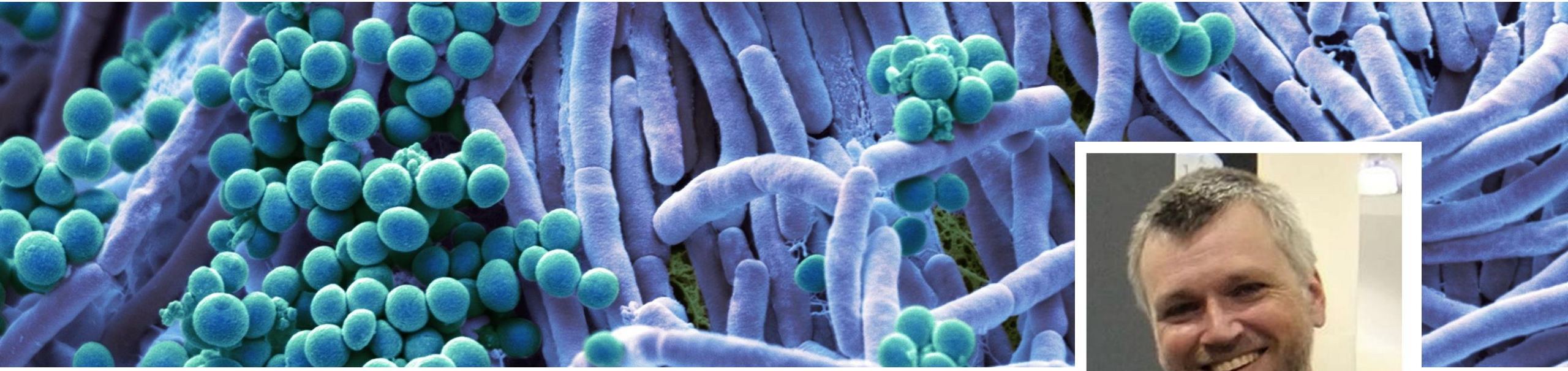
Microbiology and the ‘One Health’ concept

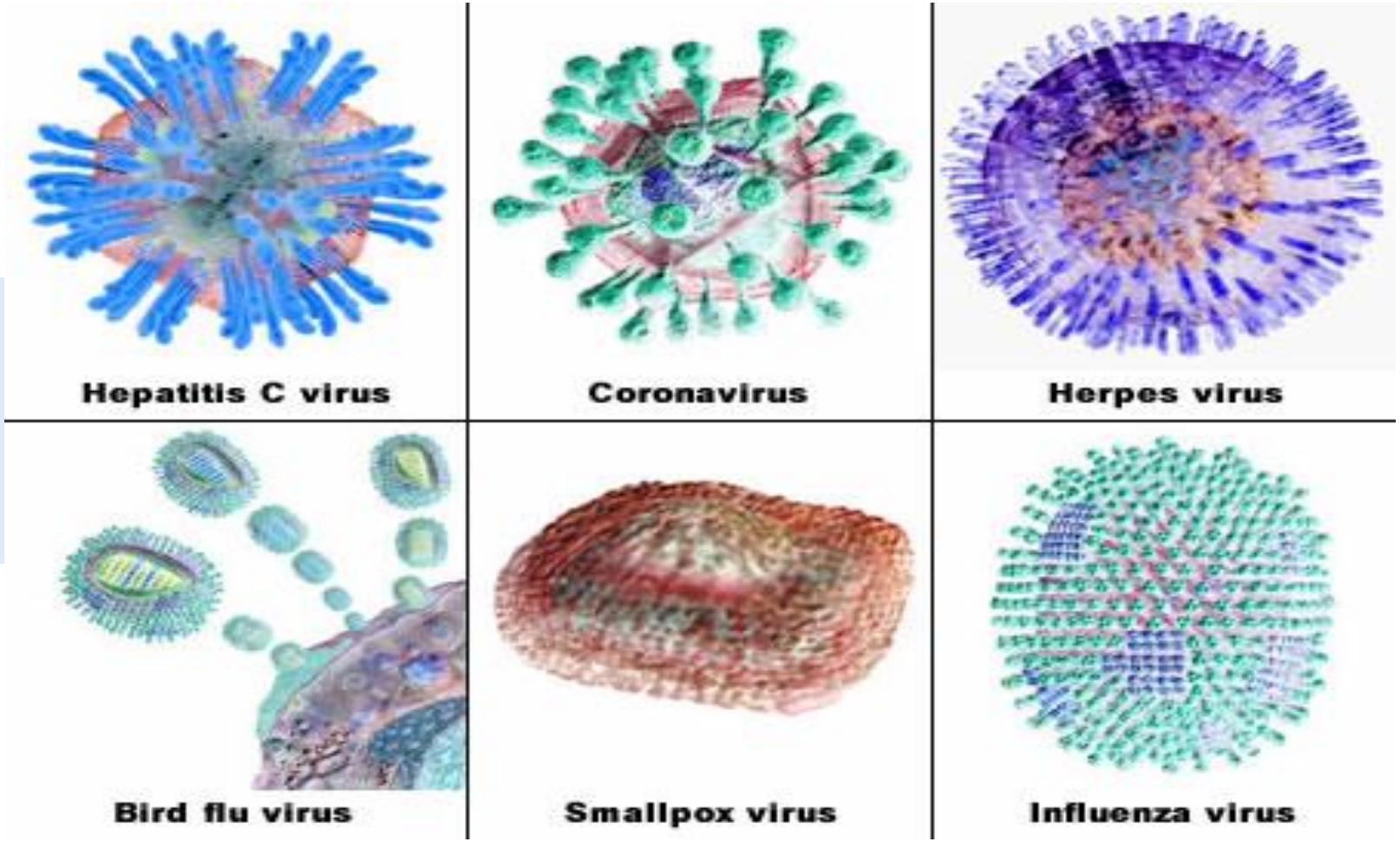


Dr. Nick Coleman

Diversity of Micro-organisms 1. Viruses

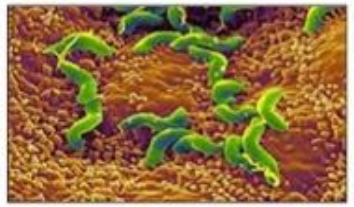
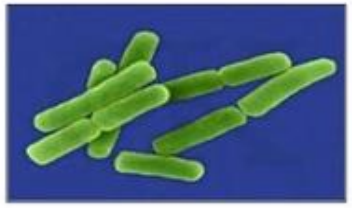
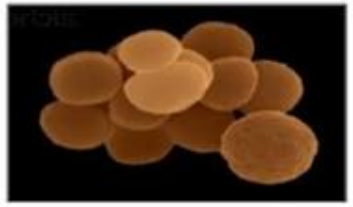
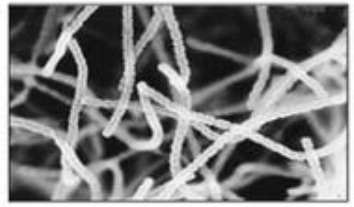
- The smallest and simplest biological entities
- Depend on host cell for replication & metabolism

Viruses are small in size and genome content but have large effects on other organisms and ecosystems



Diversity of Micro-organisms 2. Bacteria

- Unicellular structure. Smallest free-living organisms.
- Have own metabolism and replication (unlike viruses)

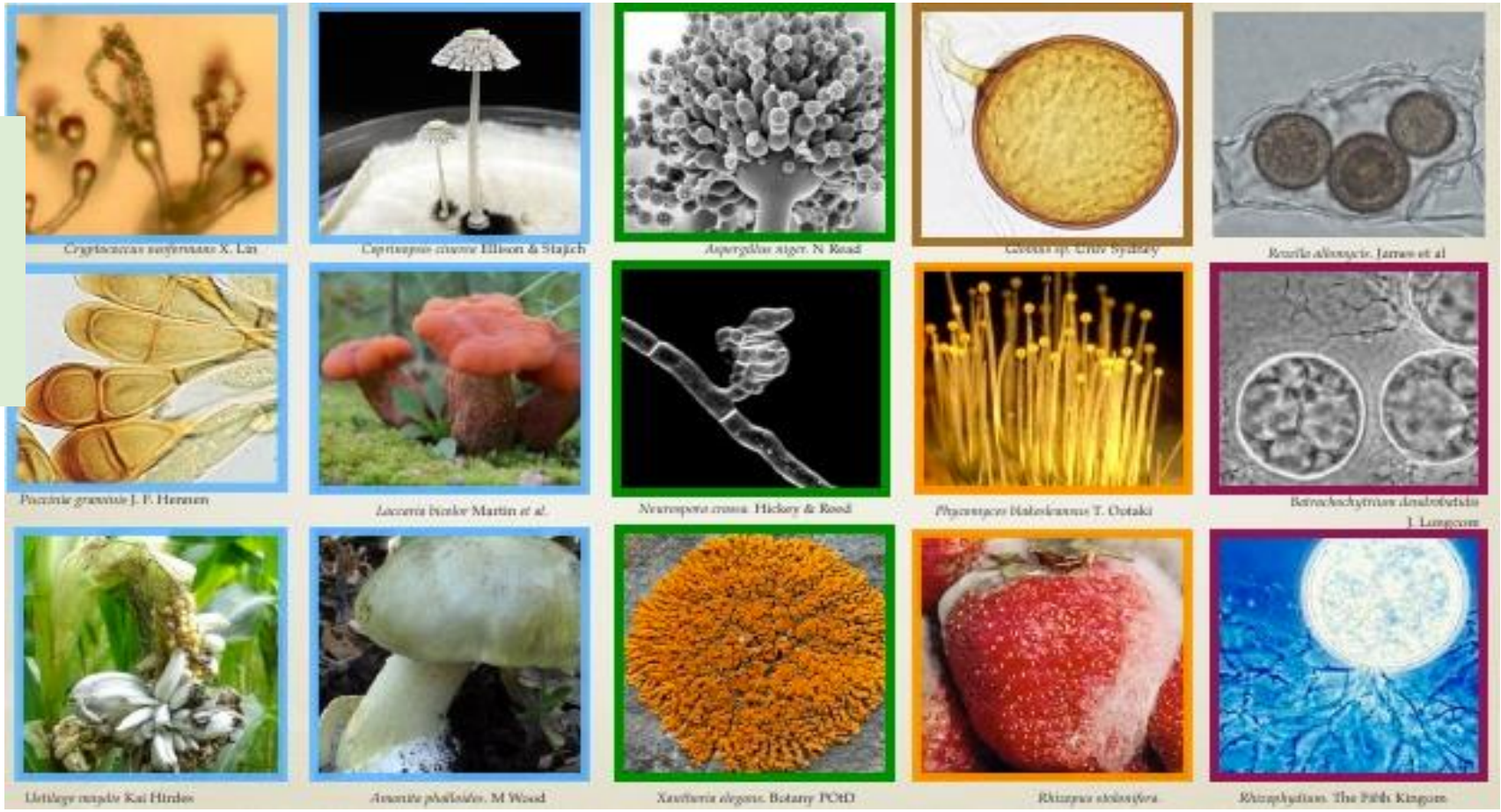
Circular (Coccus)	Rod-shaped (Bacillus)	Curved Forms	Other Shapes
Diplo- (in pairs)	Coccobacilli (oval)	Vibrio (curved rod)	 Helicobacter (helical)
Strepto- (in chains)	 Streptobacilli	Spirilla (coil)	Corynebacterium (club)
 Staphylo- (in clusters)	Mycobacteria	Spirochete (spiral)	 Streptomyces (filaments)

Simple morphologies of bacteria conceal complex biochemistry and interactions

Diversity of Micro-organisms 3. Fungi

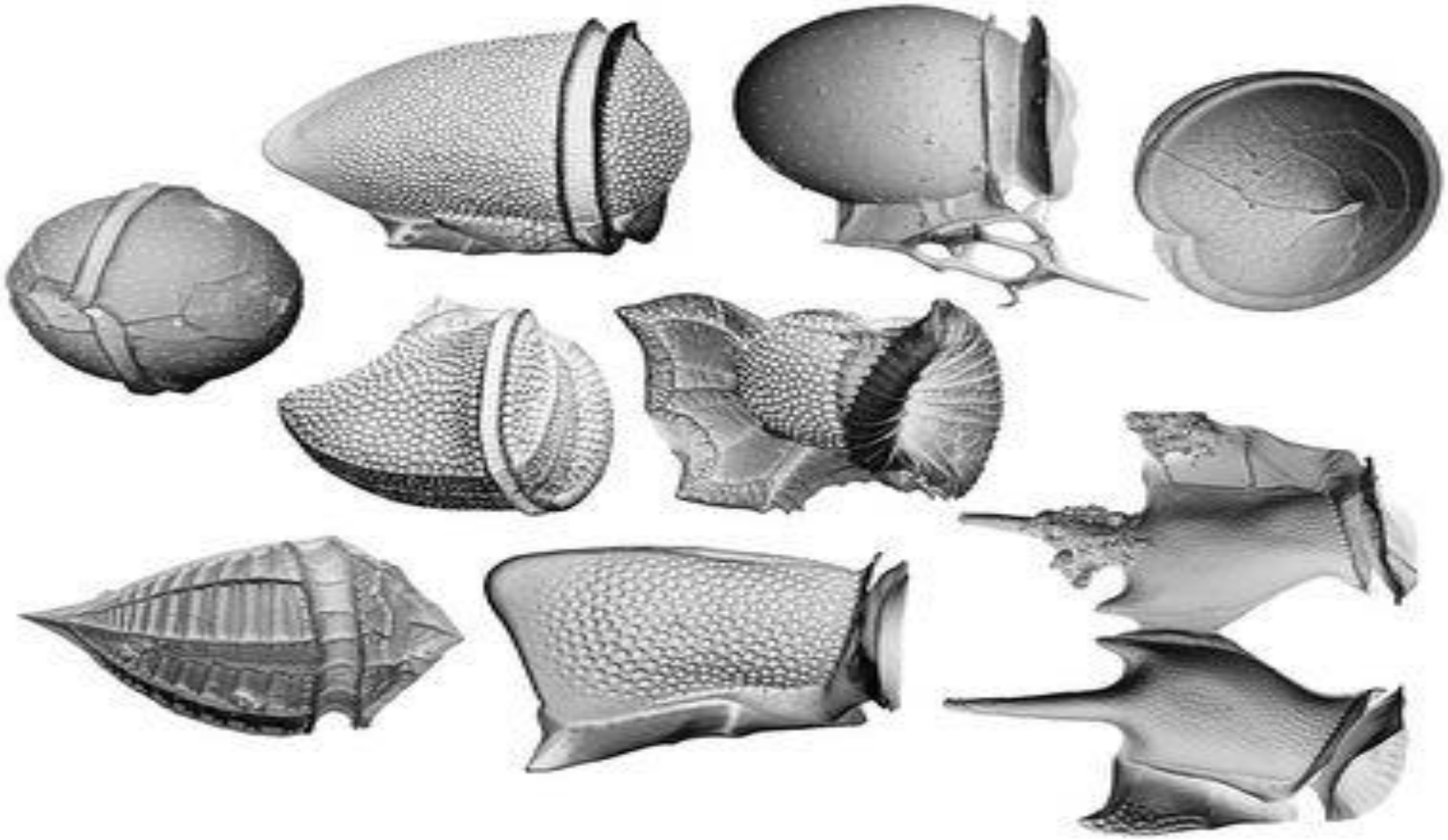
- Large complex cells (Eukaryotes); nucleus, mitochondria
- Can be unicellular e.g. yeasts or multicellular e.g. moulds

Some fungi can have both macroscopic and microscopic parts: e.g. fruiting body vs. spores of mushrooms



Diversity of Micro-organisms 4. Protists

- Large complex cells (Eukaryotes); nucleus, mitochondria
- **Protozoa**: protists that are animal-like (predatory)



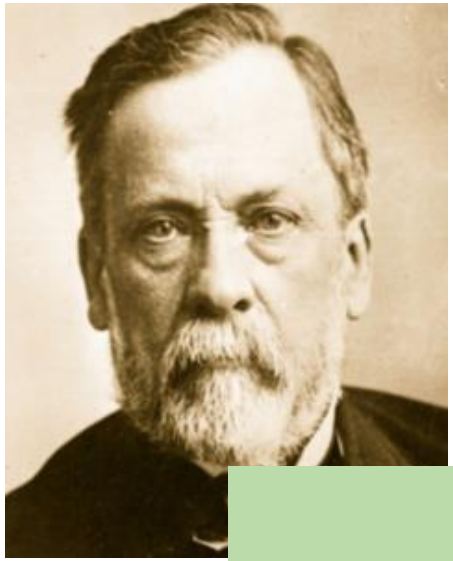
Protists are extremely diverse in morphology, lifestyles, and their evolutionary histories

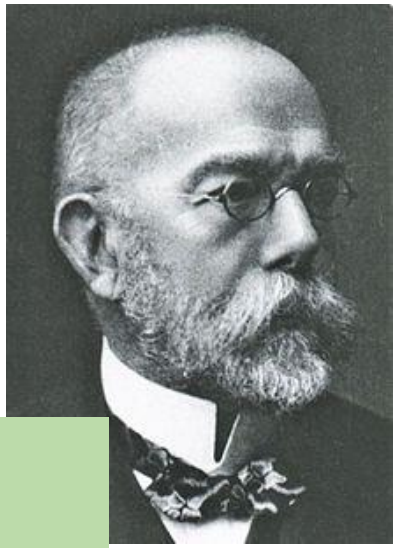
Diversity of Micro-organisms 5. Algae

- Large complex cells (Eukaryotes); nucleus, mitochondria
- **Algae**: Plant-like protists. Photosynthetic

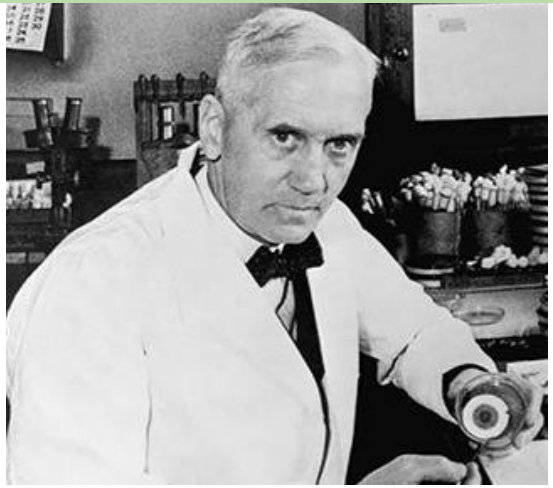
Some protists cannot easily be classified as ‘algae’ or ‘protozoa’

Exceptions to rules are very common in biology





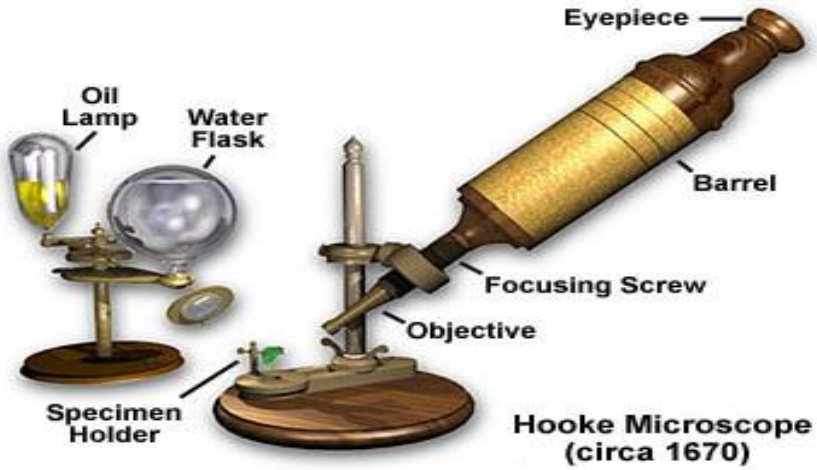
A brief history of important ideas, discoveries, and scientists in microbiology



Hooke. The idea of 'cells'

- 1664 - Robert Hooke describes microscopic structure of blue moulds, using a 30 x magnification microscope
- First to use the word 'cell'. His book "Micrographia" (1665) very influential, due to the excellent artwork

" When you spend all day indoors looking down a microscope "



Hooke Microscope (circa 1670)

van Leeuwenhoek. Discovers bacteria + protists

- 1684. Antonie van Leeuwenhoek develops powerful microscopes (300x mag.), discovers “wee animalcules” - first evidence of bacteria and protists
- He is considered the ‘father of microbiology’

van Leeuwenhoek. Discovers bacteria + protists

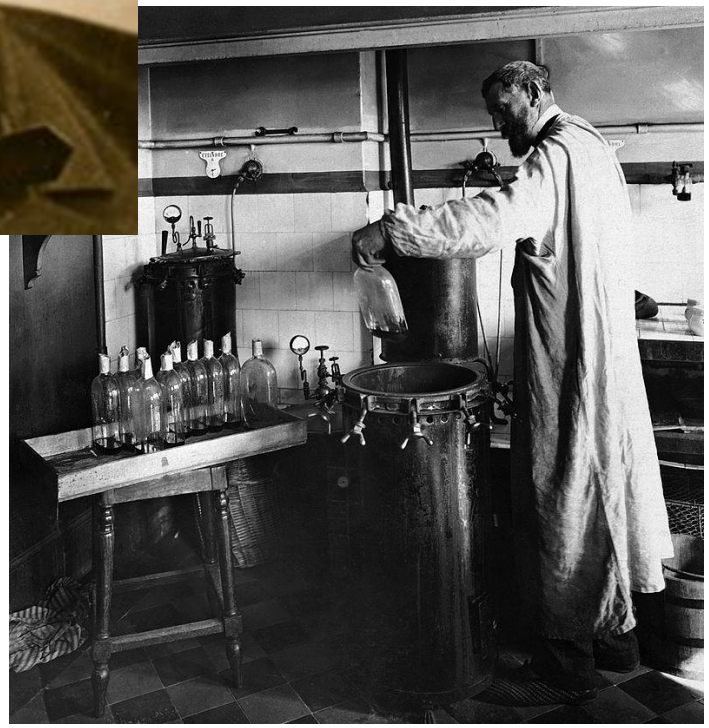
"When everyone thinks you're crazy for seeing tiny animals but you are later named 4th-greatest Dutchman of all time"

Pasteur. Life does not arise from non-life

- Louis Pasteur made many crucial contributions to microbiology :
  - Vaccination
  - Fermentation
  - Pasteurisation

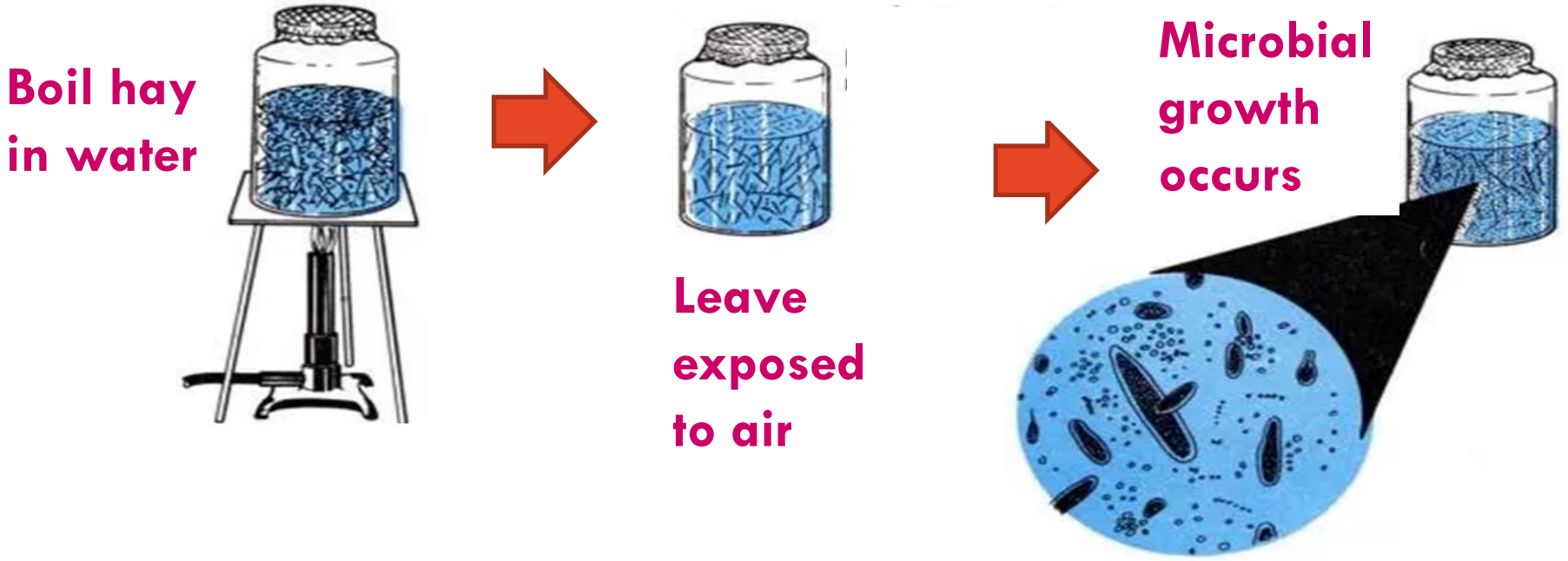
But most importantly:

- 1861: Pasteur disproved the theory of spontaneous generation – the idea that non-living *objects* can give rise to living *organisms*



Pasteur. Life does not arise from non-life

- Controversy from earlier work (1700's):
  - John Needham : a "life force" in all matter causes spontaneous generation

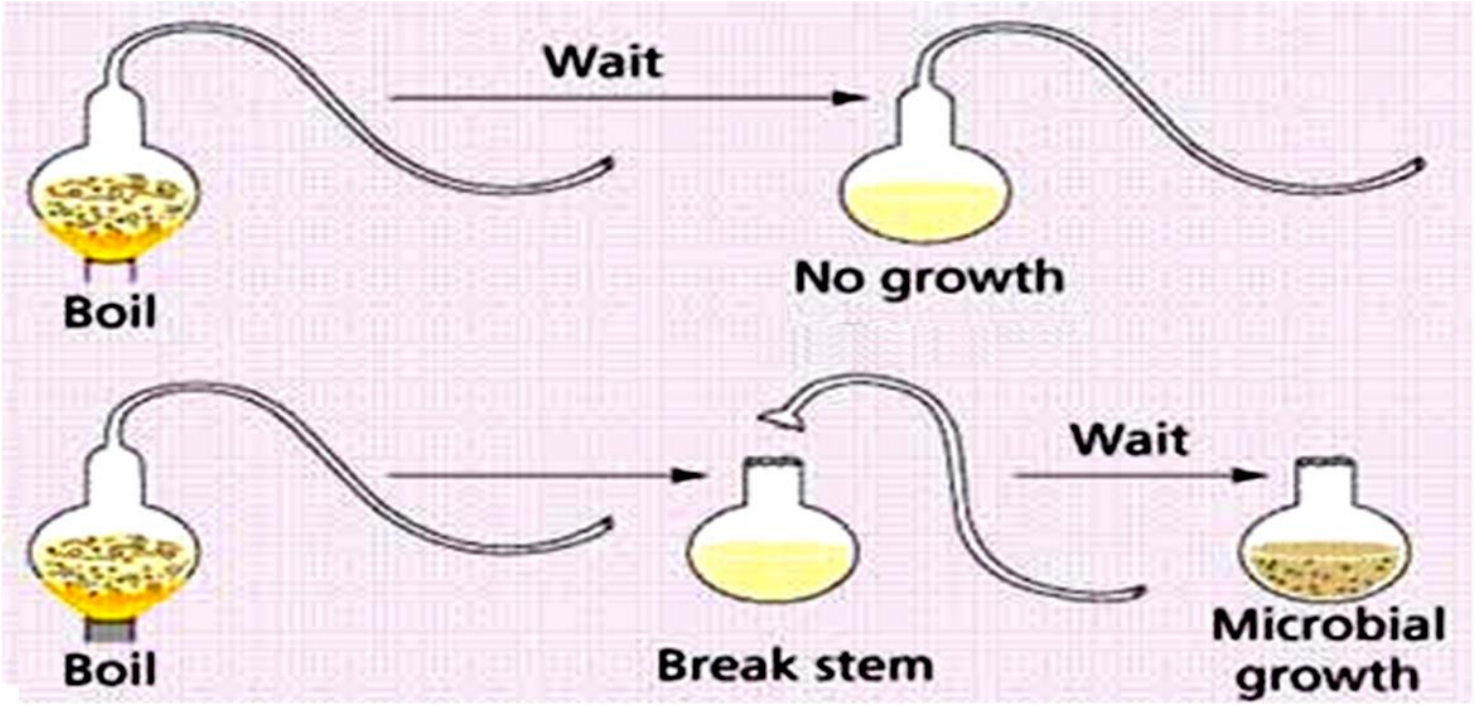


- Lazzaro Spallanzani : repeated experiment but <u>sealed the flask</u>
  - the microbes did not re-appear … ???

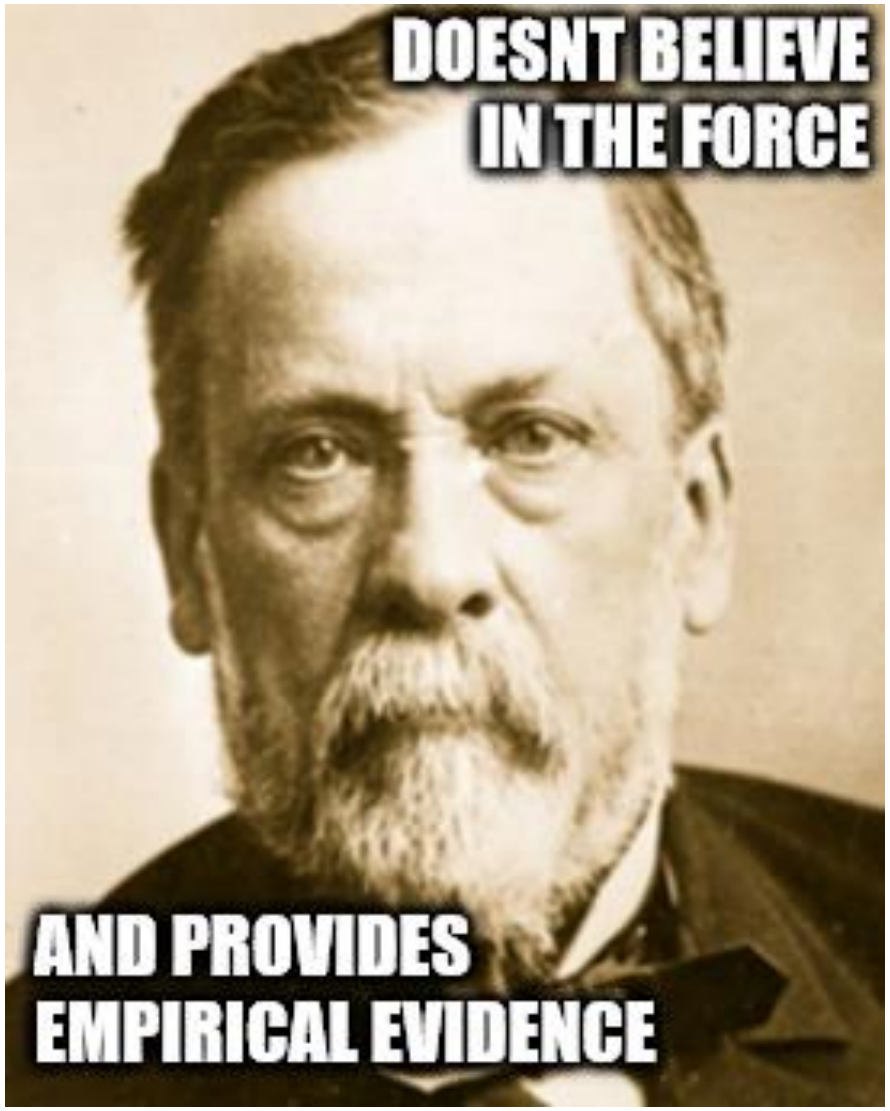
Pasteur. Life does not arise from non-life

- Is a “life force” in air causing spontaneous generation? How can we allow air to enter, but not bacteria?

- Pasteur settled the debate with an experiment using ‘swan-necked’ flasks; allow entry of air but not microbes

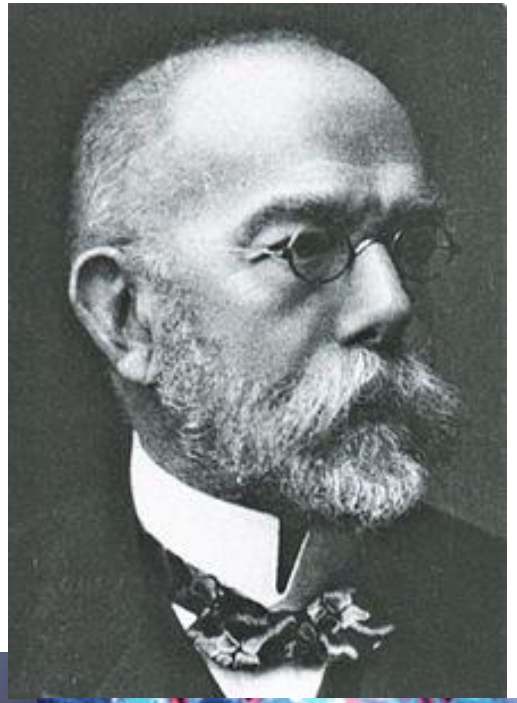


Pasteur. There is no 'life force'



Koch. Germ theory of disease, Koch's postulates

- Robert Koch pioneered:
  - staining methods for microscopy
  - use of solid growth media (agar)



- Used these methods to identify bacteria causing:
  - Tuberculosis
  - Cholera
  - Anthrax

Koch. Germ theory of disease

- 1876: Koch's most important contribution: definitive proof that microbes cause disease (i.e. germ theory)
- Along with Pasteur's work, germ theory important in disproving the idea of 'spontaneous generation'

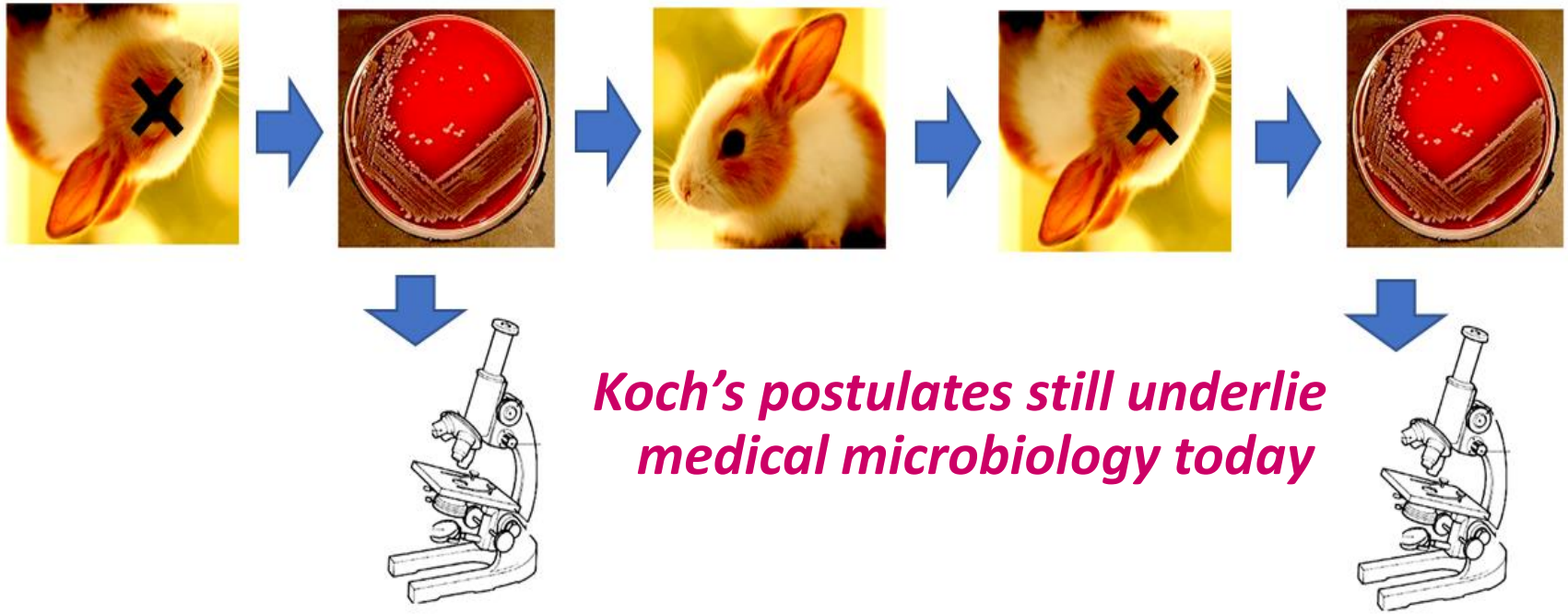
Google Doodle
10/12/2017
"Celebrating Robert Koch"

"As soon as the right method was found, discoveries came as easily as ripe apples from a tree"

Koch. Koch's postulates

An organism that causes a disease must :

- Be found in all cases of the disease
- Be isolated from the diseased host in pure culture
- Produce same disease in experimentally-infected host
- Be re-isolated from the experimentally-infected host

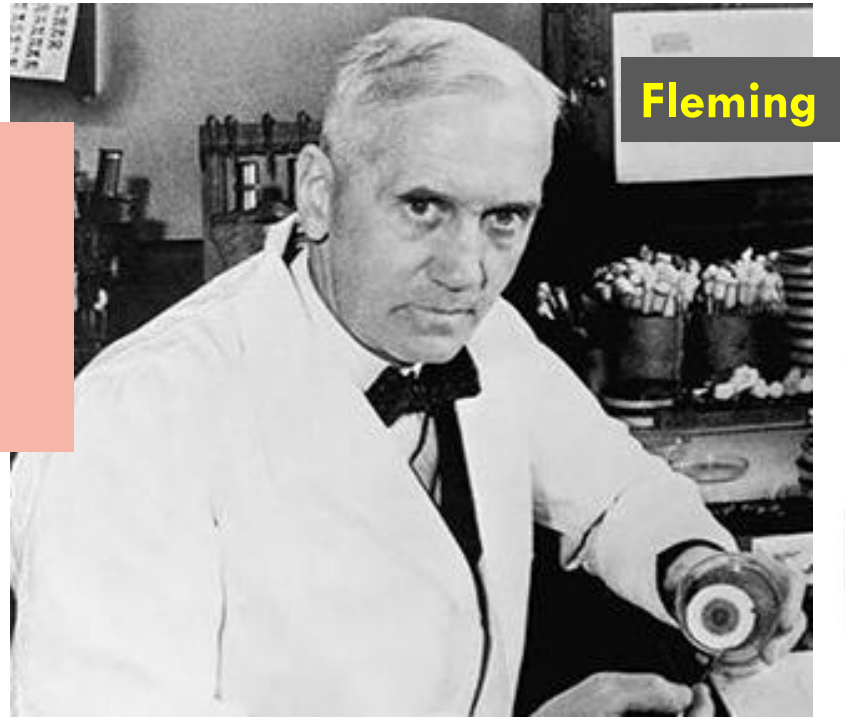


Koch's postulates still underlie medical microbiology today

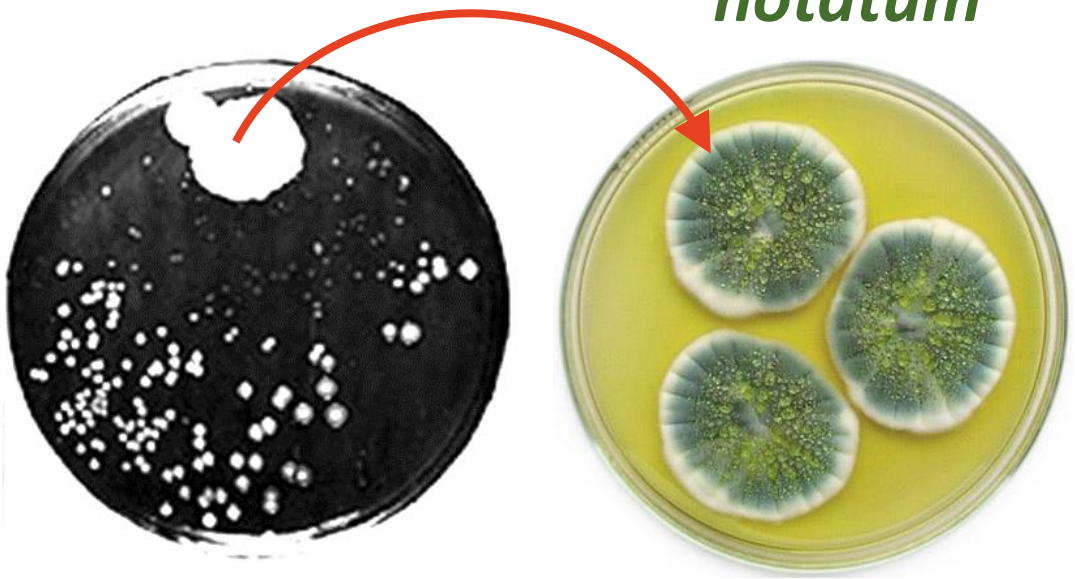
Fleming, Florey, Chain. Penicillin

- 1928: Alexander Fleming (UK) found mould growing on a petri dish killed the bacteria (*Staphylococcus*) around it
- 'Mould juice' killed many bacteria, including causative agents of scarlet fever, pneumonia, meningitis and diphtheria

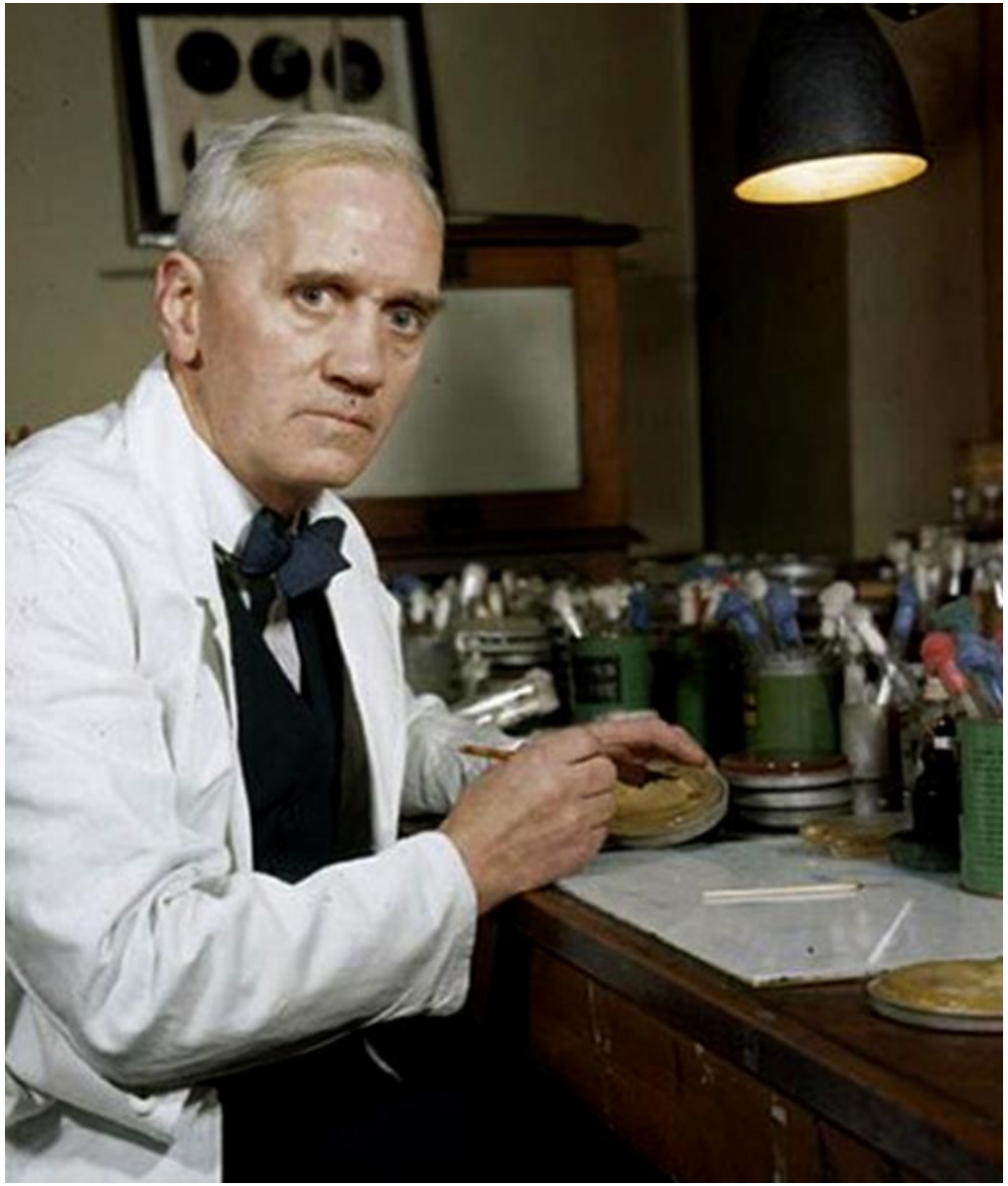
"he was a brilliant researcher, but his laboratory was often untidy"



Penicillium notatum



Fleming, Florey, Chain. Penicillin



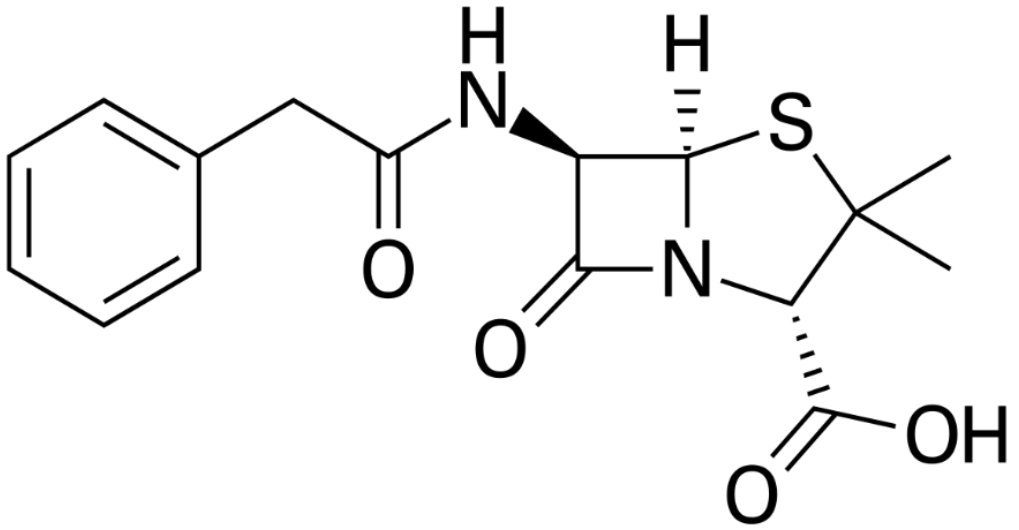
"When the photographer keeps hassling you while you're trying to streak a plate"

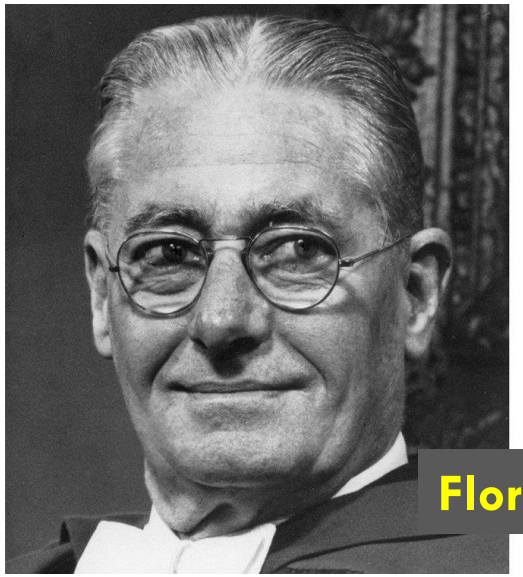
Fleming, Florey, Chain. Penicillin

- 1935-1945. Howard Florey (Aus.) and Ernst Chain (German) purified **penicillin** and developed mass production methods

- Penicillin was the first really effective antibiotic
  This discovery helped the Allies to win WWII

Discovery of many other antibiotics soon followed…

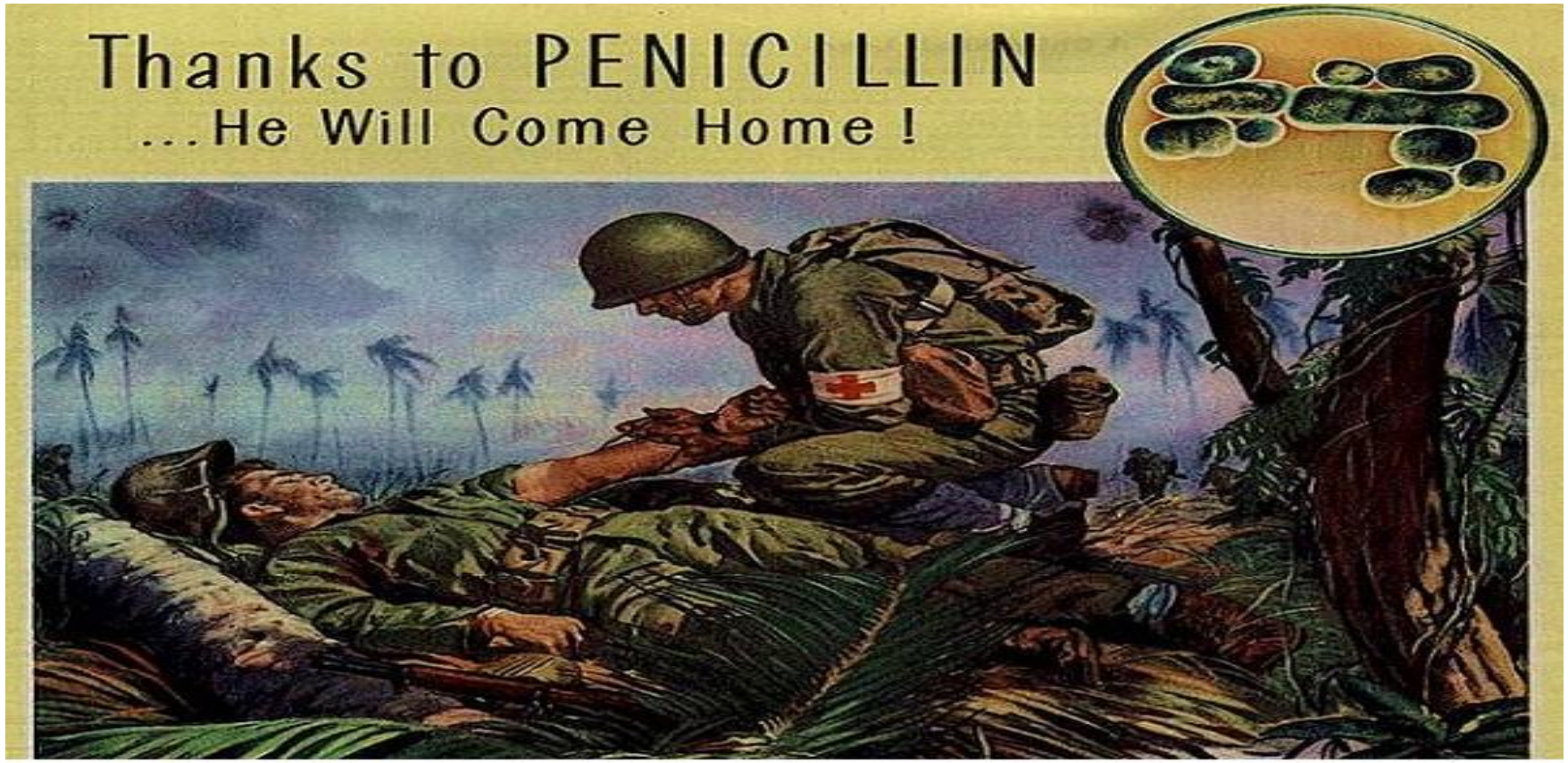




Fleming, Florey, Chain. Penicillin

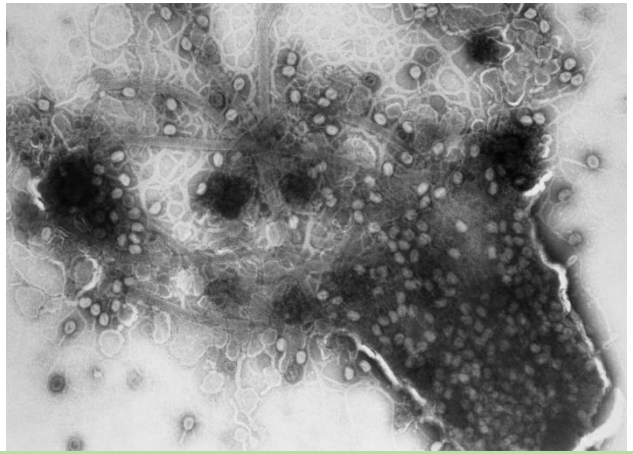
“ When your science is so good that they put your face on the money”

Fleming, Florey, Chain. Penicillin

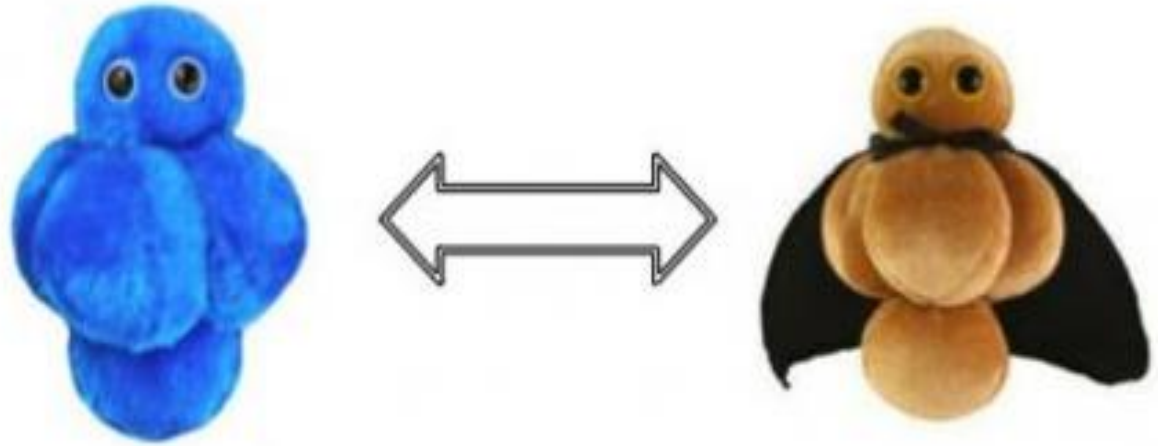


It is estimated that penicillin saved 100,000 lives in WWII, and has saved 200 million lives since then*

* http://www.newworldencyclopedia.org/entry/Alexander_Fleming



Important concepts in microbiology: normal flora, pathogens, 'one health'

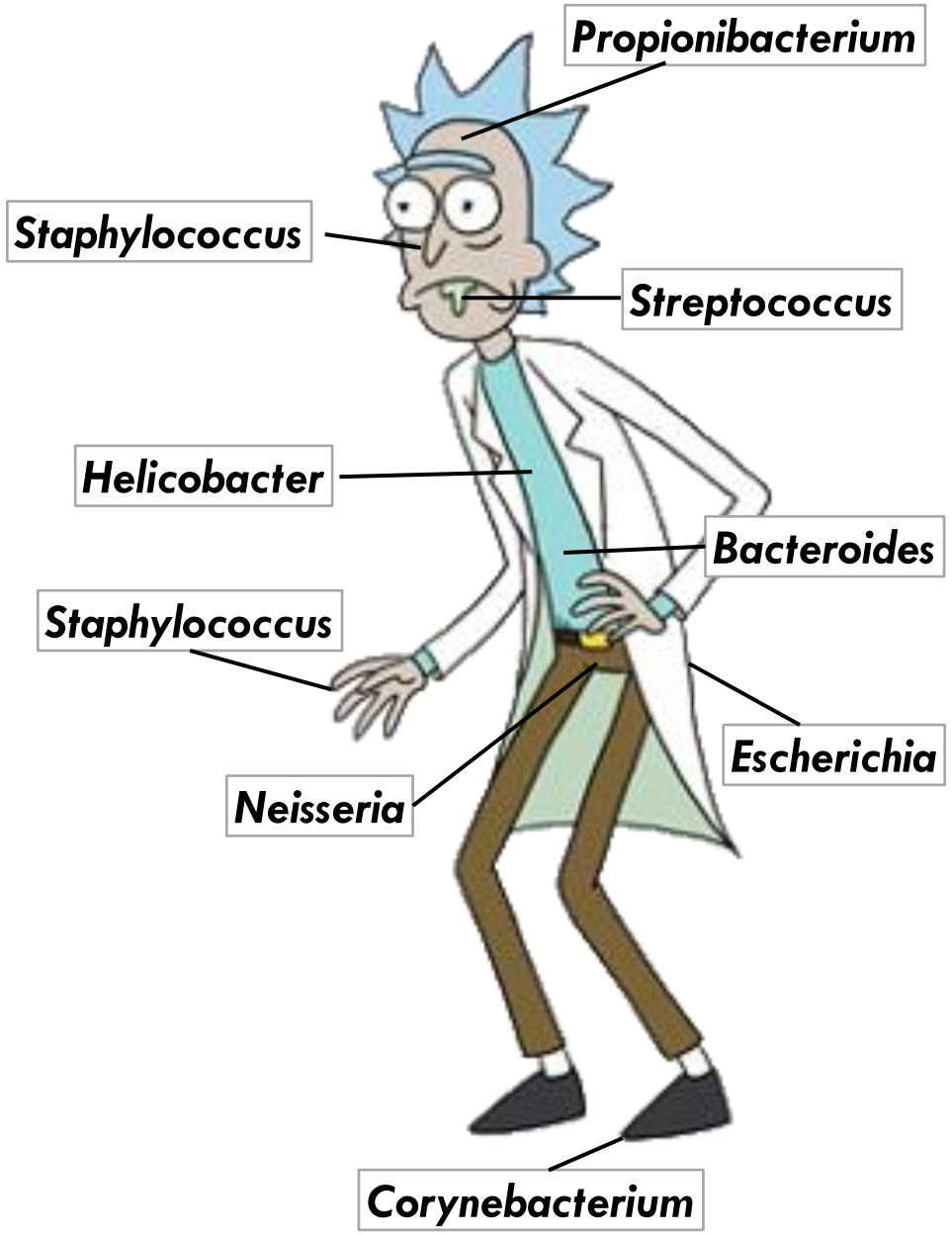


Normal flora: Microbes that live in us and on us

- Your body: approx. 30 trillion human cells
  but 40 trillion microbial cells !

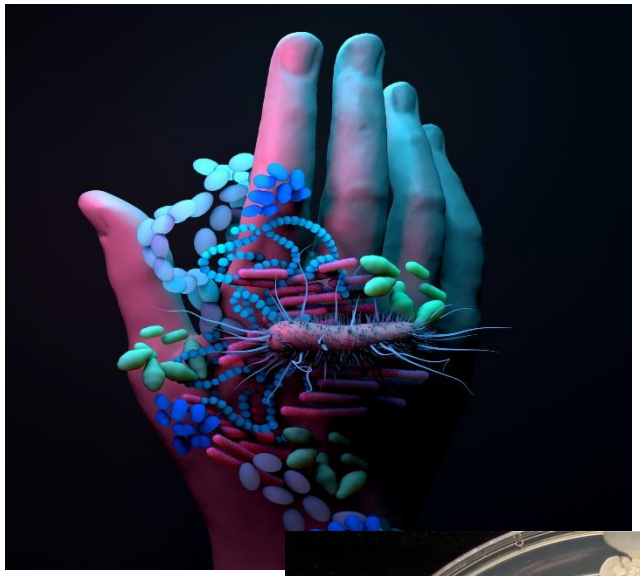
- **Normal Flora**
  - found at specific sites
  - specialised for that site
  - mostly bacteria
  - acquired at birth, from diet, and from the environment

- Concept of normal flora is flexible
  Differs between individuals, locations, times



Do we need our normal flora? (….yes …mostly)

- **Positive effects:**
  - 'prime' the immune system
  - provide nutritional benefits
  - compete with pathogens



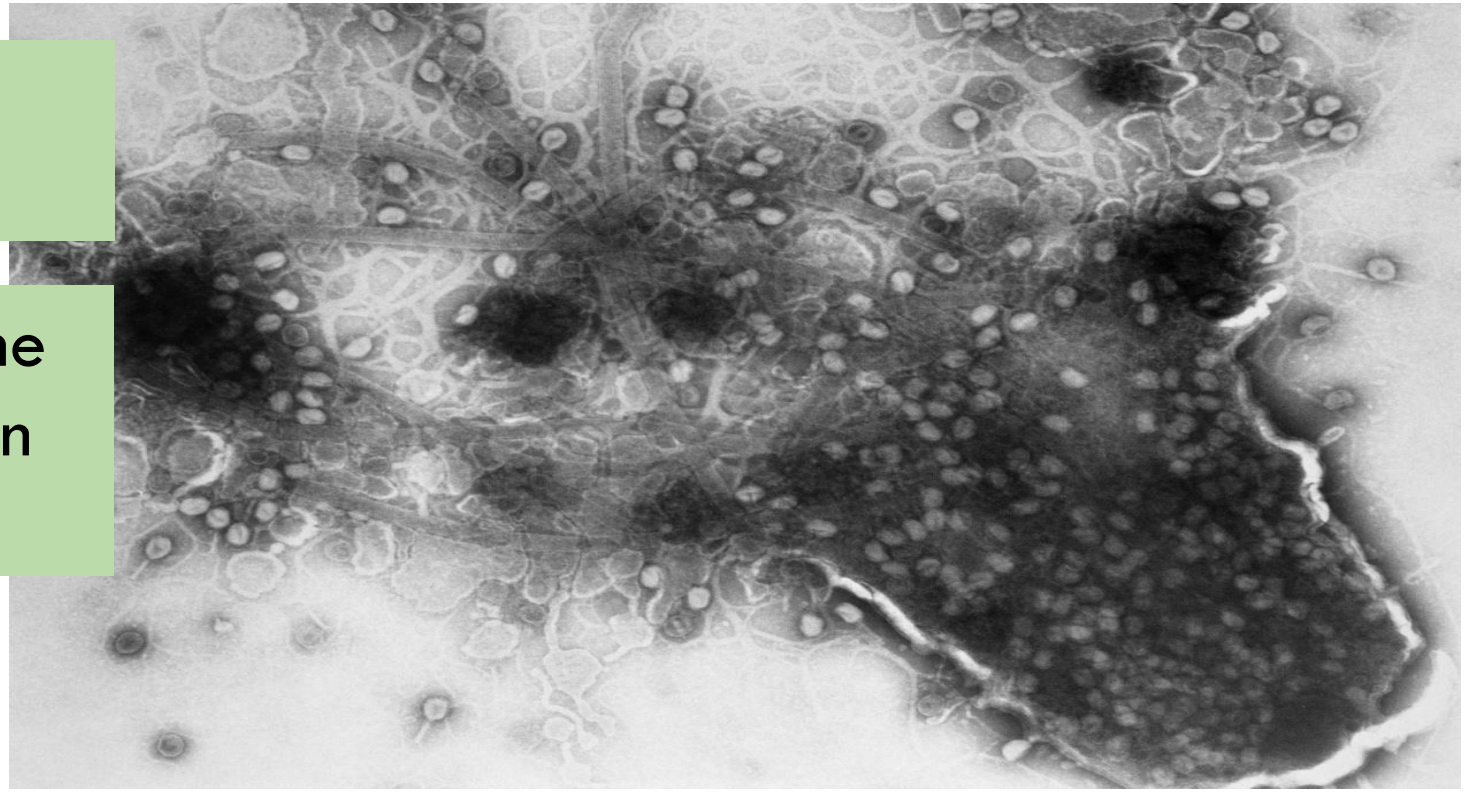
- **Negative effects:**
  - Can cause disease if moved to wrong location
    e.g. *Staphylococcus* → wound infection
  - Can cause disease even in normal habitat
    e.g. *Streptococcus* → tooth decay

Pathogens, infection, disease

- **Pathogen:** A disease-causing microorganism
- Some pathogens are <u>always</u> harmful – we call these 'obligate pathogens' e.g. viral infection usually destroys the host cell

T4 is a 'lytic' virus that infects the bacterium E.coli

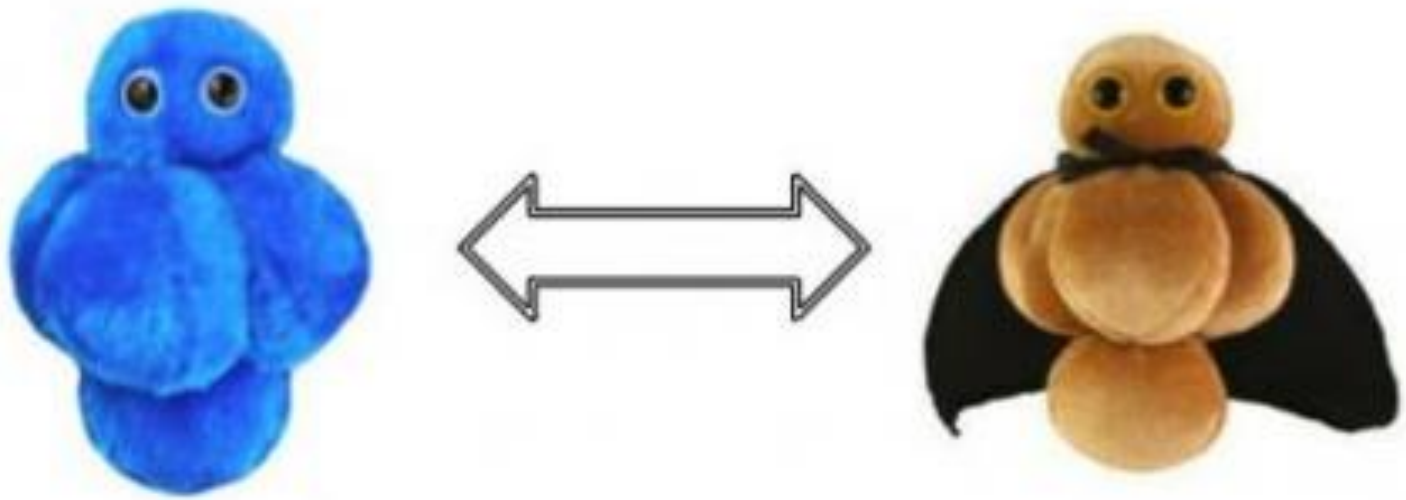
After replicating internally, the T4 virus bursts out and goes in search of fresh prey…



Pathogens, infection, disease

- Other pathogens are **opportunistic,** cause disease in specific conditions:
  - Numbers – abnormally high cell density
  - Location – get into the wrong place
  - Host health – immune system compromised
  - Virulence factors – e.g. gain antibiotic resistance

Normal
Staphylococcus



"Superbug"
Staphylococcus

Pathogens, infection, disease … are we making things worse?

- Do we need to kill 99.9% of germs in our homes ?

  No !

- Can we keep coming up with new antibiotics ?

  No !

- Does overuse of antimicrobials contribute to disease problems ?

  Yes !

Antibacterial soap in spotlight as companies clamber to remove ineffective chemicals after US ban

By Nicole Chettle

Updated 20 Nov 2016, 7:17pm

PHOTO: Chemicals used in some antibacterial soaps have been banned in the US. (ABC News: Nicole Chettle)

One Health concept … a unifying principle for microbiology

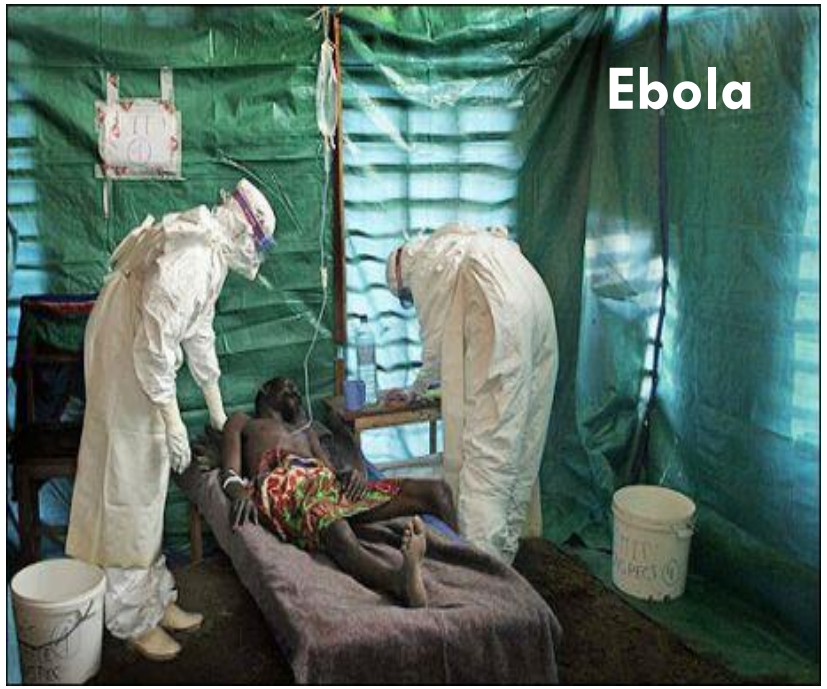
- We also need to consider animals, plants, and the environment when we are trying to manage human diseases

WHY?

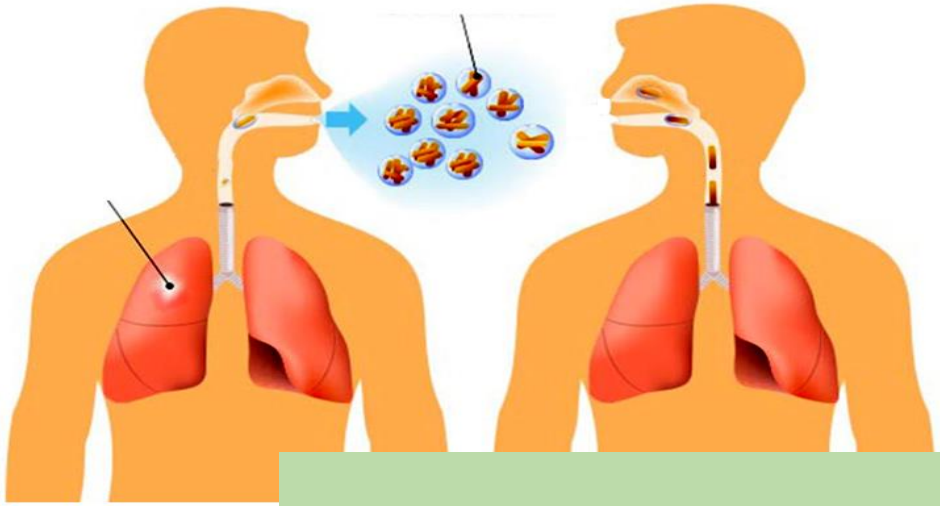
- Many human diseases originate in either the environment or in animals
- Use of antimicrobials in agriculture impacts on human pathogens
- Disease emergence and spread are influenced by urbanisation, globalisation, climate change, pollution…

Major infectious disease problems today

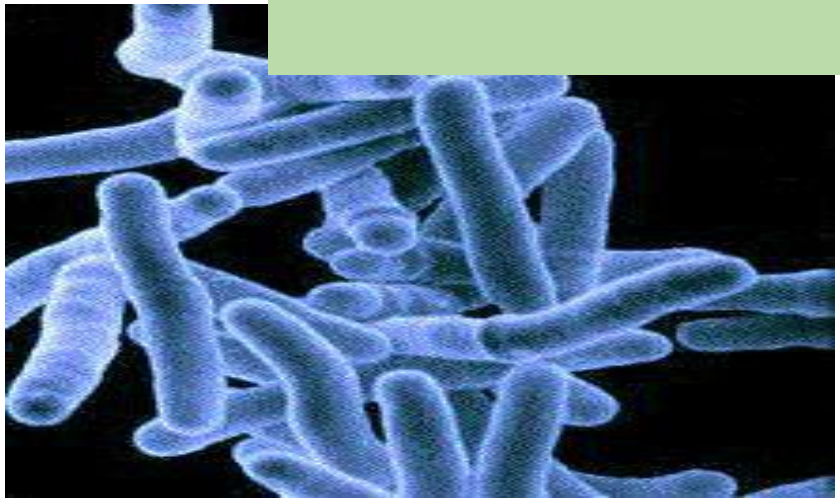
- **Emerging infections due to new pathogens**
  - Human: Covid19 !!!
    but also HIV, Zika, Ebola…
  - Animal: Chytrid fungus (frogs)
    Varroa mites (bees)

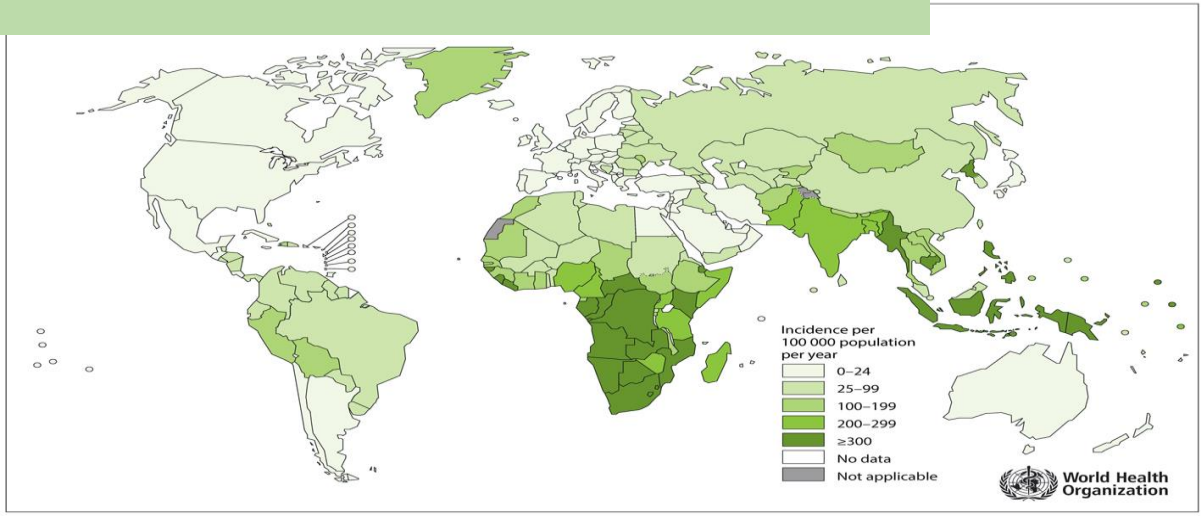


- **New problems with old pathogens**
  - Human: Malaria, tuberculosis
  - Animal: Koala *Chlamydia*
  - Plant: Panama disease (banana)



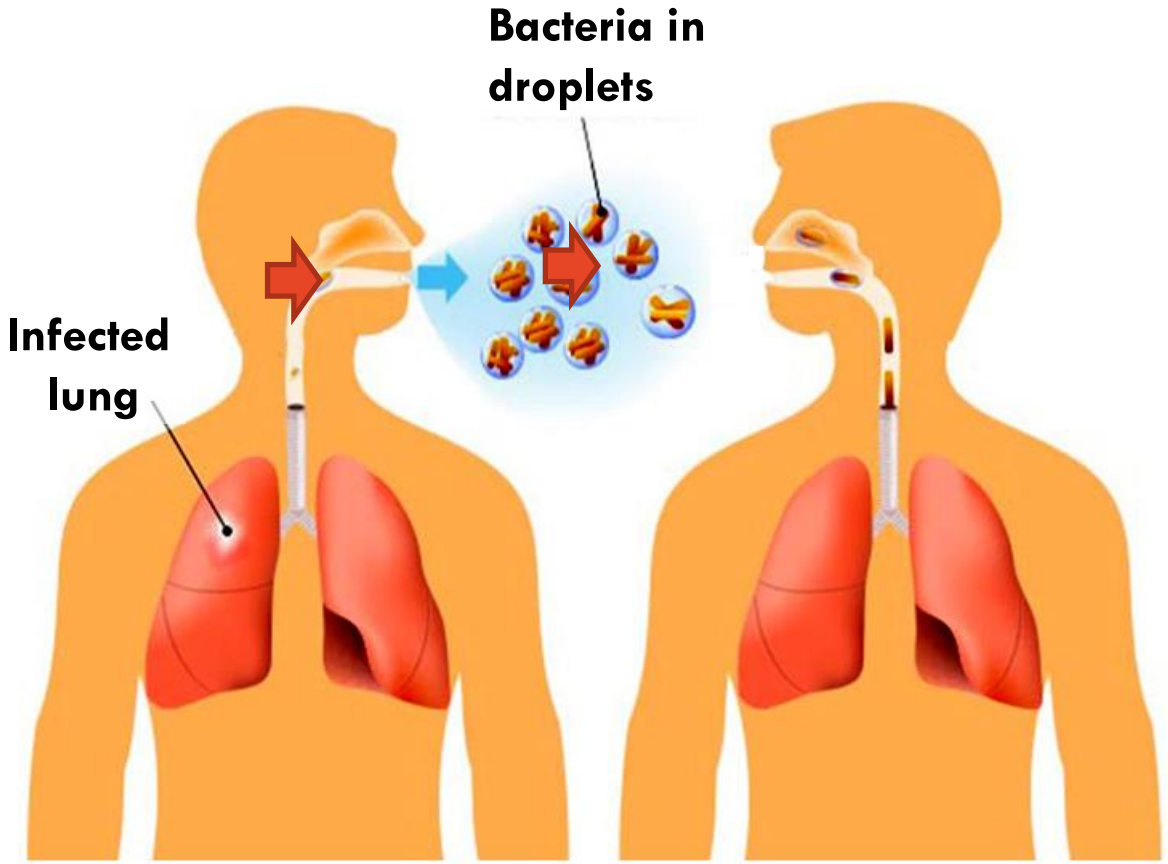
Example of a major microbial pathogen:
Mycobacterium tuberculosis





Tuberculosis (TB): old disease, new problems

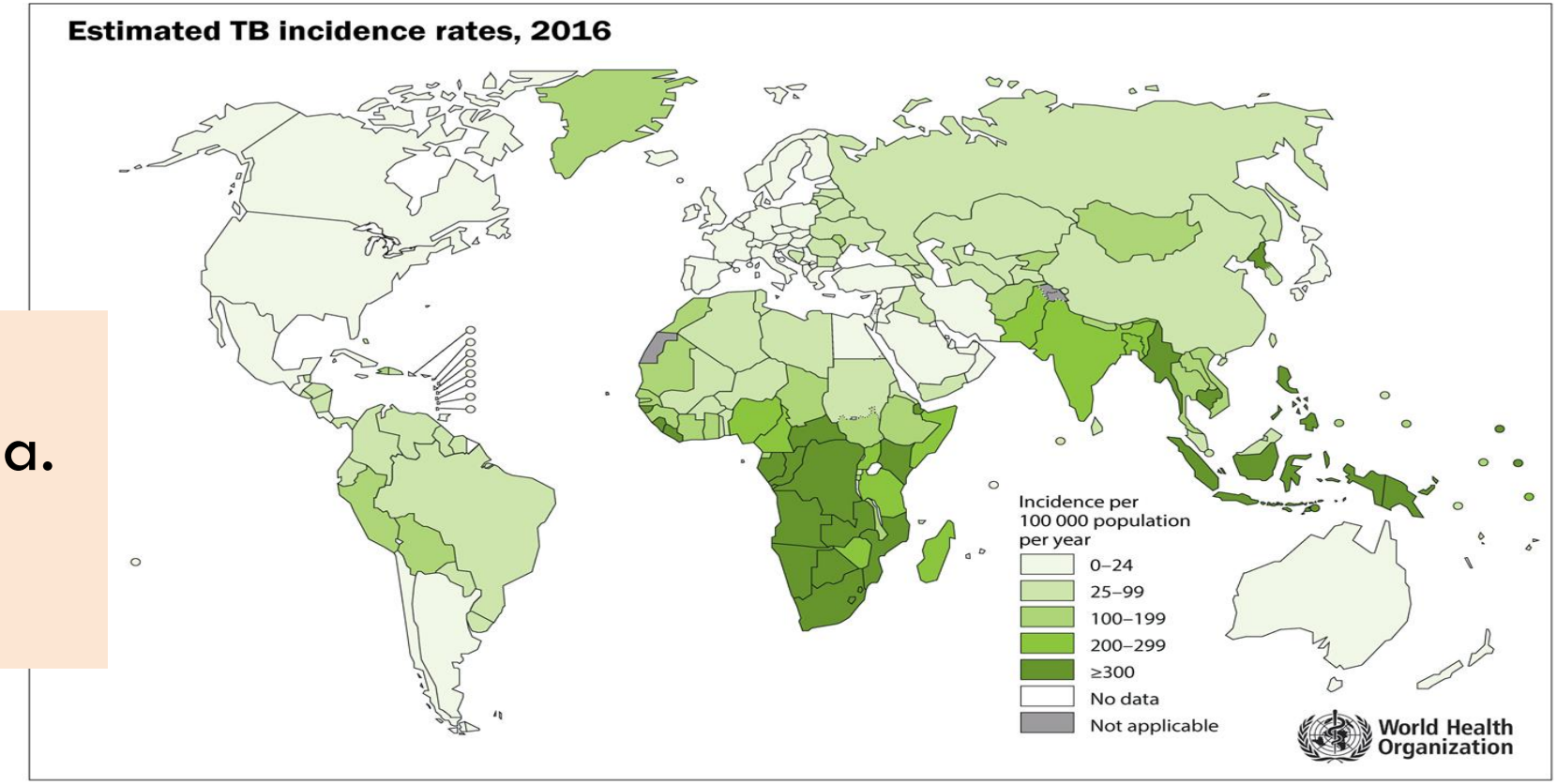
- Caused by a bacterium: ***Mycobacterium tuberculosis***
- Spreads person-to-person by airborne droplets (coughing)
- Infects lungs → cough, chest pain, weight loss, death



Tuberculosis: old disease, new problems

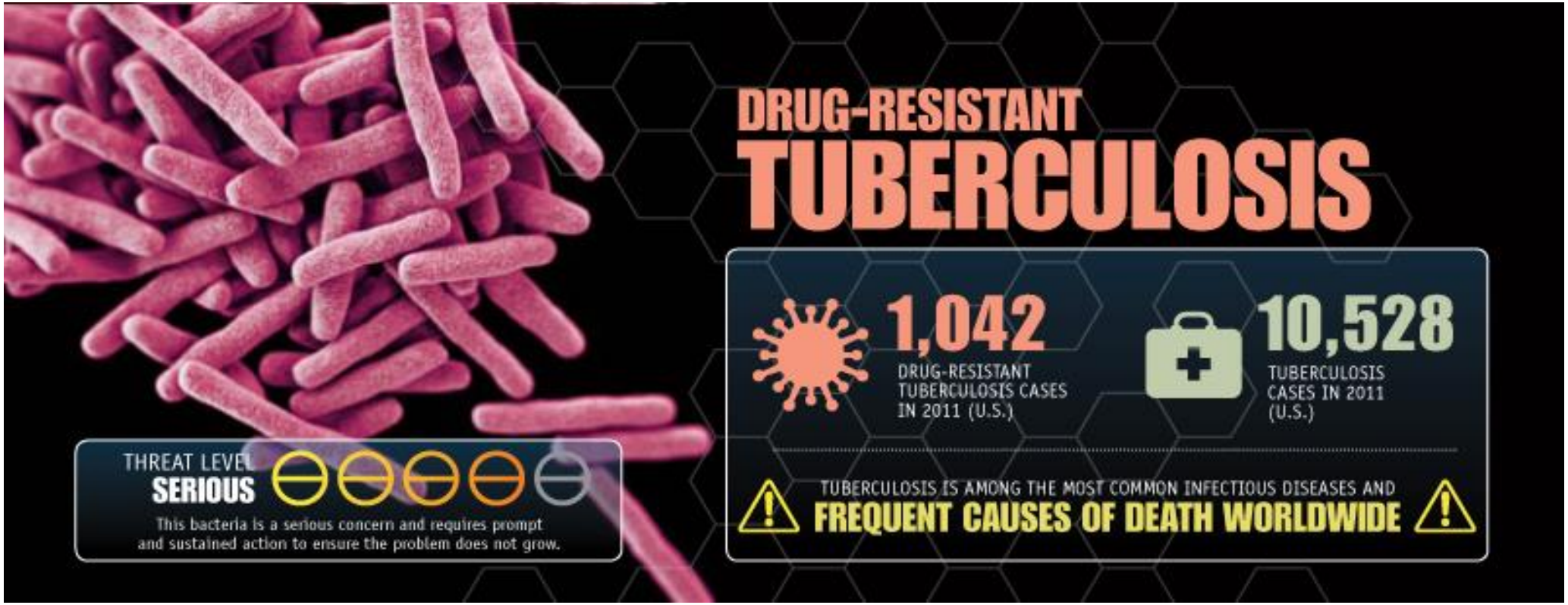
- Disease can be 'latent' for many years (no symptoms)
- Symptoms are non-specific – difficult to diagnose
- Estimated that one-third of world's population is infected !

TB is still a major killer in Africa and South East Asia. But not Australia, US, Europe … why?



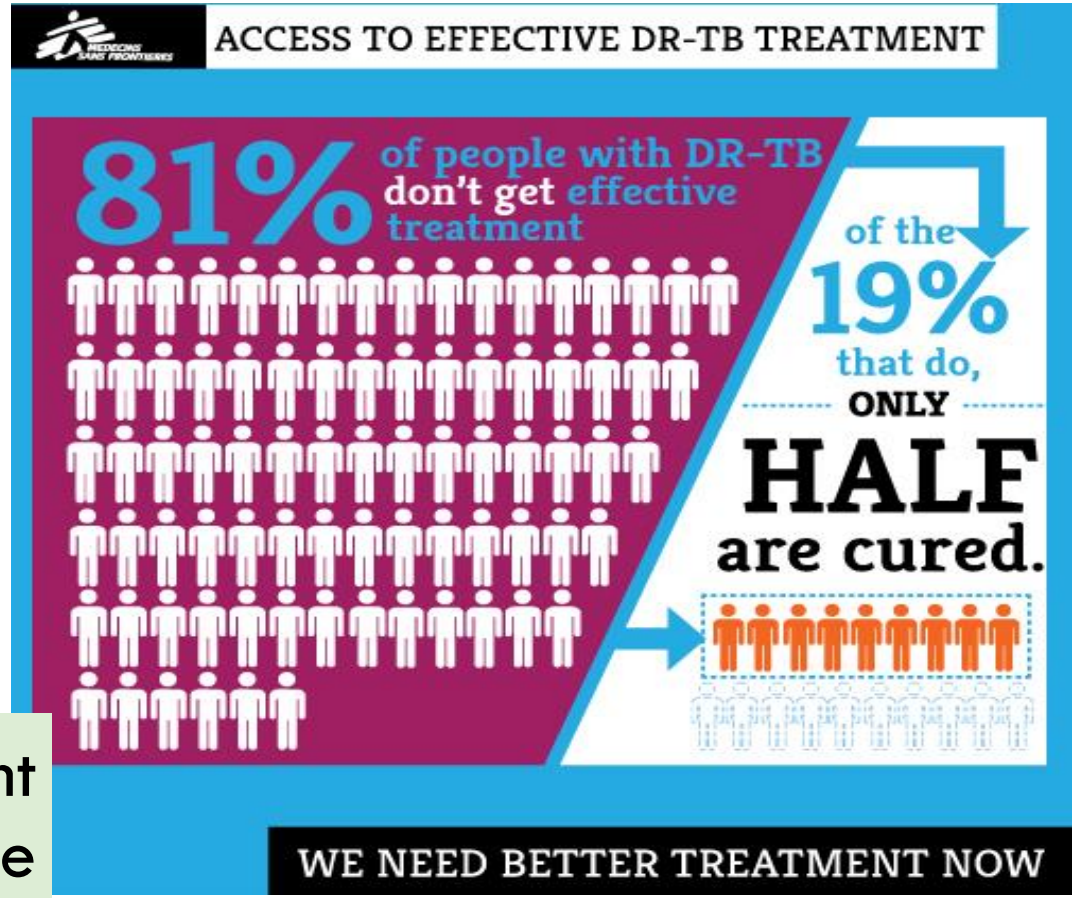
Tuberculosis: old disease, new problems

- New strains of TB are resistant to antibiotic treatment
- 'MDR-TB' : Multidrug resistant TB = bad
- 'XDR-TB' : Extensively drug-resistant TB = very bad



Tuberculosis: old disease, new problems

Drug-resistant TB is difficult to treat



…and treatment is expensive