

IB 43 (proposed number): What Lives Inside Us? Microbiomes and Symbiosis

Syllabus

Week 1: We live in a microbial world

- Earth and the origin of life (Brock's ch.1, Yong ch. 1)
- The bacterial cell and its growth (Brock's ch.2, 5)
- Bacterial diversity (Brock's ch. 3, 14, 15)

Week 2: Symbiosis and its different flavors

- Commensals, mutualists and pathogens (Brock's ch. 23, Yong ch. 2)
- Ancient symbioses: mitochondria (Brock's ch. 2 and 13)
- Inherent conflicts: partners and cheaters (Yong ch. 4)

Week 3: Bacteria for (and against) plants

- nitrogen fixing bacteria (Brock's ch. 23)
- Sap-ingesting aphids and *Buchnera* (Yong ch. 4, 7, Brock's ch. 23)
- Protection from plant toxins (Yong ch. 7, Ceja-Navarro 2015)

Week 4: The bacterial genome and its evolution

- Bacterial genomes and their interrogation (Brock's ch. 9, 13)
- Horizontal gene transfer (Brock's ch. 13, 14)
- Bacteriophages and their role in bacterial evolution (Brock's ch. 10)

Week 5: Animals and their specialized symbionts

- The bobtail squid and *Vibrio fischeri* (Yong ch. 3, Brock's ch. 23)
- Aphids and their facultative symbionts (Yong ch. 8, Brock's CH. 23)
- Insecticide-resistant stinkbug pests (Kikuchi 2012)

Week 6: Bacterial communities in and out of organisms

- Next generation sequencing and metagenomics
- What do we find and where – soil, invertebrates and vertebrates – diversity and lifestyles
- What do we find and where – the human body (Brock's ch. 24)

Week 7: The importance of organismal microbiomes

- For immunity (Yong ch. 3, 4)
- For metabolism (Yong ch. 5, Brock's ch. 24)
- The gut-brain axis (Yong ch. 3, Brock's ch. 24)

Week 8: Host-microbe evolution and co-evolution

- Evolution and co-evolution in a nutshell
- Vertical and horizontal bacterial transmission (Brock's ch. 23)
- The hologenome concept and phyllosymbiosis (Yong ch. 6, Brooks 2016)

Week 9: Microbiome imbalances and pathogenesis

- Dysbiosis and its causes ((Brock's ch. 24)
- Perturbation by antibiotics – *C. diff* (Brock's ch. 24)
- Dysbiosis and its consequences (Brock's ch. 24)

Week 10: Rebalancing the microbiome - Probiotics, prebiotics and synbiotics

- Current probiotics – from fecal transplants to yoghurts (Yong ch. 10, Brock's ch. 24)
- Prebiotics – from bacterial metabolism to treatment (Brock's ch. 24)

Next generation probiotics and synbiotics (Yong ch. 10, Panigrahi 2017).

Week 11: Pathobionts and pathogens (Yong, ch. 4, Brock's ch. 25)

Opportunistic infections

Spore-forming opportunists (*C. diff* revisited)

Salmonella and the gut microbiome (Baumler et al)

Week 12: Specialized pathogens and their tricks

Yersinia and the black death (type III secretion systems I)(Brock's ch. 4, 25, 31)

Food poisoning, enteropathogenic *E. coli* and *Salmonella* (type III secretion systems II)(Brock's ch. 25)

STDs and *Neisseria gonorrhoeae* (genomic flexibility)(Brock's ch. 25)

Week 13: Next generation therapies for microbial dysfunction and pathology

Phage therapy

Antibiotic resistance and anti-virulence drugs (Shakhnovich 2006)

Microbiome engineering and its promises (Yong ch. 10)

Attendance will not be enforced, but since the course does not rely on one textbook, and it is a synthesis of information from various sources (see Text below), attendance is highly recommended.

Course requirements: High school chemistry or Chemistry 1A, high school biology or Biology 1A/1B

Grading: Two midterms and a final exam (weighted 25%, 25% and 50%, respectively).

Required reading: *I contain multitudes* by Ed Yong (2016), Harper Collins Publishers

Recommended reading: In addition to the above-mentioned book, the course will bring together information from primary research articles. Reading these articles is recommended, and sources will be referenced for curious students. For fundamental concepts and examples, students can rely on Brock's Microbiology 15th edition.