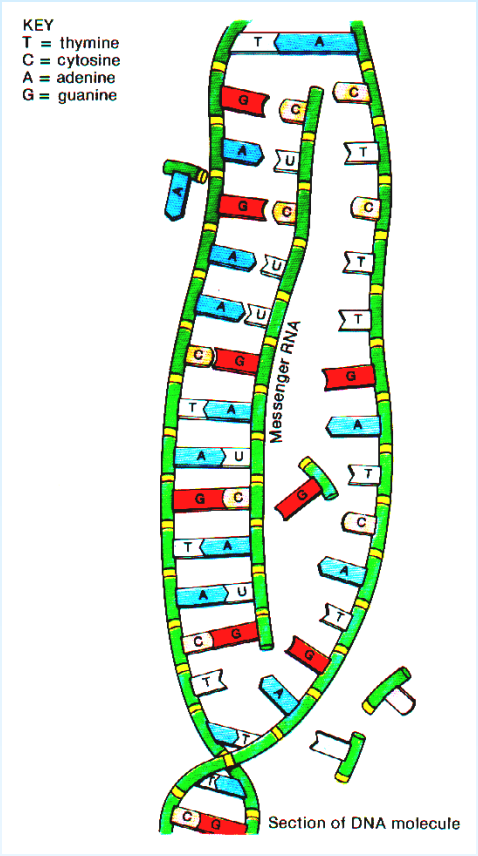
DNA Replication (3)



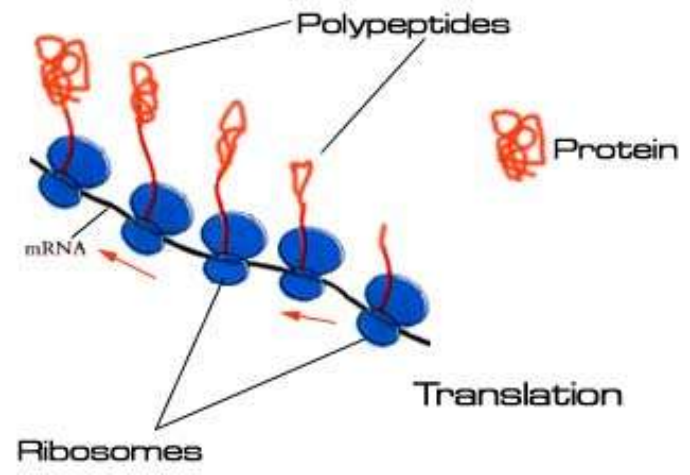


Transcription





Translation



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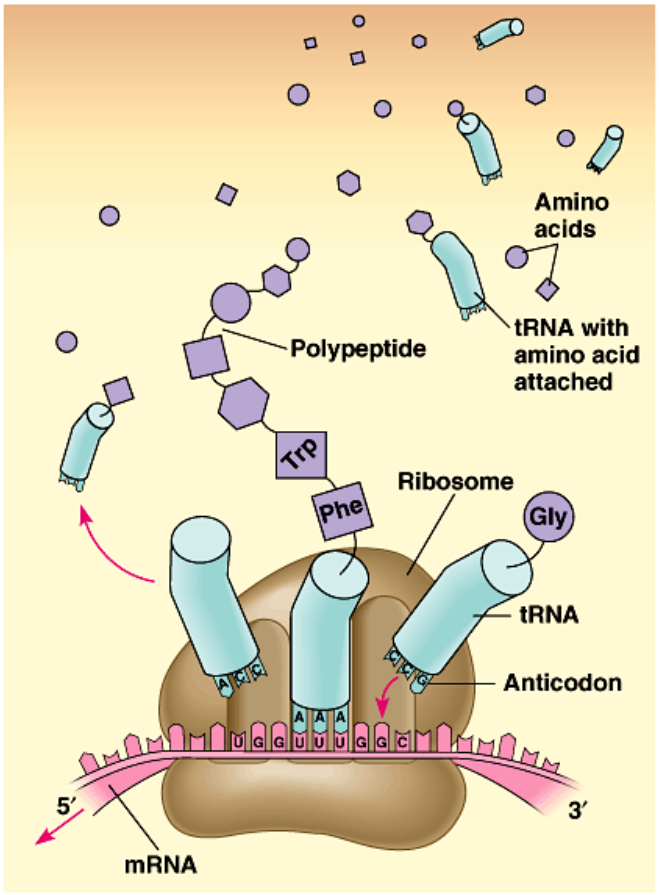
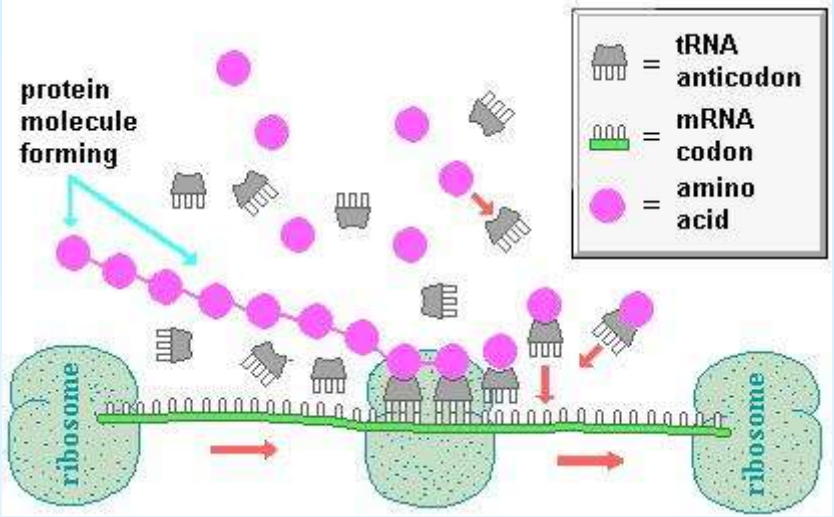
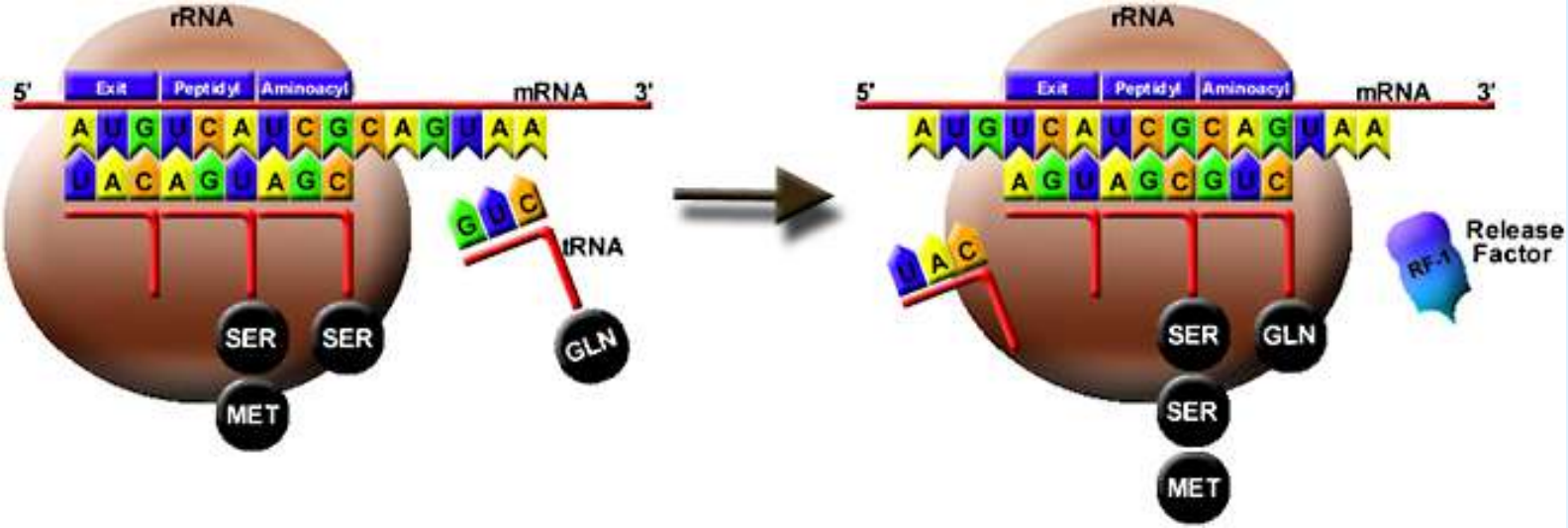


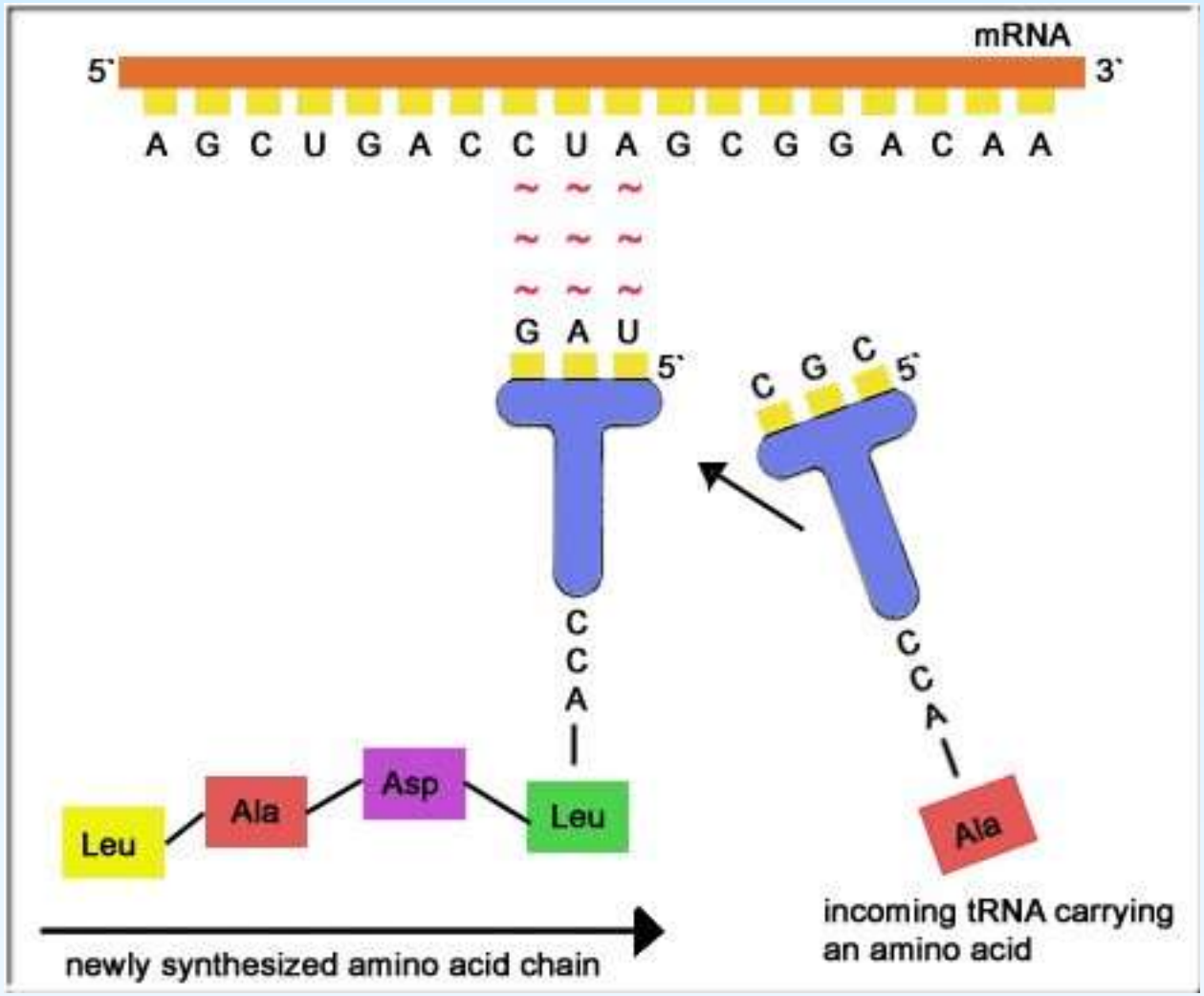
Translation (3)



Translation (4)

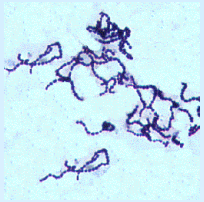


Translation (5)

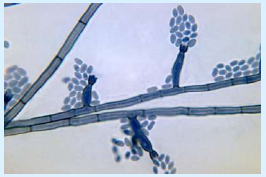


Basic Types of Microorganisms

- **Bacteria**

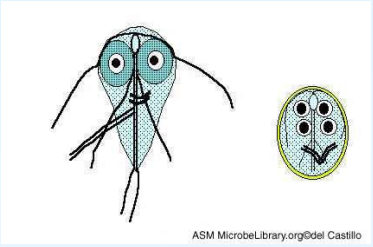


- **Fungi: yeasts and molds**



- **Viruses**

- **Protozoa**

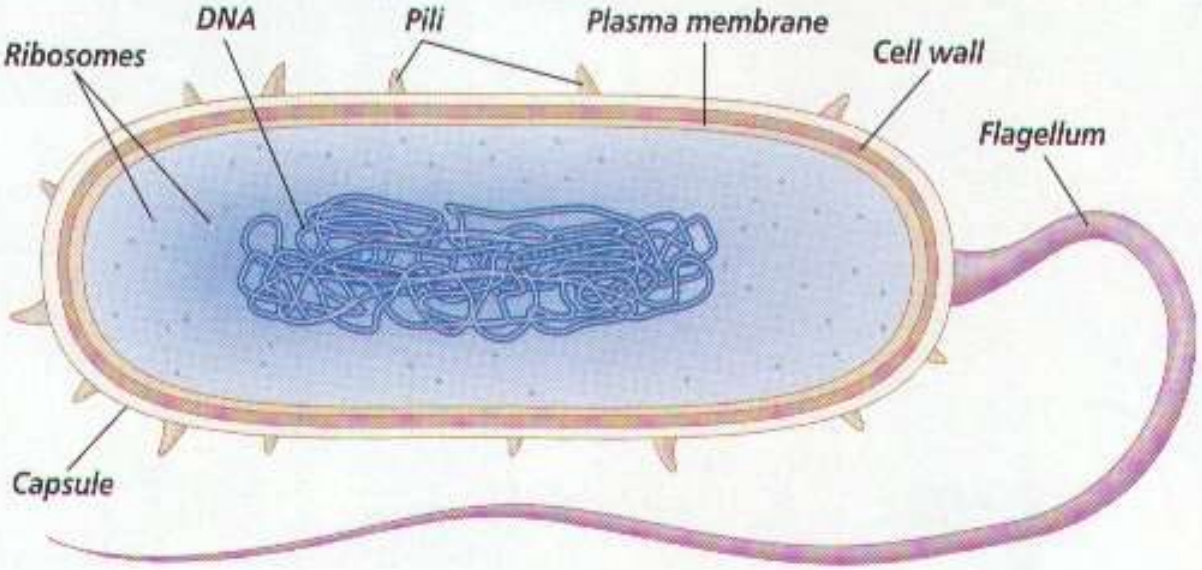


- **Algae**

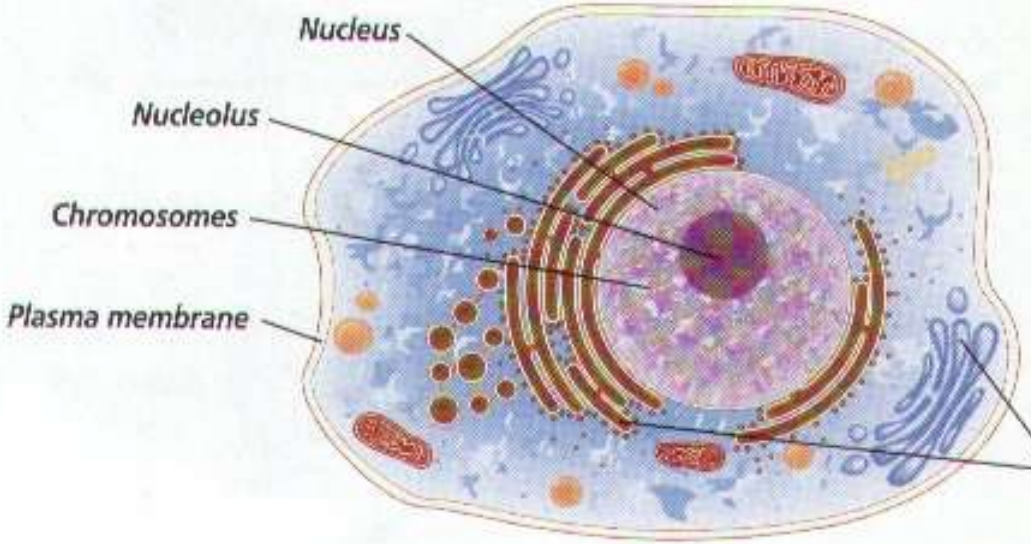
Eucaryotic and Procaryotic Cells

Properties	Procaryote	Eucaryote
Membrane bound nucleus	no	yes
Mitosis occurs	no	yes
mitochondria	no	yes
Endoplasmic reticulum	no	yes
Golgi apparatus	no	yes
Cell wall	peptidoglycan	Cellulose, chitin, glucan or none
Biochemically similar?	yes	yes
Genetic code similar?	yes	yes
Metabolic processes similar?	yes	yes

Bacteria and archaebacteria are prokaryotes. All other organisms are eukaryotes.

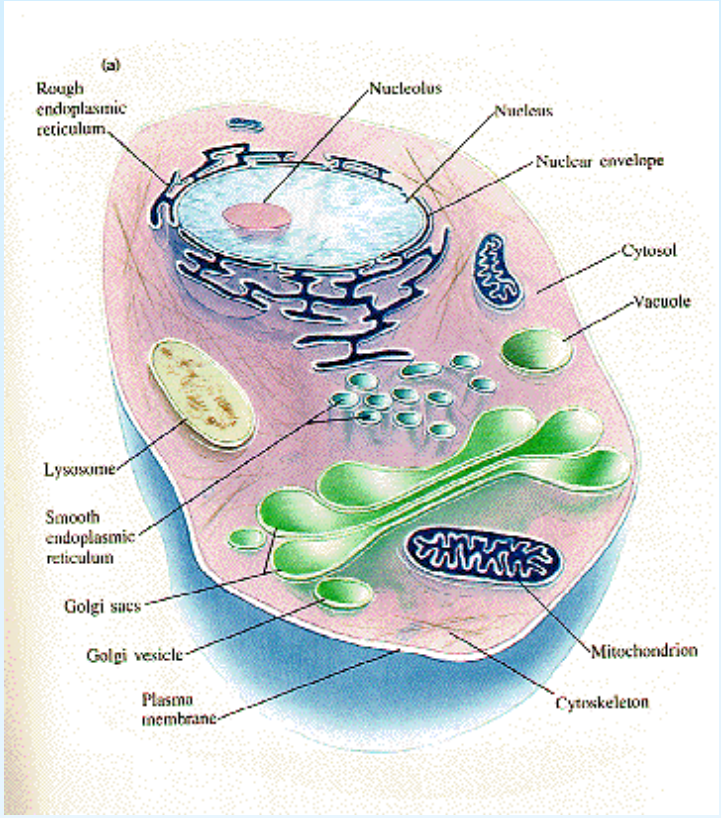


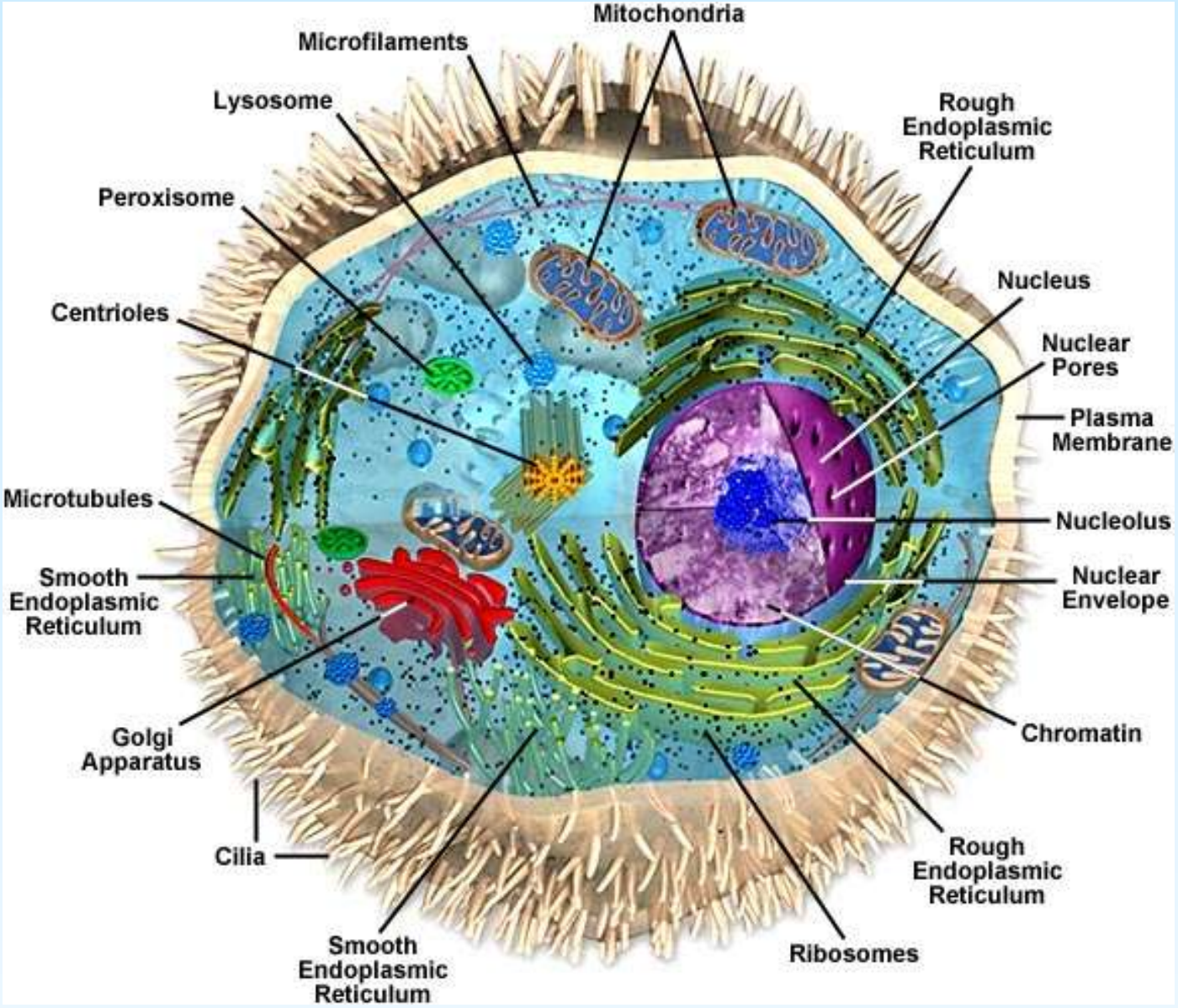
A A **Prokaryotic cell** does not have internal organelles surrounded by a membrane. Most of a prokaryote's metabolic functions take place in the cytoplasm.

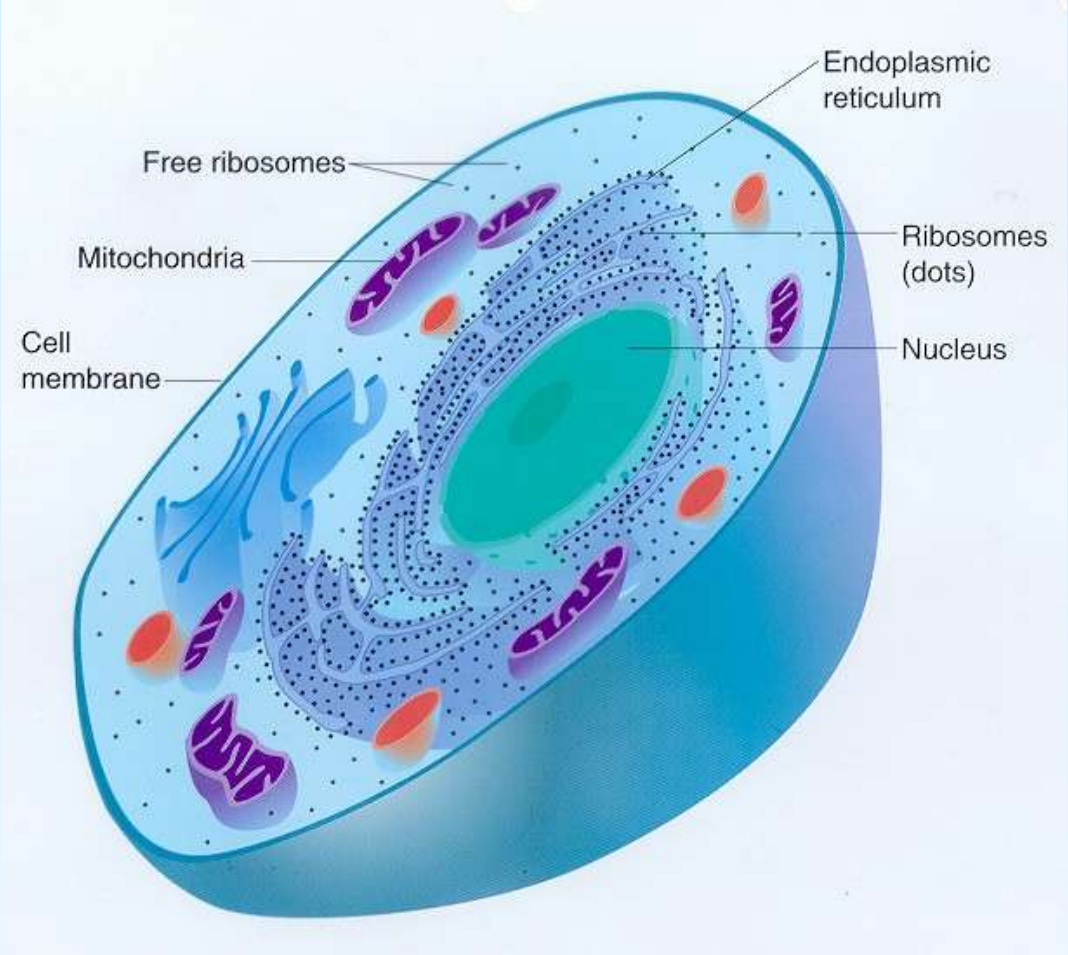


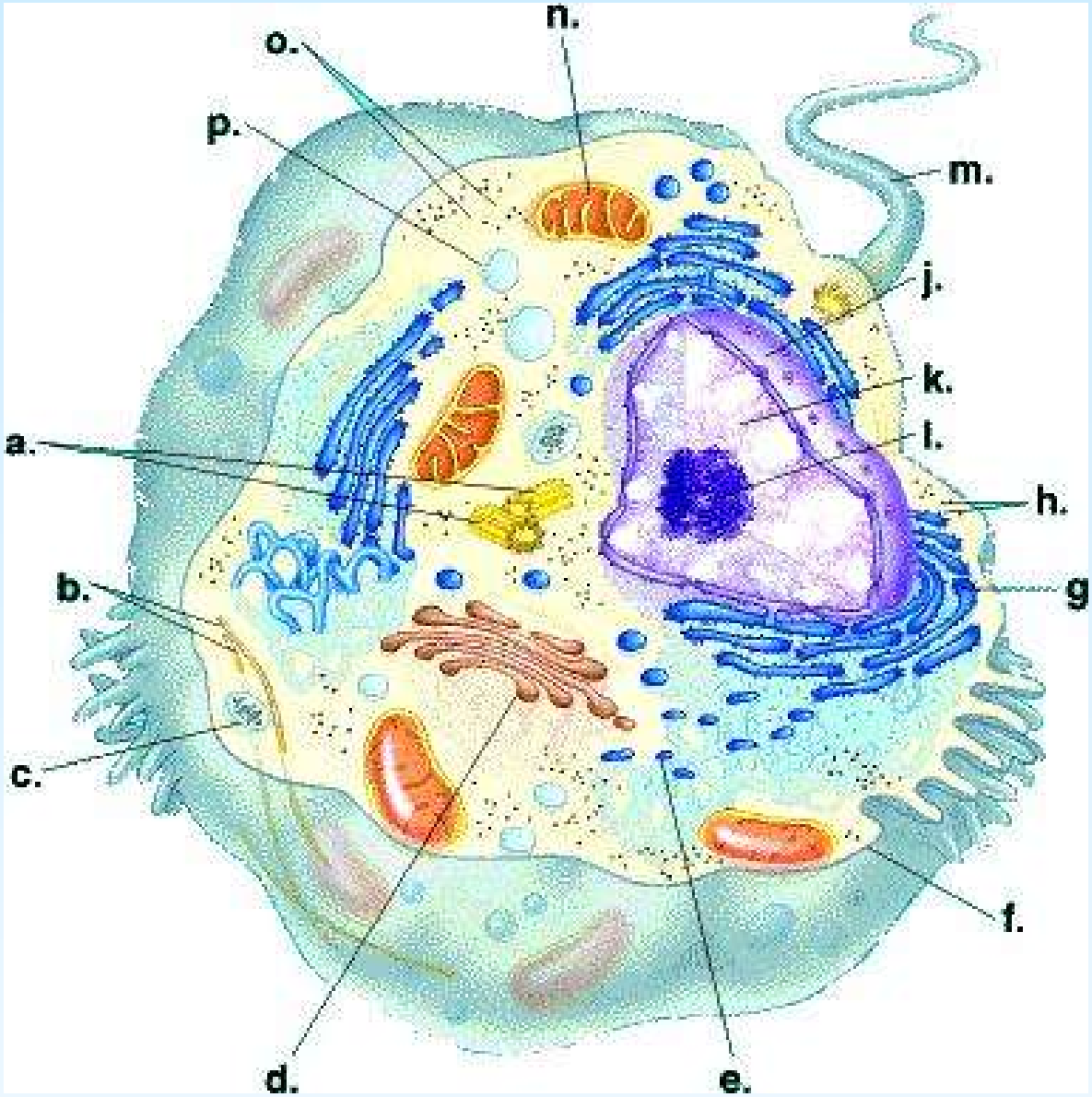
B This **eukaryotic cell** from an animal has distinct membrane-bound organelles that allow different parts of the cell to perform different functions.

Eucaryotic Cell




Mitochondria
Microfilaments
Lysosome
Rough Endoplasmic Reticulum
Peroxisome
Nucleus
Centrioles
Nuclear Pores
Plasma Membrane
Microtubules
Nucleolus
Smooth Endoplasmic Reticulum
Nuclear Envelope
Golgi Apparatus
Chromatin
Cilia
Rough Endoplasmic Reticulum
Smooth Endoplasmic Reticulum
Ribosomes


Endoplasmic reticulum
Free ribosomes
Ribosomes (dots)
Mitochondria
Cell membrane
Nucleus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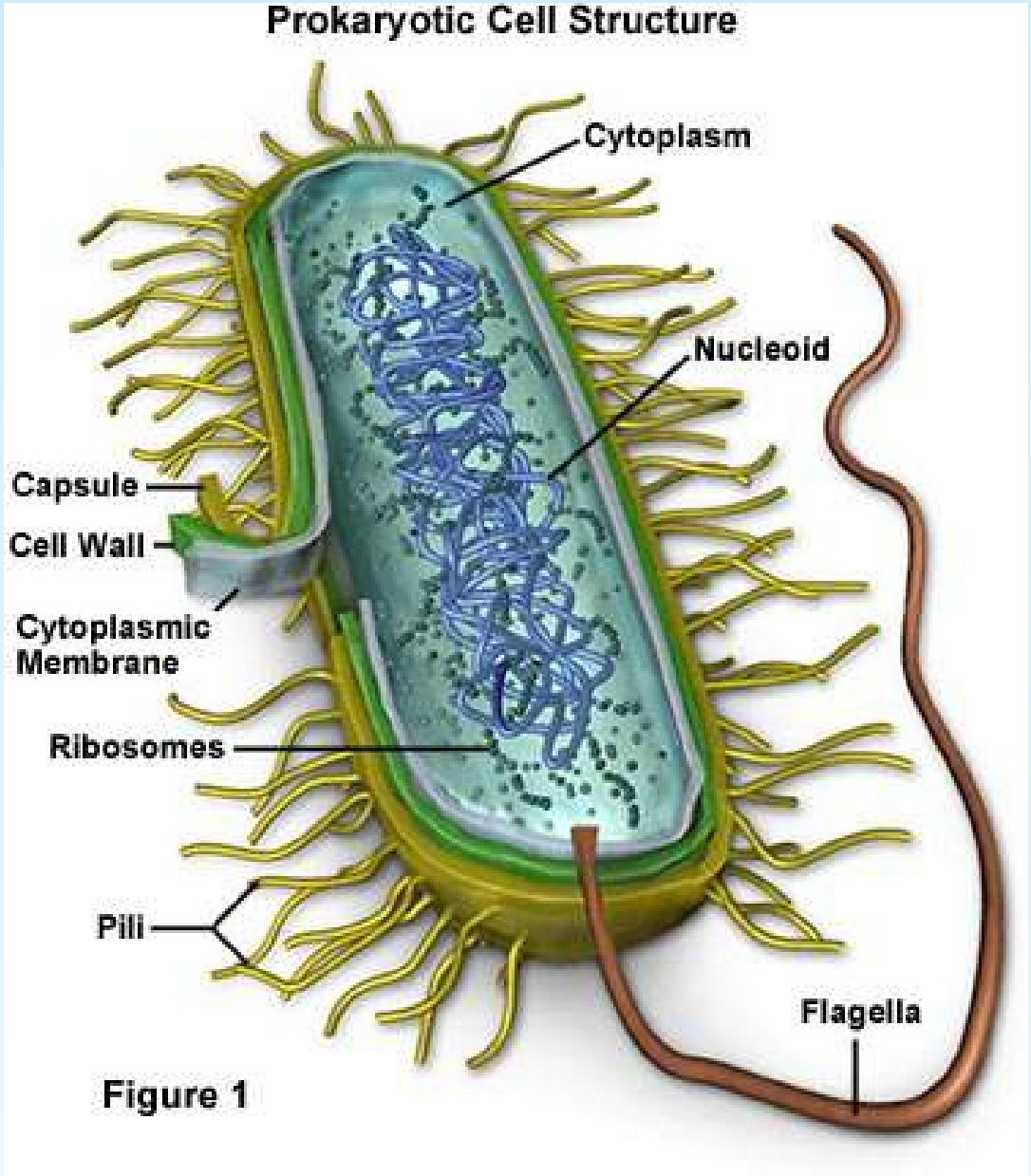
c.
f.
d.
e.

Procaryotic Cell

- DNA is not enclosed in a membrane
- No organelles
- Cell walls complex
- Binary fission (no mitosis)


Prokaryotic Cell Structure
Cytoplasm
Nucleoid
Capsule
Cell Wall
Cytoplasmic Membrane
Ribosomes
Pili
Flagella
Figure 1

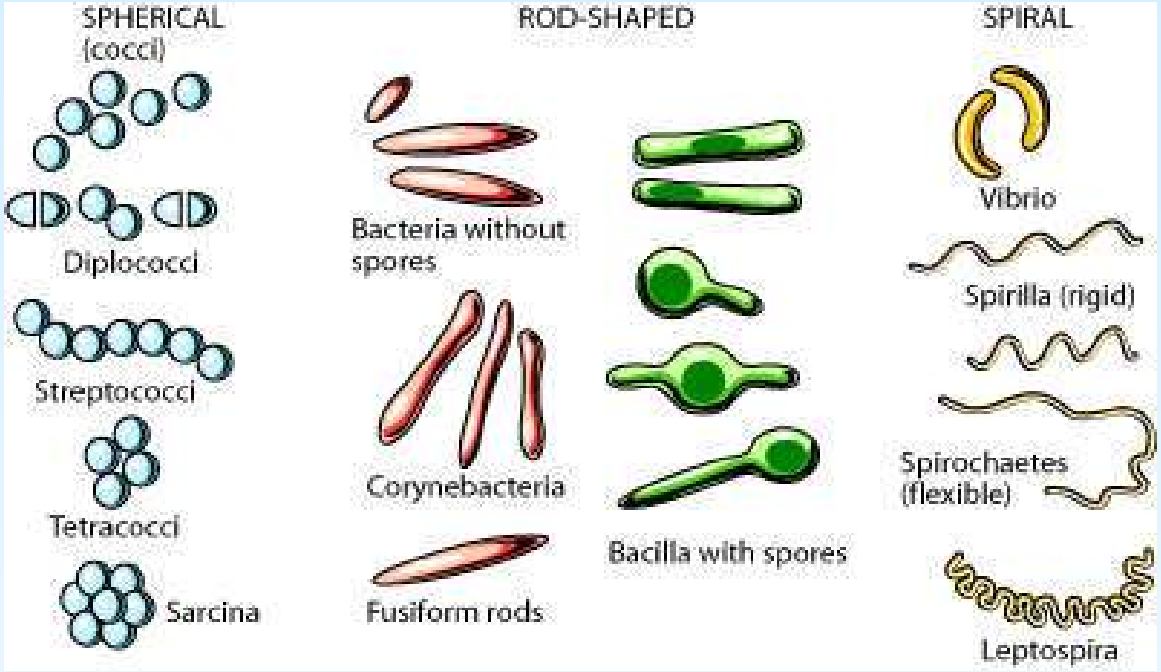
Size of Bacterial Cells

- 0.20-2.0 micrometers in diameter
- 2-8 micrometers in length
- 1 micrometer = 10^{-3} mm = 10^{-6} meter

Shape and Arrangement of Bacterial Cells

- Shape
  - Rod = bacillus (plural = bacilli)
  - Spheres = coccus (plural = cocci)
  - Spiral = spirochete
- Arrangement
  - Chains
  - Diplococci
  - Clusters

Bacterial Shapes (Morphology)



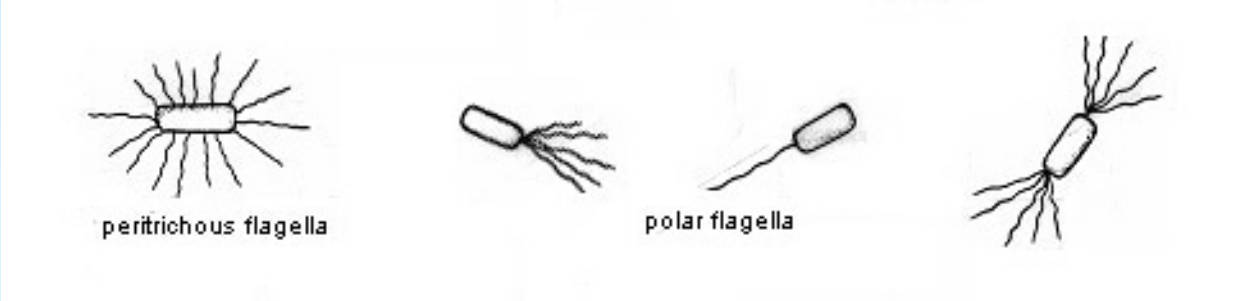
Procaryotic structures

- Capsule
- Flagella
- Pili
- Cell Wall
- Plasma membrane
- Ribosomes
- Nucleoid
- Plasmids

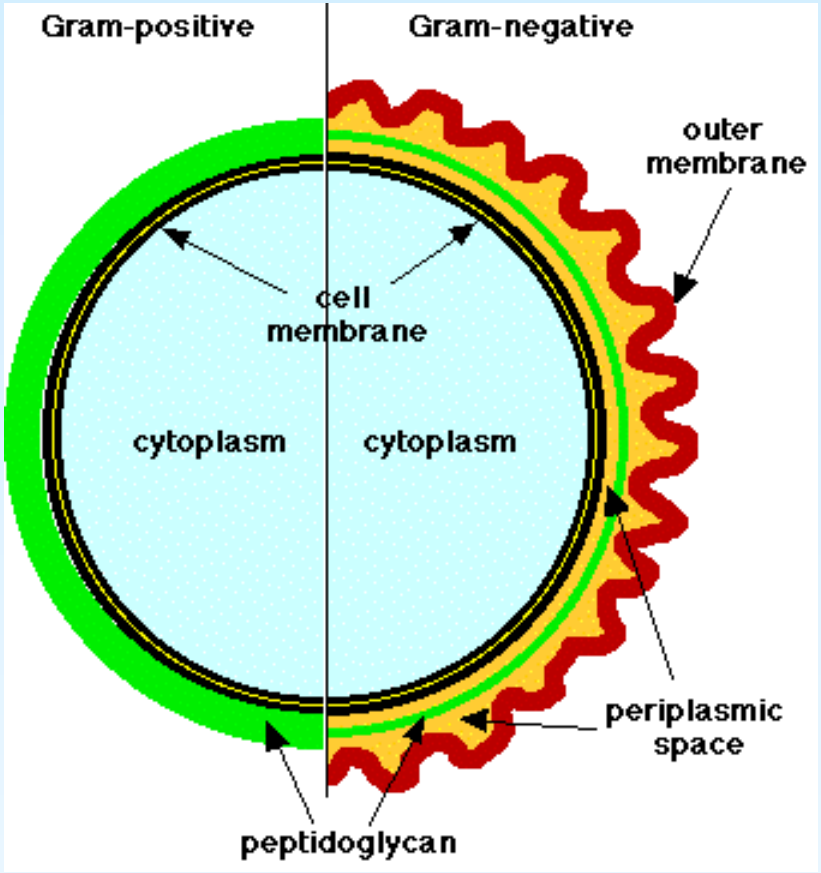
Structures External to the Cell Wall

- Capsule
  - Sticky
  - Excreted by the cell
- Flagella
  - Relatively long filamentous appendages that rotate to propel the cell
    - Polar
    - peritrichous
- Pili
  - Short, thin appendages
  - Help adherence to surfaces

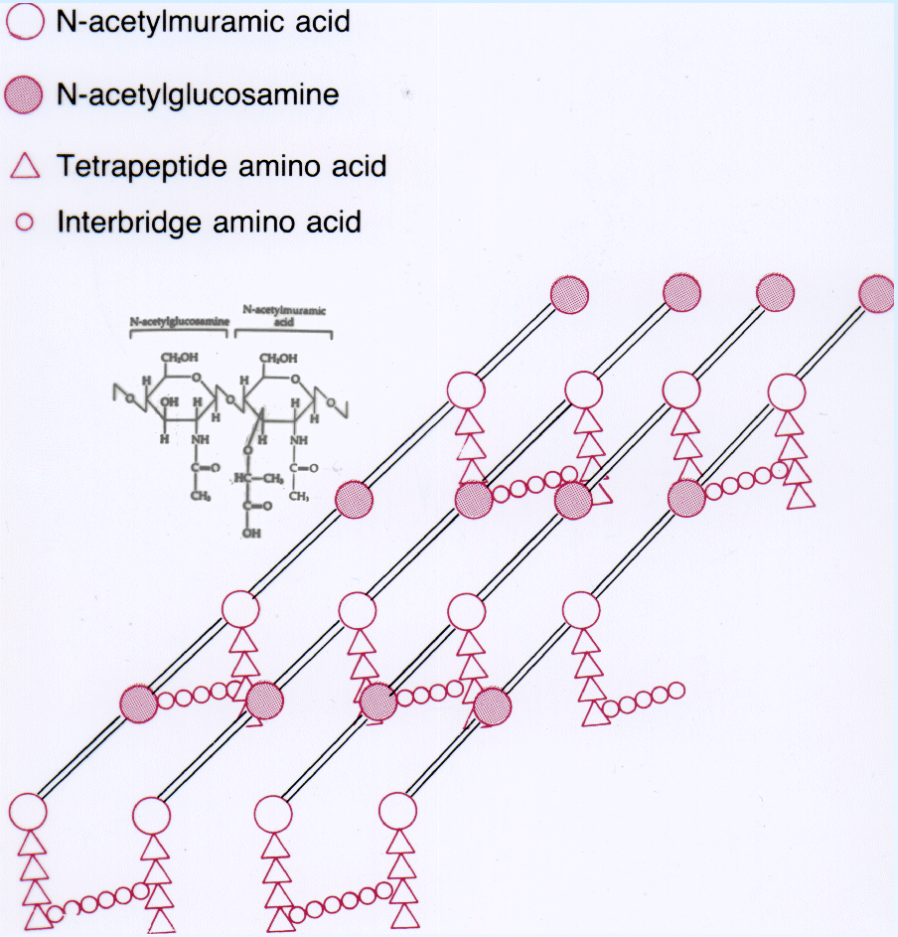
Flagella

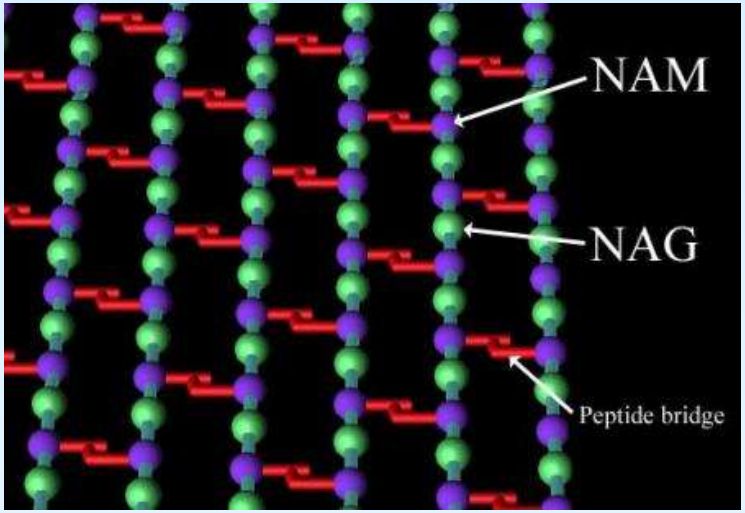


Cell Wall


Gram-positive
Gram-negative
outer membrane
cell membrane
cytoplasm
cytoplasm
periplasmic space
peptidoglycan

Peptidoglycan





Structures within the Cell Wall

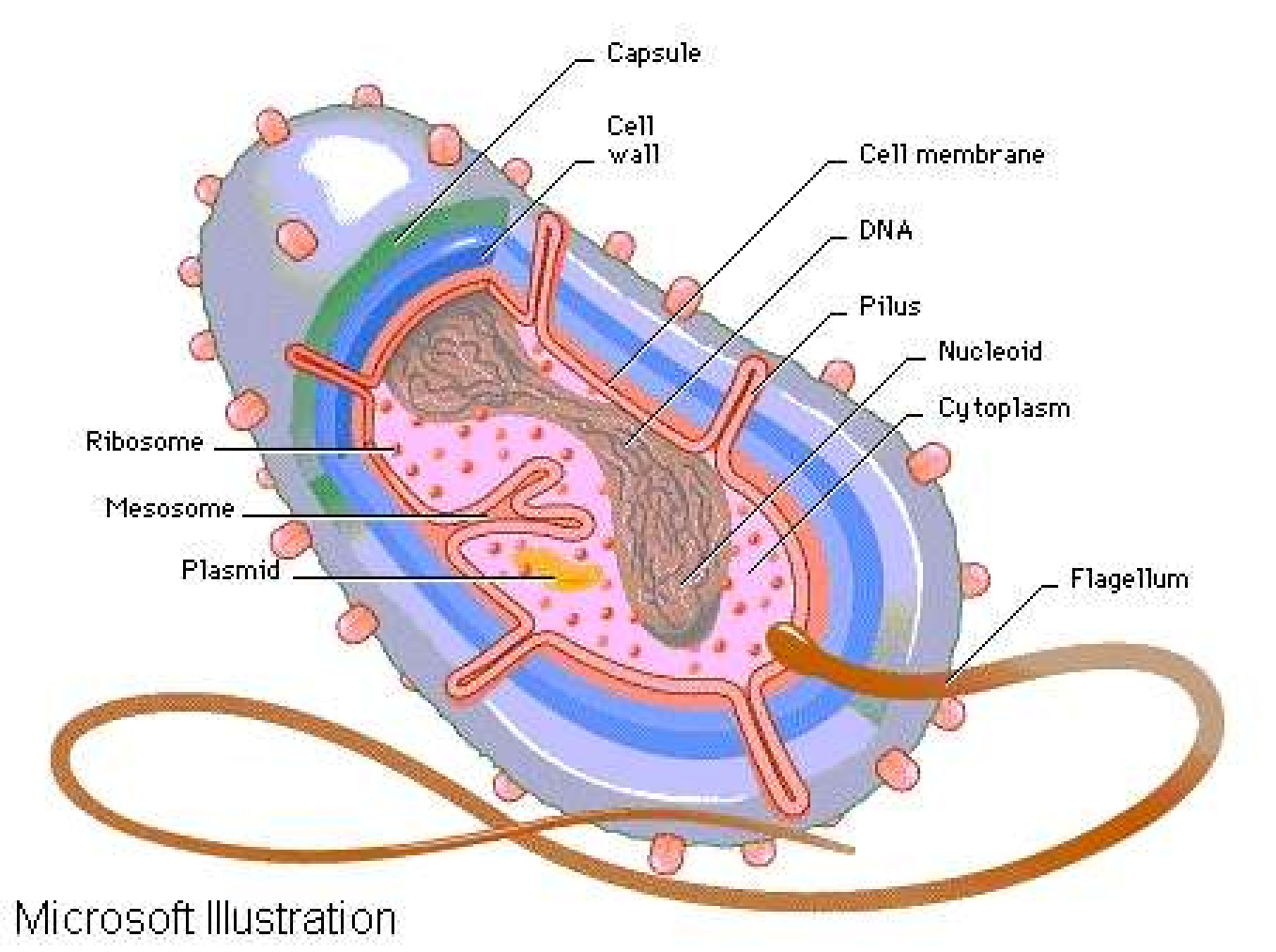
- Plasma membrane
  - Encloses cytoplasm
  - Selectively permeable barrier
  - Transport systems
  - Respiration and biosynthesis
- Cytoplasmic matrix
  - Between the plasma membrane and nthe nucleoid

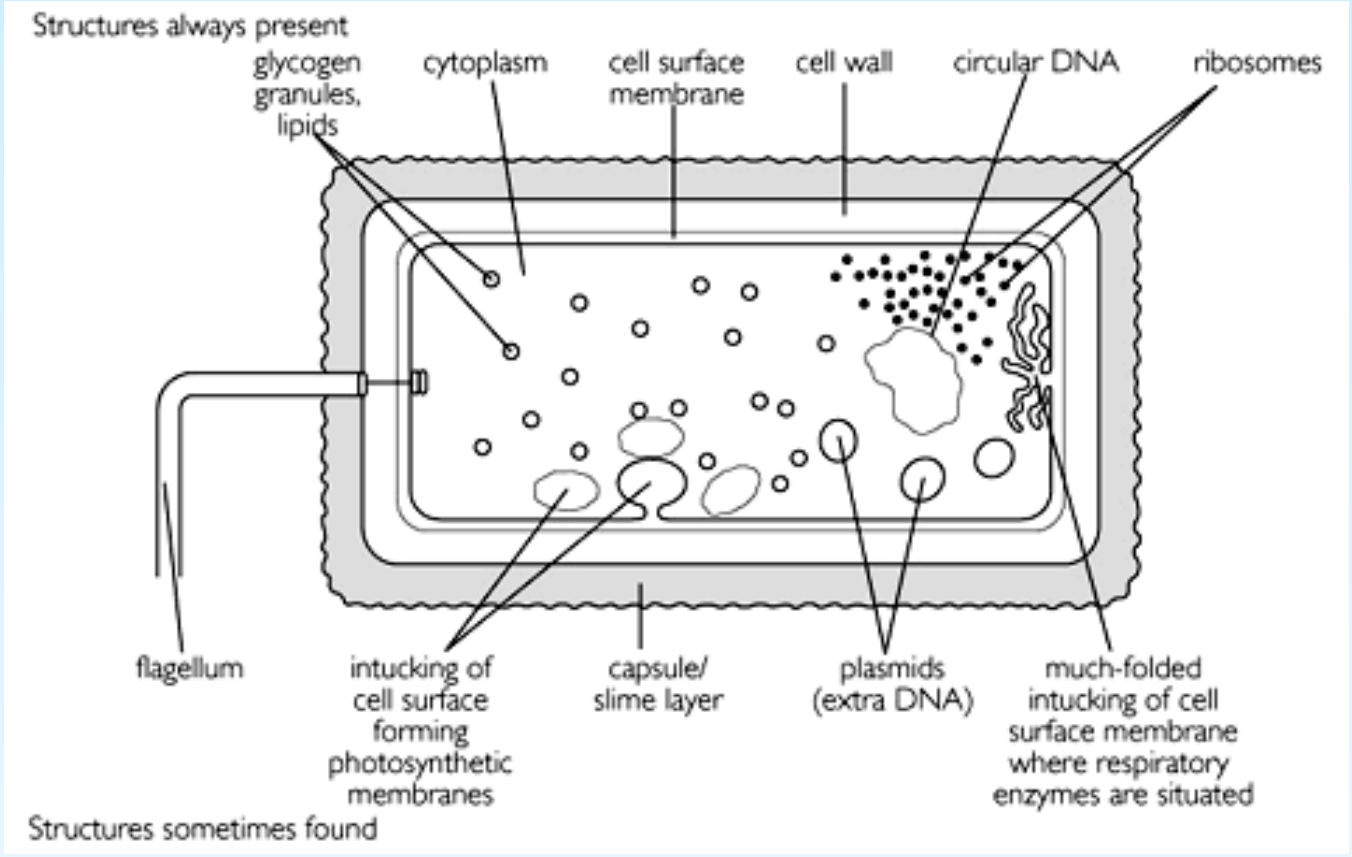
Structures within the Cell Wall (2)

- Ribosomes
  - In cytoplasmic matrix
  - Also attached to the plasma membrane
  - Site of protein synthesis
- Nucleoid
  - Chromosome – a circle of double stranded DNA

Structures within the Cell Wall (3)

- Plasmids
  - Extrachromosomal DNA
  - 5-100 genes
  - Can exist independently of chromosome
  - Usually not crucial to cell survival
  - May carry genes that give the cell an advantage (antibiotic resistance)
  - Can be transferred from one bacterial cell to another


Capsule
Cell wall
Cell membrane
DNA
Pilus
Nucleoid
Cytoplasm
Ribosome
Mesosome
Plasmid
Flagellum
Microsoft Illustration


Structures always present
glycogen granules, lipids
cytoplasm
cell surface membrane
cell wall
circular DNA
ribosomes
flagellum
intucking of cell surface forming photosynthetic membranes
capsule/ slime layer
plasmids (extra DNA)
much-folded intucking of cell surface membrane where respiratory enzymes are situated
Structures sometimes found

Bacterial Growth

- Bacteria grow in numbers, do not increase in size
- Optimal growth conditions vary with the organism
  - Carbon source
  - Temperature
  - Atmosphere
  - Other nutritional requirements

Bacterial Growth (2)

- Bacteria reproduce through binary fission
  - 1 → 2 → 4 → 8 → 16 → 32 → 64, etc.
  - This is best illustrated by a graph
- Generation time = time from parent cell to two daughter cells

Examples of Generation Times

ORGANISM	MEDIUM	TIME (MIN)
Escherichia coli	Glucose-salts	17
Bacillus megaterium	Sucrose-salts	25
Streptococcus lactis	Milk	26
Streptococcus lactis	Lactose broth	48
Staphylococcus aureus	Heart infusion broth	27-30
Lactobacillus acidophilus	Milk	66-87
Rhizobium japonicum	Mannitol-salts-yeast extract	344-461
Mycobacterium tuberculosis	Synthetic	792-932
Treponema pallidum	Rabbit testes	1980

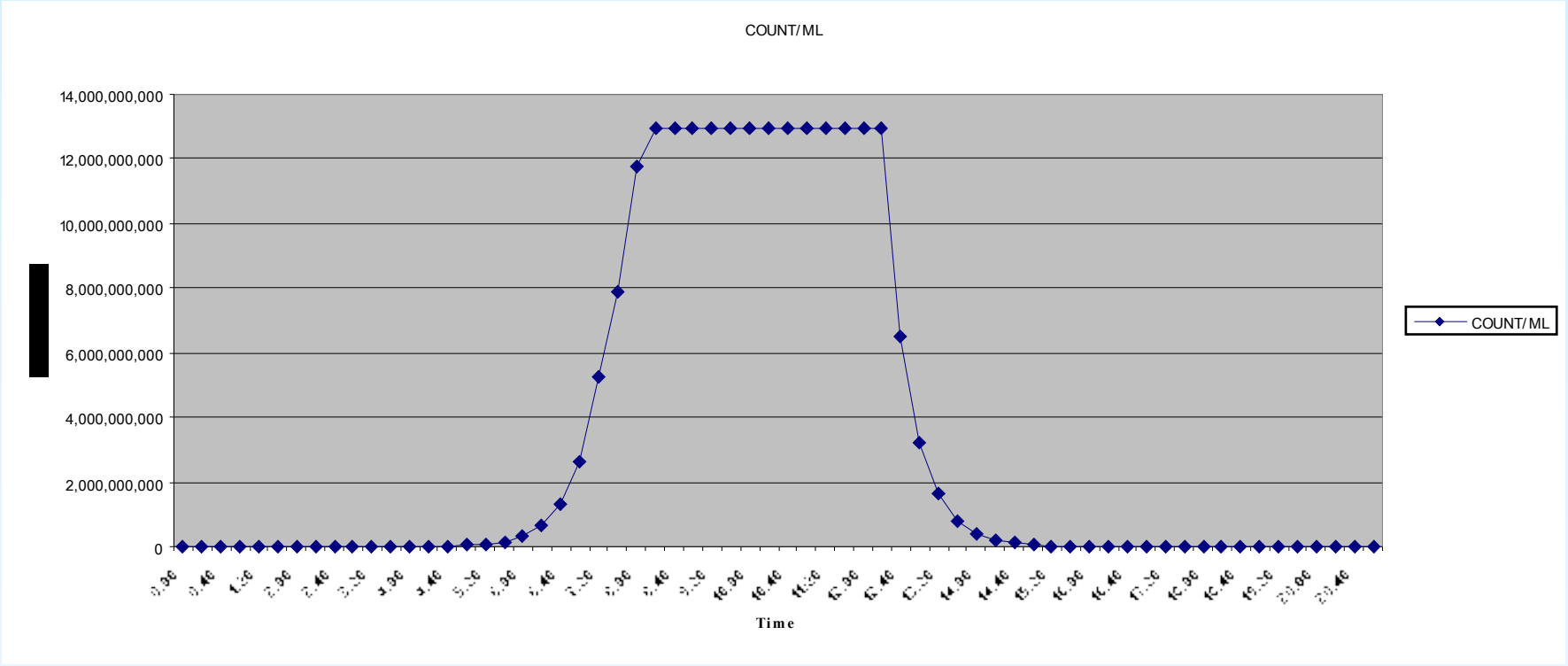
Data for Growth Curve

TIME	COUNT/ML
0:00	10,000
0:20	10,000
0:40	10,000
1:00	10,000
1:20	20,000
1:40	40,000
2:00	80,000
2:20	160,000
2:40	320,000
3:00	640,000
3:20	1,280,000
3:40	2,560,000
4:00	5,120,000
4:20	10,240,000
4:40	20,480,000
5:00	40,960,000
5:20	81,920,000
5:40	163,840,000
6:00	327,680,000
6:20	655,360,000
6:40	1,310,720,000
7:00	2,621,440,000
7:20	5,242,880,000
7:40	7,864,320,000

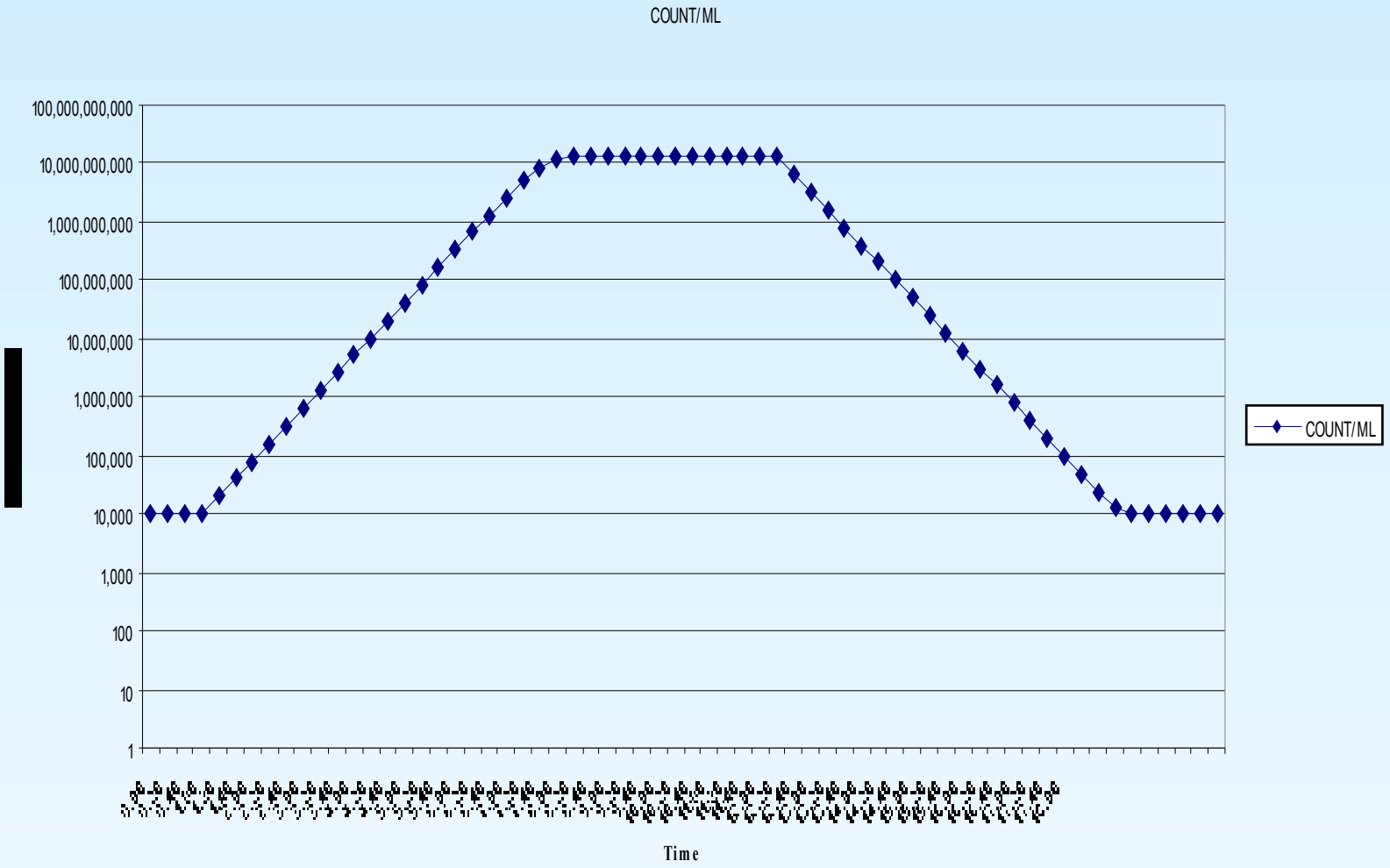
TIME	COUNT/ML
8:00	11,796,480,000
8:20	12,976,128,000
8:40	12,976,128,000
9:00	12,976,128,000
9:20	12,976,128,000
9:40	12,976,128,000
10:00	12,976,128,000
10:20	12,976,128,000
10:40	12,976,128,000
11:00	12,976,128,000
11:20	12,976,128,000
11:40	12,976,128,000
12:00	12,976,128,000
12:20	12,976,128,000
12:40	6,488,064,000
13:00	3,244,032,000
13:20	1,622,016,000
13:40	811,008,000
14:00	405,504,000
14:20	202,752,000
14:40	101,376,000
15:00	50,688,000
15:20	25,344,000
15:40	12,672,000
16:00	6,336,000

TIME	COUNT/ML
16:20	3,168,000
16:40	1,584,000
17:00	792,000
17:20	396,000
17:40	198,000
18:00	99,000
18:20	49,500
18:40	24,740
19:00	12,375
19:20	10,000
19:40	10,000
20:00	10,000
20:20	10,000
20:40	10,000
21:00	10,000

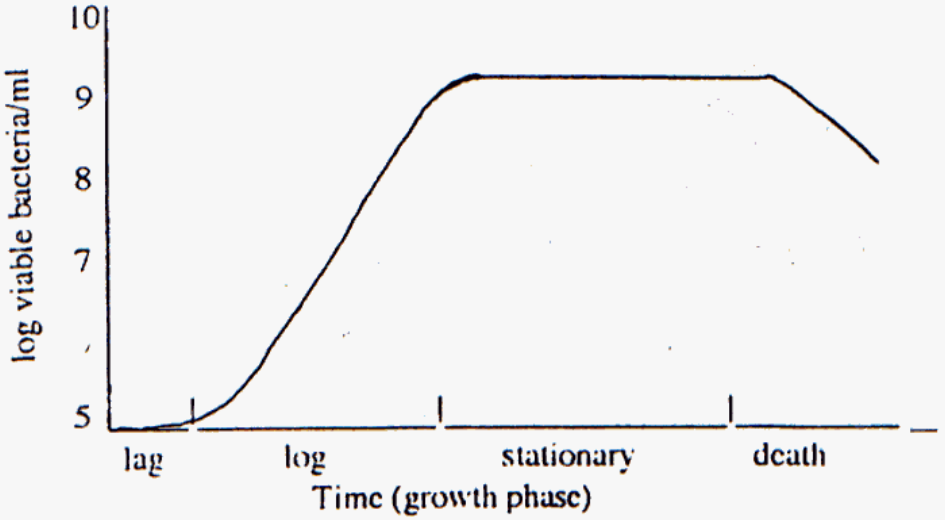
Bacterial Growth Numerical Scale

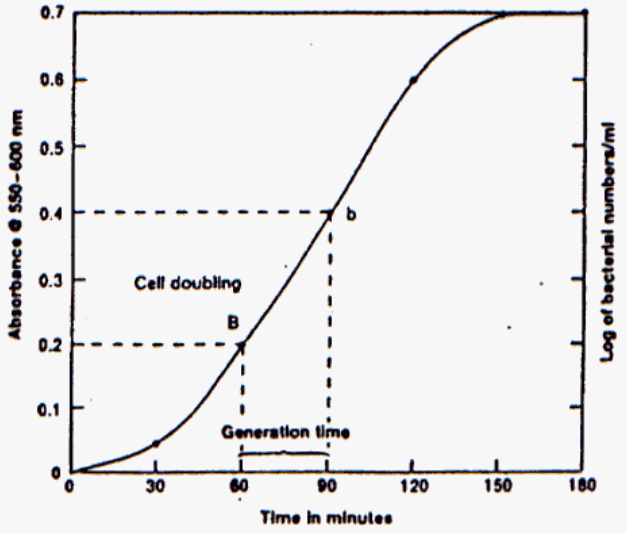


Bacterial Growth Logarithmic Scale



Growth Curve





Lag Phase

- Newly inoculated cells require a period of adjustment from a resting situation
- Cells are synthesizing enzymes, using nutrients, but not yet increasing in numbers

Log (Exponential) Phase

- Cells have reached maximum rate of cell division
- Continues as long as cells have adequate nutrition and the environment is favorable
  - In other words, optimal conditions

Stationary Phase

- Rate of cell death equals rate of cell division
- Nutrients and oxygen (for some organisms) are depleted
- Waste products accumulate

Death Phase

- Cells begin to die in exponential numbers
- Cells can no longer multiply
- Cells perish in their own waste
- Usually slower than log phase
- Some organisms may remain viable for a long time