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SISON
REVIEW CENTER

Food Technologist Licensure Exam Review

Lecture Module 1

Preface for Lecture Guide 1

Would-be board exam takers often ask: Is it better to study hard or to study smart?

We, at Sison Review Center, we offer both.

With that in mind, we present our Food Technology Licensure Exam Lecture Guides - a roadmap for your very own FTLE review journey. These materials, along with the lectures you will be receiving along the way, are specially designed to help you wade through the breadth and depth of over four years worth of Food Technology courses in just a few months worth of classes. We understand the sense of intimidating apprehension and uncertainty of studying for the board exams. With these materials, it is our sincere hope that your journey will be at least a little bit easier.

Remember, this review program alone cannot make you a Professional Food Technologist - but it can definitely show you the way.

Name:

Fantastic LGs and How to Use Them:

This is the first of a series of three lecture guides (LGs, for short), which are meant to help you make the best of your SRC lectures. Each LG is meant to work in-synch with your lectures and the overall review program, and are designed to encourage you to listen, learn, and interact with your SRC lectures. First up, your LGs serve as a general discussion outline of your review classes. The headings in your LG coincide with the major topics under each subject, while the body provides an abridged version of the lecture content.

If you have skimmed your review materials ahead of time (*you go-getter*), the first thing you may notice is "*Hey, these aren't in the order of the PRC Table of Specs"*. Don't worry (and good job on checking the TOS before your review!), the order of your subjects is by design and is a product of painstaking brainstorming and discussion among the FTLE review program founders. These materials are structured to help build up your food technology from the ground up - starting with the foundational knowledge of food technology (LG 1), the related techniques (LG 2), and lastly, their practical applications to real-life scenarios (LG3). Aside from this, you may also notice a lot of blanks. Those blanks are not printing errors but were intentionally provided to allow you to write important definitions, concepts, equations, and other terms that are important to your review. This encourages you to maximize engagement with your lectures without the pressure of having to take notes for all of your class content.

That being said, we are open to different learning styles and you are free to utilize the LGs however you want. For example, you may also try filling up the LGs some time after each lecture as a way to test how much you can recall. Even if you were unable to fill-up the LGs during the relevant class (for instance, if you missed a session), you should still be able to accomplish them based on your own review of the SRC-provided learning materials, with consultations with your classmates or your lecturers, or through independent study using whatever materials you prefer. As with the FTLE itself, how you go through the LGs is entirely up to you.

We hope that you find these LGs useful for your review. If you have any comments, suggestions, or questions regarding the LG content, please let us know. The journey for continuous improvement doesn't end when you pass the boards - and we follow the same mentality in improving the quality of our review program.

-From the SRC Food Tech Faculty Members (Jin, Mando, Mark, Riann and Sn)

The First Step: Tips on the Covered Subjects and a Message from an FTLE Passer

Before anything else, congratulations on taking that first step towards the FTLE. They say that a journey of a thousand miles begins with a single step, and we hope that your journey as a Professional Food Technologist begins with this review.

The following lecture guide covers the fundamental characteristics of our field of study (food technology) and our main focus (food!). With topics including General and Food Microbiology, Food Physics, Food Chemistry, and Basic Nutrition; it is probable that you may not particularly like (or even actively despise) one or more of the subjects mentioned. Try to work through this hang-up, the food technology boards becomes *a lot* easier (and more interesting) when you are able to connect the dots between these topics to understand food. That said, try not to stay on any single topic too much - our experience is that your breadth of knowledge counts for a lot more than depth when it comes to the FTLE.

In the same vein, do not limit yourself to thinking that the topics discussed here may be confined to this lecture guide. The concepts taught here will be the foundation of the techniques discussed in LG2 and the more specialized applications covered by LG3. For example, adequate knowledge in Food Microbiology (LG1) will make learning Microbiological Analysis of Foods (LG2) and the Philippine Microbiological Standard Limits (LG3) that much easier. The same is true for the FTLE itself, with questions pertaining to each topic having a tendency to appear in seemingly every exam.

If you need further assistance for any part of LG1, please feel free to consult with our SRC mentors - they will be happy to work with you further or provide additional tips and materials to enhance your learning.

Best of luck with your review, future PFT.

And don't forget to smile. 🙂

-Mando
Rank 1, FTLE 2023

Name:

Lecture Guide 1:

Food Composition and Basic Concepts

Lecture Guide 1
Food Composition and Basic Concepts

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INTRODUCTION TO FOOD TECHNOLOGY

- Philosophy of Food Science and Technology
- Food Technology and Other Disciplines
- Competencies of a Food Technologist
- Challenges, Issues and Concerns in Food Science and Technology

Philosophy of Food Science and Technology

- Food Science
  - The study of the_____; the causes of food deterioration; and the concepts underlying food processing (IFT.org).
- Food Technology
  - Discipline based on the _____ of study in the conversion of raw materials into safe, stable, palatable and nutritious foods.
  - Includes the _____, _____, _____, _____, _____ and_____ of food to ensure food and nutrition security, safety and the well-being of individuals, families and communities. (CHED MO 07-2019)
- Key Concepts Under Food Science and Technology
  - _____
    - The assurance that food will **not cause harm** to the consumer when it is prepared or eaten according to its intended use (RA 10611, 2013)
  - _____
    - All people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life.
    - The Four Dimensions: _____, _____,_____,_____
    - Failure to comply leads to _____, _____, _____,_____
  - Food Integrity
    - All people, at all times, have access to food which is _____, _____, and _____. The systems used to produce the food are _____, _____, _____ and _____ of all workers.
  - Food Sovereignty
    - The _____ of people to healthy and _____ food produced through _____ and _____, and their right to define their own food and agriculture systems.

Food Technology and Other Disciplines

- Food scientists focus on the **Physical, Microbial** and **Chemical** Makeup of Food.
  - Disciplines associated with the study of these are most likely associated with Food Technology

Name:

Major Disciplines relevant to Food Science

Physical	Microbial	Chemical	Data Analytics

- Allied Fields
  - Agriculture
  - Biochemistry
  - Microbiology
  - Fisheries
  - Engineering
    - _____
    - _____
    - _____
    - _____
    - _____
  - Pharmacy
  - Veterinary Medicine
  - Chemistry

Competencies of a Food Technologist

- A Food technologist should have the competencies of the graduate described by the CHED MO 07 series 2019, "Policies, Standards and Guidelines for the Bachelor of Science in Food Technology", **Section 6**
  - **6.1 Common to all programs in all types of schools**
  - **6.2 Common to the discipline**
  - **6.3 Common to sub-discipline**
  - **6.4 Common to a horizontal type as defined in CMO 46 s 2012**
- In terms of capacity or practice, RA 11052 **Section 4** enumerates the scope and practice of Food Technology
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____

- _____
- _____
- _____
- _____
- _____

Challenges, Issues and Concerns in Food Science and Technology

- Concerns in Food Security
  - Climate change
  - Population Growth
  - Resource Scarcity
  - Globalization
- Concerns in Sustainability
  - Reducing greenhouse gases in production
  - Reduction in water pollution
  - Reduction of Food waste
- Concerns in Nutrition
  - Malnutrition
  - Obesity
  - Food Safety
  - Diet-related chronic diseases
- Concerns in _____ - fair and just distribution of healthy, affordable, and culturally appropriate food to all people, regardless of their race, ethnicity, income, or place of residence..
  - Discrimination
  - Geographic limitations
  - Economic status

Lecture Guide 1
Food Composition and Basic Concepts

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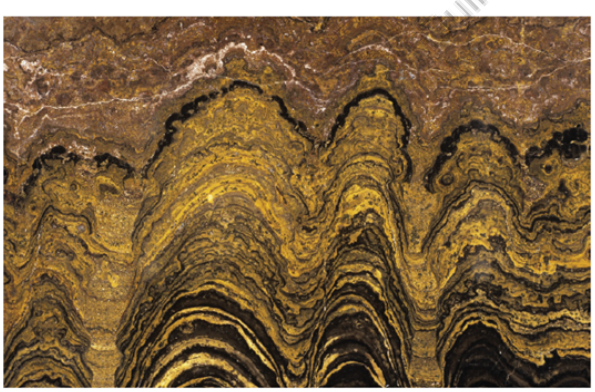
GENERAL MICROBIOLOGY

- The Microbial World
  - Definition of terms
  - Historical developments in microbial studies
- Microbial physiology and classification
- Microbial growth curve
- Factors affecting microbial growth
- Central Dogma

Introduction

- **Microbiology** is the study of life forms that are too small to be seen by the naked eye.
- Microorganisms (aka microbes) are generally <1 mm in diameter.
    - Most microbes are unicellular (composed of only a single cell).
    - Some microbes can form more complex structures or even be multicellular (composed of multiple cells with specific roles).
- Microbes are very diverse and ubiquitous and could be found in almost all environments.
    - Microbes have representatives in all three domains of life
        - 3 Domains of Life:
            - _____
            - _____
            - _____
        - Additionally, some are acellular entities or "microbes" that don't possess all properties of life
            - Properties of living organisms
                - Order and structure
                - Energy processing
                - Growth and development
                - Adaptation and evolution
                - Sensitivity or response to stimuli
                - Reproduction
                - Regulation
                - Homeostasis
            - Some acellular entities microbes that exhibit only some characteristics of life include viruses, viroids, and prions.
    - They normally exist in **microbial communities**
        - Microbes perform different roles in different environments, and their activities are regulated by their interactions with each other, their environment, and with other organisms.
- Microbes paved the evolution of life on earth
    - Cellular life first appeared between 4.3 billion years ago (BYA) and 3.8 BYA
        - These changed the atmosphere from anoxic to the current oxygenated conditions
            - The first microbes were anoxygenic (i.e. purple sulfur and green sulfur bacteria)
            - Current [O2] was only achieved around 500-800 MYA
        - Stromatolites that dated 3.5 BYA are the oldest known fossils of cyanobacterial mats

Name:



Stromatolites that dated 3.5 BYA were the earliest evident life on earth

- Currently there is an estimate of $2x10^{30}$ microbial cells occupying different environments, including places with extreme conditions in temperature, pH, pressure, and salinity.
  - _____: Microbes that can live in extreme conditions.

TABLE 1.2 Classes and examples of extremophiles[a]

Extreme	Descriptive term	Genus, species	Domain	Habitat	Minimum	Optimum	Maximum
Temperature							
High	Hyperthermophile	*Methanopyrus kandleri*	*Archaea*	Undersea hydrothermal vents	90°C	106°C	122°C[b]
Low	Psychrophile	*Psychromonas ingrahamii*	*Bacteria*	Sea ice	−12°C[c]	5°C	10°C
pH							
Low	Acidophile	*Picrophilus oshimae*	*Archaea*	Acidic hot springs	−0.06	0.7[d]	4
High	Alkaliphile	*Natronobacterium gregoryi*	*Archaea*	Soda lakes	8.5	10[e]	12
Pressure	Barophile (piezophile)	*Moritella yayanosii*	*Bacteria*	Deep ocean sediments	500 atm	700 atm[f]	>1000 atm
Salt (NaCl)	Halophile	*Halobacterium salinarum*	*Archaea*	Salterns	15%	25%	32% (saturation)

Importance of microbes

- **Microbes are important agents of nutrient cycling**
  - Microbial metabolic activities chemically and physically change their environments.
    - They play important roles in almost all biogeochemical cycles, most importantly in the cycling of nitrogen, sulfur, and carbon
    - Contributions in global concerns (i.e., climate change, agricultural productivity)
- **Microbes as agents in human health**
  - Infectious diseases are caused by bacterial and viral pathogens.
    - Pathogens: _____

    - Microbes pushed advances in medicinal technologies such as vaccination, antibiotics, and probiotics.
        - Vaccines: _____
        - Antibiotics: _____
        - Probiotics: _____
    - Applications here are valuable in other industries including wastewater treatment, food safety, and epidemiological studies.
- **Microbes and food**
    - Microbial fermentation can be used to affect the flavor and taste of foods, and control harmful microbes.
    - Microbial growth in food can cause food spoilage and foodborne diseases.
    - Microbial processing and storage explores means to improve safety and shelf-life of food.
- **Microbes have different applications in various fields**
    - Animal health
    - Agriculture
    - Water and waste treatment
    - Bioremediation
    - Biotechnology
    - Ecosystem health
    - Industry
    - Bioenergy production
    - Ecosystem health

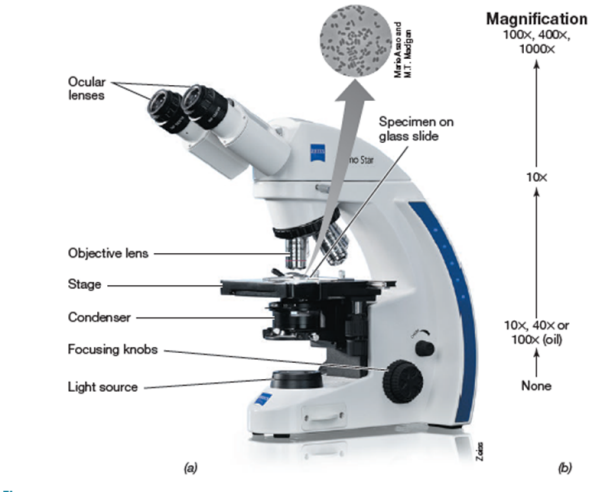
Historical development in microbial studies

Microscopy

- Microscopy revealed the microbial world
    - Robert Hooke first developed a book Micrographia (1665) devoted to microscopic observations, and coined the word “cell” from observations of plant cork.
    - Antonie van Leeuwenhoek first observed and documented bacteria (1676) which he called “wee animalcules”.
    - Developments in microscopy have since helped visualize microbes and their specific structure.
- Microscopy - The science of investigating small objects using an instrument called microscope.
    - **Compound light microscopy**
        - A modern compound light microscope has a series of lenses and uses visible light as its source of illumination.
        - The term “compound” in compound microscopes refers to the microscope having more than one lens – objective and ocular lenses.

Name:

- Parts of the compound light microscope



Parts	Function
Ocular Lens	
Objective Lens	
Stage	
Condenser	
Coarse Adjustment Knob	
Fine Adjustment Knob	
Light Source	
Objectives	

- Important concepts in microscopy:
  - Magnification - refers to the process of making an object appear larger than it is.
    - Upper limit magnification: 2000x
    - The total magnification of a compound light microscope is the product of the magnification of its objective and ocular lenses
  - Resolution
    - The ability to distinguish two adjacent objects as distinct and separate.
    - Function of the physical properties of light and a characteristic of the objective lens known as the numerical aperture

        - Numerical aperture
            - ability of the lens to gather light. Dependent on the angle of light entering the objective and the refractive index of the medium the light passes through
    - Developments in microscopy
        - Light microscopy simply illuminates a sample with visible light
            - Types of Light microscopy:
                - Bright-field - _____
                - Dark-field - _____
                - Phase contrast - _____
                - Fluorescent - _____
        - Confocal laser scanning microscopy (CLSM) couples lasers with fluorescent dyes to generate high contrast, 3D images
        - Electron microscopy uses electrons to image cells and cell structures.
            - _____ allows examination of internal cell structures at the molecular level
            - _____ allows optimal 3D imaging of cell surfaces.

Microbial cultivation

- Microbial cultivation helps understand functional diversity
    - Microbial cultures are collection of cells grown in a nutrient medium
    - A _____ is a solid or liquid nutrient mixture that contains all nutrients needed by a group or specific microbe to grow
    - A _____ is a group of millions of microbes that grew from a single unit in a solid medium.
- **Louis Pasteur used microbial cultures to debunk the concept of spontaneous generation**
    - Spontaneous generation - _____
    - Pasteur demonstrated the importance of sterilization, which helped in the development of effective sterilization procedures.
    - _____ is the state of absence of all living organisms
    - Aseptic techniques are practices that help retain sterility of cultures for microbial studies
- **Sergei Winogradsky and Martinus Beijerinck used enrichment cultures which helped broaden studies on microbial diversity**
    - Winogradsky designed media that chemically imitate natural growing conditions of the chemolithotrophic microbe, *Beggiatoa* sp.
    - Beijerinck used clear formulation of the enrichment culture technique to discover unique microbial metabolisms

Name:

- **Microbial cultivation helped establish medical importance of microbes**
    - _____ provided strong evidence that microbes can cause infectious diseases.
    - Four postulates in disease transmission
        i. _____
        ii. _____
        iii. _____
        iv. _____
- **Discovery of vaccination for smallpox from cowpox pus (1796)**
    - _____ discovered the association of immune response to viral diseases when he inoculated a child (James Phipps) with matter collected from a cowpox sore on the hand of a milkmaid
    - Upon inoculation of pus from a small pox sore, Phipps remained in perfect health
    - This process is called variolation, where people are infected with a minor form of a viral infection to prevent the person from re-infection. This also led to the development of vaccines.
- **Alexander Fleming discovered that penicillin from Penicillium has antimicrobial properties on Staphylococcus and other Gram positive bacteria (1928).**
    - He found that the growth of Staphylococcus ares was inhibited in a zone surrounding a contaminating *Penicillium sp.* in culture dishes,
        i. This leads to the finding that a microorganism would produce substances that could inhibit the growth of other microorganisms.
    - Antibiotics have since been developed to cure microbial infections and helped extend the average human lifespan.
- **Microbes pushed modern developments in genetic engineering and synthetic biology**
    - *Thermus aquaticus* was discovered as a bacterial species that can tolerate high temperatures
    - *T. aquaticus* is the source of the heat-resistant enzyme Taq DNA polymerase
        i. Taq DNA polymerase - Used in the polymerase chain reaction (PCR) DNA amplification techniques

Important subdisciplines of microbiology

Discipline	Definition
Microbial Physiology	
Microbial Ecology	
Microbial Genetics	
Medical Microbiology	
Food and Dairy Microbiology	
Industrial Microbiology	
Epidemiology	

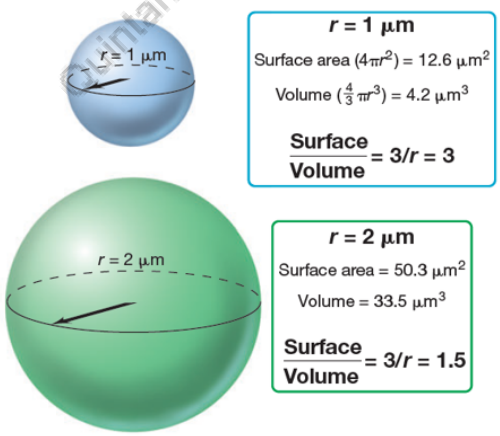
Microbial Physiology and Classification

- **General Characteristics of Microbes**
  - All cells have the following properties.
    - Structure: All cells, including microbes, exhibit similar cellular structures including a cytoplasmic membrane, cytoplasm, a DNA genome, and ribosomes.
      - Cytoplasmic membrane- _____
      - Cytoplasm- _____
      - Genome- _____
      - Ribosomes- _____
    - Metabolism: All cells take up nutrients, transform them, conserve energy and expel wastes
      - Catabolism- _____
      - Anabolism- _____
    - Growth: Information from the genome is converted into proteins, which facilitate the conversion of nutrients from the environment into new cells.
    - Evolution: Changes in the DNA may cause new cells to have new properties, leading to evolution that may be beneficial to the cell's adaptation to the environment.

Name:

- Some cells are exhibit the following properties.
  - Differentiation: Some cells can form new cell structures that can have specific roles for the organism (i.e., spores)
  - Communication: Cells can interact with each other through chemical messengers
  - Motility: Some cells are capable of movement as a response to a stimulus.
  - Horizontal gene transfer: Some cells can exchange genes with other cells by several mechanisms,

- Structure of microbial cells
  - Microbes differ primarily based on their cellular type and organization. They can either be eukaryotic or prokaryotic cells.
    - Eukaryotic cells have _____
    - Prokaryotic cells lack nucleus and membrane bound organelles.
- Microbial cell size and shape
  - Generally, prokaryotes are smaller and simpler than eukaryotes
    - Smaller cells have a higher surface area to volume ratio than larger cells. This can affect shape, nutrient exchange, metabolism, growth and reproduction.
    - Small prokaryotes rely on diffusion for transport into the cells
    - Meanwhile, larger eukaryotes use complex intracellular structures and organelles



- Microbial shapes
  - Shapes of microorganisms are their adaptations to their natural environment.

- Some microbial shapes:

Shape	Description
Coccus	
Bacillus	
Spirillum	
Spirochete	
Filamentous	

- Chemical structure of cells
  - Overall chemical composition and chemical reactions are generally similar for both eukaryotic and prokaryotic cells
    - Cells are composed of carbohydrates, proteins, nucleic acids, and lipids.
    - They use similar generally similar chemical reactions for metabolism and storing energy
- Microbes can either be unicellular or multicellular
  - Unicellular - _____
  - Multicellular - _____
- Microbes utilize different modes of nutrition based on their environments

Mode of Nutrition	Energy Source	Carbon Source	Examples
Photoautotroph			
Chemoautotroph			
Photoheterotroph			
Chemoheterotroph			

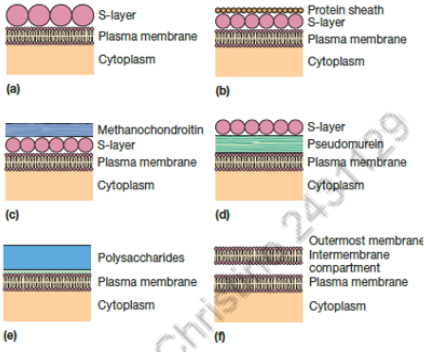
- **Classification and characteristics of different microbe**
  - All major cellular groups fall under the three living domains: Bacteria, Archaea, and Eukarya

Domain	General Characteristics
Bacteria	
Archaea	
Eukarya	

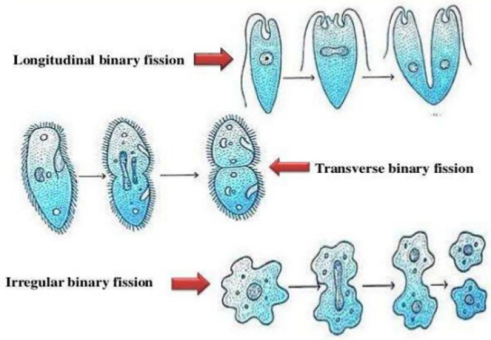
Name:

- Some microbes are considered as acellular entities that do not exhibit all but only some properties of living cells. This includes virus, viroids, and prions.

- Different kinds of microbes
  - Bacteria
    - Bacteria are prokaryotic and mostly unicellular organisms
    - They typically have cell walls composed of _____.
    - They are found in almost all environments.
    - Examples: *Escherichia coli, Staphylococcus aureus*
  - Archaea
    - Archaea are prokaryotic unicellular organisms.
    - They do not have peptidoglycan in their cell walls. The following are examples of cell wall compositions of Archaea:



    - They are mostly known to thrive in extreme environments and are generally chemoautotrophs and chemoheterotrophs.
    - Examples: *Methanococcus, Halobacterium*
  - Protozoa
    - Protozoa are eukaryotic, unicellular, animal-like microbes.
    - These microbes display a diverse range of nutrition uptake including engulfing, absorption, and some can even shift between photosynthetic and heterotrophic modes of nutrition.
    - These microbes usually reproduce via binary fission.
      - Binary fission - _____



    - Examples: *Amoeba, Paramecium, Euglena*

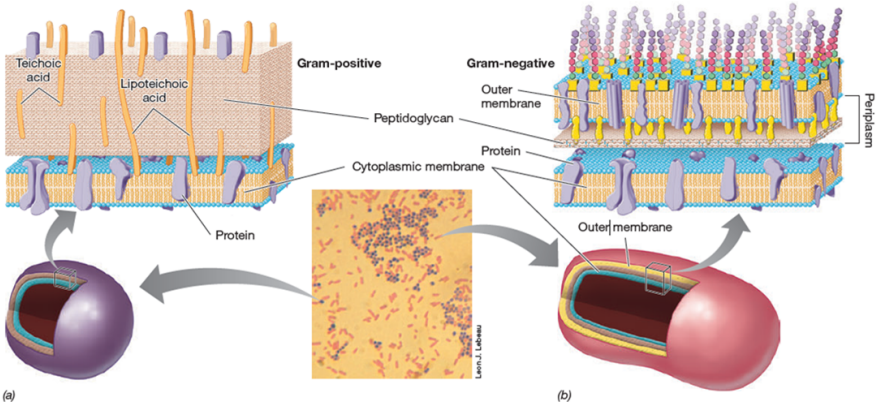
- Algae
  - Algae are a "catch-all" term for non-plant photosynthetic organisms.
  - Macroalgae are mostly eukaryotic photosynthetic organisms, while microalgae can either be prokaryotic or eukaryotic.
  - Some are capable of heterotrophic nutrition, along with their photsynthetic nature.
  - Examples: Cyanobacteria, Diatoms, Dinoflagellates
- Fungi
  - Fungi are eukaryotic organisms that are either unicellular or multicellular.
  - These are _____ and rely on organic compounds for energy and carbon source.
  - Fungi absorb necessary nutrients by extracellular digestion.
  - These can be grouped into yeasts and molds.
    - Yeasts - _____
      - Example: *Saccharomyces cerevisiae*
    - Molds - _____
      - Example: *Penicillium* sp., *Aspergillus* sp.
- Acellular entities
  - _____ are made up of a core genetic material and protein coat. They are obligate parasites that require hosts for growth and reproduction.
  - _____ are infectious agents that consist of RNA only and are replicated in a host as a template for RNA synthesis. These mostly affect plants (i.e. Potato spindle-tuber disease).
  - _____ contain only nucleic acids and need a helper virus to replicate in host cells. They may also encode gene products.
  - _____ are infectious agents composed entirely of protein. They cause disease by inducing normal proteins to fold into abnormal shapes.

Microbial morphology and structure

- Cell envelope
  - Cell envelope is made up of phospholipid bilayer that surrounds the cytoplasm, and governs interactions with the environment.
    - Functions: nutrient transport, energy conservation, cell shape maintenance, protection from stress and attack.
    - Composition generally varies, but some structures are conserved, aiding in identification and classification.
    - Major components: cytoplasmic membrane, cell wall, outer membrane, S-layers.

Name:

- Cytoplasmic membrane
  - The cytoplasmic membrane surrounds cytoplasm and separates it from the environment.
  - It is physically weak, but ideal for selective permeability that allows transport of nutrients inward and waste products outward.
    - Proteins facilitate these reactions and play important roles in energy metabolism.
  - Cytoplasmic membrane contains various proteins with hydrophobic and hydrophilic domains.
    - _____ can be embedded within the membrane but can also be transmembrane.
    - _____ are loosely attached which includes lipoproteins or associate w/ phospholipids.
      - These interact in energy metabolism and transport.
- Peptidoglycan layer
  - Peptidoglycan is a polysaccharide found in the cell walls of bacteria that provides structural strength.
  - This is composed of repeating _____ and _____ units
    - These form a mesh-like structure around the cell, providing flexibility and strength for cell pressure.
  - _____ bacteria have a thin peptidoglycan layer and an outer layer with lipopolysaccharide and porin proteins
  - _____ have a thick peptidoglycan layer with peptide cross-links between adjacent strands.



Gram-positive bacteria

Gram-negative bacteria

- Other surface structures
    - Capsules and slime layers are made of polysaccharides and proteins outside the cells. These aid in attachment and protection from predation and environmental stresses
    - Pili are filamentous protein structures used by cells for attachment, twitching motility, gene transfer, and aid in pathogenicity.
    - Flagella are used for swimming motility,
- Cellular inclusions
    - Most common inclusion bodies are poly-β-hydroxybutyric acid (PHB), used for carbon storage
    - Some aquatic bacteria have gas vesicles to aid in buoyancy
    - Some sulfur bacteria retain elemental sulfur globules
    - Magnetosomes contain iron oxide magnetites to orient with magnetic fields.
- Specialized internal structures
    - Endospores are used by some bacteria for survival in unfavorable environments.
        - These are highly differentiated dormant cells that can survive extreme heat, radiation, chemical exposure, drying and nutrient depletion.

Microbial growth and metabolism

- **Bioenergetics**
    - Transformation of energy during metabolism characterized by electron flow within the cell
    - Cellular reactions using ATP as currency through energy conservation and redox reactions
        - Oxidation reactions - _____
        - Reduction reactions - _____
    - Adenosine triphosphate (ATP)
        - Energy currency of the cell and must be constantly utilized and replenished by the cell to provide energy for cellular work and chemical synthesis
- Cellular respiration
    - metabolic pathway that breaks down glucose and produces ATP.
    - The stages of cellular respiration include glycolysis, pyruvate oxidation, the citric acid or Krebs cycle, and oxidative phosphorylation.

Name:

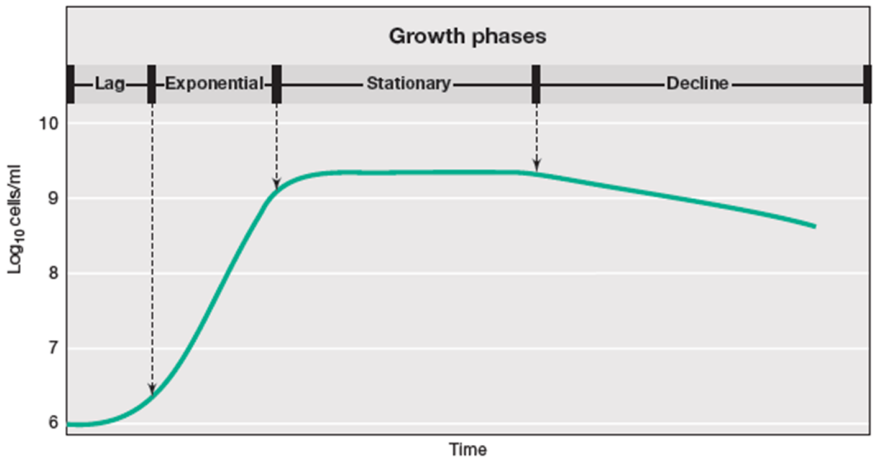
- Different stages of Cellular respiration

Metabolic process	Reactants	Products	Energy produced
Glycolysis			
Pyruvate Oxidation			
Citric acid cycle / Krebs cycle			
Oxidative phosphorylation			

- Other metabolic processes in the cell

Metabolic process	Reactants	Products	Energy produced
Pentose Phosphate Pathway			
Entner-Doudoroff pathway			
Lactic Acid Fermentation			
Alcoholic Fermentation			

Microbial Growth Curve



- Provided with the right conditions (nutrient conditions, temperature, etc) microbes can grow very quickly.
- Microbes grown in a closed system or batch culture, where no nutrient is further added nor wastes removed, display a predictable pattern in their number of population, which can be divided into 4 major phases:

Growth Phase	**On-going processes during the phase**
Lag phase	
Exponential phase	
Stationary phase	
Death phase	

Name:

Factors Affecting Microbial Growth

- **Food**
    - Microbes require the availability of different chemical nutrients for the synthesis of cellular components and overall metabolism.
        - Carbon acts as the most important of the requirements, acting as the backbone of living matter.
            - This may be supplied through either carbohydrates, proteins or lipids.
        - Other components of other macromolecules are also important in the system such as nitrogen and sulfur for protein synthesis and Phosphorus for nucleotides and ATP.
        - Trace elements such as _____, _____, _____, and _____ are important for enzymatic reactions wherein they function commonly as co-factors.
    - Controlling the amount of these sources can lead to increased or decreased growth of the organisms.
    - Reduction of available carbon sources forces the organism to create more enzymes, thus depleting energy and in essence, extending the lag phase.
    - Providing readily available carbon sources can shorten the lag phase as the organism will not need to synthesize other enzymes to adapt to the available source.

- **Acidity (pH)**
    - Microbes have ideal growth conditions with regards to medium acidity:
        - 4.6 to 9.0 = Ideal pH for microbial growth, with pH near 7.0 being most ideal
        - 4.6 to 1.0 = High acid, inhibitory except for acidophiles
        - 9.0 to 14.0 = High alkalinity, inhibitory except for alkaliphiles
    - Microbes have a tendency to change the pH of their medium creating undesirable conditions for growth.
        - The accumulation of acids and alkali bases leads to the inhibition of microorganisms, roughly outside the range of 4.6 to 9.0.
        - There are also microorganisms which require a relatively low or high acid or base concentration in order to grow.

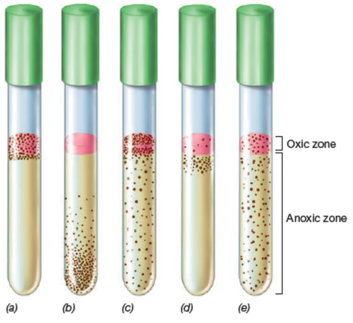
- **Temperature**
    - Generally, microbes can grow within a range of temperatures.
    - From a minimum temperature, increasing temperature conditions may increase metabolic reactions within a cell, leading to an optimum temperature where highest growth can be observed.

- Further increasing temperature beyond this may impair cellular functions and lead to a rapid decline in growth, until a maximum temperature range is reached.

Group	Minimum (℃)	Optimal (℃)	Maximum (℃)
Psychrophiles			
Psychrotrophs			
Mesophiles			
Thermophiles			
Hyperthermophiles			

- **Time**
  - This refers to the duration of exposure to ideal conditions and with respect to generation time.
  - Exposure of 2-4 hours in conditions ideal for growth can lead to exponential growth thereby reducing the lag phase and shortening the duration of the exponential phase until peak population is achieved.

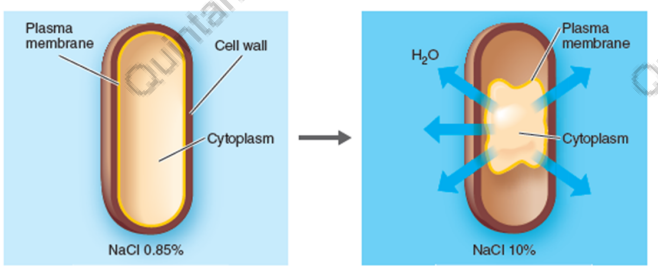
- **Oxygen Requirement**
  - Microorganisms have adapted to oxygen requirements since oxygen concentration greatly varies with respect to diffusivity into the medium as well as aeration.
  - Different groups of microbes according to their oxygen requirements are the following:



Name:

Group	Oxygen conditions
Aerobic	
Anaerobic	
Facultative aerobic	
Microaerophilic	
Aerotolerant anaerobes	

- **Moisture (Water Activity)**
  - Moisture content is mostly associated with the availability of water within the cell for cellular processes.
  - The control of the movement of water through osmotic pressure into and outside the cell can lead to controlling the growth of the microorganisms.
  - Entry and exit of water into cells can be controlled by creating a gradient between the solute content of the environment and the cell.



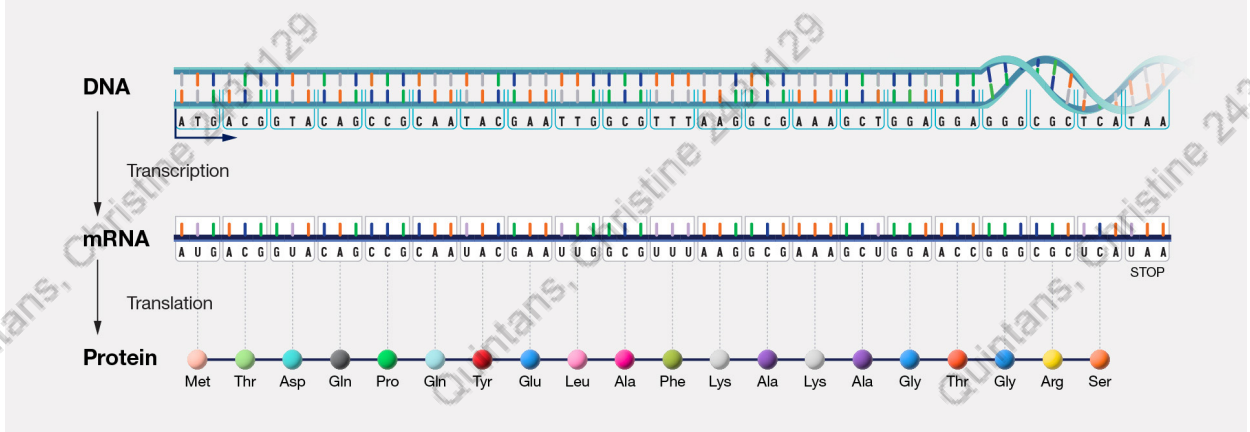
(a) Cell in isotonic solution. Under these conditions, the solute concentration in the cell is equivalent to a solute concentration of 0.85% sodium chloride (NaCl).

(b) Plasmolyzed cell in hypertonic solution. If the concentration of solutes such as NaCl is higher in the surrounding medium than in the cell (the environment is hypertonic), water tends to leave the cell. Growth of the cell is inhibited.

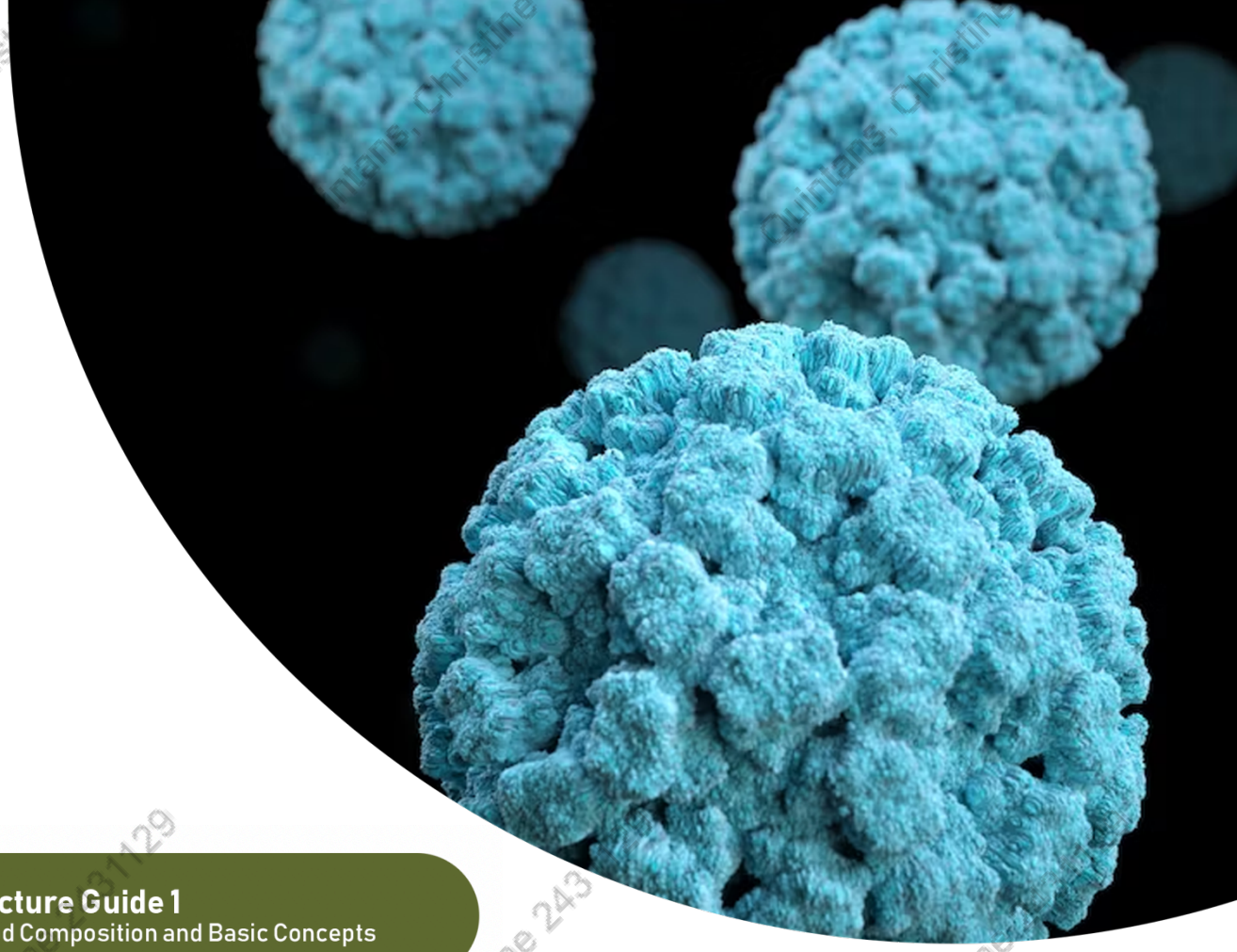
  - Water availability is expressed as water activity (A_w)
    - The ratio of the vapor pressure of air in equilibrium with a substance or solution to the vapor pressure of pure water.
    - Available water for biochemical reactions
    - Water can be bound to solutes rendering it unavailable, lowering water activity but not moisture content

The Central Dogma

- The central dogma of molecular biology was initially developed by Francis Crick in 1957.
  - This theory explains how genetic information flows from the DNA to RNA and then to functional products, proteins.
    - This process by which the DNA instructions are converted into proteins is called gene expression.
  - This is composed of three main steps:
    - Replication - _____
    - Transcription - _____
    - Translation - _____
  - Other additional steps include:
    - Reverse transcription - _____
    - RNA Replication - _____



- Deoxyribonucleic acid (DNA)
  - DNA is the hereditary material in almost all organisms, including microbes.
  - Information in the DNA is stored as a code made up of four chemical bases:
    - _____
    - _____
    - _____
    - _____
  - These bases are attached to a sugar molecule (_____) and a phosphate molecule, and pairs up with each other
    - _____ with _____
    - _____ with _____
  - A series of bases in the DNA that code for a functional protein is called a _____.



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Lecture Guide 1
Food Composition and Basic Concepts

FOOD MICROBIOLOGY

- Major Microorganisms in Food
  - Introduction
  - Harmful
  - Beneficial
  - Commensal
- Parameters Dictating Microbial Growth in Foods
  - Extrinsic
  - Intrinsic
  - Implicit
- Sample Applications of Food Microbiology
  - Sanitation
  - Preservation and Processing
  - Production
  - Recent Developments

Major Microorganisms in Food

Introduction

- Food Microbiology is the study of microorganisms (microbiology) and their role in food systems
    - Food systems = Any individual or combination of parts in the food production chain (*i.e.* farm-to-fork)
        - Post-harvest → Production / Processing → Storage & Distribution → Final Preparation → Retailing and Consumption
- Microorganisms can be generally classified based on their role in food systems into:
    - *Beneficial:* Microorganisms may be used to produce entire food products, or used to produce isolated metabolites with relevance in food systems. These include but are not limited to:
        - Processing of raw materials into fermented foods
        - Use as probiotics
        - Production of microbial metabolites such as:
            - Organic acids and alcohols
            - Polysaccharides
            - Enzymes
            - Microbial / single-cell proteins (SCPs)
            - Other bioactive compounds (antioxidants, antimicrobials, etc)
    - *Harmful*: Microorganisms can cause economic damage and threaten public health by changing the quality and safety of foods.
        - Contamination and or proliferation of pathogenic microorganisms leads to deterioration of food safety by causing disease in consumers
        - Contamination and or proliferation of spoilage microorganisms leads to deterioration of food quality
            - Either of the two can lead to widespread economic loss due to effects of food waste or costs related to foodborne disease
    - *Commensal*: Microorganisms are ubiquitous and they are naturally present without any adverse effects in most foods.
- Microorganisms may also be generally classified based on their taxonomy as discussed in General Microbiology:
    - Prokaryotes
        - _____
    - Eukaryotes
        - Fungi
            - _____
            - _____

Name:

        - Parasites
            - _____
            - _____
    - _____
- Examples of some common food-relevant microorganisms

Taxonomy	Harmful		Beneficial
	_____	_____	
_____	*Salmonella* spp. in various foods	*Pseudomonas* sp. in meat and dairy	*Lactobacillus* sp. in fermented dairy
_____	*Candida* spp. is a rare pathogen in various foods	*Zygosaccharomyces spp.* in high-sugar products	*Saccharomyces cerevisiae:* bread / baker's yeast
_____	*Aspergillus flavus* produces _____ in grains and nuts	_____ _____ aka Black bread mold	*Rhizopus oligosporus* in _____
Parasitic _____	*Entamoeba histolytica* causes _____	None known as these microorganisms cannot proliferate in foods.	None known.
Parasitic _____	*Taenia solium* aka _____ tapeworm		
Viruses	Norovirus aka stomach bug		Various bacteriophages kill specific bacteria.

- Note that the specific roles of microorganisms in foods are dependent on the food matrix and their microbiota
    - Many commensal microorganisms can cause spoilage when the population is high enough.
    - Some pathogenic microorganisms (Ex. *Staphylococcus aureus*) do not cause disease at low populations

- Prokaryotes (Bacteria) are some of the most predominant and well-studied microorganisms in food
    - Multiply in the environment, in food, and in living hosts
    - Capable of various adaptations that allow growth and survival in food systems
    - Examples include

        - _____ : Toxin-producing target microorganism in most canned foods
        - _____ : Emerging pathogen which grows in refrigerated foods and causes the disease listeriosis
        - _____ : Most common genera of acetic acid bacteria
- _____ are unicellular fungi that reproduce by budding or fission
    - One of the most common microorganisms caused in food fermentation (_____= used in production of bread and alcoholic beverages)
    - Seeing growing interest as spoilage microorganisms and as emerging pathogens
        - ubiquitous but growth in foods is slower and considered uncommon compared to bacteria
            - becomes problematic when bacterial growth is inhibited
                - Ex. Foods high in acid, salt, and sugar or those in extended cold storage
- Molds are multicellular fungi that spread via reproductive _____
    - Identified by hairy structures called _____
    - Common food spoilage microorganisms that can adjust to a wide variety of conditions
        - Optimal growth at room temperature
            - Can grow in refrigerated conditions
        - Can eventually adjust to low moisture and low pH
        - Growth requires access to _____
            - Molds are most often as surface growth
    - Produces resistant toxins (_____)

- Parasites in food may unicellular (_____) or multicellular (_____)
    - Generally unable to multiply in foods
        - Instead, presence is due to contamination or previous proliferation (*i.e.* animals infected with parasites prior to slaughter)
    - Have complex life cycles that involve growth in living hosts
    - can have very long incubation time and disease cycle

- Viruses are (biotic / abiotic) 'microorganisms' which infects specific hosts to reproduce
    - Generally (able / unable) to proliferate in foods
    - Usually transfers directly from host-to-host but may also contaminate foods
    - Viruses have simple structures which usually give them high resistance to environmental factors
    - Most known foodborne viruses are pathogenic
        - _____ is the inflammation of the liver after consumption of food or water contaminated with the _____ virus (HAV)

- Novel studies are interested in bacteriophages, viruses which reproduce by infecting specific bacteria

Harmful

- _____ and _____ microorganisms can deteriorate the quality and safety of foods, respectively
- Food spoilage caused by spoilage microorganisms may be due to excessive growth (10^5 to 10^7 cfu/g) of naturally-present microorganisms or due to presence of microbial contaminants with strong deteriorative capabilities
  - Microorganisms produce various enzymes which cause undesirable changes, such as:
    - _____, which degrade fats and oils
    - _____, which degrade proteins
    - amylases, which degrade _____
  - These deteriorative mechanisms can cause changes in pH, flavor, appearance, and odor
    - Sliminess, sourness and greening in meats are often caused by bacteria and _____
    - Production of pyocyanin by _____ spp. may cause blue discoloration in milk
    - _____ can cause bacterial soft rot in various vegetables
- Note that spoilage is product-specific
  - Unwanted growth of some known beneficial microorganisms can cause spoilage
    - Ex. *Saccharomyces cerevisiae* has many industry applications but is able to spoil a wide variety of beverages and high-sugar products
- Foodborne disease are caused by pathogenic microorganisms through the following mechanisms:
  - _____: disease caused by consumed viable microorganisms which multiply inside the body
    - Ex. *Salmonella* spp. → Salmonellosis,
      Salmonella enterica subsp. *Typhi* → Typhoid fever
      Listeria monocytogenes → Listeriosis
  - _____: disease caused by consumed toxins produced by viable microorganisms in foods
    - Ex. *Clostridium botulinum* → Botulinum toxin → _____
      Staphylococcus aureus → Staphylococcal toxins → Staphylococcal food poisoning
  - _____: disease caused by consumed viable microorganisms which produce toxins inside the body

- Ex. _____ → Cholera toxin → Cholera
  Bacillus cereus → *B. cereus* toxin → "fried rice syndrome"
  Shiga toxin-producing _____ (STEC) → Shiga toxin → various diseases

Beneficial

- The beneficial effects of microorganisms are utilized through the process of fermentation
  - Growth of certain microorganisms may be controlled:
    - in complex raw materials to produce <u>fermented foods</u>
      - Fruit juices – *Yeasts* → Wine – *Acetic Acid Bacteria* → _____
      - Coconut water – *Acetobacter xylinum* → ____ __ ____
      - Skim milk mix – *Lactobacillus casei 'Shirota'* → _____
    - in controlled systems to produce <u>food-relevant metabolites</u>
      - Substrate – *Fusarium venenatum* → _____ (brand name for mycoprotein meat substitute)
      - Milk- or whey- based substrate – *Lactococcus lactis* → _____ (bacteriocin)
      - Sugary substrate – *Xanthomonas campestris* → _____ (gum)
- The presence of microorganisms in food may also have various effects in the food itself as well as consumers
  - <u>High populations</u> of beneficial microorganisms and the <u>production of antimicrobial metabolites</u> can <u>compete</u> with harmful microorganisms
  - Microorganisms increase the <u>nutritional value of foods</u> by:
    - increasing digestibility and accessibility of various nutrients
    - production of nutritional metabolites
    - beneficial effects of the microorganisms themselves when produced in the gut ('___biotics')
      - Contrast with '___biotics', which are food compounds which, when consumed, encourage the growth of gut microorganisms

Commensal

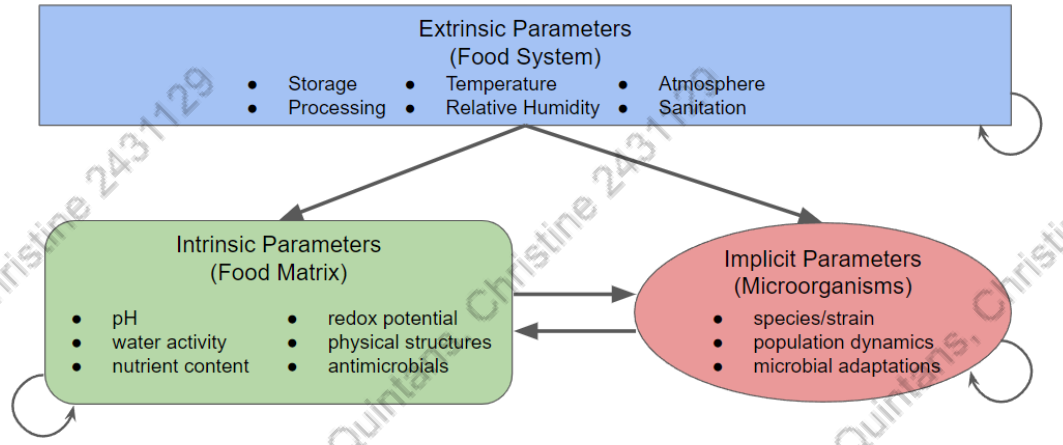
- Microorganisms are ubiquitous and and present in almost all foods
  - There is a large proportion of microorganisms that "neither help nor harm"
  - In food, commensal microorganisms are normally not cause for concern with regards to spoilage-causing potential and pathogenicity
- Commensal microorganisms can still have various effects on food systems as part of its microbiome

    - Can compete with other microorganisms
    - Synergize (encourage growth) with other microorganisms
    - Harbor and transfer genes conveying different characteristics (resistance, virulence, etc)
- "_____" : microorganisms which are usually not inherently harmful but are used as a proxy to i*ndicate* the possible presence of other harmful microorganisms

Parameters Dictating Microbial Growth in Foods

- Growth of microorganisms in foods can still be generally described by the _____ with the following stages:
    - _____ : little to no growth as microorganisms adapt to conditions
        - More unfavorable conditions = longer phase
        - Very unfavorable conditions = no growth or cell death
    - _____ : rapid growth causing rapid nutrient consumption and accumulation of metabolites
    - _____ : rate of growth and rate of death is approximately _____, due to decreasing nutrients and increasing harmful metabolites, causing little to no change in the microbial growth curve
    - _____ : rapid decrease in viable population as nutrients are exhausted and harmful metabolites accumulate
        - Some microorganisms transform to dormant forms (ex. spores) instead of dying
- In food systems, necessary parameters are manipulated to control microbial growth:
    - In _____, conditions are controlled so microorganisms enter the exponential growth up to the stationary phase to encourage production of the needed metabolites
    - We try to maintain the population of probiotic microorganisms in the mid-stationary phase to maximize _____ _____
    - In food processing, we try to reduce the initial population of _____ microorganisms as much as possible and prevent any surviving microorganisms from entering the log phase.
- Foods are complex and parameters within the food matrix, in the environment of different food systems, and in microbial communities themselves can _____ with each other
- These parameters may be categorized as <u>extrinsic</u>, <u>intrinsic</u>, and <u>implicit</u> parameters:
    - *Extrinsic*: Parameters in the food system (i.e. different _____ in the food value chain such as processing, storage, and distribution) that affect the _____ (*intrinsic parameters*) and _____ (*implicit parameters*) of foods

        - Ex. Low relative humidity during storage (_____) will decrease the water activity of foods (_____) and reduce the growth of most microorganisms (_____)
    - *Intrinsic*: Parameters inherent to the food matrix (i.e. the food product itself) that affect other intrinsic parameters as well as implicit parameters
        - Ex. Physical structures (_____) like sausage casings will affect the oxygen content inside the food (_____) and favor growth of anaerobic microorganisms (_____)
    - *Implicit*: Parameters related to microorganisms present in the food matrix which can affect other implicit parameters as well as intrinsic parameters
        - Ex. Growth of lactic acid bacteria like *Lactobacillus* spp. (_____) leads to lactic acid production, decreasing pH (_____) and inhibiting the growth of other microorganisms (_____)



Extrinsic

- Parameters present in different food system environments that can affect both the _____ as well as the microorganisms within
- Extrinsic parameters are generally the easiest to control without severely affecting food products
- Some commonly encountered extrinsic parameters are *temperature*, *relative humidity*, *atmosphere*, and *sanitation.*
    - Food production and food processing intervention often control one or more of these parameters to control microbial growth in foods
- *Temperature* (T)
    - _____ temperatures can kill microorganisms while _____ temperatures can slow down or prevent microbial growth
        - High temperatures: denature and coagulate essential _____ like those in membranes and other organelles or those proteins acting as enzymes

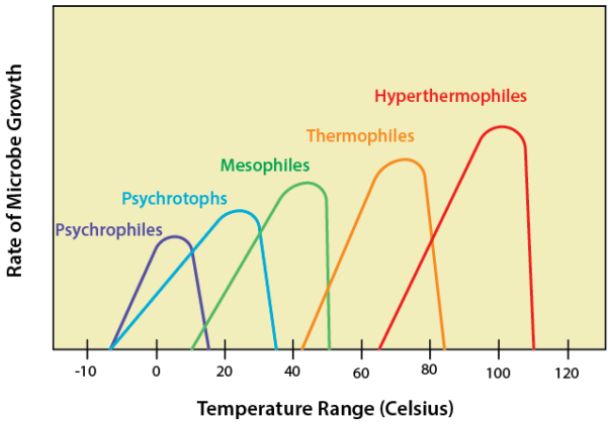
Name:

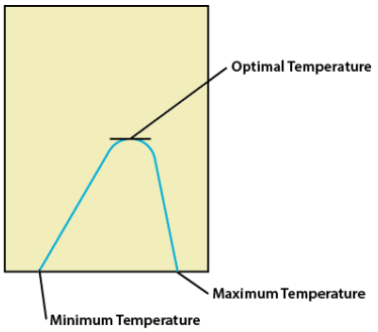
- Commonly utilized during processing
- Low temperatures: inhibits biochemical reactions of metabolic processes
  - Commonly utilized during storage and transport of foods (raw materials and finished products)

- Different kinds of microorganisms have different tolerances and preferences for temperature, with *psychrotrophs* and *thermophiles* being of particular concern:
  - Psychrotrophs: "____-loving", can grow in low temperatures and can cause problems during storage of refrigerated and frozen foods
    Examples:
    - *Listeria monocytogenes* can multiply at temperatures as low as 0 °C and causes the frequently fatal disease *listeriosis*
      - Emerging pathogen of developed countries, causing outbreaks in many refrigerated ready-to-eat (RTE) foods

    - Filamentous fungi (molds) often grow in refrigerated foods where more common bacteria are inhibited
      - Common in refrigerated bread and

  - Thermophiles: can often survive high processing temperatures and cause problems during storage of thermally-processed foods
    Examples:
    - *Bacillus stearothermophilus* causes 'flat sour' (no swelling) spoilage in canned foods
    - *Clostridium* spp. cause spoilage or disease (*C. botulinum*) in many thermally processed foods
- Concept of *"temperature danger zone"*, where pathogenic microorganisms can grow rapidly
  - Do not store foods at __ *°F*- ___ *°F (_ °C - __ °C)* for longer than ___ *hours*





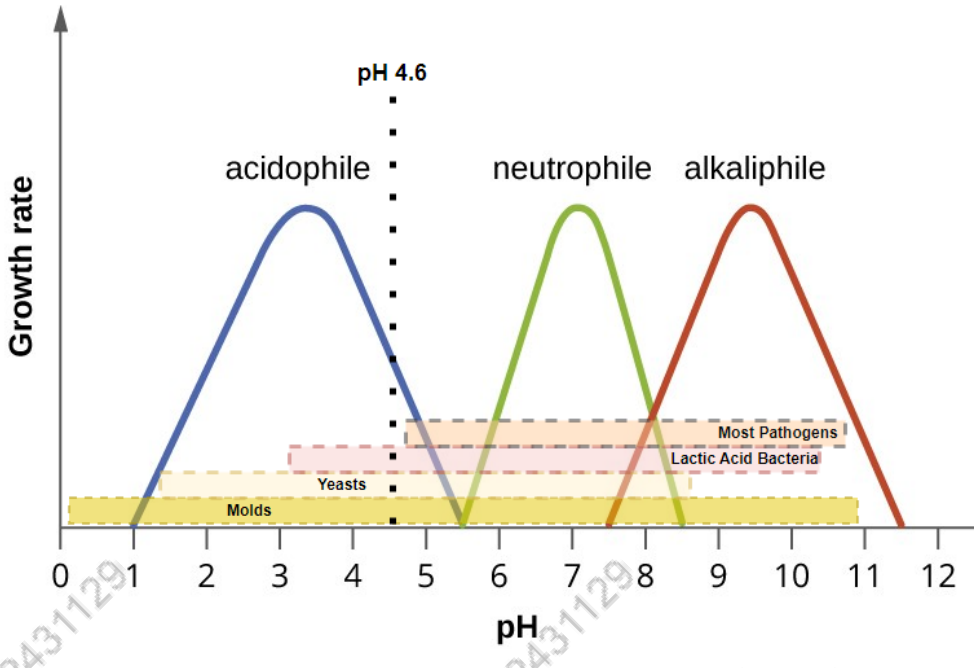
- *Relative Humidity* (RH)
    - The amount of water vapor in environmental air
    - Water activity (a_w) of foods rise or fall to match RH levels
        - Ex. a_w = 0.4, RH =0.8; food will absorb water to reach a_w closer to 0.8
          a_w = 0.9, RH =0.8; food will desorb water to reach a_w closer to 0.8
    - Food surfaces = more prone to a_w changes
    - May be controlled by several factors:
        - *Packaging* to prevent contact of food with environmental air (moisture barrier)
        - *Proper storage* to ensure food a_w is similar to environmental RH
        - *humectants / anticaking agents* which bind water
            - Ex. salt, sugar, silicon dioxide
- Atmosphere
    - The presence and concentration of certain gasses affect the growth of microorganisms
        - Aerobic microorganisms require _____ for growth
        - Some gasses (such as propylene oxide, chlorine dioxide, and ozone) have _____ activity
            - Toxicity may be a concern
        - Some gasses are mostly inert (_____, carbon dioxide) but are mainly used to displace _____
    - Gas concentrations along with relative humidity are commonly controlled with modified atmosphere interventions, such as modified atmosphere packaging (MAP)
- The environment can also be a source of contaminating microorganisms at different points throughout the food value chain
    - Controlled by quality and safety controls (GAPs, GMPs, SSOPs, PRPs, & HACCP)
    - *Post-process contamination* is a common cause of quality and safety issues in finished products

Intrinsic

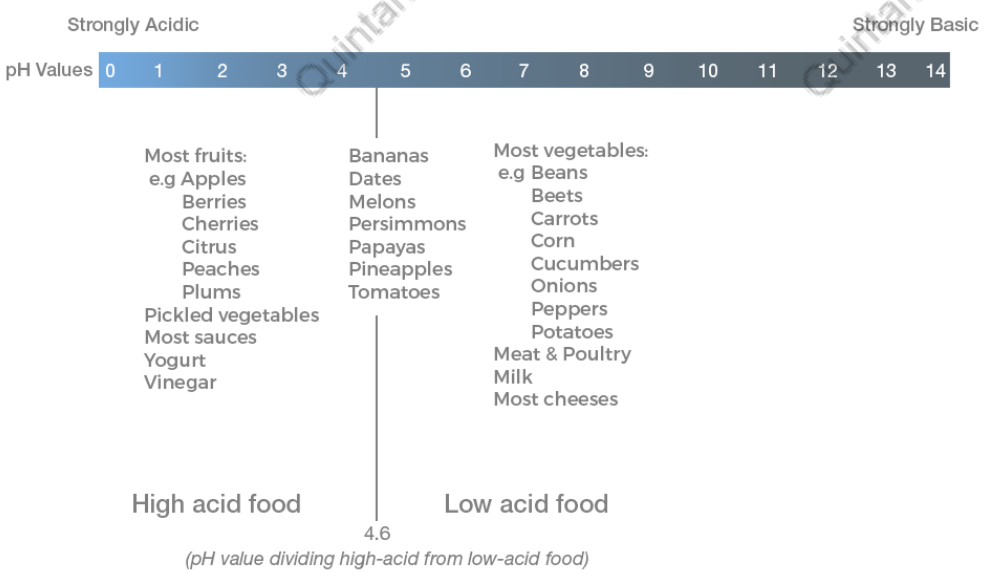
- Parameters inherent to the food matrix affect the growth of microorganisms
    - Cannot be changed without changing one or more quality characteristics of food
- Food products also act both as food and as growing medium of microorganisms
- Commonly encountered intrinsic parameters include pH, water activity (a_w), RedOx potential, nutrient composition, antimicrobial components, and physical structures of food

Name:

- *pH*



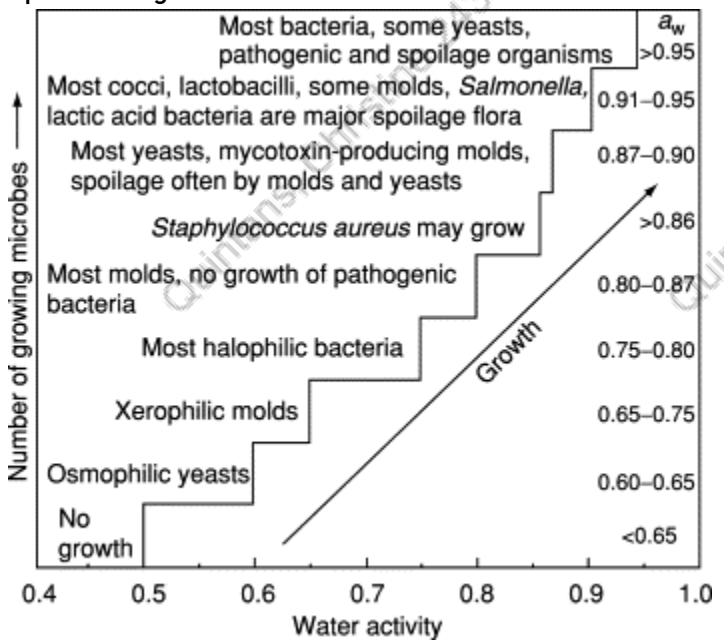
  - Most microorganisms require near-neutral internal pH (6.0-7.6)
    - pH values outside this range may be tolerated by adaptations that *maintain internal pH* or *modify external pH*
  - _____ (molds > yeasts) can adjust to a larger pH range compared to most bacteria



  - The pH of foods can dictate which microorganisms tend to grow
    - Fruits (acidic): susceptible to _____ growth
    - Meat and seafood (neutral): susceptible to growth of most microorganisms

    - Low-acid canned foods (pH < 4.6)
        - Potentially hazardous food (PHF) due to possibility of _____ growth and toxin production
        - Requires more intense ("12D") processing

- *Water Activity*
    - most metabolic processes and the relevant biochemical reactions occur in the presence of water
    - Water activity = _____ water that may be used by microorganisms
    - Lower a_w leads to:
        - _____ length of lag phase
        - _____ growth rate
        - _____ final population
    - a_w is dependent on relative humidity (RH) (extrinsic parameter)
    - Foods with a_w > 0.86:
        - _____ _____ ____ (PHF) due to possibility of _____ growth and toxin production
        - Applicable for minimally-processed foods and foods handled after processing



- *Nutrient Content*
    - Food matrices are naturally rich in nutrients which _____ microbial growth
        - Foodborne microorganisms are usually *heterotrophic*
    - Microorganisms require sources of _____ and _____ to grow
        - In foods, these usually come from sugars and proteins
    - More simple sources of the above are preferred by microorganisms
        - Preference for _____
          sugars > alcohols > amino acids > complex carbohydrates > fat

        - Preference for _____
          amino acids > peptides > complex proteins > nucleotides
        - These preferences are dependent on intrinsic characteristics
            - Most species are entirely unable to utilize fat
- *RedOx Potential*
    - Energy production in biological systems are based on reduction-oxidation (redox)
        - Recall _____ phosphorylation in the electron transport chain
        - _____ = final electron acceptor
        - Redox potential in foods is most closely related to the availability of _____
    - Only some microorganisms are able to produce energy in anaerobic conditions
    - Food production through _____ relies on the control and monitoring of redox potential
        - High redox potential = ____ microbial growth
        - Low redox potential = ____ production of necessary metabolites

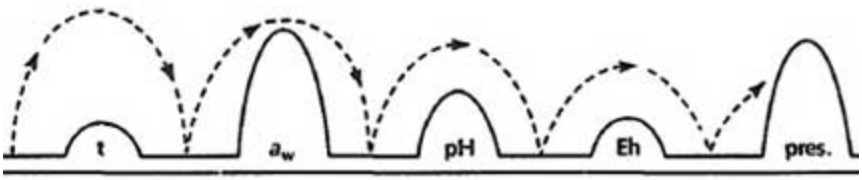
- Physical Structure
    - Food matrix structure can serve as *barriers*, preventing microbial contamination or access of microorganisms to nutrients, moisture, or oxygen (other intrinsic factors)
        - Example: Ground meat is of _____ microbial risk than whole-muscle meat as surface microorganisms are distributed throughout the food matrix and nutrients become exposed to atmospheric moisture and oxygen
    - Natural barriers are found in biological structures such as
        - Wax and peel of fruits and vegetable
        - Skin and muscle of meat and seafood
        - Shell, hull, and pith of seeds
        - Corn husks
        - Cuticle, shell, and membrane in poultry eggs
    - Artificial barriers are found in the form of packaging materials and edible films like
        - Casings of sausages and hotdogs
        - Banana leaf packaging of *kakanin*
        - Novel edible films and coatings
- Antimicrobial Components
    - May be *naturally present* in various foods or food ingredients or individually added as *food additives*

- Examples of natural antimicrobials:
  - Phenolic compounds in food essential oils:
    - *Menthol* in mint, carvacrol and thymol in oregano, *alicin* in garlic, *eugenol* in cloves, *quercetin* in onions, *linalool* in citruses

Implicit

- Implicit parameters are those relating to the microorganisms present in the food matrix
  - Both the *quantity* (population) and *type* of microorganisms present have safety and quality implications
    - Certain microorganisms only become harmful at high populations
    - Adaptations can make microorganisms more resistant or more harmful
      - Microorganisms which have been environmentally stressed can adapt to become more resistant to processing
        - Forms like *bacterial endospores* are much more resistant than viable cells
- Microbial interactions can also play a significant role in foods, especially during fermentation
  - Microorganisms can harm or help other microorganisms
    - Rice starch – _____ _____(kōji mold) → sugar – yeasts → rice wine – _____ ___ _____ → rice vinegar [helpful/synergistic relationship]
    - Lactic acid bacteria in many fermented foods inhibit the growth of harmful microorganisms [harmful/antagonistic relationship]
    - Many microorganisms may not *directly* interact with each other but still *compete* for space or resources

Multifactorial effect

- The *combined effect* of extrinsic, intrinsic, and implicit parameters can do more to control microbial growth than the individual effect of microorganisms alone
- Different stresses exhaust microorganisms and prevent them from effectively resisting additional stress
  - This is the working principle of _____ _____
  - 

Name:

Sample Applications of Food Microbiology

Sanitation

- The environment (surfaces, dust, air, personnel) are a constant source of potentially harmful microorganisms
    - _____: surfaces or particle that serve as vectors for microbial contamination
- Microbiological testing is an integral part in the development of HACCP plans and then necessary prerequisite programs (PRPs)
    - Standard Sanitation Operating Procedures (SSOPs)
- Surfaces are analyzed microbially by _____
- _____ plates are used for passive air monitoring
- _____ microorganisms are not necessary harmful but are used as a 'surrogate' to estimate possible presence of harmful microorganisms
    - _____ : estimates the overall level of microorganisms in a food or environmental sample
    - _____ : estimate the overall level of fungi in a food or environmental sample
    - _____ : generally used to estimate efficacy of hygiene and sanitation (particularly important in water)
        - _____ : a subset of the above which likely indicates fecal contamination

Preservation and Processing

- Microbial contamination and proliferation can cause economic losses along the food processing chain and lead to safety concerns at the consumer level
- In food processing, microbial concerns are prevented by preventing contamination, preventing proliferation, and reducing the microbial load of raw materials and finished products.
    - Contamination: prevented by proper sanitation and hygienic practice
    - Proliferation: prevented by control of various intrinsic and extrinsic factors (commonly low _____)
    - Microbial load reduction: ensured by proper and adequate processing
- The controlled growth of desirable microorganisms to produce antimicrobials like alcohols and acids are utilized in many food products preserved via _____

Production

- Microorganisms are used to produce both finished food products and raw materials (ingredients)
- Some samples of finished food products produced using microorganisms include:
    - Cooked soybeans → _____ → *natto*
    - Sweet tea → various bacteria and yeasts → _____

- Milk → _____ + _____ → yogurt
- Some samples of raw materials (ingredients) produced using microorganisms include:
  - Sugars → _____ → citric acid
  - GMO bacteria or fungi → microbial rennet

Recent Developments

- Various rapid methods are continuously accepted as alternatives to conventional methods
  - surface ___ test swabs as a substitute to typical microbial indicator counts
  - nucleic acid, biosensor, and immunological methods for detecting the level of pathogenic microorganisms
  - Proprietary growth media formulations that shorten the time of culture-based enumeration methods (ex. 3M Petrifilm Rapid Aerobic Count Plates)
- Use of bacteriophages in biopreservation methods which target specific harmful microorganisms
- 'Omics' technologies can give much deeper information related to microbial communities in various food systems
- Use of predictive models to assess growth of specific pathogens in various food matrices

Lecture Guide 1
Food Composition and Basic Concepts

Photo from Unsplash

PHYSICAL PROPERTIES OF FOOD

- Units and Dimensions
- Mass, Volume, and Density
- Rheological Properties
- Thermal Properties
- Electromagnetic Properties
- Optical Properties

Unit and Dimensions

- Measurement is a system of units used to express quantities (Hughton et al., 2017).
- Measurement system comprises units and dimensions, often confused but distinct.
    - Dimensions are measurable physical quantities (e.g., length and time).
    - Units are labels/names correlated to specific dimensions.
    - Example: Length (dimension) is measured in meters (unit).
- Dimensions may have multiple units with conversion factors (e.g., 1 m = 100 cm).
- Primary dimensions are independent and serve as the basis for other complex dimensions:
    - Length
        - Measurement of distance from one point to another.
        - SI unit: _____, defined using the speed of light in vacuum.
        - Standard meter = distance light travels in 1/299,792,458 of a second.
    - Time
        - Time is not directly measurable but measured as intervals between events.
        - SI unit: _____, defined using the cesium-133 atom's hyperfine transition frequency.
        - Equivalent to _____ cycles or waves of Cs-133
    - Mass
        - Measurement of matter in an object.
        - SI unit: _____, defined using the Planck constant.
        - Planck constant: $6.62607015 \times 10^{-34}$ kg m^{-1} s^{-1}.
    - Temperature
        - Measurement of an object's hotness or coldness, based on kinetic energy.
        - SI unit: _____, defined using the Boltzmann constant.
        - Boltzmann constant: 1.380649×10^{-23} J K^{-1} or kg m^2 s^{-2} K^{-1}.
    - Electric Current
        - Flow of charged particles (electrons or ions) through a conductor.
        - SI unit: _____.
        - Derived from elementary charge (e), $1.602176634 \times 10^{-19}$ C or A s.
    - Amount of Substance
        - Number of elementary entities (atoms, molecules, ions, etc.).
        - SI unit: _____.
        - Equivalent to $6.02214076 \times 10^{23}$ elementary entities (Avogadro's constant, NA).
    - Luminous Intensity
        - Amount of visible light emitted in a specific time and solid angle.
        - SI unit: _____.
        - Unit derived from luminous efficacy of monochromatic radiation.

Name:

- Derived Dimensions and Units
    - Derived dimensions are created by combining primary dimensions.
    - Example: Area (m^2) and volume (m^3) use length as the primary dimension.
    - Some derived dimensions require multiple primary dimensions.
        - Example: Speed (m/s) and acceleration (m/s^2) use both length and time.
- Metric and Customary Units
    - Multiple systems of units: Metric system (SI units) and customary system.
    - Metric system uses the International System of Units.
    - Customary systems used in the United States, however, are based on the English Engineering System of Units.
    - Equivalent metric and customary units exist for measuring primary dimensions.

Primary Dimension	SI Unit	Customary Unit
Length		
Time		
Mass		
Temperature		
Electric Current		
Amount of Substance		
Luminous Intensity		

Mass, Volume, and Density

- These are three of a matter's most basic properties, regardless of their state.
- **Mass**
    - Measure of the heaviness of an object.
    - SI unit: _____
        - Originally defined as the mass of one cubic decimeter of water.
        - Redefined in 1875 as the mass of the International Prototype Kilogram.
        - Currently defined by the Planck constant (h) as $6.626\ 070\ 15 \times 10^{-34}$ J s.
    - Net weight, Gross weight and Drained weight
        - Net Weight: The weight of the product itself, excluding any packaging.
            - Indicates the actual amount of the product that can be consumed.
        - Gross Weight: The total weight of the product and all its packaging.
            - Useful for logistics, this includes everything in the package.

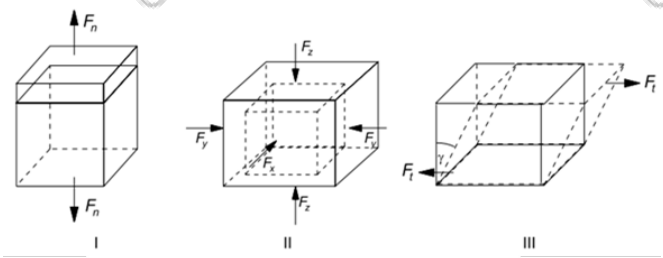
        - Drained Weight: The weight of solid parts in a food product when packed without any liquid.
            - Commonly used for canned foods, which informs the weight of the solid food minus any liquids or non-solid components.
- **Volume**
    - Derived SI unit based on the cube of the base SI unit of length, the meter.
    - One meter is defined by the speed of light in vacuum (c) as 299 792 458 m/s.
- **Density**
    - Defined as mass per unit volume (SI units: kg/m³).
    - Indicates molecular packing in a material.
    - Specific gravity: Ratio of material's density to that of water.
    - For food applications, there are three important terms:
        - Solid density:_____.
        - Particle density: _____.
        - Bulk density: _____.

Rheological Properties

- Rheology - _____
- Specifically, it studies how materials deform or flow under applied forces or stresses.
- In the context of food, rheological properties are vital for quality control, process equipment design, and transport processes.
    - Examples include the softness of cakes and bread and the viscosity of thick liquids.
- Fundamental Concepts: Stress and Strain
    - Stress (σ) is the force per unit area (N/m² or Pa).
        - Equation: $\sigma = F / A$
    - Strain (ε) is the change in length as a percentage when stress is applied.
        - Equation: $\varepsilon = \Delta l / l$
    - The stress vs. strain relationship reveals a material's rheological nature.
    - The modulus of elasticity (E) is the slope of the linear portion of this relationship.
        - Equations: $E = \sigma / \varepsilon$
- Types of Materials
    - Elastic solids: _____
    - Plastic materials: _____
    - Fluids: _____

Name:

- Types of Stress Application in Solids



I – uniaxial, II – bulk compression, III – shear

  - Uniaxial stress:_____
  - Bulk compression: _____
  - Shear force: _____
  - Resulting moduli depending on the stress applied:
    - Young's modulus (E), bulk modulus (K), and shear modulus (G).
- Fluid Behavior
  - Shear stress in fluids causes continuous deformation and fluid flow.
  - The force applied determines the velocity of flow.
- Newtonian vs. Non-Newtonian Fluids
  - Newtonian fluids show a direct proportionality between shear stress and shear rate.
  - Non-Newtonian fluids exhibit more complex relationships between shear stress and shear rate, categorized further based on their behavior.
  - Types of non newtonian fluids:
    - Shear-thinning / Pseudoplastic
      - Shear rate decreases with increasing shear stress.
      - Example: _____
    - Shear-thickening / Dilatant
      - Shear rate increases with increasing shear stress.
      - Example: _____
    - Bingham Plastic
      - Material will not flow unless a certain yield stress is exceeded.
      - Example: _____
    - Herschel-Bulkley
      - Combination of pseudoplastic and Bingham plastic behaviors.
      - Example: _____
    - Time-Dependent / Thixotropic
      - Apparent viscosity remains constant only after a finite amount of time has passed since the application of shear stress.
        - Example: _____

Thermal Properties

- Thermodynamics - _____
- Thermodynamics plays a crucial role in understanding physical phenomena in food processing.
- Specific Heat (C) - _____
  _____
    - Specific heat is typically expressed in units of energy per unit mass per degree Celsius (Joules per gram per degree Celsius, J/g°C) or in the International System of Units (Joules per kilogram per degree Celsius, J/kg°C).
    - Equations:
        - C = Q / (m * ΔT), Where:
            - C: Specific heat (J/g°C or J/kg°C)
            - Q: Amount of heat energy transferred (Joules)
            - m: Mass of the substance (grams or kilograms)
            - ΔT: Change in temperature (degrees Celsius)

Electromagnetic properties

- Electrical Properties
    - Electrical properties- _____
    - Key electrical properties include conductivity, resistivity, and capacitance.
        - Conductivity - _____
            - Conductivity plays a role in measuring oil stability and is used in ohmic heating, where electric current heats food.
        - Resistivity - _____
        - Capacitance - _____
            - Capacitance is utilized in Pulsed Electric Fields, a food preservation method involving short pulses of electricity to inactivate microorganisms.
- Magnetic Properties
    - Materials like food exhibit magnetic polarization when subjected to a magnetic field.
    - Materials are classified based on magnetic properties: paramagnetic, diamagnetic, and ferromagnetic.
        - Paramagnetic materials have unpaired electrons and weakly attract magnetic fields.
        - Diamagnetic materials lack unpaired electrons and show no magnetic polarization.
        - Ferromagnetic materials, such as Fe and Co, exhibit magnetic polarization even without an external field.

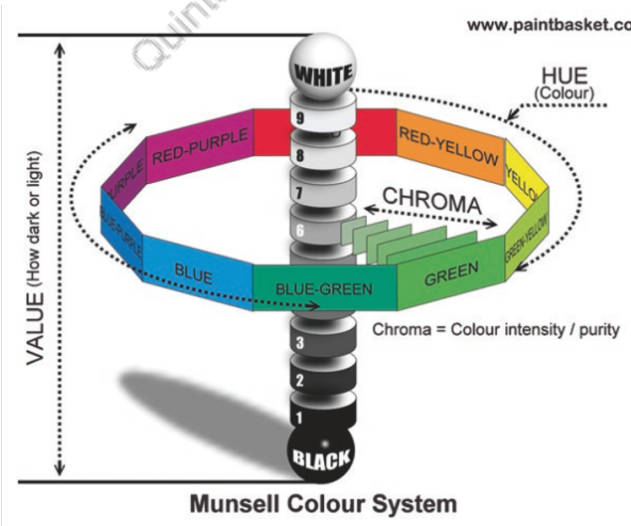
    - Magnetic Field
        - A magnetic field is a vector field where moving charges experience a force perpendicular to their velocity.
    - Nuclear Magnetic Resonance (NMR)
        - NMR - _____
        - NMR spectroscopy is used for quality control, determining sample content and purity.
    - Inducing Currents with Alternating Magnetic Field
        - A change in magnetic flux induces electromotive force (EMF) in a wire loop, following Faraday's Law.
        - Induction heating relies on this principle to generate currents for heating purposes.
            - Faraday's Law: $\varepsilon = -N\Delta\Phi/\Delta t$, where
                - ε represents induced voltage,
                - N is the number of loops,
                - $\Delta\Phi$ is the change in magnetic flux, and
                - Δt is the change in time.
- Electromagnetic properties pertain to how materials respond to the absorption or emission of electromagnetic radiation.
    - This radiation includes radio waves, microwaves, ultraviolet rays, infrared rays, and visible light rays.
    - Various types of electromagnetic radiation find applications in the food industry.
    - These electromagnetic properties are essential in various aspects of food science and technology, from preservation techniques to quality control processes.
- Applications of Electromagnetic Radiation
    - Ultraviolet rays are employed for food pasteurization and fortification.
    - Visible light rays are significant for the optical properties of food (covered in a later exercise).
- Microwaves in Food Processing
    - Microwaves are a type of electromagnetic radiation with wavelengths between _____.
    - They play a crucial role in thermal food processing methods.
    - Common applications of microwaves in food include thawing, sterilizing, baking, and drying.
- Factors Affecting Microwave Absorption
    - Various food properties influence the absorption of microwave energy.
    - Understanding these factors is essential for food product development.

Optical Properties

- Optical properties pertain to how materials respond to incident electromagnetic radiation with optical wavelengths and frequencies.
- Key optical properties include refraction, reflection, transmission, absorption, and scattering.
- Refraction
    - This occurs when light is bent as it passes through different media.
    - Light changes direction and velocity when crossing an interface between different media.
- Reflection
    - This occurs when light bounces back when it reaches the interface between two different media.
    - The light remains within one medium after contact with another.
- Transmission
    - Light passes through a medium without refraction, reflection, absorption, or scattering.
    - Transparent materials like glass, plastic, and air exhibit this property.
- Absorption
    - Occurs in media that convert light into heat, reducing the radiance of the light.
    - Common in opaque materials.
- Scattering
    - Light is redirected through reflection or refraction, causing different parts of the radiation to scatter in various directions.
- Refractometry
    - A method for measuring the refractive index of a substance.
    - Based on Snell's Law, it assesses the amount of incident light refracted by the substance.
        - Snell's Law, also known as the law of refraction, describes how light rays change direction when they pass from one transparent medium into another. It relates the angles of incidence and refraction to the refractive indices of the two media.
        - Equation: $n1 \sin \theta 1 = n2 \sin \theta 2$
            - $n1$ is the refractive index of the first medium (where the light is coming from).
            - $\theta 1$ is the angle of incidence, which is the angle between the incident light ray and the normal (perpendicular) to the surface of the first medium.
            - $n2$ is the refractive index of the second medium (where the light is entering).

- $\theta 2$ is the angle of refraction, which is the angle between the refracted light ray and the normal to the surface of the second medium.

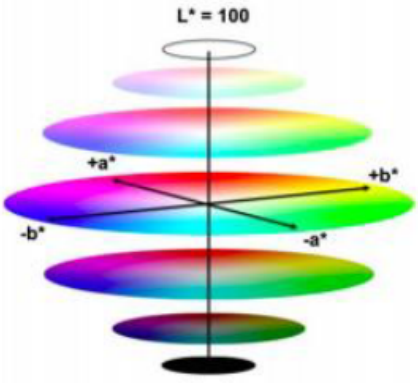
  - Often used to evaluate purity by comparing refractive indices.
- Total Soluble Solids, Brix
  - Measures the sugar content of a substance using a refractometer.
  - Reported in °Bx, where 1°Bx equals 1g of sucrose per 100 mL solution.
- Effects of Heat and Time on Color
  - Heat can degrade color in vegetables and red meat.
  - Chlorophyll degradation in vegetables causes a green color loss.
  - Myoglobin pigment in red meat can degrade, changing its color.
  - Extended storage time can lead to color changes in fruits, vegetables, and meat.
- Munsell Color System
  - Color is described in terms of _____, _____, and _____
  - _____ - 10 values distributed along a circle
    - Red (R), Yellow (Y), Green (G), Blue (B), Purple (P)
    - YR, GY, BG, PB, RP
    - Each _____ is at the midpoint of a 1-10 scale
  - _____ - 0 (black) to 10 (white)
  - _____ - 0 (central gray)
  - Written as H, V/C
    - Ex. _____
  - All colors that can be made with available pigments are represented as color chips in the Munsell book of color



Munsell Colour System

- LAB Colorspace
  - Developed by the CIE, it quantifies color using three parameters: L* (lightness/darkness), a* (red/green), and b* (yellow/blue).
    - L* ranges from 0 (black) to 100 (diffuse white).
    - Delta E (dE)

- Measures the difference between two colors in the CIELAB color space.
- Detectable by the human eye when dE ≥ 1.



Lecture Guide 1
Food Composition and Basic Concepts

Photo from Unsplash

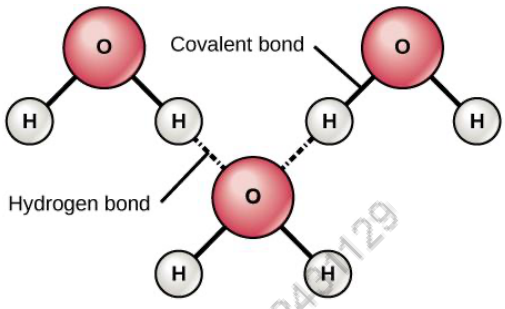
FOOD CHEMISTRY

- Macro-components of Food
  - Water
  - Carbohydrates
  - Lipids
  - Proteins
- Micro-components of Food
  - Enzymes
  - Browning Reactions
  - Colorants
  - Flavors
  - Vitamins
  - Minerals
  - Additives
  - Allergens and Toxicants

Macro-components of Food

Water

- AKA "Universal solvent"
- Important component of living cells (~70%)
- Functions:
  - _____
  - _____
  - _____
  - _____
- Structure

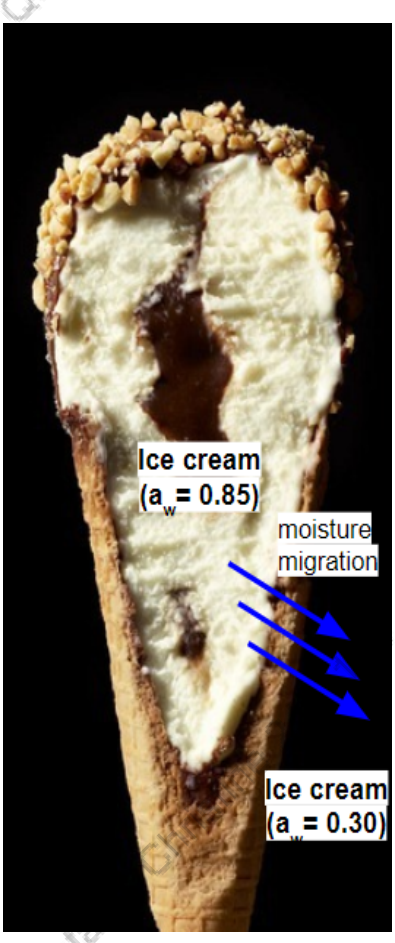


Water molecule structure
(https://s3-us-west-2.amazonaws.com/courses-images/wp-content/uploads/sites/1648/2017/06/18203545/Figure_02_01_06.jpg)

  - H and O atom within the water molecule connected via _____ (equal sharing of electrons)
  - Bond angle of _____ instead of the usual 109.5° with tetrahedral geometry
  - H atom from one H_2O molecule and O atom from another H_2O connected via hydrogen bond
    - Implication: _____
  - The lone pair of electrons in oxygen causes bent structure
    - Implication: _____
- Relatively high latent heat of vaporization and heat capacity compared to other compounds
  - Implication: _____
- Boiling point at 1 atm: _____
- Melting point at 1 atm: _____
- Density: _____ (decreases below and above 0°C)
- Expands upon solidification
  - Implication: _____
- Triple point of water: _____(point where H_2O exist as solid, liquid and gas)

Name:

- Forms of water in food
  - _____
    - Does not exhibit the flow properties and solvent capability commonly associated with water
    - Cannot be frozen
    - Difficult to remove by drying
    - Unavailable for microbial enzymatic, chemical activities
  - _____
    - Found on the surface of macromolecules (proteins and starch)
    - Caused by the hydrogen bonding of the macromolecules to water
    - Available for microbial growth, chemical reactions, enzymatic activities
  - _____
    - Unassociated with other substances
    - Has properties similar to pure water
    - Easily removed by drying
    - Available for microbial growth, chemical reactions, enzymatic activities
- _____- water with high mineral content (i.e. Ca and Mg) in the form of bicarbonates [$Ca(HCO_3)_2$, $Mg(HCO_3)_2$], sulfates [$CaSO_4$, $MgSO_4$], chlorides [$CaCl_2$, $MgCl_2$], oxides [CaO, MgO] and nitrates [$Ca(NO_3)_2$, $Mg(NO_3)_2$]
  - Results in the following problems:
    - Spotting/staining on glass
    - Deposits in hot water heaters and pipes
    - Scalding on sinks and fixtures
    - Film on bathroom surfaces
    - Food/beverage preparation issues
- Water Activity (Aw)- measurement of _____ for biological and chemical reactions in a food product
  - Aw= 1, maximum activity; Aw= 0, no activity (normally at 0% moisture)
  - Soluble solutes (salts, sugars) more likely reduce aw than colloidal or insoluble constituents (ex. Sugars and minerals > proteins)
  - Low molecular weight solutes depress water activity more than longer chain molecules (ex. Glucose (monosaccharide) > sucrose (disaccharide) or polysaccharides
  - Lower Aw ingredient gains moisture; higher Aw ingredient loses moisture (based on Salwin Equation) in case of mixing two or more food ingredients with varying Aw



- Electrolytes have double effect on reducing aw because of the dissociation into ions (actually into two moles of solutes)
- Relative vapor pressure

$$RVP = a_w = \frac{P}{P_w} \qquad ERH\ (\%) = \frac{P_{air}}{P_w} \times 100 \qquad a_w = \frac{ERH\ (\%)}{100}$$

P = vapor pressure of water in food

P_w = vapor pressure of pure water **at the same temperature and atmospheric pressure**

- At equilibrium, VP of food = AP of the air at its headspace
- Water activity of food after equilibration can be determined by measuring ERH at its headspace in an enclosed container

Name:

- Raoult's Law

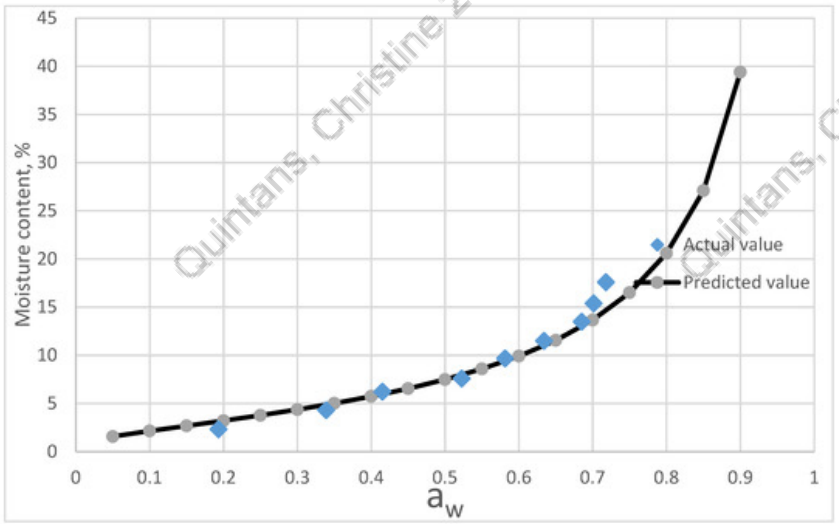
$$X_w = a_w = \gamma\left(\frac{moles\ of\ water}{moles\ of\ water + moles\ of\ solute}\right)$$

Xw = mole fraction of water
γ = activity coefficient = 1 for ideal solutes likes sugars and salts
γ is very small for large molecules

***Applicable at aw of 0.95 for most low molecular weight solutes

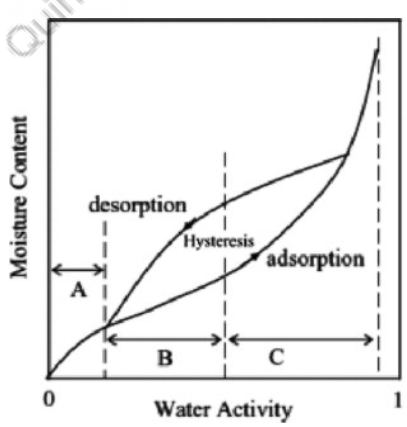
- Intermediate moisture foods (IMF)- food products with Aw of 0.6 to 0.9 such as jams, jellies, fruit cakes, condensed milk, fruit bars, smoked sausages, honey, semi-moist dog foods, partially dried products (figs, dates, jerk, etc.)

- Moisture sorption isotherm (MSI)- plot that describes the relationship between the EMC of a specific food material (expressed as mass of water per unit mass of dry matter) and Aw of the food (equivalent to ERH of the environment at a given temperature



Sample moisture sorption isotherm graph
https://www.mdpi.com/foods/foods-08-00191/article_deploy/html/images/foods-08-00191-g005-550.jpg

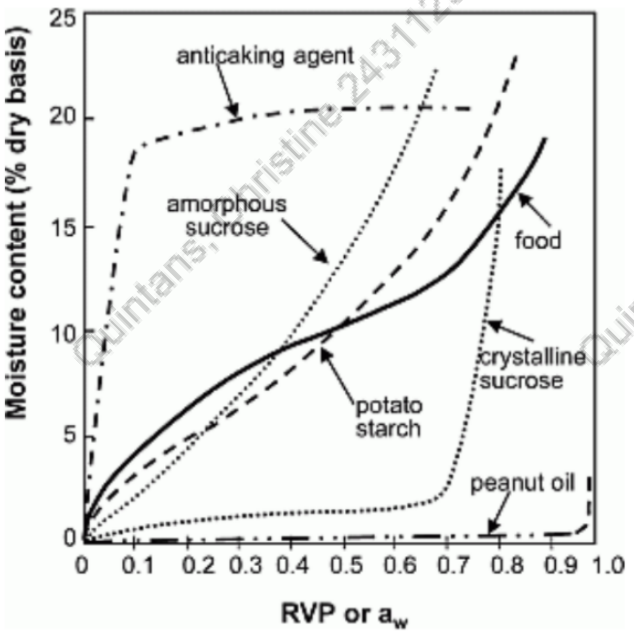
- _____ - removal of moisture (evaporation, drying) from "wet" foods
- _____ - attraction of moisture by dried foods
- _____ - discrepancy between the two isotherms (desorption and adsorption); difference of MC at the same Aw (or ERH) and temperature



Hysteresis

https://www.researchgate.net/profile/Ricardo-Andrade-7/publication/220014226/figure/fig1/AS:394019189346312@1470952903762/Sorption-isotherm-for-a-typical-food-product-showing-the-hysteresis_Q320.jpg

- EMC determination follows a definite sequence: Desorption□Resorption
- Three (3) Types of MSI (According to food hygroscopicity)

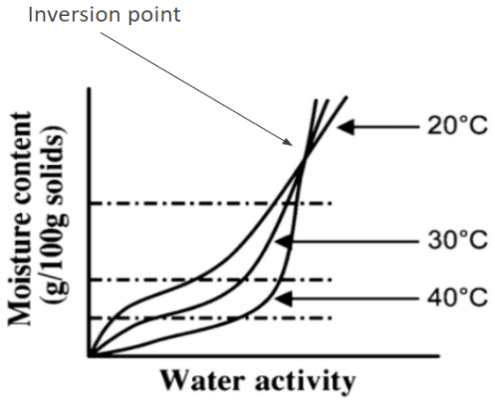


  - Type I: Crystalline materials not hygroscopic- not hygroscopic
  - Type II: Proteins, gums and amorphous materials- moderately hygroscopic
  - Type III: Anti-caking agents-very hygroscopic

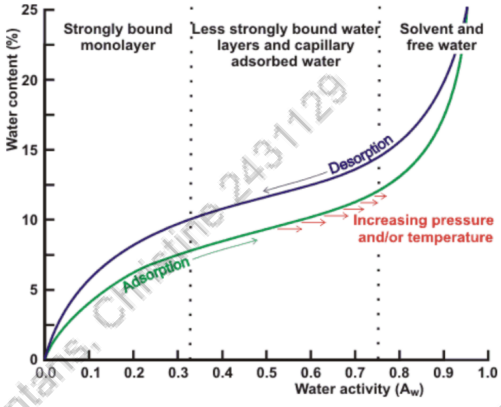
- Effect of temperature on MSI
  - At a constant moisture content, the Aw _____ with the rise of temperature

Name:

- At a constant Aw, moisture content _____ with a decrease in temperature



- Zones of MSI



- Zone I: Monolayer Region
  - Leftmost section of the isotherm
  - Tightly bound water, strongly sorbed held by water-ion and water-dipole interactions in a single layer with polar CO-, NH-, and OH- groups
  - Least mobile, behaves as part of solid matter and exceptionally hard (if not impossible) to remove
- _____
  - Moisture content at Zone 1 and Zone 2 boundary
  - Food is most stable at this moisture content
  - Aw to the left of V_M, _____ increases
  - Aw to the right of V_M, _____ increases
  - Same Aw but above Vm, chips and other snacks loss crispness
- Zone II: Multilayer Region
  - Middle section in the MSI (relatively straight)
  - Transitional region

- Water molecules appear as a multilayer
- Weak binding forces; loosely bound water, held by covalent and H-bonds
- Additional layers bound to the Zone 1 water, through physical adsorption
- Able to dissolve solutes, leading to acceleration of reaction rates
- Difficult to freeze and remove

■ Zone III: Capillary Condensation Region

- Rightmost section
- Bulk-phase water, free (in interstices), capillary forms
- Moisture available for microbial growth and enzymatic activities—food is susceptible to spoilage
- Water is mobile, freezable can easily dissolve solutes
- A dilute solution but behaves like pure water, readily available, easily removed by drying with minimal impact on food stability

- Calculation of EMC at every ERH

$$EMC\,(\%db) = \left[\frac{(W - W_i) + (W_i \times MC_i)}{W_i \times (1 - MC_i)}\right]$$

W = weight of sample at equilibrium
W_i = initial weight of sample
MC_i = initial moisture content (% WB)
$W - W_i$ = water gained or lost
$W_i \times MC_i$ = initial water in sample
$1 - MC_i$ = % dry matter (% DM)

- Calculation of MC

$$\%MC\ [Wet\ basis\ (\%WB)] = \frac{g\ H_2O\ in\ sample}{g\ wet\ sample} \times 100$$

$$\%MC\ [Dry\ basis\ (\%DB)] = \frac{g\ H_2O\ in\ sample}{g\ dry\ matter} \times 100$$

$$= \frac{g\ H_2O\ in\ sample}{g\ wet\ sample\ -\ g\ H_2O\ in\ sample} \times 100$$

$$\%MC\ [Dry\ basis\ (\%DB)] = \frac{\%WB}{100\ -\%WB} \times 100$$

Name:

Carbohydrates

- Second major food constituent after water
- General formula: _____
- Nomenclature
    - Suffix: "ose"- indicates a carbohydrate
    - Prefix
        - Aldo indicates an aldehyde group [carbonyl (C=O) group, position 1]
        - Keto indicates a ketone group [carbonyl (C=O) group, position 2]
    - Infix- the number of carbon

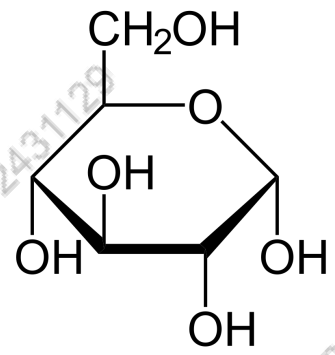
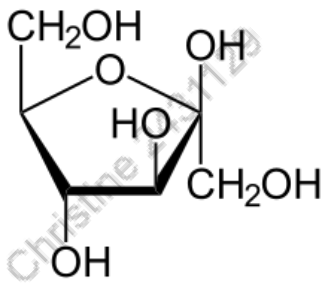
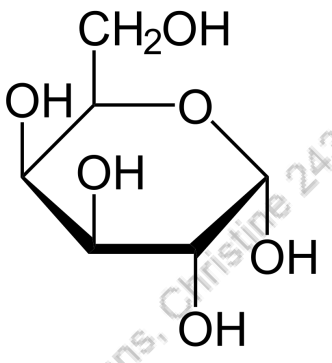
Number of Carbon atoms	Sugar
3	
4	
5	
6	
7	
8	

    - Example:
        - Aldohexose – Number of carbons: _____
        - Ketotriose – Number of carbons: _____
- Classification according to availability
    - Available carbohydrates- can be readily digested by humans
        - Sugar
        - Starch
        - Glycogen
    - Unavailable carbohydrates- cannot be readily digested by the humans
        - Water soluble
            - _____
            - _____
            - _____
            - _____
            - _____
        - Water insoluble
            - _____
            - _____
            - _____

- Classification according to number of sugar molecules
  - ____saccharides- one (1) sugar molecule
  - ____saccharides- two (2) monosaccharide units
  - ____saccharides- 3-10 monosaccharide units
  - ____saccharides- >10 monosaccharide units
- Sources of carbohydrates
  - Plants
    - Sugars: _____
    - Cellulose: _____
    - Hemicelluloses: _____
    - Starch: _____
    - Pectic substances: _____
    - Gums and mucilage: _____
    - Heteropolysaccharides: _____
  - Animals
    - Glycogen: _____
    - Lactose: _____
    - Chitin: _____
  - Algae
    - Agar: _____
    - Carrageenan: _____
    - Alginate: _____
  - Microorganisms
    - Dextran, xanthan gum: _____
    - Cellulose: _____
    - Chitin: _____
- Functions in food
  - _____
  - _____
  - _____
  - _____
  - _____
- Monosaccharides
  - Also known as:
  - One carbonyl group (C=O) in
  - One –OH group and one H per C atom
  - Alcohol group in
  - Monosaccharides are named D- or L- based on configuration about the 2nd bottom carbon atom or the chiral carbon (if there is only one)
    - ___-isomers of monosaccharides occur in foods
    - _____: most important D-aldose
    - _____: most important D-ketose

Name:

- Chemical reactions and derivatives
  - Reduction to sugar alcohols by sodium borohydride ($NaBH_4$) either electrolytically or via catalytic hydrogenation
    - Sample product: _____
  - Oxidation to aldonic, dicarboxylic and uronic acids
    - Sample product: _____
  - Reactions in the presence of acids and alkalis
    - Sample product: _____
  - Isomerization
    - Sample product: _____
  - Maillard reaction
    - Sample product: _____
- Examples

- Disaccharides
  - Examples
    - _____ + _____ = Sucrose
      Uses and relevance to food:
      _____
    - _____ + _____ = Maltose
      Uses and relevance to food:
      _____
    - _____ + _____ = Cellobiose
      Uses and relevance to food: _
      _____
    - _____ + _____ = Lactose
      Uses and relevance to food:
      _____

- _____ + _____ = Melibiose
  Uses and relevance to food:
  _____

- Reducing Properties
  - Reducing Disaccharides
    - One of two anomeric carbons has a free hydroxyl group
    - Can be oxidized by the Cu2+ in Benedict's and Fehling's solutions
  - Non-reducing Disaccharides
    - Both anomeric carbons have no free OH groups
    - No oxidizable group to react with Cu2+ in the Benedict's and Fehling's solutions

- Oligosaccharides
  - Examples
    - _____ + _____ = Raffinose
      Uses and relevance to food:
      _____
    - _____ + _____ = Melezitose
      Uses and relevance to food:
      _____
    - _____ + _____ = Stachyose
      Uses and relevance to food:
      _____

- Polysaccharides
  - General term: glycans (glucan, galactan, mannan, xylan, fructan)
  - Structure:
    - High molecular mass
    - Linear or branched
    - Homo or hetero
  - Non-reducing and mostly tasteless
  - Solubility
    - Has strong affinity for water and can take up water, swell and may undergo partial or complete dissolution depending on conditions (temperature, pH)
    - Increases with _____ degree of irregularity of chains

- Gel formation
  - _____ - continuous, 3-dimensional network of connected molecules or articles entrapping a large volume of a continuous liquid phase
  - _____ - appearance of fluid droplets on the gel surface; water is released due to retrogradation (re-bonding of polysaccharide chains)
- Starch
  - Source: _____
  - Composition
    - _____ - purely linear; repeating units of α-D-glucose with α-1,4 linkage
    - _____ - branches at α-1,6 while also having α-1,4 links between glucose units
  - Starch granules in water
    - Cold water - _____
    - Hot water
      - _____ - irreversible swelling of granule
      - _____
      - _____
      - _____
      - _____
    - _____ - the change in rheological properties of starch that occur on allowing starch solutions/ pastes/gels to stand for a few hours; rebonding of polysaccharide chains
    - _____- water is expelled as gel shrinks
  - Modified starches
    - _____ - starch is gelatinized & dried fast (using spray drier); easily dispersed in cold water; used for "instant desserts" (e.g. puddings) or baking aids
    - _____ - produced through partial acid hydrolysis; readily soluble in boiling water; lower viscosity, remains fluid after cooling; with low retrogradation; used as thickener and in papers
    - _____ - result of dry heating of starch w/ alkaline orthophosphate resulting in improved thickening properties, better paste clarity, and improved freeze-thaw stability
    - _____ - partially hydrolyzed amylose molecules produced through treatment of starch with heat, or acid, or enzyme
    - _____ - oxidized starch with a cross-linker having at least two functional groups used for food texture modification, drug delivery and controlled release of flavors
    - _____ - addition of charged or nonpolar groups to

reduce intra- and interchain interactions

- Resistant starches
  - RS1- _____
  - RS2- _____
  - RS3- _____
  - RS4- _____
- Starch degradation products
  - Acid hydrolysis: _____
  - Enzymatic hydrolysis: _____
  - Enzymatic isomerization of glucose: _____

- _____ - a type of polysaccharide for energy storage found mainly in the liver and minimally in muscles
- Cellulose
  - Most abundant carbohydrates found as principle cell wall component of higher plants
  - Crystalline, strong, resistant to hydrolysis by dilute acids and bases
  - Unbranched/linear with high molecular weight
  - Insoluble homopolymer of repeating _____ units joined by (1□4) glycosidic linkages
  - _____ + _____ = Dietary Fiber (normally associated with cellulose)
    - _____ - non carbohydrate group of compounds filling the cell walls of plants together with celluloses
  - Modified celluloses
    - _____ - produced from the physical and/or chemical modification (such as simple hydrolysis) of native cellulose
    - _____ - produced from chemical modification of cellulose through introduction of alkyl groups; soluble in cold water; and can be used to reduce amount of fat in food products by acting as fat mimic
    - _____ - most popular form of hydroxyalkylated cellulose used as stabilizer in protein dispersions (egg & milk products)
- Hemicelluloses - a large family of heteropolysaccharides including glucomannan, arabinogalactanan, arabinoxylan, glucuronoxylan, xyloglucan, etc.
  - Represented by the difference between _____ and _____ in detergent fiber systems

- Present with cellulose in almost all plant cell walls; structural function; weak,random amorphous structure; easily hydrolyzed by dilute acid or bases

- Pectic substances
  - Group of related polysaccharides, galacturonan, with different lengths and degree of methylation (DM)
  - Present in the plant cell wall and generally associated with cellulose
  - Major components of the middle lamella (glue for cell wall) in the form of calcium and magnesium pectate
  - Functions:_____
    _____
  - Degree of esterification (DE) = (number of esterified D-galacturonic acid residues per total number of D-galacturonic acid residues) x 100
    - _____ - DE > 60%
    - _____ - DE < 60% but > 0%
      - Salt form - _____
    - _____ - DE = 0% (no methyl esters)
      - Salt form - _____
- β-glucan
  - Glycans composed of β-D-glucose units
  - Found in cell walls of bacteria, b aker's yeast, mushrooms, algae, lichens, and cereals (like oats, barley, millet)
  - Types may vary depending on molecular backbone, branch point, branch length and molecular weight
  - Use: _____
- Inulin
  - A soluble fructan with 10-60 _____ units
  - Shorter chains are called fructooligosaccharides or oligofructose
  - With/without a terminal glucose unit
  - Found in yacon, jicama, garlic, chives, onions, leeks (free/raw forms of these food products are sweet due to inulin)
  - Sweet when chain length is short
  - A prebiotic that is not digested outside the colon
  - Metabolized in the colon into SCFA, carbon dioxide, hydrogen and methane
- Chitin
  - Also known as β (1-4)-2-acetamido-2-deoxy-D-glucose or N-acetyl-D-glucosamine
  - Found in _____
  - Backbone similar to cellulose w/ acetamido ($NHCOCH_3$) group in C2
  - 82.5% acetylglucosamine, 12.5% glucosamine and 5.0% water
  - Insoluble in water, dilute acids & alcohol

- Less reactive than cellulose
- Used as _____

- Mucilage
  - Soluble but indigestible complexes of _____ and _____
  - Found in almost all plants but in small quantities along with tannins
  - Large amounts in _____
  - Take up water and swell but does not dissolve
  - Form slimy masses with adhesive properties
  - High-water holding and viscous properties
  - Used as thickening and stabilizing agents in food systems
- Plant gums
  - Guar gum
    - Found in _____
    - Structure: _____
    - Hydrates completely in cold water due to high steric effect of galactose branch
    - Highly viscous solutions with any natural gum
    - Synergistic with anionic polymer
    - Dissolves at low temperature
    - For thickening (in ice cream, combined with CMC, carrageenan, locust bean gum, xanthan gum)
  - Tara gum
    - Found in _____
    - Structure: _____
    - Requires heating to disrupt the aggregates and achieve complete hydration
    - Highly viscous solutions
    - Synergistic interaction with xanthan and carrageenan to form rigid gels
    - Resistant to pH changes
    - For texture modification of dairy and frozen dessert products
  - Locust gum
    - Found in _____
    - Structure: _____
    - Highly viscous solutions
    - Synergistic interaction with xanthan and carrageenan to form rigid gels
    - Insoluble in cold water; heating needed (Δ85°C)
    - Resistant to pH changes
    - For texture modification of dairy and frozen dessert products

- Gum arabic/gum acacia
  - Found in _____
  - Structure: _____
  - High solubility, low viscosity, gels at 50% concentration, compatible with high-sugar confections
  - Emulsifier (in soft drink concentrates), prevents sugar crystallization (i.e. in caramels, toffees, pastilles).
- Gum tragacanth
  - Found in _____
  - Structure: _____
  - Slightly acidic, occurring naturally with Ca^{2+}, Mg^{2+} and Na^{+}
  - _____ - a substance that is a constituent of tragacanth and is insoluble in water but swells to form a gel
  - High viscosity
  - Thickening agent and stabilizer in salad dressings (0.4-1.2%), in fillings and icings in baked goods; additive in ice creams
- Konjac gum
  - Found in _____
  - Structure: _____
  - Firm/tough gel, water-soluble, low calorie does not melt in the mouth; may cause choking
  - Gelatin substitute (vegan diet), thickener, texture modifier, main ingredient used in shirataki noodles ("miracle noodles")

- Seaweed gums
  - Agar
    - Found in _____
    - Structure: _____
      - _____ - responsible for the gelling power; neutral long chain molecule formed by β-D-galactopyranosyl units connected through C1 and C3 with 3,6 AG residues connected through C1 and C4
      - _____ - low gelling; alternating D- and L- galactose and all polar groups in agar
    - High gelling capacity forming thermoreversible gels, prone to syneresis
    - Used as "Gulaman" bar made into dessert; Microbial culture medium
  - Carageenan (kappa, iota, lambda, etc.)
    - Found in _____
    - Structure: _____
      - _____ carrageenan- firm and brittle gel texture, potassium as optimum cation, syneresis is possible

- _____ carrageenan- elastic gel texture, calcium as optimum cation, no syneresis
- _____ carrageenan- non gelling due to more presence of sulfate groups

- Processed Euchuema Seaweed (PES) Manufacture- also known as _____
  - Cleaned and washed seaweed that has undergone alkali treatment, freshwater washing, drying and milling
- Refined Carrageenan Manufacture
  - Cleaned and washed seaweed that has undergone alkali treatment, freshwater extraction, filtration, alcohol precipitation, drying and milling
- Form viscous solutions and thermo reversible gels
- Interacts with proteins and other gums
- Used as gelling, thickening and binding agent in several processed food products from meat and dairy products as well as pharmaceutical and non-food products

■ Alginates
- Found in _____
- Structure: _____
- Dissolves in cold/hot water
- Forms solutions with high apparent viscosity
- Gels formed with divalent cations are thermally reversible
- Used for water holding, gelling, emulsifying, stabilizing

○ Microbial gums

■ Xanthan gum
- Found in _____
- Structure: _____
- High solution viscosity at low concentration
- No change in solution viscosity between 0-100°C
- Soluble and stable in acidic systems
- Freeze-thaw stable Interacts with other gums and used as stabilizer in various food products

■ Dextrans
- Found in _____
- Structure
  - Class 1: _____
  - Class 2: _____
  - Class 3: _____

- Used to treat hypovolemia (blood volume expander)
- Also used as thickener for jam and ice cream

Lipids

- Generally referred to as fats (solid) or oils (liquid) in food depending on the physical state
- Organic substances insoluble (or sparingly soluble) in water and polar organic solvents
- Soluble in nonpolar solvents (hydrocarbons, chloroform, diethyl ether, acetone, etc.)
- Key components
  - _____ - polyhydric alcohol with 3 carbon atoms
  - _____ - aliphatic monocarboxylic acids
- Basic structure of lipids
  - Formation of triacylglycerol (TAG) when OH groups in the glycerol backbone react with the COOH group of the fatty acid forming an ester and water
  - Structure similar to a tuning fork
  - Fatty acids in TAG influence their chemical and physical properties
  - TAGs with short-chain fatty acid (SCFA) are volatile and partially soluble in water
    - Length of carbon chain affect polarity and water solubility/miscibility
- Nomenclature
  - Saturated fatty acids- no double bonds; each C is bonded to four single atoms
    - Named after the hydrocarbons w/ the same # of C atoms (CH_3 replaced by COOH). Terminal letter *–oic* instead of *e*

      Ex. Hexane $CH_3(CH_2)_4CH_3$ → _____ $CH_3(CH_2)COOH$

    - As a carboxylic w/ the prefix being the hydrocarbon to which the carboxyl group is attached

      Ex. Pentane $CH_3(CH_2)_3CH_3$ → _____ $CH_3(CH_2)_4COOH$

- Common name: Butyric, stearic, oleic

No of carbon atoms	Common name
4	
6	
8	
10	
12	
14	
16	
18	
20	
22	
24	

- Numerical Expression: 4:0 (butyric), 12:0, 16:0
- Abbreviation/symbol: P for palmitic; L for Linoleic

- Unsaturated fatty acids- one or more C are linked to a second carbon by a double bond; two molecules with same number and position of unsaturation may differ in terms of configuration (i.e. cis or trans)
-

- Named after the parent saturated hydrocarbon. Terminal part *-anoic* → *-enoic* ; *di-*, *tri-* represents # of double bonds

Ex. 16:1 (hexadecenoic acid)
18:3 (octadecatrienoic acid)
20:5 (_____)
22:6 (_____)

- To indicate location of double bond, put before the name of the acid the number for each unsaturated linkage

Ex. Oleic acid (1 double bond at C9): _____

Name:

- Numerical expression:

  18:1ω9 (oleic acid with 1 unsaturation,
  9ω indicates that unsaturation is between C9 and C10)

- Generally, saturated FAs are associated with _____ sources while unsaturated FAs are associated with _____ sources
- SFAs are packed more easily and tightly compared to UFAs requiring much energy to melt
- Essential VS non-essential fatty acids (FAs)

Omega-6 Polyunsaturated Fatty Acids	Non-Essential Fatty Acids	Omega-3 Polyunsaturated Fatty Acids
 Linoleic acid (LA) C18:2n-6	 Palmitic acid (PA) C16:0 Saturated Fatty Acid	 α-Linolenic acid (ALA) C18:3n-3
 γ-Linolenic acid (GLA) C18:3n-6	 Oleic acid (OA) C18:1n-9 Monounsaturated Fatty Acid	 Eicosapentaenoic acid, EPA C20:5n-3
 Arachidonic acid (AA) C20:4n-6	 Elaidic acid (EA) C18:1n-9 trans, Trans Fatty Acid	 Docosahexaenoic acid, DHA C22:6n-3

  - Non-essential FAs- can be synthesized de novo and do not need to be provided by the diet
  - Essential FAs- need to be obtained from the diet because they cannot be made from raw materials within the body
- Simple lipids
  - Fats and oils (Triglycerides)
    - Most important lipid constituent of foods (95% total lipids in foods)
    - Glycerol + 3 Fatty acids
    - Can be pure or mixed (e.g. oil, lard, cocoa butter)
  - Waxes
    - Ester of a _____ and _____
    - Cuticle waxes on fruit & vegetable leaves to protect from predators and prevent water loss
    - Contain C24-C35 fatty acids
    - Long-chain primary and secondary alcohols
    - Examples

      Carnauba wax (from carnauba palm) $CH_3(CH_2)_{30}CO_2(CH_2)_{33}CH_3$
      Beeswax (from honey bees) $CH_3(CH_2)_{24}CO_2(CH_2)_{29}CH_3$
      Spermaceti (from sperm whale) $CH_3(CH_2)_{14}CO_2(CH_2)_{15}CH_3$

- Compound lipids
    - Esters of fatty acids with alcohol and additional groups
        - **Phospholipids**- similar to TAG but fatty acid is replaced by _____ group
        - Sphingosine derivatives
        - Sulfolipids
        - Lipoproteins
    - Found in egg yolk lipids (67% TAG, 28% phospholipids, 5% cholesterol), live, yeast and soy beans (commercial source of lecithins)
    - Used for emulsification

- Derived lipids
    - Substances derived from simple and compound lipids by hydrolysis
        - Fatty acids
        - Fat-soluble vitamins (A, D, E, K) (*to be discussed under Vitamins*)
        - Fat-soluble pigments (chlorophylls) (*to be discussed under Colorants*)
        - Fatty alcohol (lauryl, stearyl)
            - Compounds with a free 1°, 2° or 3° _____ attached to a long chain group
            - Usually long chain primary alcohols, but they can also range from as few as 4-6 carbons to as many as 22-26 carbons
            - Typically saturated and straight-chain but can also be unsaturated and with methyl branching
            - Medium-chain alcohols: lauryl, myristyl
            - Long-chain alcohols: cetyl, stearyl, cetostearyl, and behenyl
            - Used in personal care products, oral care, dishwashing, antioxidants, flavorants, fragrances, plasticizer
        - Terpenes (rubber or polyisoprene)
            - **Isoprene (C_5H_8)**- basic building block of terpenes; also called _____ due to being half a terpene
                - Multiples of C5 units (C_{15}, C_{20}, etc.)
            - **Terpenoids**- also known as _____ are derived from isoprene but have additional functional groups
            - Lipidous component that give plants their fragrance/aroma
            - Citrus essential oils are thermally labile and easily oxidized
            - Anti-inflammatory, analgesic, antiseptic antimicrobial, stimulant mucolytic, decongestant
        - Carotenoids (tetraterpenes) (*to be discussed under Colorants*)
            - Pigments in plants, algae and photosynthetic bacteria
            - Tetraterpene consisting of 8 isoprene units
            - Non-polar and soluble in organic solvents

        - Steroids (estrogen, progesterone)
            - Terpene system with a common polycyclic framework
            - Involved in the control of biological processes
            - Sterols- steroid alcohols which is a subgroup of steroids (ex. cholesterol)
- Sources of lipids
    - **Milk fats**- palmitic, oleic and stearic acid with appreciable amounts of shorter chain fatty acids (C4-C12)
    - **Coconut oil**- high _____ (40-50%); moderate amount of C6, C8, and C10
    - **Vegetable butters**- seeds of tropical trees; narrow melting range; high saturated/unsaturated fatty acid ratio; no tri saturated acyl glycerols
    - **Vegetable oils**- high _____ acids (i.e. cottonseed, corn, peanut safflower, olive, sesame)
    - **Linolenic oils**- high linolenic acids (i.e. soybean rapeseed, flax seed wheat germ)
    - **Animal fats**- lard tallow; large amounts of C16 and C18
    - **Marine oil**s- long chain omega-3 polyunsaturated fatty acids (e.g. DHA, EPA); less resistant to oxidation
- Functions in food
    - _____
    - _____
    - _____
    - _____
    - _____
    - _____
    - _____
    - _____
    - _____
    - _____
- Melting point of lipids
    - No sharp melting points due to possible combinations of fatty acids in the TAGs SCFAs alone, MCFAs alone, LCFAs alone, mixture of SC/MC/LCFAs, unsaturated alone, saturated alone, mixture of U and SFAs, mixture of SC/MC/LC/U/SFAs
    - Melting point is affected by chain length, degree of unsaturation, isomerism, positional distribution of FAs
        - Chain length: MP _____ as chain length increases
        - Degree of unsaturation: MP _____ as degree of unsaturation increases
        - Isomerism: MP of FA with trans bonds are _____ than FA with cis bonds
        - Positional distribution of FAs in the glycerol moiety: MP of TAGs vary depending on the order of position in the glycerol backbone

- Plasticity
  - property that allows fats to yield or give way to some pressure or force; makes fat soft and spreadable
  - due to ratio of solid phase to liquid phase of lipids

Solids	Plasticity
<10%	_____
10-50%	_____
>50%	_____

  - Affected by type and composition of TAGs and temperature

- Crystallization and polymorphism
  - Three (3) principal forms
    - _____: least stable; lowest melting point; hexagonal
    - _____: most stable; highest melting point; triclinic
    - _____: intermediate stability; intermediate melting point orthorhombic
  - In Shortenings
    - β'-tending fats are ideal
    - α-tending fats, too soft products
    - β-tending fats, grainy due to large crystals
  - Chocolates
    - _____: appearance of white streaks or "whiskers" due to melting of less stable form & recrystallization to a more stable form
- _____- temperature at which fat begins to emit smoke varies from oil to oil
  - "smoke" or vapor is made up of _____, a health hazard
- _____- temperature where vapor from fat ignites, blue flame
- _____- temperature where combustion is sustained, yellow flame
- Chemical properties of lipids
  - _____
    - amount of free OH group in fats
    - mg KOH required to neutralize acetic acid liberated by hydrolysis of 1 g of the acetylated substance
  - _____
    - characterizes fat in terms of chain length or average molecular weight
    - involves heating followed by titration with KOH solution
    - mg KOH required to saponify (detach FAs from glycerol backbone & react with 1 g of fat or oil under standardized conditions
    - High SV= low MW TAGS; low SV= high MW TAGs

        - Ester Value= SV- FFAV
    - _____
        - indicates the extent of hydrolytic rancidity, especially useful for assessing abuse of used oil
        - involves titration with standard base and use of phenolphthalein indicator (or till pH 8.1)
        - mg alkali (NaOH or KOH) needed to neutralize the free fatty acids (FFA) in 1g fat/ oil
        - does not include hydrolysis of TAGs but titration of FFAs already in the oil sample
    - _____
        - also known as iodine number or iodine index
        - g of I_2 absorbed by 100 g oil/fat
        - indicates the degree of unsaturation of fatty acid
    - _____
        - Indicates extent of oxidation of fats or oils
        - involves titration against sodium thiosulfate in the presence of potassium iodide (KI) with starch as indicator
        - milliequivalents of peroxide oxygen per kg TAG (mEq/kg)
        - may not be used in heated oils since peroxide is heat-labile
        - higher peroxide value for rancid TAGs
    - Test for Component Fatty Acids
        - _____ No. – ml of 0.1N alkali needed to neutralize the **volatile but water-soluble** fatty acids in 5 g fat (C4-C6); high in milk fats; may indicate adulteration of milk
        - _____ No.. – measure of the amount of **volatile, water-insoluble** fatty acids (C8-C14)
        - _____ – amount of **nonvolatile** fatty acids in 5g of saponified fat
- Lipid processing
    - Lipid extraction
        - Mechanical extraction
        - Thermal extraction
        - Solvent extraction
        - Enzyme extraction
        - Supercritical fluid extraction
        - Microwave-assisted extraction
        - Ultrasound-assisted extraction
    - Oil Refinement
        - Removal of non-fats (i.e. gums, free fatty acids, colorants, odorants) from the crude oil extract for reasons of stability, functionality, shelf-life, sensory properties, and aesthetics

- Gum removal or degumming
  - _____- sticky viscous oil-water emulsions stabilized by phosphatides (also known as phospholipids)
  - Process usually uses _____.
  - Prevent separation and separation and settling of gums during transportation and storage of crude lipid
  - Reduce oil losses in subsequent phases of refining
  - Prevent excessive darkening of oil during high-temperature deodorization
- Acid removal/alkali refining
  - Also known as neutralization to remove FFA
  - Traps preformed free fatty acids (FFA) from previous hydrolytic processes along with phospholipids and pigments to reduces sensory defects due to FFA
  - Result in less viscous oil and allows adsorption of other impurities on soap formed
- Color removal/bleaching
  - Removes colorants (chiefly carotenoids and chlorophyll), traces of hydrogenation catalysts, traces of soaps from alkali refining, chelated pro-oxidant metals, sulfur compounds, peroxides, degradation products
- Odor removal/deodorization
  - removal of aldehydes, ketones, hydrocarbons, other compounds from decomposition of peroxides and pigments

- Lipid Technology and Modification
  - Processes that aim at having fats/oils with properties that meet specification for certain food applications
  - _____ - separation into different components with similar structures, properties & functionalities via distillation or supercritical fluid
    - _____ - a fractionation method used to separate TAGs that crystallize at refrigeration temperatures from the rest (waxes and high-melting TAGs) and involves exposure of oil to refrigeration temperatures, removal of crystals/solids (cycle is repeated until no more crystals are formed)
  - _____ - turning LCFAs to SCFAs and/or MCFAs through chemical or enzyme action
  - _____ - mixing predetermined proportions of (1) specific kinds of oil or (2) fractions of a certain oil to prepare oils with specific properties and functionalities
  - _____ - rearrangement of fatty acids within the same TAG for

melting temperature requirements

- _____ - redistribution of fatty acids with other TAGs which can be random or directed
- _____ - the addition of hydrogen in lipid molecule to increase melting temp, oxidative stability and resistance to flavor deterioration due to greater saturation
  - Leads to the formation of _____

- Lipid Deterioration
  - _____ rancidity - hydrolysis of _____ bonds in TAGs via enzyme action + water, heat + water, acid or base + water
    - Can be influenced by the following factors
      - _____
      - _____
      - _____
      - _____
      - _____
      - _____
    - Effects on food
      - _____
      - _____
      - _____
      - _____
      - _____
      - _____
      - _____
      - _____
      - _____
      - _____
  - Oxidative rancidity
    - Also known as _____
    - Oxidation process involving the _____ bonds in unsaturated fatty acids
    - Three modes:
      - _____
        - _____- molecules or atoms that have unpaired electrons
        - Three major steps
          - _____
          - _____
          - _____

    - _____
        - Lipid oxidation occurring in the presence of a sensitizer such as chlorophyll, flavins, myoglobin
    - Enzymatic oxidation
        - _____- enzyme that produces lipid hydroperoxides; exist as several isoforms from plant seed such as soybeans and peas; cytoplasmic enzymes that contain nonheme iron
- The degree of unsaturation of lipids affect lipid autoxidation
  Polyunsaturated > Monounsaturated > Saturated
  Cis configuration > trans configuration
- Free fatty acids are more prone to autoxidation than acylglycerols
- Other factors that can affect autoxidation
    - _____
    - _____
    - _____
    - _____
    - _____
- Inhibition of lipid oxidation
    - _____
        - _____
        - _____
        - _____
        - _____
    - _____
    - _____
        - _____
        - _____
        - _____
- Effects on food
    - _____
    - _____
    - _____
    - _____

- _____ - a mixture of at least two normally immiscible liquids where one is scattered as microdroplets (dispersed phase) in the other (continuous phase or dispersion medium)
    - _____ - the boundary between 2 phases
    - _____ - a measure of the forces that keep the two phases separate
    - _____ - cohesive force of liquid which prevents it from flowing, spreading and mixing ; high tension = no mixing

Name:

- Types of emulsions according to composition
  - 2 liquids
    - _____ - usually more water (continuous phase) & less oil (dispersed phase)
      - *Ex. mayonnaise*
    - _____ - usually more oil (continuous phase) & less water (dispersed phase)
      - *Ex. butter, margarine*
  - 3 liquids:
    - Water-in-oil-in-water (WOW)
    - Oil-in-water-in-oil (OWO)
- Types of emulsions according to stability
  - _____ emulsion- contains a sufficient amount of emulsifying agent to keep it intact during ordinary conditions of handling and storage (ex. Mayonnaise)
  - _____ emulsion- with good stability due to viscous nature of continuous phase (ex. sweet salad dressing)
  - _____ emulsion- with little emulsifying agent; too fluid to restrict movement of oil droplets (ex. homogenized milk, vinaigrette)
- _____- ability of emulsion to resist change in its properties over time
  - Emulsion destabilization processes
    - _____- droplets collide and combine resulting in average droplet size increasing over time
    - _____- droplets rise to the surface of the emulsion due to buoyancy or centripetal force induced when a centrifuge is used
    - _____- happens alongside creaming; denser droplets sink to the bottom of the emulsion
    - _____- particles of a dispersion form larger-size clusters
    - _____- growth of large droplets at the expense of smaller ones
  - Factors affecting emulsions stability
    - _____
    - _____
    - _____
    - _____
    - _____
    - _____
    - _____

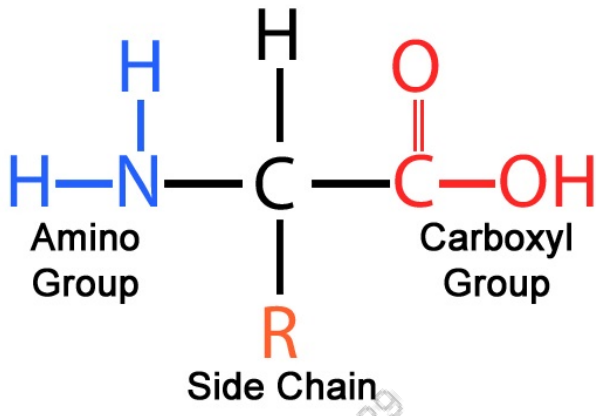
- _____ - compounds that have both polar and nonpolar groups, thus drawn to the interface between water and oil to coat the surfaces of the dispersed phase
  - Mechanism
    - _____
    - _____
  - Types
    - _____
    - _____
    - _____
    - _____
  - _____
    - Value used to choose type of emulsifier to use in a food system
    - A value of 7 means equal solubility in water and oil
    - Smaller values means greater solubility in oil HLB > 7 ; generally suitable for making foams and O/W emulsions
    - HLB < 7 ; for W/O emulsions

Proteins

- Highly complex polymers made up of amino acids linked via substituted amide bonds
- 50-55% C, 6-7% H, 20-23% O, 12-19% N and 20-30% S on w/w basis
- Biochemical reactions and processes are performed by enzymes which are also proteins
- Types
  - _____ - proteins that are not enzymatically modified in cells
  - _____ - covalently modified or complexed with non proteins
  - _____ - exists in spherical or ellipsoidal shapes
  - _____ - rod-shaped molecules containing twisted linear polypeptide chains
- Functions
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____

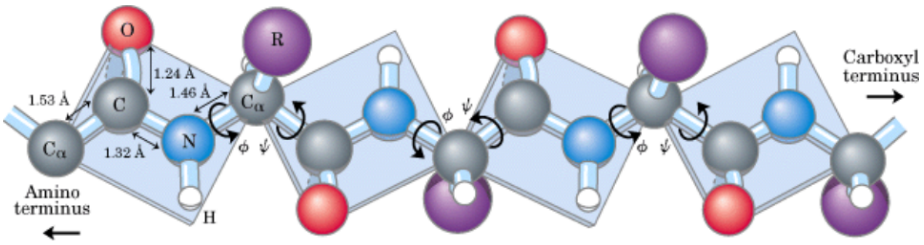
Name:

- Basic structure of proteins
  - _____ - monomer of proteins consisting of the following:
    - Amino group (L or D)
    - Carboxyl group
    - Alkyl/R group or side chain



  - Classification of amino acids based on polarity
    - Polar
      - Uncharged: Ser, Thr, Asn, Gln, Cys **(Acronym: G-CATS 🐱)**
      - Positive (basic): Arg, Lys, His **(Acronym: HArLy)**
      - Negative (acidic): Asp, Glu
    - Non-Polar
      - Aliphatic: Ala, Ile, Leu, Met, Pro, Val **(Acronym: PV MAIL)**
      - Aromatic Phe, Trp, Tyr **[(Acronym: Feeling (Phe) Tired (Tyr) from Trip (Trp)]**
  - Classification of amino acids based on availability
    - Essential: Phe, Val, Thr, Trp, Ile, Met, His, Arg, Leu, Lys **(Acronym: PVT TrIM HArLL)**
    - Nonessential: All other amino acids
  - Primary structure
    - Refers to the linear sequence in which the constituent amino acids are covalently linked through amide bonds also known as peptide bonds
    - _____ from carboxyl group to the peptide bond explain the presence of charges and reaction properties of protein apart from R
    - Contains 100-500 amino acids
    - _____ - terminus with the free α-amino group (Beginning)
    - _____ - terminus with the free α-carboxyl group (End)
    - Backbone of polypeptide: Repeating unit of –N-C-C^{α}-
    - Amino acid residue: -NH-CHR-CO-

- Peptide unit: -CHR-CO-NH-
- _____restricts rotation to a maximum of 6° (ω –angle)
- Each six-atom segment (-C^{α}-CO-NH-C^{α}-) of the peptide backbone lies in a single plane



- Secondary structure
  - Refers to the periodic spatial arrangement of amino acid residues at certain segments of the polypeptide chain
  - Stabilized by _____
    - _____ structure
      - N-H to C=O hydrogen bonds in 4th succeeding amino acid
      - Each helical rotation involves 36 amino acid residues
      - Hydrogen bonds _____ to the axis
      - Typically amphiphilic
    - _____ structure
      - C=O and N-H groups are oriented _____to the direction of the chain
      - Hydrogen bonding is possible only between segments (intersegment) and not within segment
      - Segments rich in bulky hydrophobic side chains (i.e. Val and Ile) have a tendency to form a β-sheet structure
      - More stable than α-helix structure
      - Proteins with large fractions of β usually exhibit high denaturation temperature
      - _____ - arises as a result of 180° reversal of the polypeptide chain involved in β-sheet formation
        - Hairpin-type (antiparallel); Crossover type (parallel)
        - Involves a four-residue (i.e. Asp, Cys, Asn, Gly, Tyr and Pro) segment folding back on itself stabilized by a hydrogen bond

- Tertiary structure
  - Equilibrium spatial arrangement attained when a linear protein chain with secondary structure segments folds further into a compact three-dimensional form
  - Optimization of various favorable noncovalent interactions
    - _____
    - _____
    - _____
  - _____ - regions of the polypeptide sequence that independently fold up into a tertiary structure
- Quaternary structure
  - Spatial arrangement when protein contains more than 1 polypeptide chain
  - Electrostatic & non-polar attractions between protein side chains & between exposed portions of the polypeptide backbone

- Properties of proteins
  - Relatively high water affinity
  - Forms colloidal solutions
  - Very high & indistinct melting points
  - Ampholytic and amphoteric
    - _____ - capable of ionizing into both anion and cation
    - _____ - capable of acting as an acid or a base
- Functions in food
  - _____
  - _____
  - _____
  - _____
  - _____
- Sources of proteins
  - Plant proteins
    - Cereals- contain mostly storage proteins (albumins, globulins, glutelins, prolamins)
      - Gluten- main storage protein of wheat
        - heterogenous mixture of proteins (gliadins and glutenins) with limited solubility in water
        - forms a viscoelastic dough when mixed with water capable of entrapping gas during gas formation
        - _____ - for extensibility & viscosity of dough
        - _____ - for elasticity of dough

- Soybeans (oil seeds)- good quality protein but low in methionine
  - Soy milk (aqueous extract of ground beans)
  - Taho, tofu and tokwa
  - Soy grits and flour
  - Defatted soy flakes
  - Textured vegetable protein (TVP)
  - Textured soy protein (meat mimics)
  - Soy protein concentrate (70% protein)
  - Soy protein isolate (90-95% protein)
- Animal proteins
  - Milk proteins
    - Casein proteins (80% milk protein)
      - α-casein, β- casein, κ- casein, γ-casein
      - Slower to digest than whey
      - Found in the form of micelles in milk
    - Whey proteins (20% milk protein)
      - Higher leucine content that stimulates muscle protein synthesis
      - Lactalbumin, lactoglobulin, immunoglobulins, etc.
  - Meat proteins
    - Contractile Proteins: Actin (thin filament), Myosin (thick filament)
    - Proteins which control contraction: Tropomyosin, Troponin
    - Connective tissue: Collagen, Elastin Myoglobin
      - Collagen
        - The most abundant animal protein
        - Has a unique triple helix structure resulting in a high tensile strength
        - Affected by age and part of animal
        - Becomes _____ when hydrolyzed
        - Every 3rd AA is glycine, unusually high percentage of _____
  - Egg proteins
    - Albumen Proteins: Ovalbumin, conalbumin, ovomucin
    - Yolk Proteins: Ovomucoid, vitellin, phosvitin
  - Fish proteins
    - Casein Proteins: Actin, Myosin, Collagen, Elastin, Myolabumin
- Algal proteins
  - Found in Spirulina and Chlorella
  - 50-70 g protein per 100 g dry matter
  - Lacks _____
- Microbial proteins
  - _____- derived from yeast, fungi, algae and bacteria

Name:

- Reaction of protein with other food components
    - _____ - ability of proteins to bind water is critical to the acceptability of low and intermediate-moisture foods (i.e. bakery and comminuted meats)
    - _____ - refers to the grams of water bound per gram of protein at 90-95% relative humidity
    - _____ - ability of the protein to imbibe water and retain it against gravitational force within the protein matrix; associated with juiciness and tenderness of comminuted meats
    - Solubility
        - pH: minimum solubility at isoelectric point, precipitation occurs
        - Temperature: Increasing solubility at 0 to 40°C; Denaturation above 40°C
    - _____ - transformation of a protein from the "sol" state to a "gel-like" state
        - _____- a substantially diluted system that exhibits no steady state flow
    - Maillard reaction and acrylamide formation (*to be discussed under Browning Reactions*)
- Surface functionality of proteins
    - Presence of _____ on the protein surface results in interaction with oil and water phases making it suitable as an emlusifier
        - _____ - interfacial area created by 1 mg of protein under a set of conditions
        - _____ - volume of oil that can be emulsified per gram of protein before phase inversion occurs
        - _____ - amount of protein adsorbed at the oil-water interface of an emulsion
        - _____ - percent decrease in interfacial area (i.e. turbidity) of the emulsion
    - Foaming properties
        - Ability to form a tenacious film at gas-liquid interfaces to incorporate and stabilize large quantities of gas bubbles
        - Affected by pH, salts, sugars, lipids and protein concentration
        - _____ - also known as foaming capacity; amount of interfacial area that can be created by the protein; expressed as overrun or foaming power
        - _____ - ability of protein to stabilize foam against gravitational and mechanical stresses
- Protein denaturation
    - Transformation of well-defined initial state protein to an ill- defined final state under non physiological conditions
    - Does not involve chemical changes
    - Results in disruption of secondary, tertiary and quaternary protein structure

- Effect on food
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
- Protein denaturants
  - Physical
    - Heat
      - Most commonly used denaturing agent in foods Increase kinetic energy and molecular vibrations
      - Destroys H-bonding, ionic and hydrophobic interactions
      - Reversible if mild
      - Usually occurs in the range of 40-80°C at 1 atm
    - Freezing
      - Also known as cold denaturation
      - Mainly due to weakening of hydrophobic interactions within a protein resulting in unfolding
      - Results in toughening of frozen fish, squid, etc.
      - Flash freezing (i.e. use of liquid nitrogen) is non-reversible
    - Mechanical agitation and shearing
      - Shearing, shaking, kneading, whipping, extrusion, high speed blending, homogenization
      - Force cause disruption of non-covalent bonds
      - Incorporation of air bubbles allow adsorption of protein molecules to the air-liquid interface
      - High temperature + high shear rate = irreversible denaturation
    - Hydrostatic pressure
      - High pressure □ protein deformation
      - Can occur at 25°C if the pressure is sufficiently great (1-12 kbar)
      - May result in hydration of nonpolar amino acid residues
      - Fibrous proteins are more stable to pressure than globular
      - Highly reversible in most enzymes (slow process)

- Decrease in volume caused by elimination of voids - compressibility of proteins
- Costly but does not harm essential amino acids, natural color and flavor unlike thermal denaturation

- Interfacial forces - decreased interfacial tension between phases

■ Chemical

- Acids and bases
  - pH values beyond optima cause disruption of salt bridges: double replacement reaction
  - Denaturation is greater at _____ pH than under _____ pH
  - Extreme pH values cause strong IM electrostatic repulsion due to differences in net charge of ionizable groups in the protein moiety
  - Protein most stable at _____
  - Mostly reversible except the ff:
    - Partial hydrolysis of peptide bonds
    - Deamidation of Asn and Gln
    - Destruction of sulfhydryl groups at alkaline pH
    - Aggregation
- Detergents
  - Sodium dodecyl sulfate (SDS)- disrupt hydrophobic interactions
    - If charged, can destroy electrostatic interactions
    - Denatures most globular proteins at 3-8mM
    - Complete denaturation even at low concentration (3-8 mM) Irreversible denaturation due to strong binding of SDS
- Reducing agents
  - Add 2 H atoms to make 2 SH groups
  - β-mercaptoethanol reduces disulfide bridges to 2 sulfhydryl groups
- Organic solvents
  - Weaken hydrophobic interactions & H-bonding
  - Certain organic solvent may strengthen formation of peptide H-bonds due to low dielectric permittivity
  - Decrease permittivity: enhance electrostatic interaction between oppositely charged groups and repulsion between like charges

- Heavy metal salts
  - Usually contain Hg^{2+}, Pb^{2+}, Ag^{+}, Tl^{+}, Cd^{2+} and other metals with high atomic weights
  - Disrupt salt bridges through formation of insoluble metal protein salt
  - Disrupt disulfide bonds because of high attraction and affinity to sulfur
- Organic solutes
  - Urea (4-6 M), GuHCl (3-4 M) at room temperature
  - GuHCl is a more powerful denaturant than urea because of its ionic character
  - Same mechanism as detergents
  - Form H-bonds with protein, stronger that those within the protein itself
  - Ions can alter the structural stability of proteins
  - Compared to inorganic salts: PO_4^{3-} > F^- > SO_4^{2-} > Citrate^{2-} > Tartrate^{2-} > Acetate$^-$ > Cl^- > Br^- > NO_3^-
- Common salts.
  - Low salt concentration (<0.2M) stabilizes protein structure At higher concentrations (>1M), salts have ion specific effects that influence structural ability of protein
  - Na_2SO_4 and NaF enhance protein stability
  - NaSCN and $NaClO_4$ weaken protein stability
  - Mechanism is believed to be related to their relative ability to bind to and alter hydration properties of proteins
  - Salts that stabilize proteins enhance hydration of proteins and bind weakly, whereas salts that destabilize proteins decrease protein hydration and bind strongly
  - Hoftmeister/chaotropic series: F^- < SO_4^- < Cl^- < Br^- < I^- < ClO_4- < SCN- < Cl_3CCOO^-

- Protein degradation
  - Enzyme Hydrolysis* (*to be discussed under Protein Modification*)
  - Alkali-induced degradation
    - Hydrolysis- disruption of peptide bonds via addition of water, forming the component amino acids of the protein resulting in:
      - _____
      - _____
      - _____
      - _____

        - β-elimination - intermolecular crosslinking and protein aggregation resulting in:
            - _____
            - _____
            - _____
            - _____
            - _____
            - _____
        - Racemization - process by which an L-amino acid changes into a mixture of the L- and D-forms (or the D-form changes into a mixture of the L- and D forms) resulting in:
            - _____
            - _____
            - _____
            - _____
    - Reaction with oxidizing lipids
        - _____
        - _____
        - _____
        - _____
    - Photodegradation
        - _____
        - _____
        - _____
        - _____
- Protein modification
    - Chemical Modification
        - Alkylation
            - Reaction of SH and amino groups with iodoacetate or iodoacetamide Increase in electronegativity Alter pH and solubility and protein unfolding
            - Reductive alkylation of amino groups with aldehydes and ketones Prevent progression of Maillard reaction glycoprotein formation (improve solubility and interfacial properties of proteins)
                - Aliphatic aldehyde/ketone- increase _____ of protein
                - Reductive sugar- increase _____ of protein
        - Acylation
            - Reaction with acid anhydrides (i.e. acetic anhydride and succinic anhydride) → increase in electronegativity → unfolding

- Acylated proteins are generally more soluble than native proteins
- Succinylation may impair other functional properties
  - Poor heat gelling properties
  - Impaired foaming and emulsifying properties
  - More sensitive to Ca-induced precipitation
- Irreversible reactions Resistant to pancreatic digestive enzymes → reduced nutritional value
- Enhanced lipophilicity and fat-binding capacity of proteins through reaction of lysyl residues with fatty acyl chloride or N-hydroxy-succinimide ester

■ Phosphorylation
- Reaction of protein with $POCl_3$
- Occurs at OH-group of Ser and Thr residues and –NH2 group of lysyl residues
- Highly sensitive to Ca-ion-induced coagulation □ desirable in simulated cheese type products
- Increased protein electronegativity
- At high protein concentration, may lead to polymerization □ minimize increase in electronegativity and calcium sensitivity

■ Sulfitolysis
- Conversion of disulfide bonds to S-sulfonate derivative using redox system involving system and Cu(II) or other oxidants
- Reversible reaction
- Cleavage of disulfide bond □ conformational changes
- *Ex. Sulfitolysis of proteins in cheese whey dramatically changes their pH-solubility profiles*

■ Esterification
- Esterification of Asp and Glu residues to alcohols under acidic conditions
- Stable at acid pH but readily hydrolyzed at alkaline pH

○ Enzymatic Modification

■ Enzymatic hydrolysis
- Use of proteases (i.e. pepsin, trypsin, chymotrypsin, papain and thermolysin) resulting in _____ of poorly soluble proteins
- Extensive hydrolysis may damage functional properties (i.e. gelation, foaming and emulsifying properties)

■ Plastein reaction
- Set of reactions involving initial proteolysis followed by _____ of peptide bonds by a protease (i.e. papain or chymotrypsin)
- Can be exploited to improve the nutritional quality of _____ deficient food proteins

- Protein Cross-linking
  - Reaction between ε-amino group of lysyl residues and amide group of glutamine residues catalyzed by transglutaminase to produce isopeptide cross-link
  - Can produce new forms of food proteins with improved functional properties
  - Formation of protein gels and protein films
  - Improved nutritional quality

Micro-components of Food

Enzymes

- What are enzymes?
  - Proteins
    - function is heavily affected by structure
    - factors that affect protein structure: _____
  - Biocatalysts
    - speed up a chemical reaction
    - _____ faster vs non-enzymatic
    - _____ faster vs uncatalyzed
  - Not used up in the reaction retrievable
  - Highly efficient
  - With varying degrees of _____
  - Benefits in food: _____
  - Adverse effects on food: _____

- Nomenclature
  - Enzyme Commission (EC) No.
    - Classification scheme based on the chemical reaction catalyzed
    - Composed of 4 digits
    - First no: (1-7) – type of chemical reaction catalyzed by the enzyme

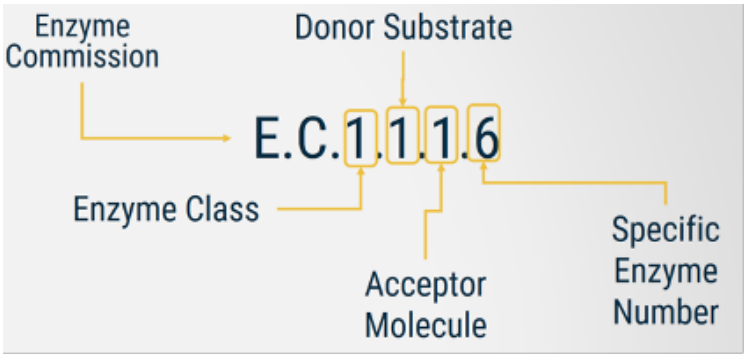
      1: _____ 5: _____

      2: _____ 6: _____

      3: _____ 7: _____

      4: _____
    - Second no: nature of donor substrate
    - Third no: nature of acceptor molecule
    - Fourth no: number of specific enzyme

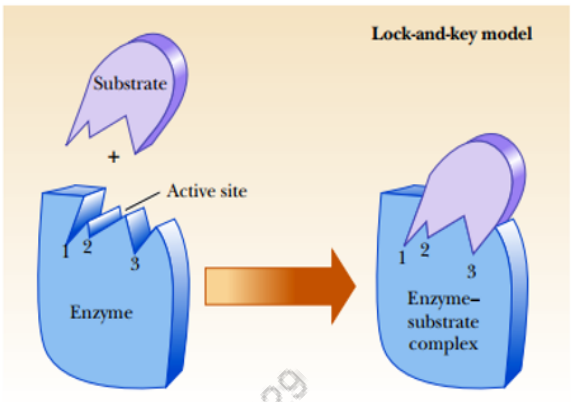
- Ex: Papain (_____)

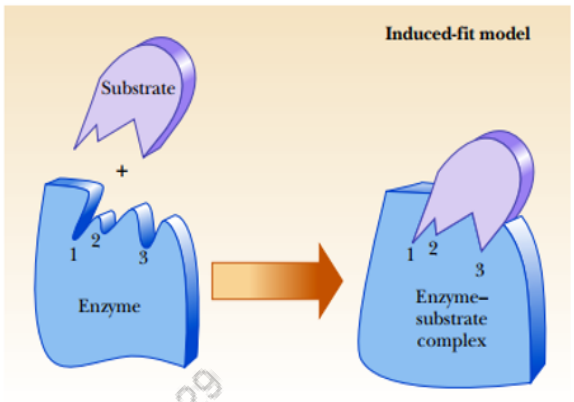


  - Systematic name: 2 main parts
    - First: name(s) of the substrate
    - Second: ending in _____; based on 6 types of chemical reactions
    - Ex: _____
  - Trivial name
    - commonly used name
    - Ex. catalase, papain, trypsin

- Classification
  - enzymes are classified based on 6 different major reactions:
    1. oxidoreductase -_____
    2. transferase - _____
    3. hydrolase - _____
    4. lyase - _____
    5. isomerase - _____
    6. ligase - _____

- Enzyme Mechanism and Kinetics
  - Enzyme action





Name:

- Enzyme kinetics
  - Michaelis-Menten Kinetics

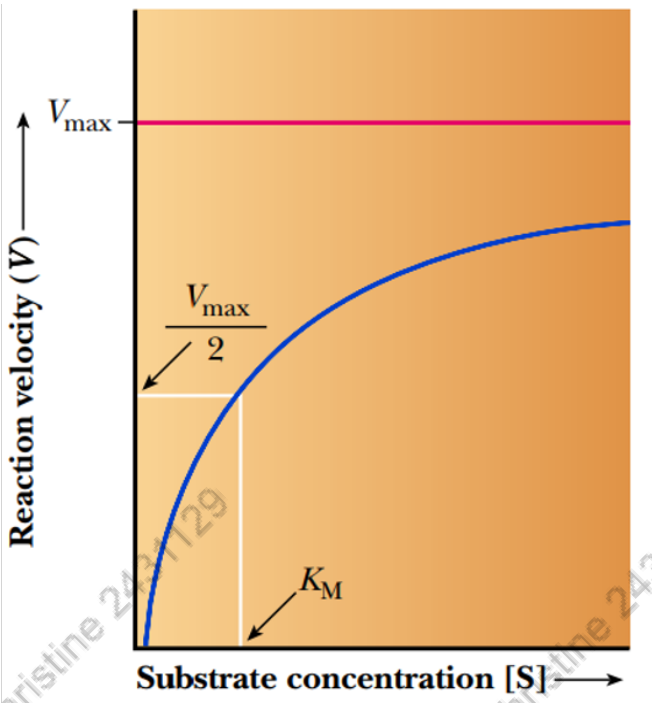
$$V = \frac{V_{max}[S]}{K_M + [S]}$$

Michaelis-Menten Equation

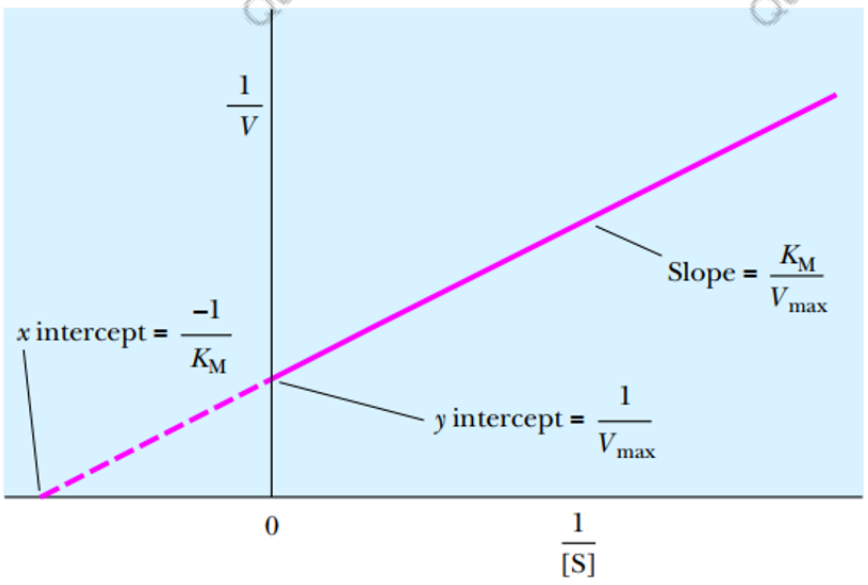
↑K_m, ↓affinity

↓K_m, ↑affinity

$V_{max}/2 = K_m$



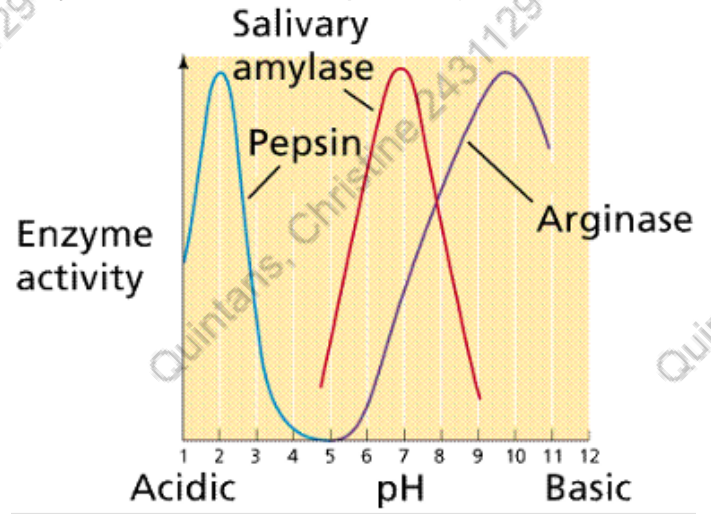
$$\frac{1}{V} = \frac{K_M}{V_{max}}\left(\frac{1}{[S]}\right) + \frac{1}{V_{max}}$$



- Factors affecting enzyme activity
  - Temperature
    - __T → __KE → __ frequency of magnitude of collisions → __ enzyme activity

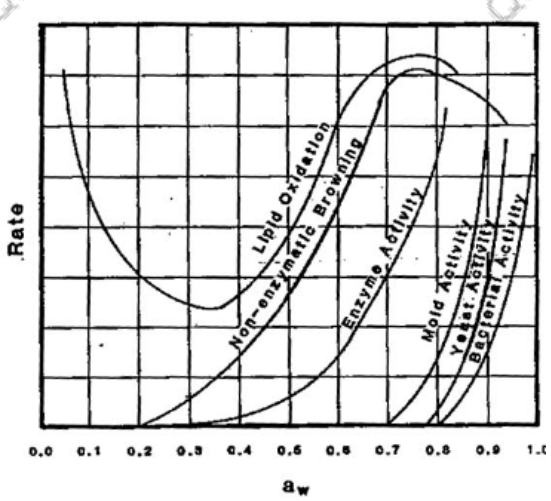
Below T_{opt}	Above T_{opt}

- pH
  - enzymes are sensitive to pH changes

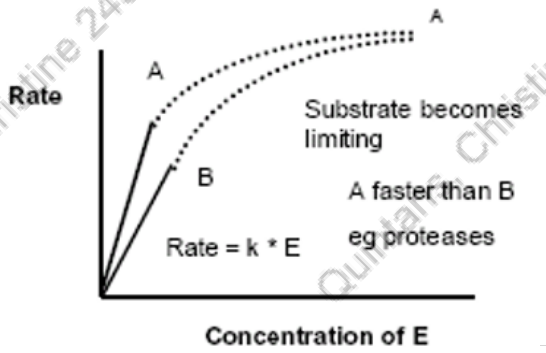


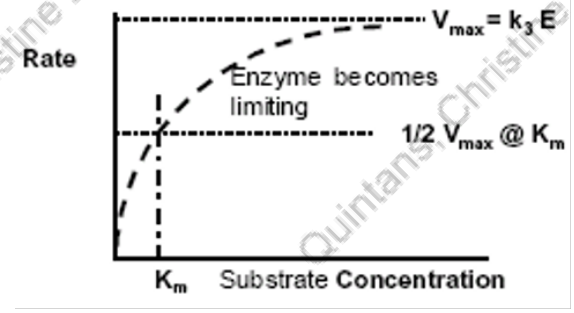
Name:

- Water activity



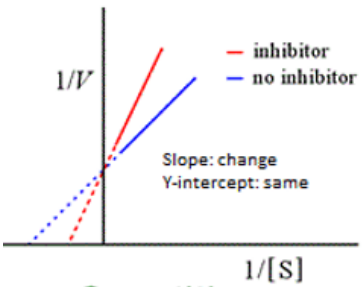
  - __A_w __enzyme activity
  - More available water as a diffusion medium collision theory
  - __A_w __solute concentration
    - __ionic strength __protein solubility
- Enzyme/substrate concentration



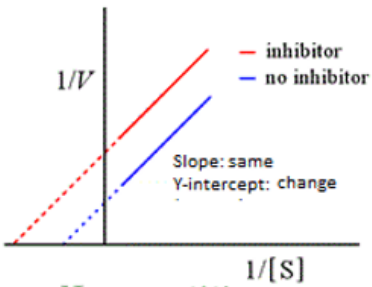


- Inhibitors

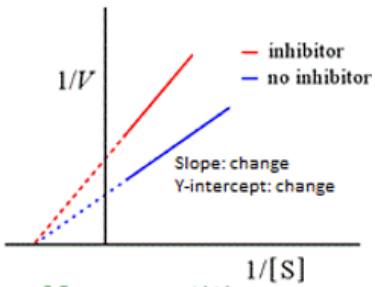
Lineweaver-Burk plots for enzyme inhibition



Competitive inhibition
K_M increased
V_{max} unaffected



Uncompetitive inhibition
K_M reduced
V_{max} reduced



Noncompetitive (Mixed) inhibition
K_M unaffected
V_{max} reduced

- Cofactors and coenzymes
  - Cofactor: _____
  - Coenzymes: _____
  - promotes enzyme activity
- Pressure
  - __pressure leads to protein _____ loss of activity
- Shearing
  - repeated addition of force leads to __T protein _____
- Ionizing radiation
  - effect varies on certain conditions/factors
    - Aw:_____
    - O_2, metal ions, or unsaturated lipids: _____

- Applications of Enzymes in Food Processing
  - Polyphenol oxidases
    - catalyze the oxidation of phenolic compounds to produce brown color on cut surfaces
    - Ex: _____
    - (+) effects: _____
    - (-) effects: _____
  - Amylases
    - catalyzes the hydrolysis of glycosidic bonds
    - critically important in physiological processes

α-amylase	β-amylase	γ-amylase

- Effects and applications
  1. _____
  2. _____
  3. _____
  4. _____
  5. _____

Name:

- Pectinases
  - pectin-degrading enzymes
  - categorized into three general types

Polygalacturonate	Pectin methyl esterase	Pectate and pectin lyases

- Application
  - fruit or vegetable extract processing
  - tissue maceration
  - tissue liquefaction
  - enhanced extraction
  - clarification
  - facilitated peeling

- Proteases
  - hydrolyzes peptide bonds
  - peptidases or peptide hydrolases
  - classification based on enzyme active site

Serine proteases	Cysteine proteases	Aspartic proteases	Metalloproteases

- Applications
  - _____
  - _____
  - _____
  - _____

- Lipases
  - catalyzes the breakdown of fats/oils into free fatty acids, monoglycerides, and diglycerides
  - Ex: _____
  - Applications:
    - _____
    - _____
    - _____
    - _____

Browning Reactions

- occur in mechanically injured fresh produce as well as in meat, fish, fruit, and vegetable products during processing and storage
- affects color, flavor, appearance and nutritive value of foods
- can be desirable or undesirable
  - (+) _____
  - (-) _____

- Mechanisms of Browning Reactions in Food

Mechanism	O_2 requirement	Amino group requirement	Optimal pH
Enzymatic Browning			
Maillard Reaction			
Caramelization			
Ascorbic Acid Oxidation			

- Enzymatic Browning
  - mainly occurs in fruits and vegetables catalyzed by the enzyme _____ when plant tissues are injured

- cutting, peeling, mishandling, bruising, exposure to poor conditions
- desirable in _____
- undesirable in _____
- catalyzed by a group of enzymes called polyphenol oxidases
  - Ex. _____
    - tyrosinase: catalyzes _____
    - catechol oxidase: catalyzes _____
- enzyme requirements: _____
- active between pH _____; inactivated at pH _____
- main substrates are _____
- mechanism for enzymatic browning
  - Requirements: _____
  - Initial reactions are enzyme catalyzed:
    1. the hydroxylation of a mono-phenol to the o-position adjacent to an existing hydroxyl group of the phenolic substrate

    2. oxidation of a di-phenol to o-benzoquinones (di-phenol oxidase activity)

- subsequent reactions involves _____ forming _____ which are dark brown, water-insoluble compounds
- Controlling enzymatic browning
  1. Use of high temperature

  2. Use of low temperature

  3. Use of non-thermal processes

  4. Use of reducing agents

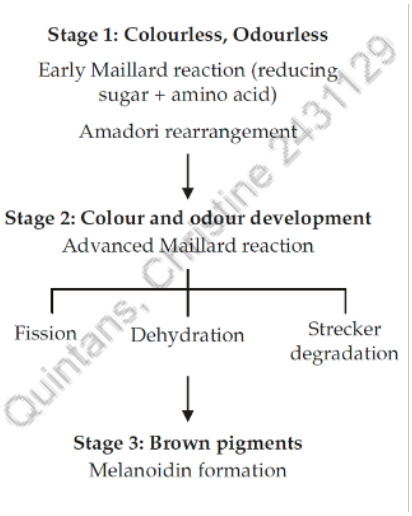
  5. Application of acidulants

6. Enzyme inhibitors

7. Chelating agents

8. Removal of O_2

- Maillard reaction
  - reaction involving the free amino group of amino acids, peptides or proteins, and the carbonyl group of a reducing sugar
  - (+) - _____
  - (-) - _____
  - Mechanism



Stage 1.

a. Addition of carbonyl group to a primary amino group of an amino acid, peptide or protein, followed by water elimination, leading to an intermediary imine which cyclizes to a glycosylamine (N-glycoside)

b. Alkali-catalyzed isomerization of aldoses and ketoses.
For aldosylamine: N-glycoside will rearrange to a 1-amino-1-deoxyketose (_____)

Name:

For ketosylamine: N-glycoside will rearrange to a 2-amino-2-deoxyaldose (_____)

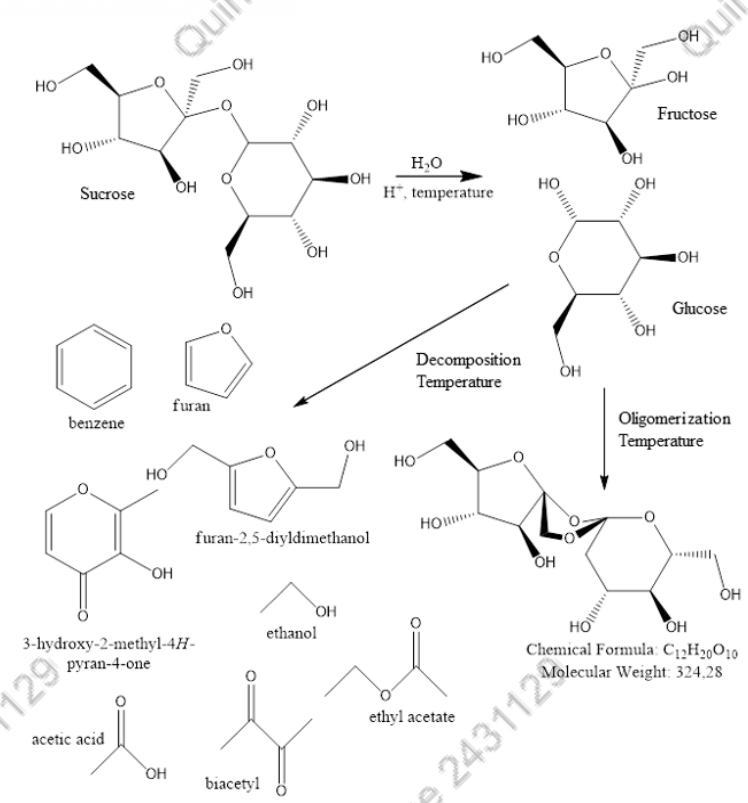
Stage 2: rearrangement, dehydration, decomposition, and/or reaction of Amadori intermediates

- moderate dehydration _____
- splitting into smaller compounds _____
- strong dehydration _____

Stage 3: reaction of intermediate products in stage 2 to form either heterocyclic flavor compounds or high-molecular weight pigments and colored compounds called _____

- Factors affecting maiilard reaction
  1. pH - _____
  2. amino acid present -_____
  3. Temperature - _____
  4. A_w - _____
  5. Type of sugar -_____
  6. Concentration - _____
  7. Use of sulfite as additive - _____

- Caramelization
  - degradation of sugars in the absence of amino acids and proteins at high temperatures produces both _____
  - facilitated by _____ products will differ depending on the catalyst used
  - can occur simultaneously with Maillard reaction



- hydroxymethyl furfural is one of the major compounds formed in acidic media
- other fragmentation products are detected in basic media
- possibility of forming antioxidative compounds and toxic compounds

- Ascorbic acid browning
  - thermal decomposition of ascorbic acid under aerobic or anaerobic conditions through oxidative or non-oxidative mechanism
  - results in the loss of nutritional value of Vitamin C in food products
  - main reason for the loss of commercial value of citrus fruits
  - __degradation, __temperature, __ concentration
  - can be controlled by _____
    _____

Colorants

- Definition of Terms
  1. Color - _____
  2. Colorant - _____
  3. Pigments - _____
  4. Dyes - _____
  5. Lakes - _____

Name:

Table 1. Classification of Colorants

Colorant	
Certified	
Dye	
Lake	
Exempt from certification	
Natural	
Synthetic	

- Importance
  1. _____
  _____
  2. _____
  _____
  3. _____
  _____
  4. _____
  _____
  5. _____
  _____

- Heme Compounds
  - responsible for the color of meat
  - Myoglobin (Mb)
    - primary pigment in mear products
    - _____ found in muscle that acts as the main storage of oxygen in them
  - Hemoglobin (Hb)
    - primary pigment of the blood

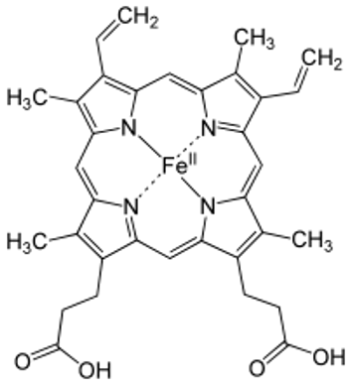
Myoglobin	**Hemoglobin**

  - Factors Affecting Myoglobin Content in Meat.

1. Species - _____
2. Muscle type - _____
3. Age - _____

4. Rearing condition - _____
_____
5. Sex - _____
6. Physical activity - _____

- Heme Structure



  - Porphyrin ring composed of 4 pyrrole rings joined together
  - Has an Fe center

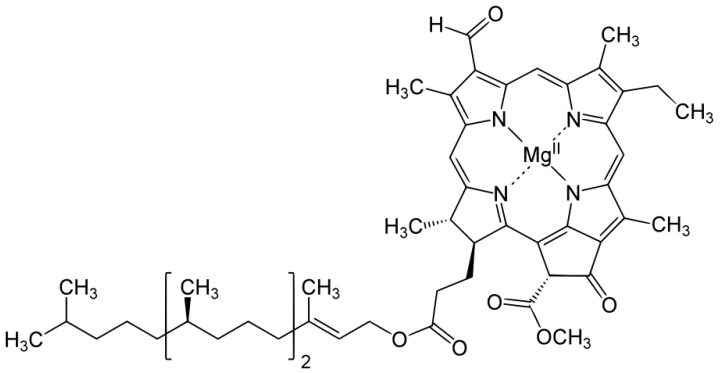
- Meat Color
  - highly dependent on the chemistry of myoglobin
    1. _____
    2. _____
    3. _____

- Major pigments in meat products

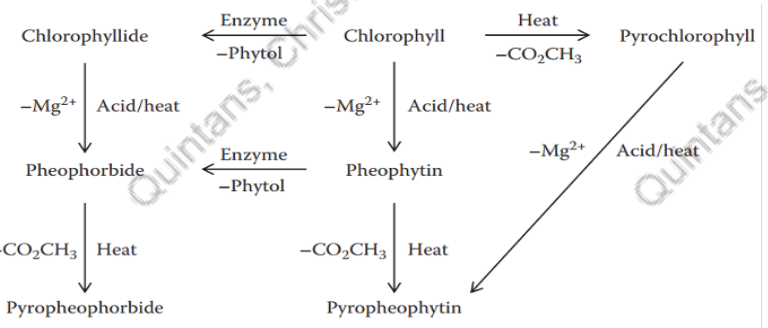
Pigment	Mode of Formation	State of Iron	State of Globin	Color
Myoglobin				
Oxymyoglobin				
Metmyoglobin				
Nitrosylmyoglobin				
Nitrosylhemochrome				
Choleglobin				
Sulfomyoglobin				
Nitrimyoglobin				
Nitrihemin				

Name:

- Chlorophyll
  - Major light harvesting pigment in photosynthetic organisms
  - Responsible for the _____ color of fresh vegetables
  - Loss of color during processing is linked to _____
  - Chlorophyll structure



  - Reactions of chlorophyll
    - Pheophytin - _____
    - Chlorophyllide - _____
    - Pheophorbide - _____
    - Pyropheophytin - _____
    - Pyro compounds - _____

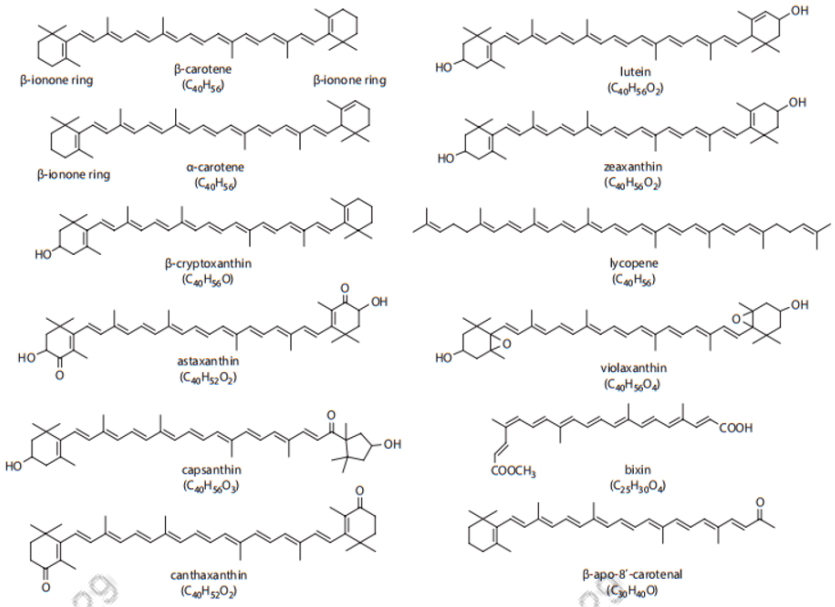


  - Degradation
    - bleaching occurs when chlorophylls are _____
    - can occur during _____
    - process is IRREVERSIBLE
  - Color Preservation
    - there are several methods to preserve the bright green color of chlorophylls
      - Acid neutralization - _____ _____
      - Coating can with ethyl cellulose
      - HTST processing
      - Formation of metallocomplexed-chlorophyll - _____ _____

- Carotenoids
  - Lipid soluble compounds
  - Provides _____ in plant and animal products
  - May elicit _____ when bound to biomolecules
  - Functions of carotenoids
    1. _____
    2. _____
    3. _____

  - Physical and Structure Properties
    - Comprised of two classes:
      - Carotenes: _____
      - Xanthophylls: _____
    - structure backbone is composed of __ isoprenoid units attached either in a head-to-tail or tail-to-tail fashion
    - highly symmetrical
    - end group may contain 2 cyclic rings, 1 cyclic ring, or none at all
    - lipophilic and heat stable
    - synthesized by plants and other photosynthetic organisms; obtained by animals through diet
    - _____ is the most widely distributed carotenoid found in plants
    - has both vitamin and antioxidative activity

  - Examples:

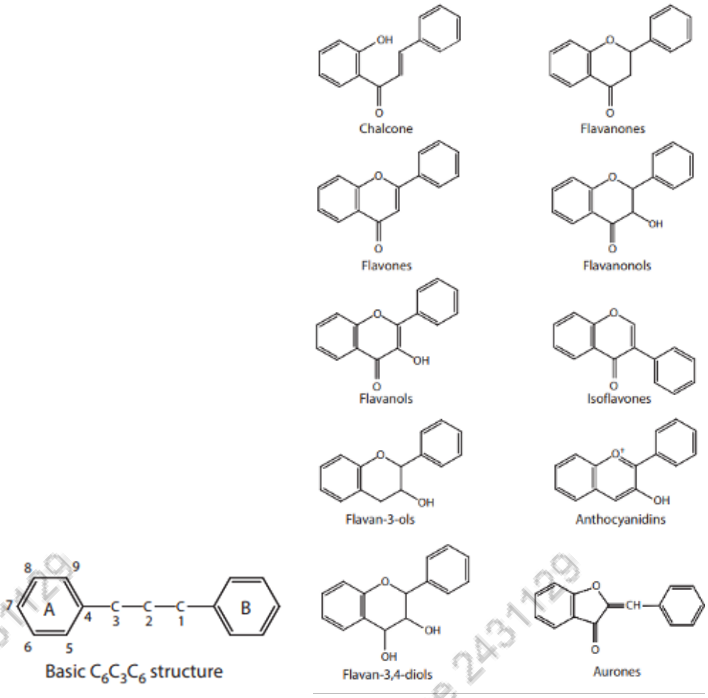


Name:

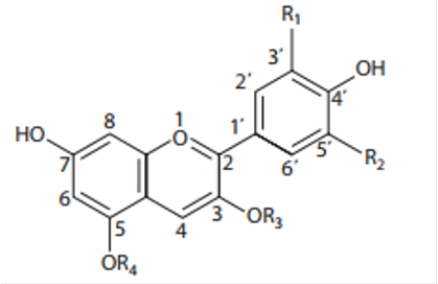
- Chemical Properties
  - Oxidation
    - Easily oxidized due to __degree of unsaturation → _____
    - Major degradation mechanism of carotenoids
    - Enzymatic activity can hasten oxidative degradation
    - Physical damage or extraction __ susceptibility to oxidation
  - Antioxidative activity
    - Can scavenge free radicals in food systems due to __degree of unsaturation
    - $\uparrow O_2$ _____
    - $\downarrow O_2$ _____
  - Isomerization
    - Exists in an all-trans configuration but isomerization can occur
    - Effect of isomerization vary
      - Positive: _____
      - Negative: _____
    - Can be induced by _____
    - _____
    - _____
- Stability
  - Freezing: _____
  - Blanching: _____
  - Lye peeling: _____
  - Heat sterilization: _____
  - Temperature: _____

- Flavonoids and Other Phenolics
  - Group of phenolic compounds that exhibits coloration in different plant products
  - Ex. _____

- Has a $C_6C_3C_6$ carbon skeleton structure



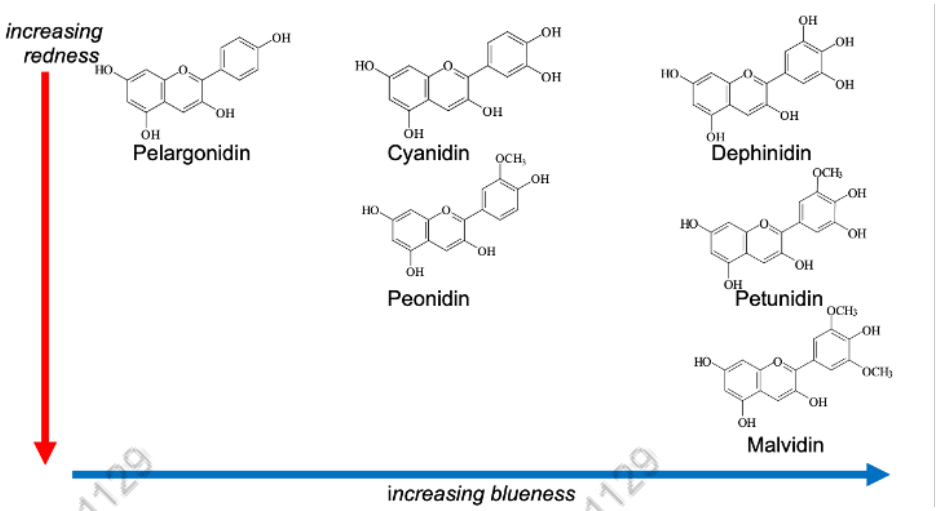
- Anthocyanins
  - One of the most broadly distributed pigment groups in plants
  - Exhibits blue, purple, violet, magenta, red, and orange coloration
  - Differs in the number of hydroxy and/or methoxy groups
  - General anthocyanin structure



  - Can exist as glycosides of polyhydroxy or polymethoxy derivatives of the salt
    - Common sugars: _____
    - Cleavage of the sugar molecule __ water solubility

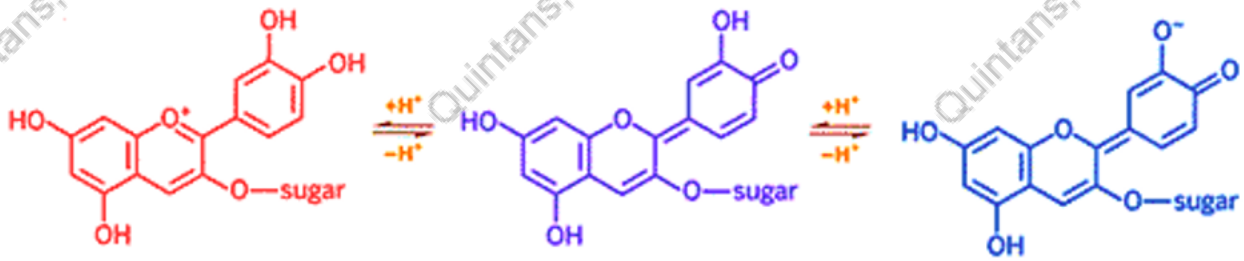
Name:

- Stability of Anthocyanins
  - Structural effects
    - color and stability of anthocyanins are affected by hydroxylation and methoxylation



    - __hydroxylation, __redness, __blueness, __stability
    - __methoxylation, __redness, __blueness, __stability
    - __glycosylation, __stability

  - pH

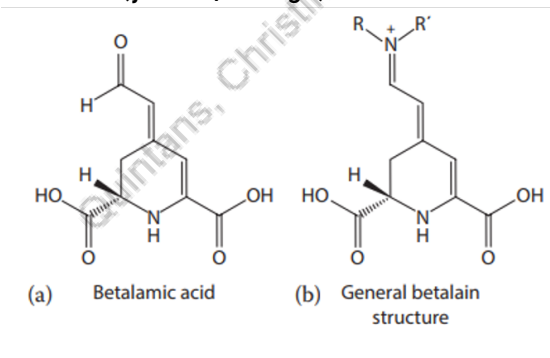


pH<3 pH=7-8 pH>11

  - Temperature - _____
  - Oxygen and Ascorbic acid - _____ _____
  - Aw - _____
  - Sugars and degradation product - _____ _____
  - Metals - _____
  - SO_2 - _____
  - Light - _____
  - Co-pigmentation - _____

- Anthoxanthins and Other Flavonoids
  - White and yellow color in foods
    - __concentration makes the product more yellow
  - Acylation and glycosylation shift light absorption properties
  - Can be involved in co-pigmentation
  - Chelation of Fe or Al ions, __ yellow saturation
  - Degrades in air or light forming red-brown stable products
- Tannins
  - Can bind to proteins and other polymers
  - Precipitates _____ used as a _____
  - Occurs in the bark of oak trees and fruits
  - Exhibits yellow white to light brown color
    - Main pigment in black teas
  - Contributes astringency

- Betalaines
  - Nitrogen-containing pigments
    - Betacyanins (red/violet)
    - Betaxanthins (yellow/orange)



  - Similar in color to anthocyanins but more pH stable
  - Water soluble and exists as zwitterions in plant cells
  - Betalains and anthocyanins DO NOT exist together in the same plant
  - Ex. _____
  - Stability
    - Greatest between pH _____
      - Hydrolysis can occur at acidic or basic pH
    - Hydrolytic cleavage also occurs during thermal degradation
    - __A_w, __degradation rate
    - Presence of _____ contributes to betalain degradation
      - stabilized by _____
    - Enzymatic degradation is facilitated by _____

Name:

- Certified Synthetic Colors
  - Dye, lakes, or pigments produced synthetically
  - Widely used because of high tinctorial power - _____
  - Generally stable compared to natural pigments
  - Less expensive and blends more easily to create different hues
  - Can be classified as azo, xanthene, triphenylmethane, and indogoid
- Colors Exempt from Certification
  - Pigments extracted from natural sources or synthetic dyes that are nature identical
  - Naturally-sourced dyes are crude extracts
  - Increase in production due to increase in demand to healthier and more wholesome food products
  - Ex. _____

Flavors in Food

- Taste Substances
  - Sweet Taste Substances
    - AH/B Theory
      - Currently accepted model for the sweetness of compounds
        - Two (2) basic requirements:
          1._____2._____
          _____
      - Electronegative atoms are essential for the sweetness of compounds
        - Weakness: cannot explain why different sugar molecules have varying degrees of sweetness
        - Solution: addition of a 3rd feature _____
          - Important feature for intensely sweet substances
          - Accounts for variation of sweetness in sugar molecules
          - Related to the bittersweet sensation

    - Bittersweet sensation
      - Bittersweet substances have structural features that allow them to interact to both sweet and bitter receptors
      - Bitterness properties depresses sweetness even at low concentrations
      - Bitterness in sugars in imparted by a combination of structural effects
        1. _____
        2. _____
        3. _____
        4. _____

- Changes in the structure and/or the stereochemistry of a sweet molecule suppresses its sweetness and induces bitterness

- Bitter Taste Substances
  - Bitterness sensation is closely related to sweetness dependence on the stereochemistry and structural features of the molecule
    - Sweet molecules require _____
    - Bitter molecules require _____
  - Believed to also follow AH/B model but orientation in the receptor site will affect its perceived taste
    - Ex. D-isomer of amino acids taste sweet; L-isomers taste bitter
  - Bitter substances have LOW taste threshold than other substances due to its low solubility in water
    - Quinine is used as the standard molecule for bitter taste
      - Detection threshold: 100 ppm
      - Used as an additive in soft drinks with tart-sweet attributes
  - bitterness blends well with other tastes and provides gustatory stimulation
  - bitterness is an important flavor attribute of other beverages like coffee, cocoa, and tea
    - Contain caffeine which is considered bitter at 150-200 ppm
    - Cocoa also contains _____ which is considered as the dominant bitter compound
  - bitterness in beer comes from the isoprenoid-derived compounds present in hops called humulones
    - _____ is most abundant substance and is isomerized to _____ during boiling
    - _____ is the precursor of the skunky flavor in light-exposed beer
      - It reacts with H_2S, and the reaction is catalyzed by light
  - bitterness can also be considered undesirable in certain food products and pharmaceutical products
    - Several debittering methods have been developed and are being used in the industry
    - Ex.
      1. _____
      2. _____
      3. _____
      4. _____
      5. _____

Name:

- bitterness in aged cheeses and protein hydrosylates is caused by the hydrophobic character of amino acids
    - All peptides contain several AH-type polar groups but vary greatly in the size and nature of their hydrophobic groups
    - Bitter taste can be predicted by obtaining the hydrophobicity value (Q)

$$Q =$$

DG – Gibbs free energy of INDIVIDUAL amino acids
n – number of amino acid residues in peptide

Q > 5855 kJ bitter
Q < 5436 kJ not bitter

- humans vary in their ability to taste bitter compounds
    - At certain concentrations, some compounds may taste either bitter, bittersweet, or tasteless
        - Ex. Saccharin, a non-caloric sweetener
    - "Supertasters" – people who are genetically endowed with the ability to intensively perceive flavors
        - This is tested in humans using the compound PROP
- bitterness may also occur in salts
    - One of the main reasons for hampering the substitution of other cations for sodium in foods
    - Bitterness in salts is related to the sum of the ionic diameters of the anion and cation
        - __ionic diameter, __bitterness
        - Salts with a total ionic diameter of < 6.5A taste purely sweet
            - Ex. $MgCl_2$ (8.50 A) taste bitter

- Salty Taste Compounds
    - salty taste is provided mainly by _____, however ____ is not used due to its toxicity
    - salts exhibit complex taste but it often falls outside the traditional taste sensations and are difficult to describe in classic terms
        - Ex. Chemical or soapy taste is sometimes used
    - cations produce the _____, while the anion will _____

        - Na and Li produce only salty taste, while K and other alkaline earth cations produce both salty and bitter taste
        - Anions inhibit the taste of the cations and may contribute their own taste
        - Ex.
            1. _____
            2. _____
    - Anion taste effects impart the flavor of many foods such as cheeses
        - Na salts of long chain fatty acids and detergents contribute a soapy flavor
    - NaCl is the main compound used to impart a salty taste
        - Aside from the salty taste, it has other several flavor effects and flavor-enhancing properties
            - Exhibited by the addition, reduction, or removal of NaCl in food formulas or recipes
            - Ex. Addition of salt to enhance the sweetness of desserts and pastries
        - Due to its negative health effects, policies have been established to reduce Na intake, but replacing Na with other cations impart unwanted flavors in the food
            - There are renewed efforts in understanding the salty taste flavor to possibly look for possible substitute

- Sour Taste Substances
    - sour taste substances are acidic in nature
        - They contain at least ONE _____
    - at the initial molecular level, sour taste is perceived by:
        1. _____
        2. _____
        3. _____
    - qualitative aspect of the sour taste response is poorly understood
        - Acid strength is NOT directly proportional to the perceived sour sensation
    - other molecular features (e.g., molecular size, molecular weight, polarity) and prior experience determines the selection of acid in the food application

- Umami Taste Substances
    - umami substances contribute to a delicious, mouth-watering taste when used in excess
    - prominent and desirable in several food products (e.g., vegetables, meats, poultry, seafood, and aged cheeses)
    - _____ are the main substances used to impart umami flavors

        - D-glutamate and the 2'- or 3'- ribonucleotides have NO flavor-enhancing activity
    - several synthetic derivatives of the 5'-ribonucleotides have strong flavor-enhancing properties
        - Difference is the substituent group in the 2-position
    - synergistic interactions between MSG and other 5'-ribonucleotides provide umami taste AND flavor enhancement
        - Hence their use commonly as mixtures commercially
        - The flavor-enhancing properties come from the joint occupancy in the flavor-receptor sites
    - 5' xanthine monophosphates, L-ibotenic acid, and L-tricholomic acid are potential candidates for commercial use
    - purified forms of umami taste compounds used in the industry are sourced microbially

- Kokumi Taste Substances
    - "Kokumi" compounds are substances that do not elicit a response for the 5 basic tastes but can enhance food palatability
    - Often described as the _____ _____
        - Ex. NaCl, S-substituted cysteine sulfoxide amino acids, glutathione, succinic acid
            - Succinic acid contributes both brothy and sour taste
    - other terms used to describe kokumi-related taste modifications are velvety, richness, creaminess, juiciness
    - examples of kokumi taste substances
        - *Vanillin-type compounds*
            - one of the most popular kokumi taste substances
            - often associated with vanillin and ethylvanillin (i.e. vanilla flavor)
            - provide flavor-modifying effects such as smoothness, richness, and creaminess most especially to sweet, fat-containing food products
        - *Maltol and ethylmaltol*
            - commercial flavor enhancer for sweet and fruit-contaning products
            - marketed for the smooth, velvety sensation imparted to products are low concentrations (~50 ppm)
        - *Alkylphenols*
            - occur mainly in milk products and the meat of ruminants
            - contributes a mouth coating, richness enhancing, juiciness sensation at very low concentrations (ng alkylphenol / g food product)
            - m-alklyl substitution provides the most influential flavor modifying effect

- Ex. m-cresol and m-(n)-propylphenol are the most important alkylphenols in bovine-derived products and food ingredients

- Pungent Substances
  - substances that causes characteristic hot, sharp, stinging sensations in spices and vegetables
  - depending on the food, some pungent compounds may elicit responses in both the nasal and oral cavities
    - Non-volatile compounds found in chili peppers, black peppers and ginger must be first aerosolized to elicit responses in the nasal cavity
    - Mustards, horseradish, radishes, watercress, onions, and cloves contain pungent substances that are readily volatilized
  - pungent spices and vegetables are used in food products to provide characteristic flavors or enhance palatability
  - usage at low concentrations is enough to provide liveliness to different food products
  - Examples
    - Capsaicinoids
      - found commonly in chili peppers
      - vanillylamides of monocarboxylic acids with varying chain length (C_8-C_{11}) and unsaturation
        - Ex. capasaicin
      - different varieties of chili peppers contain varying amounts of capsaicin
      - Ex. red chili (0.06% w/w), cayenne (0.2% w/w), Sannam (0.3% w/w)
    - Piperine
      - commonly found in black and white peppers
        - Black pepper: immature, green berries
        - White pepper: mature berries harvested at the time they are changing from green to yellow but before red
      - _____ is necessary for strong pungency
      - Loss of pungency in peppers is due to the _____ _____
      - volatile compounds that contribute to flavor of seasoned peppers: L-formylpiperidine, piperonal
    - *Gingerols*
      - found in fresh ginger
      - phenylaklyl ketones that vary in chain length (C_5 – C_9) external to the -OH substituted C atom

- tends to _____ of the product which leads to the formation of a double bond in conjugation with the keto group
    - Formation of shogoals (_____ pungent compared to gingerols)
    - exposure to _____ leads to the cleavage of alkyl chain external to the keto group
    - Formation of zingerone (_____ pungency compared to gingerol)

- Cooling Substances
    - cooling is a ----_____ that occurs when chemical come into contact with the nasal and oral tissue that stimulates nonspecific neural systems
    - caused by substances associated with mint-like flavors
        - Ex. peppermint, spearmint, wintergreen
            - L-menthol is the most used flavor substance
            - Camphor is the model compound for camphoraceous groups of compounds which produces a distinct odor aside from a cooling sensation
    - cooling effect produced by polyol sweeteners (e.g., xylitol) is different from mint-related compounds
        - Mainly attributed to the _____ of the substance

- Astringent Substances
    - astringency is the _____ along with _____ of the oral tissue
    - results from the association of _____ forming precipitates or aggregates
        - often confused with bitterness as some tannins causes both astringent and bitter sensations (e.g. in red wine)
        - the more condensed or bigger the tannin, the more astringent it is
            - large size makes it suitable for more hydrophobic interactions with proteins
            - tannins contain many phenolic groups that can be converted to quinoid structures which can cross-link with proteins
        - astringency is _____ in tea, but adding milk or cream _____ astringency due to the binding of polyphenols with milk proteins
    - too much astringency is _____ in wines hence the _____ of polyphenol tannins related to anthocyanin pigments
    - astringency in unripe bananas can lead to undesirable tastes in products that contain them

- Process of Reaction Flavor Volatiles
    - Thermally Induced Process Flavors
        - these compounds are the products of browning reactions in food
        - provides general _____
        - most are heterocyclic compounds with N, O, or S substituents
        - occurs in many foods and beverages (e.g. roasted meats, boiled meats, coffee, roasted nuts, beer, bread, crackers, cocoa, snack foods, etc.)
        - distribution of compounds depend on several factors (i.e., availability of precursors, temperature, time, and water activity)
        - production of concentrates involving these compounds involve selection reaction mixtures and conditions that mimic those occurring naturally in food
            - Ingredients: reducing sugars, amino acids, compounds with sulfur atoms
            - Ex. thiamine – it contains both N and S atoms in a cyclic structure
            - Process: heating at elevated temperatures

- Interactions with Other Food Constituents
    - Interactions with Other Food Constituents
        - aroma compounds interact with the lipids, proteins, carbohydrates, and water found in the food matrix
        - Affects retention of the volatile compounds which affect perceived intensity and quality
        - model systems are used to study these interactions
            - Ex. Model system of 1%, 5%, and 20% fat with an aroma cocktail for mayonnaise
                - 20% fat – typical balanced odor of mayonnaise
                - 5% fat – creamy and pungent odor due to decrease in intensiry of buttery and fatty notes
                - 1% fat – pungent mustard-like aroma
            - the _____ the fat content, the _____ the concentration of fat-soluble aroma compounds in the gas phase _____
            - important to understand how these interactions work
    - Interactions with Lipids
        - __solubility in the fat phase as the __chain length of the aroma compound
        - __vapor pressure as __hydrophobicity
        - fat-soluble aroma compounds tend to have _____ odor threshold in oil phases making them _____
    - Interactions with Proteins and Carbohydrates
        - the adsorption of aroma compounds on proteins and carbohydrates will vary depending on the general polarity of the biomolecule
            - Ex. proteins with high degrees of hydrophobicity will adsorb hydrophobic aroma compounds

        - 3D networks of proteins or carbohydrates may also trap volatiles within its structure
            - Ex. starch after gelatinization forms helical structures that can trap aroma compounds

- Natural and Synthetic Flavorings
    - the production of "flavored" food has been increasing with the development of newer food production methods
        - Ex. the use of protein isolates which are naturally flavorless require the addition of flavors to increase acceptability
    - aroma concentrates, essences, extracts, and individual compounds are used as additives
        - Blended in a given concentration to elicit the flavor and aroma of specific food products
    - Based on experience and sensory assessment supported by analytical data
    - Raw Materials for Essences
        - Most aroma compounds are considered as "natural"
            - Extracted from plant products or are synthetic but similar in structure to nature-derived compounds
        - Essences are a mixture of different materials from different sources
            - Essential oils
                - Obtained through steam distillation and then purified
                - Pressure and temperature used must consider the thermal degradation of the flavor compounds
                - Fractional distillation can be used to concentrate certain compounds in the essential oil
            - Extracts and absolues
                - Oil extraction is preferentially performed when essential oil content is low of important aroma compounds are lost by the distillation
                - Oil and/or organic solvents are used
                - Chromatography is used to further purify or concentrate the extract
                - Odor intensity is weaker compared to essential oils
            - Distillates
                - Aroma volatiles found in water-based products are concentrated using a simple distillation process
            - Microbial aromas
                - Microbes are fed with precursors which can act as substrates for specific enzymatic action
                    - Ex. Cheese flavor can be produced by *Penicilium roqueforti* fed with fats or oils
            - Synthetic natural aroma compounds
                - Several important aroma compounds that are nature identical are synthesized to increase availability

        - Ex. Vanillin is produced from alkaline hydrolysis of lignin, menthol is synthesized from m-cresol (petrochemical product)
    - Purity of these substances should be high to meet legal requirements and to remove unwanted flavor compounds

- Stability of Aroma Compounds
    - Aroma compounds may under degradation if they react with other substances found in the food matrix
        - Degradation pathway is dependent on the functional groups present in the compound
    - Encapsulation can protect aroma compounds against chemical degradation
        - Materials used are generally polysaccharides (e.g., gum arabic, maltodextrin, etc.)
        - Spray-drying, extrusion, or formation of inclusion complexes are used in encapsulation
        - Spray-drying involves emulsifying the aroma compounds in the polysaccharide
        - Extrusion uses a melt of wall material to encase the compounds and is cooled to solidify
        - Inclusion complexes are formed in solution and are then precipitated out

Vitamins

- Introduction
    - Vitamins are diverse group of organic compounds that are nutritionally essential
    - Functions:
        1. _____
        2. _____
        3. _____
        4. _____
    - It can also influence the chemical nature of a food product by acting as a:
        1. _____
        2. _____
        3. _____
        4. _____
    - Considered as a minor food component due to its small concentration

→Food chemistry perspective: _____ vitamin retention, _____ leaching and chemical reactions

Name:

- Toxicity of Vitamins
  - At certain consumption levels vitamins WILL exhibit toxicity (e.g., Vit A, D, and B6)
  - Toxic potential also exists in excess fortification
  - Need for continued monitoring by regulatory and public health agencies
- Sources of Vitamins
  - Food supply represents the MAJOR and CRITICALLY important source of vitamin intake. Supplements only come in 2nd
  - Food provide vitamins that are either naturally occurring in the product or those that were added during nutrification
  - Whether natural or added, there are still potential losses by chemical or physical means
    - Occurs at every step in the food chain
    - Losses are _____ but IT CAN and SHOULD be controlled
- Addition of Nutrients to Food
  - Definition of Terms:
    - Nutrification – _____
    - Restoration – _____
    - Fortification – _____
    - Enrichment – _____
  - General Guidelines in the Addition of Nutrients
    - Stable under _____
    - Physiologically available from the food
    - Present at a level where there is _____
    - Suitable of its intended purpose and in compliance with provisions governing safety
- General Causes of Variation or Losses of Vitamins in Foods
  - Inherent variation in vitamin content
    - Vitamin content in fruits and vegetables is affected by multiple factors like _____
    - During maturation, vitamin concentration is determined by _____
    - Agricultural practices and environmental conditions may also affect vitamin content of plant-derived products
    - In animal products, vitamin content is affected by their _____
  - Postharvest changes in vitamin content
    - Tissues of both plants and animals retain enzymatic activities that contribute to post-harvest changes in the vitamin content of foods
      - Oxidative and hydrolytic enzymes are able to change the distribution of chemical forms and activity of vitamins

        - Ex. Vitamin B6 – dephosphorylation and deglycosylation affects postharvest vitamin distribution and concentration
    - Generally have little influence on the net concentration of the vitamin but may affect its bioavailability
- Postharvest changes are inevitable but can be minimized most especially if proper procedures are followed during postharvest handling

■ Preliminary Treatments
- Peeling and trimming
  - Lowers the concentration of vitamins most especially for products where the nutrients are concentrated in the skin
  - _____
  - Alkaline treatment to enhance peeling will also lower the concentration of vitamins that are unstable in basic conditions (i.e. folate, ascorbic acid, and thiamine). However, this is relatively small compared to the total vitamin content
- Washing
  - Cuts that expose tissue allow the leaching out of water-soluble vitamins during washing, transportation, or exposure to brine during cooking
  - Extent is affected by _____ _____ _____
  - The extractant might also cause destruction of vitamins once extracted and is affected by _____ _____
- Milling
  - Milling reduces vitamin concentration in cereal grains as most vitamins are concentrated in the bran
  - _____

■ Effects of blanching and thermal processing
- blanching _____ _____
  - has beneficial effect on the stability of vitamins
- losses come mainly from _____ of vitamins
  - hot water can __rate of leaching of vitamins resulting in __losses
  - HTST processing improves retention of labile nutrients during blanching
- Thermal processing accelerates degradation reactions that occur slowly at ambient temperatures
  - Degradation is still affected by several factors like _____
  - _____

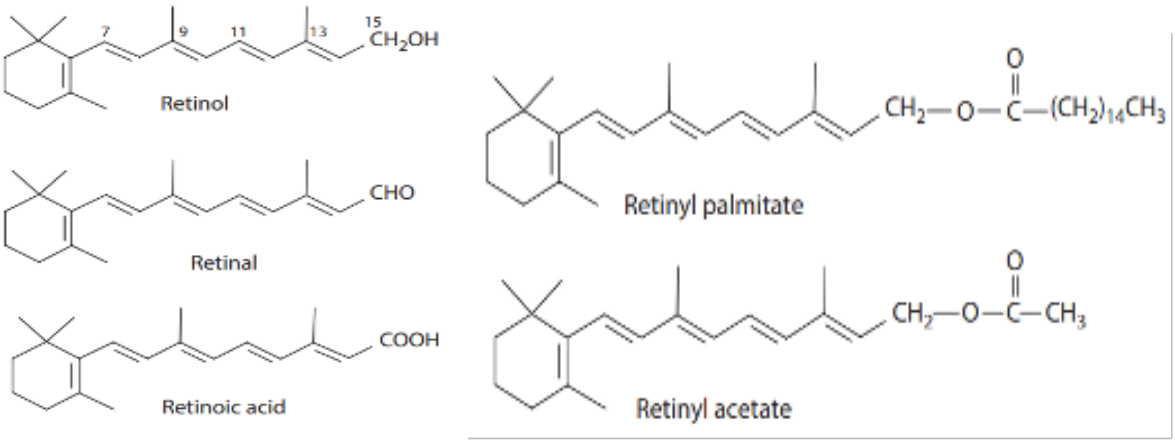
Name:

        - _____
    - Nutritional significance depends on the degree of loss and the important of the food as a source of the vitamin in a certain diet
- Vitamin losses following processing
    - Storage has small but significant effect on vitamin content
        - Affected by several factors:
            1. _____
            2. _____
            3. _____

    - Water activity also influences vitamin stability in reduced moisture foods
        - Degradation rates _____ in proportion to water activity in regions of multilayer hydration
- Influence of processing chemicals and other food components
    - Oxidizing agents: _____
    - Cl ions: _____
    - Sulfite and other sulfiting agents: _____ _____
    - Nitrite: _____
    - pH modifiers: _____

- Fat-soluble vitamins
    - Vitamin A: Retinol and Related Compounds
        - Structure and General Properties
            - Retinol and related compounds including carotenoids
                - *Retinoids* – _____
            - Carotenoids contribute significant Vit A to foods of both animal and plant origin
                - Only ___ carotenoids exhibit provitamin A activity
                - Preformed Vit. A DOES NOT exist in plants
            - For compounds to have Vit A or provitamin A activity it must exhibit certain structural characteristics
                - _____
                - _____
            - Activity of carotenoids
                - _____ exhibits greatest provitamin A activity among carotenoids
                - Carotenoids with hydroxylation on one ring have _____ activity than B-carotene; both rings have _____ activity
                - _____ isomers exhibit greatest Vit A activity

- Lipophilic compounds
  - Associate with lipid components, specific organelles, or carrier proteins lipid droplets or dispersed micelles



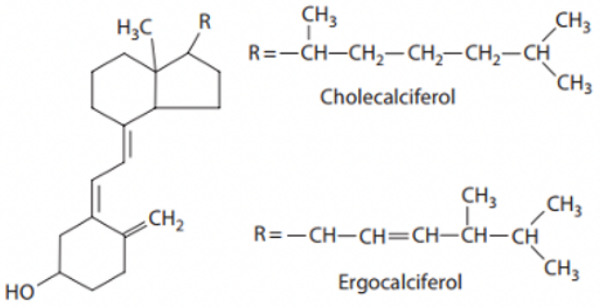
    - Stability and Modes of Degradation
      - Similar mode of degradation to unsaturated lipids
        - Direct oxidation or reaction with free radicals
      - Generally stable under prolonged storage insignificant losses
      - Loss of activity mainly due to:
        - _____
        - _____

        → _____ may diminish Vit A content and/or activity

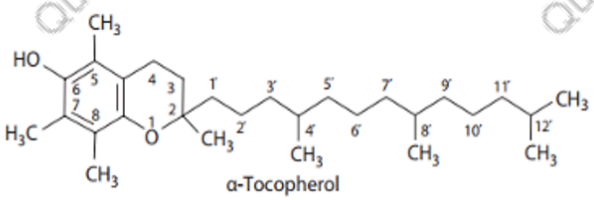
  - Vitamin D: Calciferols
    - Structure ang General Properties
      - Associated with lipid-soluble sterol analogues
        - Cholecalciferol (Vit D3) – _____
        - Ergocalciferol (Vit D2) – _____
        - Both are used in fortification
      - _____ is formed in human skin upon exposure to sunlight initial reaction is photochemical
        - Individual requirement depends on sunlight exposure
      - _____ is formed from the irradiation of a phytosterol with UV light
      - _____ is main physiologically active form
      - _____ comprises significant amount of naturally occurring Vit D in milk and meat

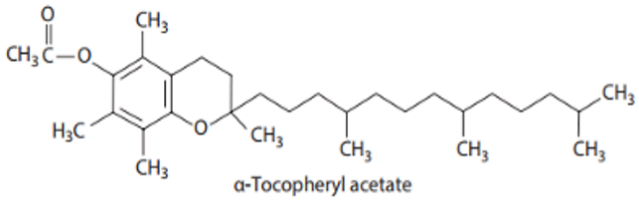
Name:

- Susceptible to degradation by _____
    - Exact mechanism of _____ degradation is still not yet clear



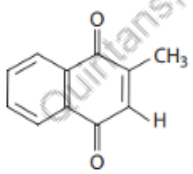
- Vitamin E: Tocols and Tocotrienols
    - Structure ang General Properties
        - α-tocopherol is viewed as the sole form having Vit E activity
            - α-tocopherol + other forms have _____
        - Stereochemistry at $C_{2,4',8'}$ influences Vit E activity
        - Synthetic form of _____ is widely used in fortification
            - Acetate ester increases stability block phenolic hydroxyl group eliminating radical-quenching activity
        - Highly non-polar exists in lipid phase of food
        - All tocopherols and tocotrienols have antioxidant activity
            - Contributes to stability of unsaturated vegetable oils
            - Influences oxidative stability of meats after slaughter
                - Acetate esters do not hot antioxidative activity



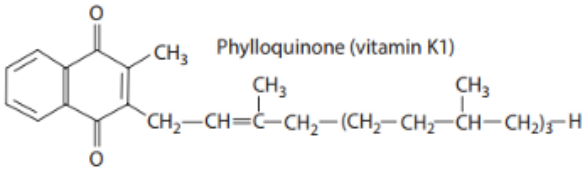


- Stability and Mechanism of Degradation
  - Vit E compounds are generally stable in the _____ of oxygen and oxidizing lipids
    - Anaerobic processing techniques have little effect on Vit E activity
  - __degradation in the presence of molecular oxygen and free radicals
  - Vit E compounds can react with compounds found in food
    - Can react with peroxyl radical to form a hydroperoxide and tocopheryl radical protective effect on food
    - Degradation products have no vitamin activity

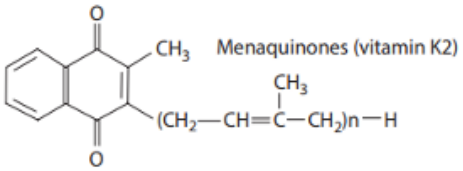
- Vitamin K: Napthoquinones
  - Napthoquinones with or without terpenoid in position 3
    - _____: synthetic form used in supplements and fortification
    - _____ (Vit K1): plant origin found in large quantities in leafy vegetables
    - _____ (Vit K2): products of bacterial synthesis by intestinal microflora
  - Quinone can be reduced to hydroquinone by reducing agents but vitamin activity is retained
  - Heat stable but degrades when exposed to sunlight
  - Hydrogenation of oils reduces Vit K activity conversion to dihydro from



Menadione



Phylloquinone (vitamin K1)

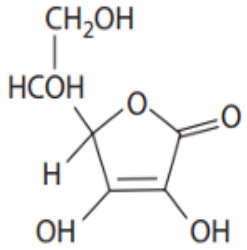


Menaquinones (vitamin K2)

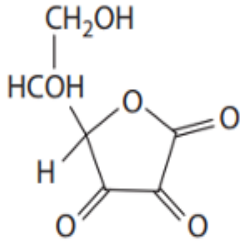
- Water-soluble Vitamins
  - Vitamin C: Ascorbic Acid
    - Structure and General Properties
      - L-ascorbic acid (AA) carbohydrate-like compound whose acidic and reducing properties are contributed by 2,3-enediol moiety

Name:

- Highly polar and acidic in character
- 2 enantiomer pairs:
  - L & D-ascorbic acid // L & D-isoascorbic acid
- AA and DHAA have vitamin activity
  - Other forms are have antioxidative activity

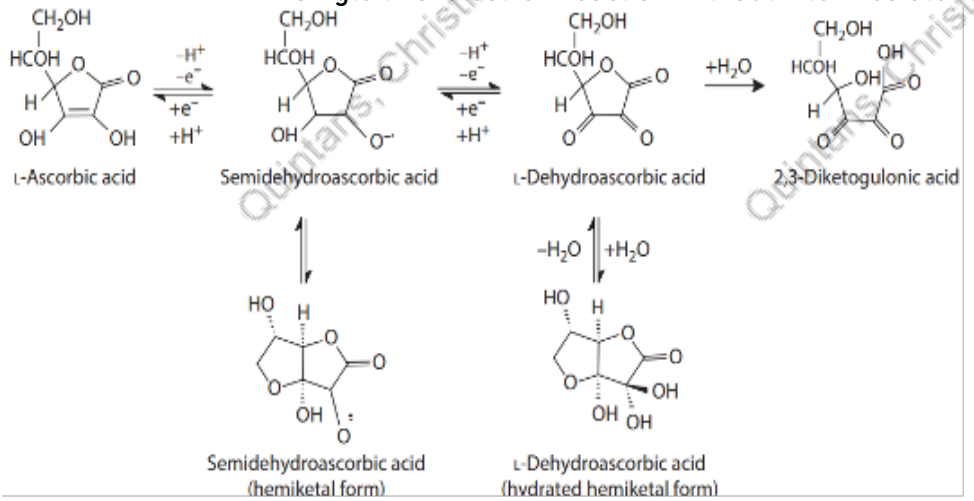


L-Ascorbic acid*



L-Dehyroascorbic acid*

- AA is added either as undissociated acid or neutralized sodium salt
- Conjugation with hydrophobic compounds improves lipid solubility
  - Antioxidative effect in lipid environment
- Two modes of oxidation
  - Two sequential one-electron transfer process
  - Single two-electron reaction without intermediate



→ _____ causes the main loss for Vit C activity

- Highly susceptible to _____
- _____ affects reaction rates
- _____ is rate-limiting step of Vit C degradation
- Ability to act as a pro-oxidant at _____

■ Stability and Modes of Degradation: Overview

- High solubility of AA _____
- Chemical degradation forms _____
- Oxidation and dehydration leads to the _____ _____

- Factors affecting degradation rate and nature of products: _____
- Foods can undergo large losses of AA during storage and handling
    - AA stability is dependent on food composition and storage condition
- Rate of oxidative degradation is a nonlinear function of pH
- Various ionic forms differ in their susceptibility to oxidation
    - _____ _____
- pH dependence of oxidation is mainly governed by _____
- _____
- At pH ≥ 8, _____

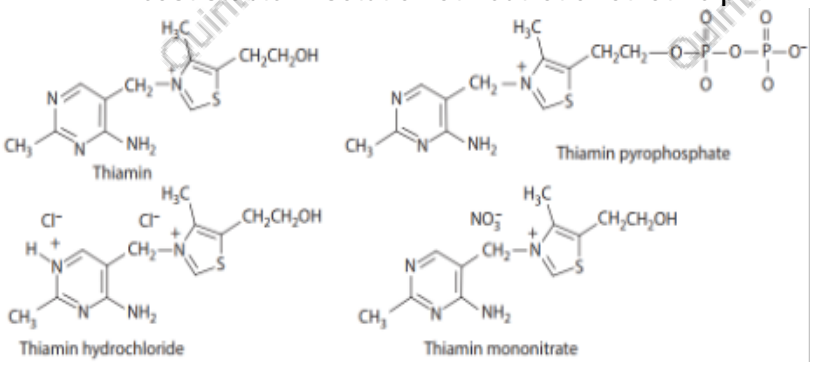
■ Stability and Modes of Degradation: Catalytic Effect of Metal Ions

- Rate of metal-catalyzed oxidation of AA is
    - proportional to _____
    - Independent of _____
- Oxidation by metal chelates is _____
- Potency of metal ions in catalyzing AA degradation depends on _____
- _____
- Values of rate constants in simple solutions differ from actual food systems _____
- ↑rate as ↑temperature
    - Rate is unaffected by presence or absence of oxygen
    - Anaerobic degradation may occur in canned products _____
- Degradation Products
    - Opening of the lactone ring irreversibly destroys Vit C activity
    - Many reactions in the degradation pathway are important as they are involved in _____
    - _____
    - Three general types of decomposition products:
        - _____
        - _____
        - _____
    - Formaldehyde may be formed during _____ → _____
    - Degradation is also associated with discoloration reactions

Name:

- Functions in Foods
  - Widely used as an ingredient due to its reducing and antioxidative properties
    - _____
    - _____
    - _____
    - _____
    - _____
    - _____
    - _____

- Vitamin B1: Thiamine
  - Structure and General Properties
    - Substituted pyrimidine linked through a methylene bridge to a substituted thiazole
    - Widely distributed in plant and animal tissues
    - Most naturally occurring is _____
    - Commercially available as the _____
    - Exhibits acid-base behavior with two dissociation constants (pK_{a1} = ___; pK_{a2} = ___)
    - Quaternary N at thiazole ring remains cationic at all pH values
    - pH dependence of thiamin degradation corresponds to pH-dependent changes in ionic form
      - Protonated thiamin has _____ → _____
    - Relatively stable to _____
    - Least stable in solution at neutral or alkaline pH



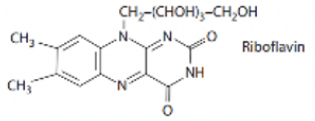
  - Stability and Modes of Degradation
    - Losses are favored when:
      - _____
      - _____
      - _____
    - Factors affecting stability
      - pH
        - _____
        - _____

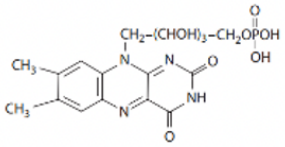
- A_w and Temperature
  - _____
  - _____
  - _____
- Nitrites
  - _____
- Sulfites and hydroxides
  - _____
  - _____
- Oxidizing agents
  - _____
  - _____
- Others
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____

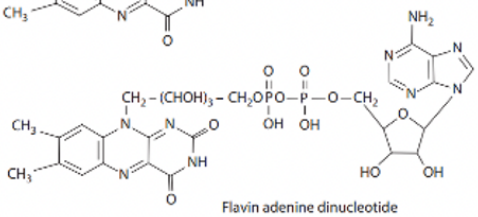
- Vitamin B2: Flavins
  - Structure and General Properties
    - All flavins contain a 7,8-dimethyl-10(1'-ribityl)isoalloxazine parent group
      - Phosphorylation at the 5' end of the ribityl group forms _____
      - Phosphorylation with a 5'-adenosyl monophosphate forms _____
    - FMN and FAD functions as _____
    - Both forms are readily converted to riboflavin by phosphatases
    - Flavins have complex chemical behavior
      - Riboflavin undergoes redox cycling among 3 different compounds
        - Flavoquinone: _____
        - Flavosemiquinone: _____
        - Flavohydroquinone: _____

Name:

- Several minor forms also exist in foods
  - Some forms have antagonistic effects on riboflavin transport and metabolism

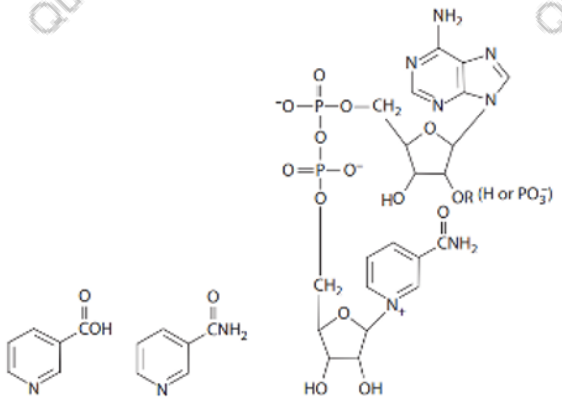






- Stability and Modes of Degradation
  - Factors affecting stability
    - pH
      - _____
    - A_w
      - _____
      - _____
      - _____
    - Light
      - Photodegradation produces 2 inactive forms - lumiflavin and lumichrome
        - _____
        - _____
      - Photolysis forms superoxide and riboflavin radicals
        - _____
        - _____
        - _____

- Vitamin B3: Niacin
  - Structure and General Properties
    - Niacin is a generic term for pyridine 3-carboxylic acid (nicotinic acid) and its derivatives that have vitamin activity
    - _____ are the most stable form of the vitamin
    - Coenzyme form are _____ → _____
    - Heat converts nicotinamide to nicotinic acid with _____



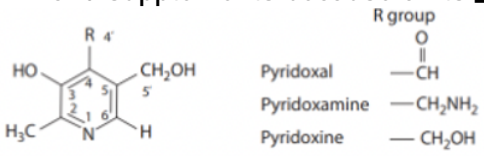
- Stability
  - Generally stable
    - Not affected by light
    - Stable during thermal processing
  - Losses occur by _____
  - May exist in several chemical forms that do not exhibit any vitamin activity must be hydrolyzed

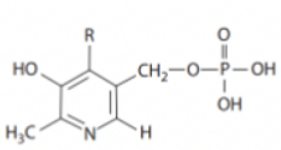
- Vitamin B5: Pantothenic Acid
  - Structure and General Properties
    - β-alanine in amide-linkage to pantoic acid (2,4-dihydroxy-3,3-dimethyl-butyric acid
    - Component of _____
    - _____
    - Essential for all living things
      - Widely distributed in both plant and animal products
      - Found in food mainly as _____
    - _____ is often used in food fortification and vitamin supplements
    - Better stability and less hygroscopic than free acid

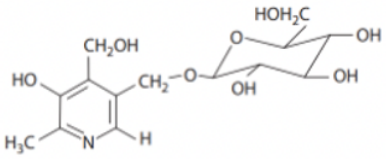
  - Stability and Modes of Degradation
    - Factors affecting stability
      - pH and a_w
        - _____
        - _____
        - _____
        - _____
      - Oxygen and light
        - _____
      - Processing
        - _____

Name:

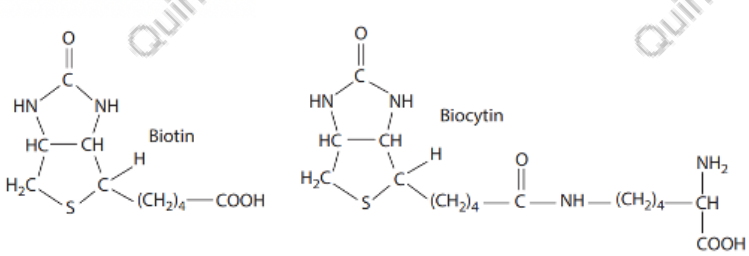
- Vitamin B6
  - Structure and General Properties
    - Exhibits complex ionization due to presence of several ionic sites
    - All forms exist in foods but in different amounts
    - _____ is primarily the form used in fortification and supplements because of its _____




Vitamin B6 5′-phosphate

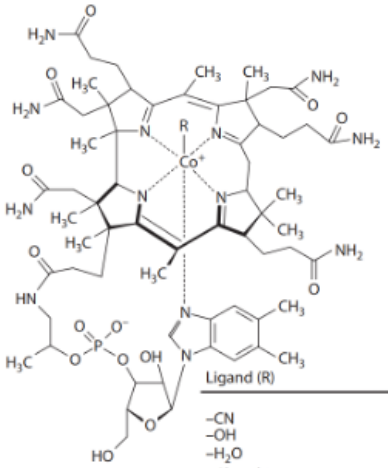

Pyridoxine-5′-β-D-glucoside

  - Stability and Modes of Degradation
    - Exposure to water can cause _____
    - Chemical changes can involve:
      - _____
      - _____
      - _____
    - Interconversion mainly happens through nonenzymatic transamination
      - _____
      - _____
      - _____
      - _____
    - All forms of Vit B6 are susceptible to light-induced degradation
      - _____
      - _____
    - Rate of nonphotochemical degradation is strongly dependent on the _____
    - All forms are stable at _____
    - Each form will have its own degradation reaction and interconversions during thermal processing
- Vitamin B7: Biotin
  - Structure and General Properties
    - Fusion of imidazolidone ring with tetrahydrothiophene ring bearing a pentanoic acid side chain
    - 2 naturally occurring, vitamin-active forms: _____
    - Catabolic products of biotin in animal tissue have no vitamin activity
    - Widely distributed in plant and animal products



- Stability
  - Stable to heat, light, and oxygen
  - Extreme pH (high or low) can cause degradation _____
  - The sulfur can be oxidized yielding an _____
  - Losses are mainly due to _____

- Vitamin B12: Cobalamin
  - Structure and General Properties
    - Group of compounds with similar vitamin activity to _____
      - Corrinoids – _____
    - _____ listed exhibit Vit B12 activity
    - _____ of Vit B12 used in food fortification and supplements superior stability and readily available commercially
      - Reddish color in crystalline state and in solution _____
    - Coenzyme form: _____
    - Little or no naturally occurring cobalamin exist in foods
      - _____
      - _____
      - _____



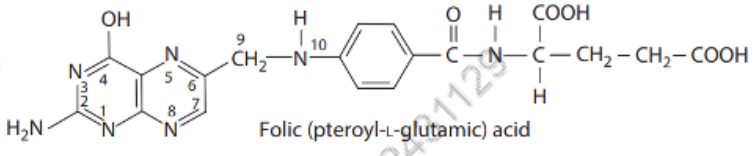
Ligand (R)	B12 Form
–CN	Cyanocobalamin
–OH	Hydroxocobalamin
$-H_2O$	Aquocobalamin
–Glutathione	Glutathionylcobalamin
$-CH_3$	Methylcobalamin
–5′-Deoxyadenosine	5′-Deoxyadenosyl-cobalamin

  - Stability and Modes of Degradation

Name:

- No significant loss under most conditions of food processing
- Ascorbic acid is known to _____ Vit B12 degradation
    - Little significance as foods with __Vit B12 have __Vit C
- Photochemical degradation produces aquacobalamin
    - Vitamin activity is retained
- Greatest stability at pH _____
- Exposure to acid _____
- Exposure to acid or alkaline conditions _____
- Interconversions may occur but has little influence on vitamin activity

- Folates
    - Structure and General Properties
        - Interconversion happens through the methenyl intermediate
        - Each form will have different stabilities
        - _____ is used in fortification and in supplements
            - _____



Folic (pteroyl-L-glutamic) acid

    - Stability and Modes of Degradation
        - Folate Stability
            - Folic acid shows _____ during processing and storage of fortified foods
                - Little degradation of folic acid occurs during _____ _____
                - Extensive losses occur during preparation and processing due to _____
                    - Overall loss depends on _____
                    - _____
                    - _____
        - Susceptible to _____
        - Factors Affecting Folate Stability
            - Light
                - _____
            - Blanching
                - _____
            - Temperature
                - _____
            - pH
                - _____
                - _____

    - Oxidative degradation
        - _____
        - _____

- Optimization of Vitamin Retention
    - Inevitable losses of nutritional value occur from farm to fork
    - Optimization of nutrient retention is a responsibility of food manufacturers and processors for the mutual interest of the industry and the public
    - Approaches to optimization of vitamin retention are based on the physical and chemical properties of each vitamin
        - _____
        - _____
        - _____
        - _____

        - Optimization of Thermal Processing Conditions
            - Both _____ are considered in thermal processing
            - Microbial inactivation requires _____while vitamin degradation requires _____ _____
            - Rate of microbial inactivation increases as a function of temperature faster compared to vitamin degradation
        - Prediction of Losses
            - Predicting magnitude of losses requires _____ _____
            - Different chemical forms react _____
            - Processing studies must _____
            - Accelerated storage studies may be performed _____ _____ _____
        - Effects of Packaging
            - In canning, food that _____ _____
            - Difference is due to _____ _____
            - Losses are minimized by _____
            - Pouches offer advantage of requiring less liquid for filling minimized leaching
            - Permeability of packaging material also affects retention during storage
                - _____
                - _____

Name:

Minerals

- Introduction
  - Overview of Minerals
    - Minerals are elements with nutritional importance OTHER THAN C, H, O, N
    - Present in relatively low concentrations in food
    - Classified as either major or trace – depending on the amount present in living organisms
      - Major: _____
      - Trace: _____
  - Principles of Mineral Chemistry
    - Solubility of Minerals in Aqueous Systems
      - Most nutrients are delivered and metabolized in aqueous environments_____
      - Many elemental form of elements exist as _____ _____
      - Forms of elements present in food vary depending on chemical properties
        - Grp IA and IIA exist as _____ _____
        - Other minerals exist as _____ _____
      - Solubility of complexes and chelates are different from inorganic salts
        - Ex. _____
    - Acid-Base Chemistry
      - Bronsted-Lowry (BL) Theory of Acids and Bases
      - Many acids and bases occur in food and follows BL acid-base chemistry
      - Phosphoric acid is one example of a mineral acid found in food
        - _____
        - _____
      - Other common mineral acids are HCl and H_2SO_4
        - Not added directly but may be generated during processing and cooking
    - Lewis Theory of Acids and Bases
      - Lewis acid: electron pair _____
      - Lewis base: electron pair _____
      - Bonding results from the interaction of orbitals of acid and base to form new molecular orbitals
        - Involved in the formation of complexes
      - Minerals are considered as _____ and ligands are considered as _____
        - In ligands, _____ are the electron donors

        - In foods, _____ _____ can be ligands
    - Denticity of ligands - _____
    - _____
        - Explains the chelate effect
- Chelates
    - Complex resulting from the combination of a metal ion and a multidentate ligand
        - Ligand forms 2 or more bonds with the metal
        - Complex must form a ring structure
    - Stability of chelates are affected by:
        - *Ring size*: _____
        - *Number of rings*: _____
        - *Lewis base strength*: _____
        - *Charge of ligand*: _____
        - *Resonance in chelating ring*: _____
        - _____
        - *Steric hindrance*: _____
        - *Chemical environment of donating atom*: relative strength of metal-ligand bonds are:
            - Oxygen as donor: _____
            - Nitrogen as donor: _____
            - Sulfur as donor: _____
    - Chelate Effect
        - Can be explained by thermodynamics
            - Concept of Gibbs free energy ($\Delta G = \Delta H - T\Delta S$)
        - EDTA
            - Hexadentate ligand
            - Formation of EDTA chelates produces large positive effects on entropy
            - EDTA chelates contain 5 rings enhanced stability
            - Forms stable chelates with many metal ions
        - Chelates are important in food and biological systems
            - Sequestrants of mineral ions which can act as prooxidants
            - Mineral chelates are used in food fortification due to enhanced solubility

Name:

- Mineral Composition of Foods
  - Ash and Individual Minerals
    - Ash – _____
      - Determined by complete combustion of the organic matter
      - Minerals in the ash are in the form of _____
      - _____

      → overestimates total mineral content
    - Individual minerals are determined by dissolving the ash in acid and subjecting the solution to the appropriate analytical method
      - Modern methods use instrumentation (i.e. spectroscopy)
- Factors Affecting Mineral Composition in Foods
  - Factors Affecting Mineral Composition of Plant-based Foods
    - Plants take up minerals from the soil through their roots
      - Sources:
        - _____
        - _____
        - _____
    - Nutrients are then transported to other parts in the plant where they are needed

    → Possibly affect variation of distribution of minerals in plant-based foods
  - Adequacy of Plant Foods for Supplying Mineral Needs of Humans
    - Essential minerals in plants are not identical to those of humans
      - F, Se, I are non-essential in plants
      - possibility of deficiencies in people with purely a plant-based diet
    - For the similar essential minerals, bioavailability and concentration are the main concerns when it comes to adequacy
      - Highly apparent for Fe and Ca
    - Improvement of mineral quality of fresh produce is a complicated process
      - Addition of minerals through the soil does not guarantee uptake within the plant
      - Movement of minerals through the food chain is also complicated
      - Modifying soil conditions might improve the uptake of one mineral but might decrease for others
    - Biofortification is used to improve concentrations and/or bioavailabilities in crops
  - Factors Affecting Mineral Composition of Animal-based Foods
    - Mineral concentration in animal foods vary less compared to plant foods
    - Changes in dietary intake only have minute effects on mineral concentration
    - Homeostatic mechanisms regulate tissue concentrations of essential nutrients

- Adequacy of Animal Foods for Supplying Mineral Needs of Humans
  - Composition of animal tissue is same with human tissue animal foods are good sources of nutrients
    - Meat, poultry, fish: _____
    - Marine fish: _____
    - Milk: _____
- Chemical and Functional Properties in Foods
  - Calcium
    - Important in the manufacture of cheeses
      - Addition of calcium prior to addition of rennet __ coagulation time
      - Curds with __Ca are crumbly; cheeses with __Ca are elastic
    - Calcium salts enhance the texture of fruits and vegetables
      - Slow the decline in firmness of fresh-cut fruits and vegetables
        - _____ _____ __
    - Calcium lactate is preferably used than calcium chloride
  - Phosphates
    - Occurs in food in many different forms
    - Several forms are approved as food additives
      - _____ _____ _____
      - Functions in food include _____
      - _____
      - _____
        - Phosphates carry negative charges while polyphosphates are polyelectroytic strong Lewis base character
  - Sodium chloride
    - Functions include enhanced flavor, control of microbial growth, improved water-binding capacity in meats, and enhanced color
      - In cheeses, it also controls the rate of lactic acid fermentation and modifies texture
      - In processed meats, acts as a preservative and promotes solubilization of muscle proteins which acts as emulsifying agents
      - In bakery products, enhances flavor, controls fermentation rate, and acts as a dough improver
    - Salt acts as both a salty taste compounds and a kokumi compound
    - The consumption of too much salt has been linked to several cardiovascular diseases
      - Research is focused on looking for appropriate alternatives

- Transition Metals
  - Iron
    - Promotes lipid peroxidation
    - Catalytic rate of ferrous iron is greater than ferric iron reason why AA can acts as a prooxidant
  - Nickel
    - Catalyst in the hydrogenation of edible oils and production of sugar alcohols
  - Copper
    - Catalyst of lipid oxidation
    - Bound copper in conalbumin stabilizes the protein against excessive denaturation

Additives

- Natural or synthetic compounds that MUST provide useful and acceptable function or attribute
- Improve quality, enhance nutritional value, functional property improvement, processing facilitation, and enhanced consumer acceptance
- Use of additives to conceal damage or spoilage is FORBIDDEN
- Use of additives is discouraged in instances where similar effects can be obtained by economical, GMP
- Compounds that are considered as additives have continually grown over the years

- Acids, Bases, and Buffers
  - Acids
    - Both organic and inorganic acids occur in natural food systems
    - Use of acids as additives have several purposes
      - _____
      - _____
      - _____
      - _____
    - The use of acids to influence pH of food is governed by the acid's dissociation constant
    - Phosphoric acid is the most widely used inorganic acid
    - Strong mineral acids are rarely used because of its possible effects on food quality
  - Chemical Leavening Systems
    - Composed of compounds that react to release gas in a dough or batter under appropriate conditions of moisture and temperature
    - Imparts characteristic porous, cellular structure to baked goods
    - Found in self-rising flours, prepared baking mixes, household and commercial baking powder, and refrigerated dough products

- Gas produced is CO_2
- Leavening salts: $NaHCO_3$, $(NH_4)_2CO_3$, NH_4HCO_3
- In dough, proteins and other ionic species can participate in the reaction
- Both the leavening acid and the dough react with the bicarbonate to form CO_2
- Proper balance of acid and base is needed as excess bicarbonate imparts a soapy taste while excess acid imparts sour or tart aftertaste
- Leavening acids have generally limited water solubility at RT
- Examples of leavening acids: phosphates and potassium acid tartrate salts, sodium aluminum sulfate

- Bases
  - Applications
    - _____
    - _____
    - _____
  - $NaOH$, Na_2HPO_4, Na_3PO_4, Na_2CO_3, MgO, $MgCO_3$, $Ca(OH)_2$
- Buffers
  - Na salts of gluconic, acetic, citric, and phosphoric acids are commonly used for buffering and tartness modification
  - Citrates are preferred over phosphates since it produces smoother sour flavors
  - K salts are used in low Na products
  - Ca salts are not used because of solubility issues
  - Effective buffering ranges
    - Citric acid-citrate: 2.1-4.7
    - Acetic acid-acetate: 3.6-5.6
    - Phosphoric acid and its anions: 2.0-3.0, 5.5-7.5, 10-12
  - Phosphate salts also acts as texture improvers in cheese products
    - Act as emulsifying salts
      - _____
      - _____
    - Improves stability of milk emulsion
      - _____
    - Increases water holding capacity of meat products
      - _____

Name:

- Chelating Agents
    - Also called as sequestrants
    - Reacts with metallic ions to form complexes that alter their effects on the food food stabilization
        - Foods naturally contain metals in a chelated form
        - Ions released by degradation pathways, may participate in reactions that affect chemical and sensorial properties
    - Examples: polycarboxylic acids (citric, malic, tartaric, oxalic, and succinic), polyphosphoric (ATP and pyrophosphate), and macromolecules (porphyrins and proteins)
    - Factors that affect chelate formation
        - Molecules or ions with unshared electron pairs can form complexes when present in proper geometrical form
            - -OH, -SH, -COOH, PO_3H_2, -C=O, NR_2, -S-, -O-
        - Environmental pH
            - -COOH is not an efficient EDG, $-COO^-$ is an efficient EDG
            - -OH may compete with chelating agents for metal ions
        - K_f of the complex
            - As K increases, more of the metal is complexed
    - Applications
        - Polyphosphates and EDTA are used in canned seafoods to prevent formation of glassy crystals of Mg
            - Also used to complex. Fe, Cu, and Zn to prevent reaction with sulfides discoloration
        - Inhibits discoloration in fruits and vegetables and sequesters Ca increases tenderness
        - Citric and phosphoric acid are used as both acidulant and chelating agent in soft drinks
        - Stabilizes fermented malt beverages through Cu complexation
        - Heavily speculated that excess use of EDTA and phytic acid could have nutritional effects in the body not enough proof

- Antioxidants
    - Prevents unwanted redox reactions from occurring in food systems
        - Commonly associated with the reactions caused by free radicals
    - Often have variable degrees of efficiency combinations are better than single additions
        - Ascorbic acid can regenerate phenolic antioxidants
        - Some chelating agents may also act as synergists
    - Tocopherols and polyphenolic substances are the most commonly used
        - BHA, BHT, propyl gallate, di-t-butylhydroquinone
            - Used as reaction terminators

- B-carotene is can also be used used singlet oxygen scavenger
- Synthetic Antioxidants
  - Butylated hydroxyanisole (BHA)
    - Mixture containing ~90% 3-BHA and ~10% 2-BHA
    - Effective in protecting lipids with short-chain FAs, and the aroma and color of essential oils
    - Often used in packaging materials allows for migration
    - Have slight phenol-like aroma
    - Acts synergistically with BHT and gallates
  - Butylated hydroxytoluene (BHT)
    - More effective antioxidant of animal fats compared to BHT
    - Degradation products also have antioxidant activity
      - Mixed products are formed in the presence of BHA
  - 2-tert-butylhydroquinone (TBHQ)
    - Only diphenol used as antioxidant
    - More effective than BHA and BHT in vegetables oils
    - Activity increases in combination with chelating agents
      - TBHQ, monoacylglycerol citrate, and ascorbyl palmitate have high thermal stability and provide optimum protection in oils during high-temp processing
    - Reacts with hydroxyphenol radicals to form semi-qunion radicals

- Antimicrobial Agents
  - Sulfites and Sulfur Dioxide
    - Functions
      - Inhibits non-enzymatic browning, enzyme-catalyzed reactions,
      - Inhibit and control microorganisms
      - Acts as an antioxidant and a reducing agent
    - Metabolized to sulfate and excreted in urine without pathologic results
      - Heavily regulated due to some sensitive asthmatics
    - Commonly used forms are SO_2 gas, and salts of SO_3^{2-}, HSO_3^-, and $S_2O_5^{2-}$
      - Na and K metabisulfites are frequently used good stability toward autoxidation in the solid phase
      - Gaseous SO_2 is used when leaching of solids causes a problem or when it is also used as an acid to control pH
    - As an antimicrobial
      - Most effective in acidic media
        - Undissociated compounds are permitted to penetrate the cell wall
      - At high pH, HSO_3^- are effective against bacteria but not yeasts
      - SO_2 is both biocidal and biostatic, effect on Gram-negative > Gram-positive
      - Possible reasons. For its antimicrobial effect:

- Interaction with nucleic acids
- Reaction of HSO_3^- with acetaldehyde
- Reduction of disulfide linkages
- Formation of addition compounds that interfere with respiratory reaction involving NAD/NADH

- As a nonenzymatic browning inhibitor
  - Reaction with carbonyl groups of reducing sugars and other compounds
  - Also removes carbonyl chromophores in melanoidin bleaching
  - Reaction with -OH groups in C4 of carbohydrate and ascorbic acid derivatives
    - Stops reactions and interfere with reactions that produce colored compounds
- As an enzyme-catalyzed reaction inhibitor
  - Reducing agent in enzymatic browning reactions
  - Coordination with Cu in PPOs permanent degradation of active site
- Other effects in food
  - Reversible cleavage of disulfide bonds in flour doughs
    - Reduce mixing time and dough elasticity easier sheeting
    - Reduces flour variability
  - Reversible bleaching of anthocyanins
  - High concentrations give unwanted off-flavors in food products during storage and cooking

- Nitrite and Nitrate Salts
  - K and Na salts are commonly used
  - Nitrite is the functional constituent
  - Used in curing mixtures
    - Nitrites react with heme to form nitrosomyoglobin pink color
    - Nitrite adds cured meat flavor
  - As an antimicrobial
    - Inhibits *Clostridia* in canned-comminuted and cured meats
      - Effective at pH 5.0 - 5.5
      - Nitrite reacts with sulfhydryl groups formation of compounds not metabolized at anaerobic conditions
  - Negative implications
    - Involved in the formations of nitrosamines carcinogenic compounds
    - Accumulation of nitrate in plants grown in heavily-fertilized soil
    - Nitrate reduction to nitrite with absorption can lead to cyanosis
      - Justification for use only in cured meats and in products where *C. botulinum* is a concern

- Acetic Acid
  - CH_3COOH, $NaCH_3COO$, or vinegar
  - Also used as an acidulant and flavorant
  - Antimicrobial activity is due to lowering of environmental pH
    - ↓pH, ↑antimicrobial activity
- Propionic Acid
  - Propionic acid, Na, and Ca salts
  - Occurs naturally in products with *Propionibacterium*
  - Antimicrobial activity is due to lowering of environmental pH and inability to metabolize 3-carbon chain long compounds
  - Usage is typically <0.3% by weight
  - Active up to pH 5.0
- Sorbic Acid and Other Medium-chain Fatty Acids
  - Medium-chain and longer, monocarboxylic, aliphatic fatty acids exhibit antimicrobial properties
    - Strong antimycotic activity
    - α-unsaturated fatty acid analogs are one of the most effective
      - inability to metabolize α-unsaturated diene system of compound
  - Sorbic acid is commonly used to prevent yeast and mold growth in numerous food products
    - Naturally obtained from berries
    - Commercial salts are chemically synthesized
    - Contributes to *trans* fat content in food
    - Max usage: 0.3% by weight
    - ↓pH, ↑activity
    - Effective up to pH 6.5
    - Diene structure interferes with cellular dehydrogenases
    - Sorbic Acid and Other Medium-chain Fatty Acids
  - Saturated FAs can also be inhibitory to molds but some are capable of "detoxifying" them
    - Decarboxylation to a β-keto acids – no inhibitory activity
    - Contributes to the flavor of mold-ripened blue cheeses
  - Other degradation/inactivation pathways
    - Decarboxylation to produce 1,3-pentadiene produces gasoline-like off flavors
    - Rearrangement to a secondary alcohol
  - Reaction with sulfur dioxide
    - Sulfonation and oxidation under aerobic conditions
    - Formation of 5-sulfo-3-hexenoic acid under anaerobic conditions
  - Binding with proteins that contain cystine and/or cysteine

- Benzoic Acid
  - Undissociated acid is the form with antimicrobial activity
  - Optimum pH: 2.5-4.0; very little antimicrobial activity at pH>5.5
  - Na and K are salts are commonly used better solubility in aqueous media
  - Used in combination with sorbic acid or parabens
  - Conc: 0.05% - 0.10% by weight
  - Mode of action
    - Lipophilic character facilitates cell entry
    - Disrupts proton motive force and inhibits metabolic enzymes
      - Depends on microbial type
  - Removed from the body by conjugation with glycine
- Parabens
  - Effective inhibitor of yeasts and molds; ineffective against bacteria
  - Conc: 0.050 – 0.10% by weight
  - ↑activity and ↓solubility as ↑alkyl chain length
  - Active at pH ≥ 7
  - Similar in properties with benzoic acid
  - Exhibits low toxicity and excreted through urine by hydrolysis of ester group and subsequent metabolic conjugation
- Antibiotics
  - Exhibits selective antimicrobial activity
  - Fear of evolution of resistant microorganisms carry overs to their use in food applications
  - Used in tandem with other preservation methods
    - Ex. Reducing severity of thermal processing
  - Ex. Chlortetracycline, oxytetracycline, nisin
    - Nisin
      - Polypeptide antibiotic
      - Used in high-moisture products
      - Active against Gram-positive bacteria and prevents spore formation
      - Nontoxic to humans and not used in medical applications

- Nonnutritive and Low-calorie Sweeteners
  - Sulfoamides
    - Cyclamate
      - Cyclohexyl sulfamic acid
      - Na and K salts, and acid form are typically used
      - 30x sweeter than sucrose
      - No known aftertaste
      - Heat stable
      - Slow onset and persistent sweetness

- Carcinogenicity has been disproven but it is still not acceptable for use in some countries

- Saccharin
  - Na and Ca salts
  - 200 – 700x sweeter than sucrose depending on concentration and food matrix
  - Exhibits bitter and metallic after taste
  - Has been found to cause low incidence of carcinogenesis in lab animals BUT scientists argue that it is nor relevant to humans
  - Saccharin is rapidly absorbed and excreted through the urine in humans
- Acesulfame K
  - 6-methyl-1,2,3-oxathiazine-4(3H)-one-2,2-dioxide
  - 200x as sweet as sucrose in 3% conc solution
  - Exhibits metallic and bitter aftertaste at high concentrations
  - Used in tandem with other low-calorie sweeteners
  - Stable at elevated temperatures and acidic environments

- Peptides
  - Component amino acids become calorically available during digestion, but its low concentration usage provides insignificant calories
  - Aspartame
    - Aspartic acid + phenylalanine + methyl
    - 18—200x sweeter than sucrose
    - Lacks some of the “sweetness qualities” of sucrose
    - Unstable at acidic conditions and elevated temperatures
      - Acid conditions: gradual loss of sweetness; temperature and pH dependent
      - Elevated pH: undergoes intramolecular condensation; favored at pH ≥ 7
    - Alkaline pH promote carbonylamino reactions most especially with glucose and vanillin loss of sweetness and vanilla flavor during storage
    - Concerns on safety:
      - Avoidance of consumption for people who lack 4-monooxygenase
        - Cannot metabolize phenylalanine
      - Production of methanol during hydrolysis
        - Metabolic conversion to formaldehyde
      - Generally, does not pose an adverse health effect

- Neotame
  - Structurally related to aspartame
    - Attachment of a 3,3-dimethylbutyl substituent to the amino group of aspartic acid
  - Increase stability and very high sweetening power (7000-13000x than sucrose)
  - Large difference in sweetness to aspartame is due to the 3,3-dimetylbutyl
    - Supplements γ-grouping with strong hydrophobicity
  - Also marketed as a flavor enhancer due to beneficial effects on flavors of some food
- Alitame
  - Aspartic acid + alanine with a novel amine
  - 2000x sweeter than sucrose
  - Exhibits a clean sweet taste similar to sucrose
  - High water solubility; good thermal stability and shelf life
    - Prolonged storage in acidic conditions produces off-flavors
  - Considered as generally safe for human consumption
  - Alanine amide moiety is minimally metabolized by the body

- Chlorosaccharides
  - Selective chlorination of sugar molecules
  - Most known example is sucralose
    - 600x sweeter than sucrose
    - Has a sweetness time-intensity profile similar to sucrose
    - No bitterness or aftertaste
    - High degree of crystallinity; high water solubility; very good stability at high temperatures
    - Stable at acidic pH
    - Limited hydrolysis to monosaccharides occur during handling and storage
    - Fructose + galactose
    - Designed to resist digestive and metabolic attack
      - Hydrolytic enzymes are unable to recognize molecular features
      - Some hydrolysis has been reported either through acid-catalyzed or microbial enzymatic processes
    - Structure
      - 3 -OH groups replaced with -Cl atoms
      - B-linkage between galactose and fructose

- Currently recognized as safe for use but considered premature as possible harmful structures can be formed upon thermal degradation
    - Chloropropanediol, ethylene chlorohydrin, chloromethane

- Polyols
    - Polyhydric alcohols – structural analogs of fully reduced carbohydrates
    - Quite water-soluble, hygroscopic, moderate viscosity at high concentrations
    - Provides water-binding capacity
    - Control of viscosity and texture, addition of bulk, moisture retention, lowering of a_w, control of crystallization, improvement or retention of softness, improvement of rehydration properties, solvent for flavor compounds
        - Rely on concurrent contributions of other compounds to functional properties
    - Occur naturally but do not contribute functional roles in food due to very low concentrations
    - Contributes cooling sensation in dry form (negative ΔH_{soln} value)
    - Simple polyols are sweet but less than sucrose (sugar alochols); short-chain can exhibit bitterness at high concentrations
        - Used as reduced-calorie sweeteners
    - Manufactured through hydrogenation of simple sugars
        - Xylitol : xylose, sorbitol : glucose, mannitol : mannose, maltitol : maltose, lactitol : lactose
    - Hydrogenated starch hydrosylates are also used as food ingredients
        - Presence of simple (e.g. sorbitol, maltilol) and polymeric sugar alcohols
    - Isomalt is derived from sucrose using several steps
    - Used as starting materials in the manufacture of other food ingredients
        - Sorbitol is used in the manufacture of Spans and Tweens
    - High-molecular weight polymeric forms have been developed for food applications
        - Polyethylene glycol 6000 - food coating and plasticizing agent
        - Polyglycerol – esterification leads to lipid-like properties
    - Polyhydric alcohols are also used in improving the stability of intermediate moisture (IM) foods

- Other Classes of Food Additives
    - Stabilizers and Thickeners
        - Hydrocolloids provide stabilization for emulsions, suspensions, and foams and acts as a thickener in some products
        - Derived from natural sources or chemically modified
        - Most are polysaccharides (e.g., gum arabic, guar gum, CMC, carrageenan, agar, starch, and pectin)
        - Hydrophilic in nature and dispersed as colloids

- Important properties: significant water solubility, increase viscosity ability to form gels, improvement of texture, inhibition of crystallization, stabilization of emulsions and foams, encapsulation of flavors
- Conc: ≤2% due to limited dispersibility
- Lack emulsifying action due to structural lack

- Masticatory Substances
  - Provides long-lasting, pliable properties similar to chewing gum
  - Natural or synthetic, and resistant to degradation
    - Synthetic substances are parepared using Fischer-Tropsch process produces synthetic paraffin
    - Chemically modified substances are produced by partial hydrogenation of wood resin followed by esterification with pentaerythriol or glyceril
    - Natural sources are derived from plant gums
  - Firming Texturizers
    - Pectic substances stabilize plant-cell structures stabilization through cross-linking of free carboxyl groups
      - Increases firmness through increased amounts of insoluble Ca pectinante and pectate
    - Ca salts are usually used (0.1-0.25%)
      - Contributes a bitter flavor at high concentrations
      - Added before canning and freezing
    - Acidic alum salts can also be used
      - Added to fermented, salt-brined pickled
    - Enzymatic firming may occur in some fruits with the pertinent enzyme
      - Pectin methylesterase is activated during low temperature blanching
      - Additional firming occurs in the presence of Ca^{2+} ions
  - Anticaking Agents
    - Used to maintain free-flowing characteristics of powdered products competes for water absorption
      - Coating particles to impart water repellency or providing insoluble particulate diluent
    - Calcium silicate hydrate ($CaSiO_3 \cdot xH_2O$)
      - Absorbs liquids up to 2.5x its weight
      - Can absorb oils and non-polar organic compounds
        i. Can be used in products with free essential oils

- Ca and Mg salts of long-chain FAs are also used as anticaking agents
    - Calcium stearate is insoluble but adheres well to particles provides water-repellant coating
- Other anticaking agents: sodium silicoaluminate, tricalcium phosphate, magnesium silicate, magnesium carbonate, microcrystalline cellulose

- Bleaching Agents
    - Primarily used in flour production to remove carotenoids
    - Bleaching agents oxidize the carotenoid pigments disrupting the conjugated system of double bonds loss of color
    - Also used as a dough improver due to the oxidation of sulfhydryl groups in gluten
    - Compounds with active oxygen (e.g., peroxides, bromates), and compounds with active chlorine (e.g., Cl_2, ClO_2, OCl^-) are used
        - The use of chlorinated compounds have potentially toxic side effects
    - Excessive oxidation leads to undesirable properties in the products (e.g., gray crumbs, irregular-sized grains, reduced loaf volume)

Allergens and Toxicants

- Allergens
    - Substances that can cause allergic reactions when exposed to
    - Immune system detects these substances as dangerous eliciting a human response against it
    - Big Eight Food Allergies

1. _____	5. _____
2. _____	6. _____
3. _____	7. _____
4. _____	8. _____

    - Control measure
        - Ensure rigorous sanitation scheme to prevent cross-contamination and complete removal of the allergen
        - Proper labeling and declaration
            - Should be explicitly stated directly below the list of ingredients
            - Ex:
                - “Contains food allergen: egg”
                - Allergen information: May contain_____”

        - Production scheduling
        - Dedicated line/equipment
- Toxicants
    - Compounds that pose health risks when ingested
    - Naturally-occurring or process-induced
    - Contaminants and adulterants may also be considered as toxicants depending on their effect on the body

    - Mycotoxins
        - Secondary metabolites produced by microfungi that are capable of causing disease and death in humans and animals
        - Formation is often "unavoidable"
        - Many efforts to address problem simply involve diversion of mycotoxin-contaminated commodities from the food supply through government screening and regulation programs
        - Ex. Aflatoxin, patulin, ochratoxin
            - Aflatoxin
                - Potent genotoxic carcinogen produced by _____ _____
                - Found in _____
                - Max limit: _____
                - Aflatoxin M1 is a less harmful form normally found in milk products
            - Ochratoxin
                - Metabolite of several species of _____
                - _____
                - Found in _____
                - Potent _____
                - Max limit depends on the commodity
                    - _____
                    - _____
    - Bacterial Toxins
        - Bacterial Enterotoxins
            - Exotoxins
                - Released primarily by _____ during their growth
                - Mostly proteins that have _____
                - Very poisonous

- *Clostridium botulinum* neurotoxin
  - *C. botulinum* are spore-forming anaerobes
  - Inadequately processed foods allow survival of spores
  - Predominant in anaerobic environments of low-acid foods
  - Blocks release of acetylcholine muscle paralysis
- *Clostridium perfringens* toxin
  - Inherent to intestine microflora; toxic once transmitted to food
  - Quorum needed to form toxin
  - Food poisoning lasts for 24 hr
- *Staphylococcus aureus* toxin
  - Inherent on skin of healthy people
  - Toxic once transmitted to food; characteristic of unhygienic food handling
  - Present in unpasteurized milk and cheese
- *Bacillus cereus* toxin
  - Two types: (1) diarrhea, and (2) emetic toxin: nausea and vomiting
  - Commonly obtained from rice and leftover food that sat too long at room temperature
  - Present in unpasteurized milk and cheese

- Endotoxins
  - Produced primarily by _____
  - Antigens, firmly bound to bacterial cell walls
  - Active without latent period

  - *Salmonella* spp. Toxin
    - All strains of *Salmonella* are pathogenic
    - Most common source of food poisoning
    - Contaminated eggs, poultry, meat, unpasteurized milk or juice, cheese, and contaminated fruits and vegetables
  - *E. coli* toxin
    - Inherent microflora in the intestine
    - Contaminated food especially undercooked beef
    - Pathogenic strain: *E. coli* O157:H7
      - Shiga toxin

- Bacterial Metabolites
  - Nitrites
    - Metabolized by microorganisms
    - Accumulation leading to absorption in the bloodstream
    - Converts hemoglobin to methemoglobin (does not carry oxygen)
    - Source: _____
  - Histamine
    - Produced by amino acid metabolism of bacteria
    - Results from the _____
    - Indicative of state of meat/fish product
  - Bongkrek
    - Produced by _____
    - Substrate are lipids
    - At high concentrations, bacterium starts making bongkrek acid
    - Bongkrek acid is highly toxic inhibits formation of ADP to ATP in the mitochondria
    - 40-50% lipid of dry content of the product (optimum)
- Heavy Metals
  - Elements that have _____
  - Toxicity depends on _____
  - Sources:
    - _____
    - _____
    - _____
    - _____
    - _____
  - Lead (Pb)
    - Sources:
      - Contamination of environment by car emissions
      - Lead piping and lead-lined tanks for domestic water supply
      - Lead content is much higher if the water is soft (acidic)
      - Pottery glaze (when glazed at T<120°C)
        - Lead found in the glazing will not transform into an insoluble form and may leach out when acidic materials are stored in the pottery
      - Canning
        - Lead was historically used to solder can joints

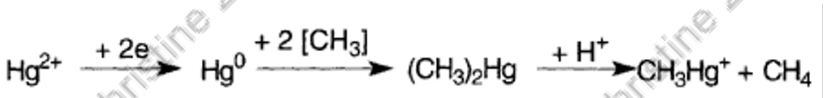
- Restrictions:
  - Most foods (CODEX): _____
  - Infant foods: _____
  - Drinking water: _____
- Bioavailability:
  - Very low water solubility
  - Poor absorption in the gastrointestinal tract
  - ¾ of absorbed is excreted in feces, urine, sweat, hair, nails
- Health effects:
  - Leads to chronic lead poisoning at _____ in blood

■ Tin (Sn)
- Sources:
  - Food – main source (fresh meat, cereals, vegetables)
  - Tin-plated containers
  - Solders
  - Alloys
- Levels:
  - Most studies concluded that high intakes of Sn are harmless
  - Minimum toxic dose: _____

■ Arsenic (As)
- As a result of naturally occurring metabolic processes in the biosphere, arsenic occurs as a large number of organic or inorganic chemical forms in food
- Forms:
  - Inorganic arsenic (III) and (V) compounds – _____
    - Inorganic arsenic trioxide (rat poison)
  - Methylated form – _____
  - Arsenobetaine – principal form in fish and crustaceans (_____)
  - Dimethylarsinylriboside (“arsenosugars”) – shellfish, molluscs, seaweed
- Elevated levels of arsenic in fish
  - Due to arsenobetaine, $(CH_3)_3 As^+CH_2 COO^-$, an organic derivative that is not metabolized by man
- Regulation
  - IARC has classified inorganic arsenic as a human carcinogen, and the estimated lifetime risk for arsenic-induced skin cancer which may be caused by drinking water at or in excess of the WHO guideline for arsenic in drinking water is estimated at $6x10^{-4}$.

Name:

- Mercury(Hg)
  - Forms
    - Free metal (Hg^0)
    - Inorganic mercuric (Hg^{2+}) salts
    - Alkyl mercury compounds
  - Lipid soluble, readily absorbed and accumulate in erythrocytes and the central nervous system
  - Sources
    - Broken thermometers (not regarded as particularly toxic)
    - Antifungal mercurial seed dressings – alkyl mercury compounds
    - Industrial pollution of coastal waters (fish & seafoods) – alkyl mercury compounds
  - Methylmercury
    - Dangerous levels of methylmercury will accumulate even at inorganic mercury salt or free metal form
    - Various anaerobic methane-producing bacteria will carry out the ff rxn, with methyl groups donated by methylcobalamin:



  - Regulation:
    - Adult of 70 kg: _____
      - Of which a maximum of _____ – from highly toxic methylmercury
  - Mercury poisoning
    - Contamination of Minamata Bay, Japan by CH_3Hg^+
    - Fish and shellfish: 29 mg/kg (300 µg/day intake)
    - Damage to central nervous system
    - Mothers gave birth to children with cerebral-palsy-like symptoms

- Toxins Developed During Processing
  - Polycyclic Aromatic Hydrocarbons (PAHs)
    - Large group of environmental contaminants & carcinogens & co-carcinogens
    - Fused aromatic rings (partially hydrogenated or alkylated)
      - simplest = naphthalene
    - Present in both processed and unprocessed foods

- Occurrence:
  - _____
  - _____
  - _____
- Distribution in foods
  - _____
  - _____
  - _____
  - _____
  - _____

■ Acrylamide
- Chemical used for industrial processes
  - Paper, dyes, plastics, treatment of drinking and waste water
- Probable human carcinogen, neurotoxic
- Found in foods cooked or heated at _____
  - High occurrence in _____
- Also found in cigarette smoke
- Formed by the reaction of _____
- _____
- Lower risk of exposure:
  - _____
  - _____
  - _____

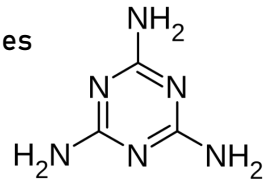
■ Phthalates
- Chemicals that soften and increase flexibility of vinyl and plastic
- Used in cosmetics, toys, wallpapers, food packaging, plastic wrap
- Exposure:
  - Air, water, food, using products that contain phthalates
- Health concerns:
  - Suspected endocrine disruptor
  - "reasonably anticipated to be a human carcinogen

○ Other Organic Compounds

■ Melamine
- Synthetic triazine compound and an organic base
- Important industrial chemical:
  - Melamine resin (hard-wearing thermosetting plastic)
  - Melamine+formaldehyde
  - Manufacture of durable Tupperware, worktops, whiteboards

Name:

- Other uses:
  - Fire retardant, fertilizer, pigments, glues
- Health concerns:
  - No direct human studies
  - Results of animal testing predicative
  - Bladder stones
  - With cyanuric acid, can crystallize and form bladder stones
  - Carcinogenic effect under certain circumstances
- Symptoms of melamine poisoning
  - Irritability, blood in urine, no urine, kidney infection, high blood pressure



Lecture Guide 1
Food Composition and Basic Concepts

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BASIC NUTRITION

- Brief Introduction to Nutrition
- Macro and micronutrients
- Factors affecting food choices
- Qualitative Dietary Tools
- Quantitative Dietary Tools
- Health and Nutrition Claims
- Basic Computations in Nutrition

Brief Introduction to Nutrition

- **Nutrition** is the science of _____, the _____, and other substances therein, their action, interaction, and balance in relation to health and disease and the processes by which the organism _____, _____, _____, _____, _____, and _____ food substances (Council on Foods and Nutrition, 1963)
- _____ refers to the food and drink that is regularly consumed by an individual (or a group)
- _____ is a chemical component needed by the body to perform one or more of the following functions: provide energy (_____), contribute to body structure (_____), and/or regulate chemical processes in the body (_____).
    - Six classes: (1) _____, (2) _____,
      (3) _____, (4) _____,
      (5) _____, (6) _____,
    - _____ is the capacity to do work and measured in _____ (amount of energy required to raise the temperature of 1kg of water by 1°C)
        - Metabolizable energy of nutrient/substances
            - Carbohydrates: _____ kcal/g
            - Protein: _____ kcal/g
            - Fat: _____ kcal/g
            - Alcohol: _____ kcal/g
- _____
    - measurement of the extent to which an individual's physiological need for nutrients is being met
    - condition of the body resulting from the utilization of essential nutrients
    - _____ means that the body has adequate supply of essential nutrients that are efficiently utilized such that growth and good health are maintained at the highest possible level
    - _____ is the pathological state resulting from a relative or absolute **deficiency or excess** of one or more essential nutrients.
    - _____ is the inadequate consumption and utilization of one or more vitamins and/or minerals, manifesting in a wide spectrum of metabolic, physiological, and functional disorder
- Nutritional assessment methods
    - _____ - estimation of nutritional status on the basis of measurements of the physical dimensions and gross composition of an individual's body
    - _____ - includes tests which measure either a nutrient in body fluids (blood or plasma) or tissues or the urinary excretion rate of the nutrient and its metabolite

- _____ – methods to detect signs and symptoms associated with malnutrition such as but not limited to checking of eyelids, palpation of thyroid gland, examination of throat, etc.
  - _____ is a manifestation of disease apparent to the patient
  - _____ is a manifestation of disease that the physician perceives
- _____ – evaluation of the food consumption of individuals or households
- _____ – other factors influencing nutritional status such as household consumption, education, literacy, ethnicity, religion, income, employment, material resources, water supply, household sanitation, access to health facilities, etc.

Macro and Micronutrients

- Macronutrient
  - Present in relatively high amounts in the body: @ 0.005% of body weight or above
  - Carbohydrates, proteins, fat, water
  - Common function: main energy source

  - Carbohydrates
    - Dominant energy source in terms of quantity
      - Glucose provides _____
      - Glucose is _____ energy
      - Glycogen is stored and reserve energy
    - Can either simple sugars or complex carbohydrates
      - (Refer to the discussion of carbohydrates in Food Chemistry)
      - Fiber
        - Structural parts of plants
        - Bonds of fibers cannot be broken down during the digestive process
          - Minimal or no energy available
        - Soluble dietary fiber
          - Natural gel-forming fibers; form gel matrix altering solubility or enzyme hydrolysis
          - Ex. _____
          - 90-99% fermented in the colon, useful in lowering blood cholesterol, managing obesity, cardiovascular diseases, DM, and preventing colon cancer

- Insoluble dietary fiber
  - Ex. _____
  - 10-15% fermented in the colon, contribute bulk to stools, help prevent constipation and colon cancer
  - May help control DM
- Health benefits of dietary fiber
  - _____
  - _____
  - _____
  - _____

- Recommended Intake
  - Sugar - _____
  - Starch - _____
  - Fiber - _____

- Lipids
  - Energy storage → energy dense
  - Generally insoluble in water
  - Serve as structural components of cells
  - Roles of lipids in the body
    - _____
    - _____
    - _____
    - _____
  - Recommended intakes
    - No PDRI or upper limits on fat intake has been set
      - Suggest a diet low in saturated fat, trans fat, cholesterol
      - Provides 20-30% of energy
    - Daily values have been place on food tables using 30% as guidelines
    - Lipid ratios
      - Polyunsaturated/saturated ratio: 2:1
      - Omega 3 to omega 6 1:4
    - EPA and DHA: 90-120 g fish oils lower plasma triglycerides
    - Fish intake: 2-3 fish meals per week shown to benefit normal individuals
    - Cholesterol: daily intake should be 200-300 mg
- Proteins
  - Functions
    - _____
    - _____
    - _____
    - _____
    - _____

Name:

- Animal protein vs plant protein
  - Animal protein is complete and more protein per gram
  - Plant protein is incomplete and less protein per gram
- Complementarity
  - Plant combinations which provide adequate amounts of essential amino acids to adequately support human protein synthesis
  - Rice (high Met) and beans (low Met)
  - Milk (high Lys) and corn (low Lys)
- Nitrogen balance
  - Used to indicate the balance of amino acids that are added to the body to those that are removed
    - Positive balance - _____
    - Negative balance - _____
- Factors affecting protein utilization
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
- Protein requirements
  - Caloric contribution: 10-15% of TEA
  - Protein requirement per kg BW per age group
    - Infants: _____
    - Children: _____
    - Early adolescents: _____
    - Older adolescents: _____
    - Adults: _____
  - Factors that affect requirement
    - _____
    - _____
    - _____
    - _____
    - _____
    - _____
    - _____
- Health effects
  - Heart disease
    - _____
    - _____
    - _____

- Cancer
  - _____
    _____
- Bone loss
  - _____
  - _____
- Weight control
  - _____
  - _____
- Kidney diseases
  - _____
  - _____

- Water
  - Most abundant component in the body
  - Requirements
    - Depends on a person's body weight, lifestyle, and environmental temperature
      - Infants: _____
      - Adults: _____
      - Others: physically active persons, pregnant and lactating
  - Deficiency and dehydration
    - Elderly (blunt thirst mechanism)
    - Excessive loss (sweat, physical activity, pathological conditions)
  - Toxicity
    - Too quick consumption of water without electrolytes, kidney malfunction → accumulation of water in the body

- Micronutrient - present in the body in amounts less than < 0.005% of body weight
  - Vitamins and minerals

  - Vitamins
    - Organic compounds distinct from macronutrients
    - Natural components of food
    - Not synthesized in the body in amounts needed for physiological needs
    - Causes a specific deficiency syndrome in their absence or insufficiency
    - Does not provide energy but enables the body to use the energy from the macronutrients
    - Two general classes: fat-soluble and water-soluble
    - Characteristics of Vitamins

Name:

Water-soluble	Fat-soluble

- Fat-soluble Vitamins
  - Vitamin A compounds
    - Compounds having qualitatively the biological activity of retinol
      - Retinoids: retinol, retinal, retinoic acid
      - Pre-vitamin A carotenoids
    - Calculating RE from β-carotene
      - 1 RE = 1 ug retinol
        = 6 ug β-carotene
        = 12 ug other carotenoids
    - Sources of Vitamin A
      - Animal-derived
        - _____
        - _____
        - _____
      - Plant-derived
        - _____
        - _____
        - _____
    - Factors that influence Vit A utilization
      - _____
      - _____
      - _____
      - _____

- Functions
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
- Vitamin A Deficiency
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
- Toxicity
  - Acute toxicity: results from ingestion of single or several closely spaced large doses (100x RDI)
  - Chronic toxicity: recurrent ingestions of excessive doses (10x RDI)

- Vitamin D
  - Calciferol
  - Also called the “sunshine vitamin”
  - Precursors: ergosterol, 7-dehydrocholesterol
  - Sources:
    - _____
    - _____
  - Factors that influence Vit D utilization
    - _____
    - _____
  - Functions
    - Maintenance of calcium and phosphorus homeostasis by:
      - _____
      - _____
      - _____

    - Recommended Intake
        - Set to meet the body's needs when exposure to sunlight is not enough
        - Period of skeletal development for infants and children
        - Supplementation for individuals who are consistently shielded from sunlight
    - Vit D deficiency
        - Children: Rickets
            - A disease involving impaired mineralization of the bone
        - Adults: Osteomalacia
            - Develop in adults whose epiphyseal closures make that portion of the bone resistant
    - Toxicity
        - Hypervitaminosis D
            - _____ for infants and children
            - _____ for adults
            - Elevated serum calcium and phosphorus levels
            - Calcinosis of kidney and lungs
- Vitamin E
    - Tocopherols
    - Fat-soluble antioxidant
    - Sources:
        - _____
        - _____
    - Factors that influence Vit E utilization
        - _____
        - _____
        - _____
        - _____
    - Functions
        - Most important lipid-soluble antioxidant in the cell
            - _____
            - _____
            - _____
    - Vit E deficiency
        - Rare but it targets _____
        - Cellular level: increase in oxidation of membranes → cell injury and necrosis

- Toxicity
  - Least toxic, not largely stored in the body

- Vitamin K
  - Antihemorrhagic vitamin
  - Naturally occurring forms:
    - Phylloquinone:_____
    - Menaquinones:_____
    - Menadione:_____
  - Sources:
    - _____
    - _____
  - Functions
    - _____
    - _____
  - Vit K deficiency
    - Rare: lipid malabsorption, chronic antibiotic therapy and liver disease
      - Newborn: hemorrhagic disease
      - Adults: delayed blood clotting time, increased incidence of hip fractures in older adults
  - Toxicity
    - Phylloquinones and menaquinones: not toxic
    - Menadione: hemolytic anemia in rats and severe jaundice in infants

- Water-soluble Vitamins
  - Vitamin C
    - Most easily destroyed vitamin
    - Synthesized by most plants and animals from glucose and galactose
    - Active forms: ascorbic acid, dehydroascorbic acid
    - Sources
      - Plant
        - _____
        - _____
      - Animals
        - _____
    - Functions
      - _____
      - _____
      - _____

        - _____
        - _____

    - Deficiency
        - 45-80 days after deprivation
        - Adults: _____
        - Children: _____
    - Effects of excessive intakes
        - _____
        - _____
        - _____

- Vitamin B1
    - Thiamin
    - Anti-beriberi vitamin, aneurin, antineuritic factor and morale vitamin
    - Essential role in carbohydrate metabolism and neural function
    - Occurs as: _____
    - Sources
        - Thiamin pyrophosphate
            - _____
            - _____
        - Free thiamin
            - _____
    - Functions
        - _____
        - _____
        - _____
    - Human Requirements
        - Based on levels of carbohydrate intake
        - Increased under conditions that elevate metabolic rate
        - Infants: based on thiamin levels typically found in milk
    - Deficiency
        - Beri-beri (severe deficiency)
            - Associated with diets deficient in vit B1 and high in carbohydrartes
        - Wenicke-Korsakoff Syndrome
            - Due to chronic alcoholism, alse seen in pregnant women with excessive vomiting

- Effects of excessive intakes
  - _____
  - _____

- Vitamin B2
  - Essential for the metabolism of carbohydrates, lipids, and amino acids
  - Supports antioxidant protection
  - Co-enzyme of flavins
  - Sources
    - _____
    - _____
    - _____
  - Functions
    - _____
    - _____
    - _____
  - Human Requirements
    - A function of protein intake → growth, pregnancy, and lactation
  - Deficiency
    - Some symptoms similar to B1
    - Advanced: ariboflavinosis
  - Effects of excessive intakes
    - _____
    - _____
- Vitamin B3
  - Niacin
  - Refers to nicotinic acid and nicotinamide niacinaminde
  - Co-enzyme form: NAD/NADH, NADP/NADPH
  - Sources
    - _____
    - _____
    - _____
    - _____
    - 60 mg L-tryptophan = 1 mg niacin
  - Functions
    - _____
    - _____
    - _____
    - _____

    - Human Requirements
        - Expressed in terms of niacin equivalents (NE) → from preformed niacin and tryptophan
        - Requirements are directly related to energy intake and requirements
    - Deficiency
        - Early stages: muscular weakness, anorexia, indigestion, and skin eruptions
        - Severe: Pellagra
    - Effects of excessive intakes
        - _____
        - _____
- Vitamin B5
    - Pantothenic acid
    - Occurs as an integral part of coenzyme A and 4-phosphopantetheine
    - Sources
        - _____
        - _____
        - _____
    - Functions
        - _____
        - _____
    - Deficiency
        - Rare but observed in severely malnourished humans → impairments in energy production
    - Effects of excessive intakes
        - No known toxic effects of oral pantothenic acid in humans or animals
- Vitamin B6
    - Pyridoxine
    - Several forms: _____
    - All are converted to metabolically active form: _____
    - Sources
        - Widely distributed in foods
        - Unstable in heat processing
        - _____
        - _____
        - _____

- Functions
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
- Human Requirements
  - Requirement increases as the intake of protein increases because of its role in amino acid metabolism
- Deficiency
  - Not by dietary depletion, but through medications (isoniazid)
  - Milk-based formula with vit B6 destroyed in processing
- Effects of excessive intakes
  - _____
  - _____

- Vitamin B7
  - Biotin
  - Plants and animals: small fraction as free form, most are bound to biotin dependent enzymes
  - Sources
    - _____
    - _____
    - _____
  - Functions
    - _____
      - _____
  - Deficiency
    - Simple deficiency is rare
    - Induced by feeding with raw egg white (avidin)
    - GI tract disorder, infants receiving breastmilk with low biotin, incomplete parenteral nutrtion
  - Effects of excessive intakes
    - No toxic effects even in large amounts
- Vitamin B12
  - Generic descriptor for all cobalamins that exhibit anti-pernicious anemia activity

- Contains porphyrin-like cobalt-centered corrin molecules
- Most active: cyanocobalamin and hydroxycobalamin
- Sources
  - _____
  - _____
- Functions
  - _____
  - _____
  - _____
- Deficiency
  - Impaired cell division of bone marrow and intestinal mucosa and RBS
  - Advanced: neurologic abnormalities
- Effects of excessive intakes
  - Has no appreciable toxicity
  - Excess amount that exceed the limited binding capacity of plasma are excreted unchanged in the urine and in the feces

- Folate
  - Generic descriptor folic acid and its derivative compounds
  - Metabolically active form: FH_4 (tetrahydrofolic acid)→ carrier of single carbon moieties
  - In nature occurs as dihydrofolate and tetrahydrofolate
  - Sources
    - _____
    - _____
  - Functions
    - _____
      _____
      _____
  - Deficiency
    - Associated with increased risk of cardiovascular diseases, neural tube defects and megaloblastic anemia
  - Effects of excessive intakes
    - Not toxic if from food
    - Toxic if 1000x requirement given by parenteral route

- Minerals
  - Inorganic crystalline, homogeneous substances
  - Comprise 4-6% of body weight
  - Absorption is affected by:
    - _____
    - _____
    - _____
    - _____
  - Found in foods in varying amounts depending on soil and water quality
  - General functions
    - Structural
      - _____
    - Regulatory
      - _____
      - _____
      - _____
      - _____
  - Macrominerals
    - >0.005% of body weight
    - Required in >100 mg/day
    - Sodium, chloride, potassium, calcium, phosphorus magnesium
    - Mainly functions as electrolytes
      - _____
      - _____
      - _____
      - _____
      - Common cause of deficiency are dehydration and kidney disorders

    - Sodium
      - Primary regulator of fluid volum as principal cation
      - High sodium triggers thirst
      - High sodiul diet is associated with high blood pressure
      - Dietary recommendation is to limit intake
      - High intkae is associated with increased calcium extretion
      - High sodium foods do not always taste salty
      - High sodium foods are usually low in potassium
      - Deficiency and Toxicity
        - Hyponatremia: _____
        - Hypernatremia: _____

- Chloride
  - Maintains fluid and electrolyte balance as the major anion
  - Part of HCl secreted in the stomach
  - Commonly associated with sodium
  - Lost during vomiting, diarrhea, heavy sweating
  - Deficiency and Toxicity
    - Hypochloremia: _____
    - Hyperchloremia: _____
- Potassium
  - Major intracellular cation
  - Functions in maintaining fluid and electrolyte balance
  - Maintains cell's integrity
  - Maintains normal hearbeat
  - Deficiency and Toxicity
    - Hypokalemia: _____
    - Hyperkalemia: _____
- Calcium
  - Most abundant mineral
    - _____
    - _____
    - _____
  - Present in the intracellular and extracellular fluid
    - _____
    - _____
    - _____
    - _____
    - _____
    - _____
  - Source
    - Milk and milk products
    - Sardines with bones; anchovies
    - Dark green leafy vegetables
    - Calcium-set tofu
  - Deficiency and Toxicity
    - Osteoporosis
    - Stunting
- Phosphorus
  - Found in large amounts in hydroxyapatite of bones and teeth
  - Part of DNA and RNA
  - Stores energy as ATP
  - Activates B vitamins during energy metabolism

    - As part of phospholipids
    - Maintains acid-base balances
    - Sources
        - Meat, fish, poultry
        - Legumes
        - Liver
        - Broccoli
- Magnesium
    - Indirectly participates in energy metabolism through Mg-requiring enzymes
    - Participates in insulin release
    - Normal nerve and heart functioning
    - Participates in muscle contraction and blood clotting (inhibitor)
    - Deficiency and Toxicity
        - Osteoporosis
        - Stunting
- Requirements

Age Group	Ca (mg)	Mg (mg)	P (mg)	Na (mg)	Cl (mg)	K (mg)
16-18 y/o						
19-29 y/o						

Name:

	Description	Functions
Fe		
Zn		
Fu		
F		
Cr		
Se		
I		
Mn		
Mb		

- Trace Minerals

	Source	Deficiency	Toxicity
Fe			
Zn			
Fu			
F			
Cr			
Se			
I			
Mn			
Mb			

Name:

Factors affecting food choices

- Nutritional factor
    - Healthier food alternative - shifting towards healthier food alternatives to address diet-related diseases such as malnutrition and cardiovascular diseases
    - Plant-based foods
        - _____ - someone that does not eat any animal flesh such as meat, poultry, or fish
        - _____ - someone that does not eat any animal flesh and also avoids consuming dairy, eggs, and any other ingredients derived from animals
    - _____ - foods that offer health benefits beyond their nutritional value
- Geographical and climatic factor- determines what foods were grown and made available for selection
    - Availability of food (including seasonality)
    - Diversity of food
- Cultural factor - dictates what foods are acceptable, perpetuate certain food combinations and ways of eating
    - Ethnic influence - ethnic groups have certain ways of preparing foods, food combinations, and flavors that identify them
    - Place of birth- people will try to continue to eat in the same manner they were exposed to when they move to a new location.
        - _____ - tendency of people to adapt the diet of a new place they currently reside in
    - Eating manners - culture dictated socially acceptable ways of consuming food.
        - Eating using the right hand is common in India and many parts of Asia
        - Use of chopsticks in China and Japan
        - Use of chopsticks and long handled spoon in Korea
        - Use of fork and knife in Western countries
- Religious factor
    - Catholicism- observance of fasting during Lenten Season
    - Buddhism and Hinduism- practice of veganism
    - Judaism- Kosher dietary laws
        - Kosher animals that are ruminants with split hooves, and chew their cud are allowed
        - Blood not allowed; mixing of milk and meat not allowed
    - Islam- Halal dietary food laws
        - Haram (forbidden)- pork, carnivorous animals with fangs, birds with sharp claws, land animals without ears, shark, products containing

gelatin made from the horns or hooves of cattle, blood, imporper slaugheting method, decaying carcass, intoxicants
        - Halal (lawful or permitted) - all other food products not previously mentioned
- Economic factor
    - _____ - limiting economic factor for purchasing food
    - Types and brands of food
    - Frequency of patronage
    - Type of procurement shop (e.g., grocery vs sari-sari stores)
    - Convenience- creation of convenience foods to simplify or eliminate food preparation (e.g., RTD, RTE products)
- Psychological and sociological factor
    - Family and social environment
        - Food habits are initially formed at home and later on by the social interactions they make in school, work, and social groups
    - Foods as a status symbol
        - Foods are regarded as inexpensive vs expensive foods (rarity, perceive health benefits); celebratory foods vs daily fare (complexity of procedures and rarity of ingredient
    - Psychological factors
        - Influence people's response to information about the nutritional quality and safety foods (e.g., natural vs manufactured; genetically modified food or ingredients; processed vs unprocessed; organic vs non-organic foods; nutritional information (fortified or enriched)]
- Sensorial factor
    - Deciding what to eat based on the sensory perception of food: sight (appearance and color), smell, touch (texture), sound, taste and flavor
    - Sense of _____ - mostly influence the decision of consumers to purchase food product in the market

Qualitative Dietary Tools

- _____ tools devised to aid in " planning, procuring, preparing, serving & consuming meals for both normal & therapeutic diets of individuals or groups
- **Qualitative dietary tools** - translate quantitative nutritional requirements into simple, practical and nontechnical language
- Dietary principles illustrated by the qualitative guides

Name:

- _____ - providing foods of a number of types in proportion to each other, such that foods rich in some nutrients do not crowd out the foods that are rich in other nutrients
- _____ - eating a wide selection of foods within and among the major food groups
- _____ - providing enough but not too much of a substance

- Other principles related to diet planning
  - _____ - diet provides sufficient energy & nutrients to meet the health needs of healthy people
  - _____ - achieved when energy (kcal) intake is equivalent to kcal output. This is the key of weight management
  - _____ - foods that deliver the most nutrients for the least food energy
- Examples of Qualitative Dietary Tools
  - Pinggang Pinoy
    - Developed by the FNRI-DOST as a new, easy to understand food guide that uses a familiar food plate model to convey the right food group proportions on a per meal basis to meet the body's energy and nutrient needs of an adult.
    - This is a visual tool to guide Filipinos in consuming the right amount of food in every meal for five (5) population groups namely, kids, teens, adults, elderly, pregnant and lactating women.
  - Food Pyramid
    - Guide on how much (1) fats and oils, (2) sugar, (3) meat and poultry, (4) milk and milk products, (5) vegetables, (6) fruits, (7) rice and rice products and (8) water or beverages should a Filipino eat in one day.
    - Also encourages Filipinos to exercise and practice personal and environmental hygiene for a healthy living.
    - Differs in seven (7) population groups namely toddlers, kids, teens, adults, elderly, pregnant women and lactating women
  - Nutritional Guidelines for Filipinos (2012) AKA *10 Kumainments*
    1. Eat a variety of foods everyday to get the nutrients needed by the body. -
    2. Breastfeed infants exclusively from birth up to _____ months and then give appropriate complementary foods while continuing breastfeeding for _____ years and beyond for optimum growth and development
    3. Eat more vegetables and fruits to get the essential vitamins, minerals, and fiber for regulation of body processes
    4. Consume fish, lean meat, poultry, egg, dried beans or nuts daily for growth and repair of body tissues

5. Consume milk, milk products, and other calcium-rich food such as small fish and shellfish, everyday for healthy bones and teeth
6. Consume safe foods and water to prevent diarrhea and other food-and water-borne diseases
7. Use _____ to prevent Iodine Deficiency Disorders
8. Limit intake of salty, fried, fatty, and sugar-rich foods to prevent cardiovascular diseases
9. Attain normal body weight through proper diet and moderate physical activity to maintain good health and help prevent obesity
10. Be physically active, make healthy food choices, manage stress, avoid alcoholic beverages, and do not smoke to help prevent lifestyle-related non-communicable disease..

Quantitative Dietary Tools

- **Quantitative dietary tools -** includes dietary reference intakes, tables containing the chemical composition of food, and similar materials or tools
- Examples of Quantitative Dietary Tools
    - Food Composition Table (FCT)
        - A dietary tool that contains numerical values indicating the total amount of the constituents in foods
        - Values present are considered bioavailable and not the amount absorbed
            - **Bioavailability-** the proportion of a nutrient which enters the circulation when introduced into the body and can be used for normal; body functions
        - Used to calculate the nutrient intakes of individuals or groups provided quantitative methods have been used to collect the food consumption data
        - An updated version of the tool was made last 2019 containing 1542 food items categorized in 17 food groups. Parts of the FCT include:
            - Food ID number
            - Food name and descriptors and scientific name
            - Alternate name, if applicable, Filipino name or other common name
            - Edible Portion (E.P.)
            - Food values per 100g E.P. for proximate content (water/moisture, energy, protein, fat, carbohydrate, fiber, and ash)
            - Food values per 100g E.P. TDF and Total Sugars
            - Food values per 100g E.P. for minerals (Na, Ca, P, Fe)

Name:

- Philippine Dietary Reference Intakes (PDRI)
  - A set of dietary standards that include
    - _____
    - _____
    - _____
    - _____
    - _____
  - PDRI 2015 version updated the _____ _____ with the following changes:
    - _____
    - _____
    - _____
    - _____
    - _____
    - _____
    - _____
    - _____
  - Purpose
    - For planning and assessing diets for individuals and groups,
    - Developing food-based dietary guidelines, formulating standards and regulations on food fortification, nutrition labelling and claims, and food safety
    - Designing and evaluating food and nutrition assistance programs,
    - Determining food bundles
    - Setting food production targets
    - Other related uses that require consideration of nutrient and dietary intakes.
  - Sex and life stage groupings
    - Male and female
    - Infants (Age range: _____)
    - Children (Age range: _____)
    - Adults (Age range: _____)
    - Pregnant Women
    - Lactating Women
  - Included macro and micronutrients
    - Energy
    - Macronutrients: Protein, Carbohydrates, Total Fats, Fatty Acids (_____ and _____), Dietary fiber
    - Micronutrients: Ca, Zn, Mg, F, P, Fe, Na, Se, Na, K, Cl
    - Vitamin A, B1, B2, B3, B6, Folate, B12, C, D, E and K

- Food Exchange List (FEL)
  - Made up of food groups called **exchange list** that contains food items with approximately the same amounts of energy and macronutrients (CHO, CHON, Fat) within the list
  - Used as a guide in prescribing and planning meals for healthy and therapeutic diets, as well as an educational tool by nutrition professionals in clinics and hospitals, fitness centers, and other health care facilities
  - Also includes serving size and equivalent exchange [*ex.* 1 exchange of Vegetable A = 1 cup raw (25 g)]
- Nutrition Labels *(to be discussed in the next topic)*

Health and Nutrition Claims

- **Health Claim –** Any representation that states, suggests or implies that a relationship exists between _____ and _____
  - _____ - describes the physiological role of the nutrient in growth, development and normal functions of the body
    - *Ex.* _____
  - _____ - specific beneficial effects of the consumption of foods or their constituents, in the context of the total diet on normal functions or biological activities of the body
    - *Ex.* _____
  - _____ - claims relating to the consumption of a food or food constituent, in the context of the total diet; relating to the reduced risk of developing a disease or health related condition
    - *Ex.* _____
  - _____ - claim is that nutrients, foods or their constituents can play a role in preventing, treating or curing diseases
    - *Ex.* _____
- **Nutrition Claim –** Any representation which states, suggests or implies that a food has particular nutritional properties including but not limited to the energy value and to the content of protein, fat and carbohydrates, as well as the content of vitamins and minerals
  - _____ - describes the level of a nutrient contained in a food

Name:

Claim	Meaning of claim
Sugar free	_____
Calorie free	_____
Low calorie	_____
Fat free	_____
Low fat	_____
More, added	_____

- _____ - a claim that compares the nutrient levels and/or energy value of two or more foods
  - *Ex.* _____

Basic Computations in Nutrition

- Desirable Body Weight (DBW)
  - Tannhauser's (Broca) method
    1. Express height in cm
    2. DBW (kg) = height (cm) – 100
    3. Adjusted DBW (kg) = DBW – (DBW x 10%)
       Alternative formula: DBW x 0.9
    4. Round off to the nearest whole number

Example:

25 yrs old, Male with height of 5'9"
Step 1: 5'9' = 69 inches x (2.54cm/inch) = 175.26 cm
Step 2: DBW (kg) = _____
Step 3: Adjusted DBW (kg) = _____

- Nutritionist - Dieticians Association of the Philippines (NDAP) Method

Height	Female	Male
5 ft	106 lbs	112 lbs
1 inch less than 5 ft	-4 lbs	
1 inch more than 5 ft	+4 lbs	

*1 lbs = 0.45 kg (convert only at the end of the calculation)

Example:
25 yrs old, Male with height of 5'9"

- Body Mass Index (BMI)

$$BMI = \frac{weight\ (kg)}{(height\ (m))^2}$$

Example:
25 yrs old, Male with height of 5'9" and weight of 76 kg

Name:

- Total Energy Requirement (TER)
  - Krause Method
    - TER/day = DBW x Physical Activity (PA) Factor

Physical Activity	Physical Activity (PA) Factor
Bed rest	27.5
Sedentary	30
Light	35
Moderate	40
Heavy	45

Example:
25 yrs old, Male with height of 5'9" and weight of 76 kg and moderate PA

  - TER can also be based on PDRI (2015)

Recommended Energy Intakes per day

Life stage/ age group	Weight (kg)		Energy (kcal)	
	M	F	M	F
Infants, mo				
0–5	6.5	6.0	620	560
6–11	9.0	8.0	720	630
Children, y				
1–2	12.0	11.5	1,000	920
3–5	17.5	17.0	1,350	1,260
6–9	23.0	22.5	1,600	1,470
10–12	33.0	36.0	2,060	1,980
13–15	48.5	46.0	2,700	2,170
16–18	59.0	51.5	3,010	2,280
Adults, y				
19–29	60.5	52.5	2,530	1,930
30–49	60.5	52.5	2,420	1,870
50–59	60.5	52.5	2,420	1,870
60–69	60.5	52.5	2,140	1,610
≥ 70	60.5	52.5	1,960	1,540
Pregnant				+300*
Lactating				+500

Abbreviations: M–Male, F–Female, E–Energy
*For 2nd and 3rd trimesters only

- Caloric Distribution
  - Method 1: Percentage Distribution
    - CHO: 55-70% → use 65%
    - PRO: 10-15% → use 15%
    - Fat: 20-30% → use 20%

  - Method 2: Non-Protein Calories (NPC) Distribution
    1. Determine calories from protein based on g PRO/kg DBW
       Adults: 1.1 g PRO/kg DBW
    2. Compute for NPC:
       CHO: 55-80% of TER → use 70%
       Fat: 25-45% of TER → use 30%

Example:

How many grams of carbohydrate must a 25-yr old male with height of 5'9" , weight of 76 kg and moderate PA consume to meet its TER?

Name:

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