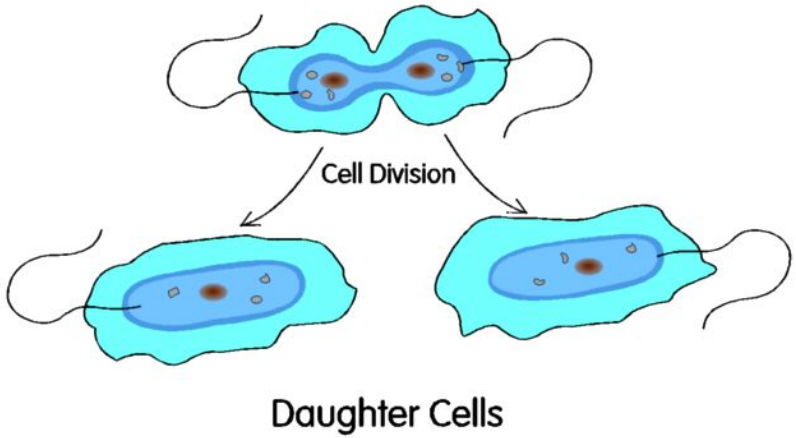
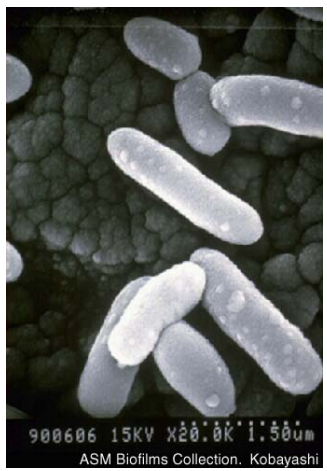
Bacterial Requirements

Growth and Nutrition

Bacterial Reproduction

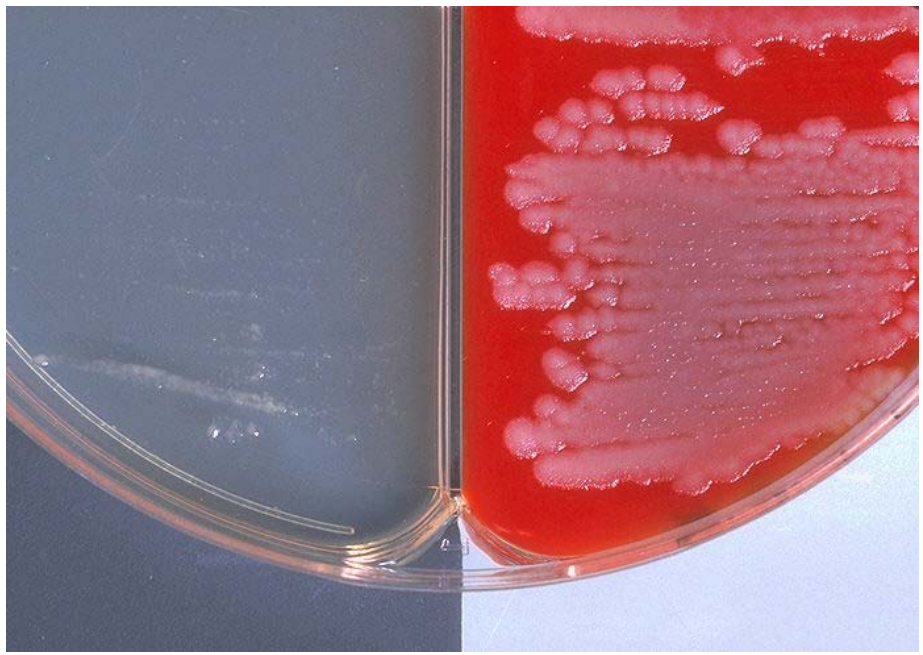
- Reproduction
  - Binary Fission
  - Budding
  - Fragmenting
- Function
  - Increase number of cells
  - Genetic recombination possible
- End result : Growth



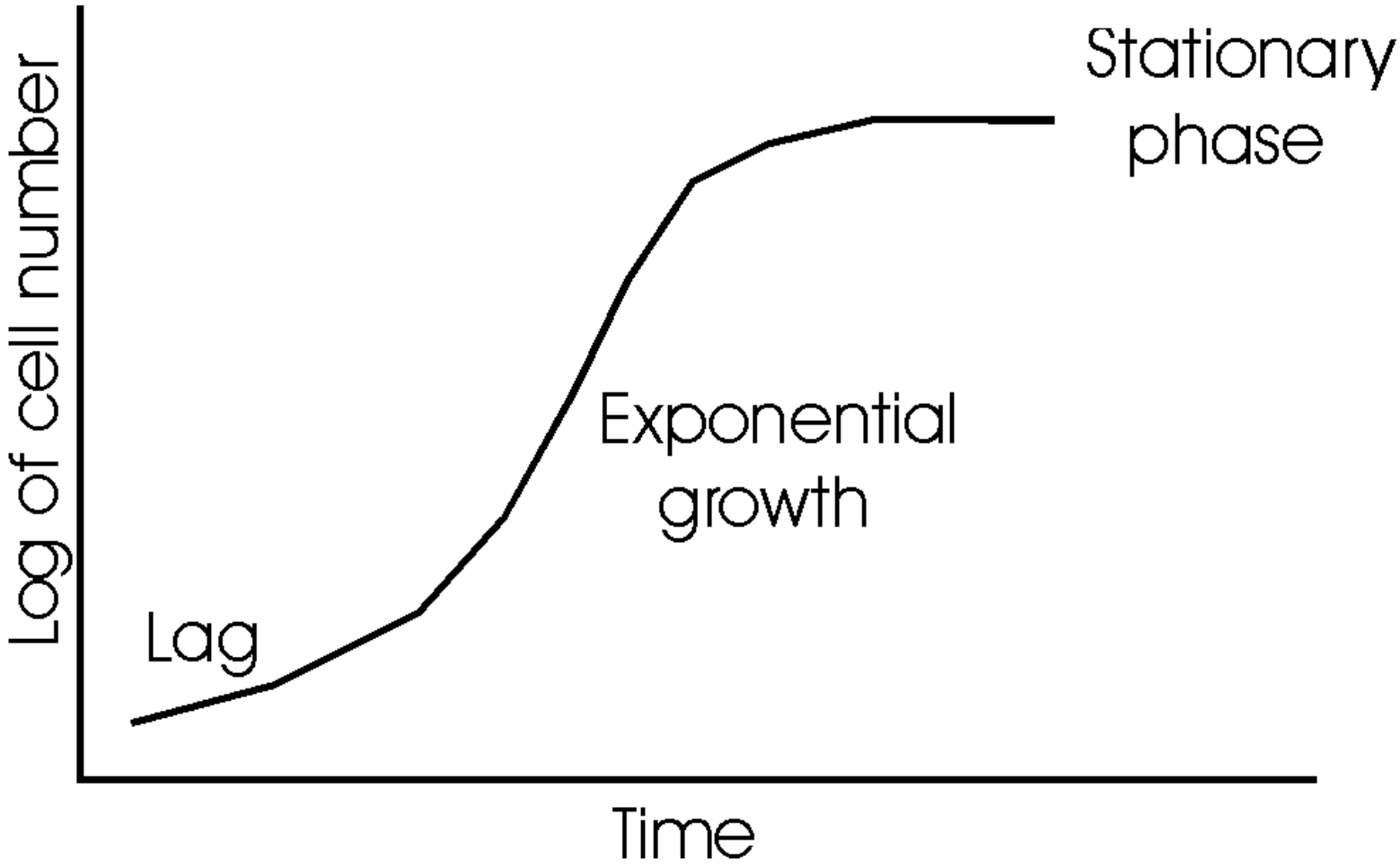


Generation Time

- Define
- Time
- Reason
- Requirements
  - Physical
  - Chemical
- Result
  - Genetic recombination
  - Mutations

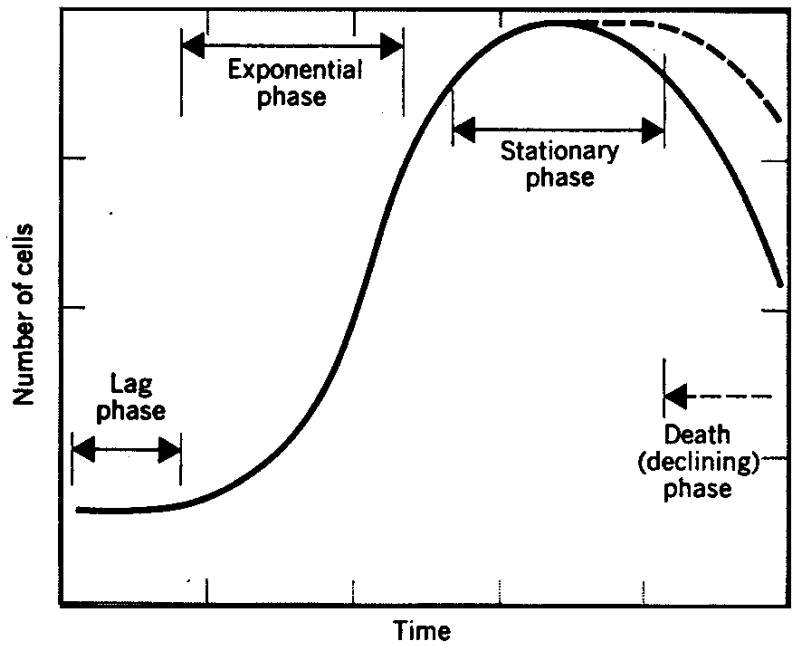


Growth Curve Graph

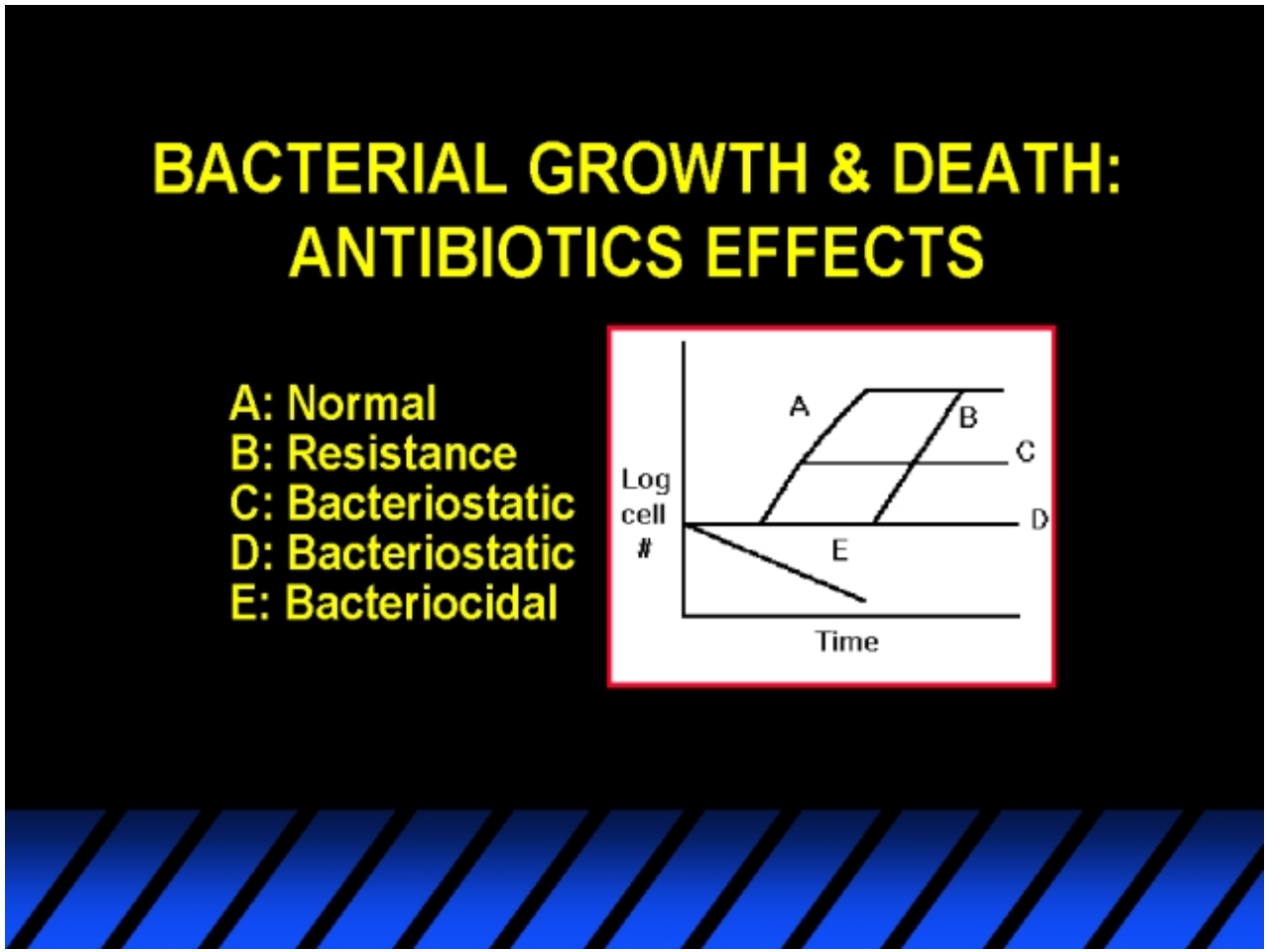


Growth Curve Labeled Phases

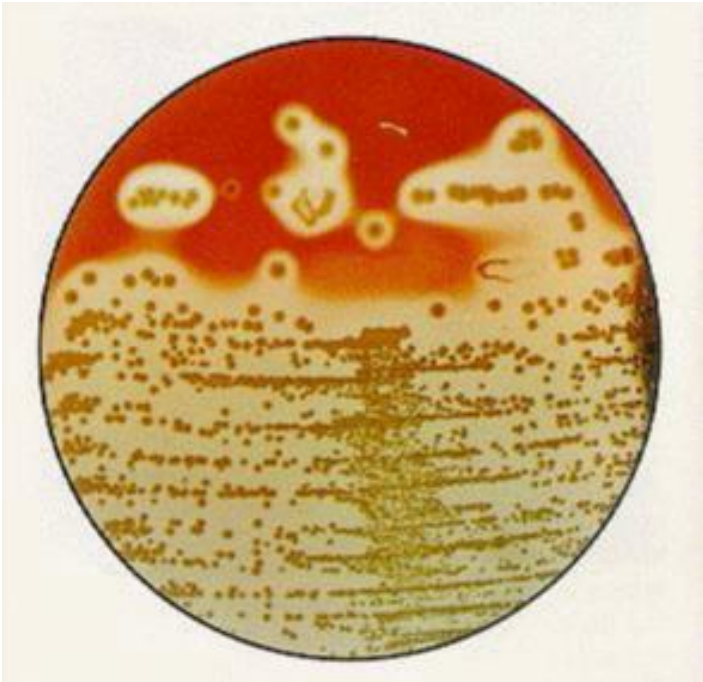
- Lag phase
  - Adaptive
  - Start metabolism
  - 1-3 days
- Log phase
  - Generation time doubles
  - Most metabolically active
- Stationary phase
  - Growth = death
- Death phase
  - Requirements decrease
  - Possible spore formation



Growth Curve Changes due to AB

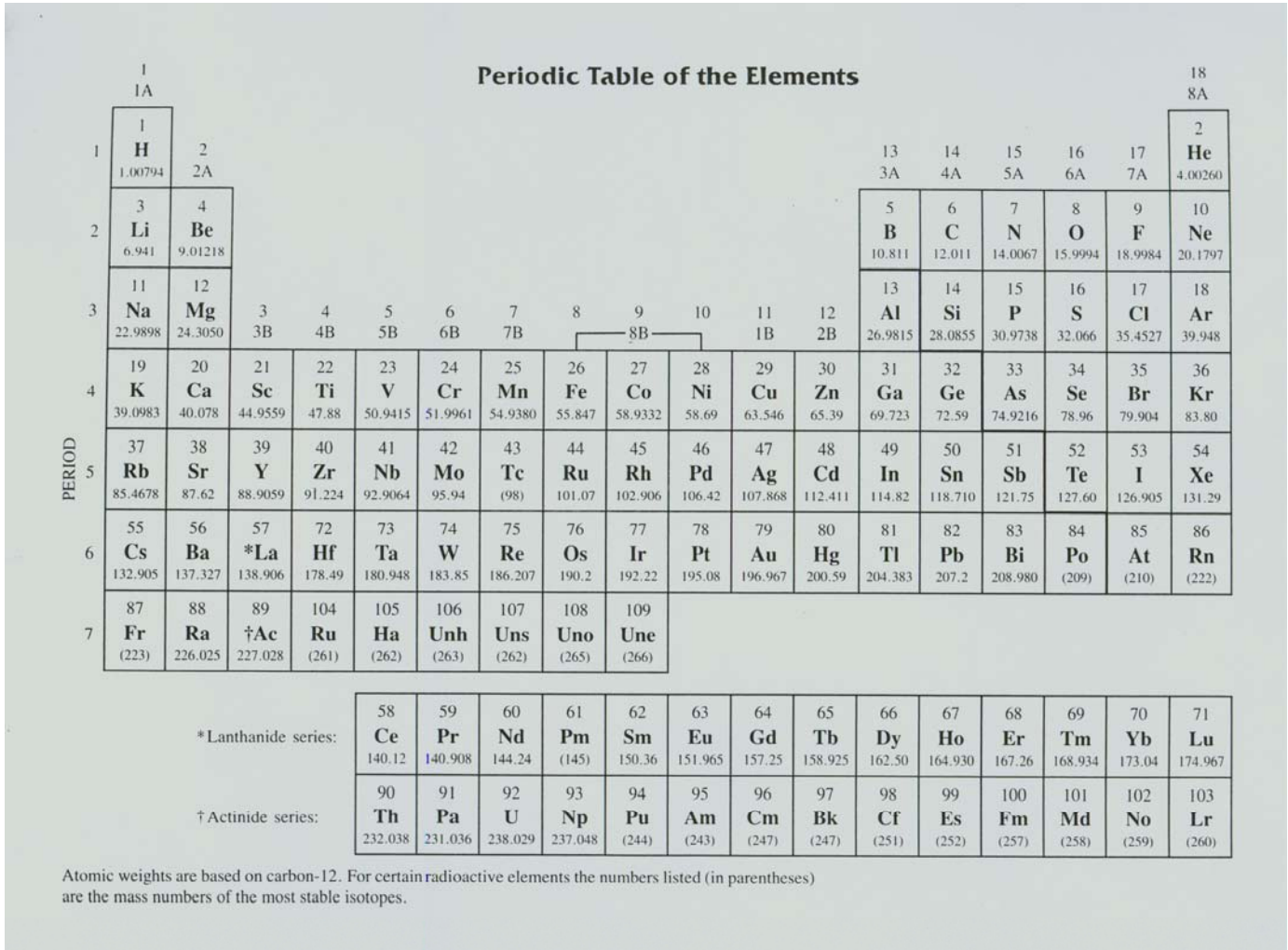


Measurement of Microbial Growth



- CFU
- Serial Dilutions
- Pour Plate
- Spread Plate
- Direct
  - Number counted / fov
- Indirect
  - Turbidity
  - Metabolic activity

Nutritional Requirements



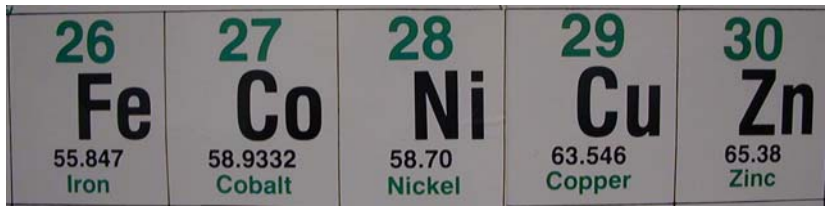
Periodic Table of the Elements

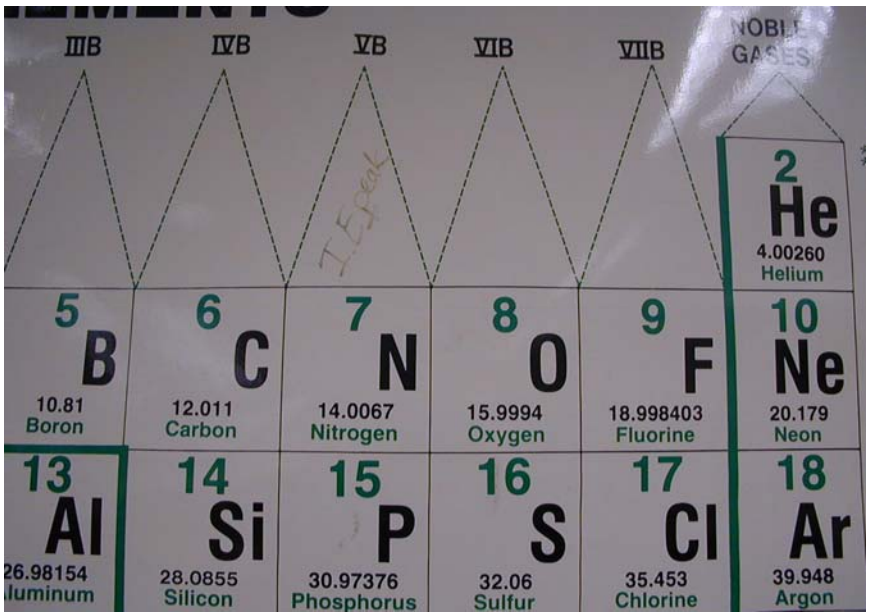
PERIOD	1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1	1 H 1.00794	2 2A																2 He 4.00260
2	3 Li 6.941	4 Be 9.01218											5 B 10.811	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.1797
3	11 Na 22.9898	12 Mg 24.3050	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 Al 26.9815	14 Si 28.0855	15 P 30.9738	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
4	19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.88	23 V 50.9415	24 Cr 51.9961	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.69	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
5	37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.224	41 Nb 92.9064	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.906	46 Pd 106.42	47 Ag 107.868	48 Cd 112.411	49 In 114.82	50 Sn 118.710	51 Sb 121.75	52 Te 127.60	53 I 126.905	54 Xe 131.29
6	55 Cs 132.905	56 Ba 137.327	57 *La 138.906	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.207	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.967	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.980	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra 226.025	89 †Ac 227.028	104 Ru (261)	105 Ha (262)	106 Unh (263)	107 Uns (262)	108 Uno (265)	109 Une (266)									

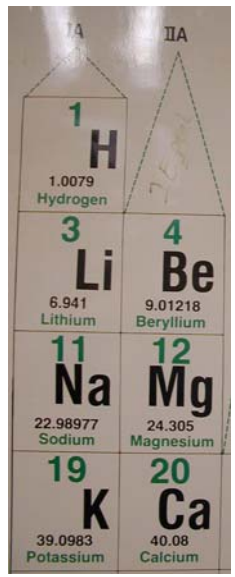
*Lanthanide series:	58 Ce 140.12	59 Pr 140.908	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.965	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.967
†Actinide series:	90 Th 232.038	91 Pa 231.036	92 U 238.029	93 Np 237.048	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

Atomic weights are based on carbon-12. For certain radioactive elements the numbers listed (in parentheses) are the mass numbers of the most stable isotopes.

Macro and Trace Elements



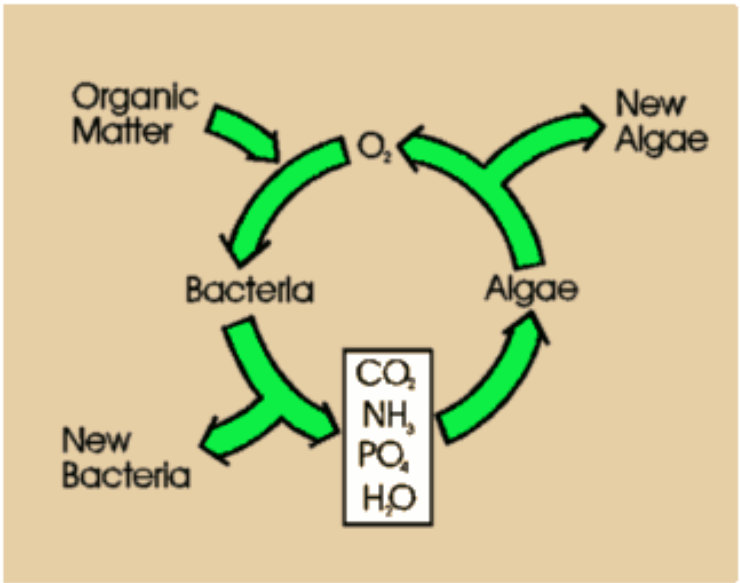


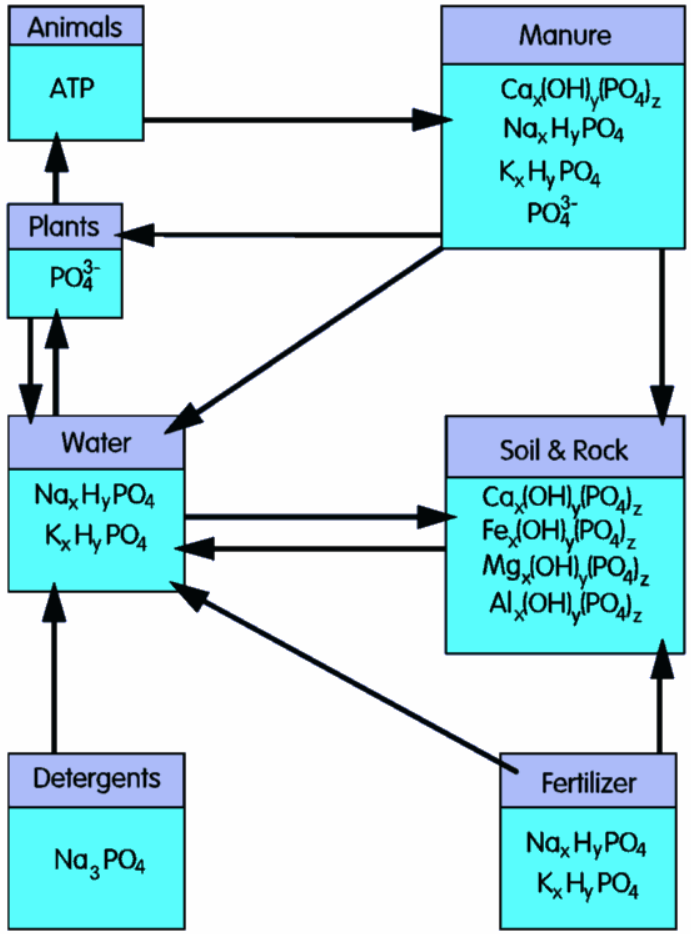


Nutritional Element Use

Carbon	Main component
Oxygen	Cell water, aerobic respiration
Nitrogen	AA, NA, coenzymes
Hydrogen	H20
Phosporus	Nucleotides, PL, LPS
Sulfur	Several AA; coenzyme

Cycles

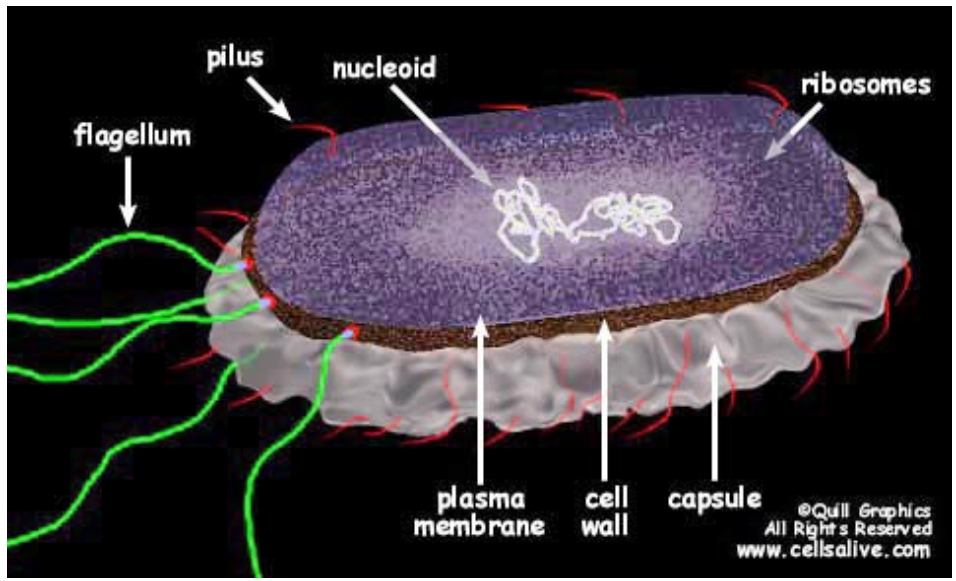

Organic Matter
O_2
New Algae
Bacteria
Algae
CO_2
NH_3
PO_4
H_2O
New Bacteria


Animals
ATP
Manure
$Ca_x(OH)_y(PO_4)_z$
$Na_xH_yPO_4$
$K_xH_yPO_4$
PO_4^{3-}
Plants
PO_4^{3-}
Water
$Na_xH_yPO_4$
$K_xH_yPO_4$
Soil & Rock
$Ca_x(OH)_y(PO_4)_z$
$Fe_x(OH)_y(PO_4)_z$
$Mg_x(OH)_y(PO_4)_z$
$Al_x(OH)_y(PO_4)_z$
Detergents
Na_3PO_4
Fertilizer
$Na_xH_yPO_4$
$K_xH_yPO_4$

Metal Ions and Trace Minerals

- Potassium
- Magnesium
- Calcium
- Iron
- Cobolt
- Zinc
- Copper
- Manganese

Cofactors in enzymatic reactions in the cell



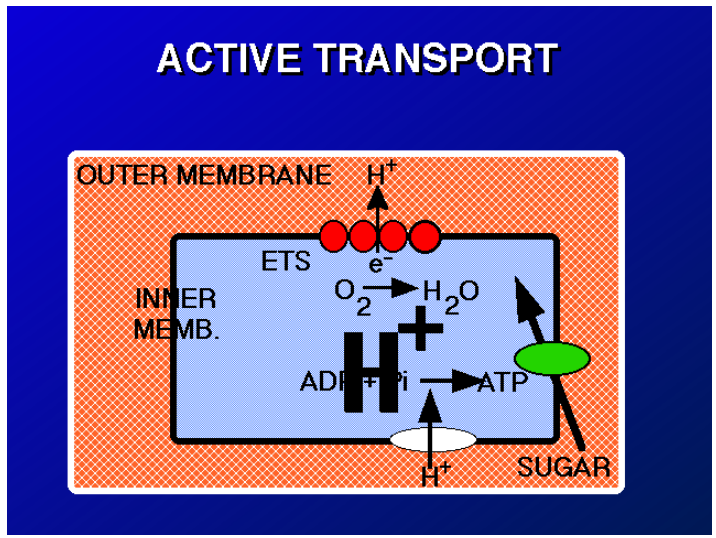
Growth Factors: Vitamins

- Folic Acid
- Biotin
- Niacin
- Pantothenic acid
- Riboflavin [B2]
- Thiamine [B1]
- Pyridoxine [B6]
- B12
- K

involved in many

Metabolic Reactions

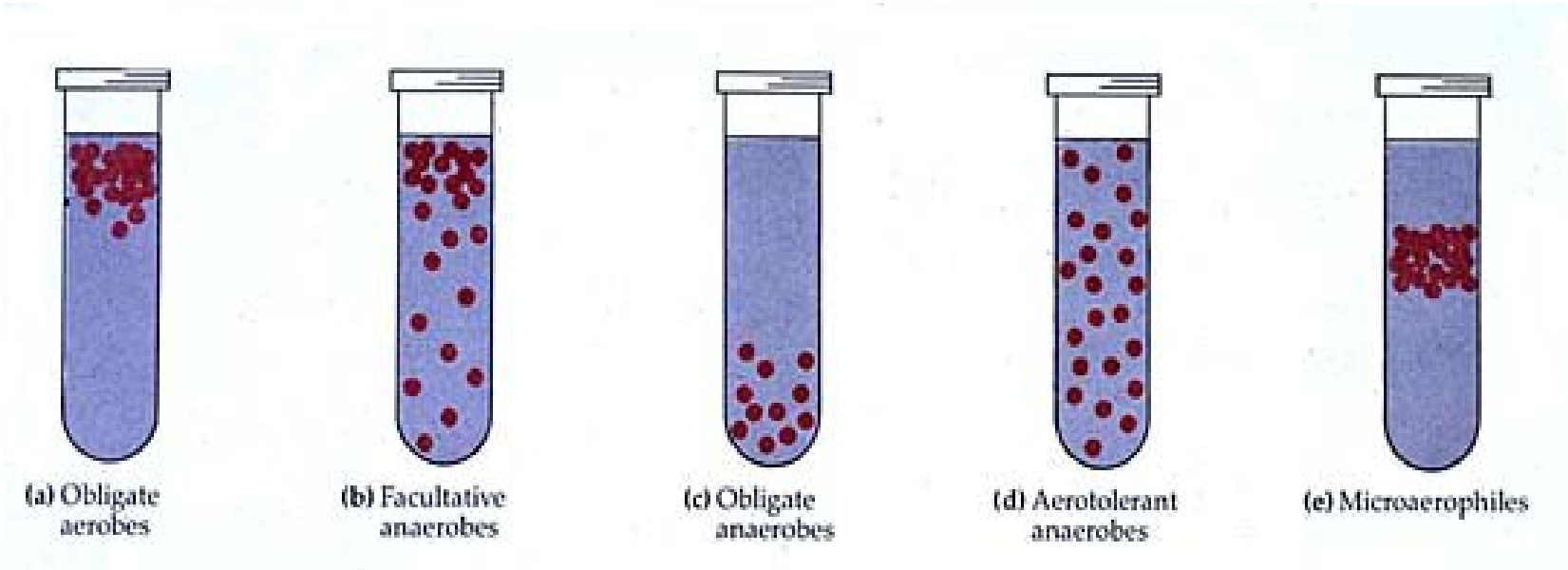
redox
deamination
decarboxylation
transamination
synthesis



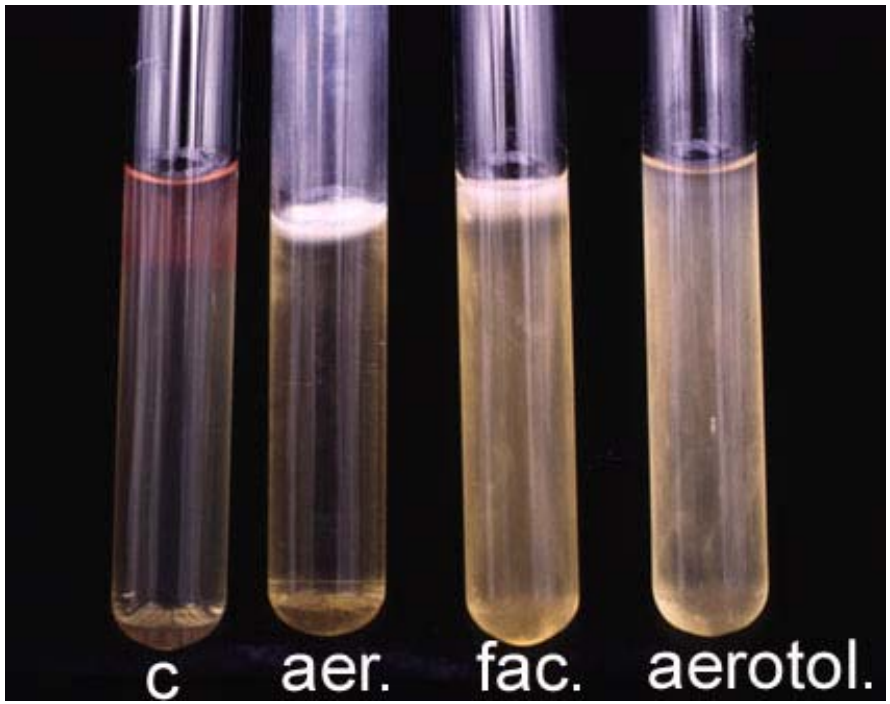
Oxygen Requirements

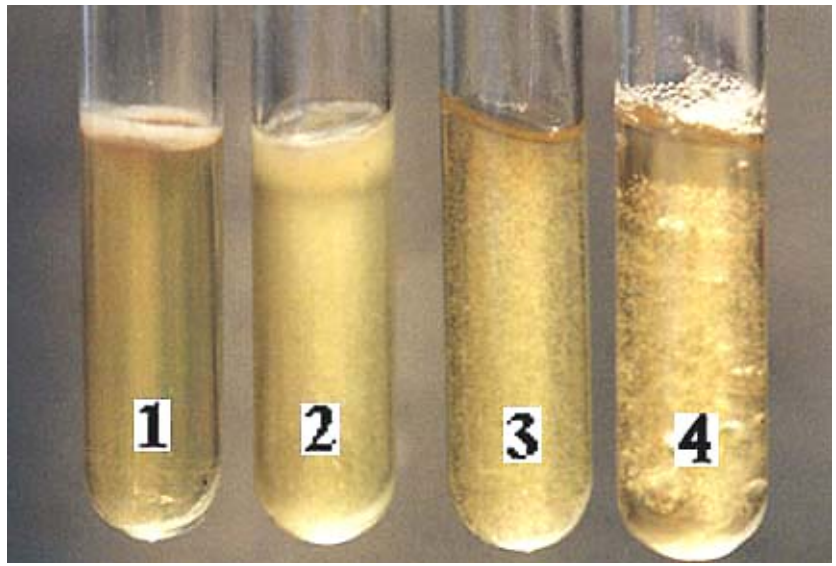
- Obligate Aerobes
- Microaerophiles
- Aerotolerant aerobes
- Obligate Anaerobes
- Facultative Anaerobes
- Capnophiles

Oxygen Requirement Classification



Aerobic / Anaerobic Lab Tests



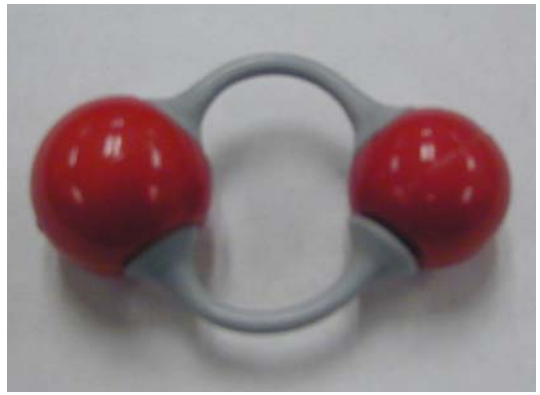


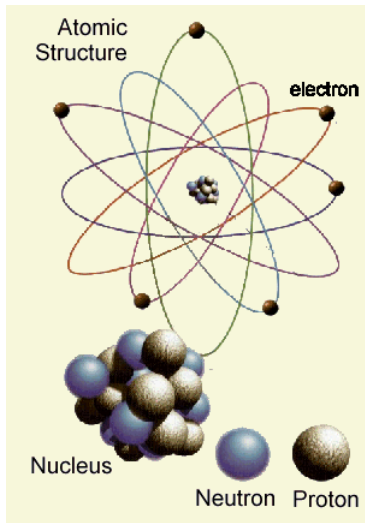
aerobe FA aerotolerant anaerobe

Oxygen Forms

- Normal
- Toxic
  - Singlet: 1O2

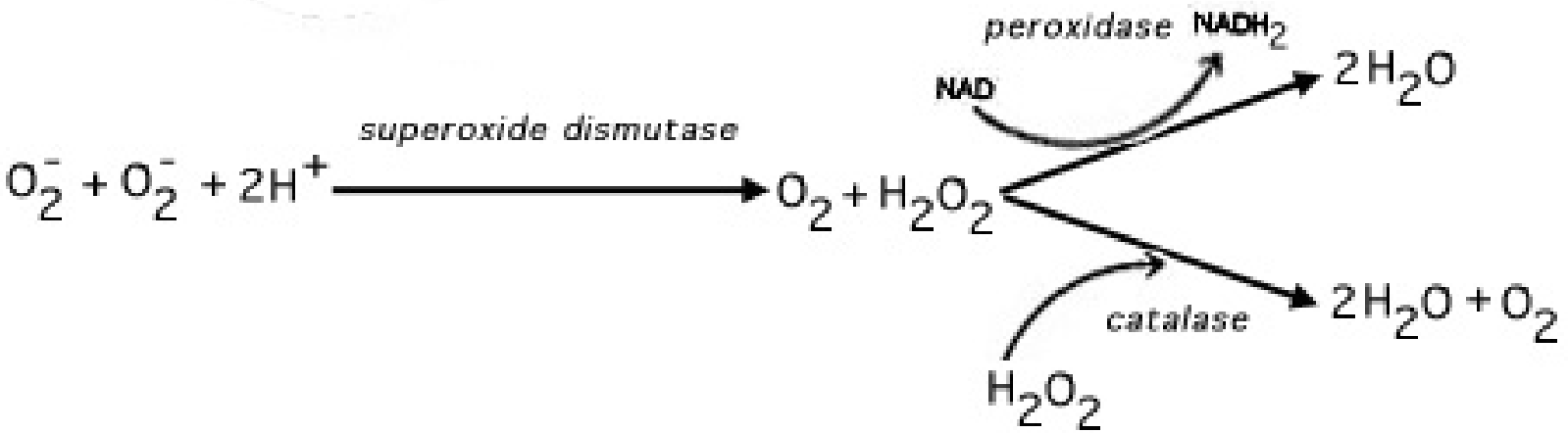
    with electrons in higher energy state
  - Superoxide radical: O2-
  - Peroxide Anion: O2=
  - Hydroxide radical: OH- from incomplete reduction of hydrogen peroxide [H2O2]



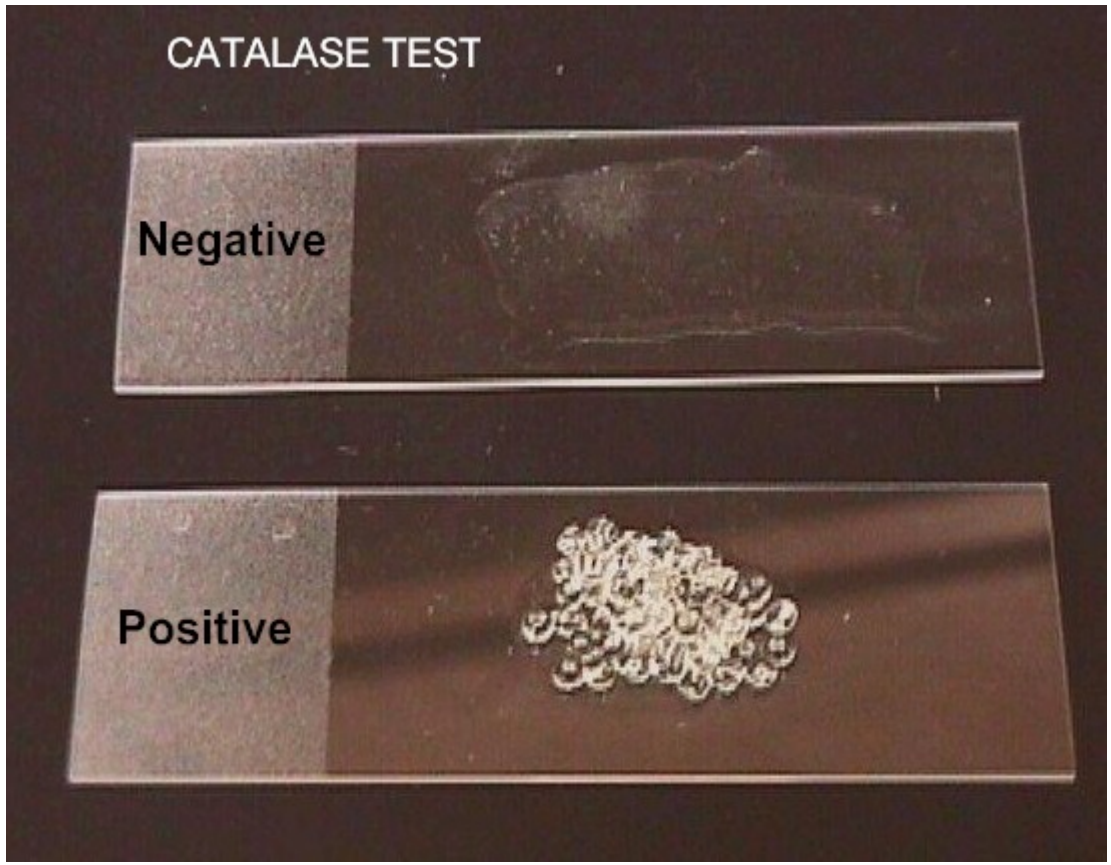


Enzyme Presence to Detoxify O2 -

	Superoxide	Catalase	Peroxidase
Abligate Aerobes and FA	+	+	-
Aerotolerant Anaerobes	+	-	+
Obligate anaerobes	-	-	-



Catalase Test



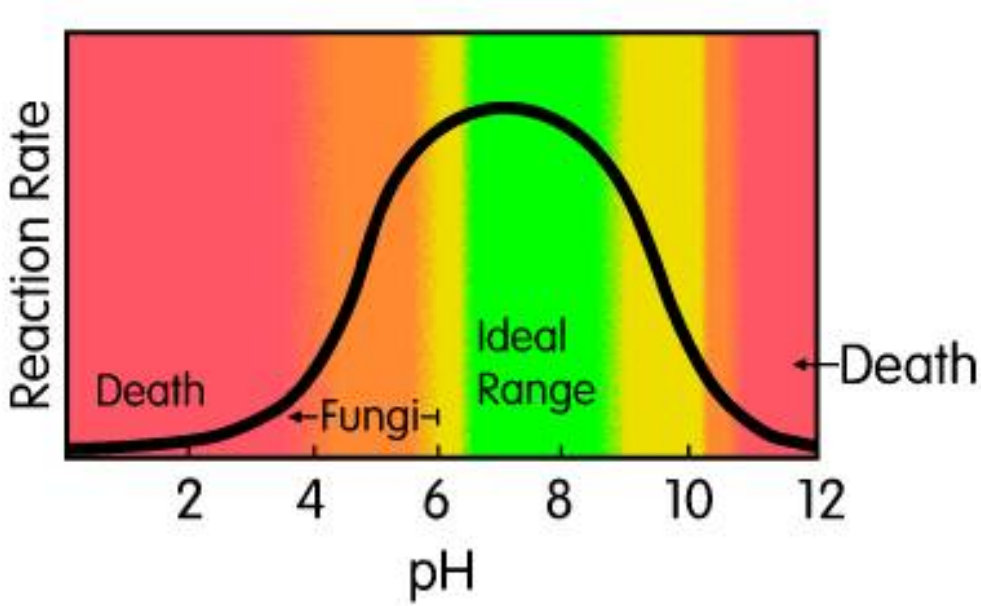
Bacterial Examples of O2 Groups

- Obligate Aerobes
  - *Pseudomonas*
- Microaerophiles
  - *H. pylori*
- Aerotolerant aerobes
  - *Streptococcus*
  - *Lactobacillus*
- Obligate Anaerobes
  - *Clostridium*
- Facultative Anaerobes
  - *E. coli*
  - *Stapylococcus*
- Capnophilic
  - *Campylobacter*

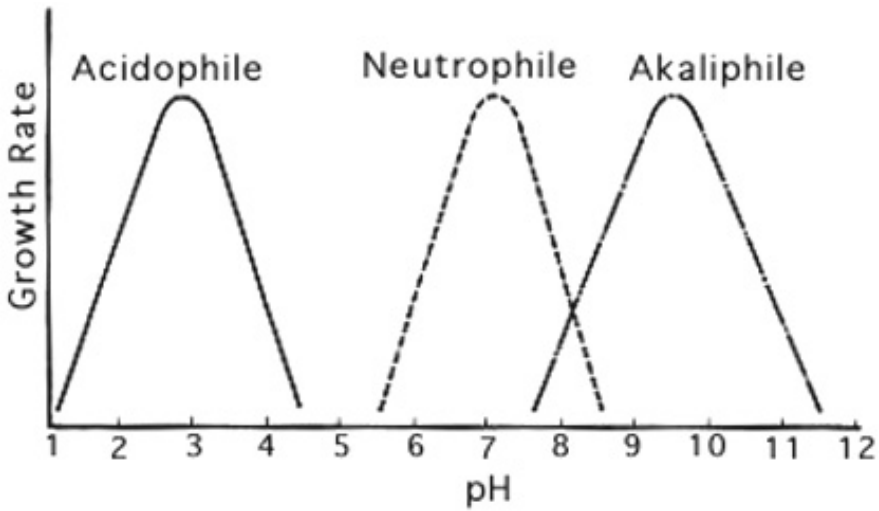
E coli

Staph

Physical Requirements: pH



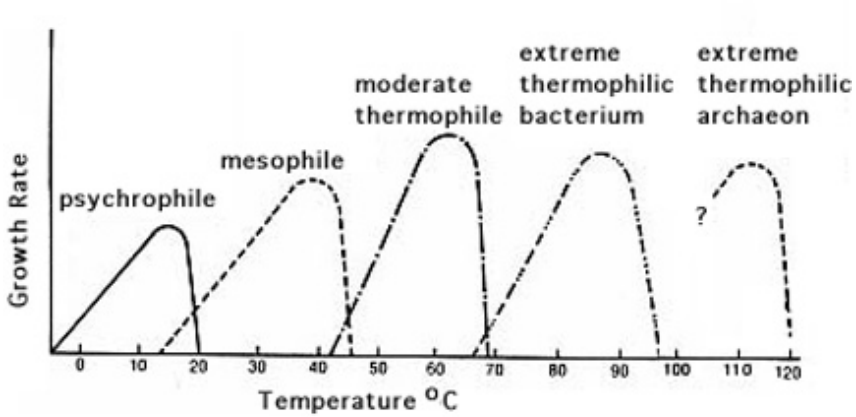
pH Groups

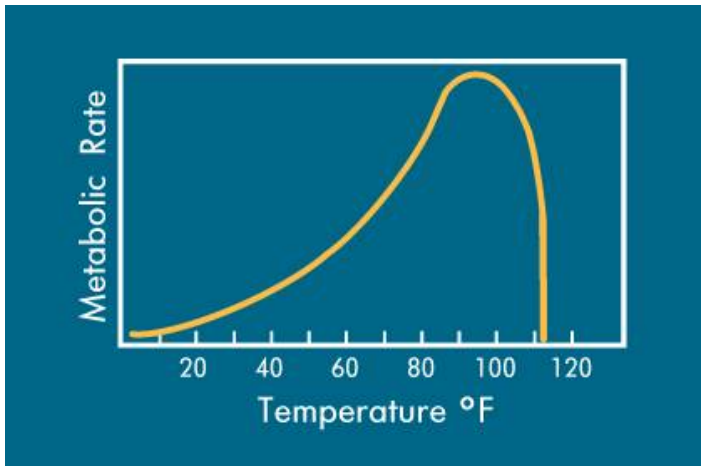


- Acidophile
  - *Bacillus acidocaldarius*
  - *Lactobacillus acidophilus*
- Neutrophile
  - *E. coli*
  - *Staphylococcus aureus*
- Akaliphile
  - *Streptococcus pneumoniae*
  - *Nitrobacter sp*.

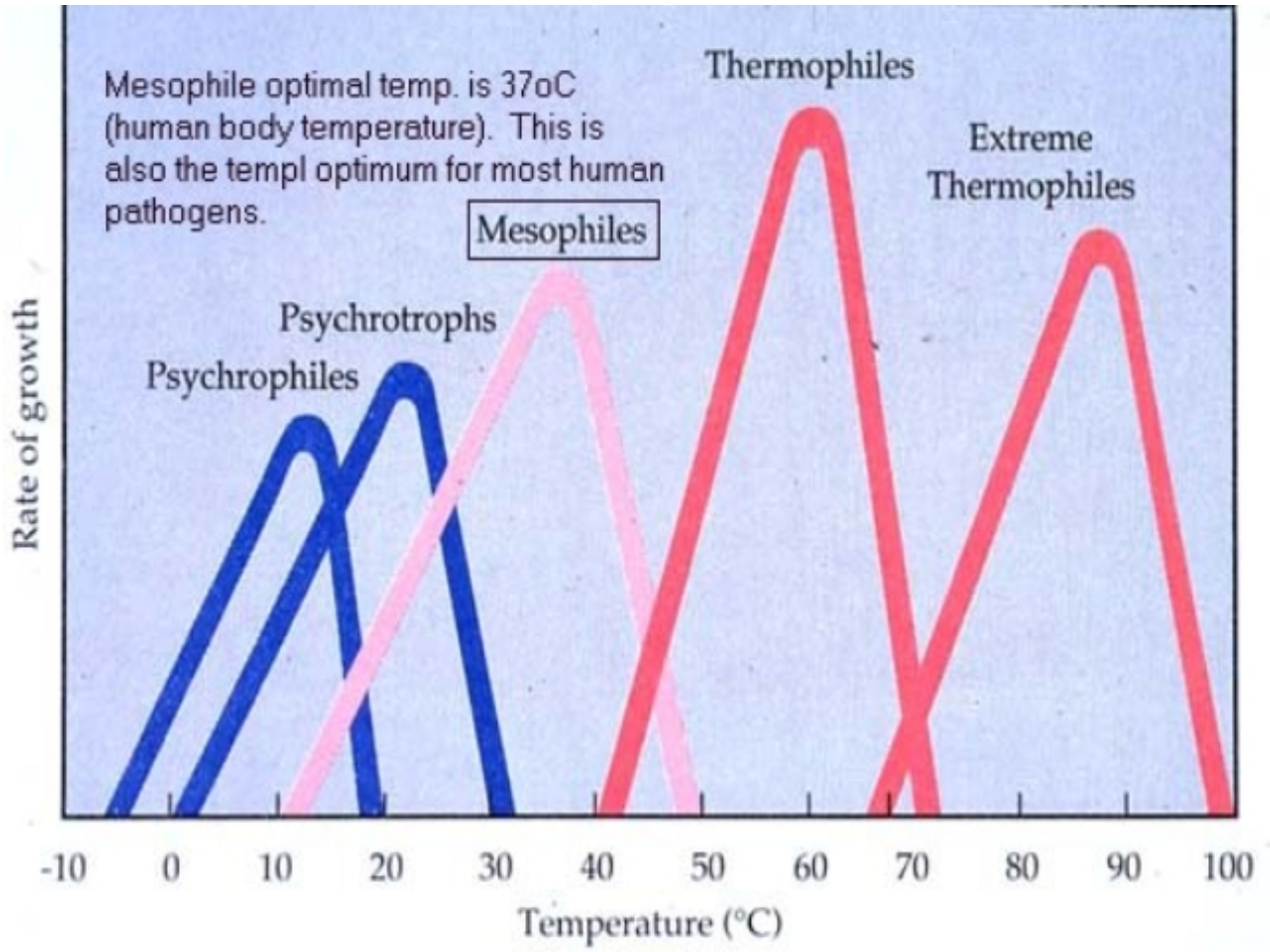
Physical Requirements: Temperature

- Psychrophile
  - Unsaturated FA in cell membrane
- Psychrotroph
  - Refrigeration
  - Room temperature
- Mesophile
  - Warm Blooded Animals
- Thermophile
  - Saturated FA in cell membrane





Psychrotrophs and Mesophiles



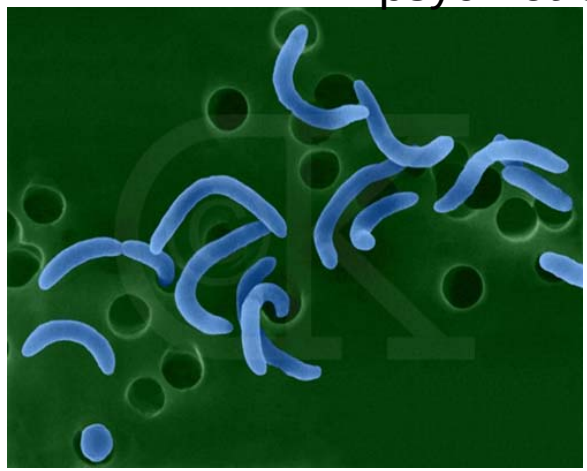
Bacterial Examples: Temperature

psychrophile

mold

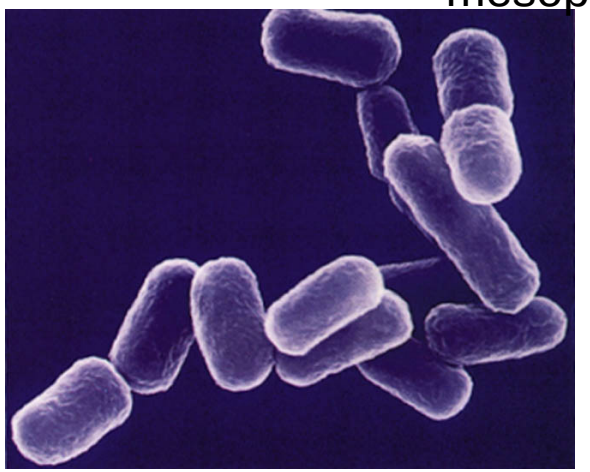
psychrotroph

Vibrio



mesophile

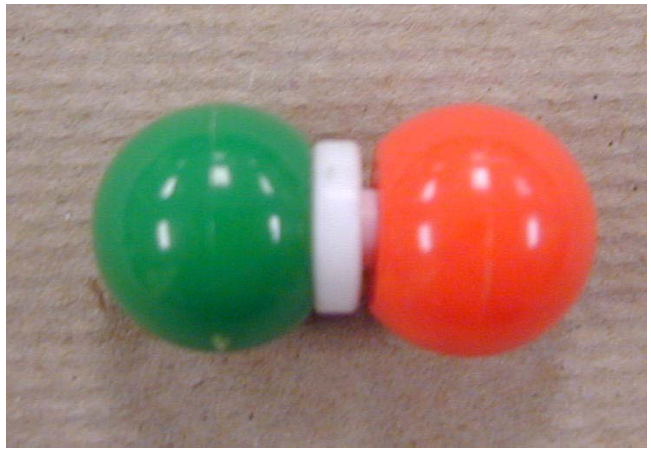
E coli



thermophile

Archaea

Physical Requirements: Salt



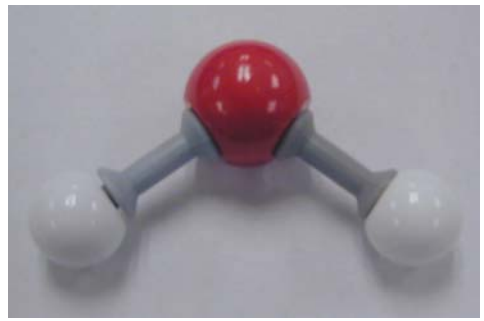
- Extreme Halophile : 30 % NaCl
- Obligate Halophile : 15% NaCl
- Facultative Halophile : 2% NaCl
- Halotolerant : NaCl not needed, can grow in low salt

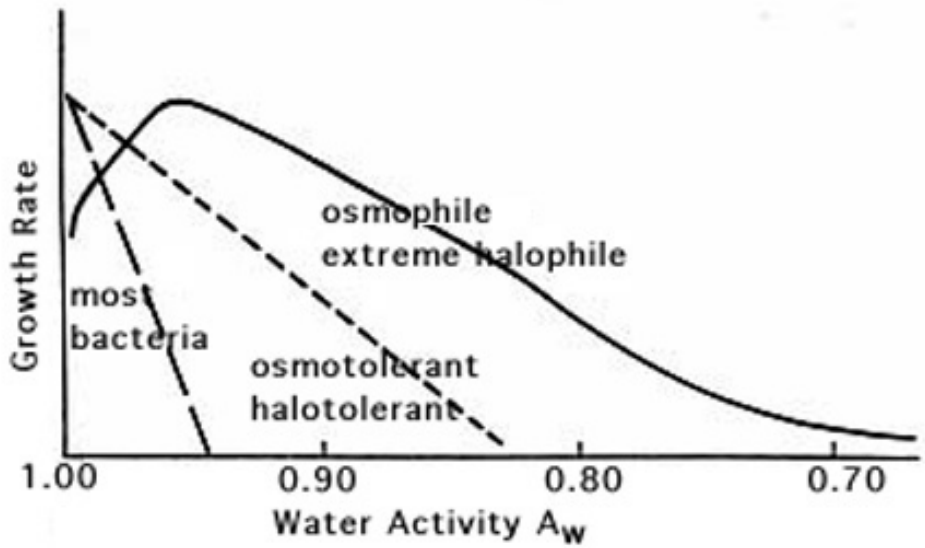
Extreme Halophiles

Great Salt Lake

Osmosis and Water Activity

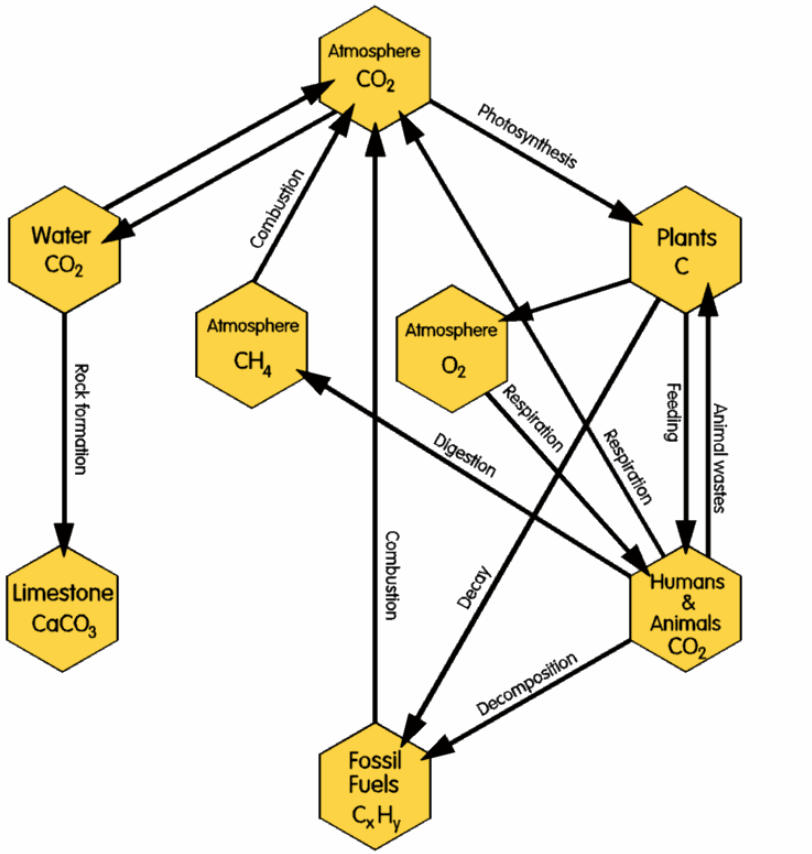
- Activity of water [Aw]
  = 1.0 for pure water
- Aw for human blood
  = 0.99
- Range required
  0.7-1.0 Aw
  - *E.coli* requires Aw of 0.91
  - Stapylococcus requires Aw of 0.85





Nutritional Groups

- Photoautotrophs
- Chemoautotrophs
- Photoheterotrophs
- Chemoheterotrophs
  - Many bacteria
  - Most all Eukarya
- How Acquire Electrons
  - Organotrophs
  - Lithotrophs

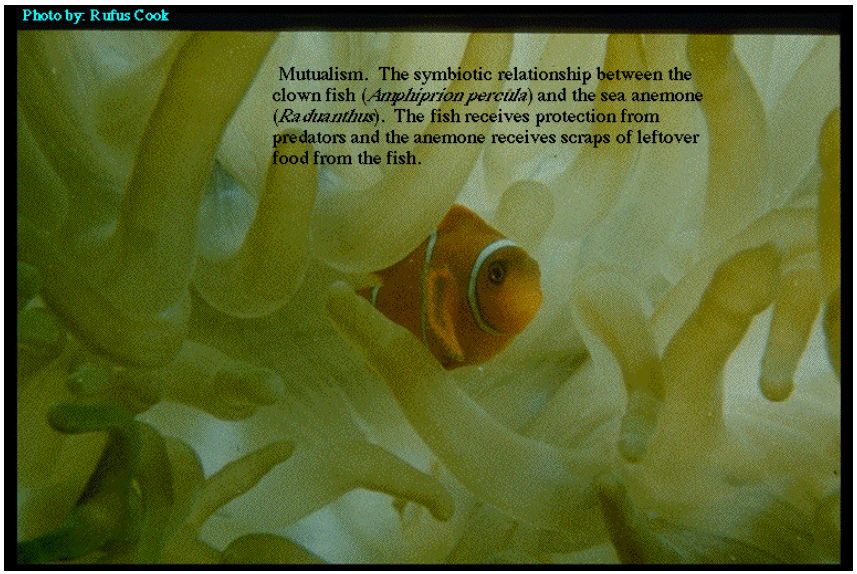


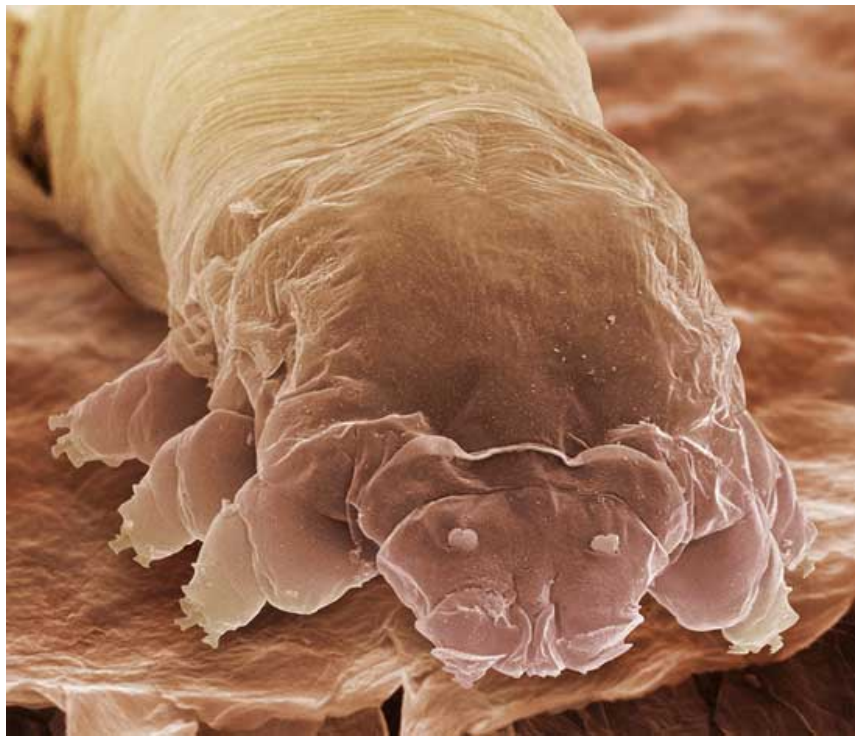
Symbiotic Relationships

- Close ecological relationship between individuals of two or more different species

- Mutualism
- Commensalism
- Synergism
- Parasitism
- Competition
- Neutralism
- Biofilms

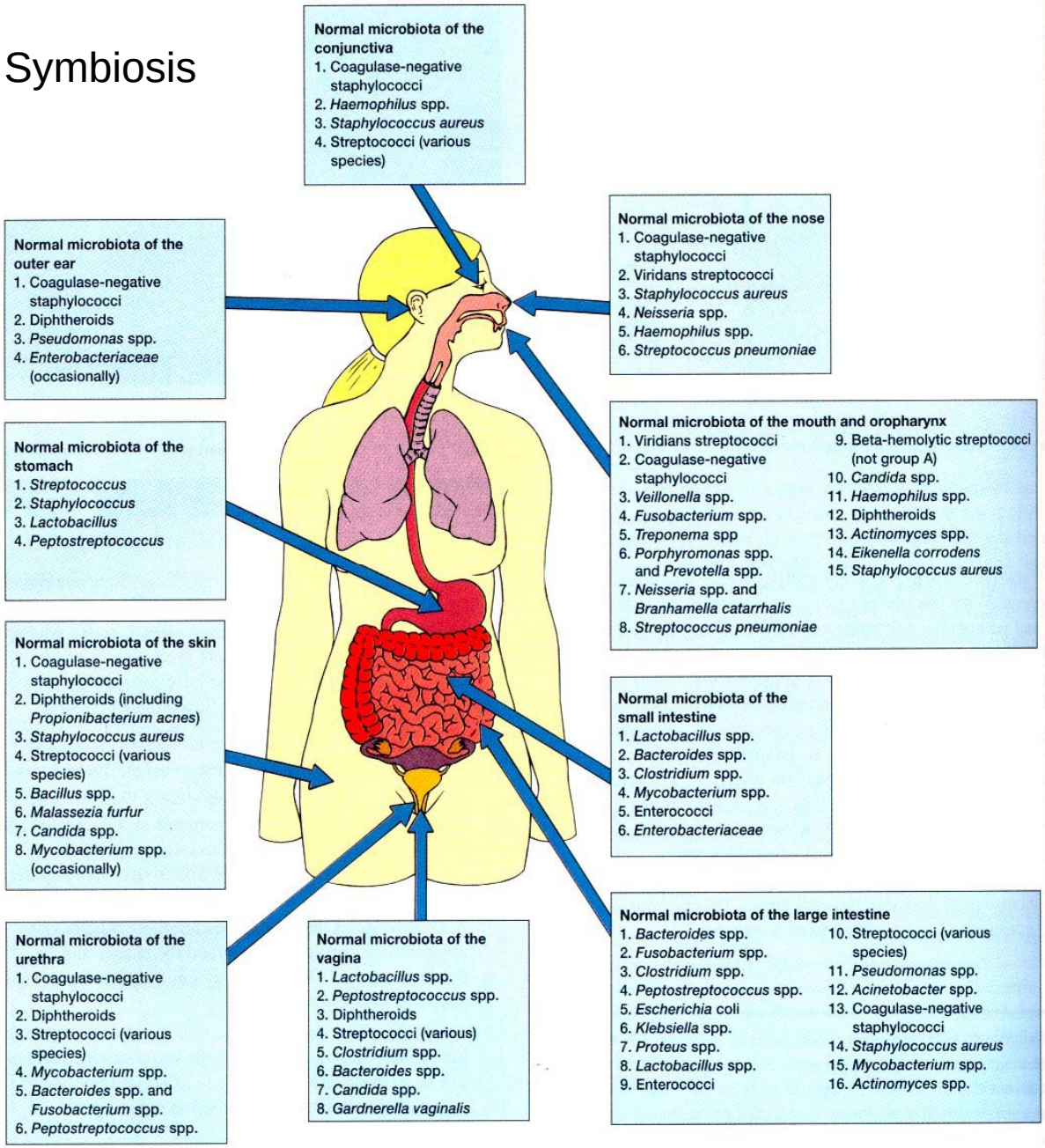
Mutualism: Both Benefit



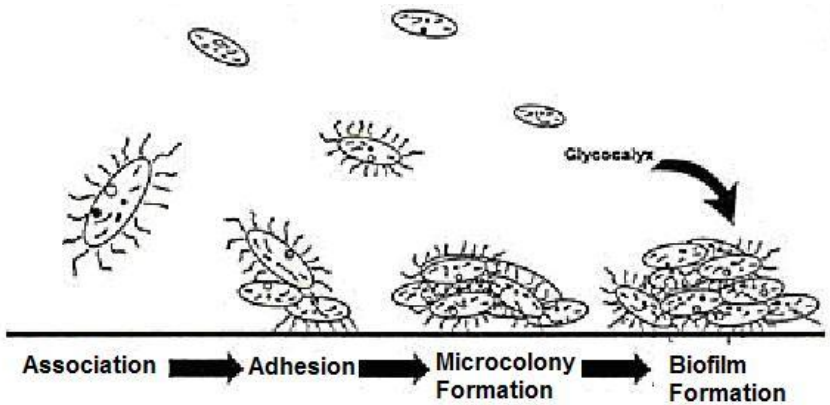


Human Eye-lash mite

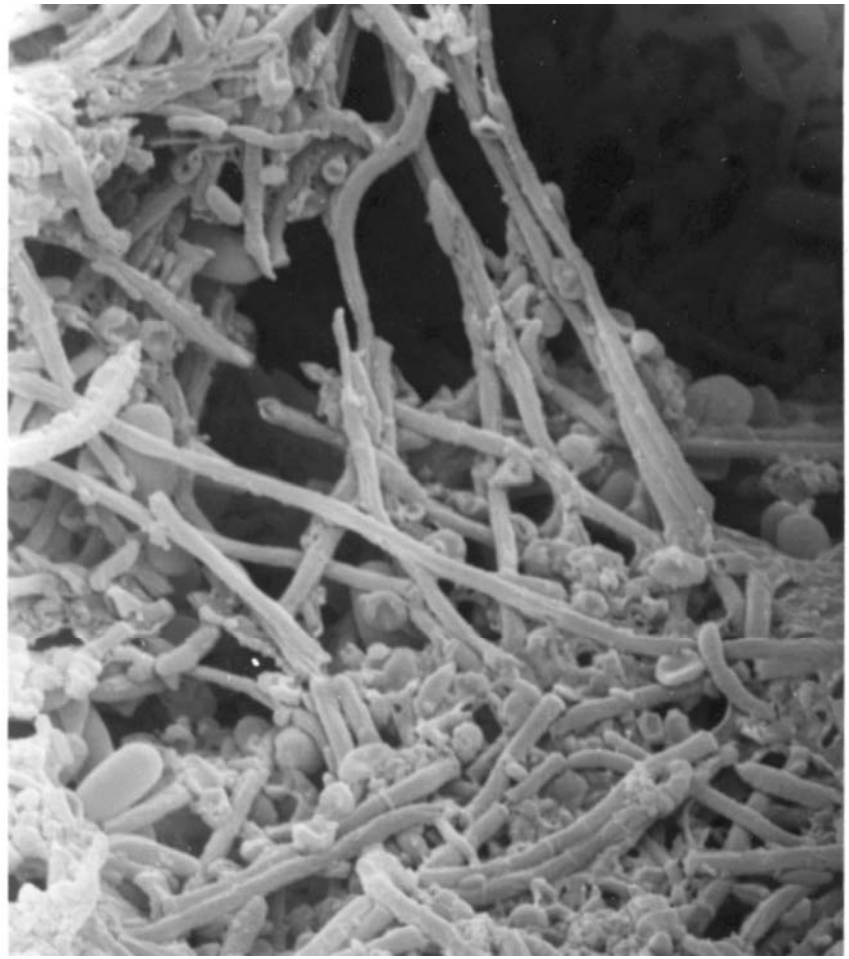
Bacterial Symbiosis



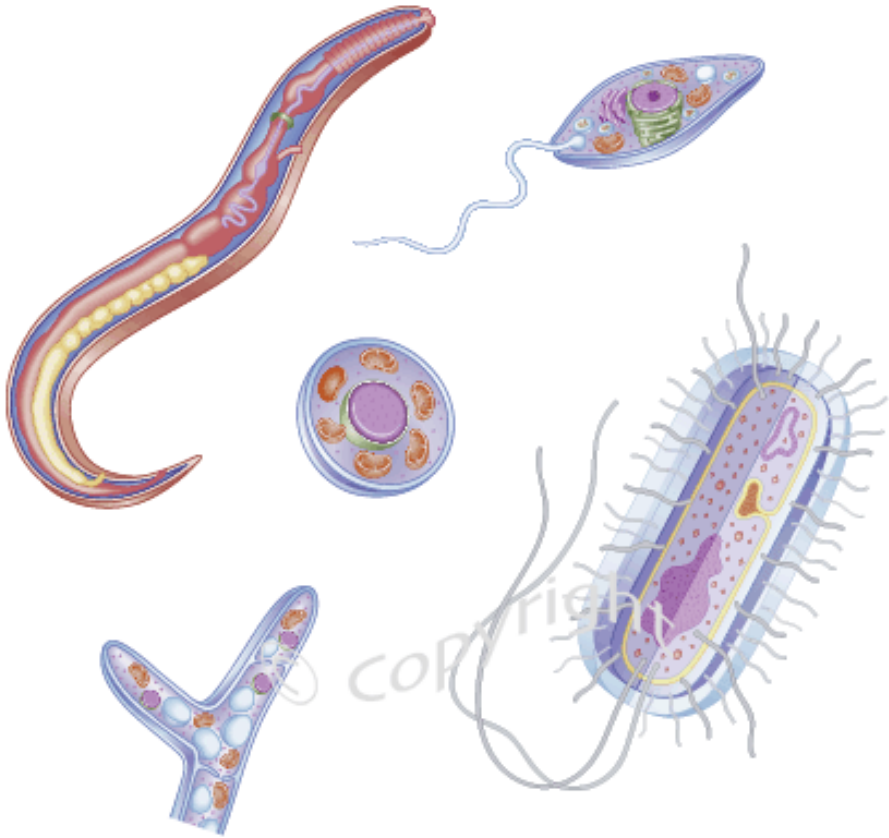
Biofilms



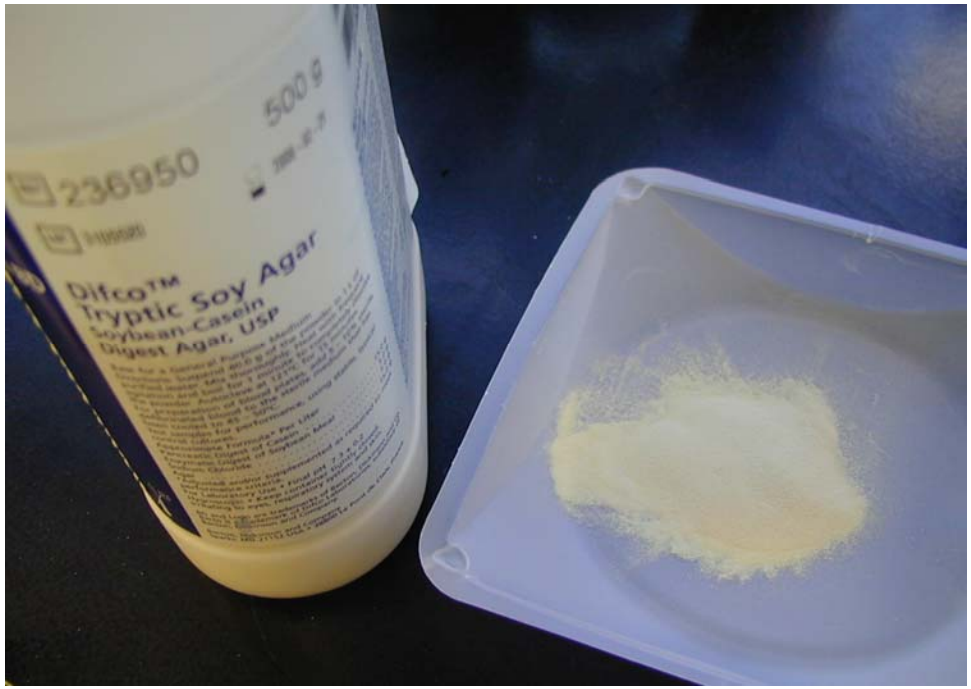
Schematic Representation of Biofilm



Parasitism

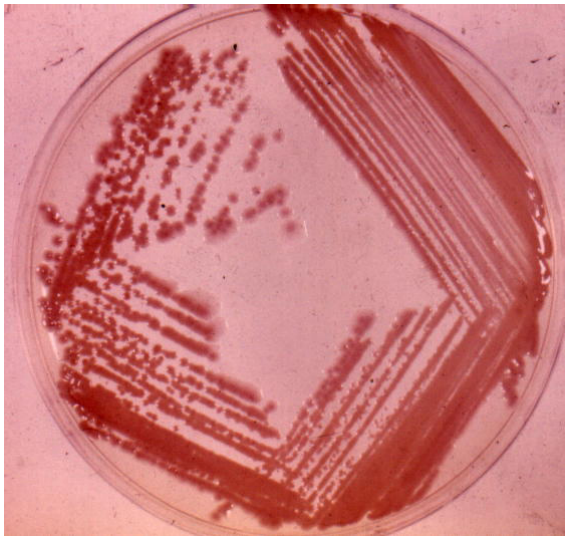


Agar


236950
500 g
Difco™
Tryptic Soy Agar
Soybean-Casein
Digest Agar, USP

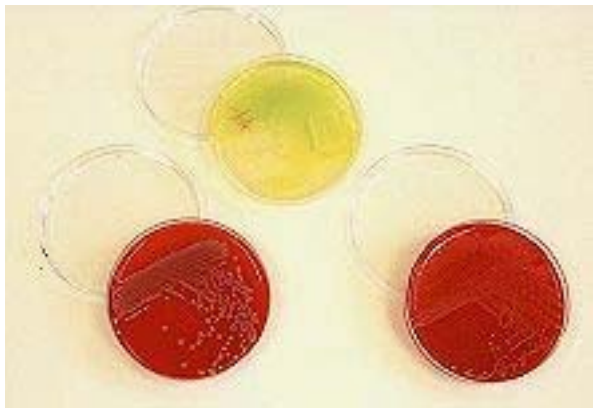

236950
500 g
Difco™
Tryptic Soy Agar
1000 mL
900
800
700
500
400
300

Culturing Organisms



- Inoculum
- Medium
- Pure Culture
- Sterile

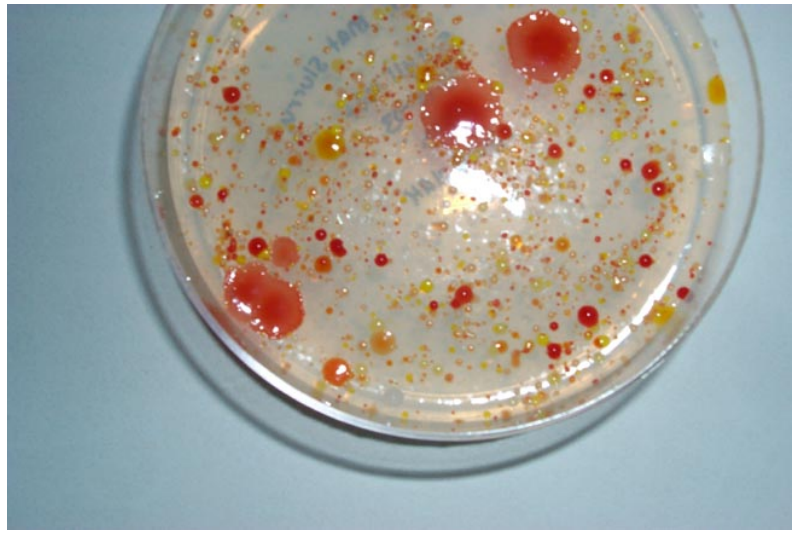
Cultivation Media

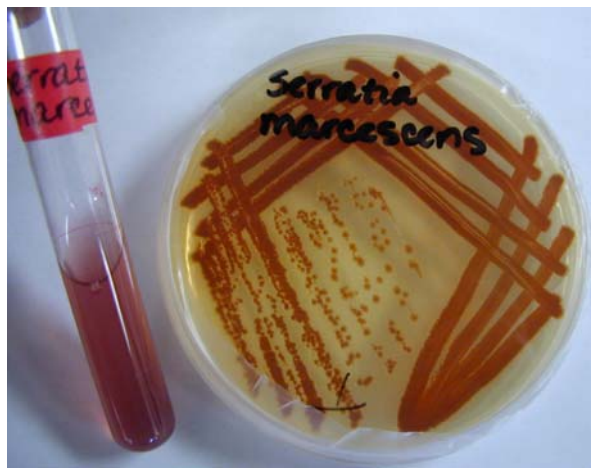


- Chemically Defined
- Complex Undefined
  - General Use
  - Enriched
  - Selective
  - Differential
  - Anaerobic

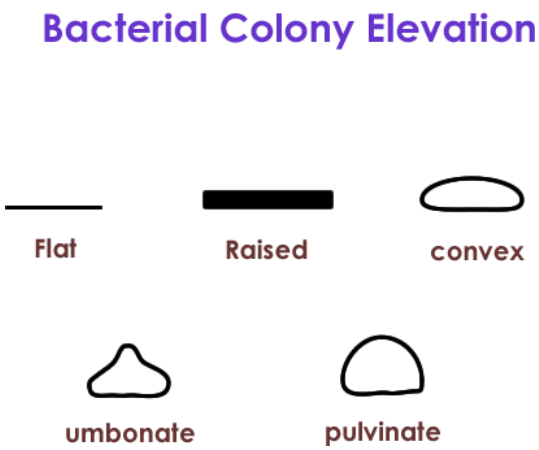
Cultural Characteristics

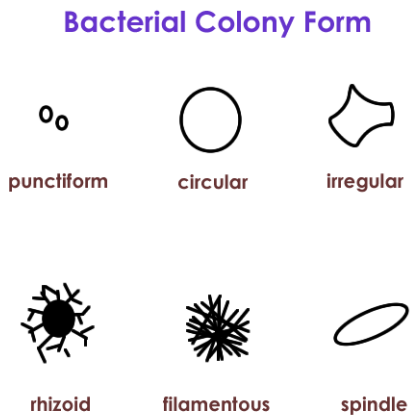
- Solid Media [Petri]
  - Color
  - Size
  - Shape
  - Elevation
  - Margin
- Broth Media
- Slant
- Gelatin Liquefaction

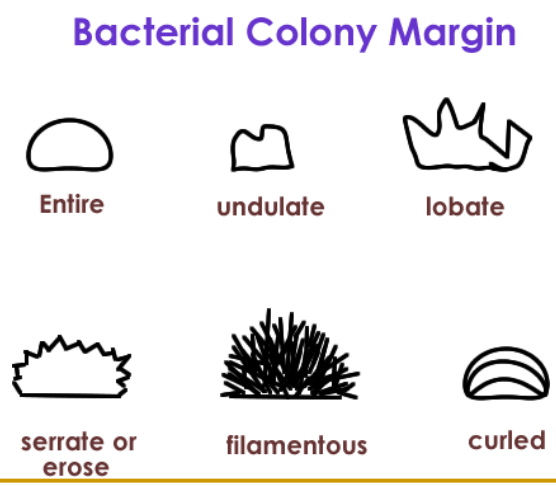




Colony Characteristics on Agar Plate

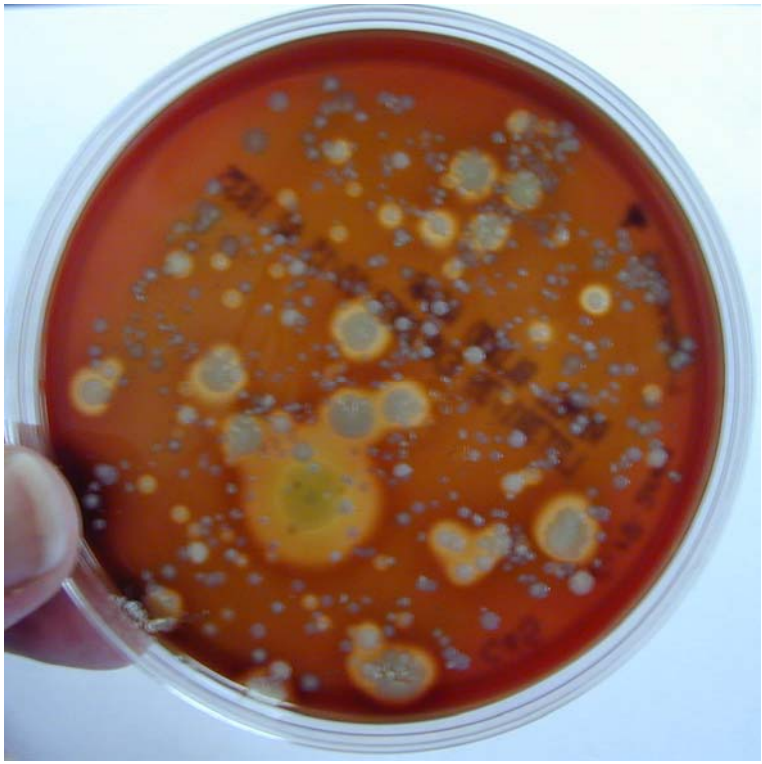






Complex General Media: Nutrient (TSA) Agar

Enriched Media

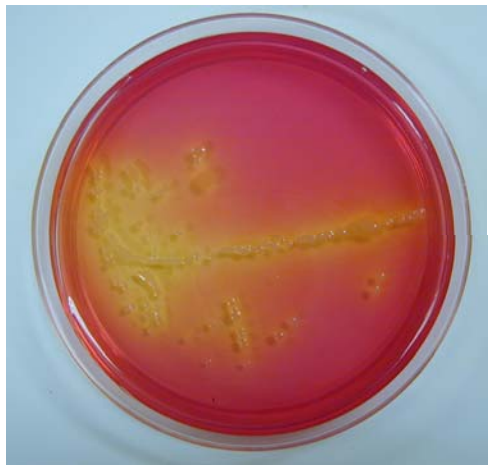


Selective and Differential Media

C-CNA

MAC

MSA



EMB

Special Media

MH-T

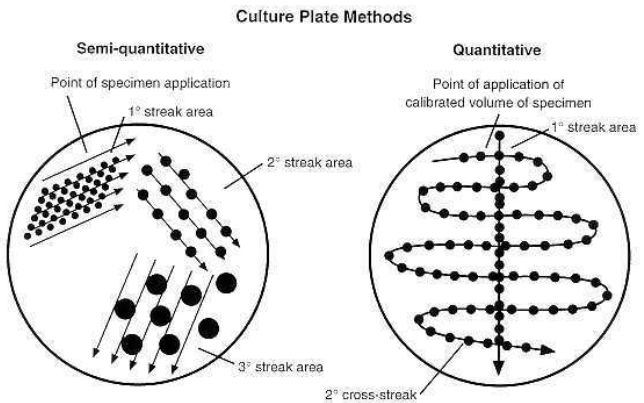
SAB

SS

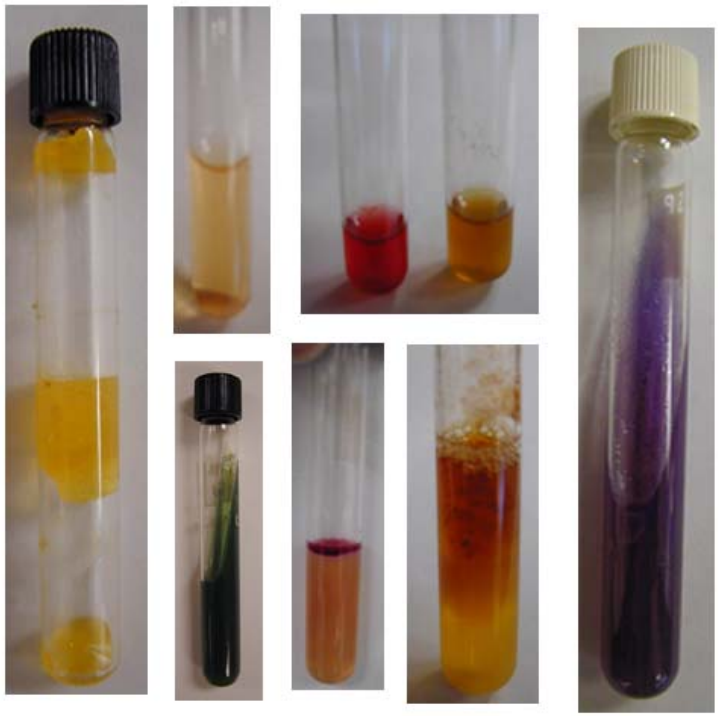
Snyder Deep

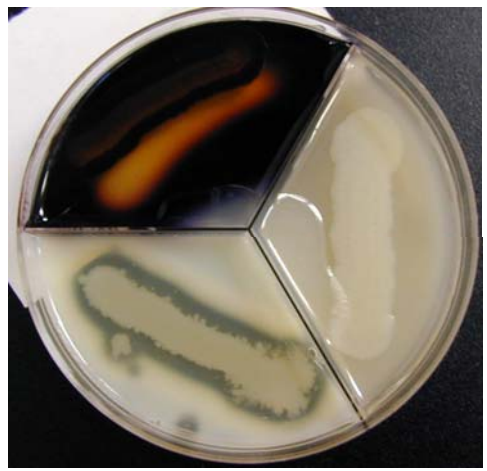
Anaerobic Culture Methods

Isolation Techniques

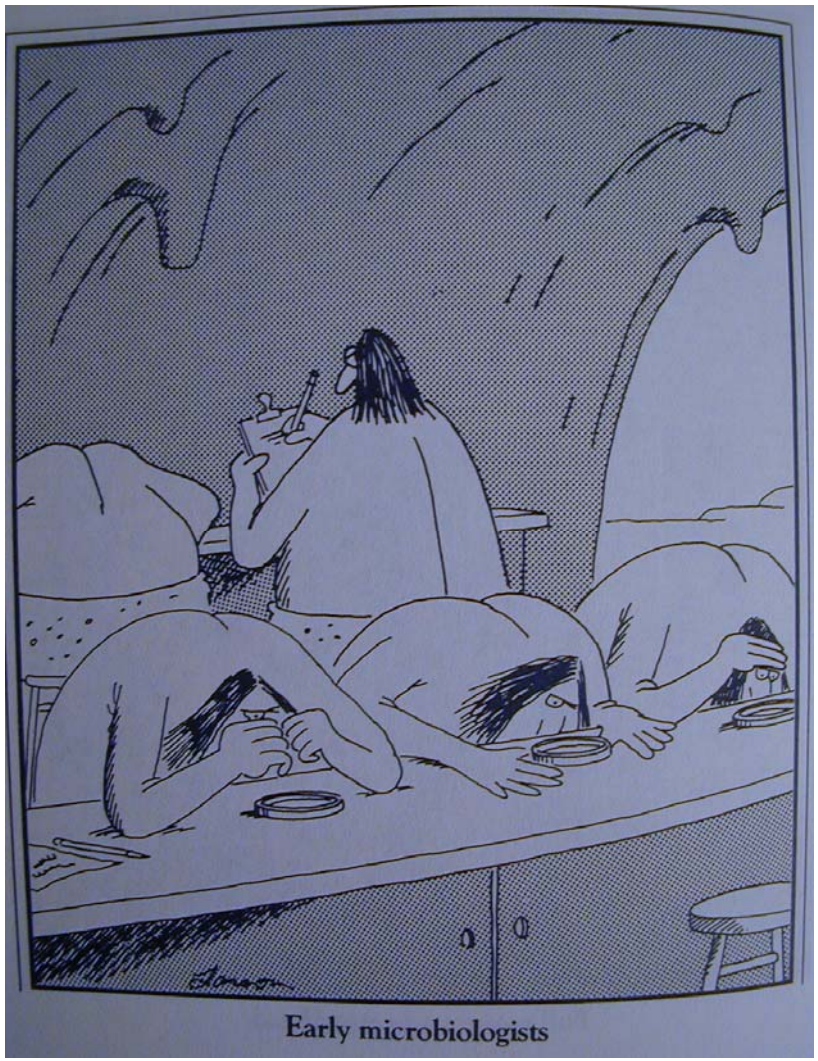


Biochemical Reactions





Questions?



Early microbiologists