



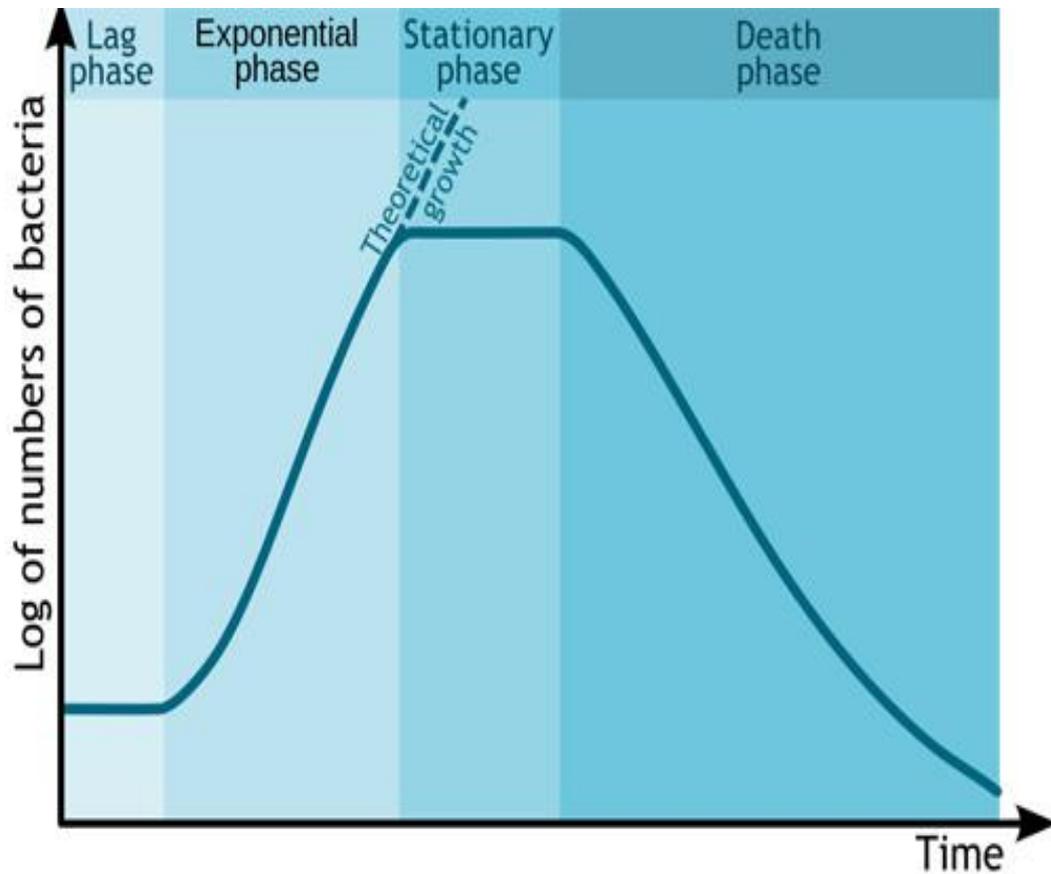
# About Science Prof Online PowerPoint Resources

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Alicia Cepaitis, MS  
Chief Creative Nerd  
Science Prof Online  
Online Education Resources, LLC  
[alicia@scienceprofonline.com](mailto:alicia@scienceprofonline.com)

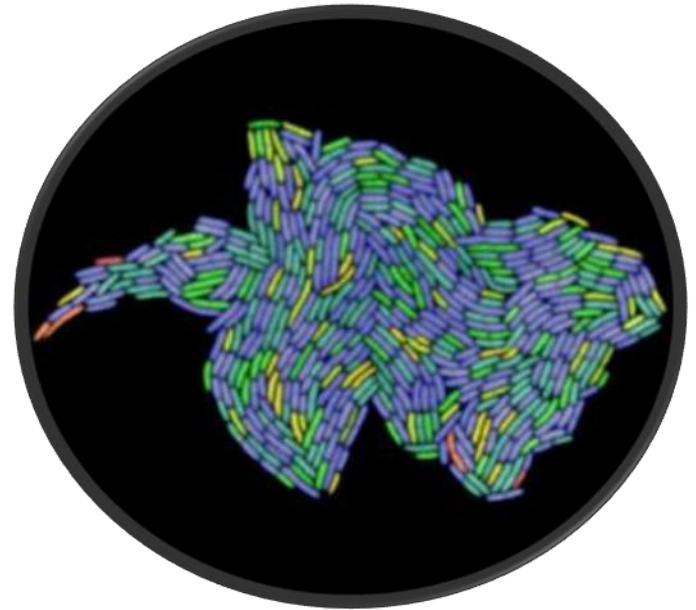
Tami Port, MS  
Creator of Science Prof Online  
Chief Executive Nerd  
Science Prof Online  
Online Education Resources, LLC  
[info@scienceprofonline.com](mailto:info@scienceprofonline.com)

# Microbial Growth



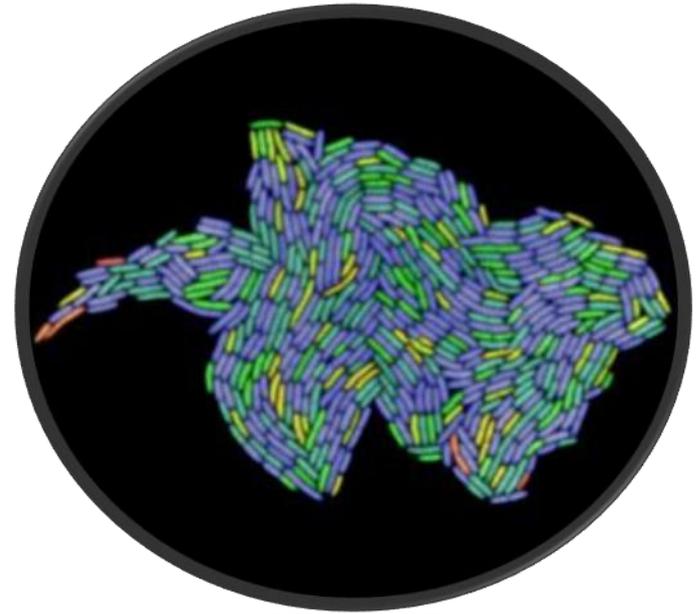
# Life & Metabolism

- All living organisms obtain \_\_\_\_\_ (\_\_\_\_\_) from their environment.
- Nutrients are needed as building materials for the cell and as a source of energy to do cellular work.
- Nutrients are metabolized (broken down) into simpler molecules and \_\_\_\_\_.



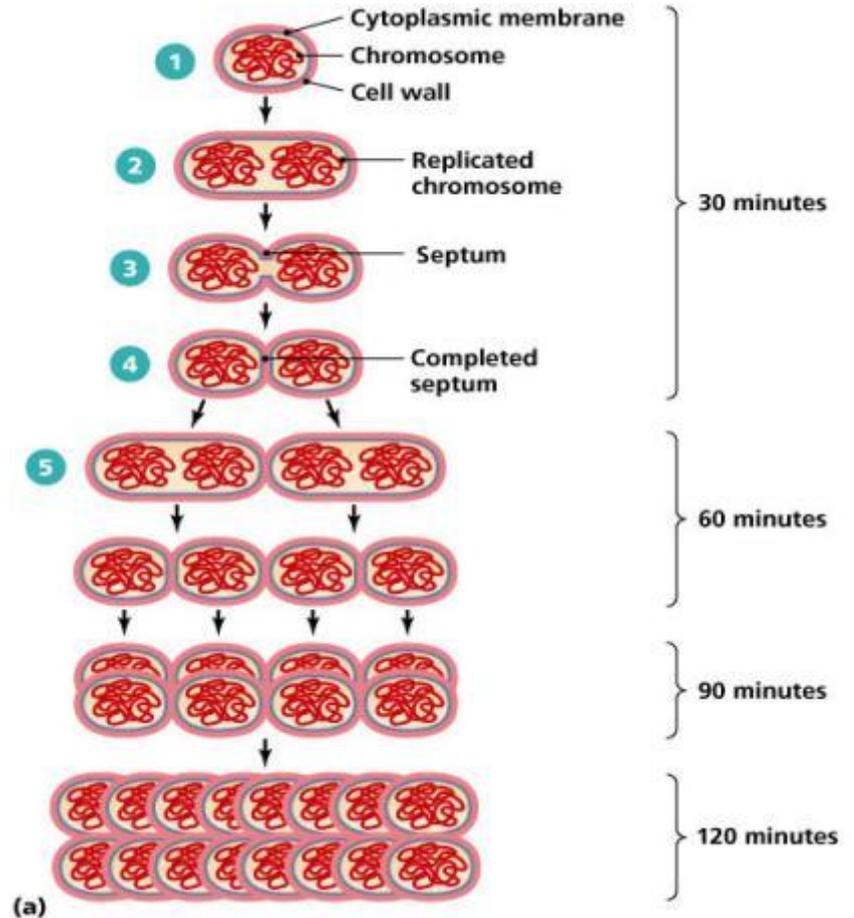
# Microbial Growth

- Refers to increase in the \_\_\_\_\_ of microbes (reproduction) rather than an increase in \_\_\_\_\_ of the microbe.
- Result of microbial growth is the \_\_\_\_\_ = aggregation of cells arising from single parent cell. →
- The time required for growth and reproduction is known as the doubling or \_\_\_\_\_.



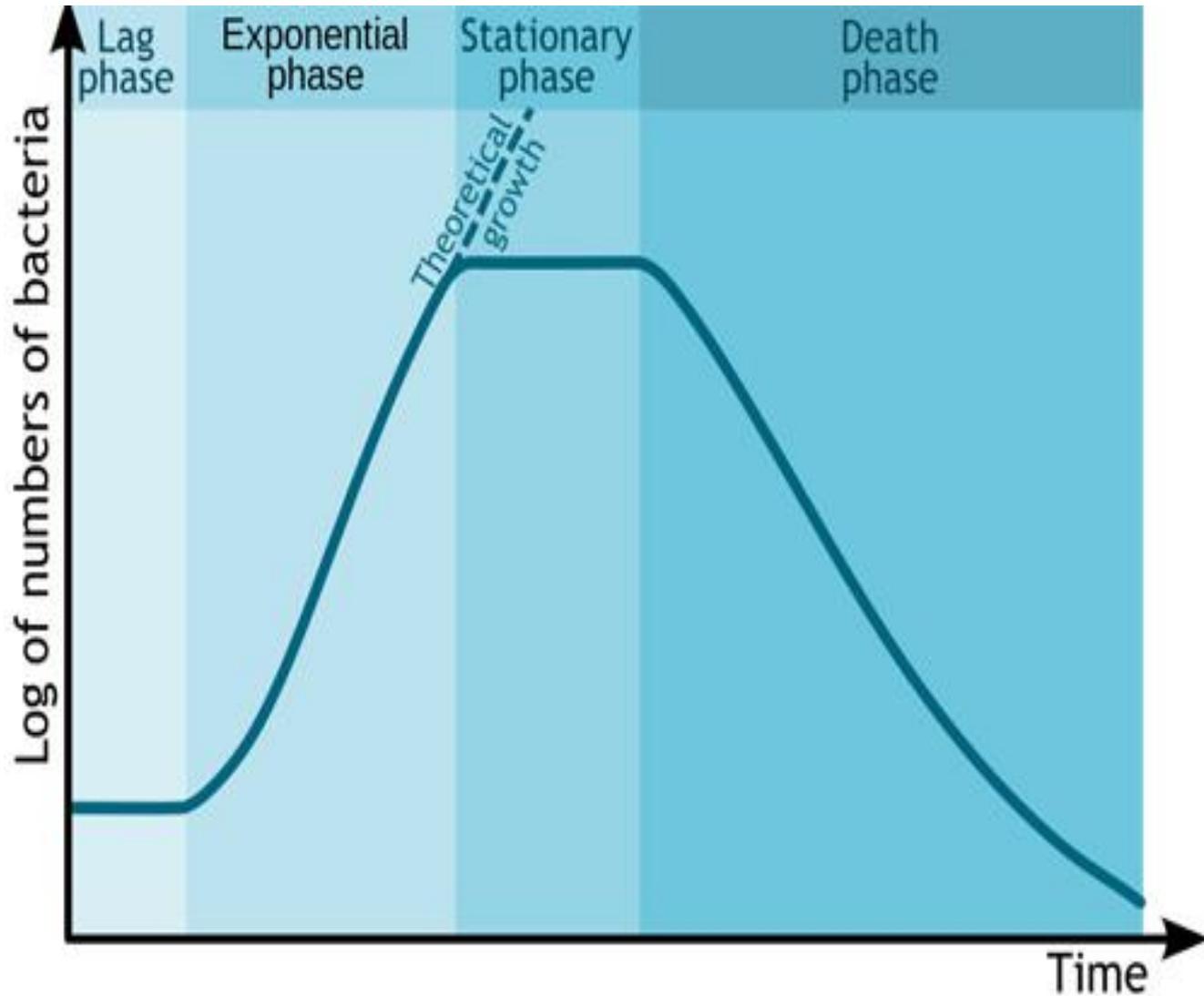
# \_\_\_\_\_ in Cell Count From Binary Fission

Generation Number	Cell Count
0	1
1	2
2	4
3	8
4	16
5	32
10	1,024
20	1,048,576



Let's watch a time lapse movie of [E. coli population growth](#).

# Bacterial Population Growth Curve



# Generation Time Under Optimal Conditions

(at 37°C)

## Organism

## Generation Time

*Bacillus cereus*

28 min



*Escherichia coli*

12.5 min



*Staphylococcus aureus* (causes many types of infections)

27-30 min



*Mycobacterium tuberculosis* (agent of Tuberculosis)

18 - 24 hrs



*Treponema pallidum* (agent of Syphilis)

30 hrs



# Mycolic Acid, Generation Time & Disease

## Meet the Microbe! \_\_\_\_\_

"GRAM-POSITIVE" Bacteria

Q: Why is "Gram-positive" in quotation marks?

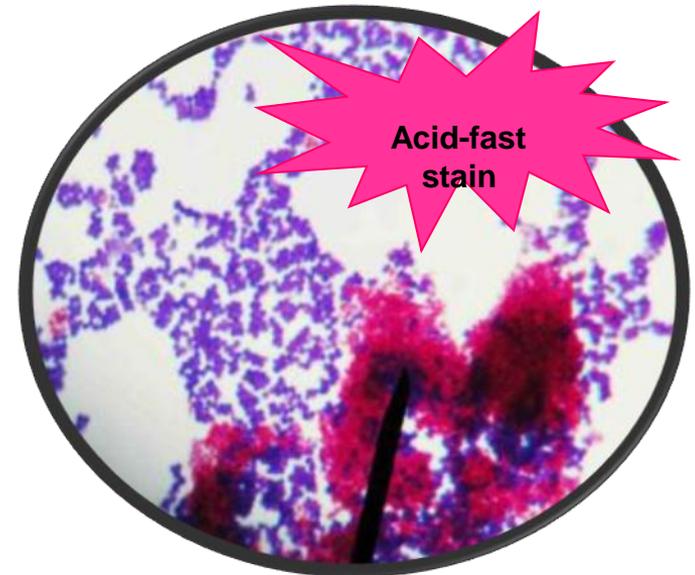
Genus of rod-shaped, acid-fast bacteria.

**Mycolic acid** in cell wall gives *Mycobacteria* many characteristics that defy medical treatment, including:

- ✓ increased resistance to chemical damage & dehydration
- ✓ allows the bacterium to grow inside macrophages, hiding it from host's immune system

*M. tuberculosis* doubles population every 18-24 hours, while *M. leprae* doubles population about every 14 days.

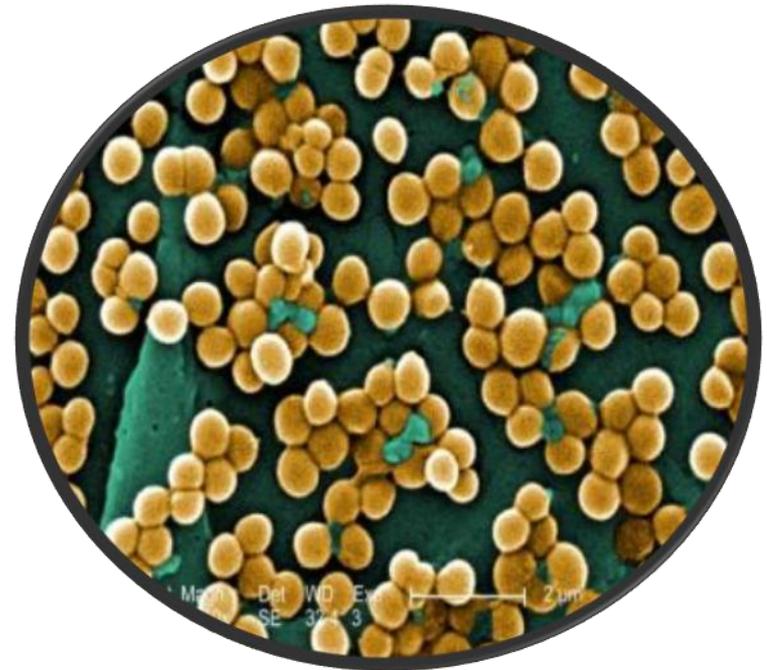
Extremely long generation time; contributes to the chronic nature of both diseases.



Images: TB Culture, [PHIL #4428](#); Acid fast stain, *Mycobacteriapink*, T. Port

# Factors Influencing Microbial Growth

- Nutrition
- Oxygen
- Temperature
- pH
- Osmotic Pressure



This scanning electron micrograph (SEM) depicts numerous clumps of methicillin-resistant *Staphylococcus aureus* bacteria, commonly referred to by the acronym, MRSA, by Janice Haney Carr, [PHIL #10046](#)

# Microbial Nutrition

- Organisms use a variety of **nutrients** for:
  - their energy needs
  - to build organic molecules & cellular structures.
- Most common nutrients contain necessary elements:
  - \_\_\_\_\_
  - **Oxygen**
  - **Nitrogen**
  - **Hydrogen**
- These 4 elements make up 95% of dry weight of bacterium.
- The other 5% is composed of Calcium, Copper, Iron, Magnesium, Manganese, Phosphorus and Iron.
- Other elements that are needed are \_\_\_\_\_.
- These elements are needed in extremely small amounts, can be obtained through water intake.



# Microbes & Oxygen

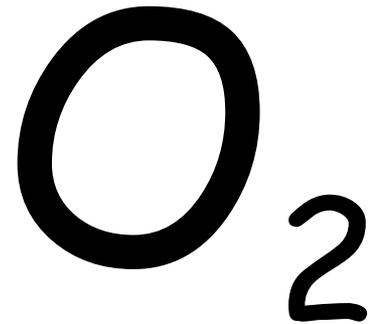
- **Obligate** \_\_\_\_\_ - Need oxygen to stay alive.  
*Aerobic respiration = Use of O<sub>2</sub> to break down food into useable energy.*

- **Obligate** \_\_\_\_\_ - Die in presence of oxygen.  
It is poisonous to them.  
*Anaerobic respiration = break down food into useable energy without the use of O<sub>2</sub>.*

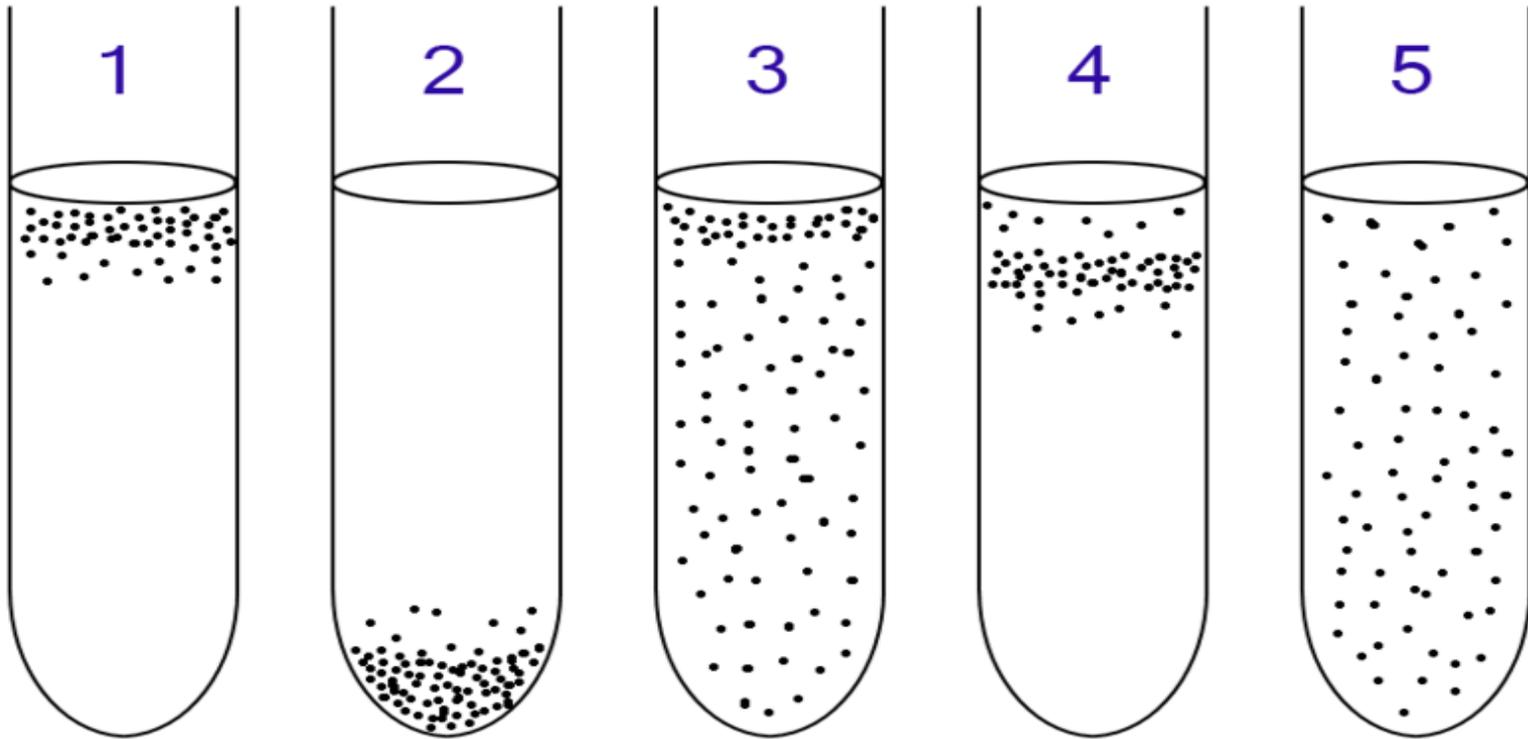
- \_\_\_\_\_ **Anaerobes** - Not strict aerobes or anaerobes.  
*Many yeasts and enteric bacteria...Escherichia coli and Staphylococcus aureus.*

- \_\_\_\_\_ **bacteria** - Require oxygen levels lower than that found under normal atmospheric conditions (*Helicobacter pylori* - found in stomach).

- \_\_\_\_\_ **Anaerobes** - Don't use oxygen, but are not killed by it.  
*(Lactobacilli - This genus will make pickles from cucumbers and cheese from milk.)*

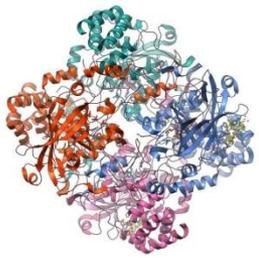


# Microbes & Oxygen

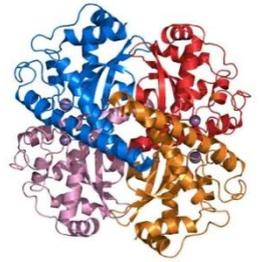


**Aerobic and anaerobic bacteria can be identified by growing them in liquid culture:**

- 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.



# Microbes & Oxygen



Using oxygen ( $1/2 O_2$ ) in metabolism creates toxic waste.

Microbes that are able to use aerobic respiration produce enzymes to detoxify oxygen:

**Catalase:**  $H_2O_2 \rightarrow H_2O \text{ and } O_2$

**Superoxide dismutase (SOD):** oxygen radical  $\rightarrow H_2O \text{ and } O_2$

Microbes that don't make these enzymes cannot exist in the presence of oxygen.

# Meet the Microbe! *Campylobacter jejuni*

Gram negative, spiral-shaped rod.

Have flagella, are motile.

Close relative of *Helicobacter*.

**Microaerophilic** bacterium.

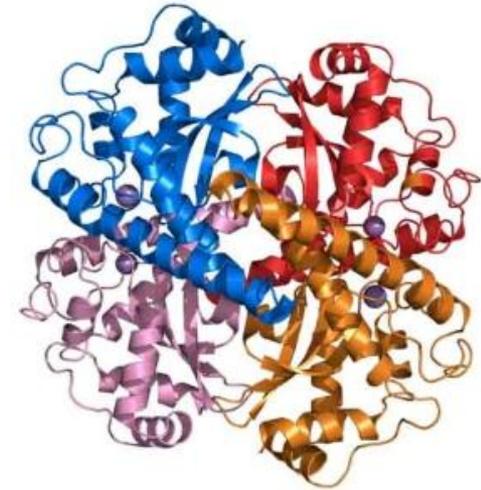
- Campylobacter infections are \_\_\_\_\_.  
Commonly found in animal feces. We catch this from animals, particularly birds.
- Causes "food poisoning". One of the most common causes of human gastroenteritis in the world.
- 2 - 4 million cases in US per year, peaking in summer months. Usually not life-threatening. Resolves within 24 hours - one week.
- Problem with *C. jejuni* being antibiotic resistant, because we put antibiotics in animal feed.





# Microbes & Temperature

- 
- Three-dimensional shape because of the temperature sensitive hydrogen bonds.
  - These bonds will usually break at higher temperatures, and protein become \_\_\_\_\_.
  - Denatured proteins lose function.



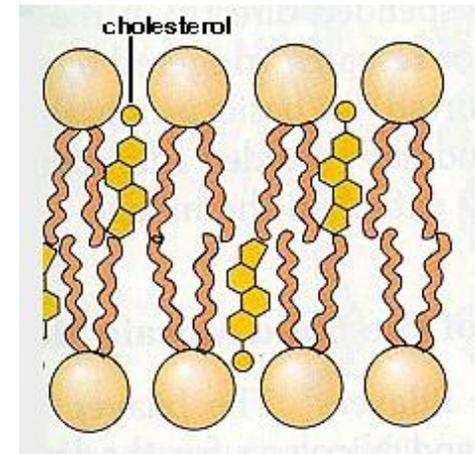
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Also temperature sensitive.

Become **brittle** if temperature is too low.

If temperature too high, lipids will be more **liquid** in form.

Outside membrane cannot preserve the integrity of the cell and it will disintegrate.



# Effects of Temperature on Growth



5°C

40°F



25°C

77°F



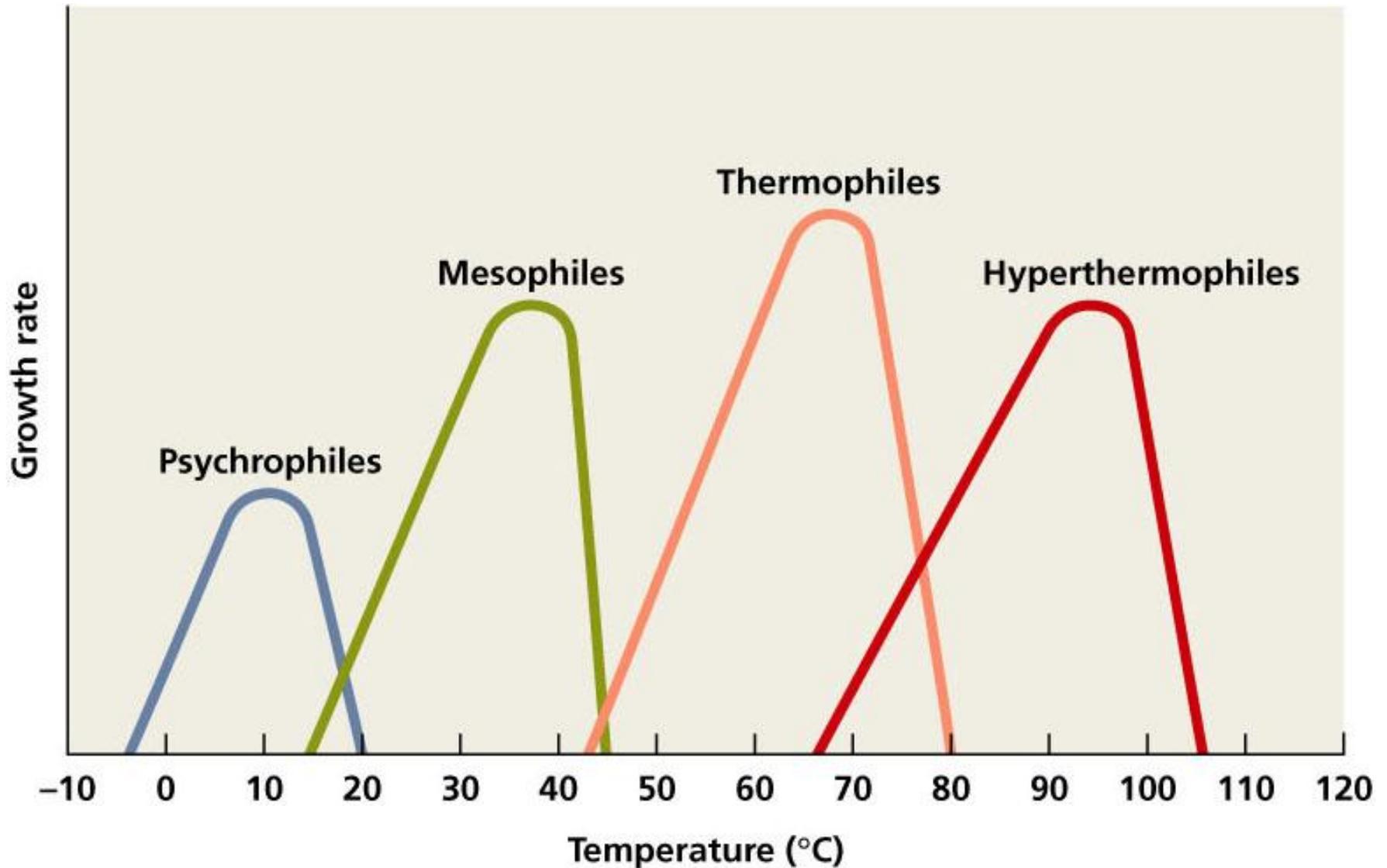
35°C

95°F

Most of our plates are incubated at 37°C (98.6°F).

Conversion C to F =  $1.8 \times C + 32$

# Categories of Microbes Based on Temperature Range



# Meet the Microbe!

Psychrophilic \_\_\_\_\_: *Chlamydomonas nivalis*

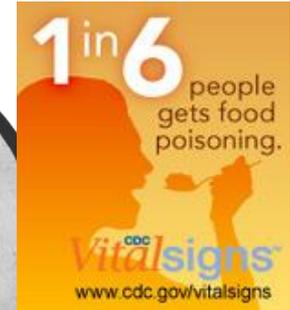
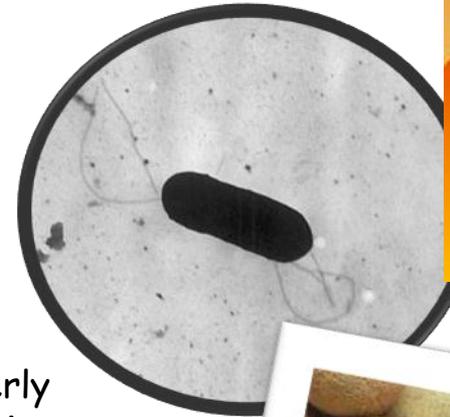


# Meet the Microbe! *Listeria monocytogenes*

Gram positive, rod-shaped \_\_\_\_\_.

- *L. monocytogenes* is widely distributed; found in soil, water, animals, birds, insects.
- Responsible for disease listeriosis.
- Rarely pathogenic in healthy adults (mild flu-like symptoms).
- Can be lethal in pregnant women, fetuses, newborns, elderly and immune compromised, causing meningitis or bacteremia.
- Transmitted from environment (contaminated food and water) to human, except in the case of pregnant woman passing on to fetus.
- In vulnerable populations can have a case fatality rate of 25%.
- Facultative intracellular pathogen. Triggers its own phagocytosis.
- *Listeria* are very hardy. Can grow in temperatures ranging from 39°F (refrigerator) to 99°F.

**Q:** What microbes have we discussed in previous lecture that are at the other end of the temperature spectrum?



## CDC Investigation Announcement:

As of October 6, 2011, a total of 109 persons infected with outbreak-associated strains of *Listeria monocytogenes* have been reported from 24 states. All illnesses started on or after July 31, 2011.

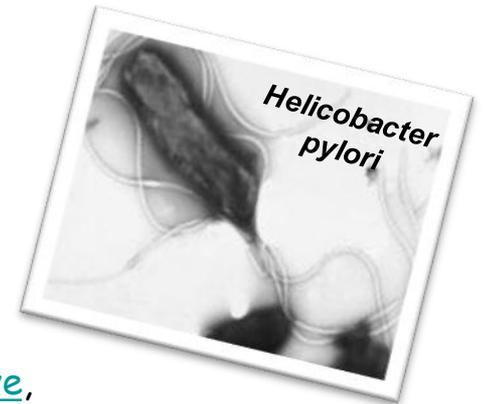
Twenty-one deaths have been reported: One woman pregnant at the time of illness had a miscarriage.

# Microbes & pH

As with temperature, bacteria have minimum, optimum and maximum pH ranges.

- 
- **Protozoans and most bacteria** have an optimum pH range of 6.5 to 7.5.
  - pH range of human organs and tissues.
- 
- **Most fungi & some bacteria** grow best in acid niches.
  - **Obligate acidophiles** have to live in an acidic environment.
  - **Acid-tolerant Microbes** will survive in an acid environment, but do not prefer that.

## Meet the Microbe!

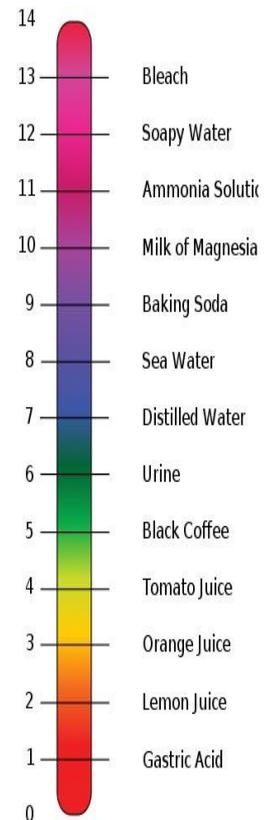


- Gram-negative, microaerophilic, and acidophilic bacterium.

- Can thrive in the stomach and upper small intestines and cause ulcers.

- However, many who are infected do not show any symptoms.

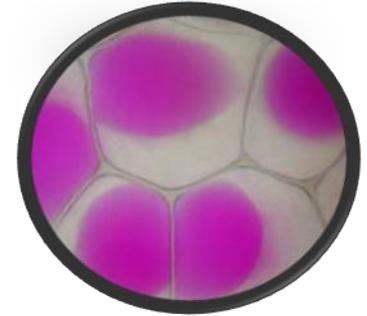
- *Helicobacter spp.* only known microorganisms to thrive in highly acidic environment of stomach.





# Microbes & Water: Osmotic Pressure

- H<sub>2</sub>O important reactant in many metabolic reactions.
- Most cells die in absence of water.
  - Some have cell walls that retain water.  
*Q: What genus comes to mind?*
  - Endospores and cysts can cease most metabolic activity for years.  
*Q: What organisms make endospores? Which make cysts?*
- Cell walls of bacteria prevent them from exploding in a **hypotonic** environment, but most bacteria are vulnerable in **hypertonic** environments.
- Many bacteria can be plasmolyzed by high concentrations of solutes.
- The water moves out of the bacterium and it dies of 'hyperosmotic shock' (desiccation).



*Q: Why can you keep honey on the cupboard for months, even years, without it spoiling?*



# Glycocalyx & Osmotic Pressure

## Obligate \_\_\_\_\_

- Must live in a niche of high salt content.
- Can grow in an environment up to 30% salt.
- If placed within a freshwater environment, they will burst and die.

## \_\_\_\_\_ Halophiles

- Can survive and tolerate high salt niches, but do not require them to living.

Some bacteria have an additional layer outside of the cell wall called the **glycocalyx**.

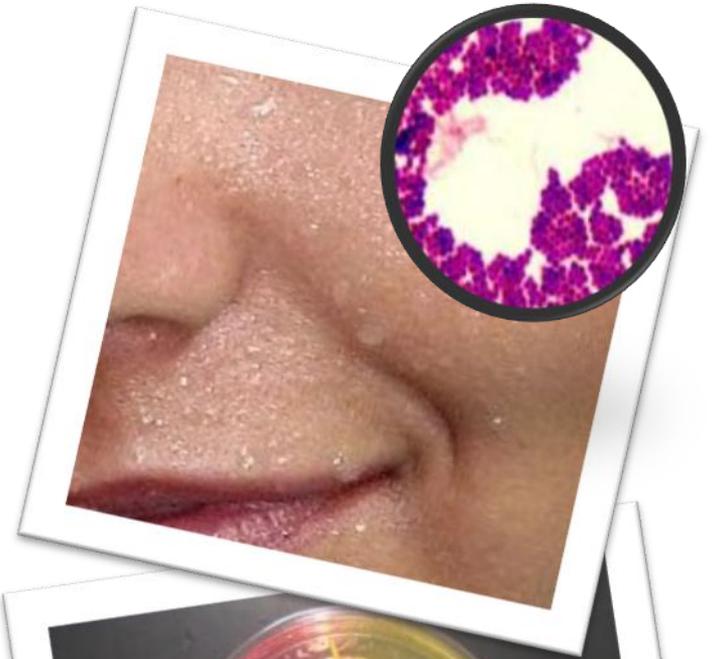
One type of glycocalyx is called a \_\_\_\_\_

glycoproteins loosely associated with the cell wall.

- cause bacteria to adhere to solid surfaces and help prevent the cell from drying out

## Meet the Microbe!

The slime layer of *Staphylococcus epidermidis* allows it to grow on the salty environment of the skin.



# Confused?

Here are links to fun resources that further explain cellular respiration:

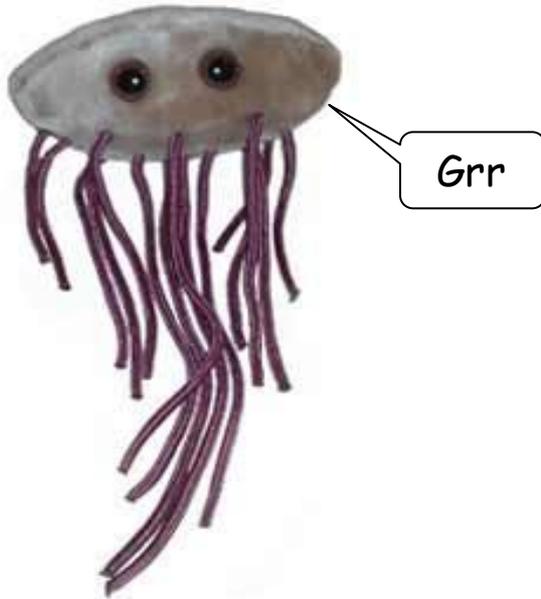
- [Microbial Growth Main Page](#) on the Virtual Cell Biology Classroom of [Science Prof Online](#).
- "[Germs](#)". Music by Weird Al Yankovic. Video by RevLucio.
- [E. coli population growth](#) time lapse video.
- **Diffusion, Osmosis & Active Transport Main Page**, Virtual Cell Biology Classroom of [Science Prof Online](#) website.
- [Bacterial growth](#) video and narration, YouTube, Dizzo95.
- "[The Osmosis Song](#)" music video by Duanie Films.
- [Osmosis Demonstration](#) with raw egg by thsharpe.
- "[Osmosis Jones](#)" movie trailer. If you haven't seen this yet, you must watch it immediately! It's awesome!

# Smart Links



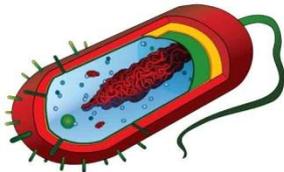
# Are microbes intimidating you?

*Do yourself a favor. Use the...*



## Virtual Microbiology Classroom (VMC) !

The VMC is full of resources to help you succeed,  
including:



- practice test questions
- review questions
- study guides and learning objectives

You can access the VMC by going to the Science Prof Online website

[www.ScienceProfOnline.com](http://www.ScienceProfOnline.com)