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Reproduction In Bacteria

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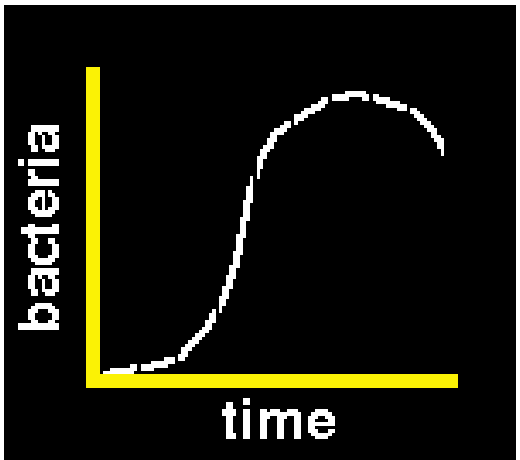
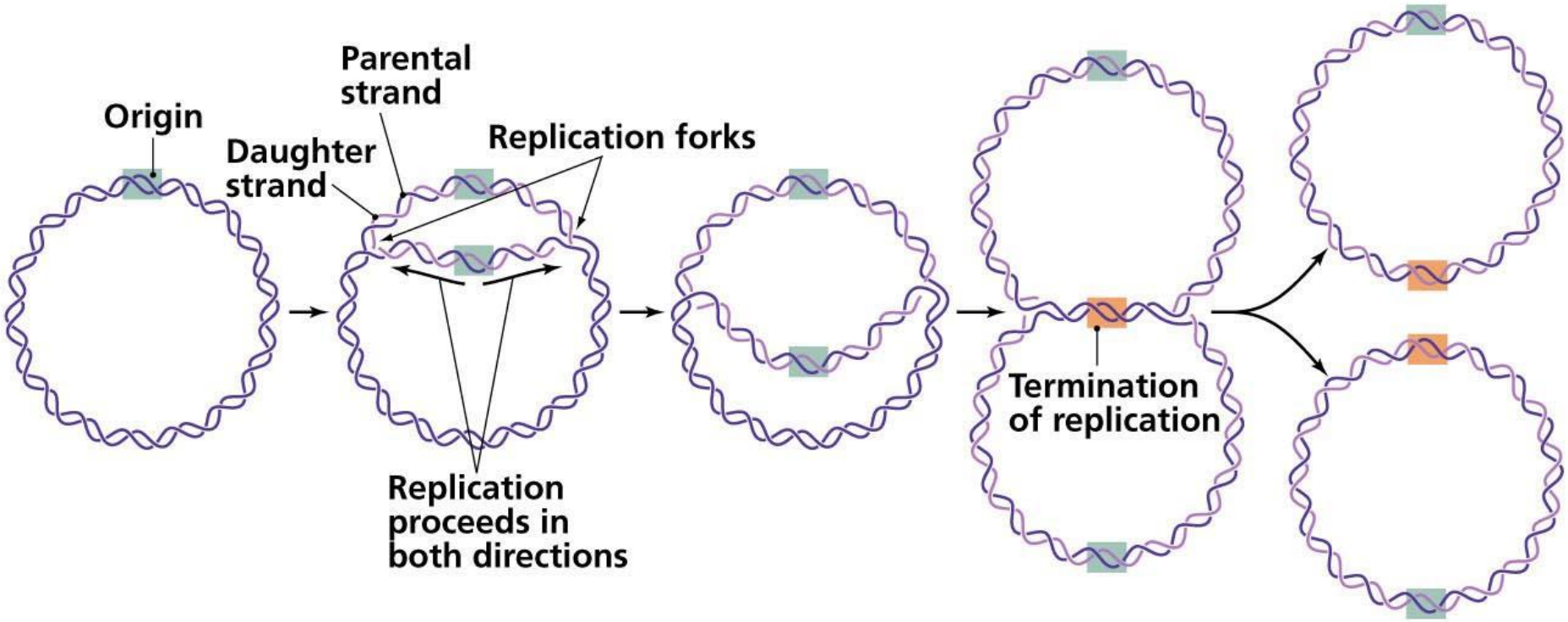
Reproduction in Bacteria

Purpose of reproduction: pass on genetic information to create more of the same species, keeping species in population

Bacteria grow and reproduce without hesitation:
E.coli can reproduce every 20 min.
So, every 48 hr: 2^{144} E.coli
(>>> # of humans that ever lived)



Overview of bacterial replication



For ALL cells, the first step in Reproduction is Replication Of DNA:

How is this done?

Directions for making a new strand lie within complementary base pairing rules

A-T

G-C

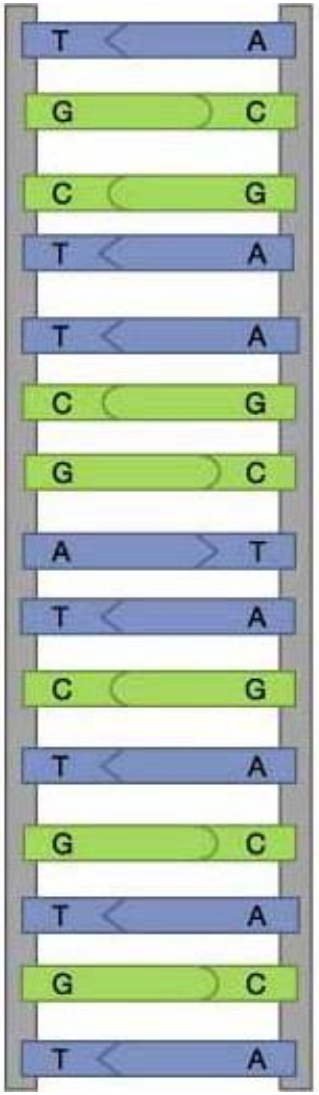


Fig. 4.10

DNA replication ...

1. hydrogen bonds broken
DNA helix separates

2. nucleotides line up according to
complementary base pairing
on the separate strands

3. new strands polymerize (reform H-bonds)
Two DNA molecules have been formed
each has 1 strand from original molecule
and 1 new strand

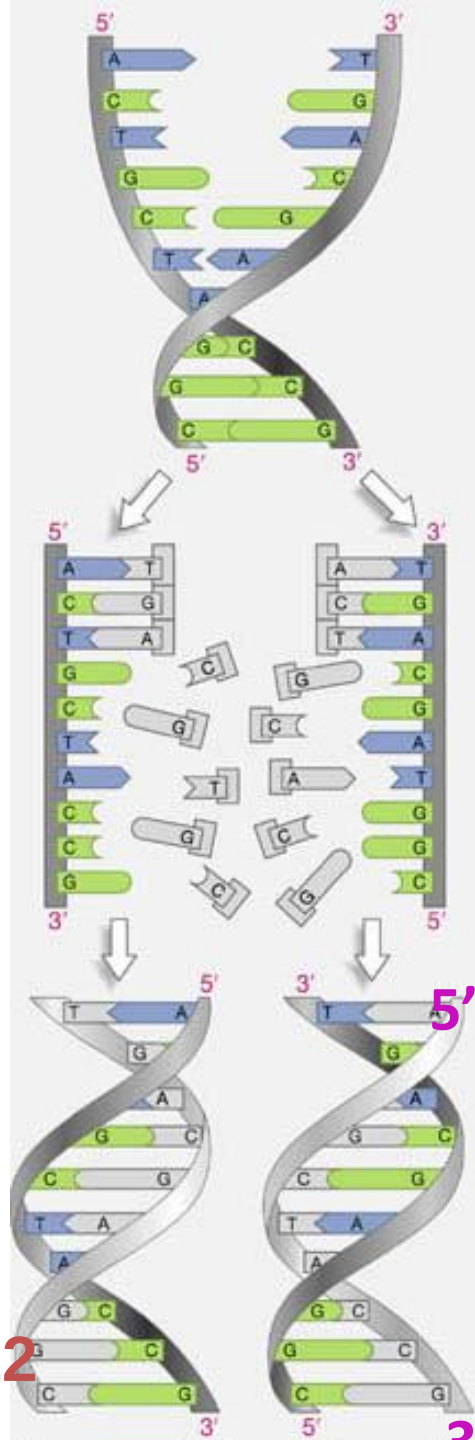
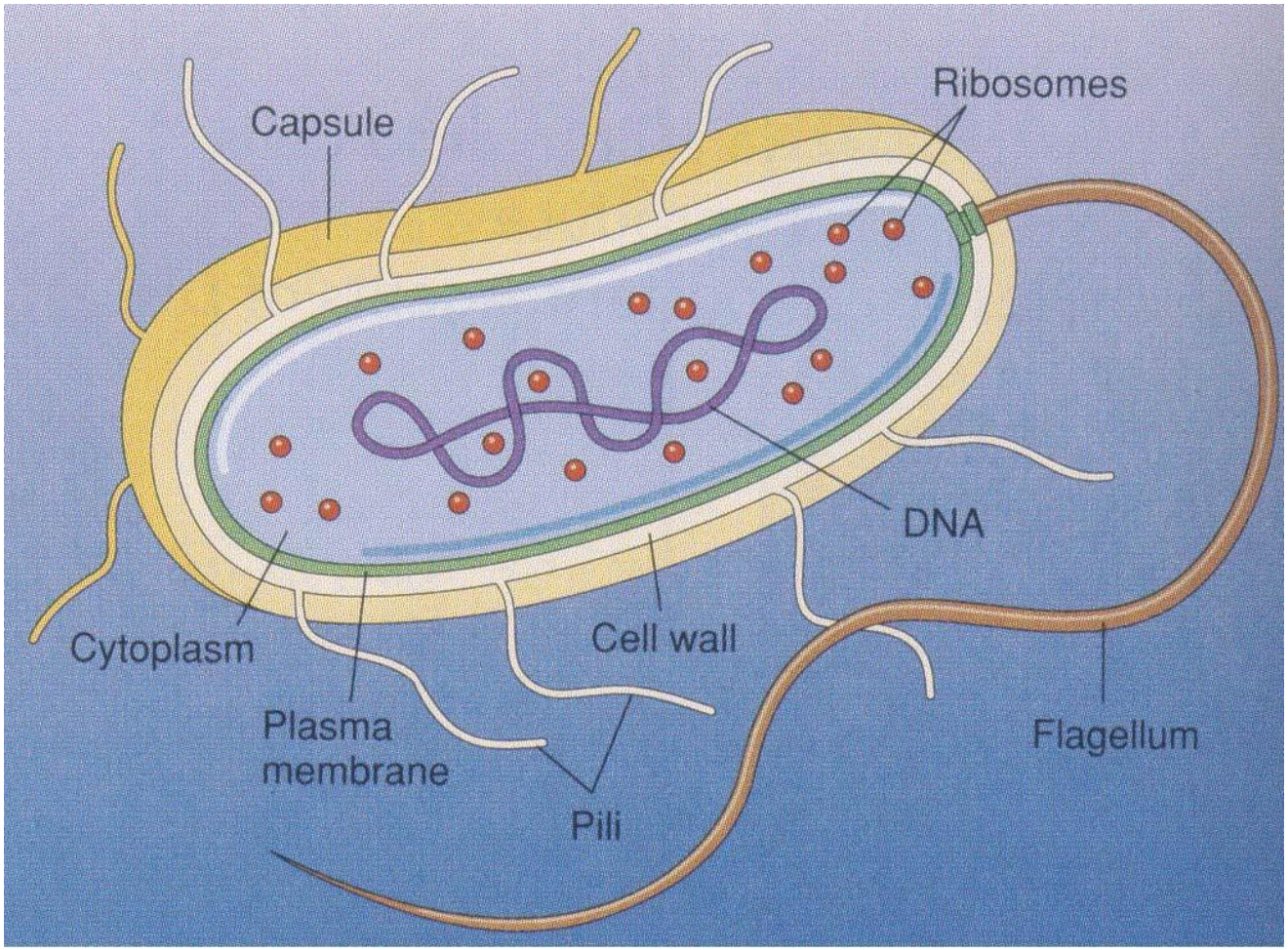


Fig. 4.12

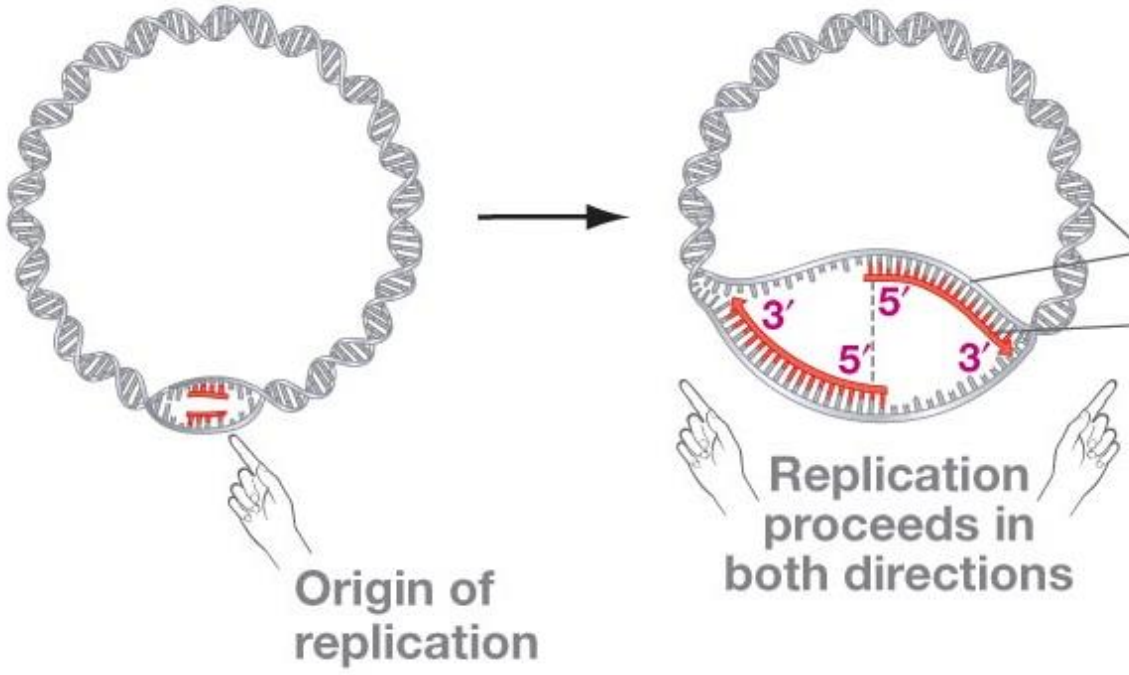
http://www.youtube.com/watch?v=hfZ8o9D1tus&feature=related

Eukaryotes: replication in nucleus

Prokaryotes: replication in cytoplasm



DNA in Prokaryotes on a Circular Chromosome Replication Occurs Bi-directionally



(a) A chromosome being replicated

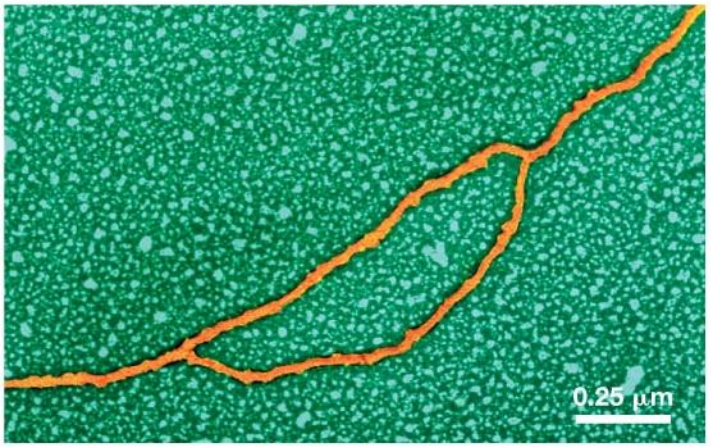


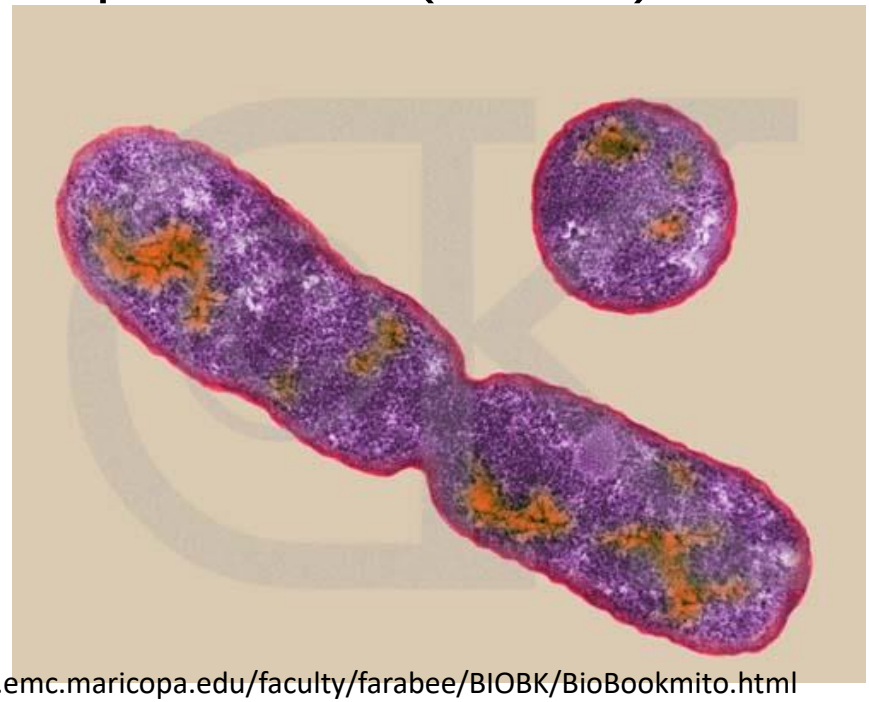
Fig 14.10

Once DNA is replicated, the cell divides into 2 = **asexual reproduction** (No meiosis, no gametes, one parent)

The specific process for asexual reproduction in bacteria is **Binary Fission**

Your non-sex cells divide by asexual reproduction (mitosis)

E.coli dividing by binary fission



http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookmito.html

Prokaryotic Asexual Reproduction

"Binary Fission" = divide in half

Fig. 11.8

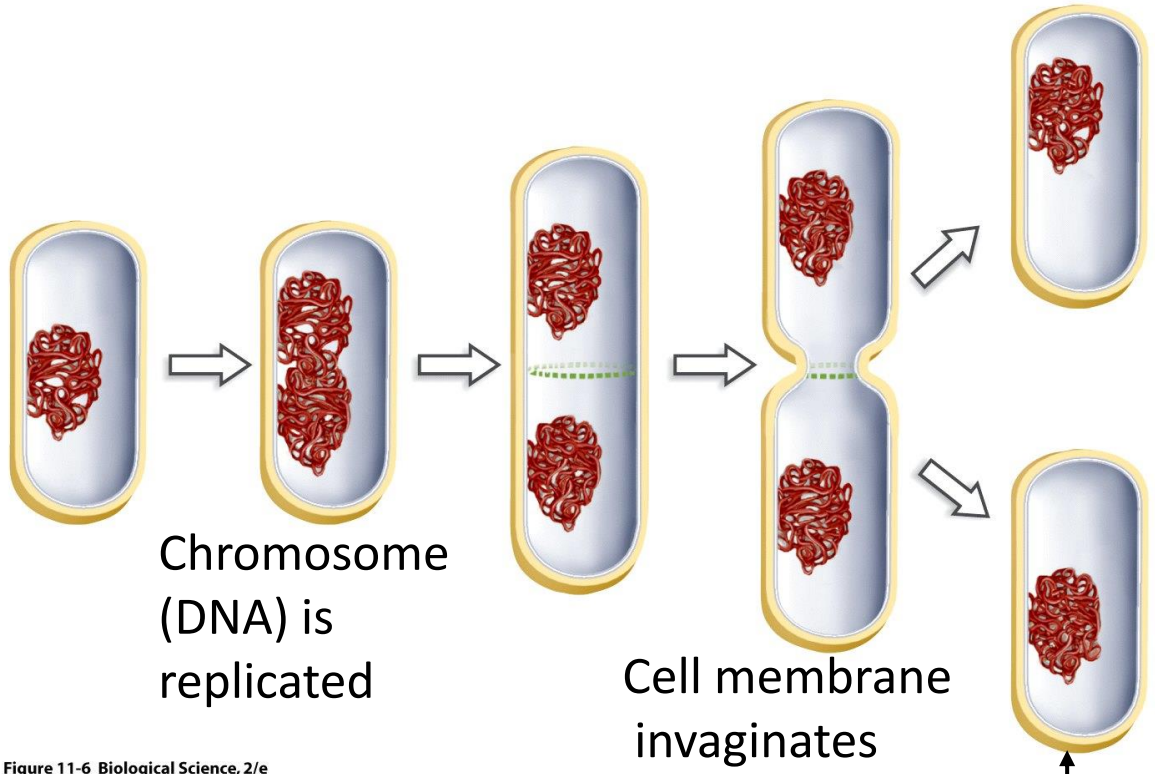


Figure 11-6 Biological Science, 2/e
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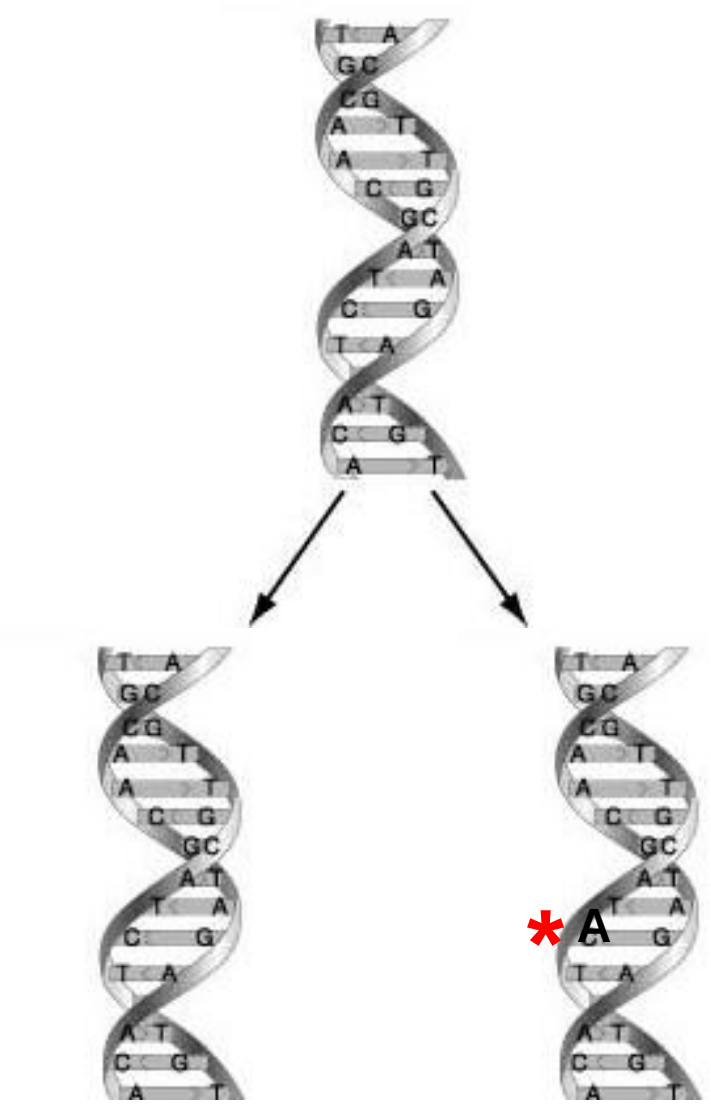
Fission = cells separate, resulting in two daughter cells which are **IDENTICAL** to each other and the original parent cell

Resulting cells are identical unless **a mutation** (i.e. a base pairing mistake) has occurred.



Bacterial Mutation rate:
("error" rate is 1/1 million).

Most mutations are deleterious - a few are beneficial (1%).

*Mutations create the **variation** upon which natural selection acts.*

An idea of how many mutations you would get in one culture tube of bacteria

~ 3ml of culture: 3 billion (3000 million) bacteria

1/million have a mutation

3000 mutant bacteria

No effect

~2970

Deleterious

Beneficial

~30

Reproduction versus DNA exchange

In eukaryotes: The same process is used for reproduction and introducing variation into a population (sex)

In prokaryotes: Reproduction occurs by binary fission this is fast and efficient but does not introduce much variation

Introducing variation into a prokaryotic population is done by 3 different processes, none of which result in reproduction

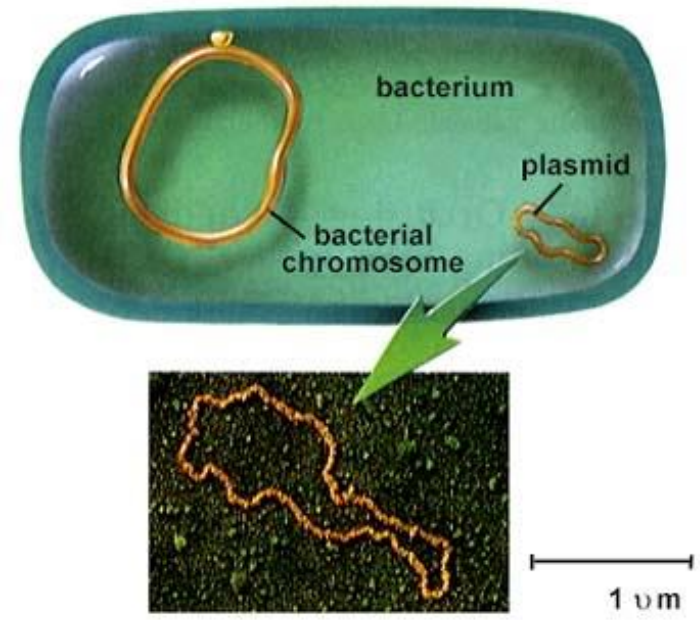
All of them involve transferring DNA from one bacteria to another: The result is a unique combination of genes (variation).

Bacterial DNA comes in two forms

Most genes are on one circular chromosome

Bacteria also have some of their genes on plasmids

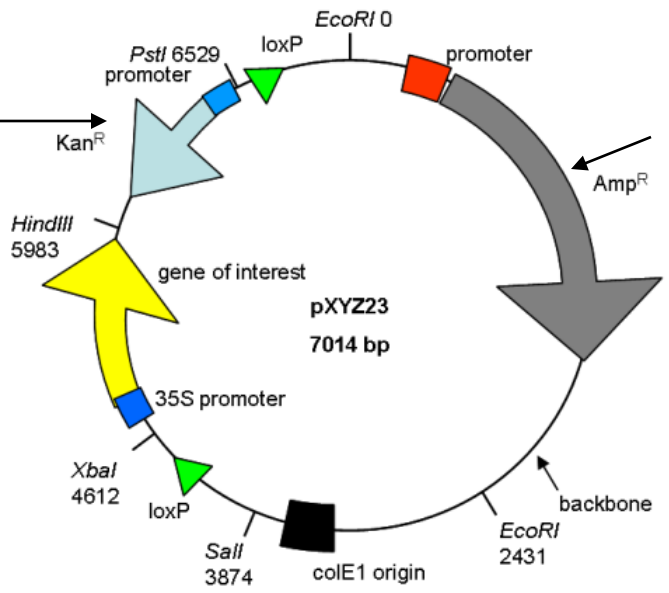
Plasmids are: small (<1/20th the size of the chromosome) circular pieces of DNA that replicate independently of the chromosomal DNA



Bacterial DNA comes in two forms

Plasmids typically carry genes only required under unusual circumstances (host-defense evasion genes or antibiotic resistance genes)

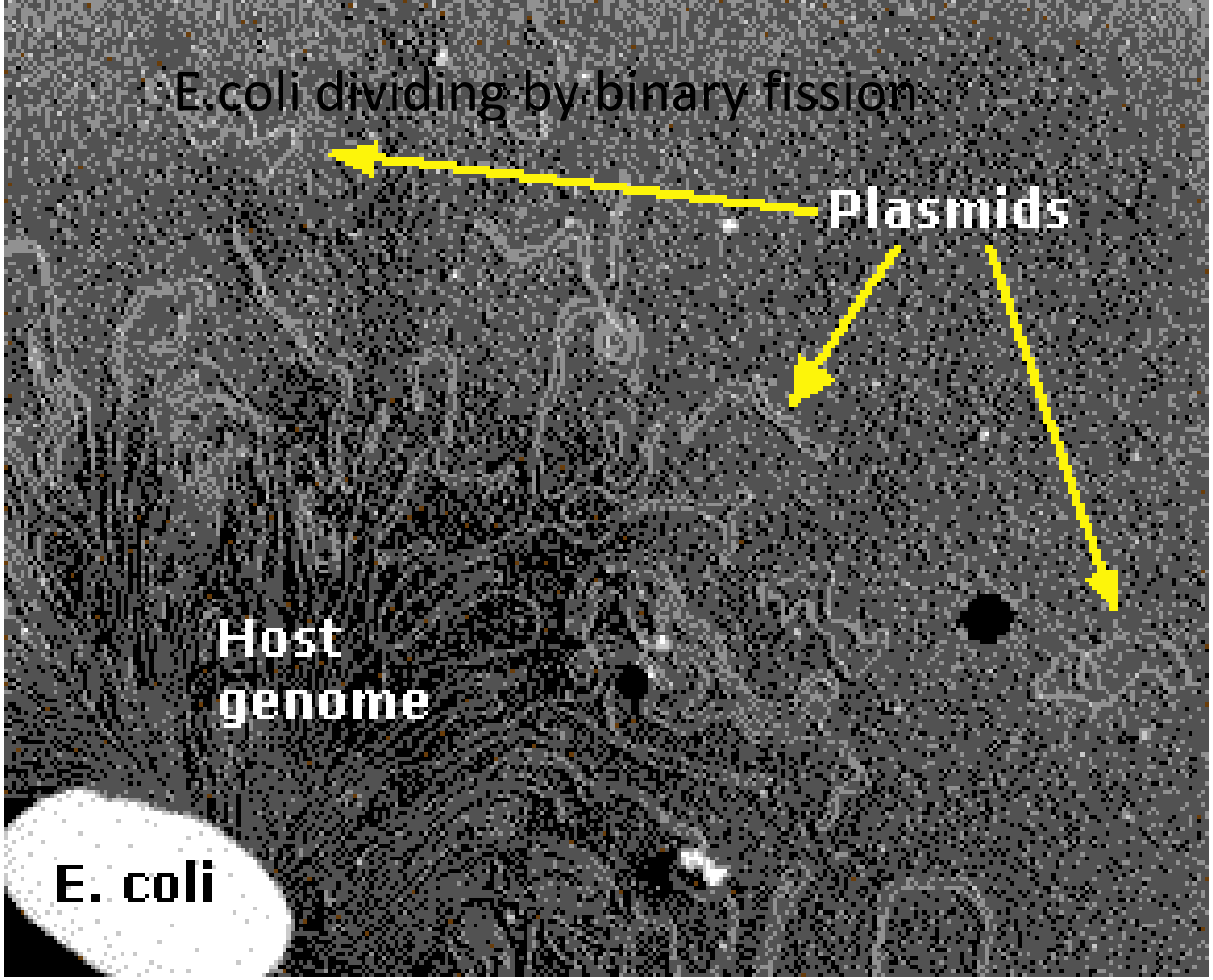
kanamycin resistance



ampicillin resistance

In E.coli alone, 3000 plasmids have been identified

When DNA exchange occurs, can be chromosomal DNA or plasmid DNA but plasmid DNA is the most readily exchanged



Electron micrograph of an E. coli cell ruptured to release its DNA.
The tangle is a portion of a single DNA molecule containing over 4.6 million base pairs encoding approximately 4,300 genes.
The small circlets are plasmids.
(Courtesy of Huntington Potter and David Dressler, Harvard Medical School.)
http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/R/RecombinantDNA.html

Three mechanisms of DNA exchange ...

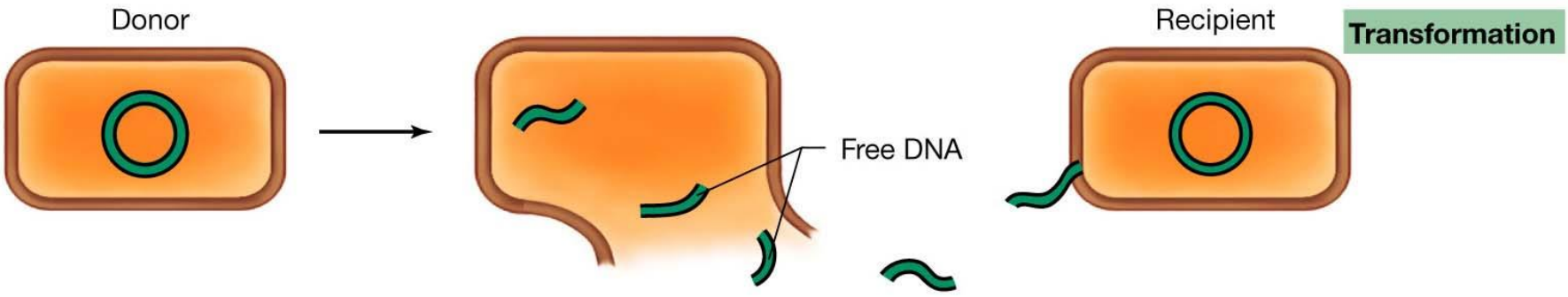
Transformation – pg 341
Bacteria take up free DNA released by other bacteria

Transduction
DNA transferred from bacterium to bacterium by viruses

Conjugation
Genetic transfer involving bacterium-to-bacterium contact

None of these result in reproduction

Transformation: bacteria take up free DNA released by other bacteria.



Not all bacteria are “competent” (can be transformed)
This is genetically controlled

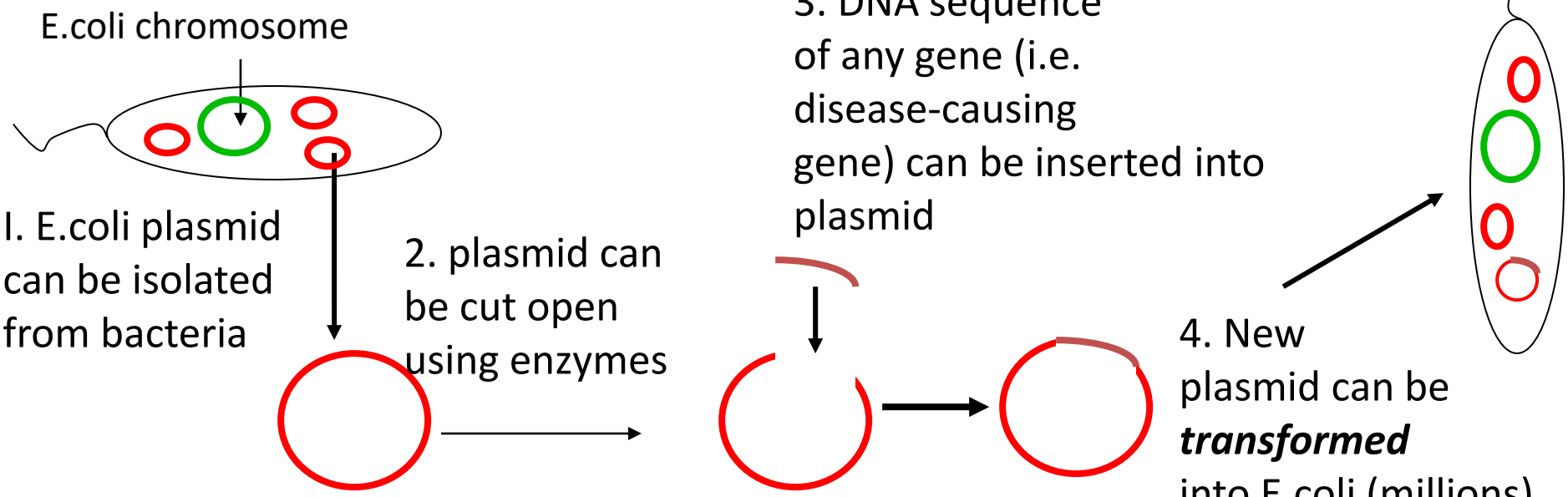
Recall: Can take up a piece of chromosomal DNA
or entire plasmid but plasmid transfer more frequent

Principle of Recombinant DNA Technology is exploiting plasmid transformation in E.coli

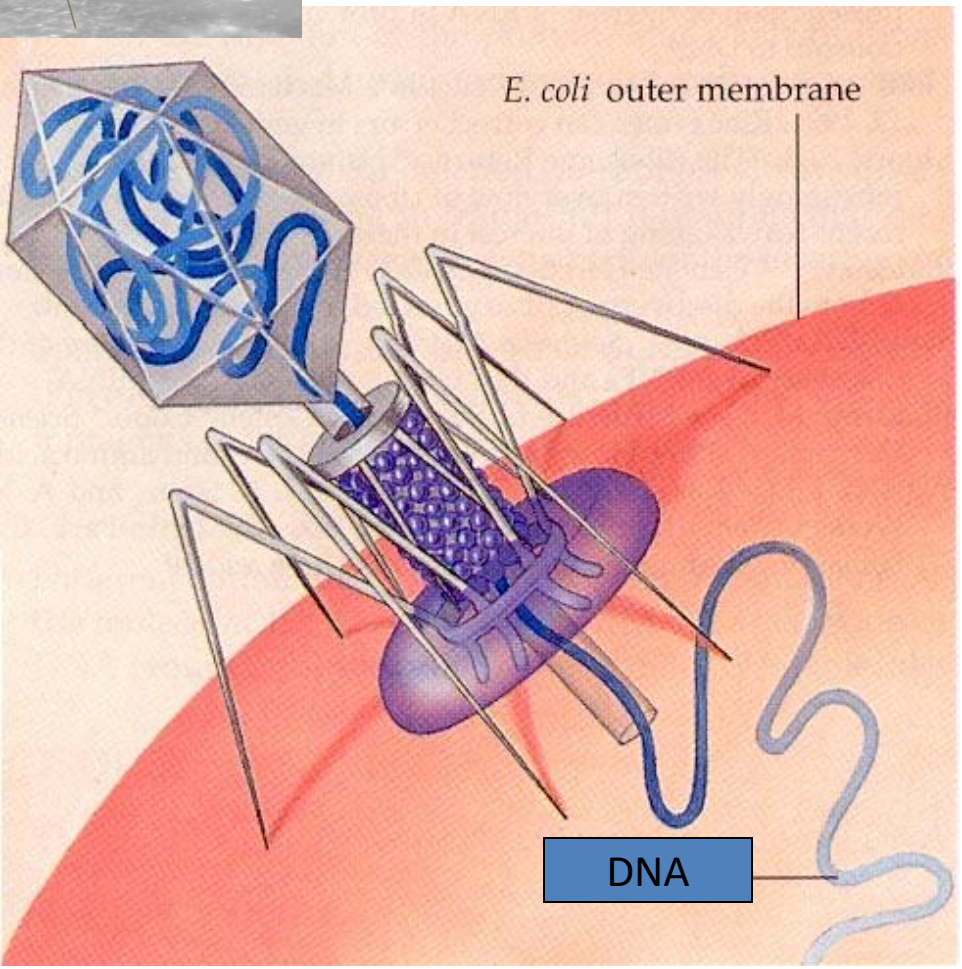
Some bacteria are naturally competent.
You can also induce competence in the lab.

Goal is to use E.coli as a gene-making machine.
for a gene you are interested in

5.Now millions of E.coli cells will express your gene giving you lots of material to work with



Transduction by Bacterial Viruses (Phages)

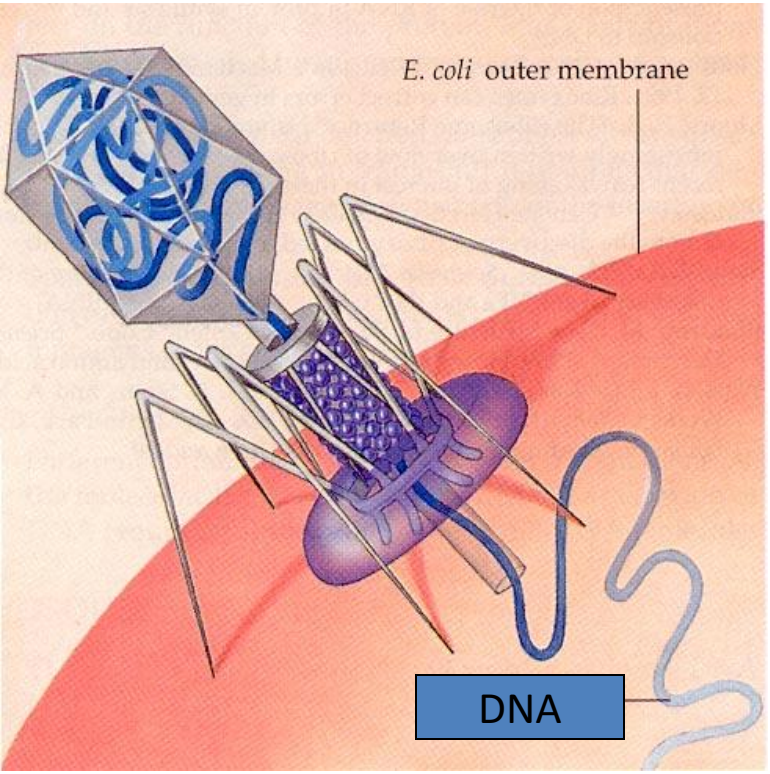


- When phages infect a bacterium, they can mistakenly **pick up DNA from the bacterium**

- As part of it's infection process, the phage injects It's DNA into the bacteria **Any bacteria DNA in the virus will also get injected into the new recipient bacterium**

http://www.youtube.com/watch?v=9hzUjx_oD8E&feature=related

Transduction
Some more about phages



Phages kill bacteria

Attempts to use them in medicine include:

As anti-bacterials (limited success)

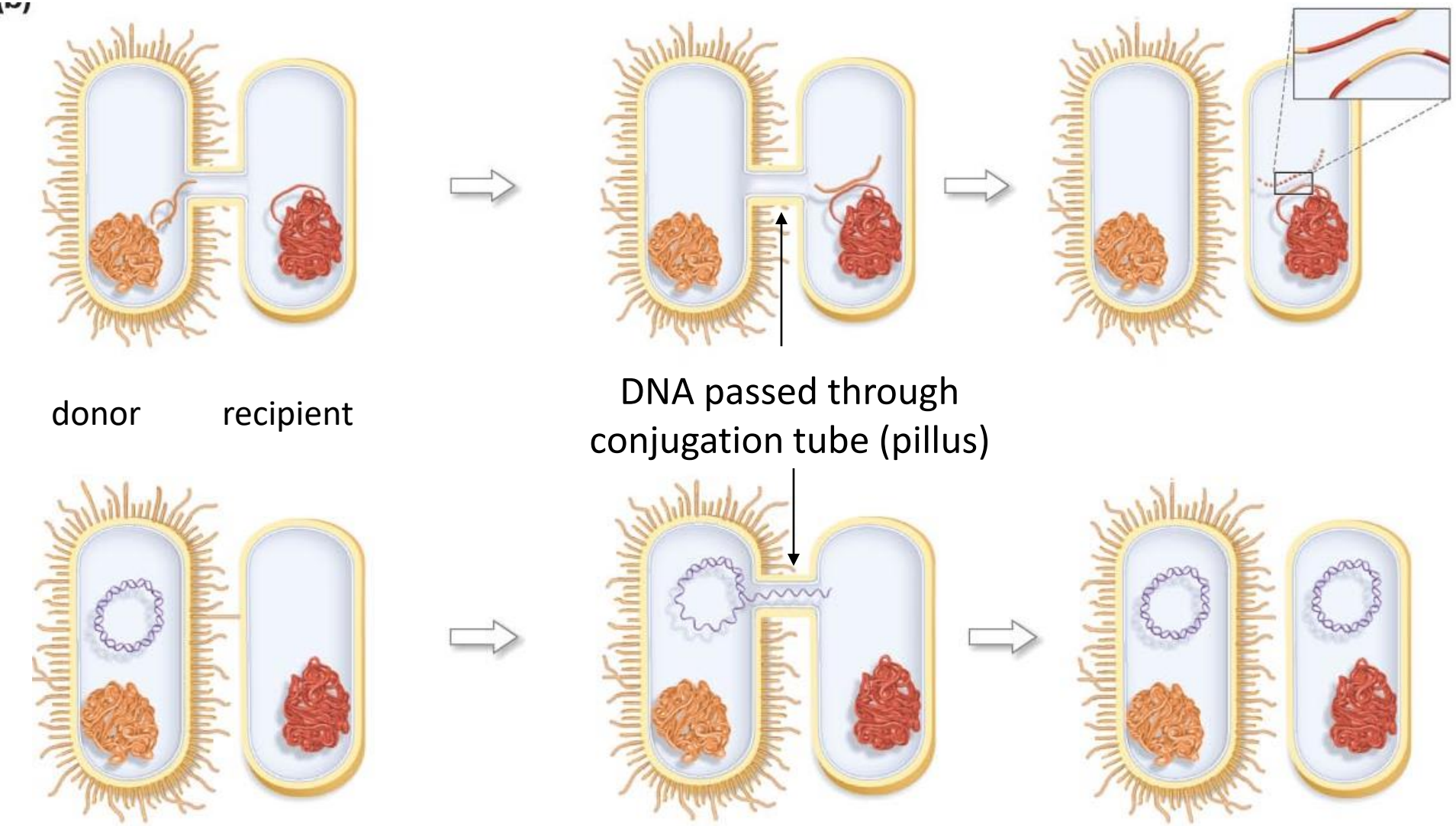
Rubbing on Deli Meat (FDA approved)

Soak bandages for burn victims

10 x more numerous than bacteria

Conjugation: Transfer of DNA directly from one bacterium to another

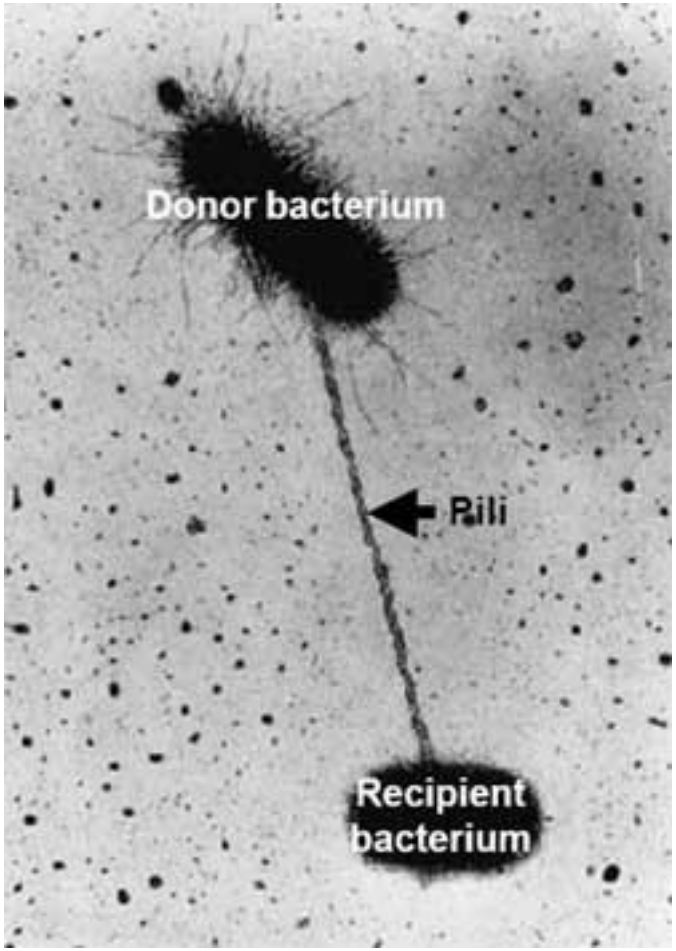
Transfer of piece of chromosomal DNA = recombination



Transfer of entire plasmid

Fig 12.10

Electron Micrograph of Conjugation



Transformation, Conjugation and Transduction:

These 3 processes allow bacteria to mix up DNA frequently which is why they are such a genetically diverse group

Leads to good things like cycling nutrients that we need, maybe even fueling our cars in the future

These 3 processes ALSO allow bacteria to share their genes with each other and help a friend out.

Good for them, bad for us…

Plasmid Typically Carry Genes For:

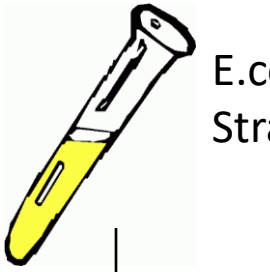
Antibiotic Resistance

Virulence

Antibiotic Resistance Genes on Plasmids

Encode for proteins that inactivate antibiotic or prevent its uptake
Plasmids can carry a variety of resistance genes and as you learned this plasmid can be transferred to bacteria 3 different way

Transfer of plasmids can be observed in lab and in nature



E.coli Strain 1

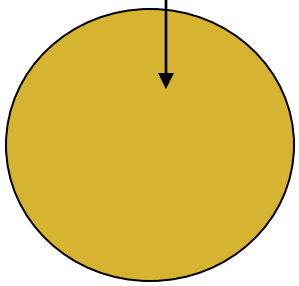
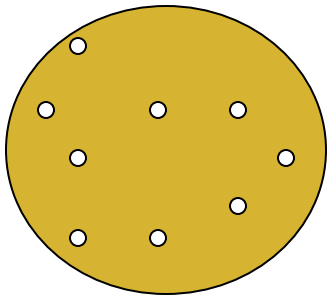


Plate with growth media and ampicillin: <u>no growth</u>

E.coli Strain 2



<u>Growth!</u>
b/c it has amp^r on it's plasmid

Conjugate E.coli 1 and 2

OR

Remove plasmid from E.coli 2 & place it in liquid media with E.coli 1. E. coli 1 will take up the plasmid by transformation

Result: E.coli 1 and 2 can both grow on ampicillin media

more antibiotic resistant bacteria AND multi-drug resistant bacteria AND more virulent bacteria

Plasmid can be transferred between species & genera!
For example, one resistance plasmid can transfer itself between bacteria in the genera *Escherichia*, *Klebsiella*, *Proteus*, *Salmonella* & *Shigella*!

One bacterium can harbor multiple plasmids with antibiotic resistance genes or virulence genes and the spread to wealth to his friends

Summary of Bacterial Reproduction and Sex

Bacterial Reproduction: binary fission

- Replicates DNA/cell
- No exchange of genetic material
- Mutations = only source of variation

Bacterial Sex: transformation, transduction, conjugation

- Exchange of genetic material
- Does not involve reproduction
- Can occur between distantly related bacteria
- Significant source of variation: mixing DNA

THANK YOU