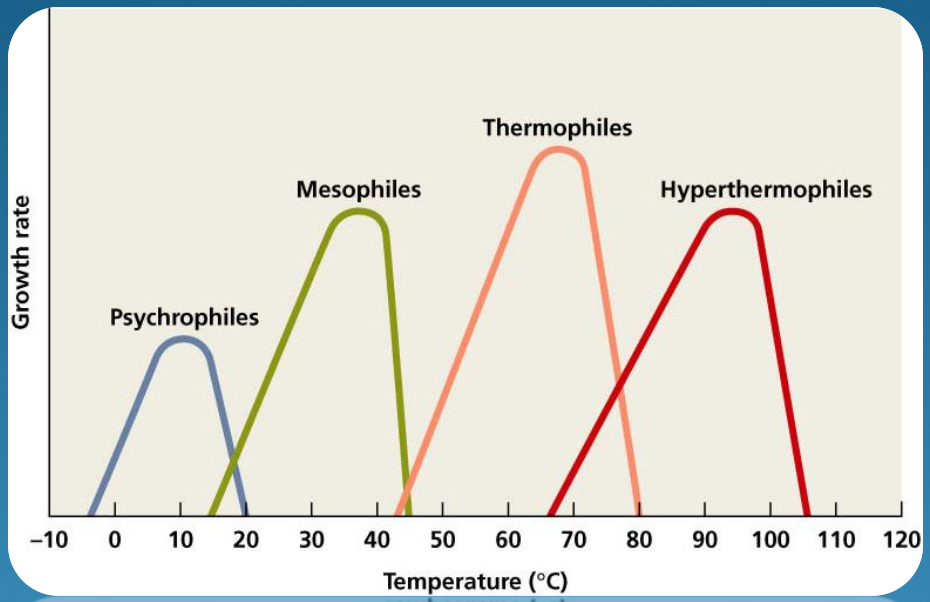

Nutritional Requirements of Bacteria

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Factors influencing microbial growth

- Nutritional requirements
- temperature
- oxygen requirements
- pH
- Osmotic Pressure

- Requirements for Growth of Bacteria
  - Chemical requirements
  - Physical requirements

1. Chemical requirements for Growth of Bacteria

Representative Functions of the Major Elements

Chemical	Function
Carbon, oxygen, and hydrogen	Component of cellular constituents including amino acids, lipids, nucleic acids, and sugars.
Nitrogen	Component of amino acids and nucleic acids.
Sulfur	Component of some amino acids.
Phosphorus	Component of nucleic acids, membrane lipids, and ATP.
Potassium, magnesium, and calcium	Required for the functioning of certain enzymes; additional functions as well.
Iron	Part of certain enzymes.

2. Physical for Growth of Bacteria

3 cardinal temperatures

- **Minimum temperature** – lowest temperature that permits a microbe's growth and metabolism
- **Maximum temperature** – highest temperature that permits a microbe's growth and metabolism
- **Optimum temperature** – promotes the fastest rate of growth and metabolism

3 Temperature adaptation groups

1. **Psychrophiles** – optimum temperature below 15^{o}C, capable of growth at 0^{o}C
2. **Mesophiles** – optimum temperature 20^{o}-40^{o}C, most human pathogens
3. **Thermophiles** – optimum temperature greater than 45^{o}C

3 temperature adaptation groups

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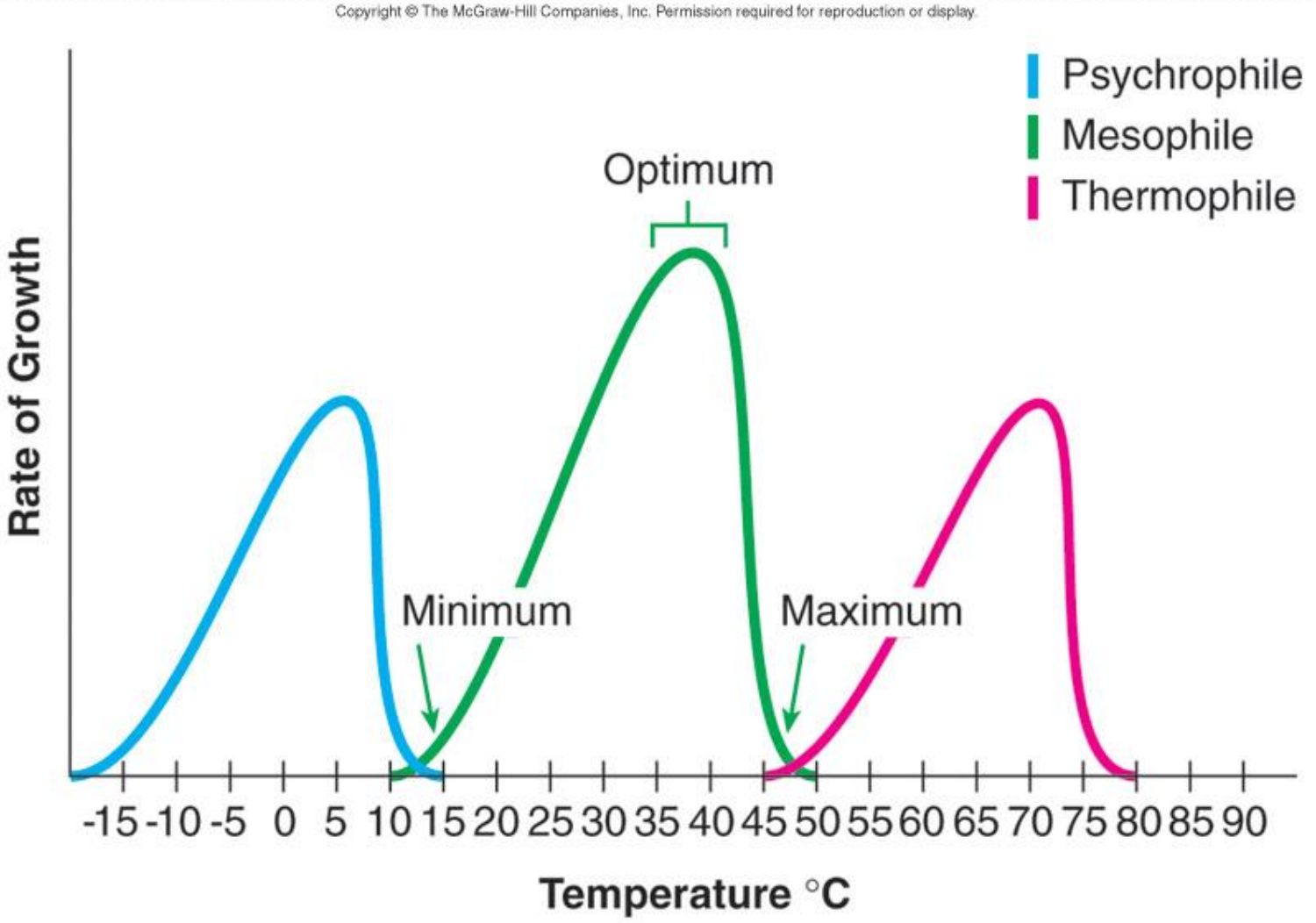

Oxygen requirements

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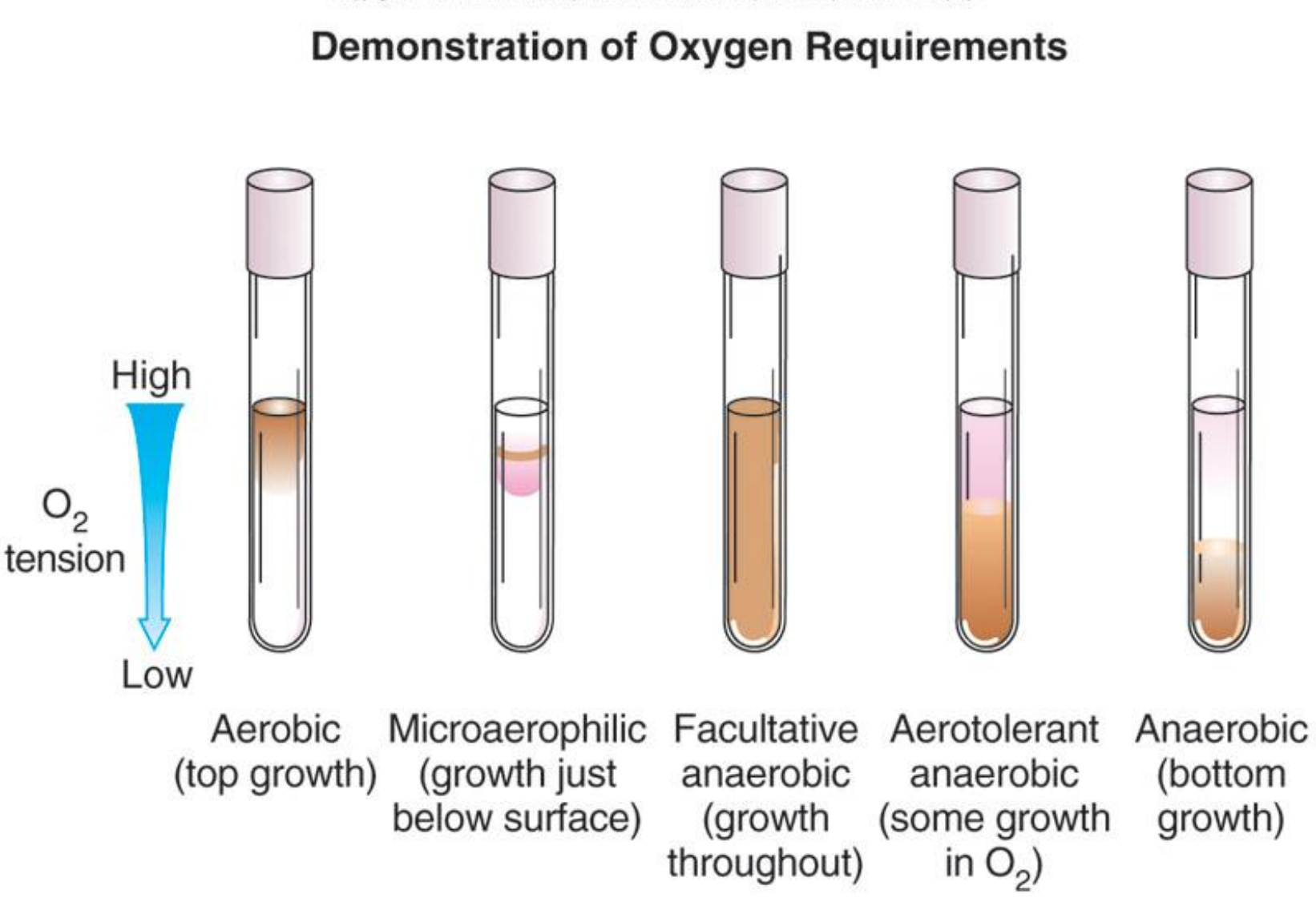

Aerobic and anaerobic bacteria can be identified by growing them in liquid culture:

1: Obligate aerobic bacteria gather at top of test tube to absorb maximal amount of oxygen.
2: Obligate anaerobic bacteria gather at bottom to avoid oxygen.
3: Facultative anaerobes gather mostly at the top, since aerobic respiration is most beneficial; but as lack of oxygen does not hurt them, they can be found all along the test tube.
4: Microaerophiles gather at upper part of test tube, not at top. Require O_2, but at low concentration.
5: Aerotolerant bacteria are not affected by oxygen, and they are evenly spread along the test tube.

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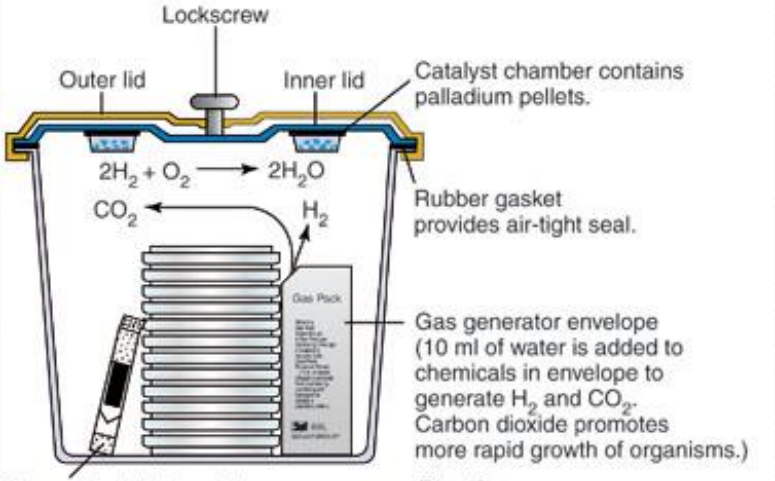
(a)



(b)

PH

- Acidophiles:
  - Grow optimally between ~pH 0 and 5.5
- Neutrophiles
  - Growoptimally between pH 5.5 and 8
- Alkalophiles
  - Grow optimally between pH 8 – 11.5

- Bacteria maintain an internal neutral pH, but may survive
- in a wide range of acidic or alkaline environments

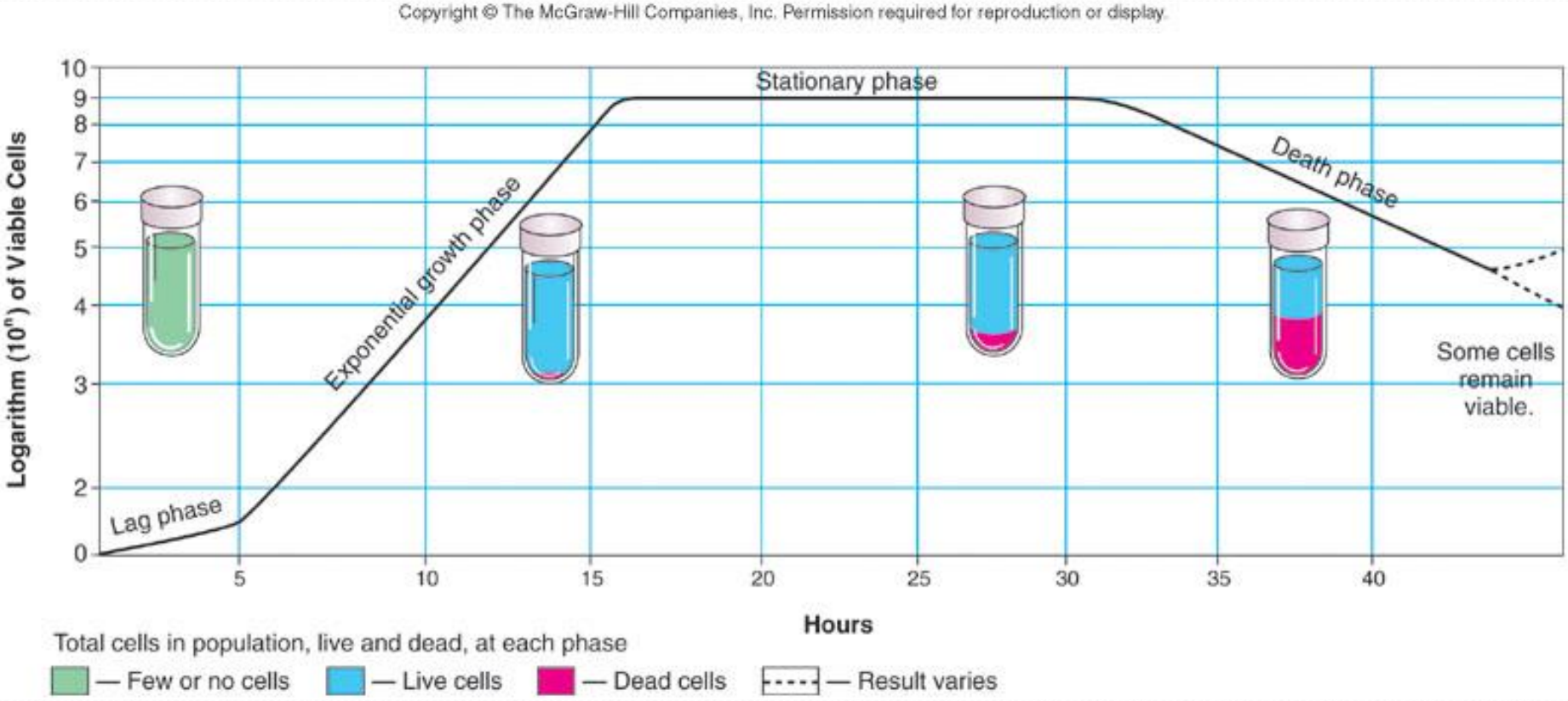
How?

- *H. pylori*- produce urease; generates ammonia and raises pH of immediate environment

Other bacteria use proton pumps

- acidophiles- out
- alkalophiles- in

Growth curve



Growth curve

1. Lag phase – "flat" period of adjustment, enlargement; little growth.

- Bacteria are first introduced into an environment or media
- Bacteria are "checking out" their surroundings
- cells are very active metabolically
- # of cells changes very little
- 1 hour to several days

2. Exponential growth phase – a period of maximum growth will continue as long as cells have adequate nutrients & a favorable environment

- Rapid cell growth
- population **doubles** every generation
- microbes are sensitive to adverse conditions
  - antibiotics
  - anti-microbial agents

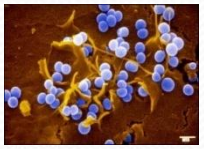
3. Stationary phase – rate of cell growth equals rate of cell death cause by depleted nutrients & O_2, excretion of organic acids & pollutants

- Death rate = rate of reproduction
- cells begin to encounter environmental stress
  - lack of nutrients
  - lack of water
  - not enough space
  - metabolic wastes
  - oxygen
  - pH
  - Endospores would form now

4. Death phase – as limiting factors intensify, cells die exponentially in their own wastes

- Death rate > rate of reproduction
- Due to limiting factors in the environment

Generation Time Under Optimal Conditions *(at 37°C)*

Organism	**Generation Time** *(min)*	
Bacillus cereus	28	
Escherichia coli	12.5	
Staphylococcus aureus	27-30	
Mycobacterium tuberculosis	792 – 932	
Treponema pallidum	1,980