

The Process of Growth

- Metabolism required for growth, both anabolic and catabolic. ~2000 reactions!
- Usual Definition: **Increase in cell numbers**
Other definitions possible – spores, UMC's, respiration, viable but nonculturable, morphology changes (life cycle)
- Divide via Binary Fission: 3 mechanisms involved!
Cell Elongation – cell wall
DNA Replication – rate limiting step
Cell Division – septum formation

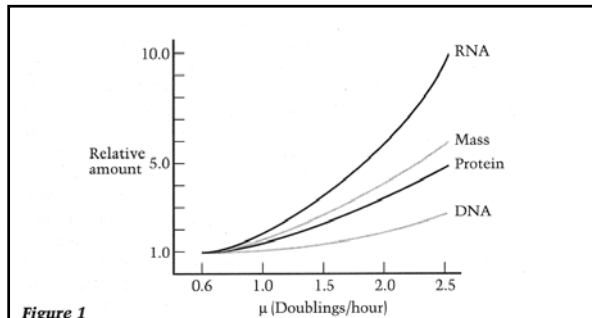
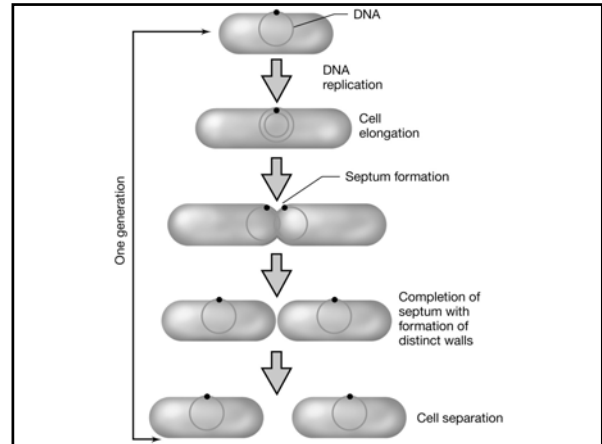


Figure 1

Effect of nutrition-imposed growth rate on the composition of *Escherichia coli* B/r. All values are expressed in amounts per cell normalized to values at $\mu = 0.6$ (mass = 1.48×10^{-13} g; protein = 1.00×10^{-13} g; RNA = 2.0×10^{-14} g; DNA = 6.3×10^{-15} g). (Plotted from data in Bremer and Dennis, 1987.)

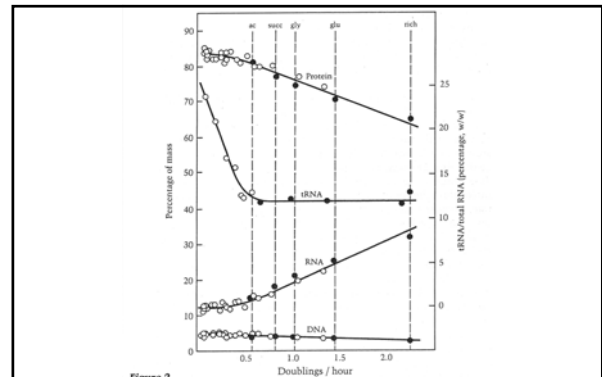
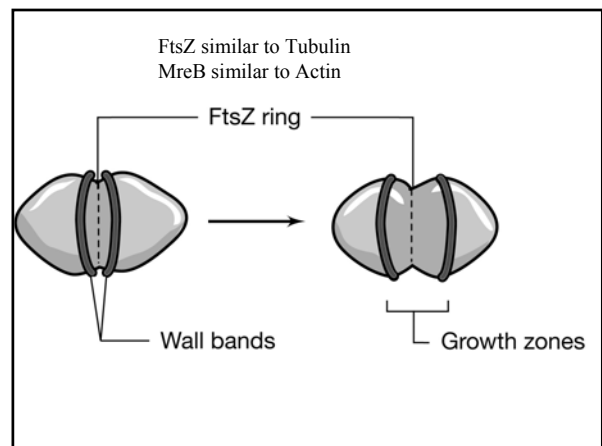
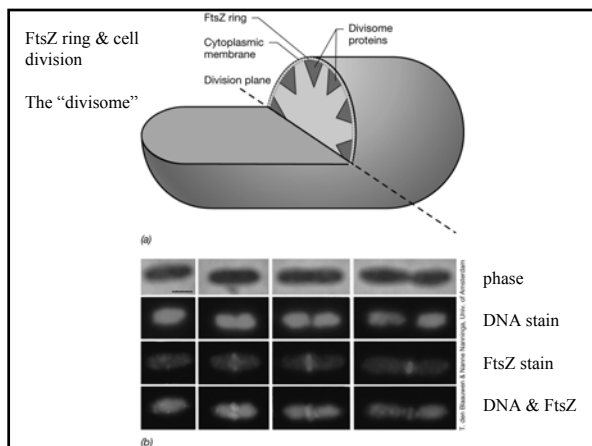


Figure 2

Effect of growth rate on the cellular proportions of protein, RNA, and DNA. Filled circles refer to results from cultures undergoing balanced growth in batch culture in various media; open circles are from cultures growing in a glucose-limited chemostat. (From Jacobsen, 1974.)



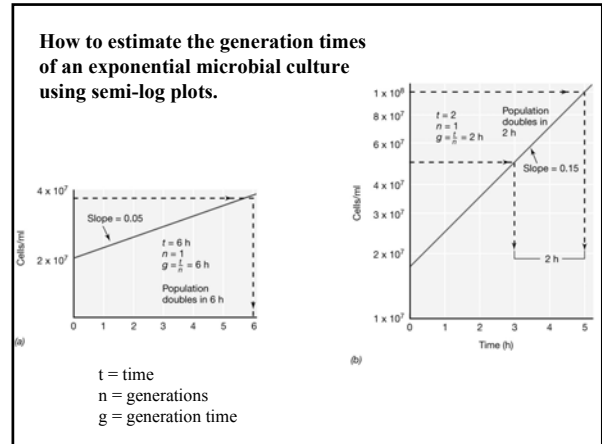
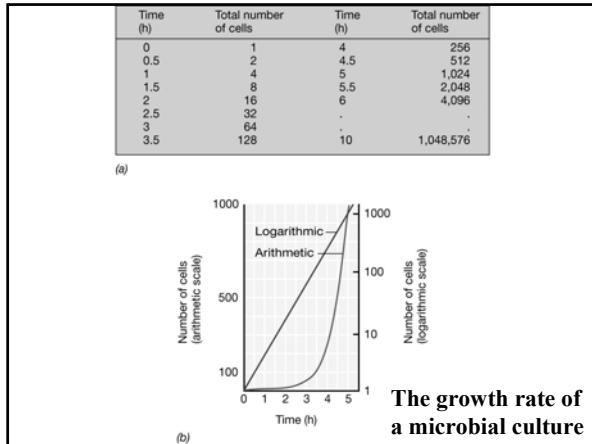
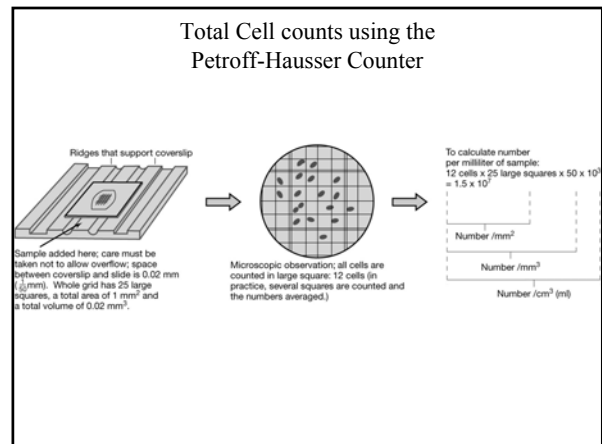
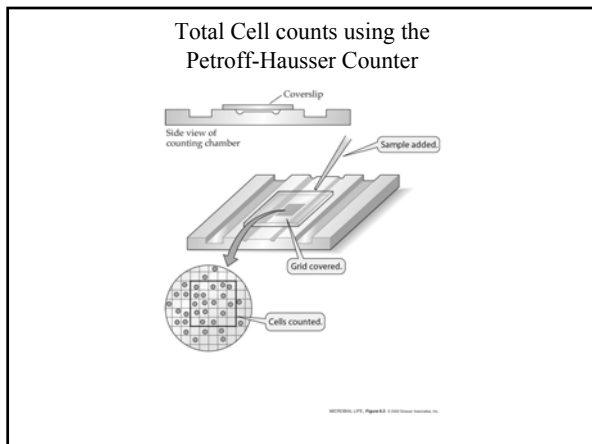
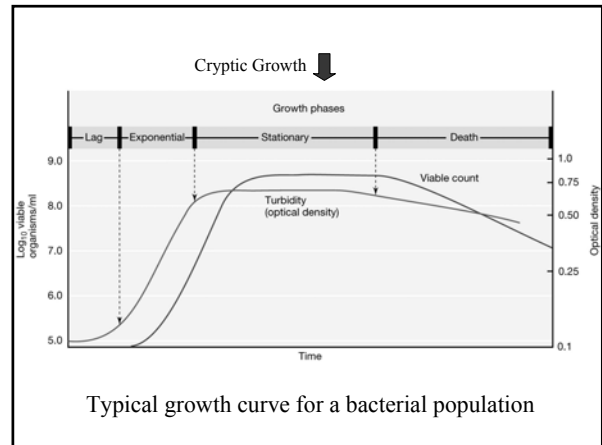
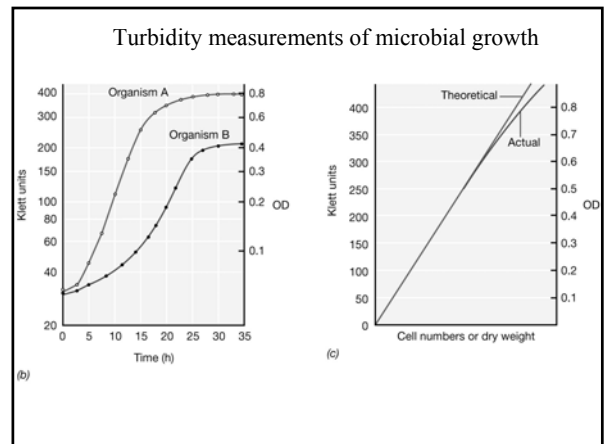
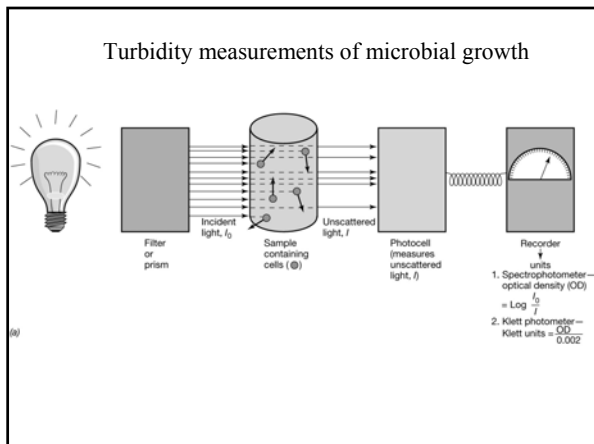
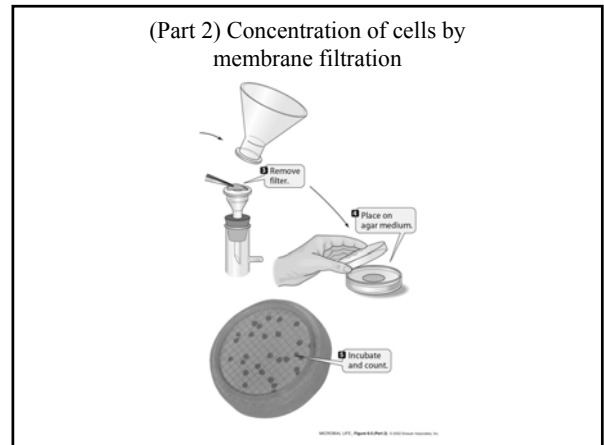
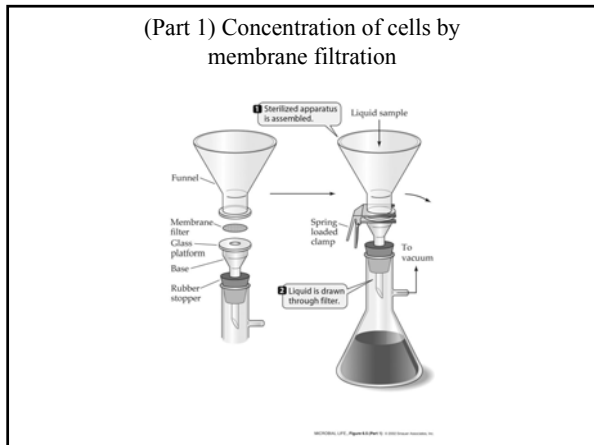
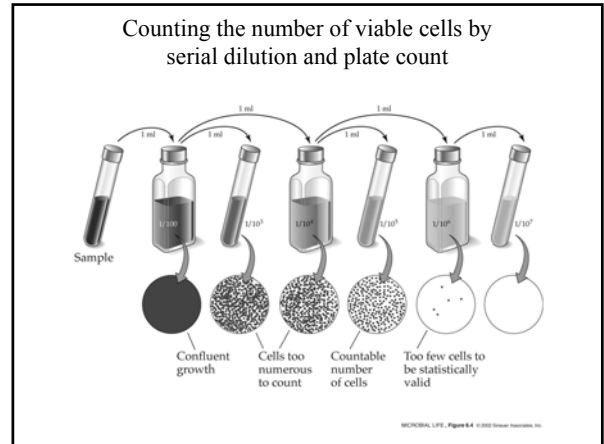
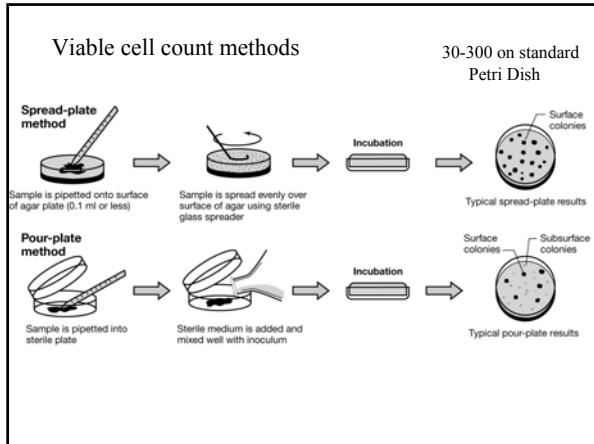


Table 6.1 Approximate generation times for several organisms growing in media optimal for growth

Species	Generation Time
<i>Escherichia coli</i>	20 min
<i>Bacillus subtilis</i>	28 min
<i>Staphylococcus aureus</i>	30 min
<i>Pseudomonas aeruginosa</i>	35 min
<i>Thermus aquaticus</i>	50 min
<i>Thermoproteus tenax</i>	1 hr 40 min
<i>Rhodobacter sphaeroides</i>	2 hr 20 min
<i>Sulfolobus acidocaldarius</i>	4 hr
<i>Thermoleophilum album</i>	6 hr
<i>Thermophilum pendens</i>	10 hr
<i>Mycobacterium tuberculosis</i>	13 hr 20 min





The Process of Growth

- Continuous Culture: The wonders of the Chemostat
 - Steady State
 - Reproducible Physiology
 - Fine control

Key parameters – K_s , μ_{max} , Yield

Closed systems vs. Open systems vs. Nature!

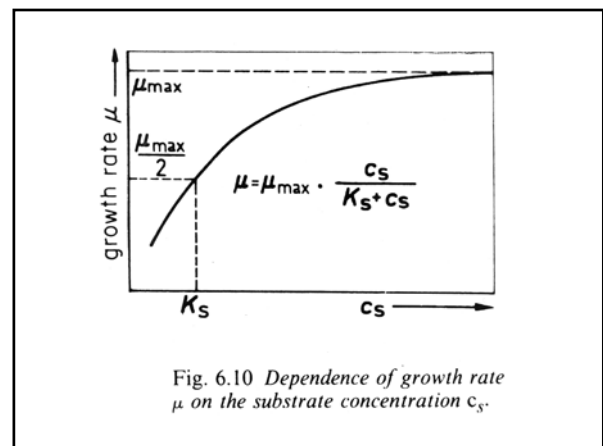
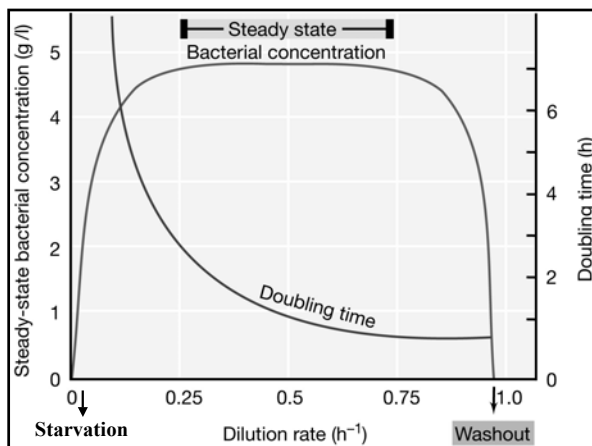
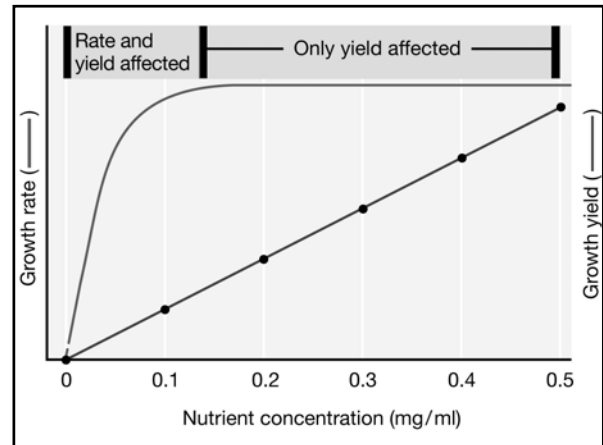
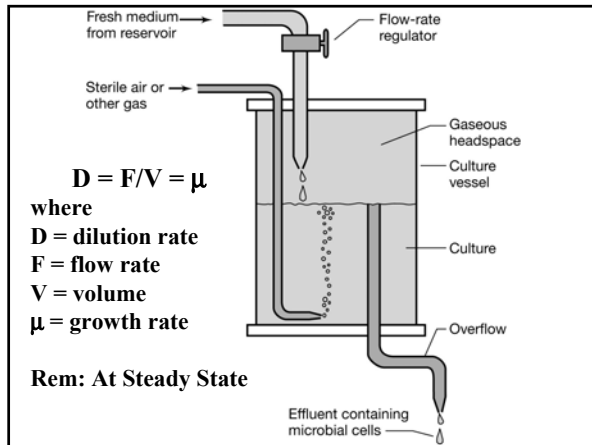
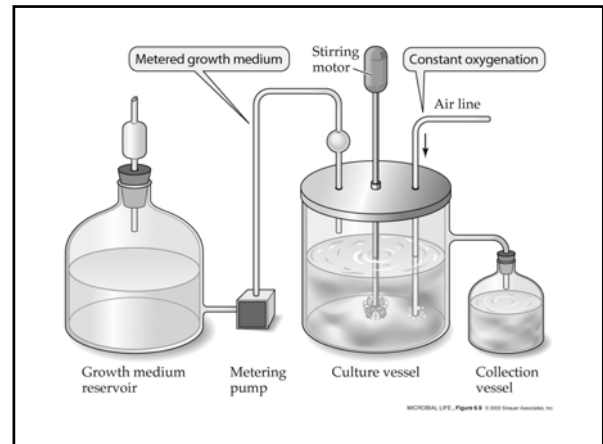


Fig. 6.10 Dependence of growth rate μ on the substrate concentration c_s .

Steady-state relationship between substrate concentration and output of bacterial mass

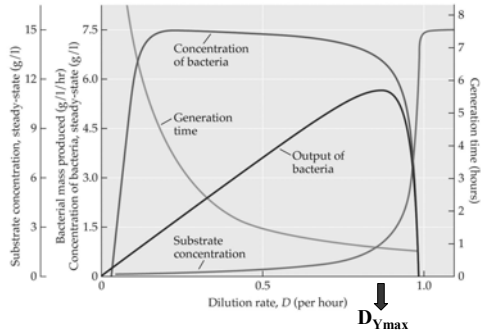


Table 6.2 Growth yields of anaerobic bacteria utilizing glucose as the energy source

	Mol ATP/Mol Glucose	Y_{max} (g of cell/mol Glucose)	Y_{ATP} (g of cell/mol ATP)
<i>Lactobacillus delbrueckii</i> ^a	2	21	10.5
<i>Enterococcus faecalis</i> ^a	2	20	10
<i>Zymomonas mobilis</i> ^b	1	9	9

^aHomolactic fermentation, Embden–Meyerhof pathway (see Chapter 10).

^bAlcoholic fermentation, Entner–Doudoroff pathway (see Chapter 10).