Lecture 6: Fungi, antibiotics and bacterial infections

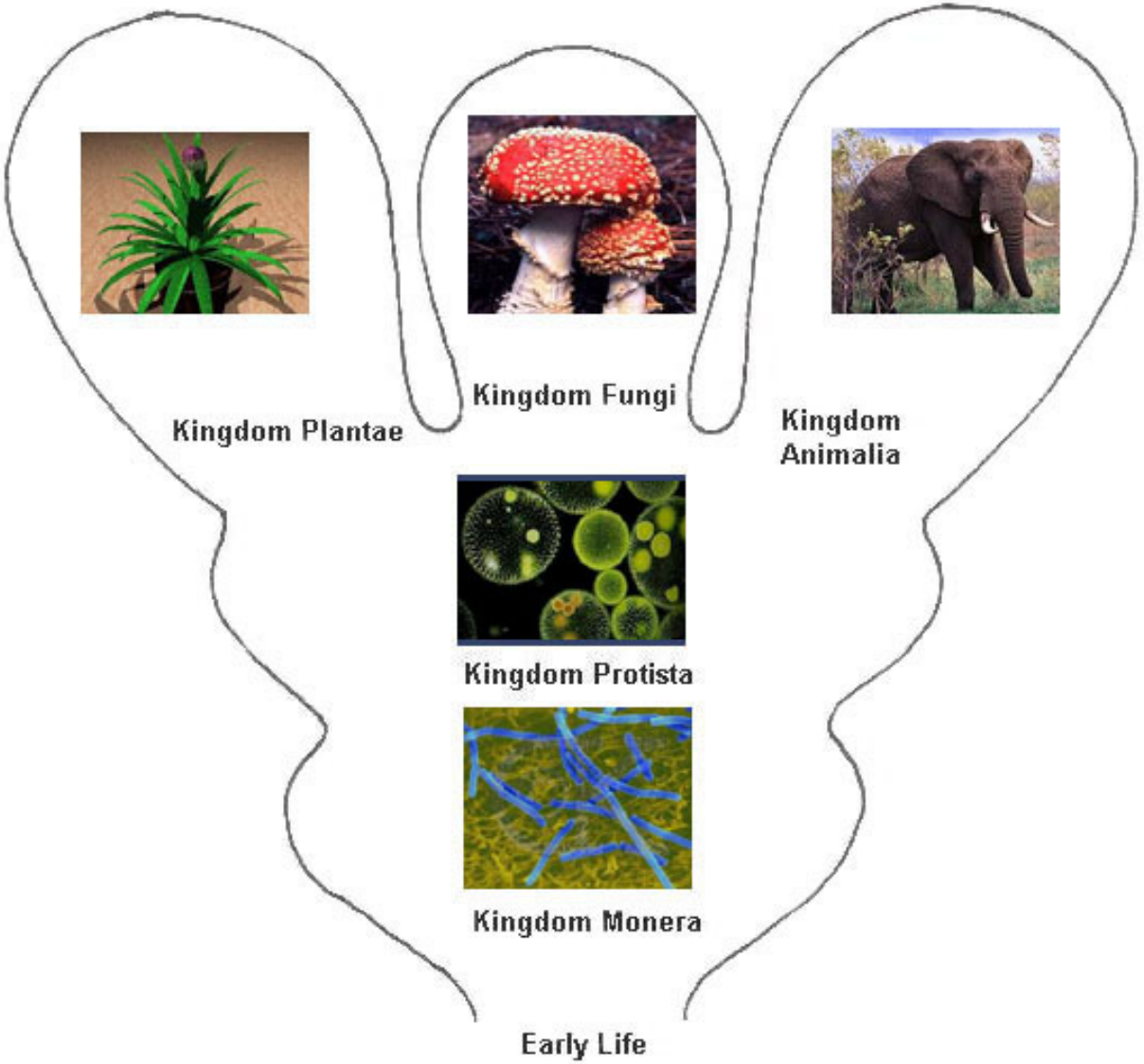
Outline

- Eukaryotes and Prokaryotes
- Viruses
- Bacteria
- Antibiotics
- Antibiotic resistance

Lecture Outline Section 4

Lecture	
1	Plants and human health
2	Willow and aspirin
3	Opium poppy and morphine
	Pain
4	Plants and human reproduction
5-6	Infectious diseases
	Quinine and malaria
	Fungi, antibiotics and bacteria
7	Pacific yew and cancer
8	Vitamins and Nutrition
9-10	Stimulants: tea, coffee and cocaine
	Tobacco
11	Marijuana and hallucinogens
12	Review
13	Test

The Kingdoms of Life



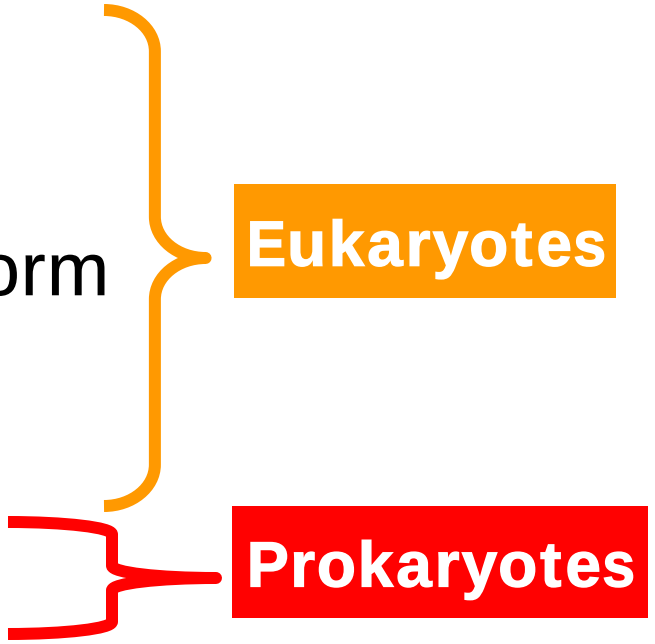
Eukaryotes

Prokaryotes

Human pathogens

Pathogen = an organism or biological agent that causes disease to its host

- Insects e.g. Lice
- Arachnids e.g. Ticks
- Parasitic Worms e.g. Tapeworm
- Fungi e.g. Tinea
- Protozoa e.g. Malaria
- Bacteria e.g. Salmonella
- Viruses e.g. Influenza

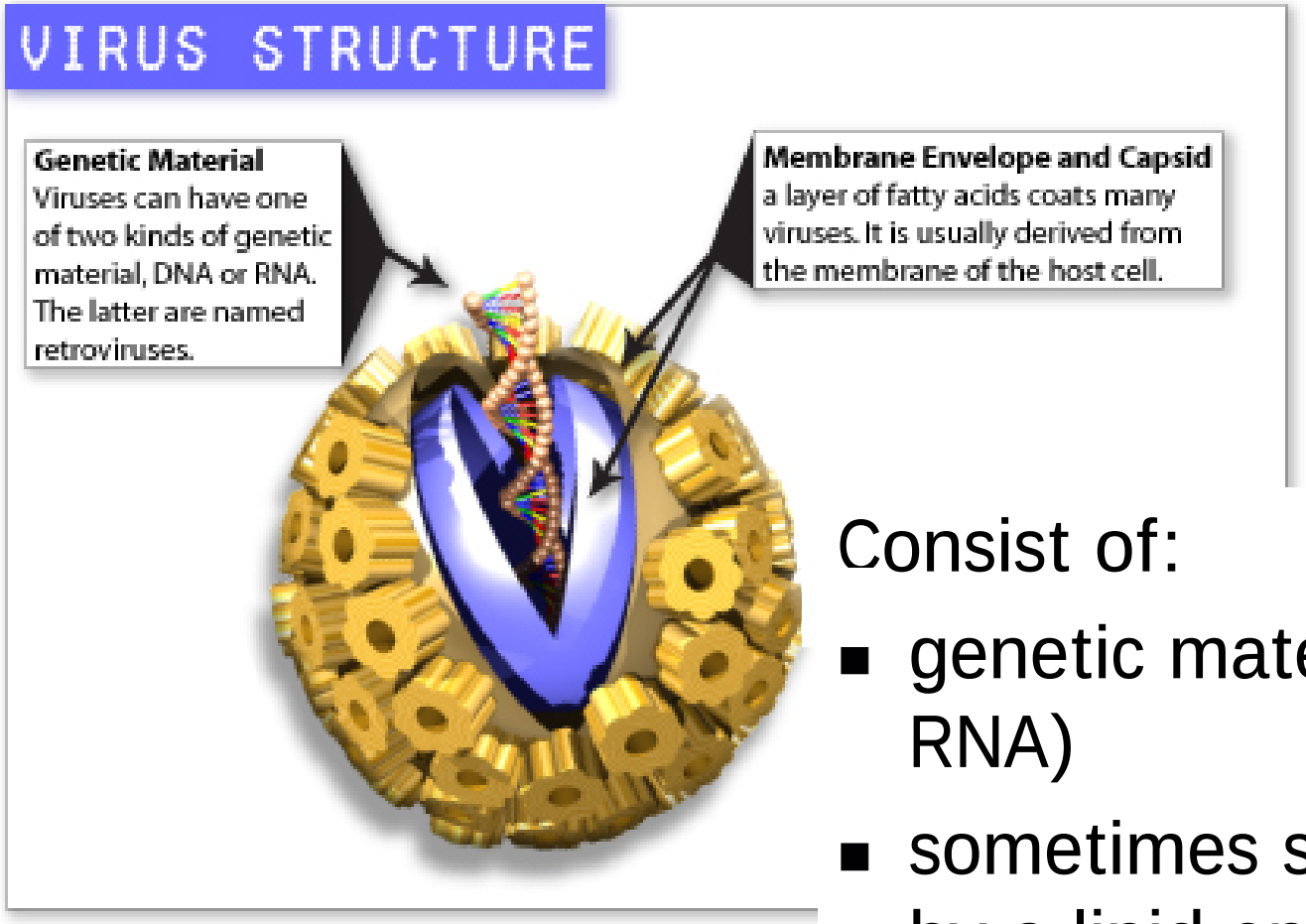


Viruses

- Viruses do not fit into the standard definition of “life”
- “Biological Agents”
- Microscopic particles made up of biological material
- Do not have metabolism
- Do not grow
- Require a host cell in order to replicate

Viruses attacking an *E. coli* bacterial cell

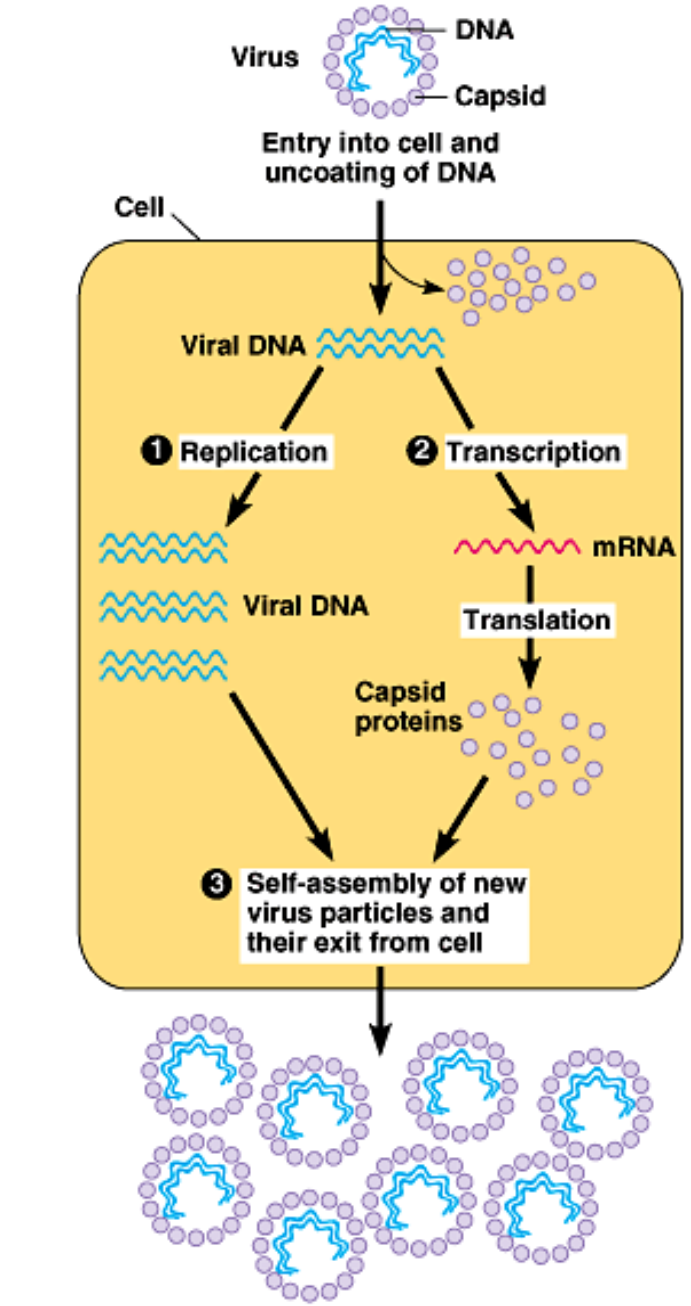
Viruses



Consist of:

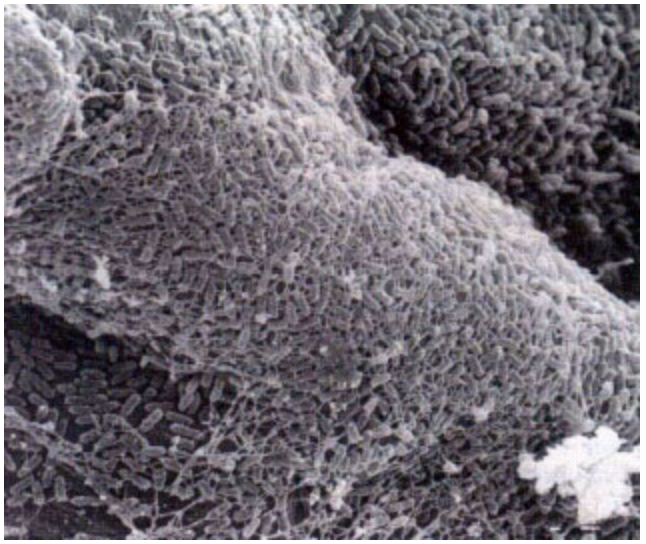
- genetic material (DNA *or* RNA)
- sometimes surrounded by a lipid envelope
- Capsid - protein coat

Viruses require a living cell to replicate



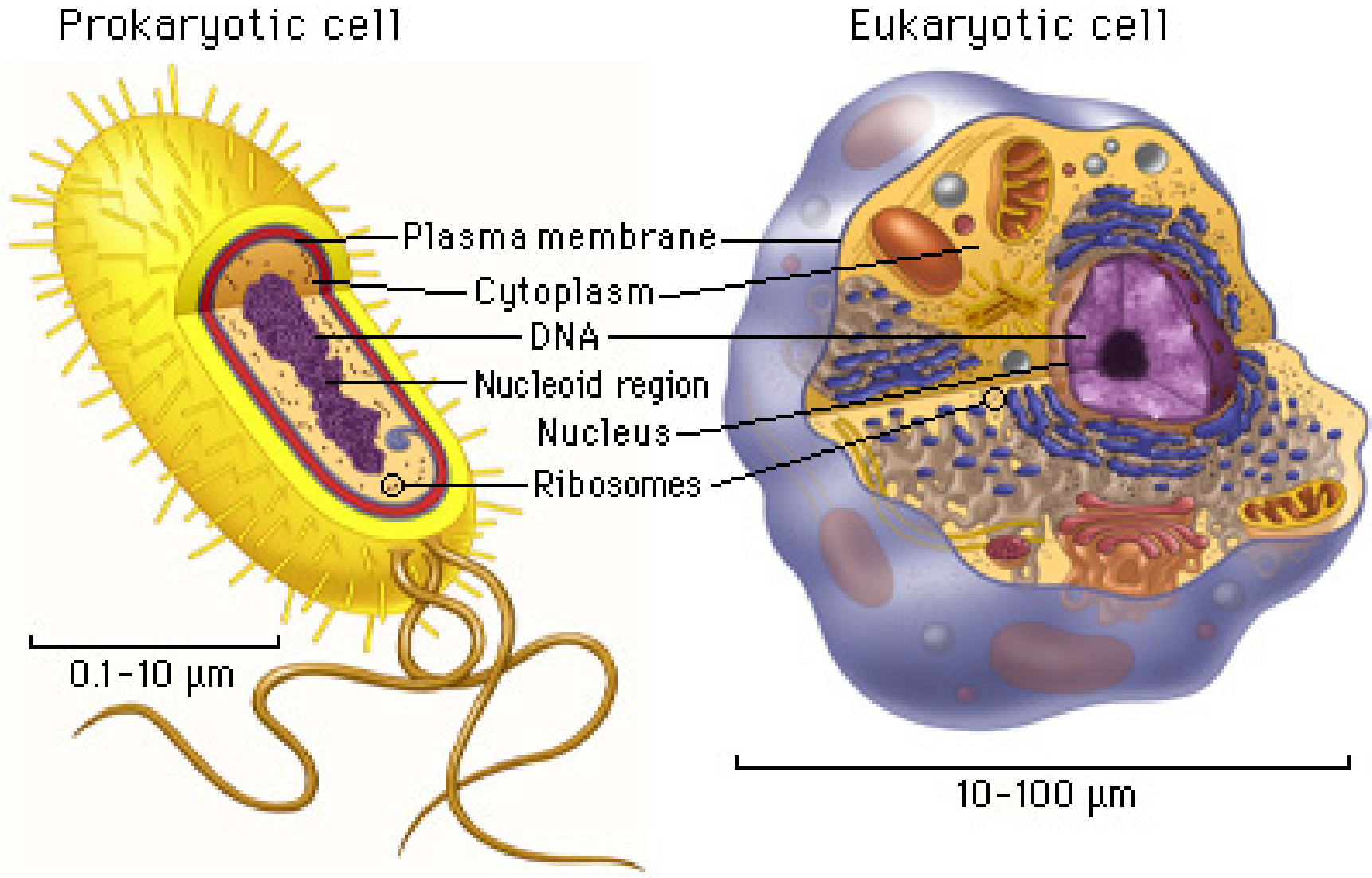
Bacteria

- Are everywhere!
- On every surface of the body
  - Including digestive tract
- Harmless
- Beneficial
- Pathogenic
  - absorb nutrients and release toxins that damage cells and tissues.
  - Bacterial toxins can cause disease even when bacteria are destroyed



Healthy gut flora

Bacteria are Prokaryotes



http://www.schenectady.k12.ny.us/putman/biology/data/cells/common.html

Prokaryotic Cells	Eukaryotic Cells
Small (0.1 – 10 microns)	Larger (10 – 100 microns)
Free floating DNA	DNA enclosed within membrane bound nucleus
No organelles	Membrane bound organelles with specific functions
70S Ribosomes for protein synthesis	80S Ribosomes for protein synthesis
Cell wall made of peptidoglycan	Either no cell wall or cell wall made of other substances

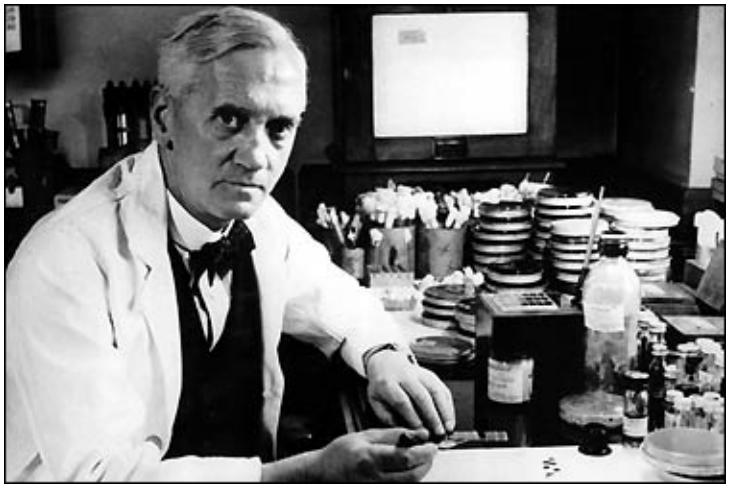
Fungi

- Not Plants – no photosynthesis
- Similar lifestyle → numerous secondary metabolites
- Medicinal and psychoactive substances
- Source of many antibiotics

History of Antibiotics

- Throughout most of human history life expectancy 20 -35 years
- Most deaths from infection and disease
- Clean water and hygiene
- 2500 yrs ago Chinese used molds to treat infection, also Egyptians and Greeks
- Antibiotics discovered in 20th century

Penicillin

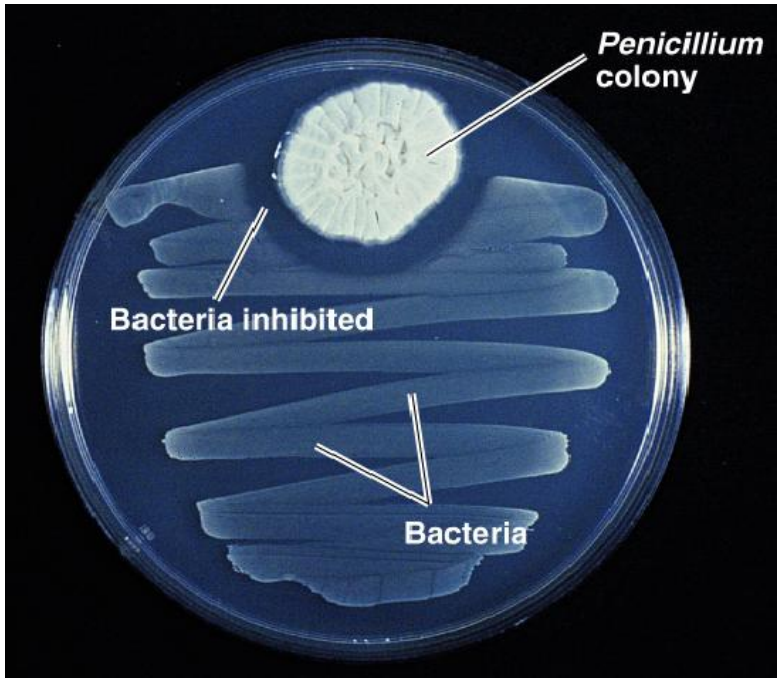


Antibacterial activity in *Penicillin notatum* by Alexander Fleming in 1928

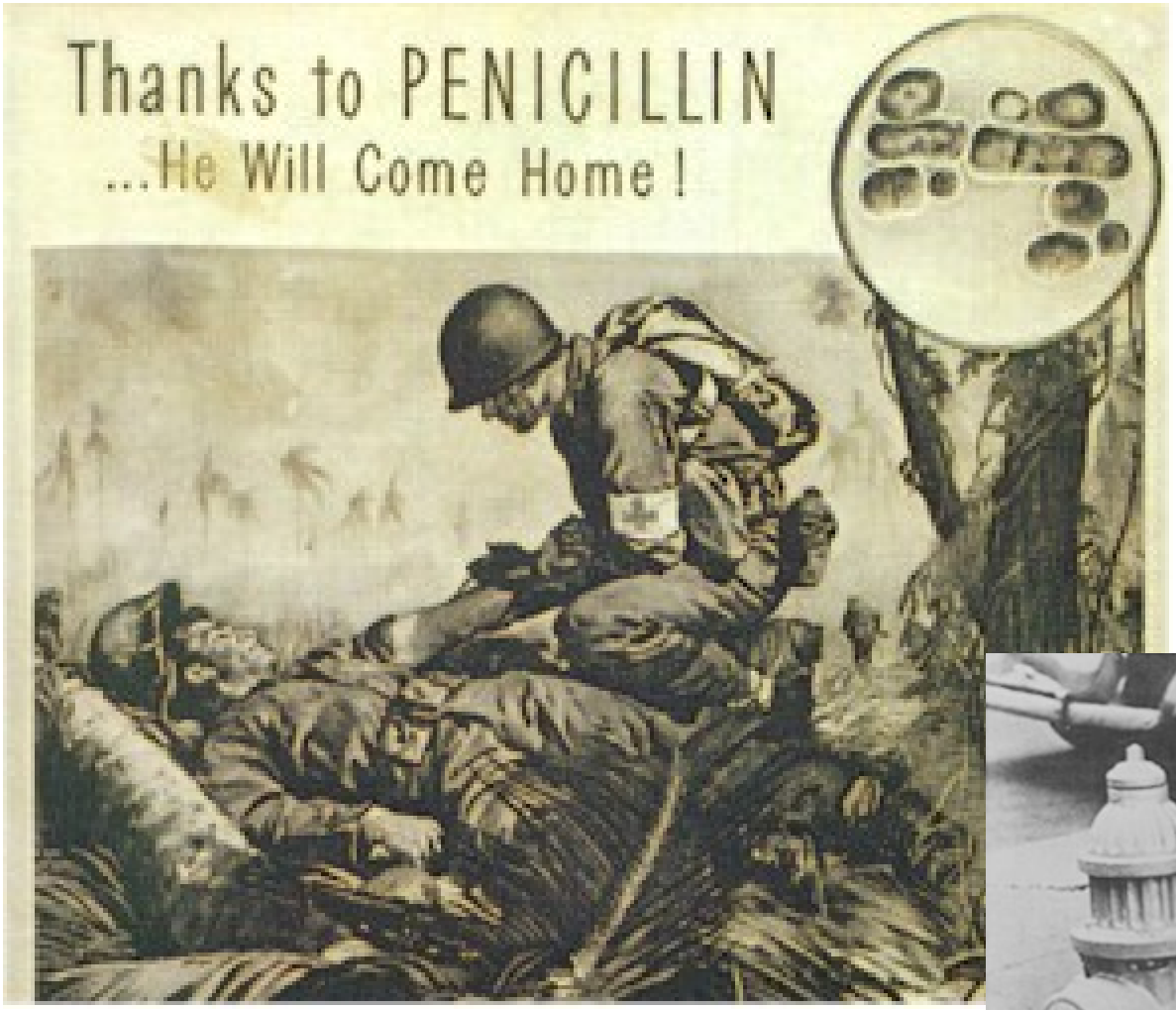
Research continued by Howard Florey and Ernst Chain

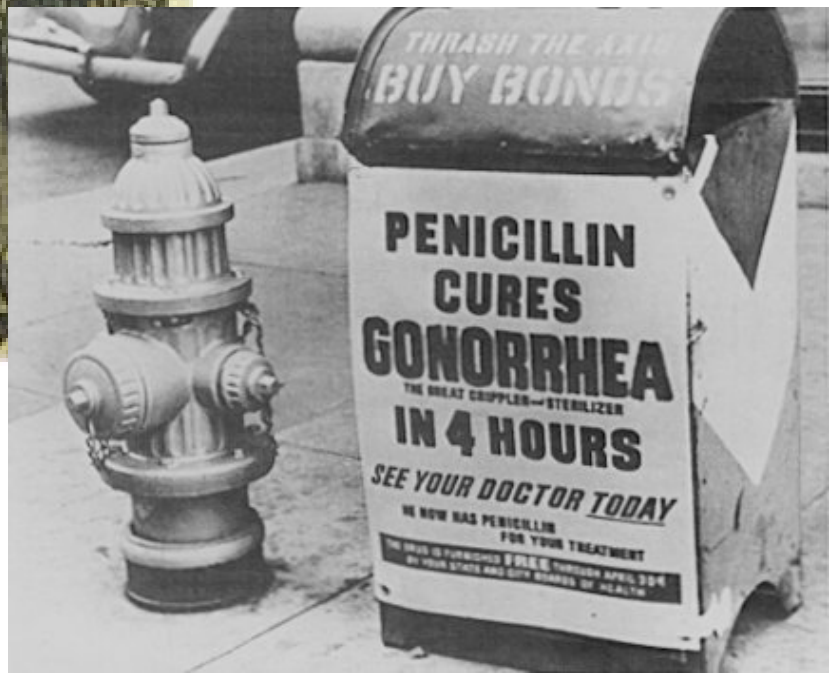
Mass production of penicillin in 1940s

Nobel Prize 1945



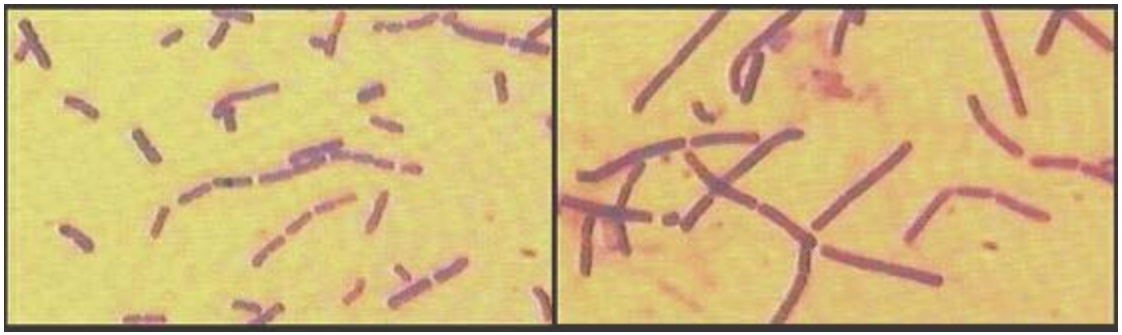
Inhibition of bacterial growth by a contaminating colony of *Penicillium notatum*


Thanks to PENICILLIN
...He Will Come Home!

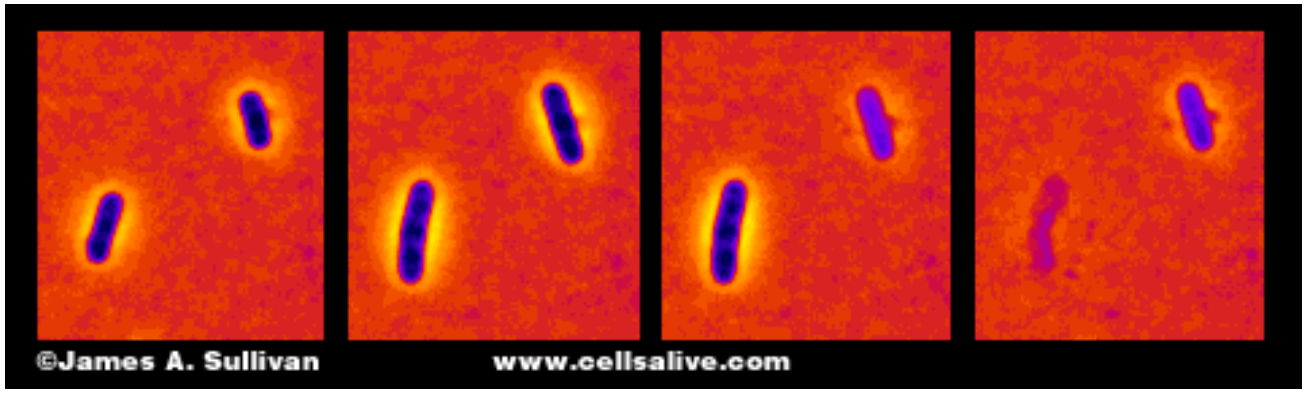

BUY BONDS
PENICILLIN
CURES
GONORRHEA
IN 4 HOURS
SEE YOUR DOCTOR TODAY

Mechanism of action of penicillin

Inhibits synthesis of bacterial cell walls



- ampicillin + ampicillin

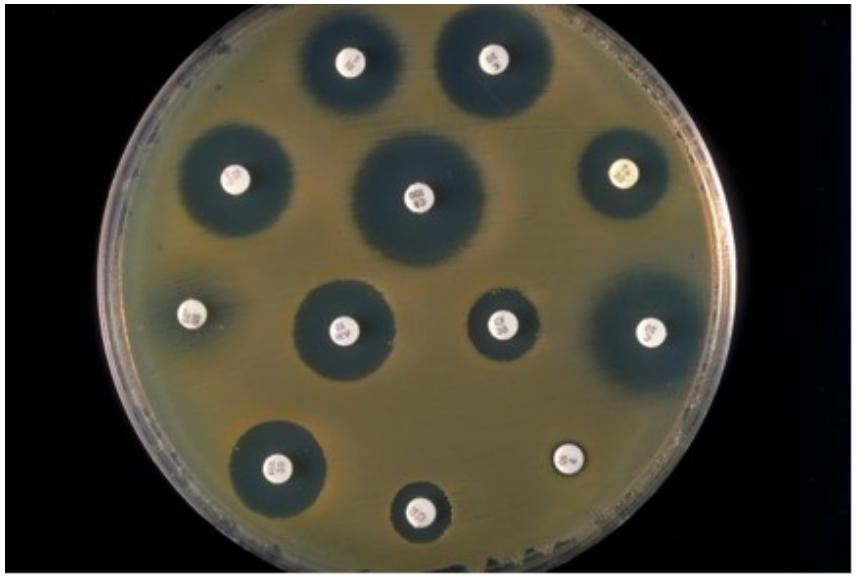


What are antibiotics?

- Drugs that prevent the growth of bacteria
- Attack prokaryotic cellular processes
- Do not affect eukaryotic cells
  - Do not harm human cells
  - Cannot be used for fungal or parasitic diseases
- Are not effective against viruses
- Characterised based on target specificity
  - Narrow or broad spectrum

Other antibiotics

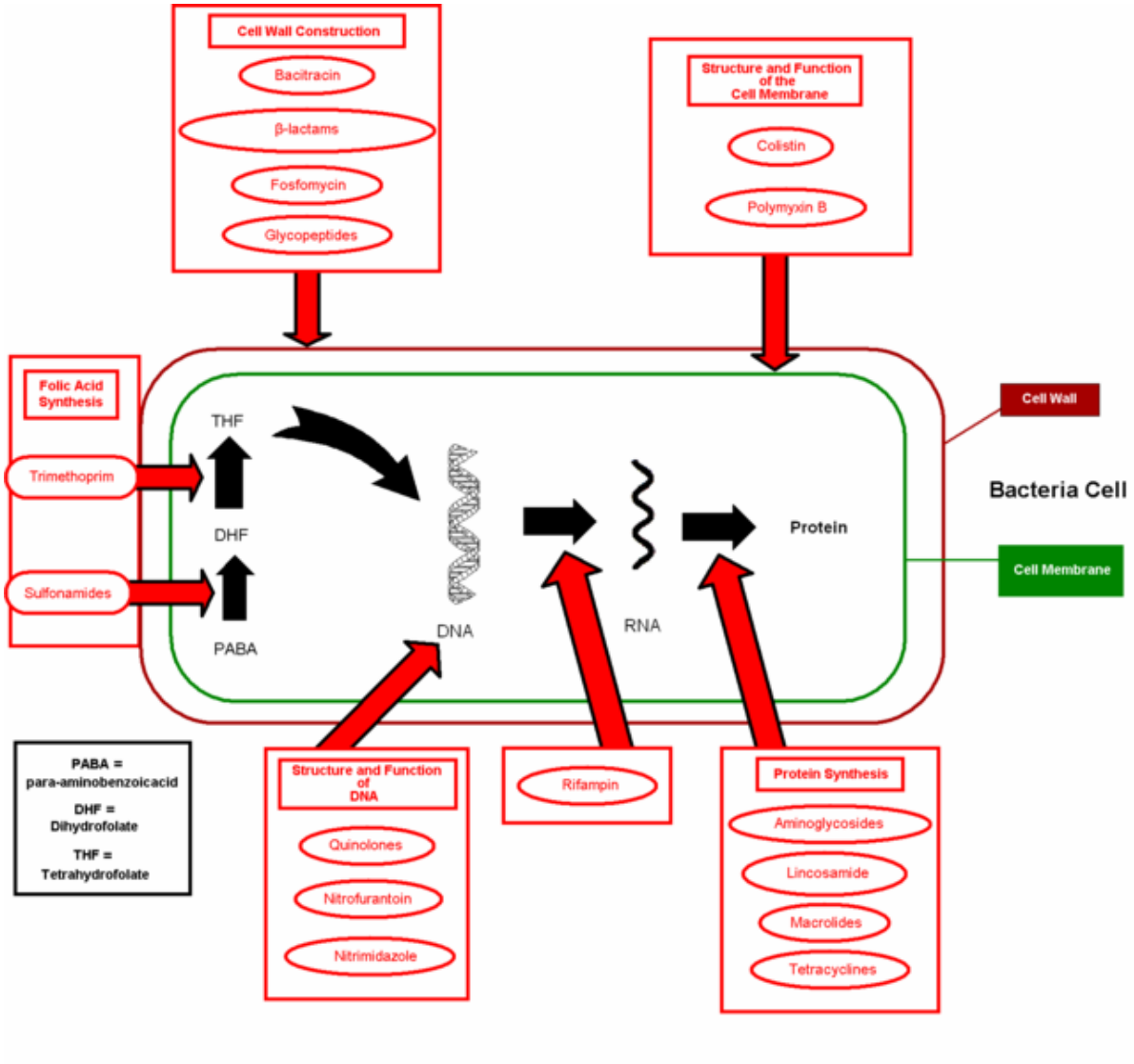
- Most are natural compounds or based on natural compounds
- Isolated from numerous fungal and bacterial sources



Screening for new antibiotics

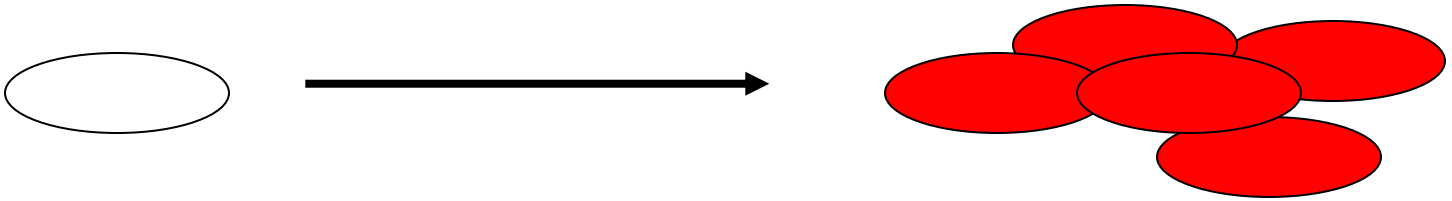
Mechanism of action of antibiotics

- Inhibition of cell wall synthesis
- Inhibition of protein synthesis
- Attack on cell membranes
- Disruption of nucleic acid synthesis
- Interference with metabolism



Problem: Antibiotic resistance

Antibiotic use and misuse



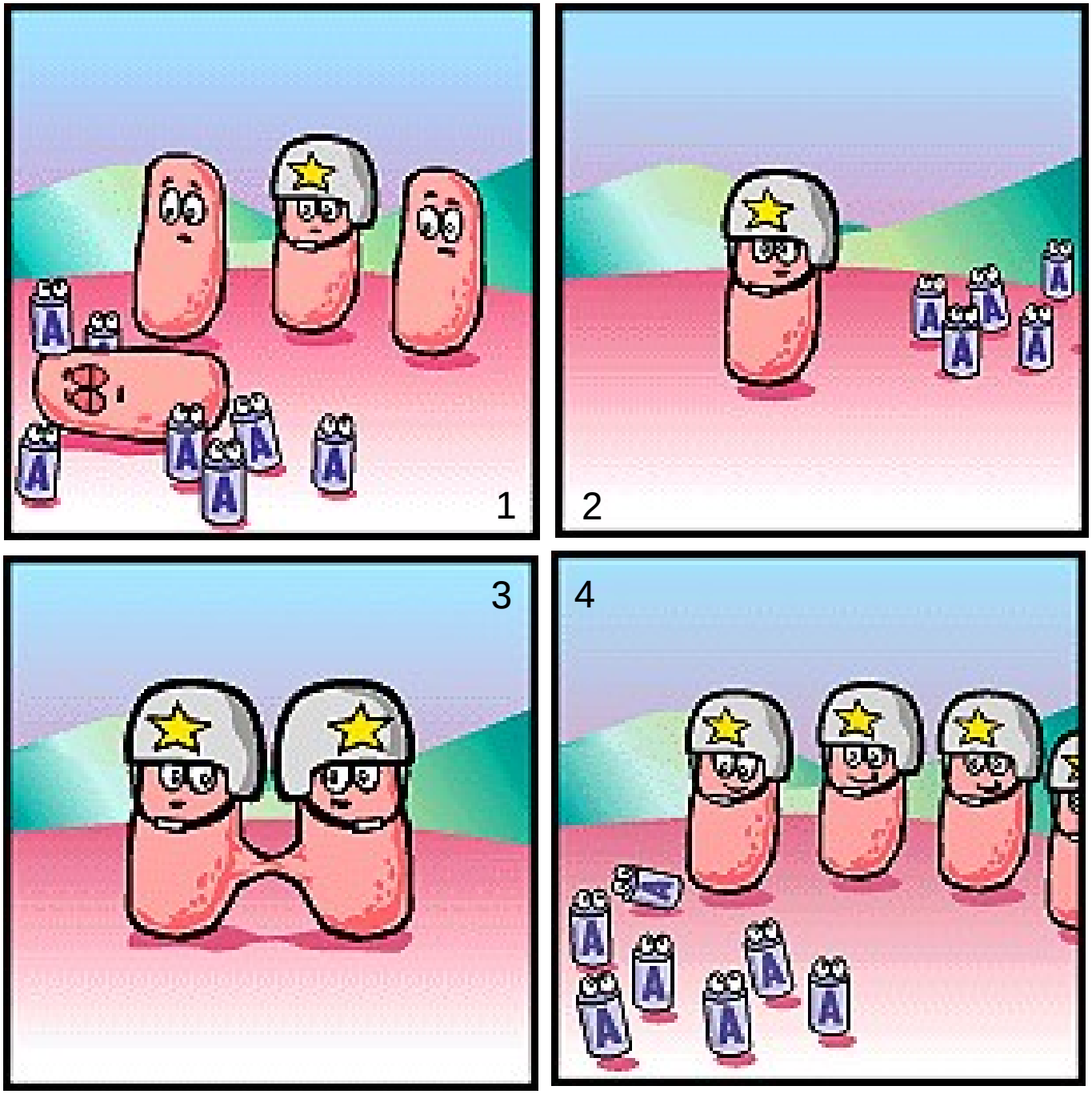
Antibiotic-resistant bacteria

How Do Bacteria Develop Resistance?

- Presence of antibiotics provides selection pressure for spontaneous mutants (1 in 10^6) with increased resistance
- High population density $\rightarrow$ efficient gene transfer
- Short generation time $\rightarrow$ rapid evolution

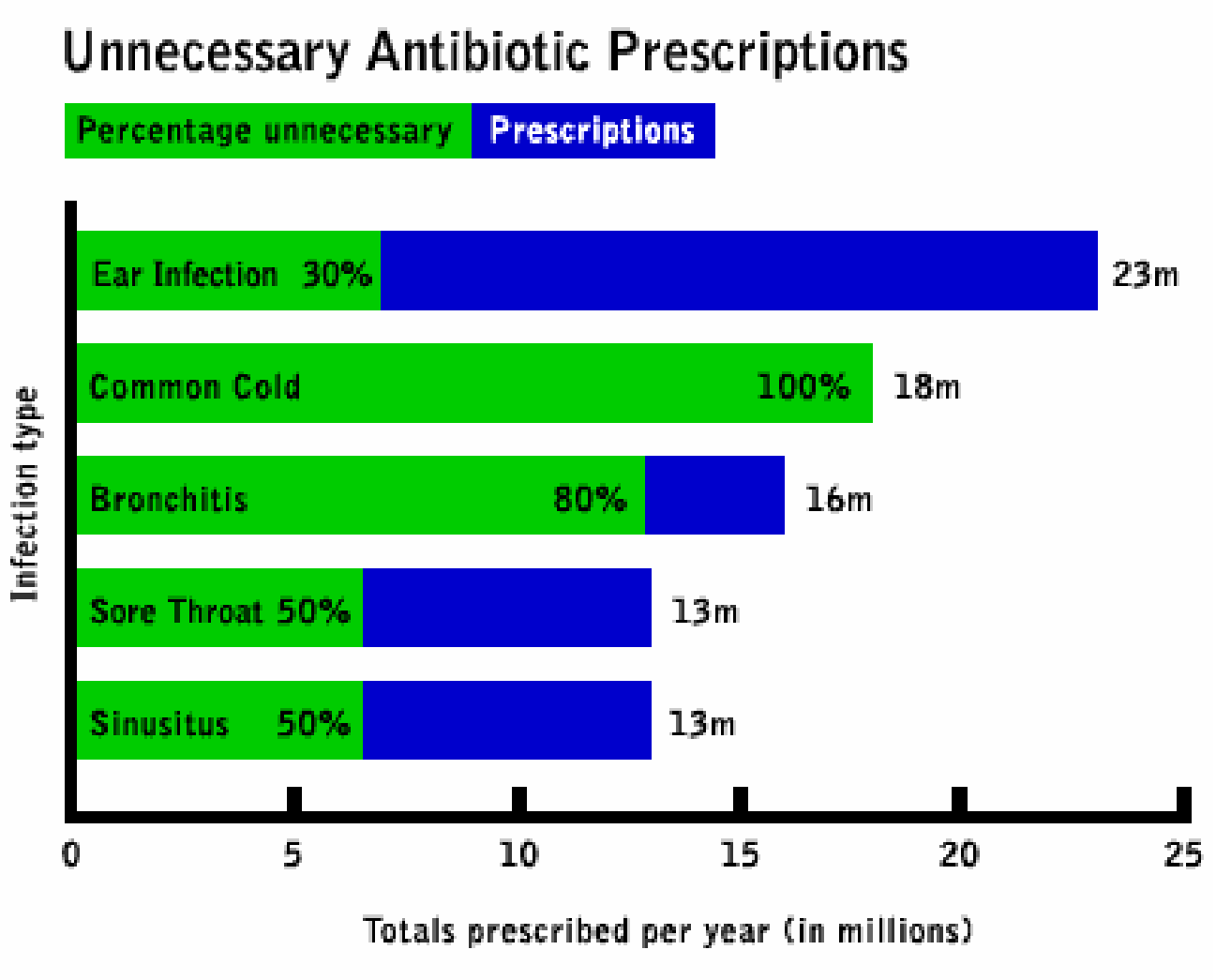
How Does it work?

- Inactivating enzymes
- Alter antibiotic target
- Pump antibiotics out of the cell


1
2
3
4

Antibiotics in Agriculture

- In USA - 70% of antibiotics used in livestock production
- Continual subtherapeutic doses fed to animals increases growth
  - Compensates for overcrowded unsanitary conditions
- Sprayed on crops for treatment of plant bacterial diseases
- Spread of resistance to human pathogenic bacteria



More than 50 million unnecessary antibiotic prescriptions are written each year in the United States for patients outside of hospitals, according the the Centers for Disease Control and Prevention

Sample question

1. Why are most antibiotics ineffective for treating viral infections?

a) Viruses are too small, and antibiotics are not able to bind to them.
b) Most antibiotics target prokaryotic cells, and viruses use eukaryotic cells to replicate.
c) Antibiotics act primarily by inhibiting the synthesis of the cell wall, and viruses do not have cell walls.
d) Over the years, viruses have developed resistance to antibiotics, therefore, they are no longer useful.
e) None of the above.

Sources: (Required readings in blue font)

Cell Structure and Function.

http://www.schenectady.k12.ny.us/putman/biology/data/cells/intro.html

The microbial world. Penicillin and other antibiotics.

http://helios.bto.ed.ac.uk/bto/microbes/penicill.htm#Top

Levetin, E. and McMahon, K. 2006. *Plants and Society, 4th ed.*, McGraw Hill, New York.