

Chapter 18.



Bacterial Genetics

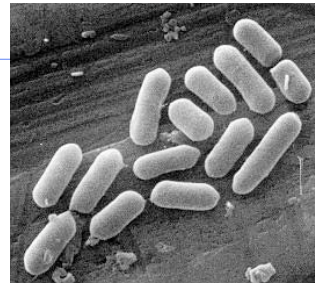
Why study bacterial genetics?

- **Its an easy place to start**
 - ◆ **history**
 - ◆ **we know more about it**
 - **systems better understood**
 - ◆ **simpler genome**
 - ◆ **good model for control of genes**
 - **build concepts from there to eukaryotes**
 - ◆ **bacterial genetic systems are exploited in biotechnology**



Bacteria

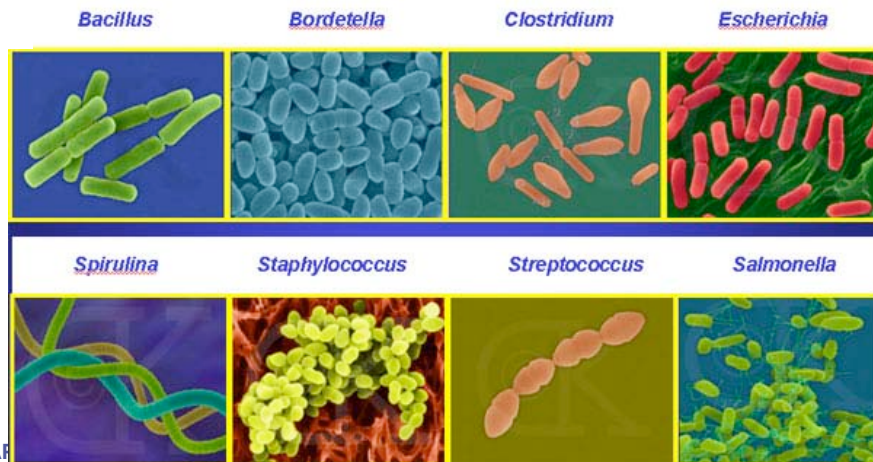
- **Bacteria review**
 - ◆ one-celled organisms
 - ◆ prokaryotes
 - ◆ reproduce by mitosis
 - binary fission
 - ◆ rapid growth
 - generation every ~20 minutes
 - 10^8 colony overnight!
 - ◆ dominant form of life on Earth
 - ◆ incredibly diverse



2004-2005

Bacterial diversity

rods and spheres and spirals... Oh My!



Rods

Spheres

Spirals

Bacterial diversity



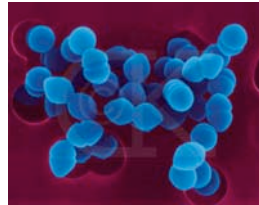
Borrelia burgdorferi
Lyme disease



Treponema pallidum
Syphilis



Escherichia coli O157:H7
Hemorrhagic E. coli



Enterococcus faecium
skin infections

AP B

2004-2005

Bacterial genome

- **Single circular chromosome**

- ◆ haploid

- ◆ naked DNA

- no histone proteins

- ◆ ~4 million base pairs

- ~4300 genes

- 1/1000 DNA in eukaryote

[Intro to Bacteria video](#)

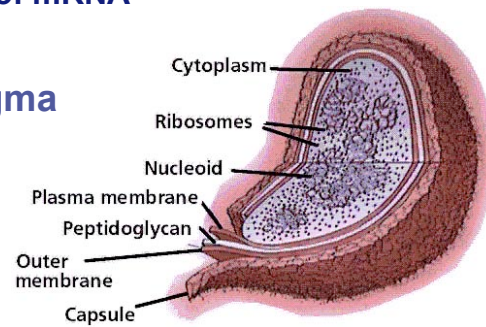
Genome = all the DNA of an organism

Eukaryotes

- 1000 times more DNA
- only 10 times more genes
 - introns, spacers, inefficiency

No nucleus!

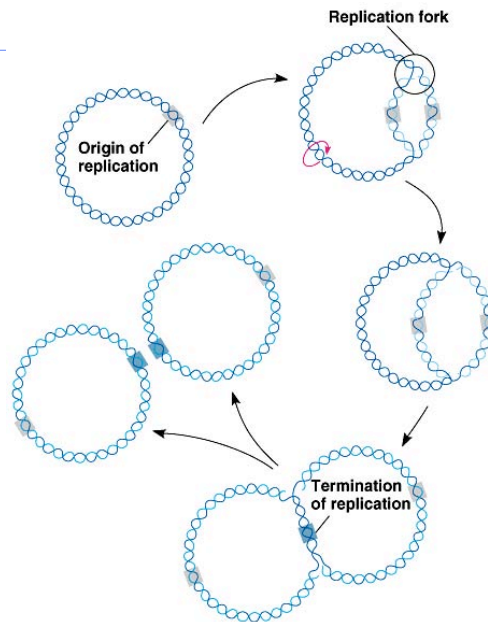
- **No nuclear membrane**
 - ◆ chromosome in cytoplasm
 - ◆ transcription & translation are coupled together
 - no processing of mRNA
 - ◆ no introns
 - ◆ **but Central Dogma still applies**
 - **use same genetic code**



AP Biology

Binary fission

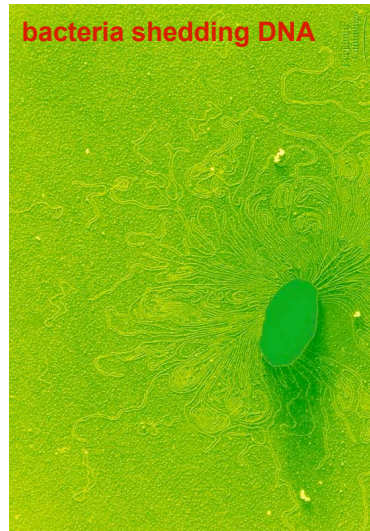
- Replication of bacterial chromosome
- Asexual reproduction
 - ◆ offspring genetically identical to parent
 - ◆ where does variation come from?



AP Biology

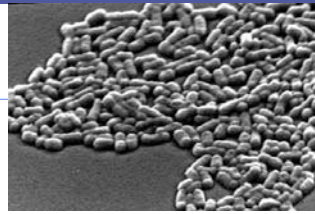
Variation in bacteria

- Sources of variation
 - ◆ spontaneous mutation
 - ◆ transformation
 - plasmids
 - DNA fragments
 - ◆ transduction
 - ◆ conjugation
 - ◆ transposons



Spontaneous mutation

- Spontaneous mutation is a significant source of variation in rapidly reproducing species
- **Example: E. coli**
 - ◆ human colon
 - ◆ 2×10^{10} new E. coli each day!
 - ◆ spontaneous mutations
 - for 1 gene, only ~1 in 10 million replications
 - each day, ~2,000 bacteria develop mutation in that gene
 - but consider all 4300 genes, then:
 $4300 \times 2000 = 9$ million mutations per day per human host!



Transformation

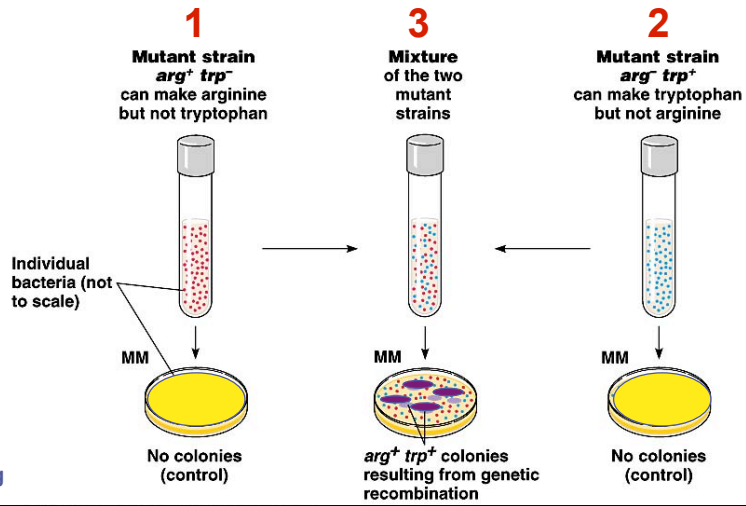
- **Bacteria are opportunists**
 - ◆ pick up naked foreign DNA wherever it may be hanging out
 - have surface transport proteins that are specialized for the uptake of naked DNA
 - ◆ import bits of chromosomes from other bacteria
 - ◆ incorporate the DNA bits into their own chromosome
 - form of recombination

While *E. coli* lacks this specialized mechanism, it can be induced to take up small pieces of DNA if cultured in a medium with a relatively high concentration of calcium ions.

In biotechnology, this technique has been used to introduce foreign DNA into *E. coli*.

Swapping DNA

Genetic recombination by trading DNA



Plasmids

■ Plasmids

◆ small supplemental circles of DNA

- 5000 - 20,000 base pairs
- self-replicating

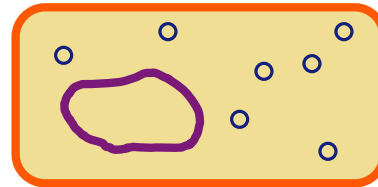
◆ carry extra genes

- 2-30 genes

◆ can be exchanged between bacteria

- bacterial sex!!
- rapid evolution
- antibiotic resistance

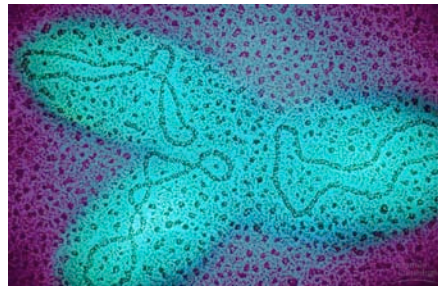
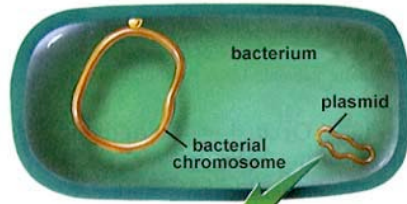
◆ can be imported from environment



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Mini-chromosomes

Plasmids



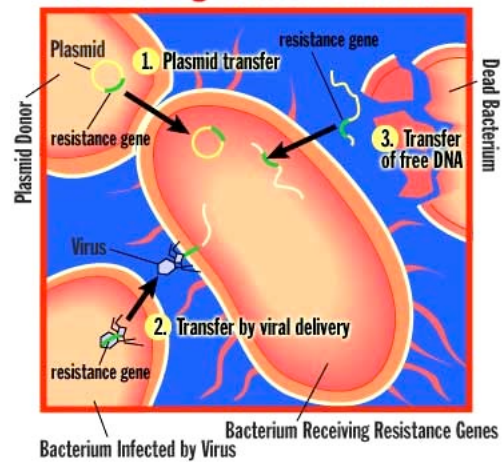
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Plasmids & antibiotic resistance

■ Resistance is futile?

- ◆ 1st recognized in 1950s in Japan
- ◆ bacterial dysentery not responding to antibiotics
- ◆ worldwide problem now

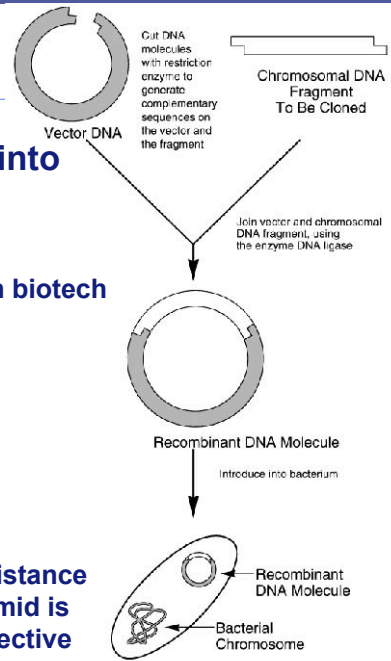
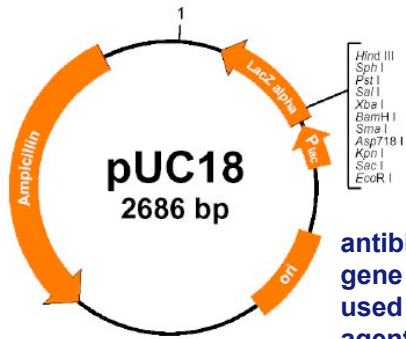
Transferring Resistance Genes



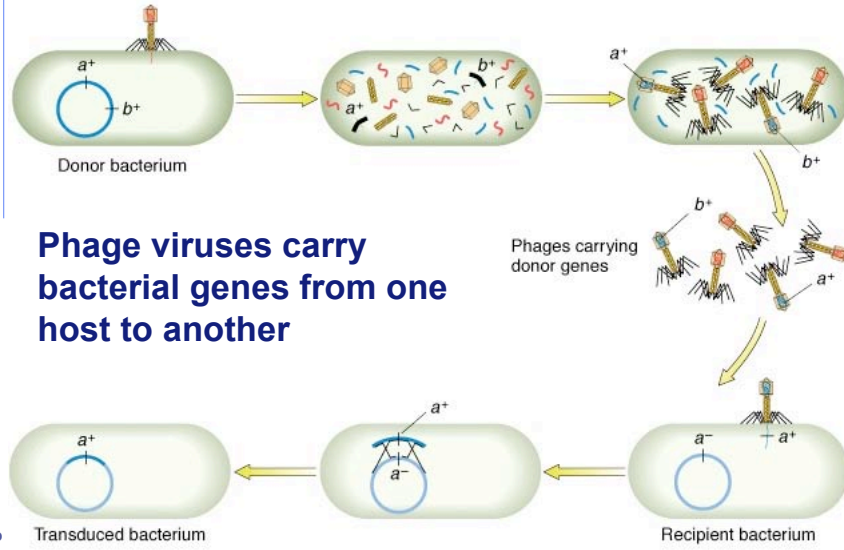
[Resistance in Bacteria video](#)

Biotechnology

- Used to insert new genes into bacteria
 - example: pUC18
 - engineered plasmid used in biotech



Transduction



Conjugation

- **Direct transfer of DNA between 2 bacterial cells that are temporarily joined**
 - ◆ results from presence of F plasmid with F factor
 - F for “fertility”
 - ◆ E. coli “male” extends sex pilli, attaches to female bacterium
 - ◆ cytoplasmic bridge allows transfer of DNA

