Reading for today: Chapter 6 – On Growth
Problem set due today
Today: Growth – in microorganisms it’s different from in metazoans – increase in number of organisms instead of size
  - Binary fission
  - Other methods:
    - Organisms that replicate their DNA many times over, than split into many parts at once
Next week: metabolic regulation

Binary Fission
  - Time from bacterium to bacteria is a generation
  - Generation time is how long it takes
  - 20 minutes is a rather fast generation time. 8 minutes is the world record.
  - We look for bacteria that can replicate fast, or that can replicate in extreme conditions.
  - Cell content replicates before division.

Fts proteins and the “divisome”
  - FtsZ aligns before division
  - The most intense signal occurs at the center edges due to the 3-dimensional shape

Peptidoglycan synthesis
  - Peptidoglycan needs to be extended for the cell to grow
  - The balance needs to be right, so cell integrity isn’t compromised
  - Antibiotics bind to DNA binding proteins like FtsI, so that those enzymes aren’t available for the peptidoglycan synthesis, and the bacterium lyses. (Autolysins without autolysis)
  - The FtsZ ring leaves a scar in the cell wall, which you can see later

Peptidoglycan structure
  - Two planes with cross-links in between. These cross-links give it its integrity
  - MreB allows a variety of shapes -- not just spheres

Exponential Growth
  - Because bacteria undergo binary fission, they can replicate into mind-boggling numbers very fast (exponential rate)
  - After two days of unregulated growth one bacterium’s offspring would weigh more than the earth (assuming a 20 minute generation time)
  - Make a logarithmic plot of change in numbers as a function of time
Growth Parameters
- Write out equations
- There will be homework problems relating to this growth
- Related growth parameters

The growth cycle
- Why aren’t bacteria always doubling? What limits their growth?
  - They exhaust their nutrients, causing the growth curve to level off
  - Build up of toxic waste products
- The cell has to replicate everything before it divides
  - Therefore if you move a cell from a bad medium to a good one, there’s a lag before it begins to grow.
- Stationary phase – in a batch culture, for the most part things stay the same.
- Death – in bacteria, this is exponential, like growth (very important)
  - It’s not clear what’s going on here – people have speculated.

Total cell count
- Demonstration: Prof. Schauer shows the class a counting chamber
  - Grid etched on with a laser
  - Two raised ridges – glass coverslip fits directly over, allowing you to measure the space between the platform and the coverslip – count through a microscope
  - The same concept and method is used for bacterial, blood cells, environmental samples, etc.
- Problems with this method:
  - Not very precise
  - Hard to see
  - Doesn’t distinguish live cells from dead ones
  - Requires phase contrast microscope to count unstained cells
  - Dilute samples must be concentrated

Viable count
- This is the more common method – dilute sample many times over
- Demonstration: Prof. Schauer displays samples of test tubes with successive dilutions – each test tube is progressively less cloudy.
- Then you plate the resulting tubes and wait for colonies to appear
- You want to count a plate with between 30 and 300 cells
  - Otherwise the error becomes too high
- Demonstration: Prof. Schauer displays agar plates resulting from each successive dilution
- This kind of evaluation is difficult for slow-growing bacteria – you have to leave the plate to grow for up to a month.
- This method doesn’t work for bacteria that can’t make colonies
- These bacteria might be viable, but clump (you can use detergents to try to fix this problem)
  - Some organisms don’t separate, but come in chains
    - Plating methods
      - Sometimes putting the agar on top is useful, because it stops the bacteria from moving around

- Turbidity as an indirect measure
  - Light scattering off of organisms
  - Depends on morphology of organisms – larger organisms scatter more light
  - You can quantify organisms by measuring the light scattering
    - Photometers
    - This is advantageous because you can still keep using the sample

- Chemostat culture
  - Instrument called a chemostat – bioreactor of sorts – you grow bacteria in it
  - Open system
  - Number of bacteria and rate of growth are kept constant
  - It enables you to control both the bacterial concentration and the doubling time.

- Cardinal temperatures: extremophiles
  - Temperature as an environmental condition – controls rate and yield
  - For every organism, you can determine maximum, optimum, and minimum temperatures for growth
  - The optimum is always closer to the maximum than it is to the minimum
  - Classes of organisms
    - Some organisms can grow in up to 113°C
    - Organisms can grow anywhere that there’s water
  - Psychrophiles
    - It’s very clear why organisms can’t grow at very high temperatures: proteins denature, etc.
    - However, it’s less clear why they can’t grow in low temperatures: you lose hydrogen bonding, but that’s about all that changes
    - True psychrophiles, that prefer very cold temperatures, are rare
    - Those organisms can’t handle warmer temperatures – therefore they live only in areas where it’s cold all year round: the North and South Poles, glaciers.
  - Hyperthermophiles
    - Most of these are archaea
    - Archaea probably originated at very high temperatures: thermal vents, magma
    - They grow in superheated, high pressure water, over 100°C
- They have positive supercoiling of DNA – everything else on earth has negative-coiled DNA
- Problems with membrane stability – remember, archaea have different membranes from us (eukaryotes can never grow above 50°C

- Thermophiles
  - Important source of enzymes for biotechnology
  - Differently colored band at Yellowstone: each colored band is a different thermophile

- Extremophiles of pH and osmolarity
  - They maintain their internal cell environment
    - They don’t, for example, have such low pH or such high salt concentration inside the cell as they do outside
  - Accumulate inorganic ions or make organic solutes
  - Compatible solutes
  - Note: freezing is similar to dehydration: what kills cells as they freeze is the loss of H₂O as it forms into crystals
  - Demonstration: Prof. Schauer shows the class a device for creating an anaerobic atmosphere for growth
  - Toxic forms of oxygen