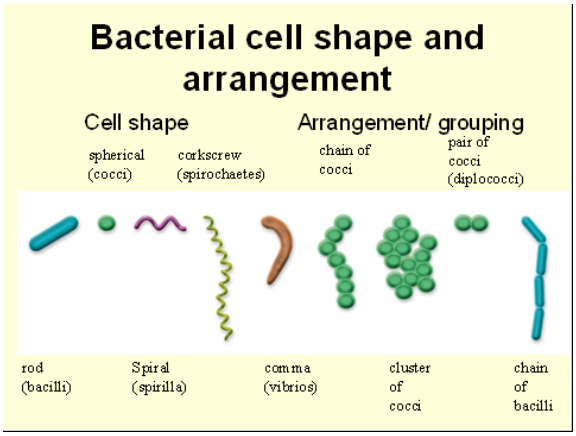
Microbiology

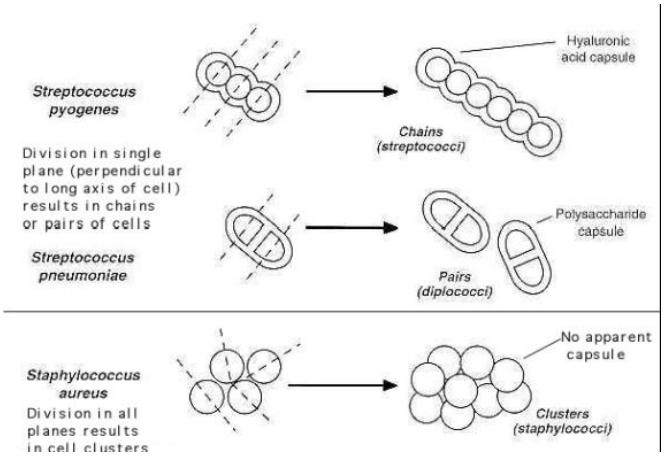
Week 1 - Microbiology and landmarks

- Microbiology - study of micro-organisms too small to see with the naked eye - Prokaryotic - no true membrane bound nucleus (bacteria, archaea) Prokaryotes generally single chromosome, no membrane, although still have genetic material, have no distinct nucleus. Eukaryotic - membrane-bound nucleus (fungi, protozoa). Viruses - acellular.
- 3 domains of life - Archaea, bacteria and eukarya. Microbes dominate diversity.
- Prokaryotes - (no nucleus), unique wall, size (no in colony), range of source of nutrients – fixation to heterotrophs, range of environments. Multiply very rapidly, E. Coli every 20 min, offspring - pathogenicity.
  - Bacteria – peptidoglycan wall - Mostly very small 1-6 µm in size, unicellular, Diverse range of nutrition, Found in diverse range of environments, mostly harmless, many beneficial, others cause serious disease.
  - Archaea - non-peptidoglycan wall, complex lipids, Evolved from early forms of life that appeared on earth. Many found in extreme environments, Now know they are everywhere, first non-extreme archaeon isolated in 2004.
- Eukaryotes:
- Fungi - Size varies enormously (~10,000 Kg!). Mycelium with spores, Yeast single cell budding fungi, Degrade organic matter, absorptive heterotrophs. Require preformed organic carbon as energy source and as building block, release many degradative enzymes, absorb simple breakdown products .Chitin wall prevents phagocytosis, Produce hyphae and mycelium with specialised structures for spore production. Yeasts single-celled reproduce by budding.
- Protists - very diverse group, don't belong to animal, plant or fungi, size range from 1-150um.
- Viruses - Acellular, not “free-living”, DNA or RNA core surrounded by capsid / envelope. Smallest microbe (< 0.4 µm), filterable. Require a cell to multiply, infect most living cells. Causative agents of many diseases.
- History of microbes -
  - 3.5 - 3.8 billion years ago - Appearance of first recognisable cells, Cyanobacteria, Produce oxygen during photosynthesis - $6H_20 + 6CO_2$ ® $C_6H_{12}0_6 + 60_2$ (sunlight and chlorophyll).
  - 2 billion years ago - Oxygen concentration rises to 16%. Development of eukaryotes
  - 300 million years ago - Appearance of multicellular organism- evolve in presence of microbes.
  - 8000 years ago - Milk first fermented into cheese, Microbes used to preserve food
  - Middle ages - Appearance of bubonic plague, 1347 - 1351 The Black Death, A third of Europe’s population die, By 1420s 75% of Europeans dead.
  - Post-Renaissance - Jenner invents vaccination, 1798
  - Modern era - Spanish flu, 1918, Pandemic kills >20 million worldwide, Discovery of penicillin, 1929, Winning the battle against bacterial disease, Smallpox eradicated, 1979, AIDS (HIV) identified, 1980’s
- Microbes still essential to balanced ecosystem - all nutrient cycles need microbes - degrade organic matter, recycle carbon, fix nitrogen (rhizobium), recycling nitrogen.
- Microbes and diseases - Tuberculosis (TB) - *Mycobacterium tuberculosis.* Infects 20% of World’s population, Causes 3 million deaths every year. Influenza (’flu’) - Constantly evolving virus, Pandemic in 1918 killed >20 million people, Next pandemic , 5-150 million deaths. Ebola virus. Fungi and protozoa also cause disease - Candidiasis (Thrush) - *Candida albicans,* Wide range of possible clinical effects, Cause much discomfort but few deaths. Malaria - *Plasmodium* spp. Humans infected after mosquito bites, 300 million new cases per year and > 1 million deaths. No known Archaeal diseases.

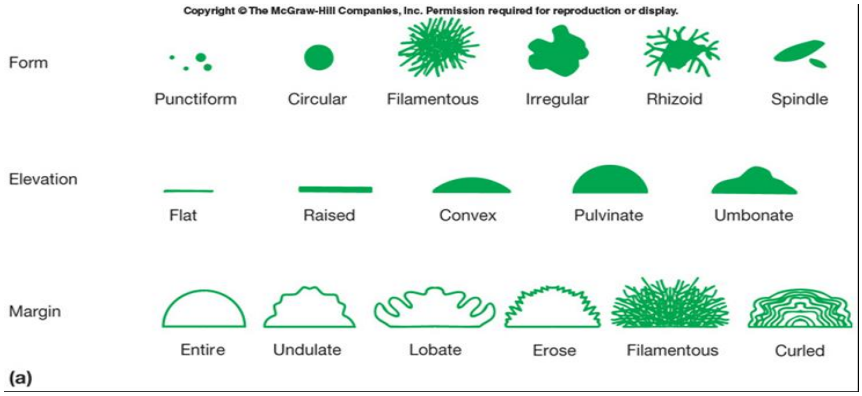
Week 2 - Bacteria form and function

- Bacteria cell shape and arrangement - Microbes in all different shapes – rods, cocci, spiral, filamentous, curved - see picture.





- Cell morphology - First step in classical identification of bacteria: Gram positive (purple) – rods or cocci, Gram negative (pink) – rods, cocci, curved. Ones that do not stain. Grouping - Diplococci - 2 cocci together. Chains, repeated divisions in one plane - can be rods or cocci. Grape like clusters - cocci in several planes. Pleiomorphic- bacilli in palissades - cocci break up. Grouping dependant on division, see picture above.
  - Gram negative - Examples - *Escherichia coli* (G-ve rod)commensal, gut – humans and animals, Best studied microbe, Pathogenic strains, O157. *Neisseria meningitidis* (Gram –ve cocci) Human only host, colonises throat and infects blood and brain, Meningitis.
  - Gram positive - Examples - *Lactobacillus acidophilus (rod).* Yoghurt production, Non-pathogenic. *Staphylococcus aureus* (Gram +ve cocci) - MRSA, Colonises skin, nose, Normal inhabitant but- Boils, Different systemic infection.
  - Non-staining - *Treponema pallidum* (G-ve) Spirochaete, Syphilis. *Mycobacterium tuberculosis* (G-ve) - Acid fast stain, tuberculosis.
- Colony morphology - describes bacteria, looks are form, elevation and margin.



- Structure of prokaryotic cell:
  - Motility from flagella - move towards sources of nutrients - chemoattractants, and away from toxic agents - chemorepellants, moves counterclockwise - swims one direction, move clockwise, tumble

- Pathogen - organism capable of inducing damage. Commensal (non-pathogenic) - parasitic association with the host. Virulence of a bacterium depends on - infectivity, inasiveness and pathogenic potential. Disease is a balance between virulence of pathogen and resistance of host.
- Identifying causative pathogen - Koch's postulates - Organism must be present in all cases (absent in healthy individual) Organism must be isolated from host and grown as pure culture. Disease must be reproduced by inoculation of experimental host with pure culture. Micro-organism must be isolated from experimentally infected, diseased host. Limitations: inability to grow in pure culture, no good experimental animal, opportunistic association with healthy individual, intoxication - disease without microorganism.
- Stages of pathogenesis:
  - Reservoir and transmission - Human respiratory system – airborne, inanimate objects, hands etc. Water/ food- faecal/oral route, Animals (zoonoses) – insect vector. Humans; soil – direct contact; sexually transmitted; wound puncture eg rusty nail. Microbes adapted to mode of transmission and infection. Mode of transmission often dictates site of infection. Respiratory – entry via lungs, may or may not disseminate. Oral – GI tract, generally local eg most Salmonella but may become systemic eg typhoid. Insect vector – often injected into blood, by passes skin, Direct contact, sexual genital tract mucosal surface or wound puncture, Microbes are adapted to mode of transmission AND to site of entry.

Bacterium	Disease	Reservoir	Transmission
Mycobacterium tuberculosis	TB/ human	Human	Air-borne
Bordetella pertussis	Whooping cough	humans	Air-borne
Yersinia pestis	Pneumonic plague/ humans, rodents	Humans/rodents	Air-borne
Yersinia pestis	Bubonic plague/ humans, rodents	Human/rodents	Arthropod borne (flea) (zoonoses)
Borrelia burgdoferi	Lyme disease	Deer and mice	Ticks (zoonoses)
Bacillus anthracis	Anthrax/ animals, humans	Animals/ spores soil	Direct contact
Neisseria gonorrhoeae	Gonorrhoea/ humans	Humans	Direct contact
Clostridium tetani	Tetanus	Soil	Direct contact
Vibrio cholerae	Cholera/ humans	Water/ humans	Water, food borne
Salmonella spp, Shigella spp	Gastroenteritis/humans	humans	Food borne
Clostridium botulinum	Botulinum/ humans, animals	Soil, water	Food-borne

  - Adhere to and colonise host - pili (fimbriae) - long thin structures extending from cell surface, terminal adhesins, bind specifically to host cell carbohydrate. *Colonisation* - establishment of a site of bacterial reproduction on or within host may initiate invasion of host tissue.
  - Evasion of host immune system - *Capsule* - Carbohydrate, anti-phagocytic, May mimic host molecules, Enzymes - destroy components of immune system, Modify surface molecules to mimic host antigens, Invade host cells, hide from immune system. Requirement of capsule for virulence – protection from phagocytosis, Outline principle of smooth and rough colonies, Thought protein or CHO, not DNA likely to carry genetic information.
  - Growth and multiplication in select environment - adapt to environment - temp, pH, redox potential, osmolarity, nutrients, iron, differential gene expression.
  - Damage - responsible for symptoms of disease - degradative enzymes, aid spread of bacterium and toxins interfering with normal physiological process, e.g. Cholera toxin. Induce inappropriate immune response, results in disease.
  - Dissemination - Leave host, return to reservoir, find new host - sneezing, coughing, diarrhoea, decomposition of dead body, lesion, contact.