SCIENCE OF SAFE FOOD

Special Processes for Food Service

October 16, 2017

Lincoln Lancaster County Health Department

University of Nebraska–Lincoln

FOOD FROM THOUGHT

THE FOOD PROCESSING CENTER

INFUSE

Introduction to Food Microbiology

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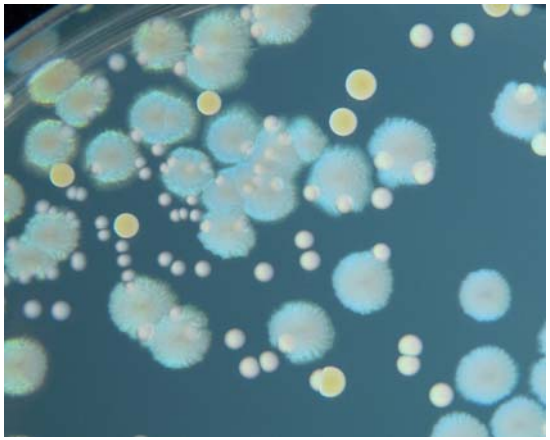
Microorganisms and Foods

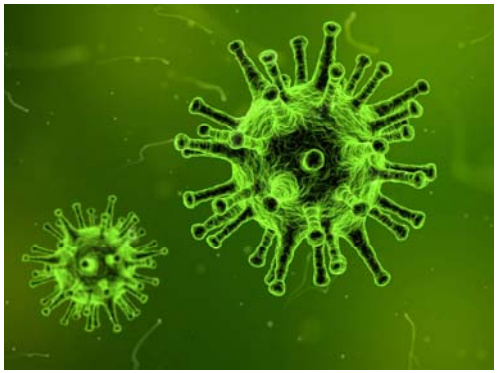
Raw foods normally contain microorganisms!!!

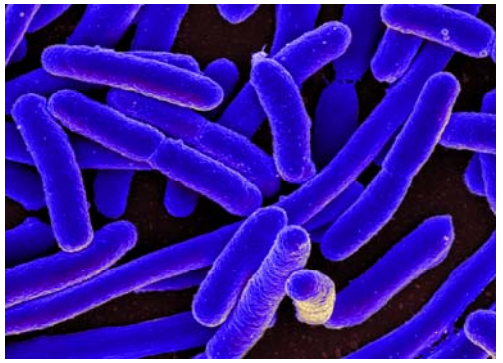
Microorganisms and Foods

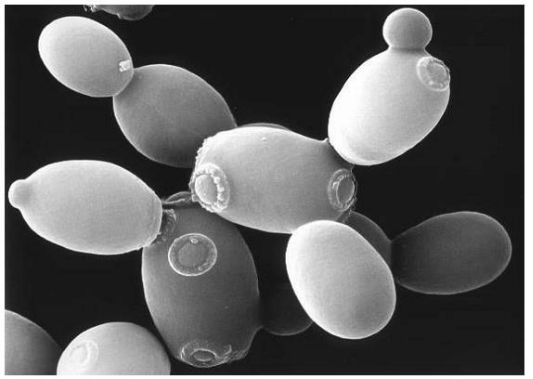
Microorganisms of concern include:

- Molds
- Yeast
- Bacteria
- Viruses









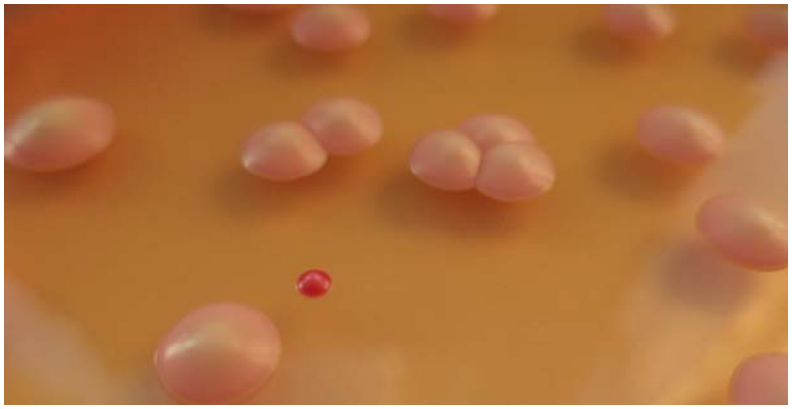
Source: mpg.de

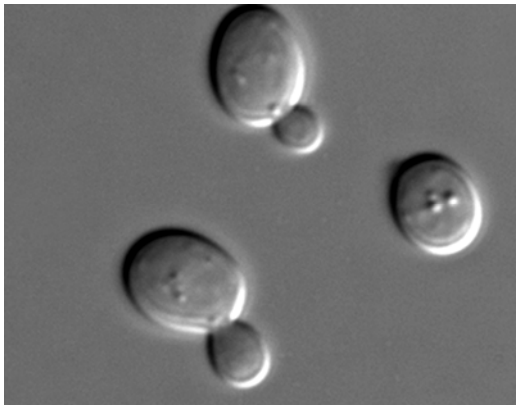
Molds

- Multicellular, tubular filaments
- Reproduce by fruiting bodies (spores)
- Larger than bacteria and yeasts
- Widely distributed in nature (soil, air)
- Survive on many substances
- Given right conditions will grow on almost any food
- More tolerant to cold than heat

Yeasts

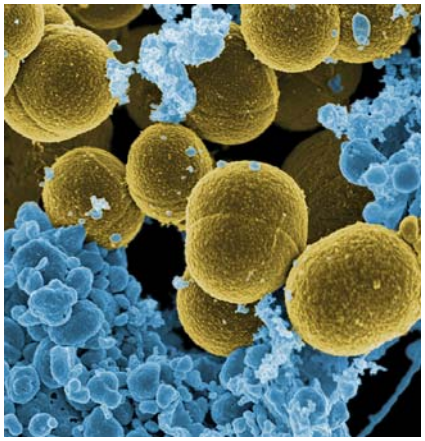
- Unicellular, usually egg-shaped
- Smaller than molds, larger than bacteria
- Reproduction by budding
- Widely found in nature
- Associated with liquid foods with sugar and acid





Bacteria

- Most important and troublesome
- May produce and release enzymes or toxins into the foods
- Single cell, microscopic
- Several shapes and forms



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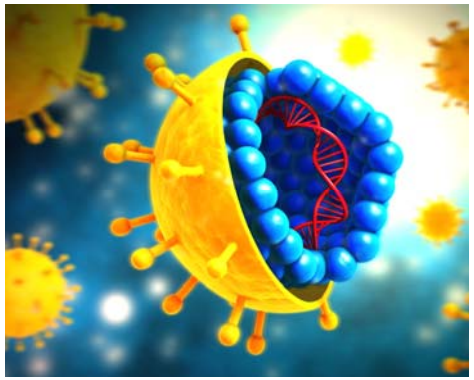
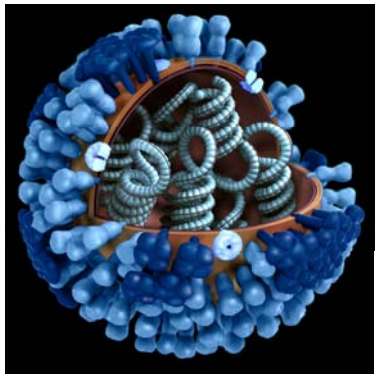
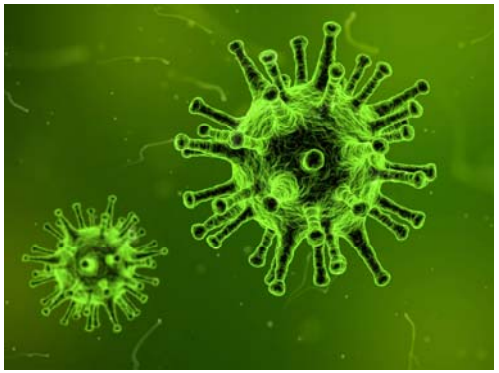
Viruses

- Small infectious agent that replicates only inside of living cells
- While not inside a cell, it exists as a viral particle (virions):
  - Genetic material
  - Protein coat
  - Envelope of lipids, in some cases
- A virion is 1/100 the size of a bacterium

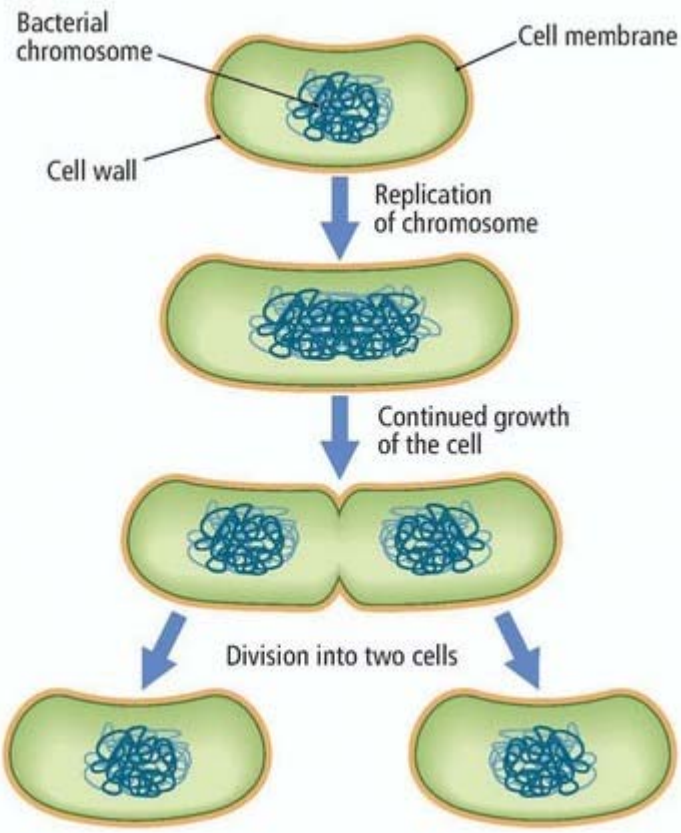






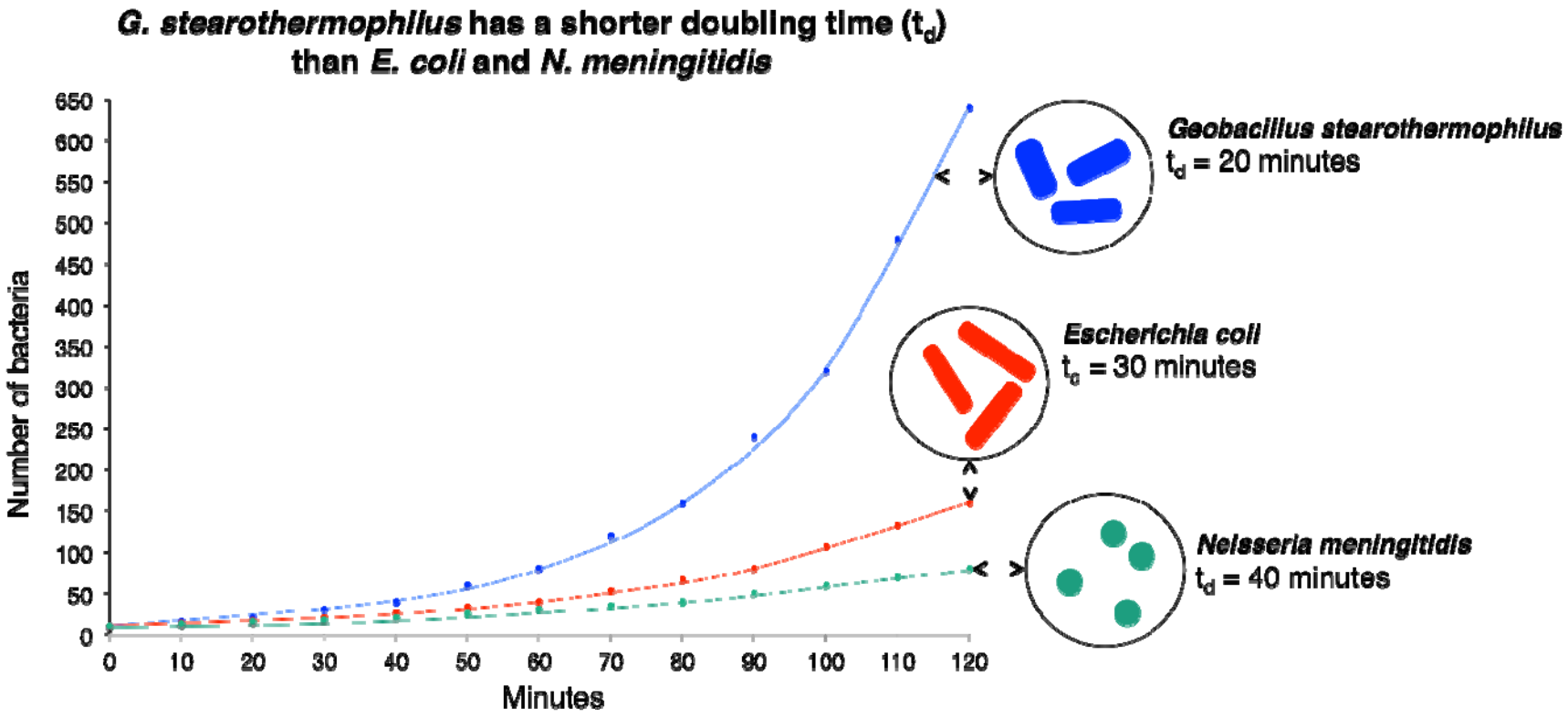
Reproduction of Bacterial Cells

- Reproduction by division (fission)
- Referred as “growth”
- Under optimum conditions a cell divides every 20-30 minutes



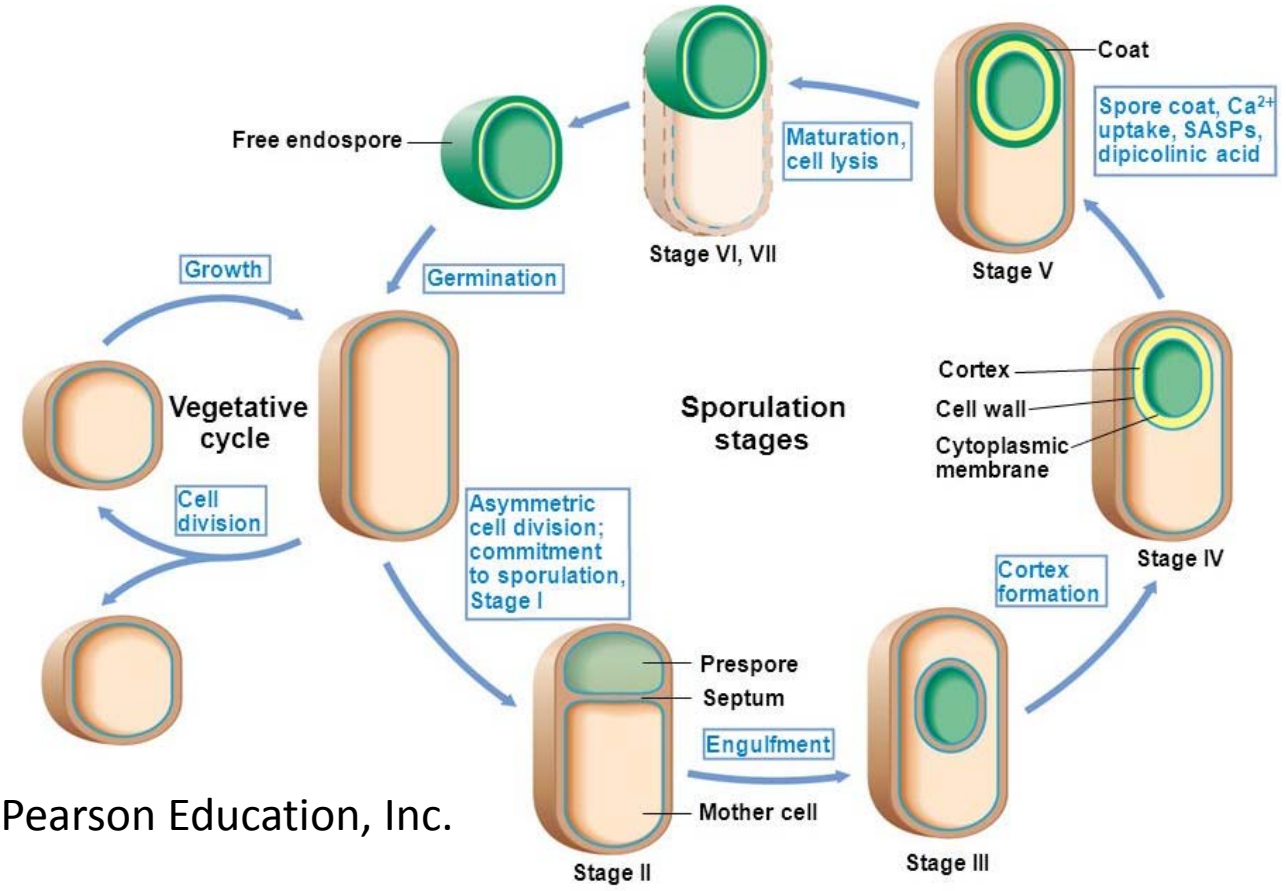
http://www.leavingcertbiology.net

Reproduction of Bacterial Cells

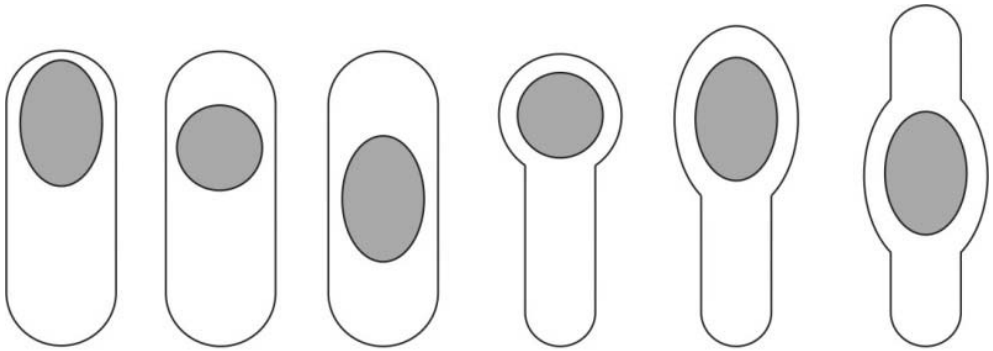


Sporeforming Bacteria

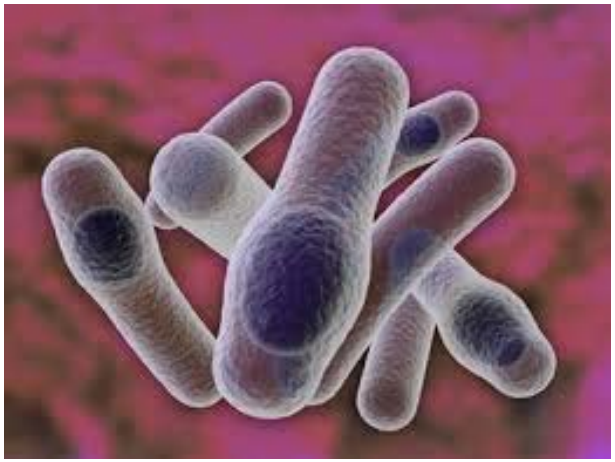
- Bacterial spores are resistant to heat, cold and chemical agents
- Vegetative cells are less heat resistant



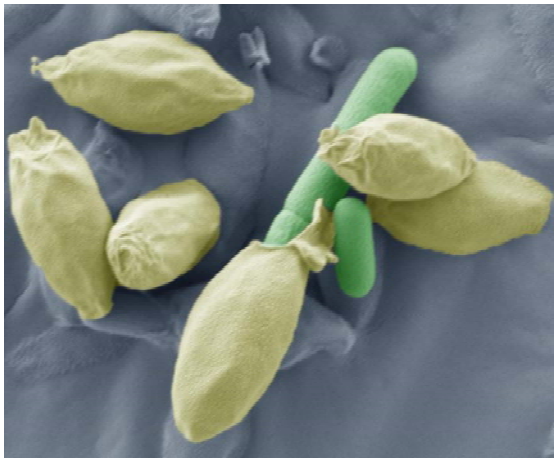
Sporeforming Bacteria



2013 Department of Microbiology, Institute of Biology, Faculty of Science, Eötvös Loránd University, Budapest.



Don Albrecht, AlbrechtGFX



Kathryn Cross, Institute of Food Research

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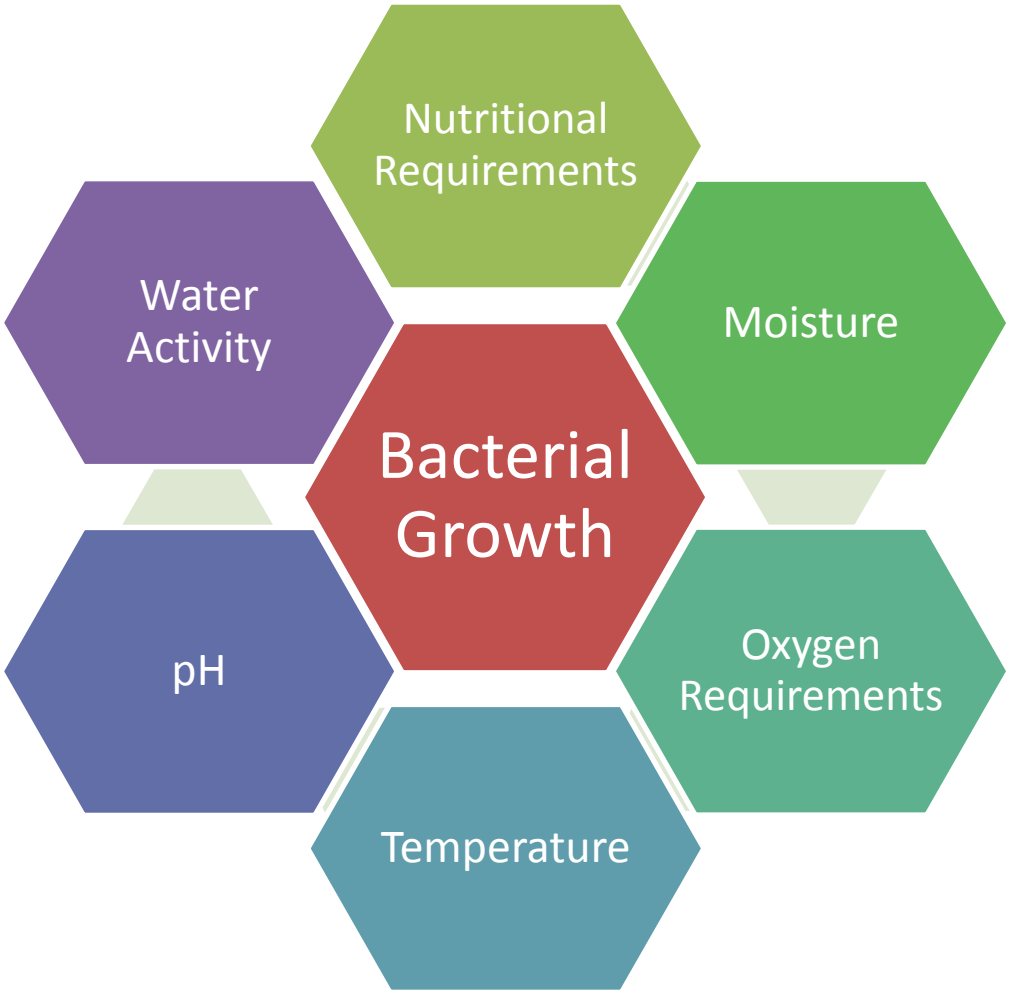
Factors Affecting Bacterial Growth and Survival



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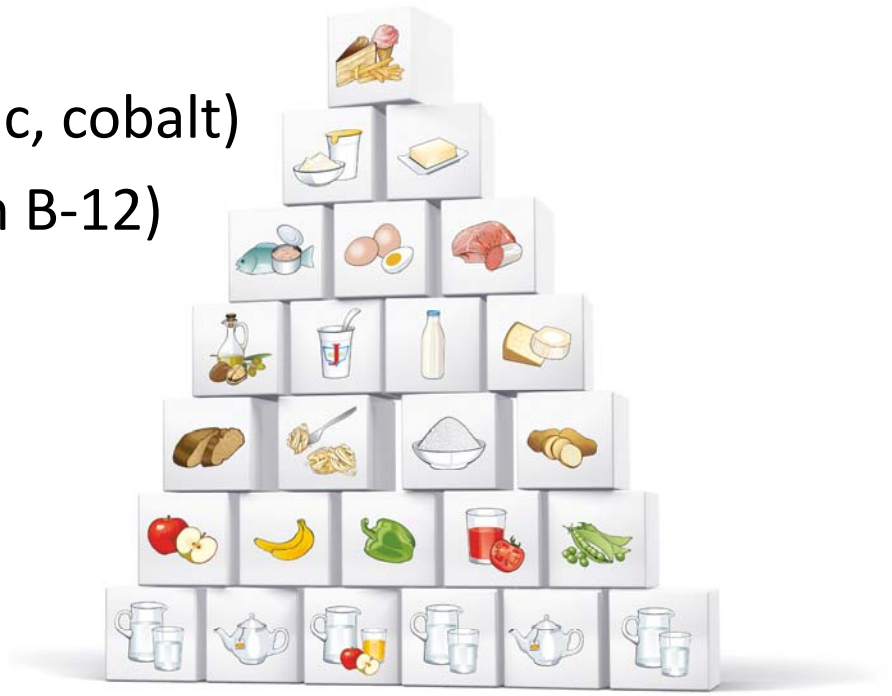
Nutritional Requirements

- Carbon source
- Nitrogen sources
- Sulfur and phosphorus
- Trace elements (i.e. copper, zinc, cobalt)
- Vitamins (i.e. folic acid, vitamin B-12)



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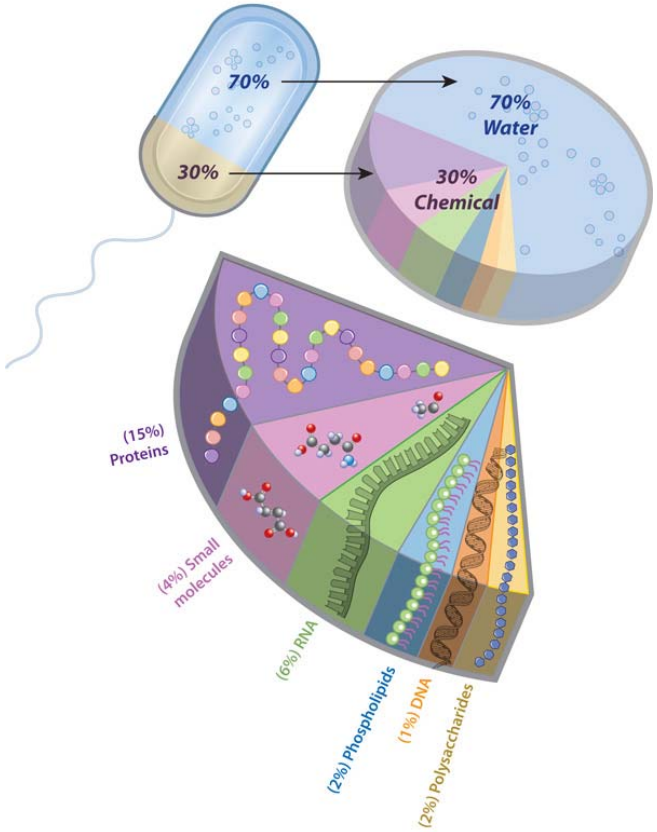
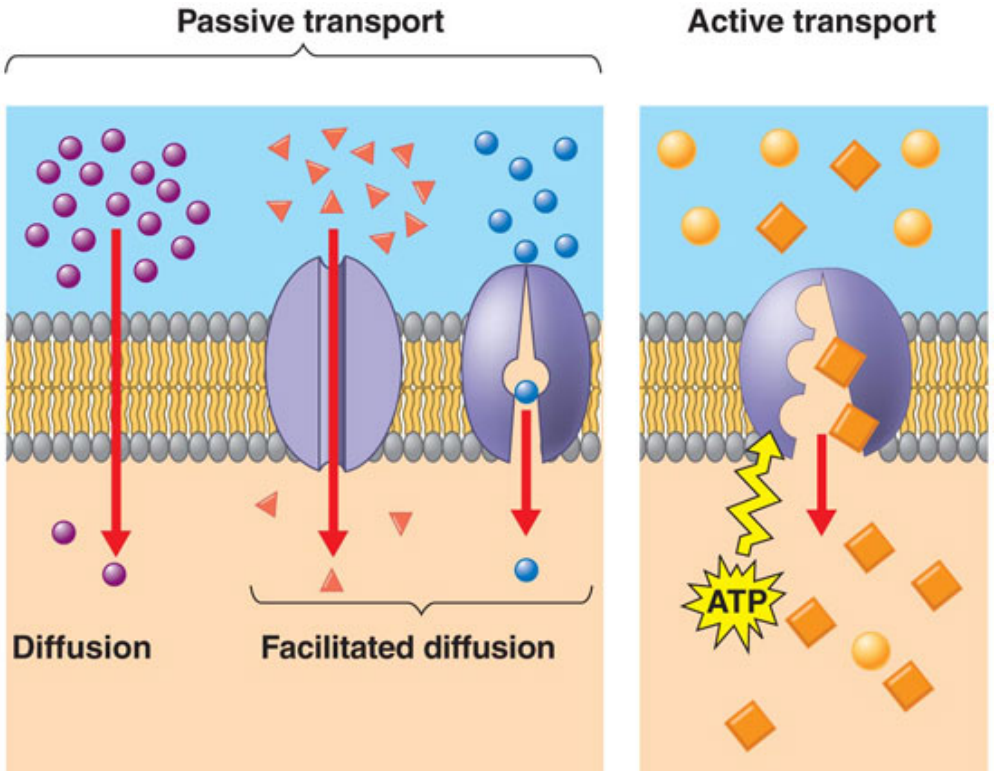
Moisture

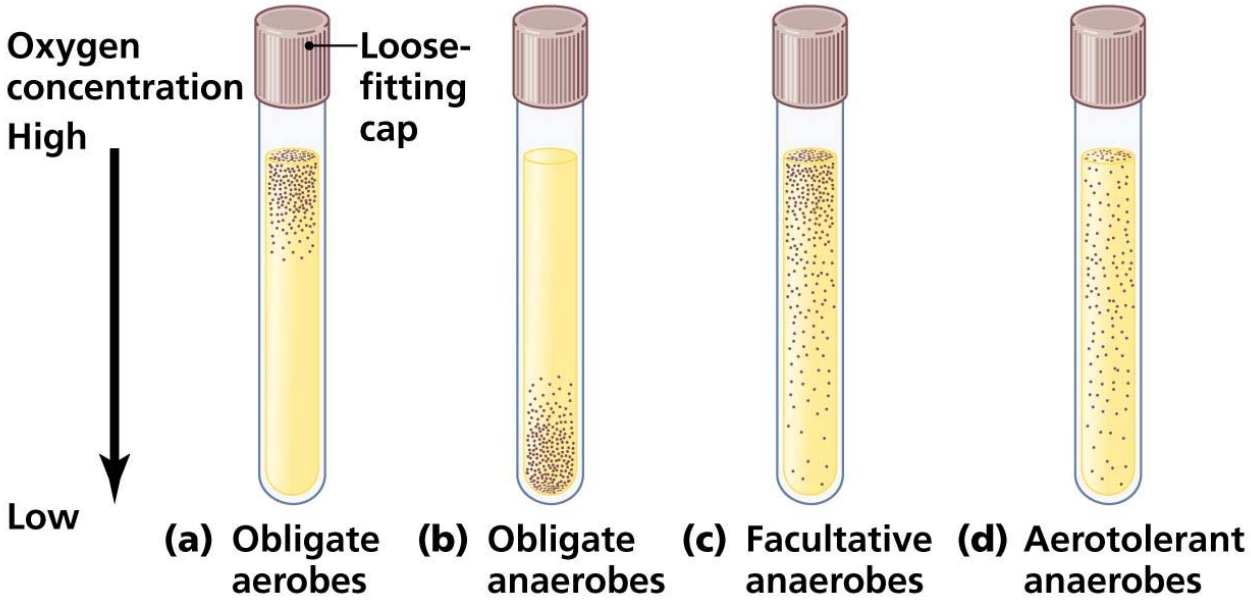




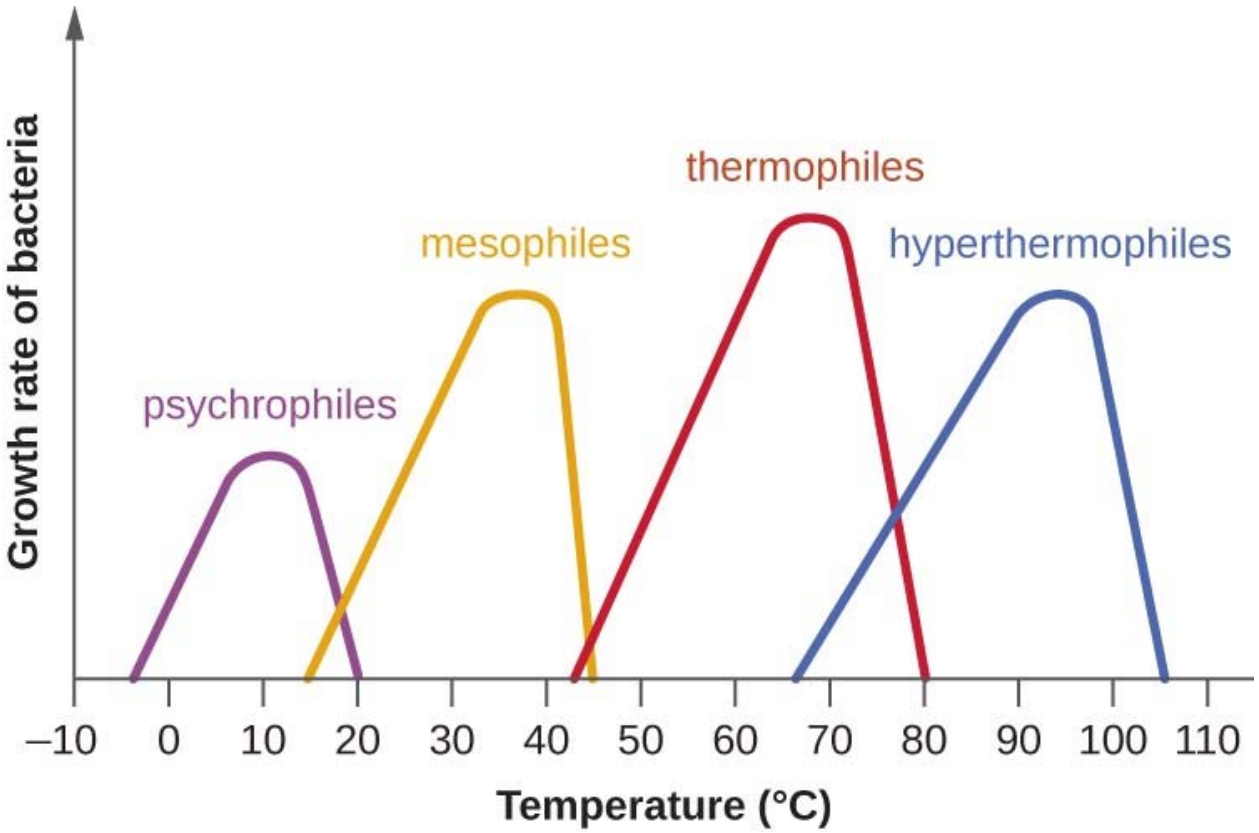
http://kmbiology.weebly.com

Oxygen Requirements

- Aerobes
- Anaerobes
- Facultative anaerobes



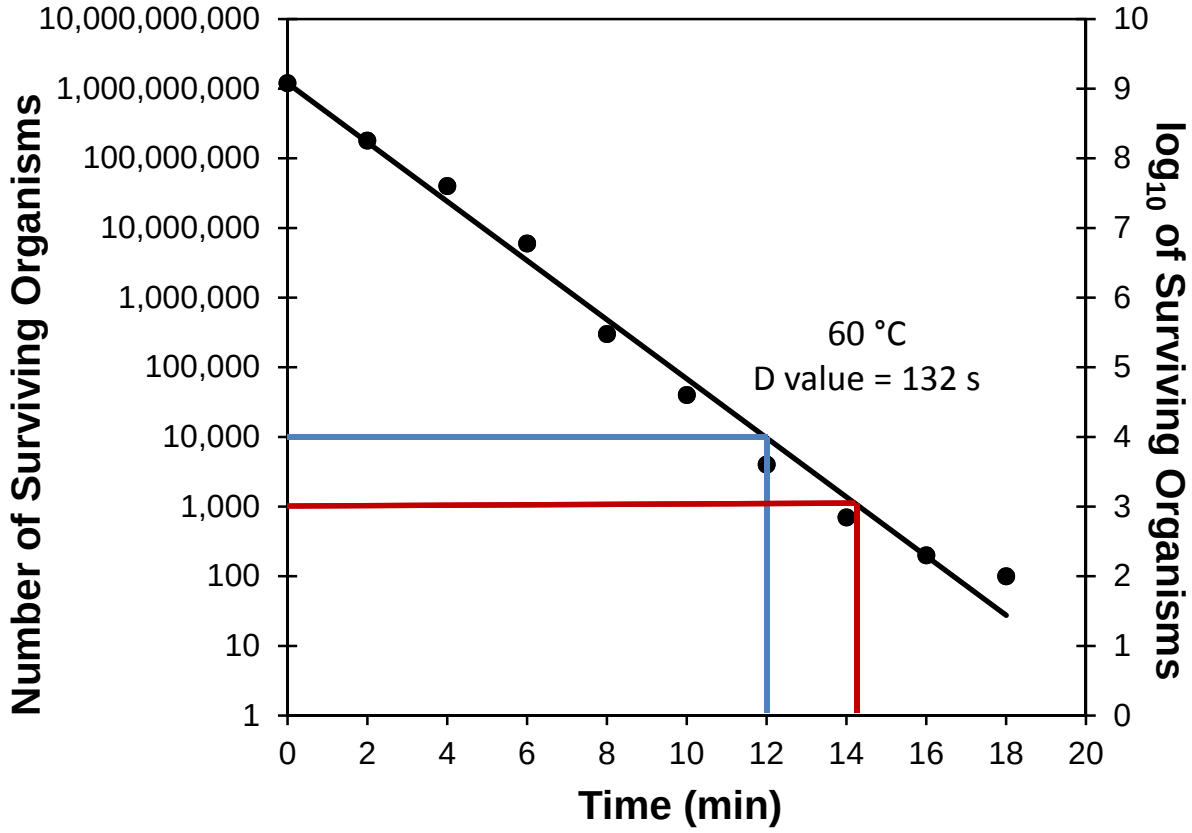
Temperature



https://courses.lumenlearning.com/microbiology/

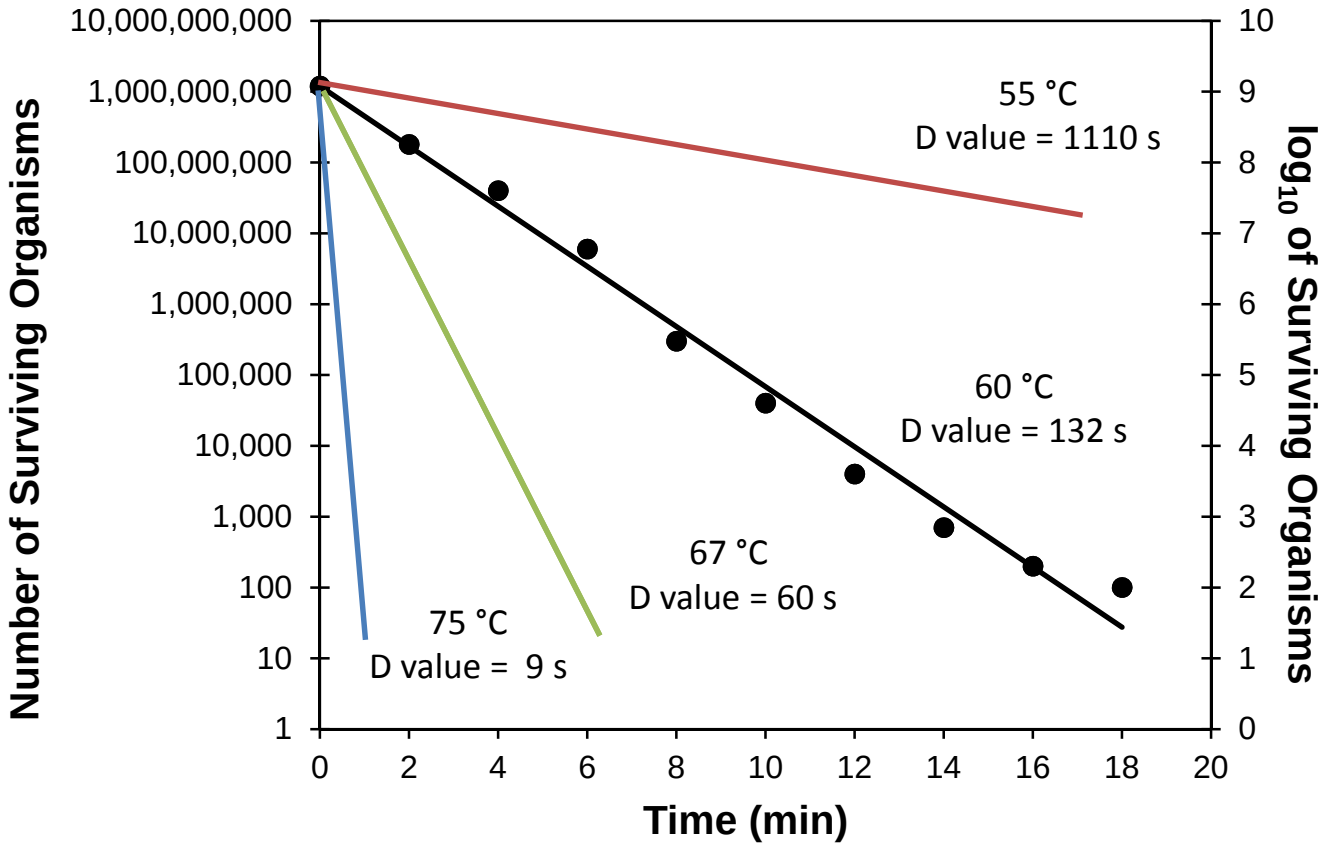
Temperature

Thermal death curve of microorganisms at a certain temperature:



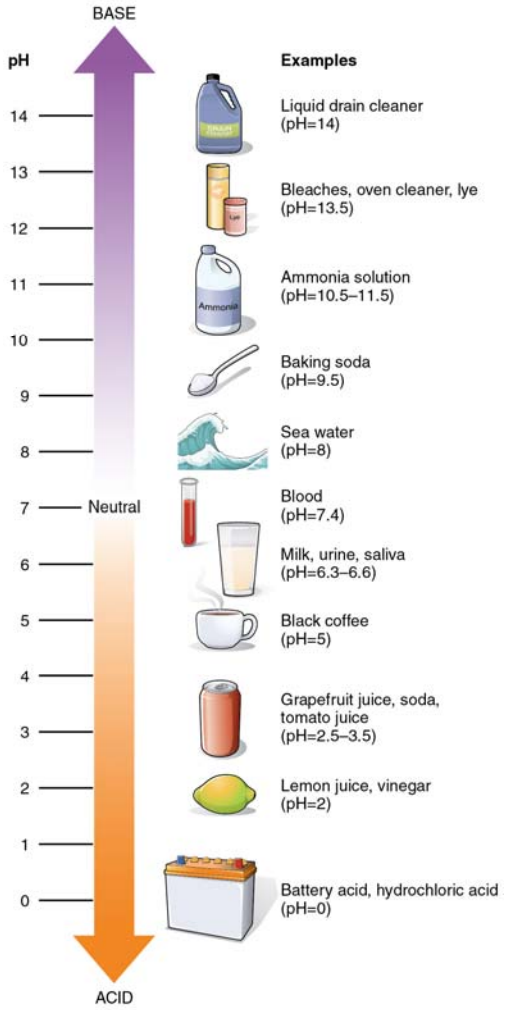
Temperature

Thermal death curve of microorganisms at different temperatures:



pH

- It refers to the degree of acidity or alkalinity
- Organisms have a most favorable pH range for growth
  - Yeast and mold: lower pH
  - Bacteria: neutral pH



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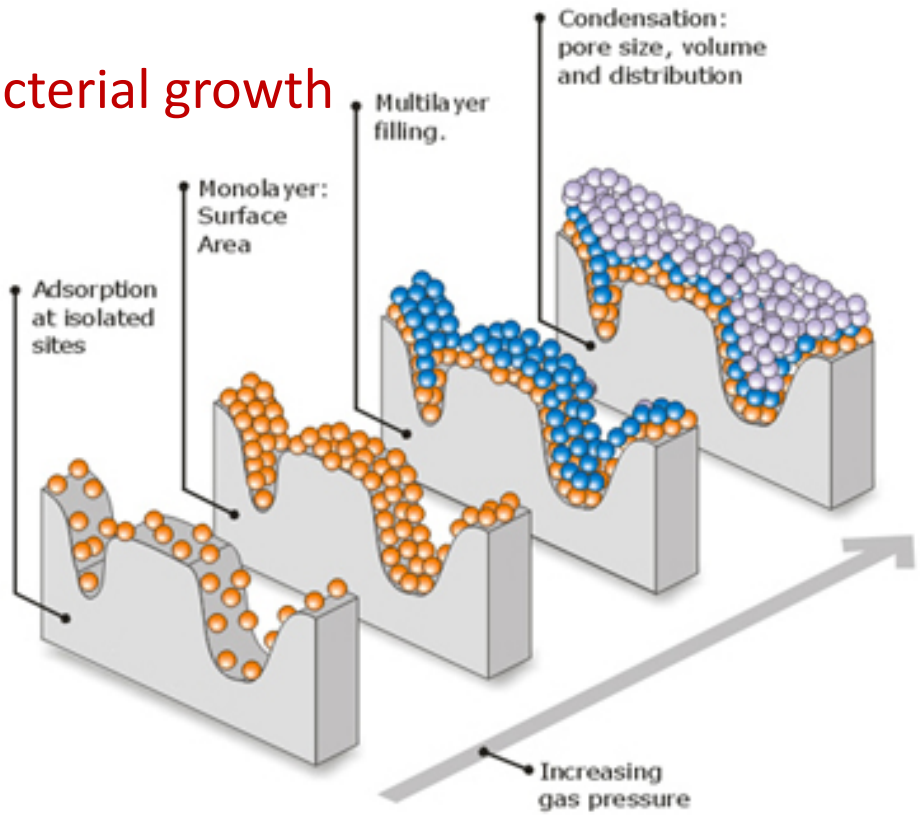
Water Activity (a_w)

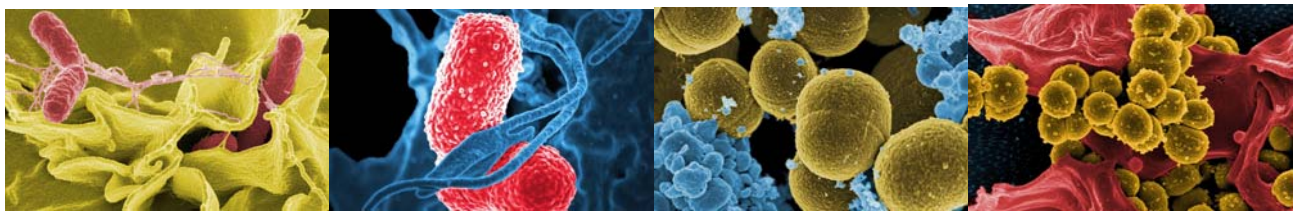
- Water availability is important for bacterial growth
- Influenced by water-binding capacity of ingredients
- Most foods:
  - A_w > 0.95 which support bacterial growth



https://muse.union.edu

Water Activity (a_w)

Microorganisms	Minimal a_w for Growth
Molds	0.75
Yeasts	0.88
Clostridium botulinum	0.93
Salmonella	0.93
Staphylococcus aureus	0.85



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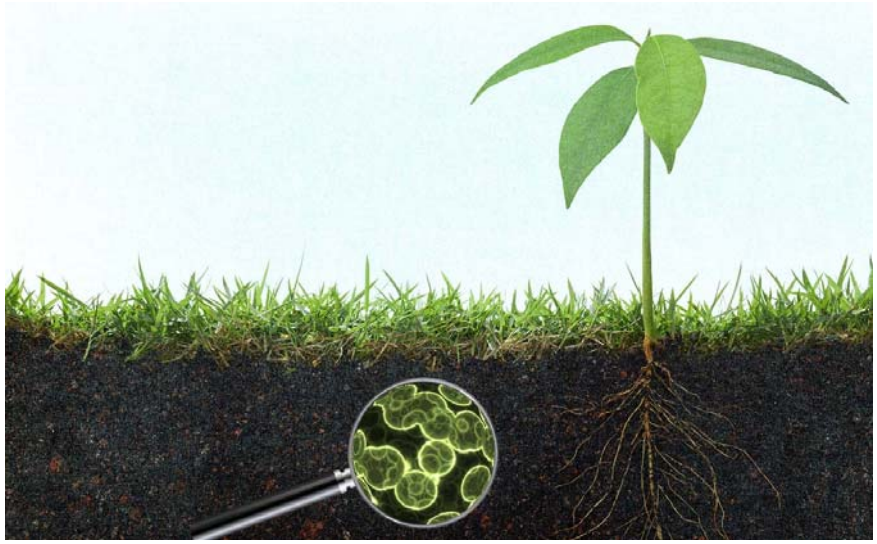
Sources of Foodborne Organisms



Modern Farmer Media, 2017

Soil

Water

http://www.crystalclearwater.co

Microorganisms

Characteristics and behavior:

- The Good,
- The Bad, and
- The Ugly

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The Good

- We add them to foods
- Ferment foods to make flavors and textures we like
  - Examples: yogurt, cheese, sour cream, pickles and bread

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The Good

- Properties of fermented foods:
  - Enhanced preservation
  - Enhanced nutritional value
  - Enhanced functionality
  - Enhanced organoleptic properties
  - Increased economic value

The Bad

- Change food and cause them to “go bad” or spoil

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The Ugly

- Can make us sick - pathogens
- Illness can range from mild to life-threatening
- Bacterial foodborne illnesses:
  - *Salmonella* spp.
  - *Campylobacter* spp.
  - *Bacillus cereus*
  - *Staphylococcus aureus*
  - *Clostridium botulinum*
  - *Clostridium perfringens*
  - *Escherichia coli*
  - *Listeria monocytogenes*

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The Ugly

	% from the total cases	% of cases hospitalized	% of deaths
Norovirus (viral)	58%	26%	11%
Salmonella non-typhoidal	11 %	35%	28%
Clostridium perfringens	10 %		
Campylobacter spp.	9 %	15%	6%
Staphylococcus aureus	3 %		
E. coli O157		4%	
Listeria monocytogenes			19%
Subtotal	91 %		

Adapted from: CDC, 2011

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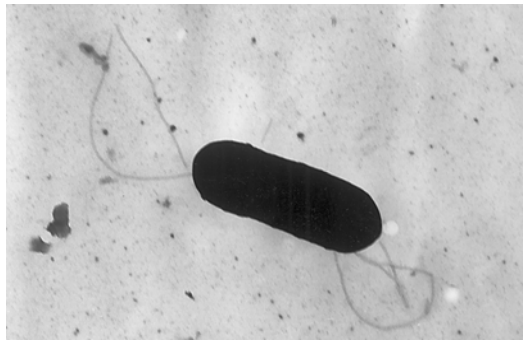
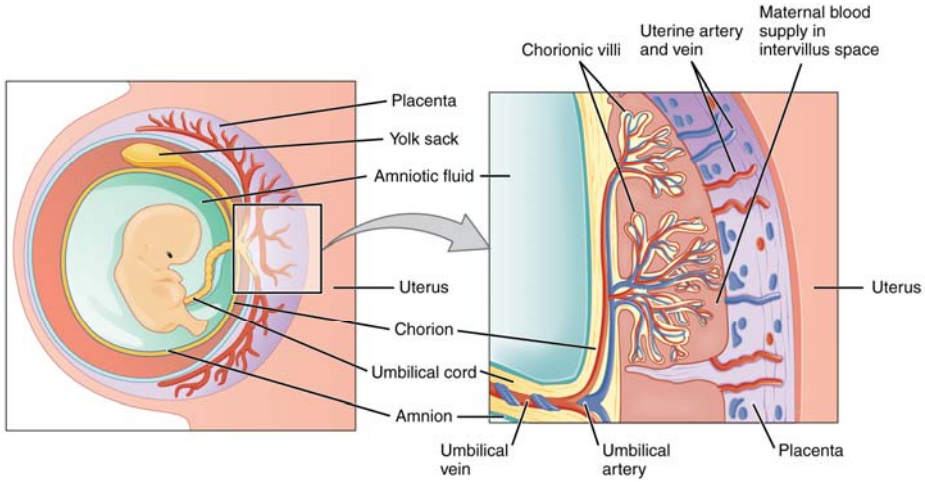
Listeria monocytogenes

- Widely spread in nature
- Only this specie, it is associated with pathogenicity in humans
- High mortality rates (around 20-30%)
- Capable of crossing the placenta barrier





Listeria monocytogenes

- Symptoms
  - Flu-like disease (headache, fever and gastroenteritis)
  - Could advance to septicemia or meningitis
- Incubation period
  - 2-5 weeks
- Associated with different foods such as:
  - Meats (hams and sausages)
  - Dairy products (raw milk, pasteurized milk and cheeses)

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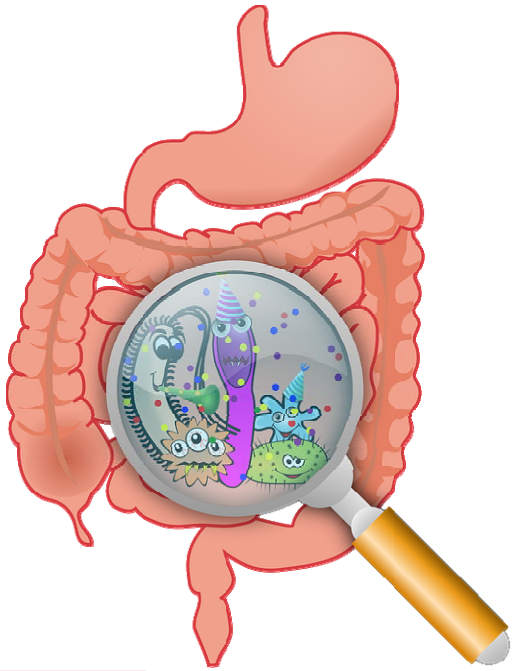
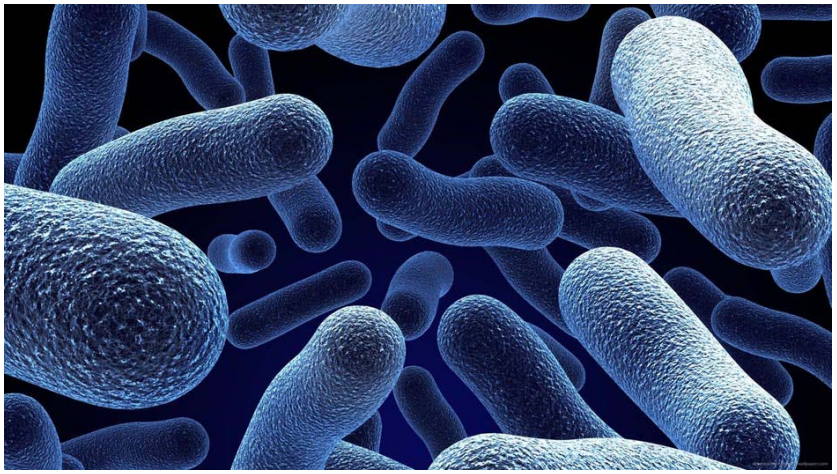
Staphylococcus aureus

- Commonly found on the skin and in the nose of about 30% of individuals
- Some of them has been reported with antibiotic resistance
- Toxin producer bacteria
  - Usually case of intoxication
- Symptoms
  - Vomiting
  - Diarrhea



Bacillus cereus

- It has been found in soil and food production environment
- Sporeformer bacteria
  - Spore survives the heat in some processing and may germinate in the food
  - Ability to produce infection and intoxication
  - Toxin production:
    - pH > 6
    - $a_w > 0.94$



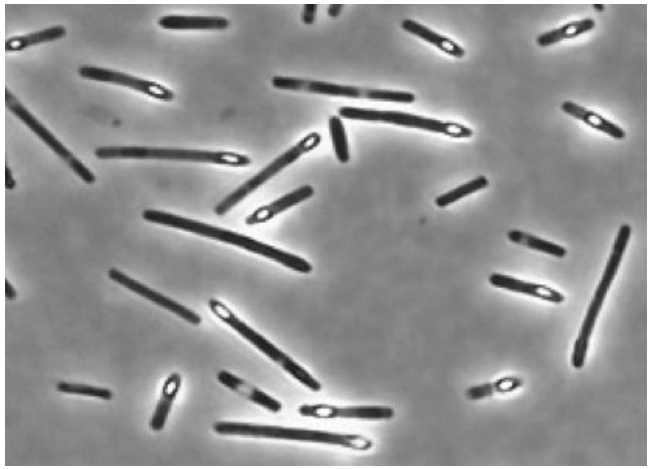
Bacillus cereus

- Diarrheal syndrome
  - Abdominal pain, diarrhea, nausea (moderate)
  - Incubation period between 10-14 hours
  - Toxin produced in the intestines
  - Infection Doses: 10^7 cells/g of food
  - Usually from dairy and meat products

- Emetic syndrome
  - Vomiting and nausea
  - Incubation period: 1-5 hours (very similar to an intoxication)
  - Toxin produced in the food (heat stable)
  - Infection Doses: 10^8cells/g of food
  - Usually from pasta and starchy food

Clostridium perfringens

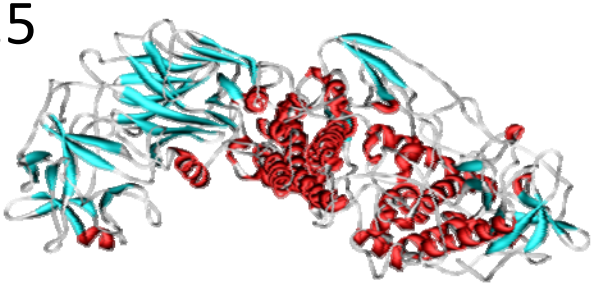
- Anaerobic microorganism
- 20 to 30% of the human population are carriers
- Toxin producer (enterotoxin)
- Symptoms
  - Nausea
  - Abdominal pain
  - Diarrhea
  - Less commonly vomiting
- Self limiting in healthy individuals
- Associated with:
  - Meat and poultry dishes
  - Meat products

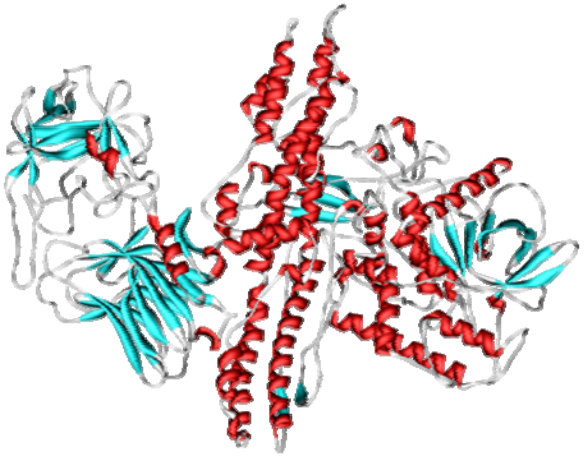


Clostridium botulinum

- Anaerobic microorganism
- Spore is heat resistant
- Do not grow or produce toxin below pH 4.5

- Toxin (neurotoxin):
  - The most powerful toxin known by humans
  - 1 nanogram is enough to kill a human
  - Used for cosmetic purpose



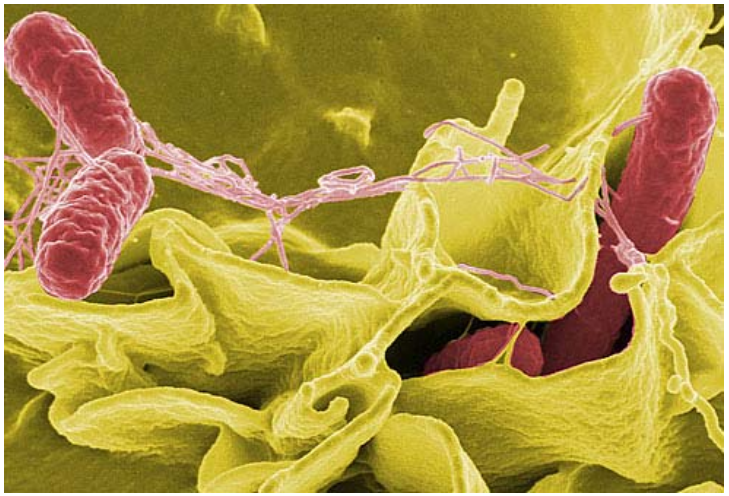


Clostridium botulinum

- Symptoms
  - Dryness of the mouth and throat
  - Double vision, fixed pupils and difficulty focusing
  - Nausea and vomiting
  - Progressive paralysis that induces cardiac and pulmonary failure
- Mortality rate: 30- 60% of the cases
- Associated with:
  - Domestic canning of meat, fruits and vegetables

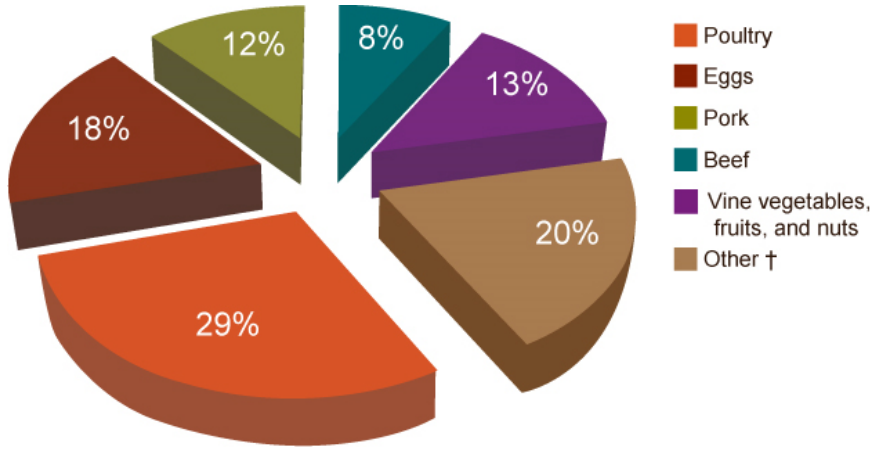
Salmonella spp.

- Most of the strains are pathogenic for humans or animal
- Can be classified in two groups:
  - *Salmonella* Typhi: Typhoid fever
  - *Salmonella* non-typhoidal: Gastroenteritis
    - Around 1.4 million of cases per year in USA



Salmonella spp.

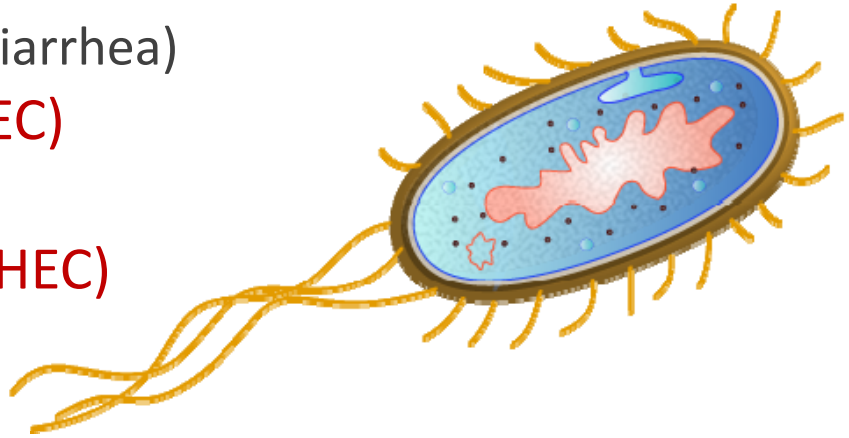
- Non-typhoidal *Salmonella:*
  - Incubation period: 2 to 28 days
  - Symptoms
    - Diarrhea
    - Cramps, chills, abdominal pain
    - Nausea and vomiting
  - Duration
    - 2 or 3 days
  - Associated with:
    - Mainly poultry and eggs products



http://www.cdhd.ne.gov

Escherichia coli

- Subcategories according to their virulence properties:
  - Enterotoxigenic *E. coli* (ETEC)
    - Gastroenteritis (traveler's diarrhea)
  - Enteropathogenic *E. coli* (EPEC)
    - Infant diarrhea
  - Enterohemorrhagic *E. coli* (EHEC)
    - Hemorrhagic colitis
  - Enteroinvasive *E. coli* (EIEC)
    - Dysentery (similar to *Shigella*)
  - Enteroaggregative *E. coli* (EAEC)
    - Persistent diarrhea, mainly in children



Escherichia coli

- *Escherichia coli* (EHEC) O157:H7
  - Incubation time: ranges from 3-8 days
  - Symptoms:
    - Diarrhea and cramps, progressing to a severe bloody diarrhea
    - Fever and vomiting
    - Complication may progress to Hemolytic Uremic Syndrome (HUS)
    - Renal failure in children
  - Mortality rate ranges from 3 to 5% of the cases
  - Associated with:
    - Ground meat
    - Raw milk and juices
    - Produce, fruits and sprouts

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Campylobacter jejuni

- Symptoms:
  - Cramps
  - Fever
  - Vomiting
  - Diarrhea
- Incubation: 2-5 days
- Duration: 2-10 days
- Associated with:
  - Raw and undercooked poultry
  - Unpasteurized milk
  - Water

Norovirus spp.

- Virus: single-stranded RNA, non-enveloped
- Causes gastroenteritis
- Incubation period
  - 24 to 48 hours
- Symptoms
  - Nausea and vomiting
  - Diarrhea and cramping
- Duration
  - 1 or 2 days
- Associated with:
  - Leafy greens
  - Fresh fruits
  - Shellfish

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Food Processing and Preservation

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Introduction to Food Microbiology

Andreia Bianchini, Ph.D.
Associate Professor

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