Introduction to Food Technology

Department of Food Technology
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Introduction

- **Food Technology** is a branch of food science that deals with the production processes that make foods.
- DEFINITION; food technology is the application of food science to the selection, preservation, processing, packaging, distribution and use of safe nutritions and wholesome food.

Scope of food technology

- Food technology is developed as a discipline to systematically organize and link the various kinds of knowledge which are necessary to inform human activity in food handling, processing, distribution and marketing.
- Food technology applies…
- the principle and concepts of engineering to problems of handling and processing.
- studies the interrelationship between the properties of materials and the changing methods of handling and manufacturing them.

Components of food technology

- Food analysis and chemistry

- Food quality factors and this measurement
- Food microbiology, mycology, toxicology
- Food processing and engineering.

CANNING…..


THYMUS
SALVIA
CORIANDR
BASILICUM
RADISH
CIBOULE
ZUCCHINI
CAROTA
PETRO SELINUM
BEANS
TOMATO



CANNING....

- Canning is defined as preservation of foods in hermetically sealed containers and usually implies heat treatment as the principal factor in prevention of spoilage.
- Heating is the principle factor to destroy the microorganisms and the permanent sealing is to prevent re-infection
- The process was invented after prolonged research by **Nicolas Appert** of france in 1809.
- Appert's method consisted of tightly sealing food inside a bottle or jar, heating it to a certain temperature and maintaining the heat for a certain period, after which the container was kept sealed until use.

50 years before levis Pasteur was able to explain why the food so treated did not spoil the heat killed the micro organisms in the food, and the sealing kept other micro organisms from entering the jar.

- In 1810 Peter Durand of England patented the use of tin coated iron cans instead of bottles, and by 1820 he was suppling canned food to the Royal Navy in large quantities.
- 19th centuary Samuel C Prescott and William Underwood of the united states set canning on a specific basis by describing specific time temperature heating requirements for sterilizing canned foods.



Growing



Harvesting



Transporting



Grading



Cold Storage ▸ Washing



Peeling



Coring/Halving/Slicing



Blanching



Filling



Sealing



Cooking



Cooling



Storage



Labelling



Despatch



Cans production…

- cans consisted of a sheet of tin – plated iron that was rolled into a cylinder , onto which the top and bottom were manually soldered.
- 20th century – modern sanitary or cans open-top
- parts were interlocked ,that are grimped and pressed together.
- The modern tin made by 98.5% sheet steel with a thin coating of tin.
- They are automatically manufactured at a rate of hundreds of cans per minute.

Vegetables, fruits, meats, diary products– stored in tin cans

soft drinks and other beverages– stores in aluminum cans



Production process

- Blanching



- Grinding



- Mixing with additional suitable ingredients



Filling cans

- Automatic done by machines.
- Cans filled with solid foods and contents
- Can passed through the water bath or steam bath





Exhausting and sealing

- Replace the air in the can as much as possible
- This heating expands the food and drives out air

Exhausting methods a) Thermal *exhausting (Steam vacuum)*

(b) Mechanical exhausting: (machine vacuum)

**Using lid sealed*

**after that heat sterilize and cooling the can partial vaccum within the container.*

**they are vaccum packed. Using vaccum can sealing machines*

**sealed cans then sterilized, at high temperature for long time to kill all the micro organisms to avoid contamination .*

Washing..



- After the cans are closed, they pass through a detergent spray washer to remove grease and other material
- The washing should consist of hot water (66°C) then by suitable pre-rinse, detergent spray wash. Followed by a fresh warm water rinse (66°C).

Thermal processing..

- The cans must be processed (heat treated) immediately after closing (hermetic sealed) at suitable time and temperature
- **Thermal processing** is defined as the combination of temperature and time required to eliminate a desired number of microorganisms from a food product.

vegetative bacteria are killed at --. 80C/30min

Spore formers at a --- temp.110C/30min.

For destroying the spores-- 121C/3min.



Cooling…

- Immediately after processing, the cans are cooled in water to a temperature of 36°C to 42°C. to avoid thermophilic spoilage or can rust.
- If the cans are cooled much below 36°C, they may not dry thoroughly and rusting well result.
- If the cans are cased at temperatures much over 42°C, thermophilic spoilage may occur.



Application …

- Pressure most of the nutrients..
- Proteins and CHO, fats are unaffected.
- Vitamin B is retened in can during high temper.
- Some vitamins and minerals may dissolve into the syrup but they retain their nutritive value if they are consumed.



Packing.....



Introduction ..

- Packaging is a process of covering, wrapping of goods into a package. Packaging involves designing & producing the wrapper for a product.
- Packaging is next to grading and branding.
- Packaging is essential for offering goods in safe, and secured position to consumer.

Packaging provides following benefits to the goods to be exported:

- **Physical Protection** – Packaging provides protection against shock, vibration, temperature, moisture and dust.
- **Marketing**: Proper and attractive packaging play an important role in encouraging a potential buyer.
- **Convenience** - Packages can have features which add convenience in distribution, handling, display, sale, opening, use, and reuse.
- **Negative** :The design of the package should not give any negative message.
- Companies sometimes change packaging to update their image and reach a new market.



TYPES OF PACKAGING

CONSUMER PACKAGING

- Designed for consumers convenience and appeal, marketing consideration and display.
- The main emphasis is on marketing.

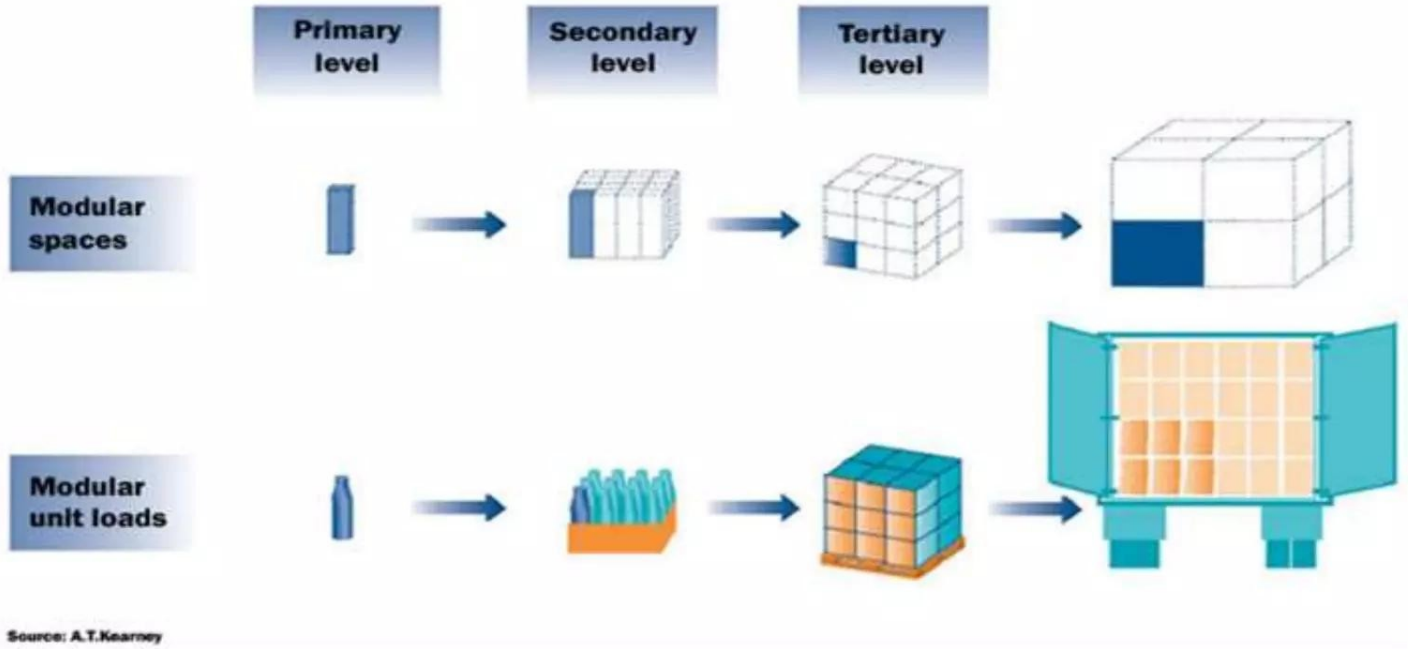
INDUSTRIAL PACKAGING

- It is designed to focus on the handling convenience and protection during transportation.
- The main focus is on logistic.



- The classification of packaging can also be based on level of packaging done on the product.

- **Primary** : -Direct contact with product. & Maintain product quality.
- **Secondary** : -It contains product and primary pack presentation , protection
- **Tertiary** : -Transport shipping , warehouse storage, bulk handling



Functions of packaging..

1. Promotion & Selling of product
2. Defining product identity.
3. Providing information.
4. Ensure safe use.
5. Protecting the product.

Promotion & Selling of product

- Promotion & Selling of product. Customer reaction to a package and brand name is an important factor in determining marketplace success or failure.
- Attractive, colorful and visually appealing packages have promotional value
- A well designed package is a powerful selling device because it helps the product stand out from its competitors





Defining product identity

- Packaging is sometimes used to promote an image such as prestige. Convenience or status. Can be a crucial part of marketing strategy particularly in advertising.



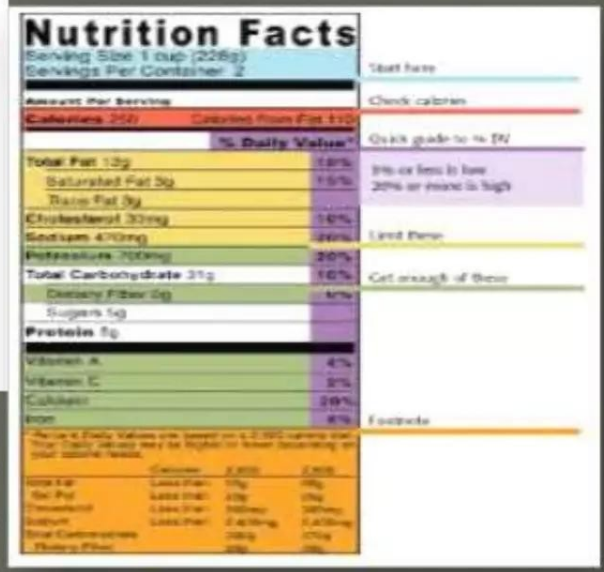




Providing Information

- Packages give directions for product use, information about contents, guarantees, nutritional information, and potential hazards





Ensure safe use

Packaging helps to eliminate potential injuries or misuse of a product.

Formerly glass containers are now plastic.

1. Childproof caps
2. Tamper resistant packages.

Including stickers, labels, tags, or paint



Protecting the product

- Packages protect a product during shipping, storage, and display, prevent tampering, and protect against spoilage and breakage





Factors Influencing Packing..

Type of Product

- Large and heavy objects- Crates
- Powders like cement – Bags
- Liquids like acetic acid – Drums or Containers
- Small and heavy items – Wooden Crates
- Bulky materials like cotton - Bales









Thank you folks...for your patience

Food Science Basics

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Ready, to immerse yourself in the world of food science?

- Ever wondered why bananas turn brown?
- Never sure which microorganisms in food can be harmful?
- Ever wondered why your chocolate mousse stays light and fluffy?





- Ever wondered why your pancake batter rises and forms air bubbles when baked?
- Never understood why your newly developed product changes color?

Week 4

- This deck is part of a 6 week course on the basics of food science, discussing all of these topics!
- It's a course for, amongst others:
  - Food Professionals
  - Food Bloggers
  - Chefs
  - (High school) students
- Besides food physics (this week's topic) we'll be discussing: food chemistry, food microbiology and some food packaging!
- Want to take the complete course? Sign up at: https://foodcrumbles.teachable.com/courses/food-science-basics/



Let’s get going!

After two sessions packed with food chemistry it’s time for a new topic: food physics.

This week we'll be zooming in on the following:

- Phase transitions: ice, water and gas; the basics!
- Water activity - so important for reasons you'll learn below
- Mixtures of components and phases

What is food physics?

- Before we get started, we will have to understand what food physics actually is. In the first session you've read a little about that already, but I guess we'll have to refresh your memory a little. So start by reading a little more on other pages and remember to return once you're finished!:
  - What is food physics? on foodcrumbles.com
  - Browse through this page, it gives you loads of fascinating examples.
  - Boston University has a nice article about a food physics course.
  - A good teaser to start with, several fun food phenomenon explained using physics from the physics.org website.

What is food physics?

- One of the big differences between food physics and food chemistry is that chemistry is all about transformations and reactions of molecules. Different molecules go in than those that come out.
- With physics, we generally keep the same molecules, however, based on their environment, these molecules might behave very differently. A common parameter is temperature.



Content

1. **Temperature, Kinetics & Phases**
2. Water activity
3. Foams, Emulsions & Gels

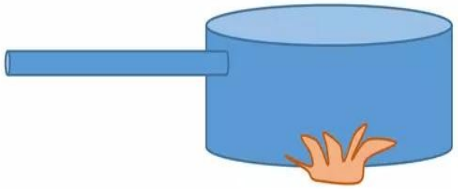
Temperature & Kinetic Energy

- Molecules are always moving, unless they are at the lowest temperature possible (-273°C). Any temperature above that, which is the case for our foods, and molecules will be moving. The speed at which they move depends on the temperature of the molecules. The higher the temperature, the more the molecules will move around.

- The faster the molecules move, the more energy these molecules have. This is defined by the law of kinetics.
- The faster a molecule moves, the more energy it has, the more likely it is to bump into others with sufficient speed to cause for instance a chemical reaction!

Temperature & Kinetic Energy

- If a molecule moves at a higher speed than another molecule and they bump into each other, the faster molecule will transfer part of its energy to the slower moving molecule.
- This is exactly what happens if you mix boiling hot water with cold water. The fast and slow moving molecules will move next to and into one another. In the end all will move at a new average speed which is somewhere in between that of the hot and cold molecules.



Phases & phase changes

- Now that we've learned that molecules move faster at a higher temperature we can go to the next step: phases.
- At a certain temperature the energy of the molecules becomes such that they will transition into a new phase. An every day example is water: ice is the solid phase, water is the liquid phase and water vapour is the gaseous phase.
- Using this example, you will probably be able to tell that the solid phase is always the one at the lowest temperature, whereas the gas is always the warmest phase.

Phases & phase changes

- The temperature at which a molecule is solid, liquid or a gas depends on the molecule itself. Oils set at a different temperature than water for example. This is caused by the attractive forces between molecules.
- Molecules, small as they are, exert quite a lot of different types of forces on one another. This influences at which temperature they'll be either solid, liquid or a gas.
- If molecules tend to attract one another quite intensely, it will take a lot more energy (thus higher temperature) to move into a liquid or gas phase.

Phases & phase changes

- Let's look into the three most common phases in more detail:

1. **Solid**: solid the energy of the molecules (the kinetic energy) is not enough to overcome the attractive forces to allow molecules to move around. The molecules pretty much sit at the same spot and vibrate there.
2. **Liquid**: In a liquid molecules don't stay put at their place anymore, but they aren't able to float around freely. They will still stay together together though and will not fill up an entire space.
3. **Gas:** In a gas the molecules can go completely loose. They will fill up the entire space they're in.

Phases & phase changes

An Example

- Let's discuss with an example.
  Take an ice cube, try pouring water out of the ice cube. Won't work will it? All the molecules will stay put in this little cube, they stay at their spot.
- Now take the liquid water. You can actually pour liquid water, but, the water will stay at the bottom of your glass. It will not fill up the complete glass.
- Then, when water evaporates from your pan of boiling water it will go everywhere.

Phases & phase changes

An Example

- These three different phases and the effect of temperature on molecules can be seen everywhere in food. You'll see next week how important temperature is for microbiology and last week you've seen that temperature influences chemical reactions. In food and cooking we use phase transitions all the time, melting things (e.g. melting sugar), evaporating moisture (e.g. baking bread) or solidifying molecules (e.g. cookie dough in the fridge).
- Want to see an example of working with different phases? Read my post on the ideal gas law!



Content

1. Temperature, Kinetics & Phases
2. **Water activity**
3. Foams, Emulsions & Gels

Water Activity

- The next important physics topic has all to do with water: the water activity. Water activity plays an important role in a lot of different processes in food.
  For instance: A lot of micro-organisms require a minimum water activity to be able to grow and a lot of chemical processes don't take place when the water activity is too low (or too high, though that's less common)!

Water Activity

Definition

- So what is this water activity? Let's get formal first: the water activity is the partial vapor pressure of water divided by the vapor pressure of pure water.
- In more common terms: the water activity defines how much of the water in a product is ‘available’, or, in other words, unbound.
- The scale of water activity goes from 0 to 1. If something has a water activity of zero (I wouldn't know of an example in food) it doesn't have any available water. Pure water, without any additions, has a water activity of 1.
- Note: The water activity is not the same as the concentration of water! Products with the same water content might have a totally different water activity, based on how the water is 'bound'.

Water Activity

Influencing the value

- So how does the water activity of a product go up or down?

1. Water activity can be reduced by getting rid of water. So if you dry a piece of meat or dry a cookie, the water activity will go down.
2. Water can be bound more. The two most common ways to ‘bind’ water in food are by adding sugar & salt. Even though the water will not literally bind to the sugar, it will float around it. By 'floating' around it is not available anymore.

    Two examples:

    A sugar solution with 50% sugar and 50% water has a water activity below 0,92. Still quite high!

    A salt solution with 10% salt, the rest water, has a water activity of 0,94. More effective, but keep in mind, this will taste really very salty!

Water Activity

& Movement of molecules

- One of the most important applications of water activity (besides food microbiology) is in product design. Water activity influences how a product will behave over time.
- Without going into the theory in too much detail : water activity is related to the energy content of molecules. Two foods with a different water activity have a different energy. They will want to equal this out, reach an equilibrium. As long as water is able to travel through the layers, the water activity of both will be the same over time.
- So, if two products with a different water activity are place on top of each other, water molecules will start moving from the product with the highest water activity to that with the lower water activity.

Water Activity



Biscuit & Jam

- An example: Let's take a dry biscuit that you cover with strawberry jam. Unfortunately, you've forgotten about your biscuit with jam and when you return a few hours later your biscuit is soggy. The water has moved from the jam into the biscuit!
- If you want your product to stay crunchy and moist, you will have to come up with a way to overcome the movement of water.



Content

1. Temperature, Kinetics & Phases
2. Water activity
3. **Foams, Emulsions & Gels**

Foams, Emulsions & Gels

- So, physics is not about transforming molecules, but it is all about mixing and influencing molecules without changing them.
- It is now time to apply some of the basics. Remember, the different phases we discussed? Food physics is interested in mixing these different phases, without the molecules actually dissolving or reacting. Instead, the different components will 'float' around each other.

Foams, Emulsions & Gels

- There are a lot of different possible combinations, to name just a few (find the whole list on Wikipedia):
  - Gas in liquid: this is a foam!
  - Liquid in a gas: a mist
  - Liquid in liquid: an emulsion, think of water and oil, these don't mix well and don't dissolve in one another.
  - Liquid in a solid: a gel

Foams, Emulsions & Gels

Since we've already covered quite some ground today we will not zoom in the science of these so-called dispersions. Instead, read several of the posts advised below in which we‘re focusing on foams.





Foam 1: Meringue - a foam which is baked in the oven to stay stable
Foam 2: Marshmallows - a foam which is stabilized with gelatin

Foams, Emulsions & Gels

Since we've already covered quite some ground today we will not zoom in the science of these so-called dispersions. Instead, read several of the posts advised below in which we‘re focusing on foams.





Foam 3: Chocolate mousse - stabilizing a foam with solid chocolate

Foam 4: Italian meringue - stabilizing a foam using heat and sugar

Chemistry of Food

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Learning Objectives

- Convert grams of fat, protein, and carbohydrates into kcal
- Name four carbohydrates and describe their chemical makeup
- Classify carbohydrates
- Compare the sweetness of various sugars
- Name three uses of carbohydrates in foods

What is nutrition?

- Process by which the foods people eat provide the nutrients needed to grow and stay healthy
- Nutrients:
  - Naturally occurring chemical substances found in food
- 6 categories:
  - Proteins
  - Lipids
  - Vitamins
  - Minerals
  - Water
  - carbohydrates

What is nutrition?

- Kilocalories- energy (kcal)
  - Proteins
  - Fats
  - Carbohydrates
- Conversion:
  - 1 gram of protein or carbohydrate = 4 kcal
  - 1 gram of fat = 9 kcal

Carbohydrates

- Carbohydrates come from plants
- Simple:
  - Different forms of sugar
  - Monosaccharides & disaccharides
- Complex:
  - Starches and dietary fiber
  - polysaccharides

Carbohydrates

- Named carbohydrates because hydrates of carbon
  - Composed of hydrogen and carbon
  - $C_n(H_2O)_n$
- Major function: provide energy
- Although not essential, important in many body functions

Carbohydrate Functions in Food

- Flavor enhancing & sweetening
  - carmelization
- Water binding
- Contributes to texture
- Hygroscopic nature/water absorption
- Provides food for yeast
- Regulates gelation of pectin dispersing molecules of protein or starch

Carbohydrate Functions in Food

- Acts to subdivide shortening for creaming control crystallization
- Prevents spoilage
- Delaying coagulation protein
- Gives structure due to crystals
- Affecting osmosis
- Affecting color of fruits
- Affecting texture (viscosity, structure)
- Contributes flavor other than sweetness

Carbohydrate Functions in Food

- May have multiple functions
  - Example: lollipops-
    - Control crystallization
    - Gives structures
    - Flavor enhancer and sweetner

Monosaccharide

- 6 carbons
  - Hexoses
  - Glucose (aka dextrose), fructose, galactose
- 5 carbons
  - Pentoses
  - Ribose, deoxyribose

Disaccharides

- Two monosaccharides linked together
  - Sucrose- 1 glucose + 1 fructose
  - Lactose- 1 glucose + 1 galactose
  - Maltose- 2 glucose
- Linked together by removing water (dehydration)
- Broken by adding water back (hydrolysis)

Sweetness

- Not all sugars have same sweetness
- Cola-type 10-12% sugars
- Depends on formula (mix)
- Table 3-3
- Several applications in foods
- Table 3-1

Sugars in Foods

- Color, texture, sweetness
- Major role as sweetener
- Honey, sorghum/molasses, maple syrup, and selected fruit juice- sweetener substitute for cane and beet sugar
- Glucose & fructose are most soluble and enhance browning

Sugars in Foods

- Inversion-
  - Hydrolysis of sucrose into fructose and glucose
- AKA invert sugars
- Need an enzyme or acid

Carmelization

- Process of applying heat
- Sugars dehydrate and breakdown
- Complex reaction but simple to do
- Example: peanut brittle
- Once melting point is reached sugar will carmelize
- Each sugar as its own melting point

Crystallization

- Can be a problem in variety of products
- Example: crystallization of lactose
  - Make nonfat milk difficult to disperse
  - Make frozen desserts gritty

Crystallization

- Candies:
- Divided into two groups-
- Crystalline and noncrystalline
- Crystaline: fudge, donfant, many others
- Noncrystaline: caramels, brittles, taffies, marshmallows

Crystallization

- Rate of crystallization depends on speed at which nuclei grow into crystals

Crystallization

- 4 factors:
- Concentration-
  - More concentrated = faster
- Temperature-
  - Higher temperature = slower
- Agitation
  - Mixing = faster
- Impurities-
  - Fats and protein

Polysaccharides

- Combinations of more than 2 sugars = oligosaccharides
- If very large called polysaccharides
- Added to foods for a variety of reasons
- Increase dietary fiber content
- Thicken
- Starch most common polysaccharide
- “Gum” naturally occurring added to food

Polysaccharides-Starch

- Starch most common polysaccharide
- Made of glucose units linked together
- Storage form of energy for plants
- Glycogen storage form of energy for animals
- Starch forms granules
- Vary is size and shape depending on type of plant

Polysaccharides-Starch

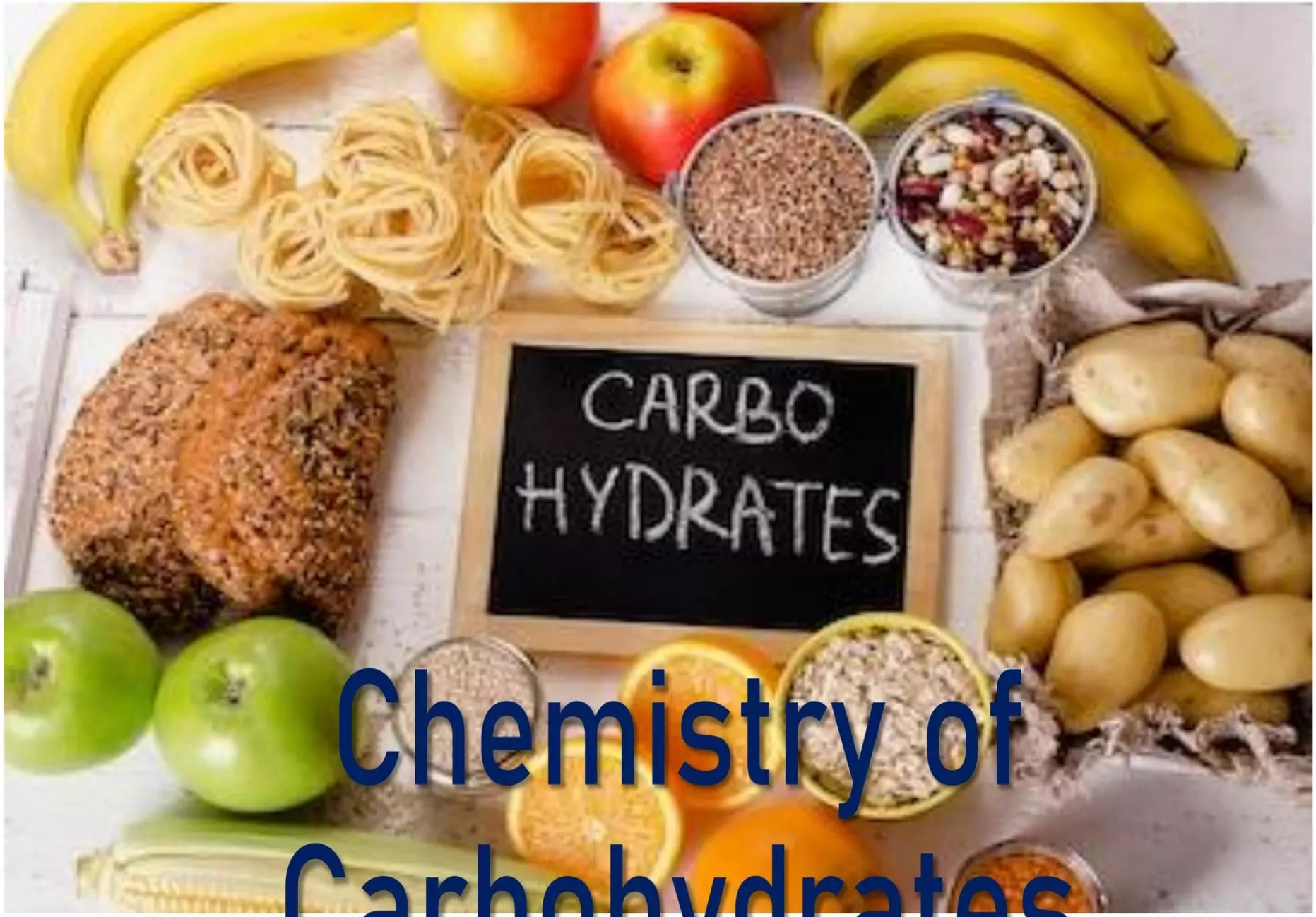
- Two- types:
- Amylose and amylopectin
- Amylose = 20-30% of most native starches
  - Some starches only contain amylopectin
    - Example: cornstarch

Polysaccharides-Starch

- Amylose contributes to gel formation
  - Reversible up to between 140℉ – 158℉
- Temperature affects gelatinization (irreversible swelling)
  - Starts between 140℉ – 158℉
- Increase in water absorption
- Gelatinization range
  - Temp. in which all granules are fully swollen

Chemistry of carbohydrate

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Chemistry of Carbohydrates

POINTS TO BE COVERED

- Introduction to carbohydrates
- Definition of Carbohydrates
- Functions of Carbohydrates
- Classification & Nomenclature of Carbohydrates
- General Properties of Monosaccharides & Glucose / Fructose
- Biomedical Importance of Monosaccharides
- Reactions of Monosaccharides
- Glycosides
- Disaccharides
- Polysaccharides

Introduction

Carbohydrates:

- Widely distributed in nature, both in animals and plants tissues.
- A major source of energy from our diet.
- All carbohydrates contain the elements carbon (C), hydrogen (H) and oxygen (O) with the hydrogen and oxygen being present in a 2 : 1 ratio.

Defination

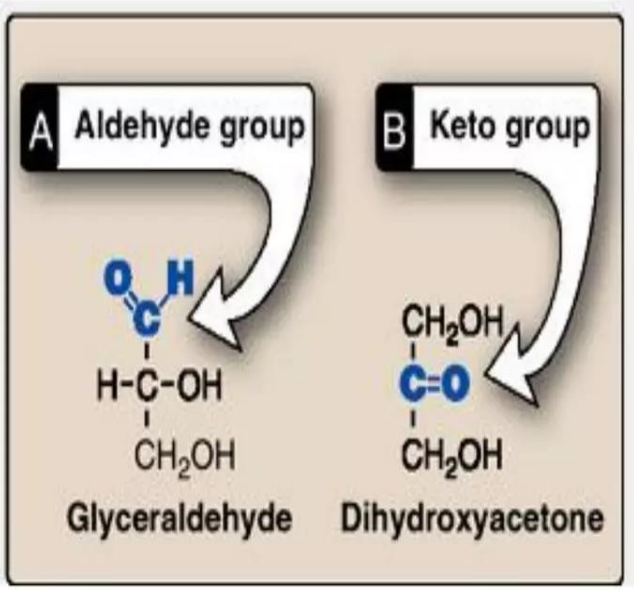
Carbohydrates:

- Defined as polyhydroxy aldehydes or ketones or compounds that yield these on hydrolysis.
- General formula : $C_n(H_2O)_n$.
- Also called as "saccharides".

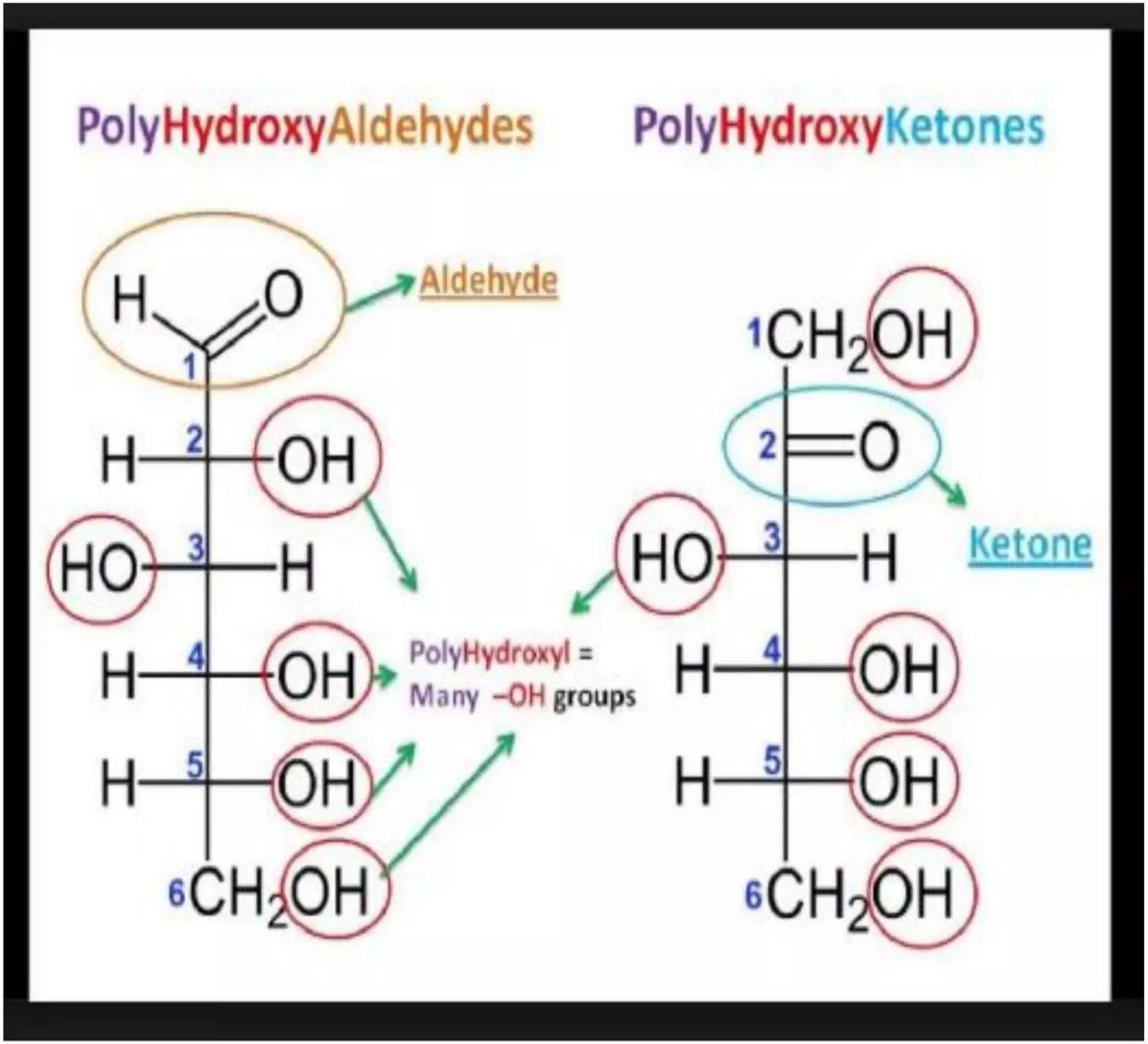
EXAMPLES

The formula for glucose is $C_6H_{12}O_6$

The formula for sucrose is $C_{12}H_{22}O_{11}$



an aldose (A) and a ketose (B) sugar.


PolyHydroxyAldehydes
PolyHydroxyKetones
Aldehyde
Ketone
PolyHydroxyl =
Many –OH groups
1
2
3
4
5
6
H
O
OH
HO
CH2OH

Functions

Carbohydrates:

- Major sources of energy in the body.
  - Brain cells and RBCs are almost wholly dependent on carbohydrates as the energy sources.
  - Energy production – 4 kcal/ g.
- Storage form of energy.
  - Starch and Glycogen
- Excess carbohydrates converted into fats.

- Glycoproteins and glycolipids are components of cell membranes and receptors.

- Structural basis of many organisms.
  - Cellulose of plants
  - Exoskeleton of insects
  - Cell wall of microorganisms
  - Mucopolysaccharides as ground substances in higher organisms.

Classification & Nomenclature of Carbohydrates

Carbohydrates are classified into four major groups:

1. **Monosaccharides**: Molecules having only one actual sugar group. (Greek, mono= one; saccharide = sugar). They cannot be further hydrolysed into smaller units.

2. **Disaccharides**: When two monosaccharides are combined together with elimination of a water molecules.

3. **Oligosaccharides**: When 2-8 sugars joined together. (Greek, Oligo = many)

4. **Polysaccharides**: When more than 10 sugars units are combined. (Greek, Poly = many)

Monosaccharides (simple sugar)

- Simplest carbohydrates
- Colorless, crystalline solids that are freely soluble in water
- Most are sweet in taste.

Monosaccharides: are those which cannot be hydrolysed further into simple forms also called as simple Sugars.

General formula : $C_n(H_2O)_n$.

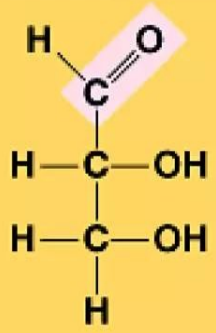
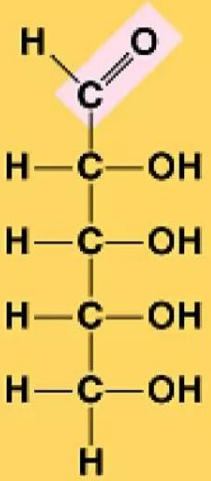
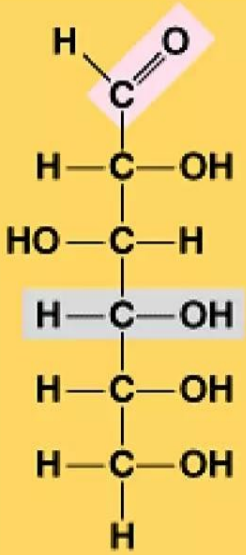
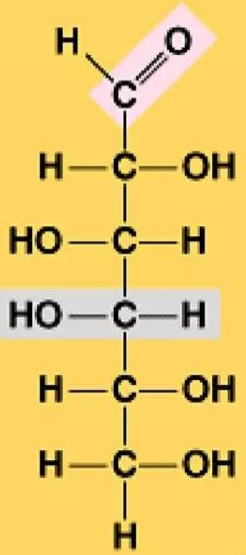
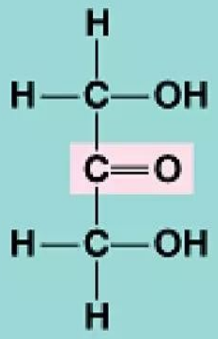
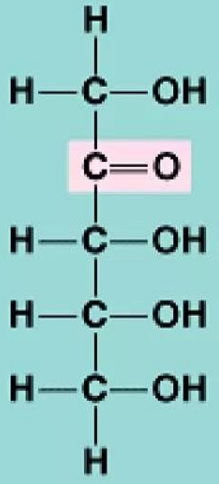
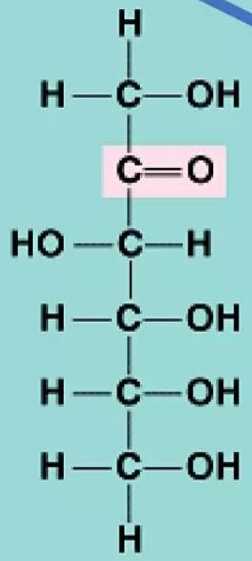
They are subdivided further into :

Based on the number of carbon atoms.

Based on whether aldehyde (-CHO) or ketone (-C=O) groups.

Classification of Monosaccharides

No. of Carbon	Type of sugar	Aldoses	Ketoses
3	TRIOSES	Glyceraldehydes	Dihydroxyacetone
4	TETROSES	Erythrose	Erythrulose
5	PENTOSES	Ribose, Xylose	Ribulose, xylulose
6	HEXOSES	Glucose, Galactose	Fructose
7	HEPTOSES	Glucoheptose	Sedoheptulose

	Triose sugars ($C_3H_6O_3$)	Pentose sugars ($C_5H_{10}O_5$)	Hexose sugars ($C_6H_{12}O_6$)	
Aldoses	 Glyceraldehyde	 Ribose	 Glucose	 Galactose
Ketoses	 Dihydroxyacetone	 Ribulose	 Fructose	

Most abundant monosaccharide in nature

BIOLOGICAL IMPORTANT MONOSACCHARIDES

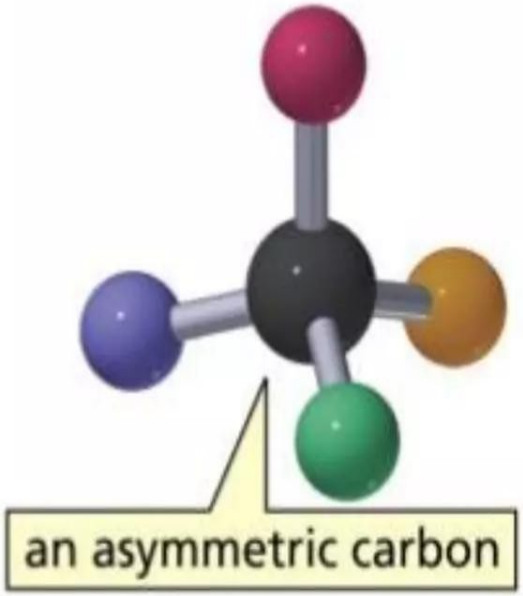
TYPES	EXAMPLE	IMPORTANCE
Trioses	Glyceraldehyde, Dihydroxyacetone	✔ Intermediates of glycolysis, ✔ Precursor of glycerol (for lipid synth)
Tetroses	D-Erythrose	✔ Intermediates of carbohydrate metabolism
Pentoses	D-Ribose	✔ Structural element of nucleic acid, RNA, co-enzymes.
Hexoses	D-Glucose	✔ Main sugar of the body.
	D-Fructose	✔ Converted to glucose & utilized by the body.
	D-Galactose	✔ Synthesized in mammary gland to make the lactose of milk.
	D-Mannose	✔ Constituent of glycoprotein, glycolipids

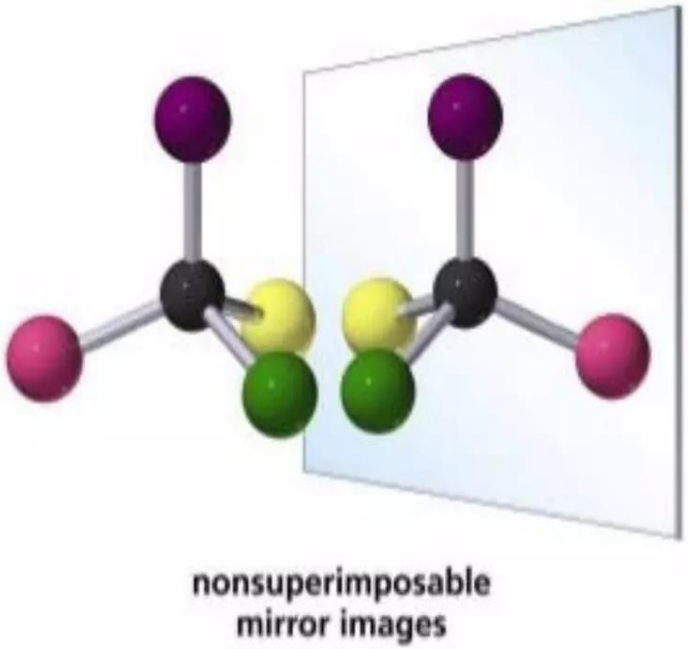
General Properties of Monosaccharides

1. Structure of Glucose & Fructose
2. Various forms of isomerism
   - D- & L- Isomers
   - Optical Isomers
   - Epimers
   - Anomers
3. Mutarotation

ASYMMETRIC CARBON

- Asymmetric carbon: carbon with 4 different groups bonded to it
- No plane of symmetry
- Mirror image is non-superimposable



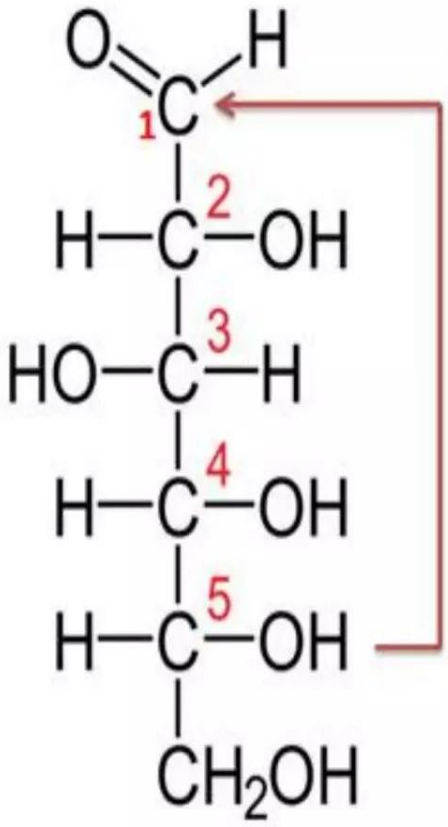


PYRANOSE AND FURANOSE RING STRUCTURE

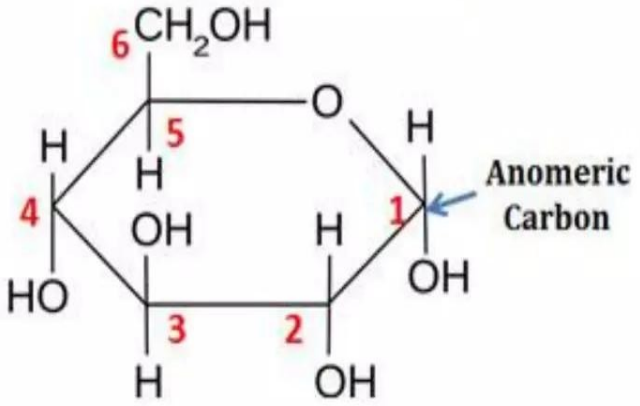
The reaction between the aldehyde group of C-1 with the alcoholic group of C-4 or C-5 results in the formation of hemiacetal. Similarly, the reaction between the keto group of C-2 of fructose with the alcoholic group of C-5 results in the formation of a hemiketal.

The glucose exists in biological systems not as a rectangle, but as a pyronose ring.

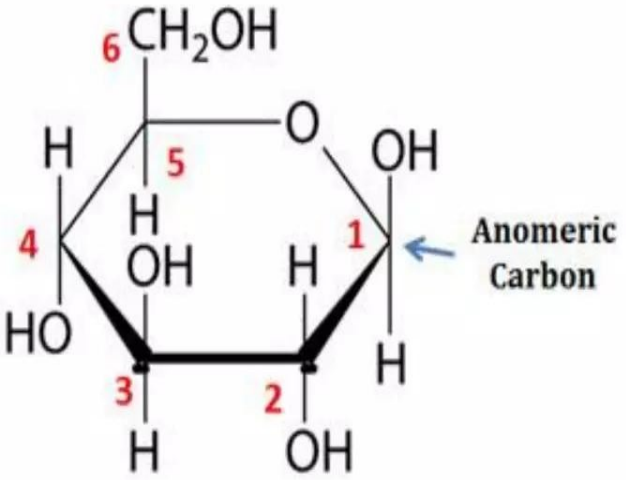
Formation of Cyclic Structure of Glucose (Aldohexose)



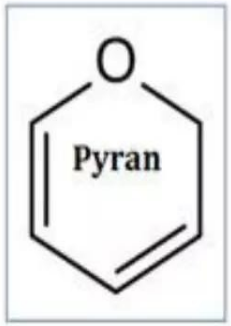
D-Glucose



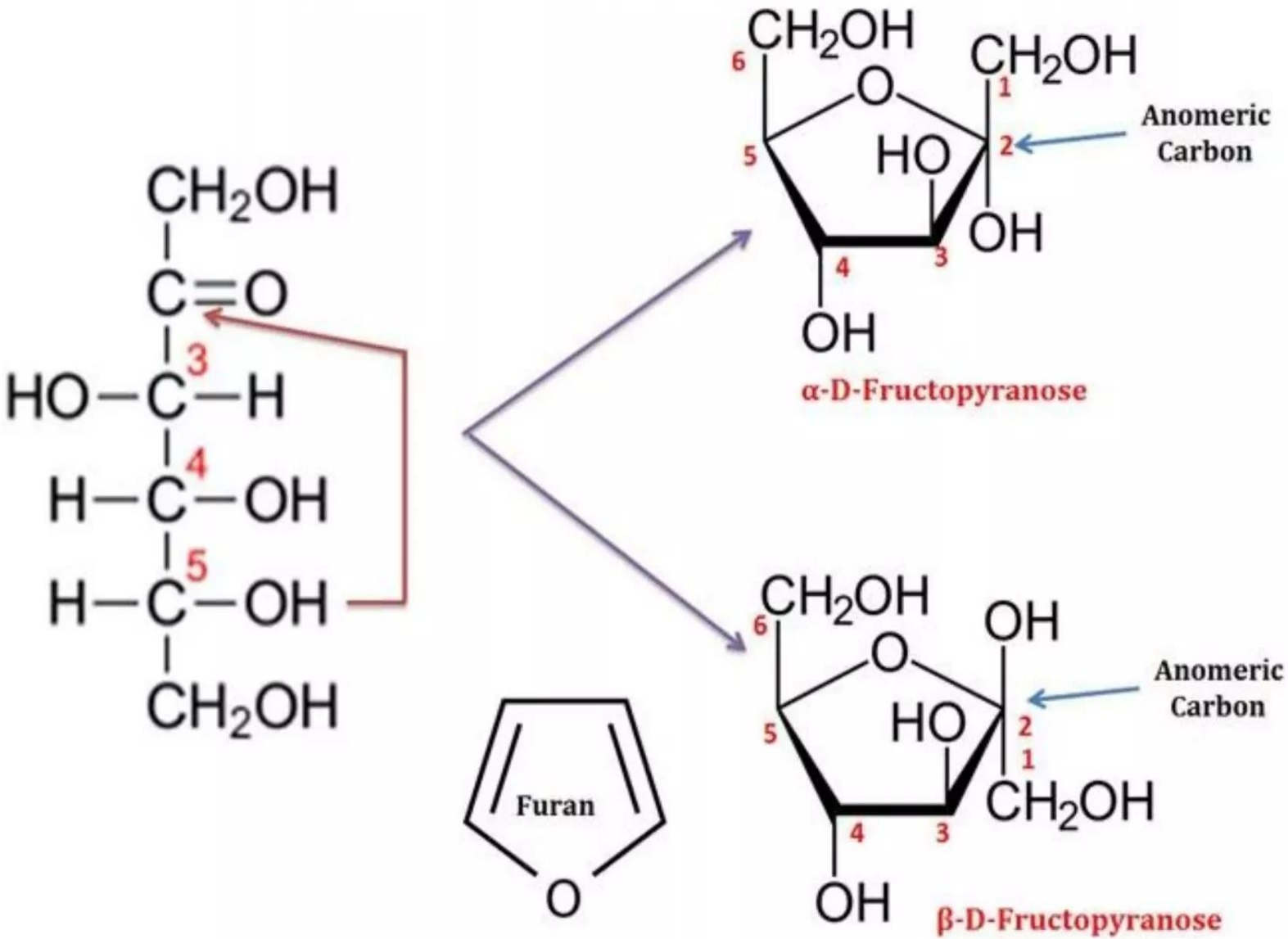
α-D-Glucopyranose



β-D-Glucopyranose

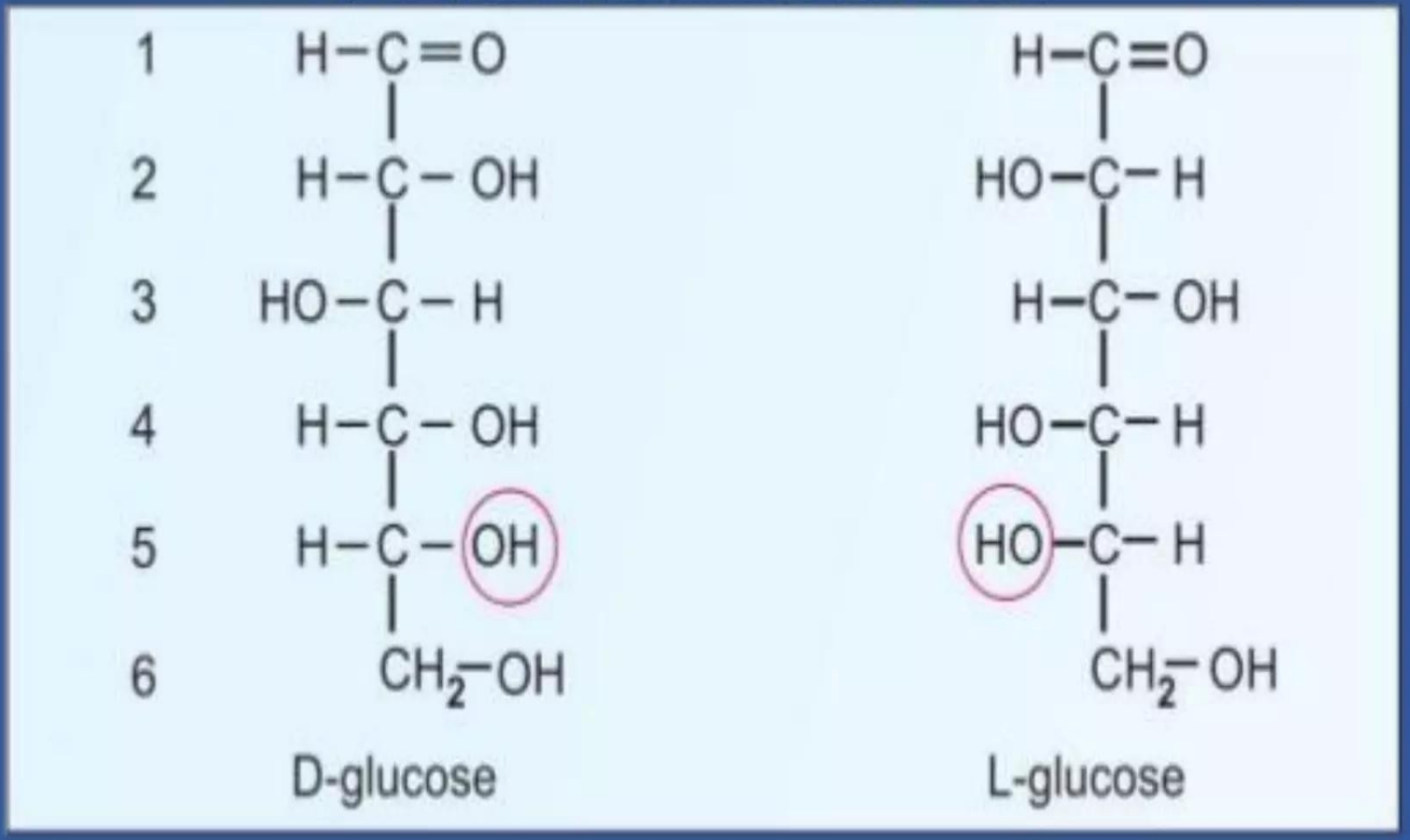


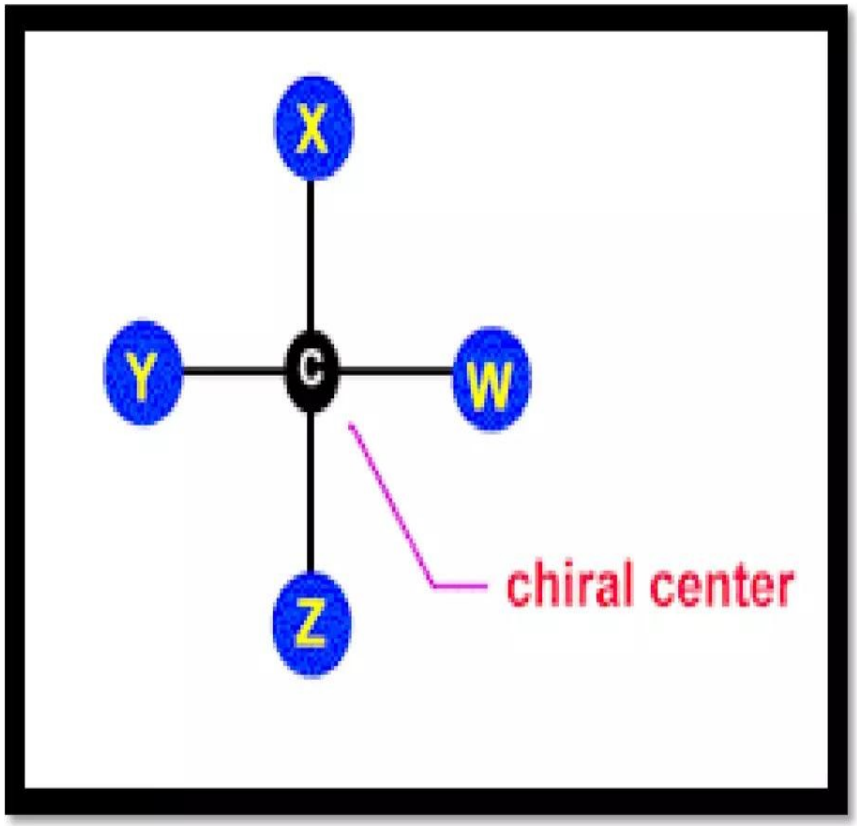
Formation of Cyclic Structure of Fructose (Ketohexose)



Reference Carbon Atom of Sugars

Penultimate (reference) carbon atom





The presence of asymmetric carbon atoms in a compound gives rises to the formation of isomers of that compound.

STEREOISOMERISM

Definition: Compounds having same structural formula, but differing in spatial configuration are known as stereoisomerism.

The number of possible stereoisomers depends on the number of asymmetric carbon atoms by the formula 2^n [Vant Hoff's rule].

where n = number of asymmetric carbon atoms.

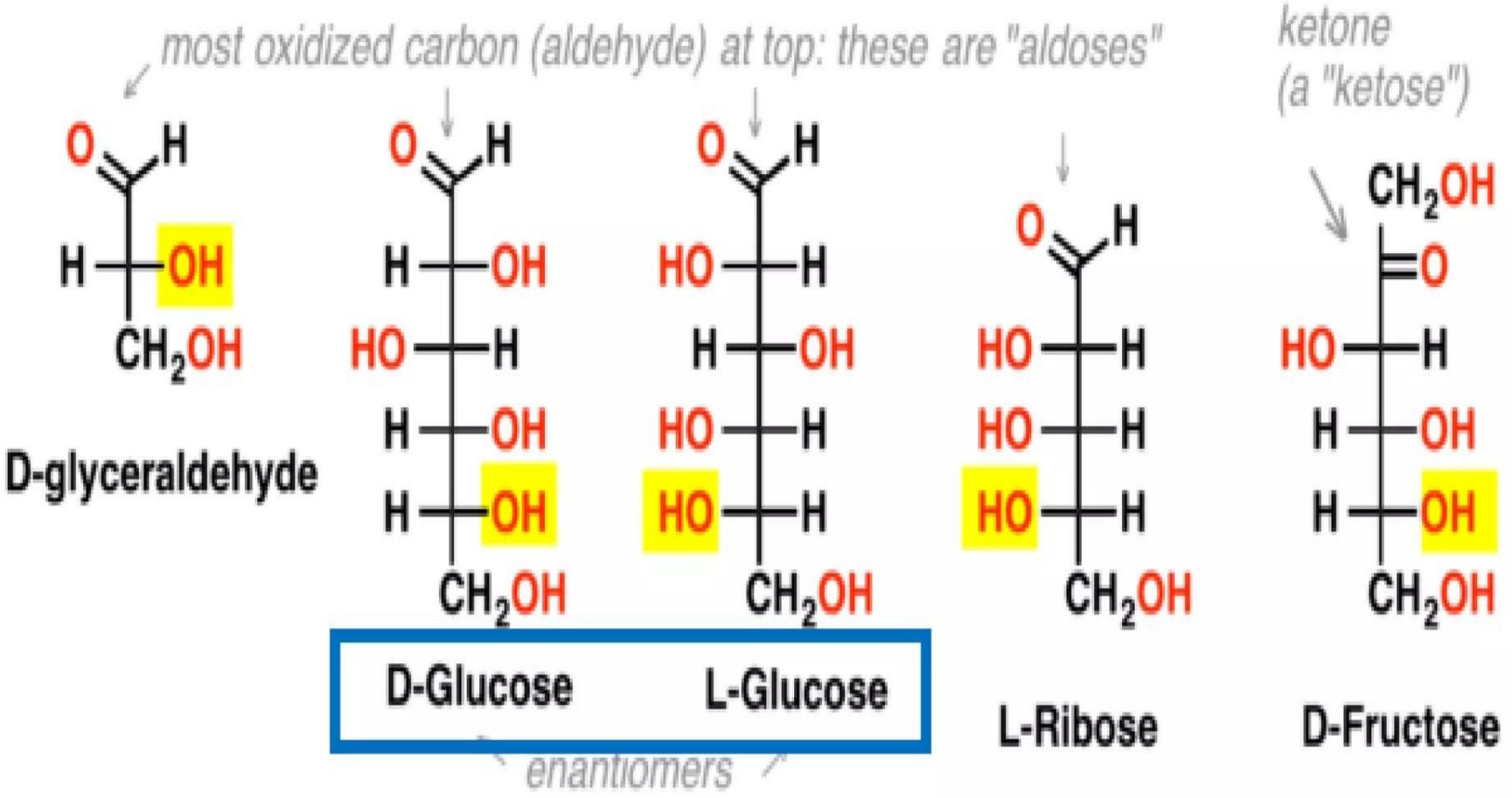
D – AND L- ISOMERS

The orientation of the H and OH groups around the carbon just adjacent to the terminal primary alcohol carbon (e.g., carbon atom 5 in glucose) determines the family to which the sugar belongs.

When the OH group on this carbon is on the right, the sugar is a member of D-series; when it is on the left, it is member of the L-series.

The distribution of the H and OH groups in the other carbon atoms in the molecule is of no importance.

- If the OH on the bottom chiral center points to the **right**, the sugar is **D**
- If the OH on the bottom chiral center points to the **left**, the sugar is **L**



The majority of the monosaccharides occurring in the body are the D-series.

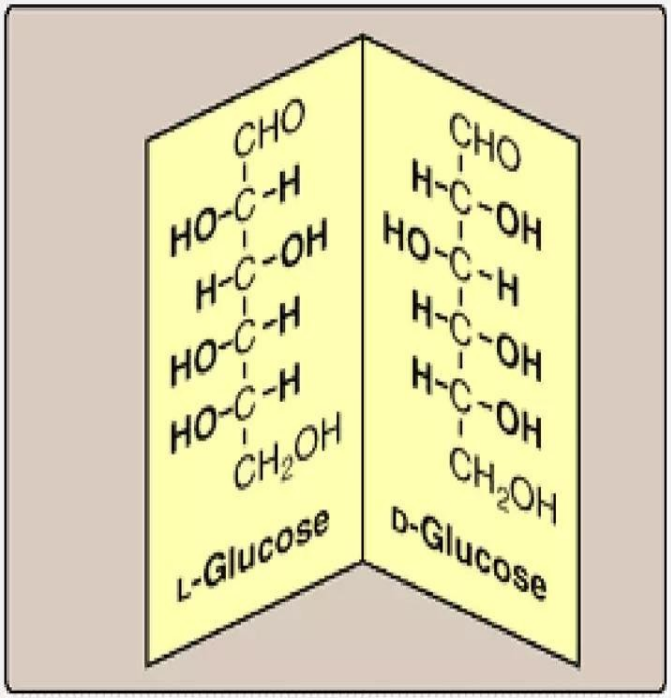


Figure 7.5 Enantiomers (mirror images) of glucose.

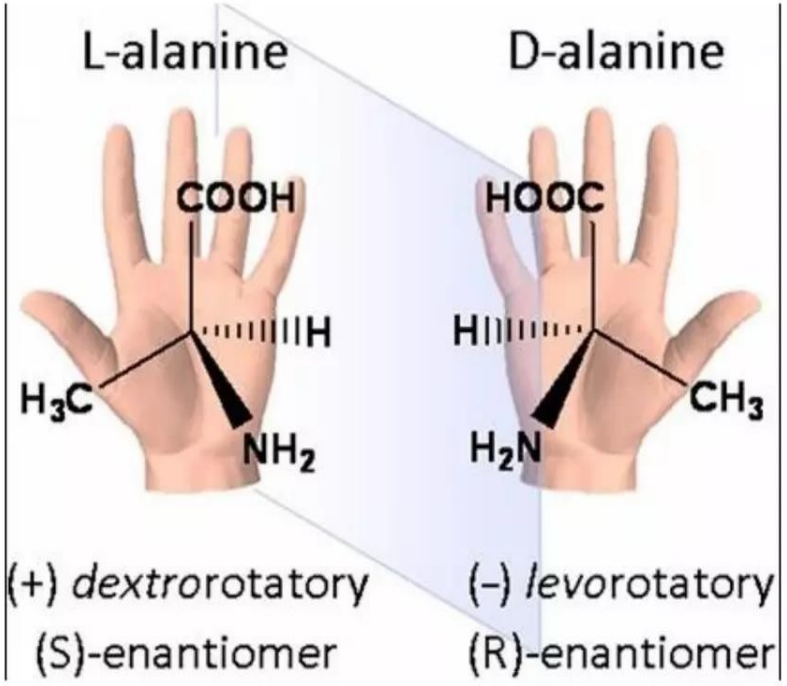
OPTICAL ACTIVITY OR OPTICAL ISOMERISM

The presence of asymmetric carbon atoms also confers optical activity on the compound.

When a beam of polarized light is passed through a solution exhibiting optical activity, it will be rotated to the right or left in accordance with the type of compound (i.e. optical isomer).

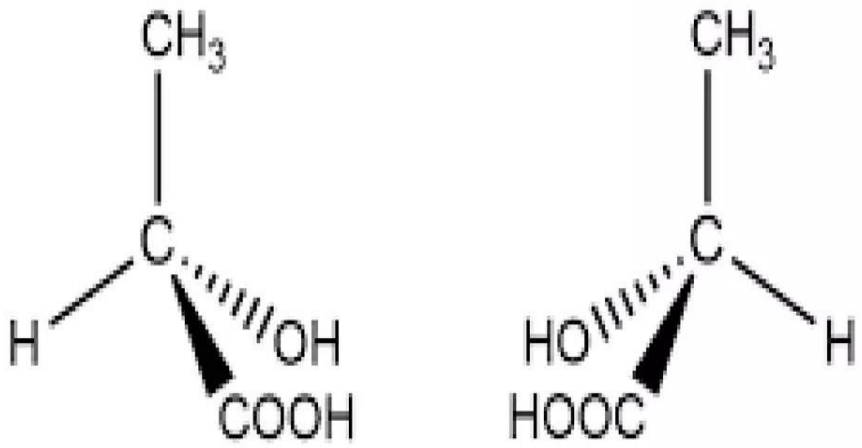
Right side = dextorotatory (+)

Left side = Levorotatory (-)



RACEMIC OR DL MIXTURE

When equal amount of dextrorotatory and levorotatory isomers are present, the resulting mixture has no optical activity.

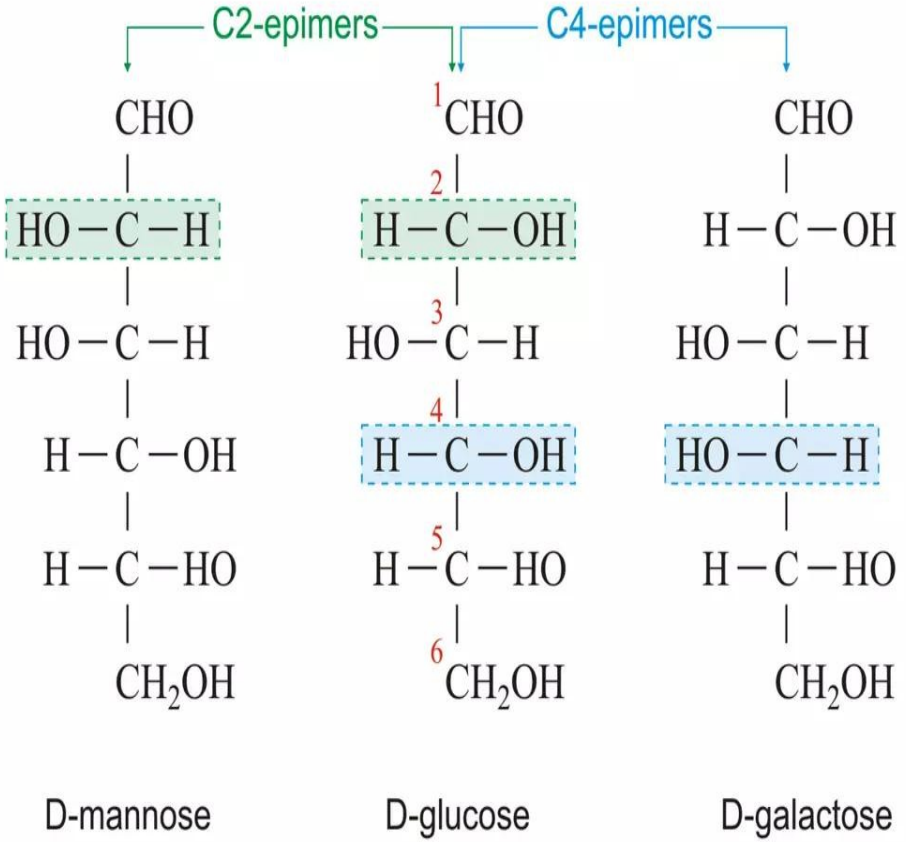


(R) - Lactic Acid 50% + (S) - Lactic Acid 50%

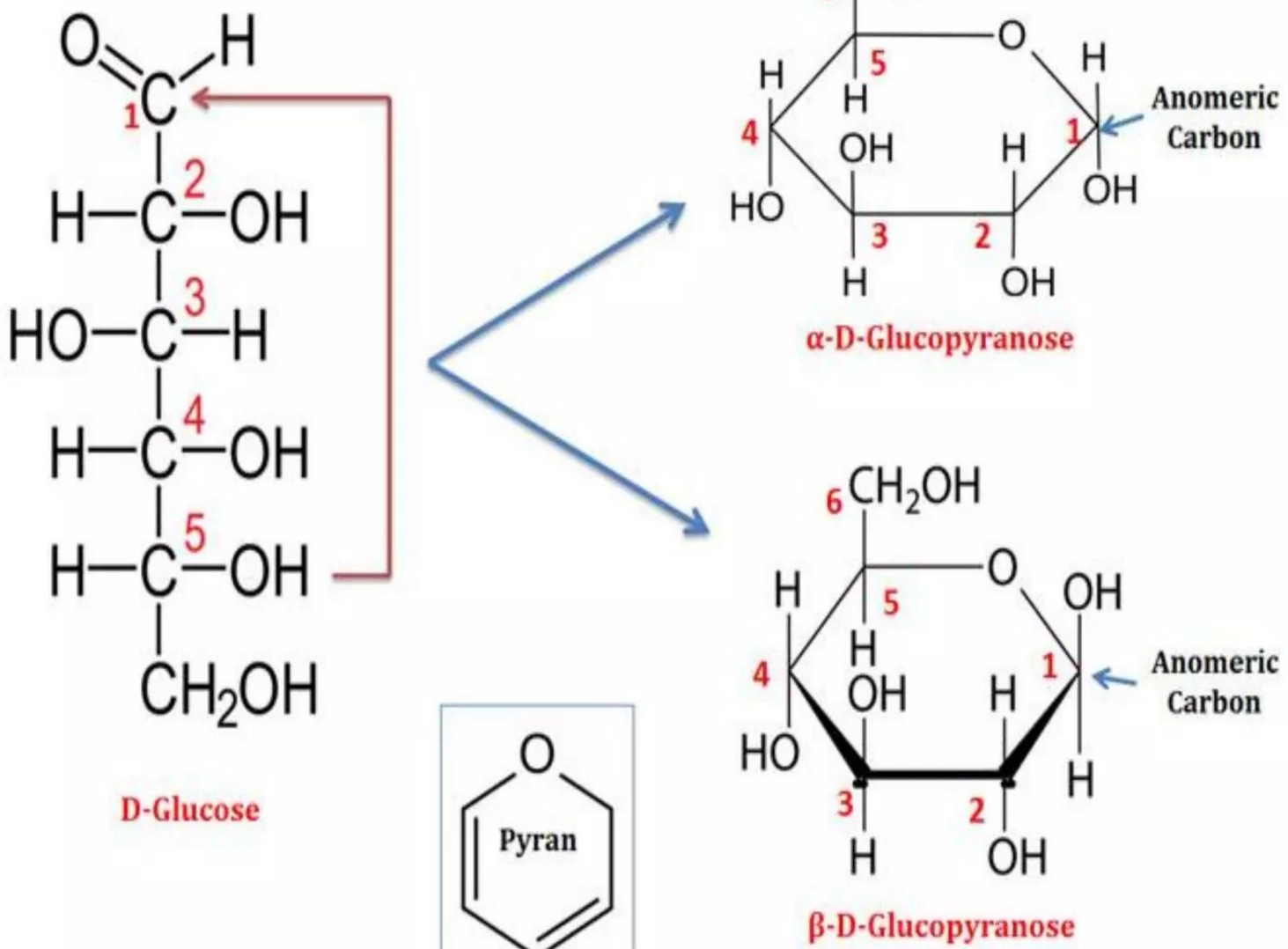
Racemic Mixture

EPIMERS

Two sugars which differ from each other only in the configuration around a single carbon atom, are called 'epimers'.

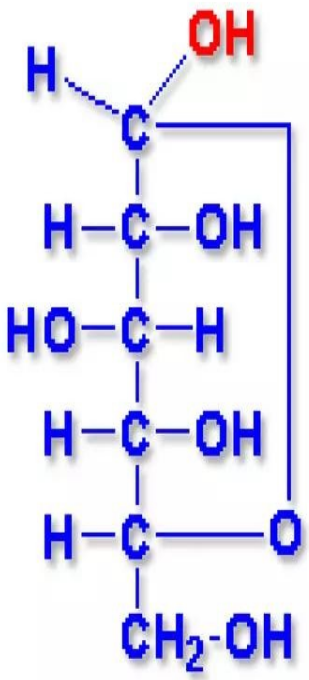


ANOMERS


D-Glucose
Pyran
α-D-Glucopyranose
β-D-Glucopyranose
Anomeric Carbon
Anomeric Carbon

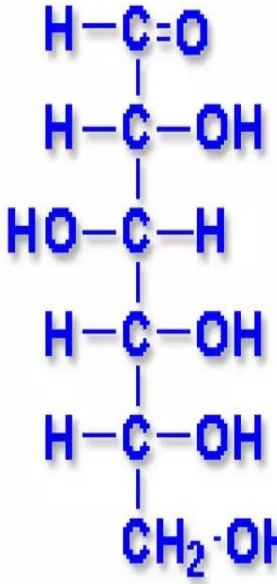
MUTAROTATION

- A freshly prepared solution of glucose crystallized from water or alcohol at low temperature exhibits specific optical rotation of +112^{o} . But, a solution of glucose crystallized from water above 98^{o} c, has specific rotation of +19^{o} only. When both of the solutions are kept for some time, the rotation gradually changes to 52.5^{o} and remains constant there. This is known as MUTAROTATION.

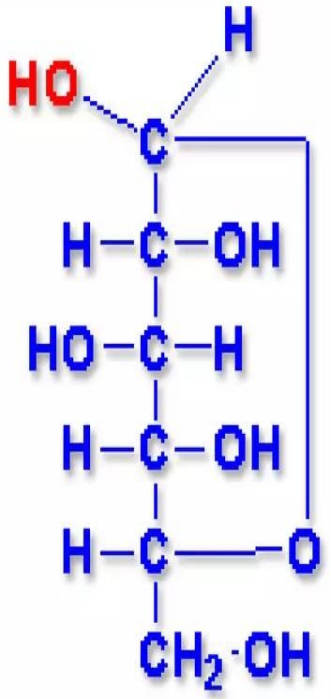


αD-glucose

+ 112°



D-glucose
(straight chain
formula)
+52.5°



βD-glucose

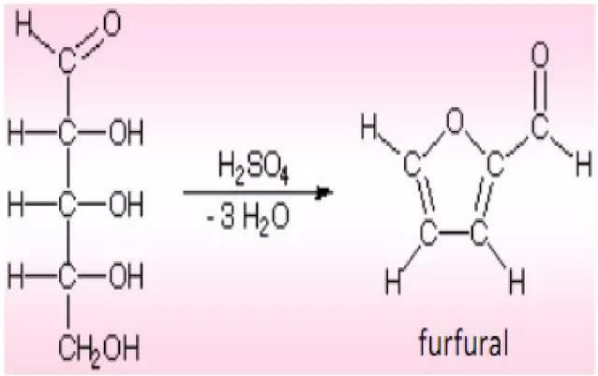
+19°

CHEMICAL PROPERTIES / REACTIONS OF MONOSACCHARIDES

1. Action of strong Acid: Furfural Formation
2. Action of Alkaline Enediol formation
3. Oxidation: Sugar acid formation
4. Reduction: Sugar Alcohol formation
5. Action of Phenylhydrazine: Osazone formation
6. Osazone formation
7. Reduction to form alcohols
8. Formation of esters
9. Amino sugars
10. Deoxy sugars

1. FORMATION OF FURFURAL DERIVATIVES

- Monosaccharides when treated with concentrated sulphuric acid undergo dehydration with the removal of 3 molecules of water. Therefore hexoses give hydroxymethyl furfural and pentoses give furfural. The furfural derivative can condense with phenolic compounds to give coloured products.
- This forms the basis of Molisch test & Seliwanoff's test.
- It is a general test for carbohydrates.



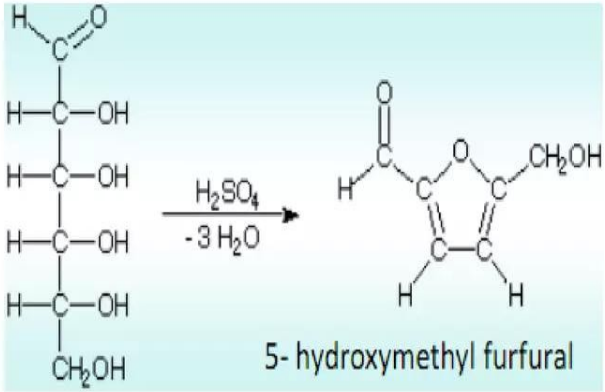
Pentose

α-naphthol

[Present in the reagent]

Purple ring





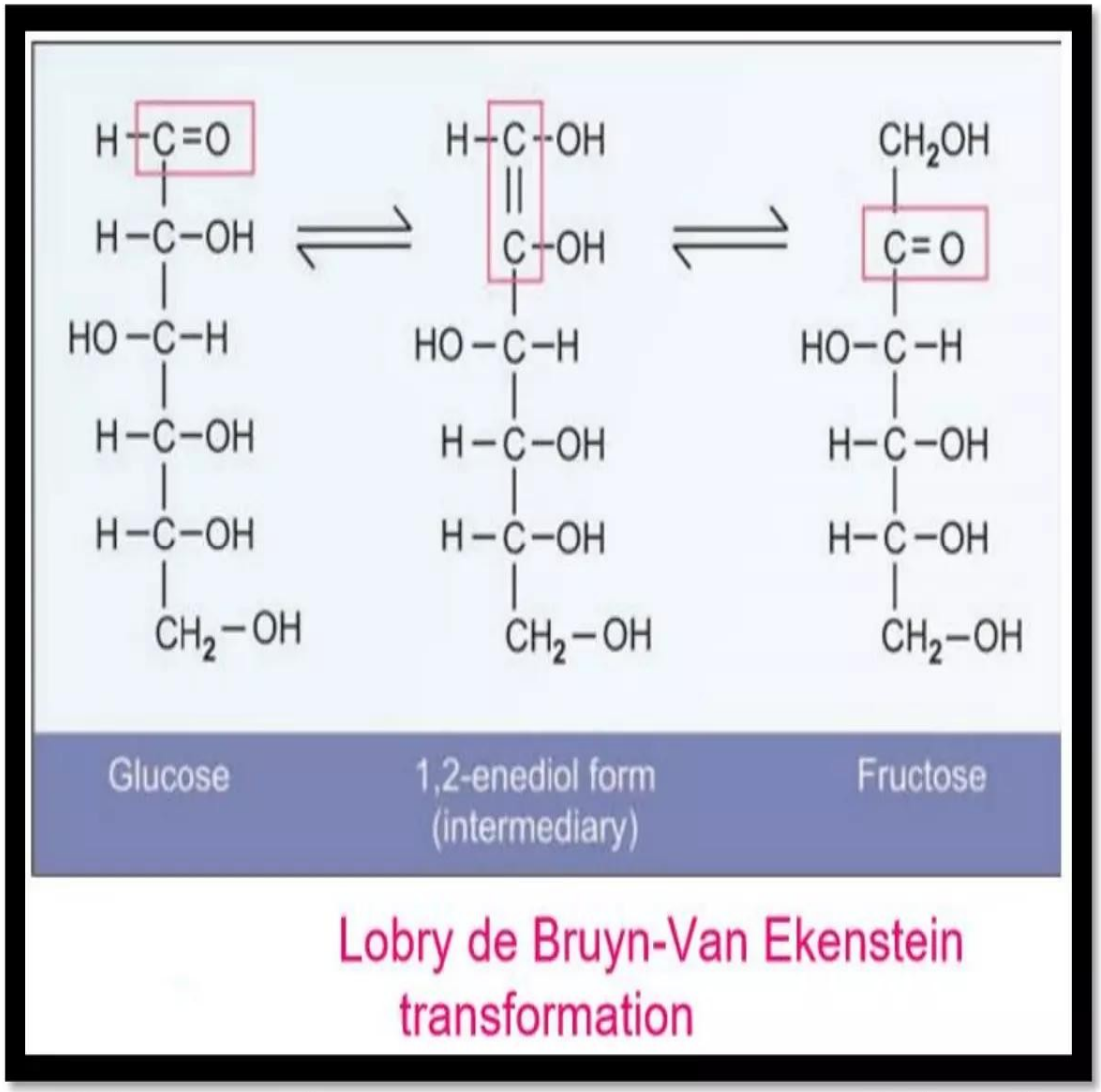
Hexose

α-naphthol

Purple ring

2. ENEDIOL FORMATION

- In mild alkaline solutions, carbohydrates containing a free sugar group (aldehyde or keto) will **tautomerize** to form **enediols**, where two hydroxyl groups are attached to the double-bonded carbon atoms.
- In mild alkaline conditions, glucose is converted into fructose and mannose.
- The interconversion of sugars through a common enediol form is called **Lobry de Bruyn-Van Ekenstein transformation .**



Enediols are highly reactive, sugars are powerful reducing agents in alkaline medium. When oxidising agents like cupric ions are present, sugars form a mixture of carboxylic acids by breaking at the double bonds.

Benedict's Reaction:

- Benedict's reagent is very commonly employed to detect the presence of glucose in urine (glucosuria).
- It is a standard laboratory test employed to diagnose diabetes mellitus.
- Benedict's reagent contains sodium carbonate, copper sulphate and sodium citrate.
- In alkaline medium, sugars form enediol, cupric ions are reduced, correspondingly sugar is oxidized. Any sugar with free aldehyde/ keto group will reduce the Benedict's reagent. Therefore, this is not specific for glucose.

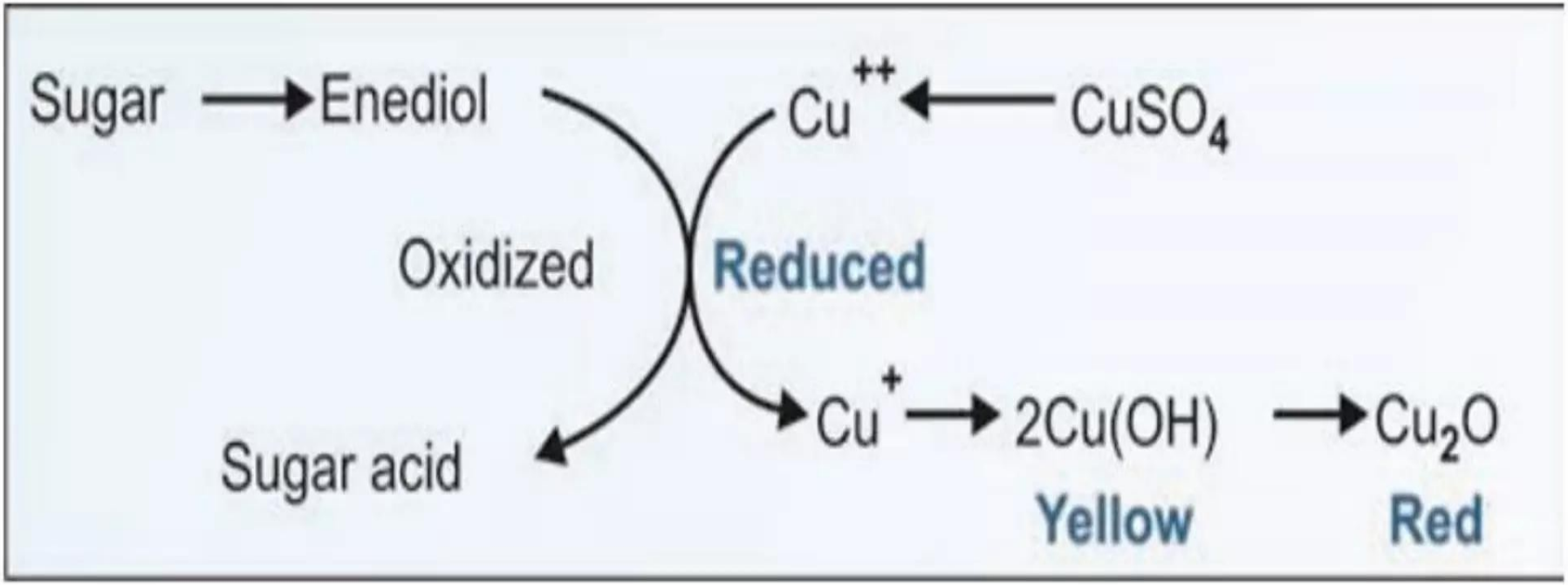


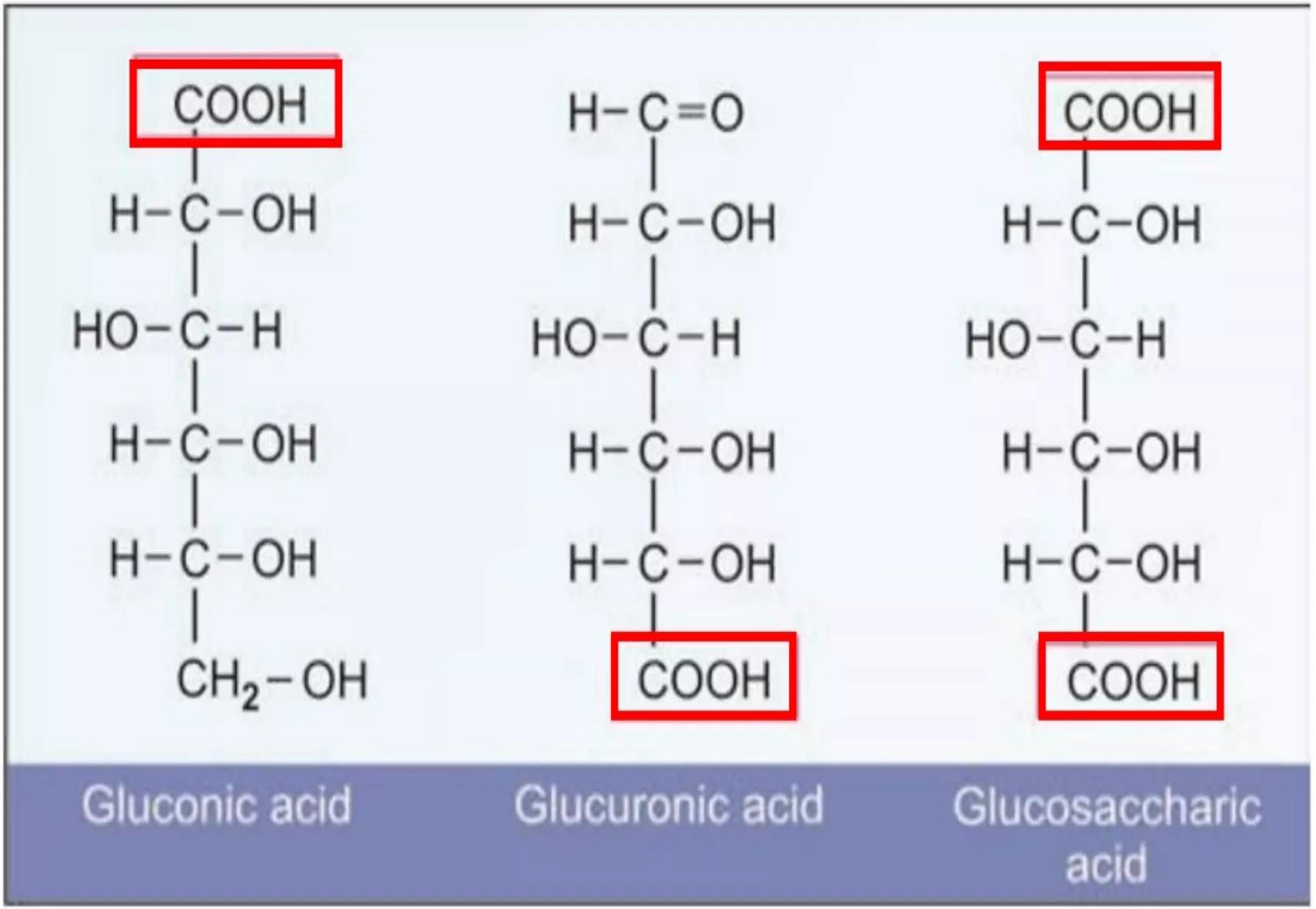
Fig. 6.9. Benedict's test, principle

3. OXIDATION OF SUGARS

a) Under mild oxidation conditions (hypobromous acid, Br_2/H_2O), the aldehyde group is oxidized to carboxyl group to produce aldonic acid.

b) When aldehyde group is protected, and the molecule is oxidized, the last carbon becomes COOH group to produce uronic acid.

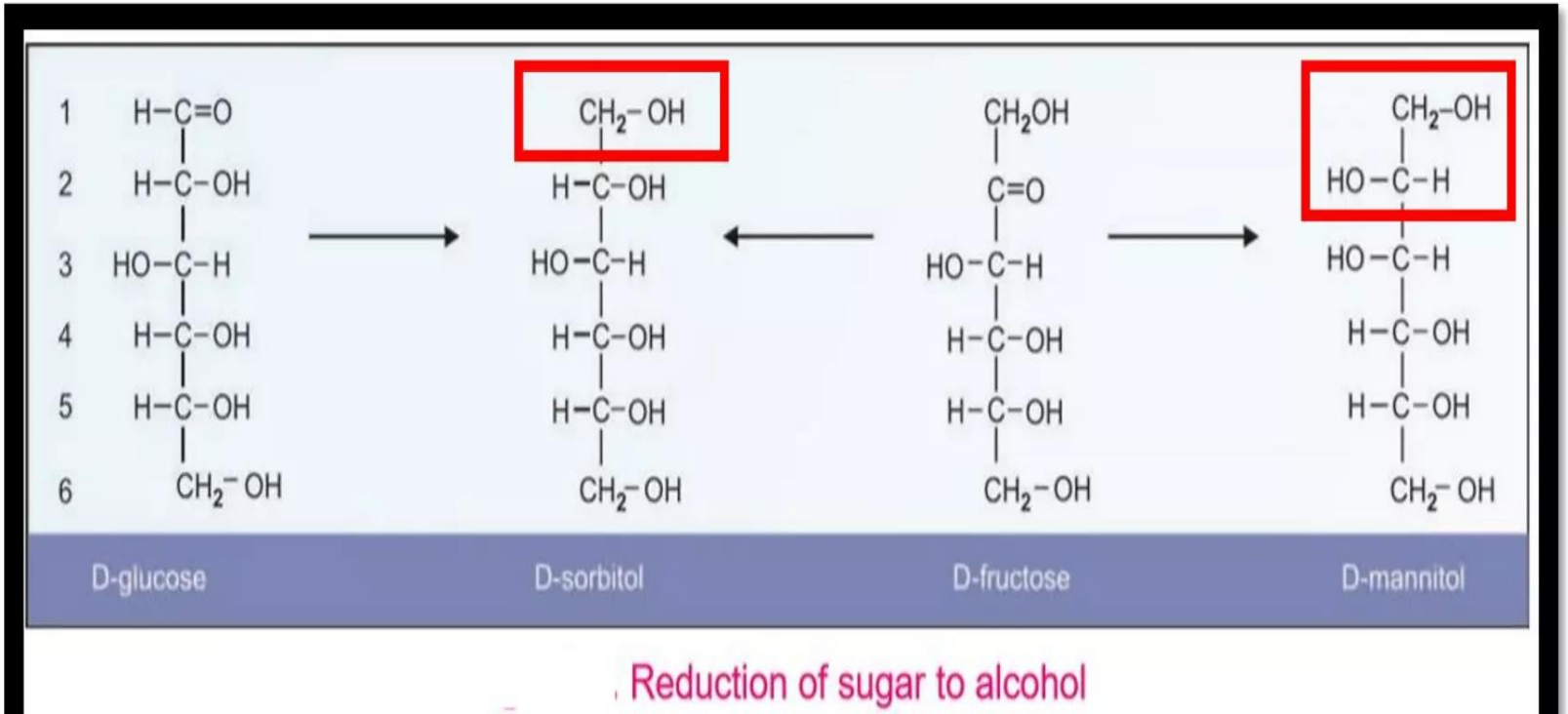
c) Under strong oxidation conditions (nitric acid + heat), the first and last carbon atoms are simultaneously oxidized to form dicarboxylic acids, known as saccharic acids


COOH
H–C–OH
HO–C–H
H–C–OH
H–C–OH
CH2–OH
H–C=O
H–C–OH
HO–C–H
H–C–OH
H–C–OH
COOH
COOH
H–C–OH
HO–C–H
H–C–OH
H–C–OH
COOH
Gluconic acid
Glucuronic acid
Glucosaccharic acid

Sugar Acids

4. FORMATION OF SUGAR ALCOHOLS

The monosaccharides may be reduced to their corresponding alcohols by reducing agents such as sodium amalgam or with hydrogen under pressure. Similarly, ketoses may also be reduced to form keto alcohol.



Reduction of sugar to alcohol

- Glucose is reduced to sorbitol.
- Mannose to mannitol.
- Fructose becomes sorbitol and mannitol.
- Galactose is reduced to dulcitol.
- Ribose to ribitol.

Sorbitol, mannitol and dulcitol are used to identify bacterial colonies. Mannitol is also used to reduce intracranial tension by forced diuresis. The osmotic effect of sorbitol and dulcitol produces changes in tissues when they accumulate in abnormal amounts. e.g Cataract of lens

5. OSAZONE FORMATION

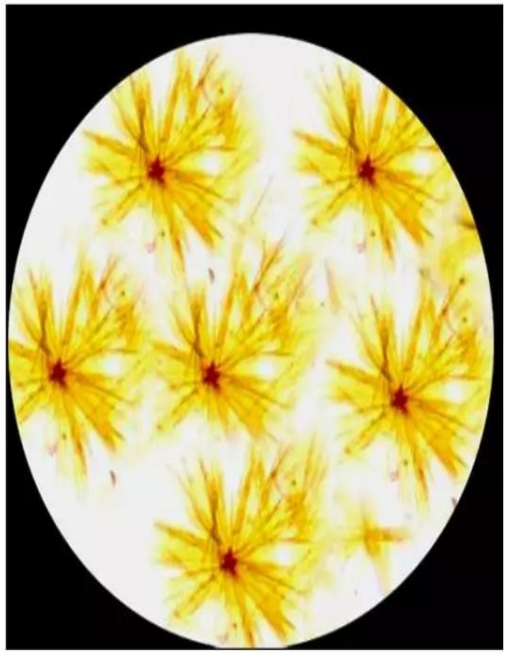
- All reducing sugars will form osazones with excess of phenylhydrazine when kept at boiling temperature.
- Osazones are insoluble.
- Each sugar will have characteristic crystal form of osazones.
- The differences in glucose, fructose and mannose are dependent on the **first and second carbon atoms**, and when the osazone is formed these differences are masked.
- Osazones may be used to differentiate sugars in biological fluids like urine.





NEEDLE SHAPE / BROOM LIKE

GLUCOSE / FRUCTOSE / MANNOSE



SUNFLOWER SHAPE/HEDGE HOG SHAPE

MALTOSE



COTTON BALL / POWDER PUFF SHAPE

LACTOSE

Biologically Important Hexose Derivatives

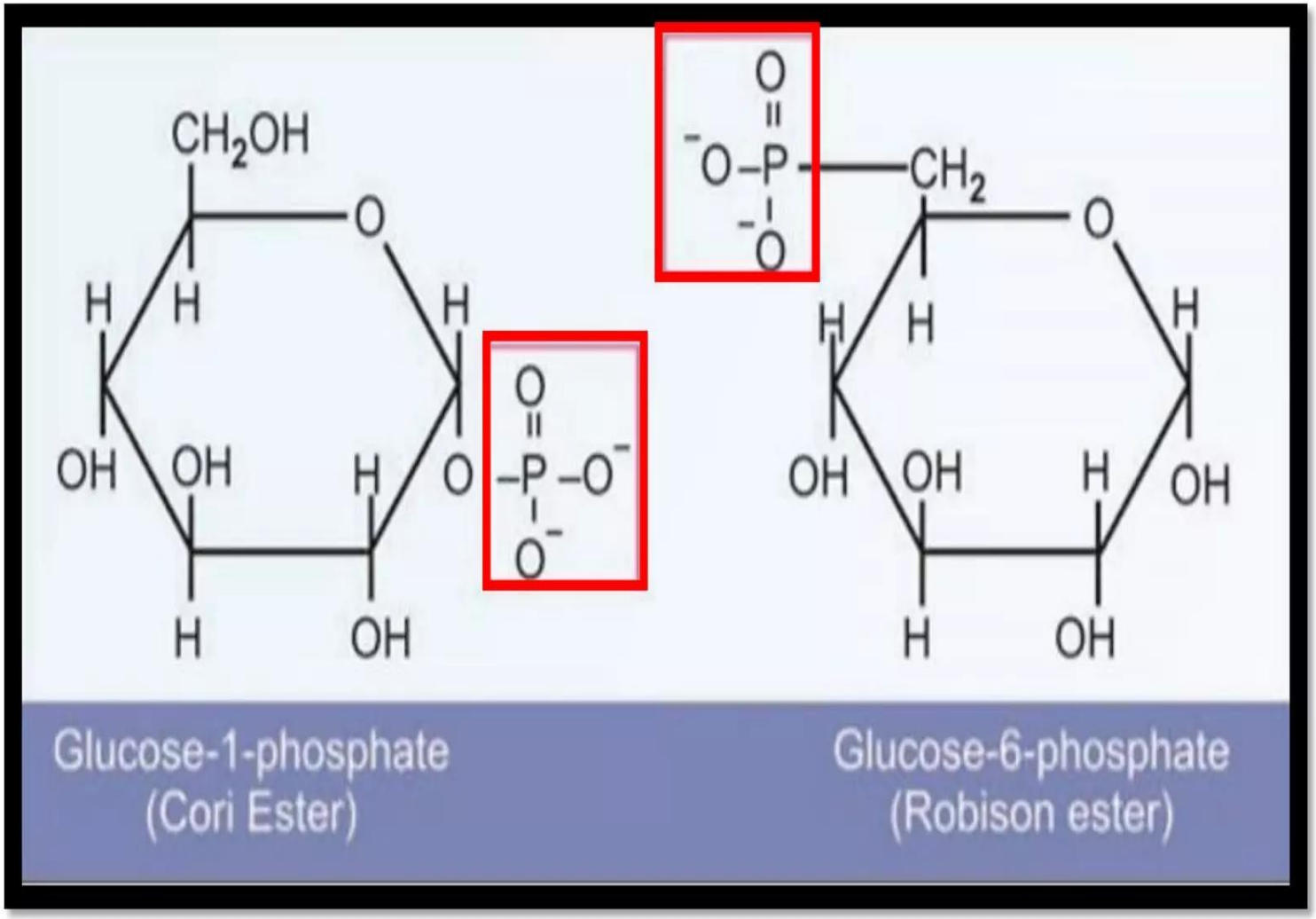
- Phosphorylated derivatives
- Amino Sugars
- Deoxy Sugars
- Sugar Acids
- Sugar Alcohols

6. PHOSPHATE DERIVATIVE OF MONOSACCHARIDE

The alcohol group of sugars may react with acids to form esters.

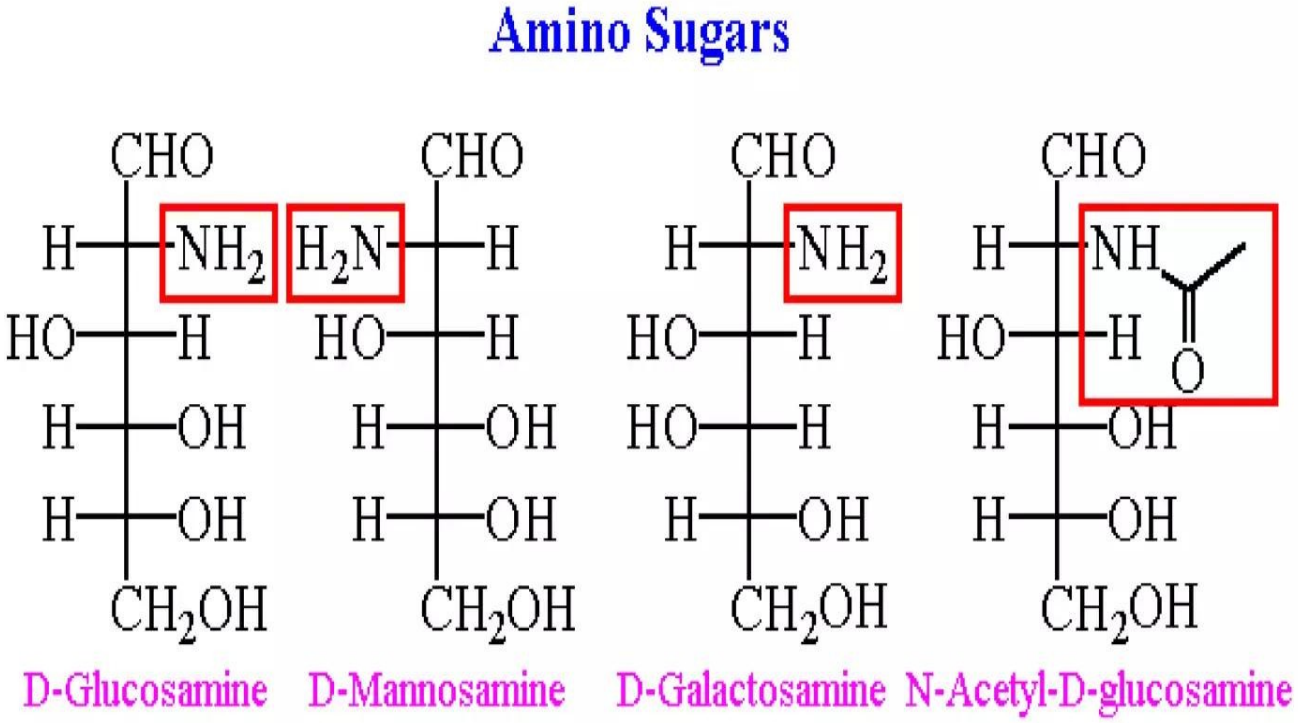
Phosphoric acid esters of sugars are important as intermediate products during metabolism.

Examples: Glucose-1-phosphate, Glucose-6-phosphate, fructose-6-phosphate


Glucose-1-phosphate
(Cori Ester)
Glucose-6-phosphate
(Robison ester)

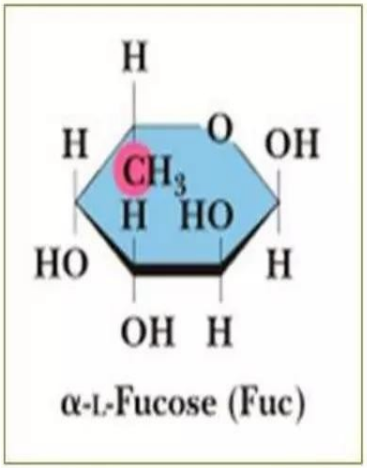
7. AMINO SUGARS

Sugars containing –NH2 group are called amino sugars.

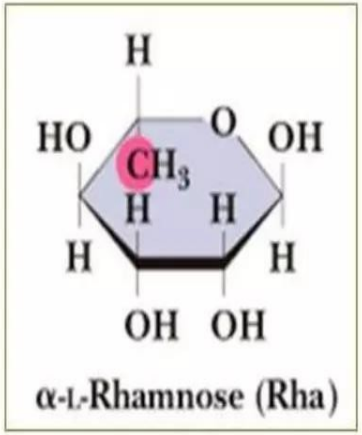


8. DEOXY SUGARS

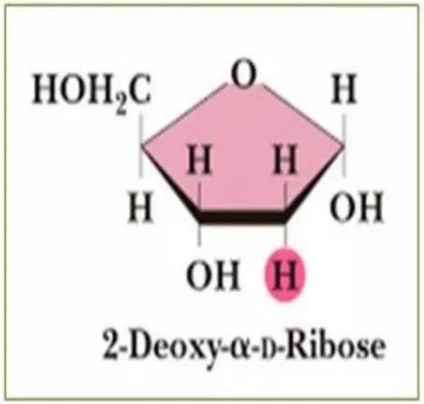
- The sugars in which oxygen of a –OH group has been removed are called deoxy sugars.



α-L-Fucose (Fuc)



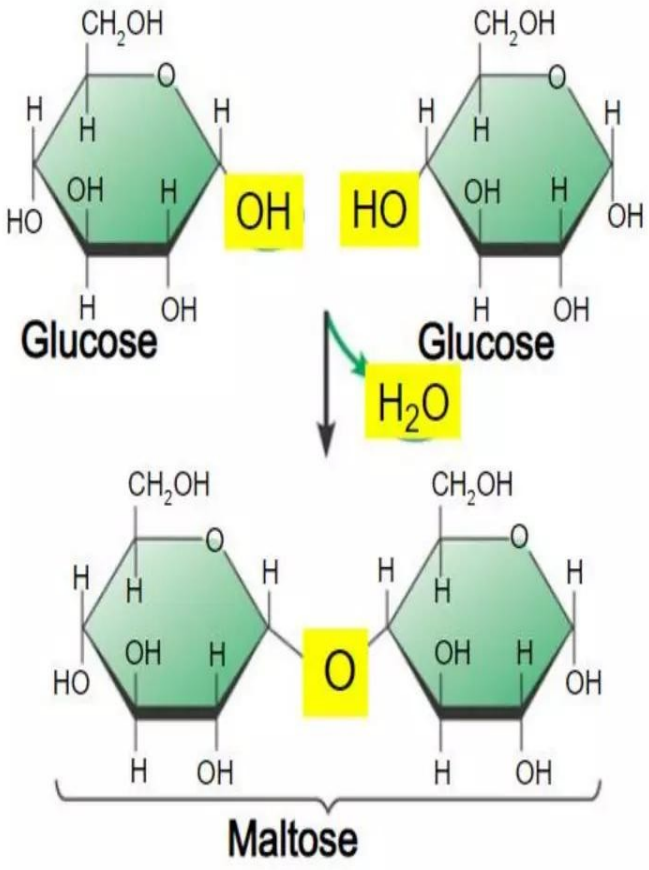
α-L-Rhamnose (Rha)



2-Deoxy-α-D-Ribose

(they are part of glycoproteins and glycolipids)

Figure 3.5 **Disaccharide formation**



Diasaccharides

Diasaccharides

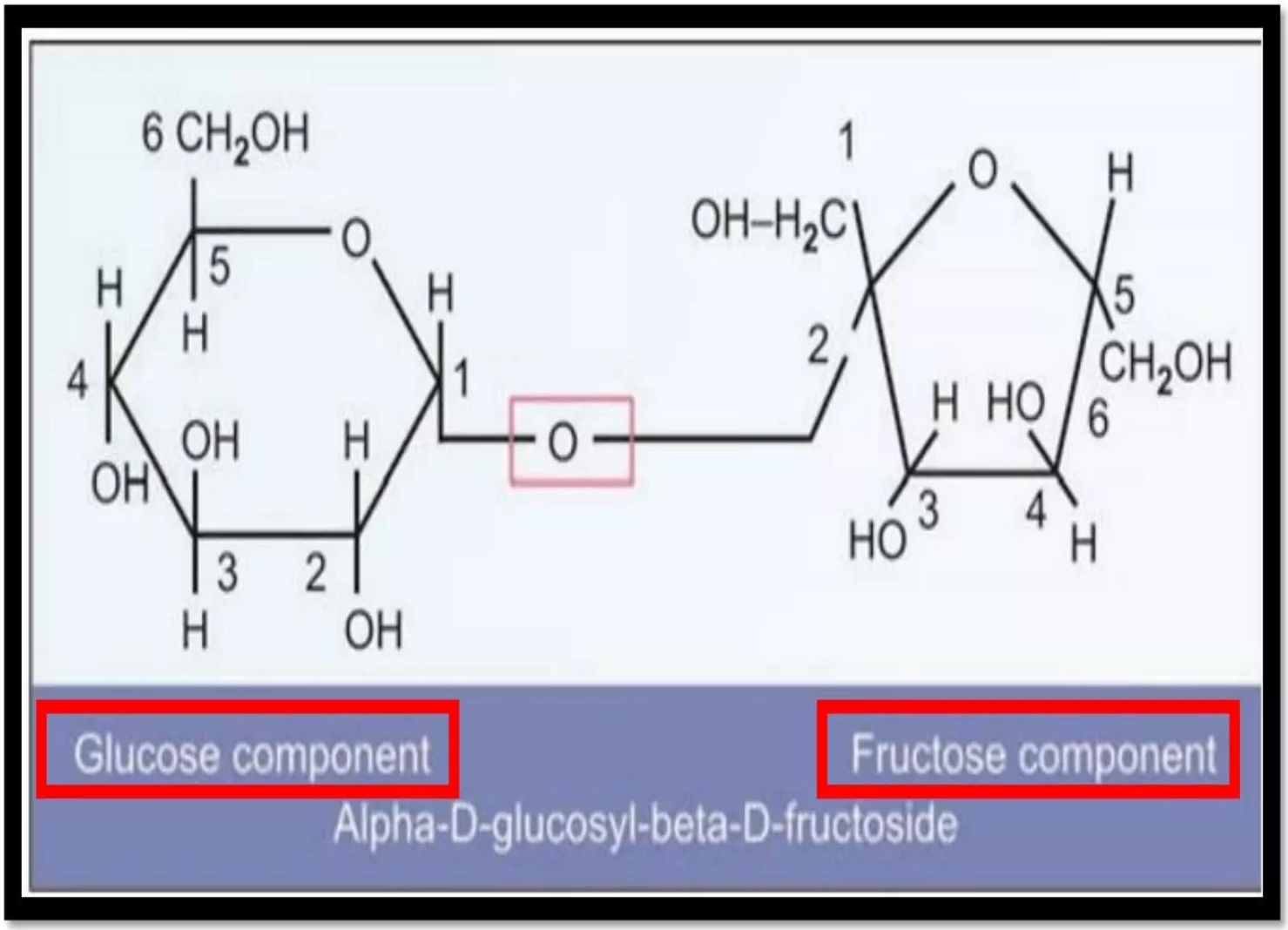
When two monosaccharides are combined together by glycoside linkage, a disaccharide is formed.

Biologically important disaccharides are

1. Sucrose
2. Maltose
3. Lactose.

Sucrose

- It is the sweetening agent known as cane sugar.
- It is present in sugarcane and various fruits.
- Sucrose contains glucose and fructose.
- Sucrose is not a reducing sugar; and it will not form osazone. This is because the linkage involves first carbon of glucose and second carbon of fructose, and free reducing groups are not available.



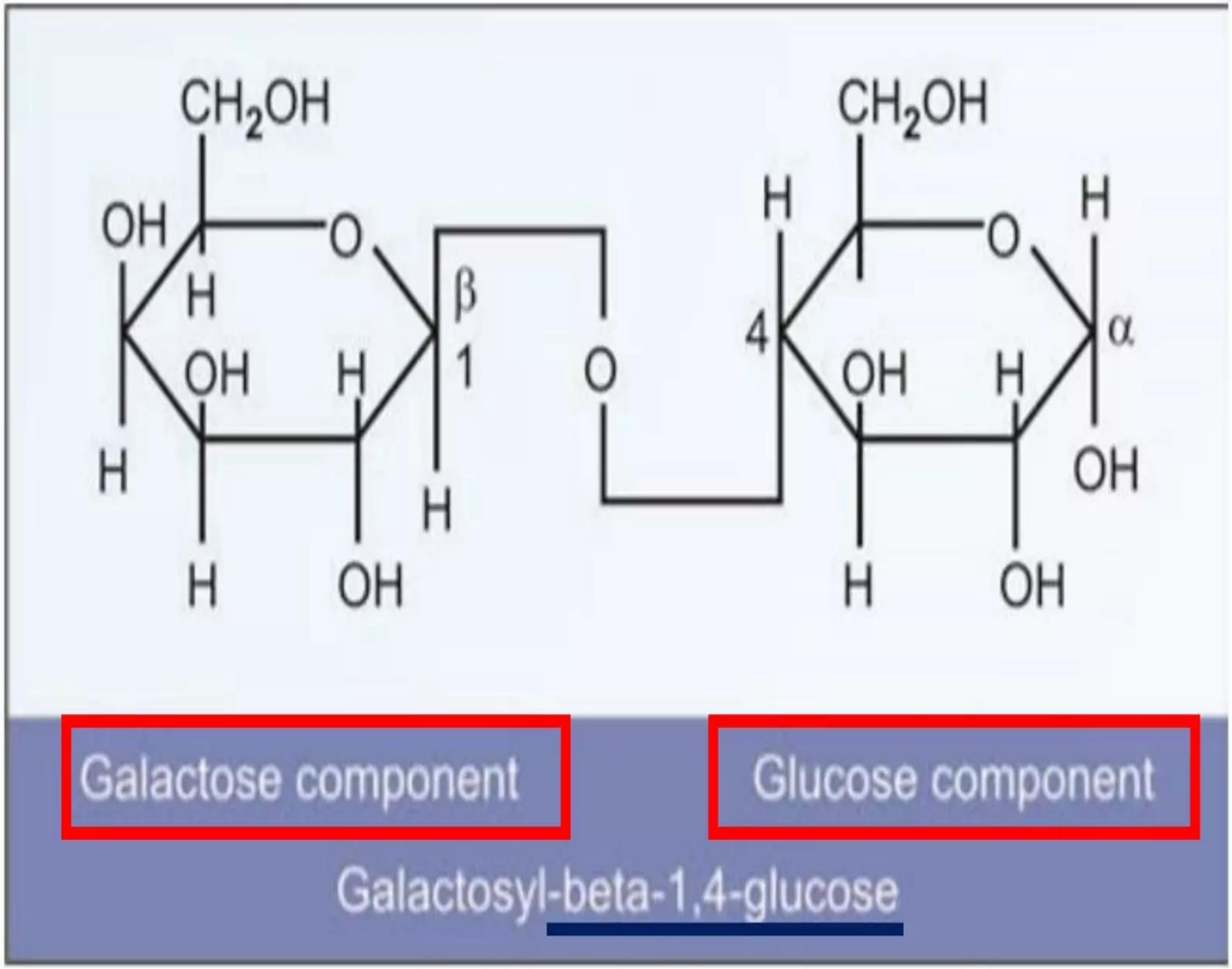
C1 of glucose and C2 of Fructose attached by glycosidic bond

- When sucrose is hydrolysed, the products have reducing action. A sugar solution which is originally nonreducing, but becomes reducing after hydrolysis, is identified as sucrose (specific sucrose test).
- Hydrolysis of sucrose (optical rotation +66.5°) will produce one molecule of glucose (+52.5°) and one molecule of fructose (–92°). Therefore the products will change the dextrorotation to levorotation, or the plane of rotation is inverted. Equimolecular mixture of glucose and fructose thus formed is called "invert sugar".

- The enzyme producing hydrolysis of sucrose is called sucrase or invertase.
- Invert sugar is sweeter than sucrose.

Lactose

- It is the sugar present in milk. Also called **MILK Sugar.**
- It is a **reducing** disaccharide.
- On hydrolysis lactose yields glucose and galactose. Beta glycosidic linkage is present in lactose.
- The anomeric carbon atom of beta-galactose is attached to the 4th hydroxyl group of glucose through beta-1,4 glycosidic linkage.


CH2OH
OH
O
H
β
1
OH
H
H
H
H
OH
O
CH2OH
H
H
4
O
α
OH
H
OH
H
OH
Galactose component
Glucose component
Galactosyl-beta-1,4-glucose

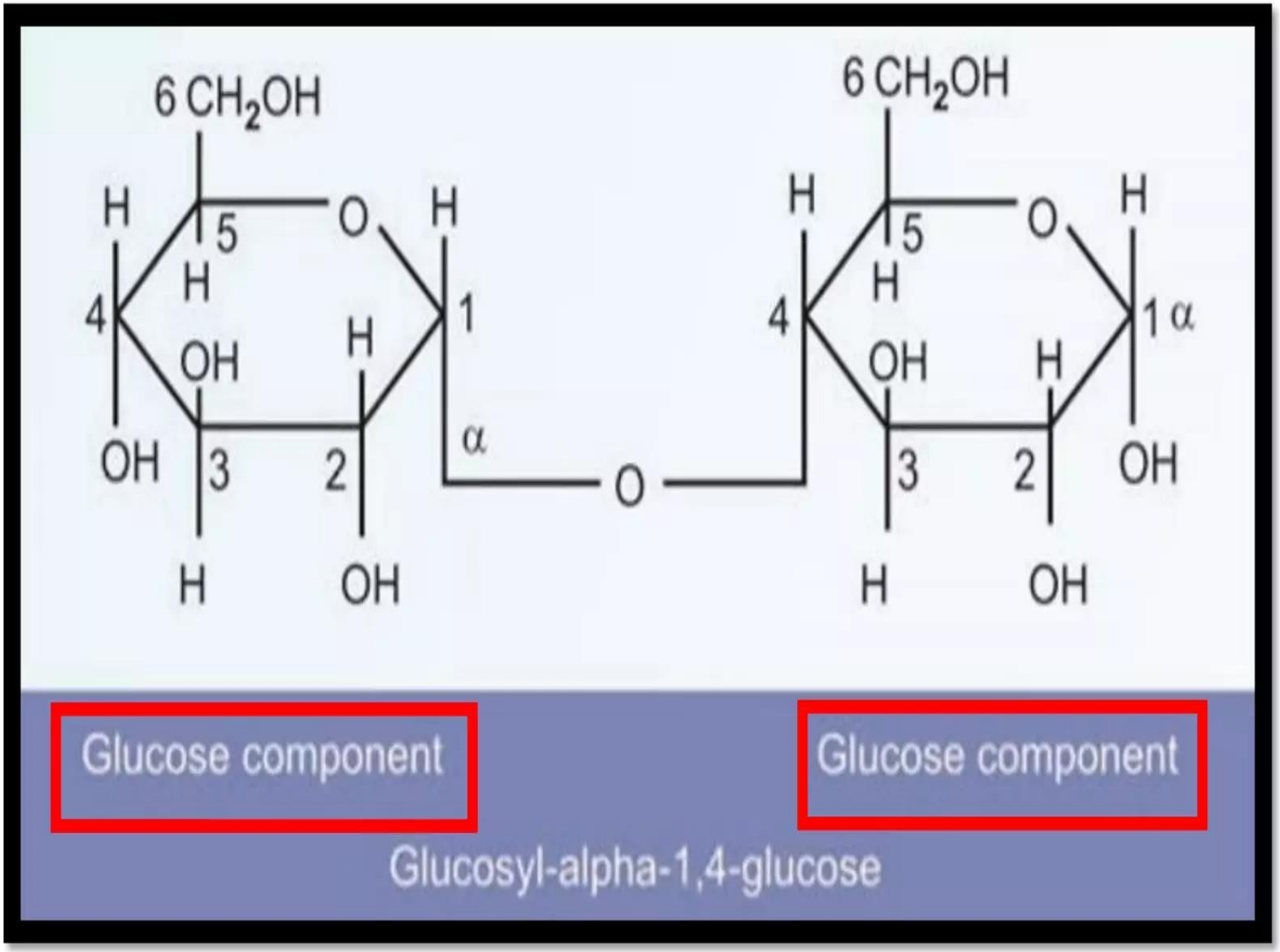
- Lactose forms osazone which resembles "hedgehog" or powder puff shaped.



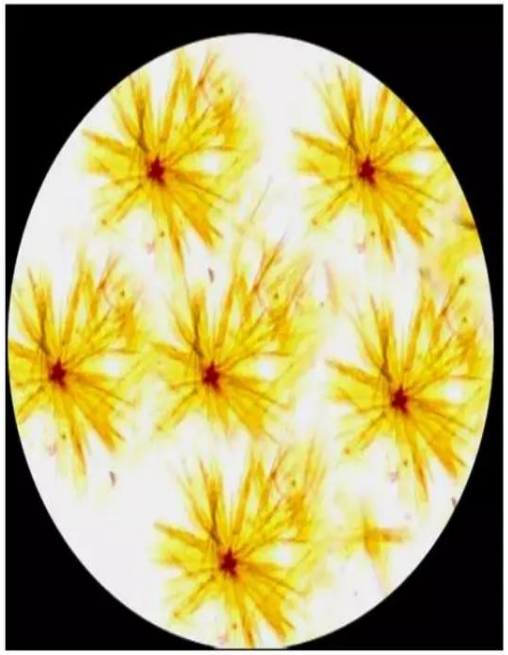
- Lactose present in milk, can be hydrolysed to glucose and galactose by the enzyme lactase present in intestinal juice.

Maltose

- It is a reducing disaccharide.
- It contains two glucose residues.
- There is alpha-1,4 linkage, i.e. the anomeric 1st carbon atom of one glucose is combined with 4th hydroxyl group of another glucose through alpha-glycosidic linkage.


6 CH2OH
H
5
O
H
4
H
1
OH
H
α
OH
3
2
O
H
OH
6 CH2OH
H
5
O
H
4
H
1 α
OH
H
OH
3
2
OH
H
OH
Glucose component
Glucose component
Glucosyl-alpha-1,4-glucose

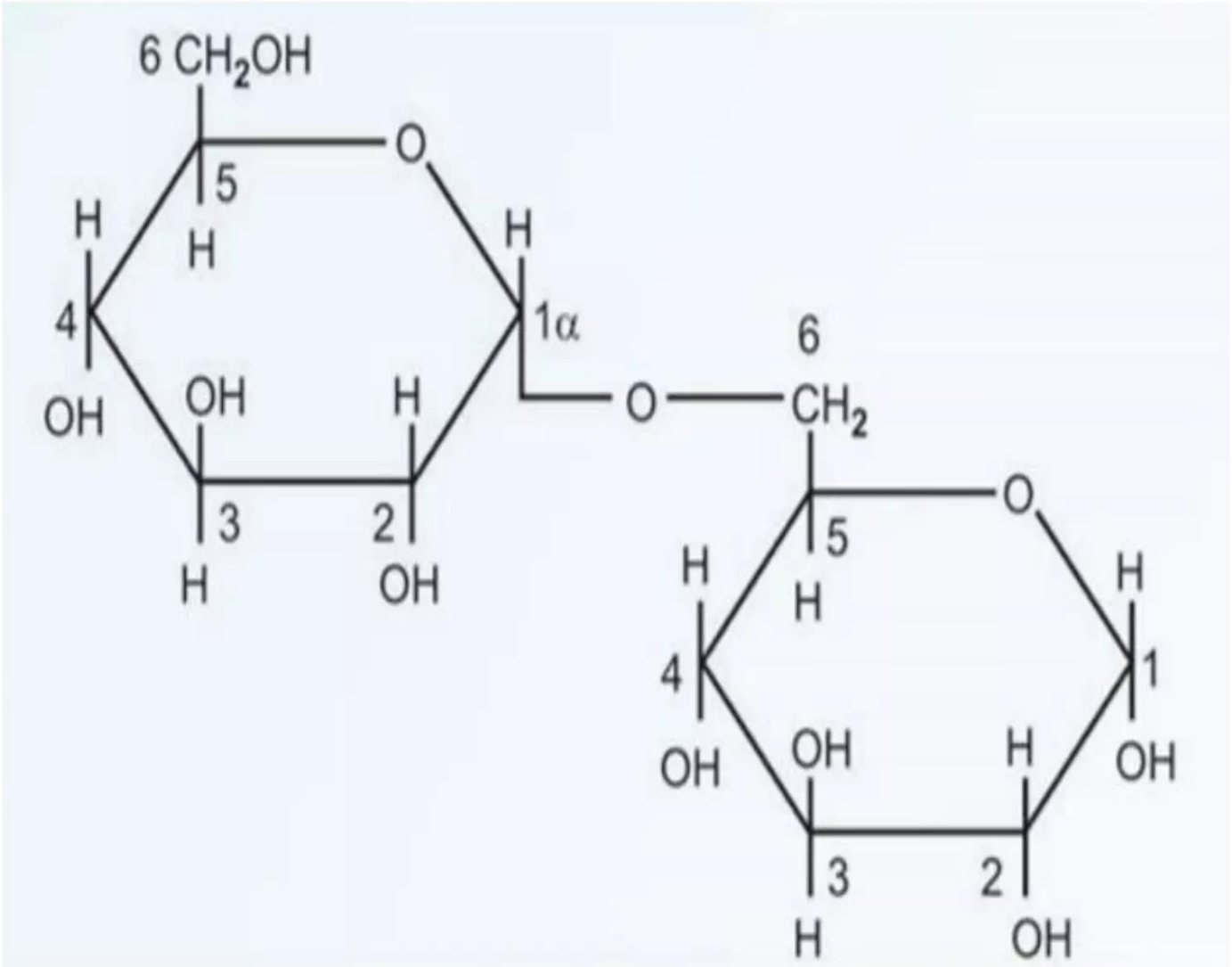
- **It forms petal shaped or sunflower shaped crystals of maltose-osazone.**



- It is formed by acid hydrolysis or enzymatic hydrolysis on starch.

Isomaltose

- It is also a reducing sugar.
- It contains 2 glucose units combined in **alpha -1, 6 linkage**.
- Thus first carbon of one glucose residue is attached to the sixth carbon of another glucose through a glycosidic linkage.
- Partial hydrolysis of glycogen and starch produces isomaltose.
- The enzyme oligo1,6-glucosidase present in intestinal juice can hydrolyse isomaltose into glucose units.



Two glucose residues in alpha-1,6 linkage

Monosaccharides

Glucose	aldohexose
Galactose	4th epimer of glucose
Mannose	2nd epimer of glucose
Fructose	Ketohexose

Disaccharides

Glucose + Galactose = Lactose (reducing)

Glucose + Glucose = Maltose (reducing)

Glucose + Fructose = Sucrose (nonreducing)

POLYSACCHARIDES

POLYSACCHARIDES

- These are polymers of monosaccharides.
- They are not sweet in taste.
- Do not exhibit reducing properties of aldehyde or keto group.

- They may be

Homopolysaccharides: single kind of monosaccharides, e.g. starch, glycogen and cellulose.

Heteropolysaccharides: are composed of two or more different monosaccharides.

e.g. hyaluronic acid, chondroitin sulphate.

Homopolysaccharides

- Starch
- Dextrins
- Glycogen
- Cellulose
- Inulin
- Dextrans

Starch

- It is a polysaccharides of glucose.
- Occurs in cereals such as wheat, rice, corn and barley, in potatoes, legumes, seeds, nuts.
- Storage form (foods) in plants.



structure

Starch is composed of amylose and amylopectin.

a. Amylose:

It is soluble in hot water.

It occurs to the extent of 15-20 percent in starch molecules.

It is a polymer of 200-1000 α-D glucose molecules united with α-1,4 glycosidic linkage.

It forms an unbranched long chain.

It gives blue colour with iodine.

Its molecular weight 4,00,000 D or more.

b. Amylopectin

It is insoluble in hot water.

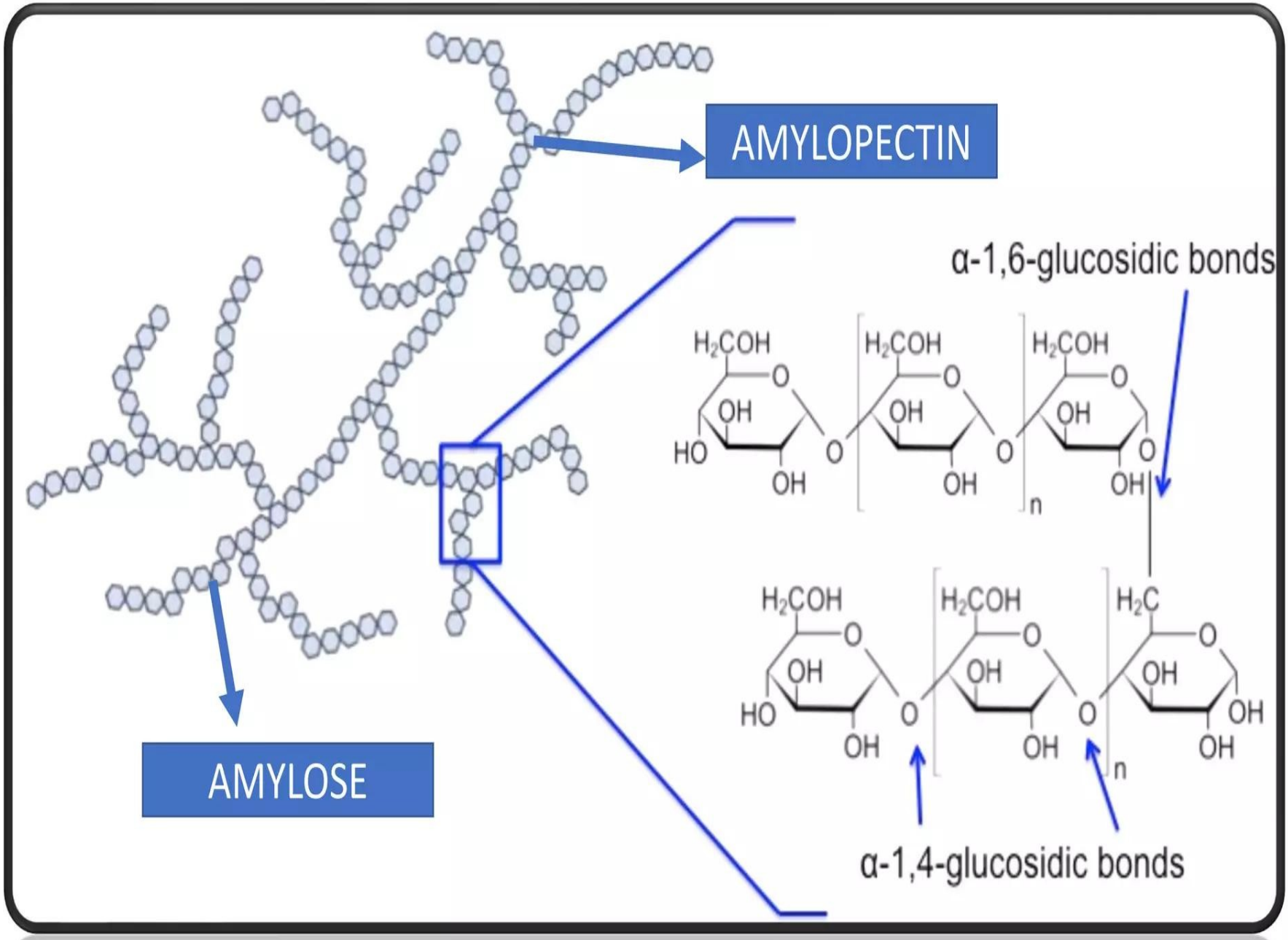
It occurs to the extent of 80-85 percent in starch molecules.

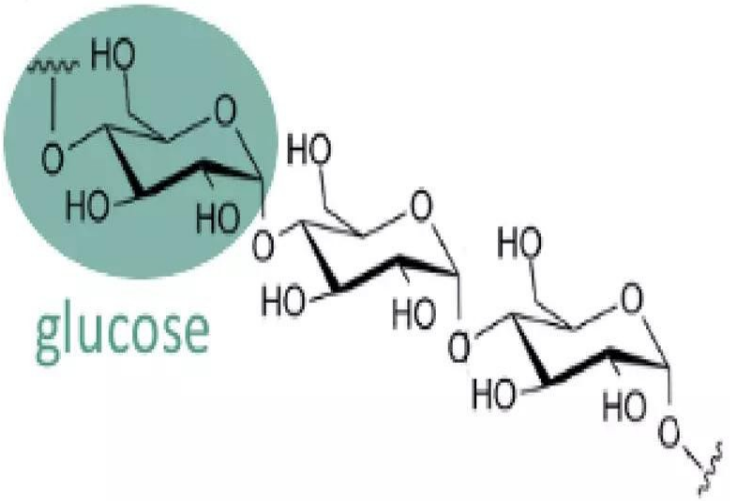
It is a polymer consist of hundreds of chains of α-D glucose molecules united with α-1,4 glycosidic linkage which are joined like the branches of a tree, by α-1,6 glycosidic linkage at branching point.

It forms an branched structure and similar to glycogen.

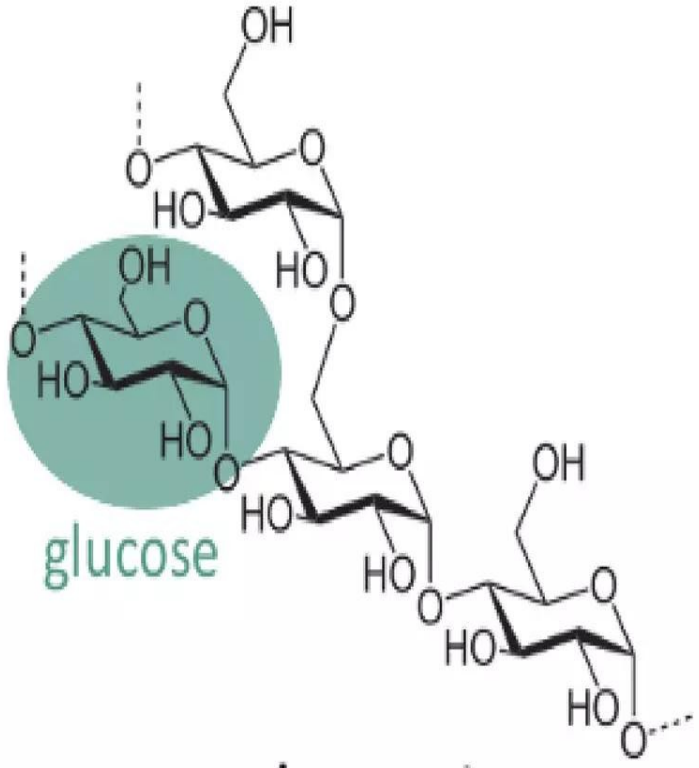
It gives violet colour with iodine.

It forms a gel in hot water.


AMYLOPECTIN
α-1,6-glucosidic bonds
AMYLOSE
α-1,4-glucosidic bonds



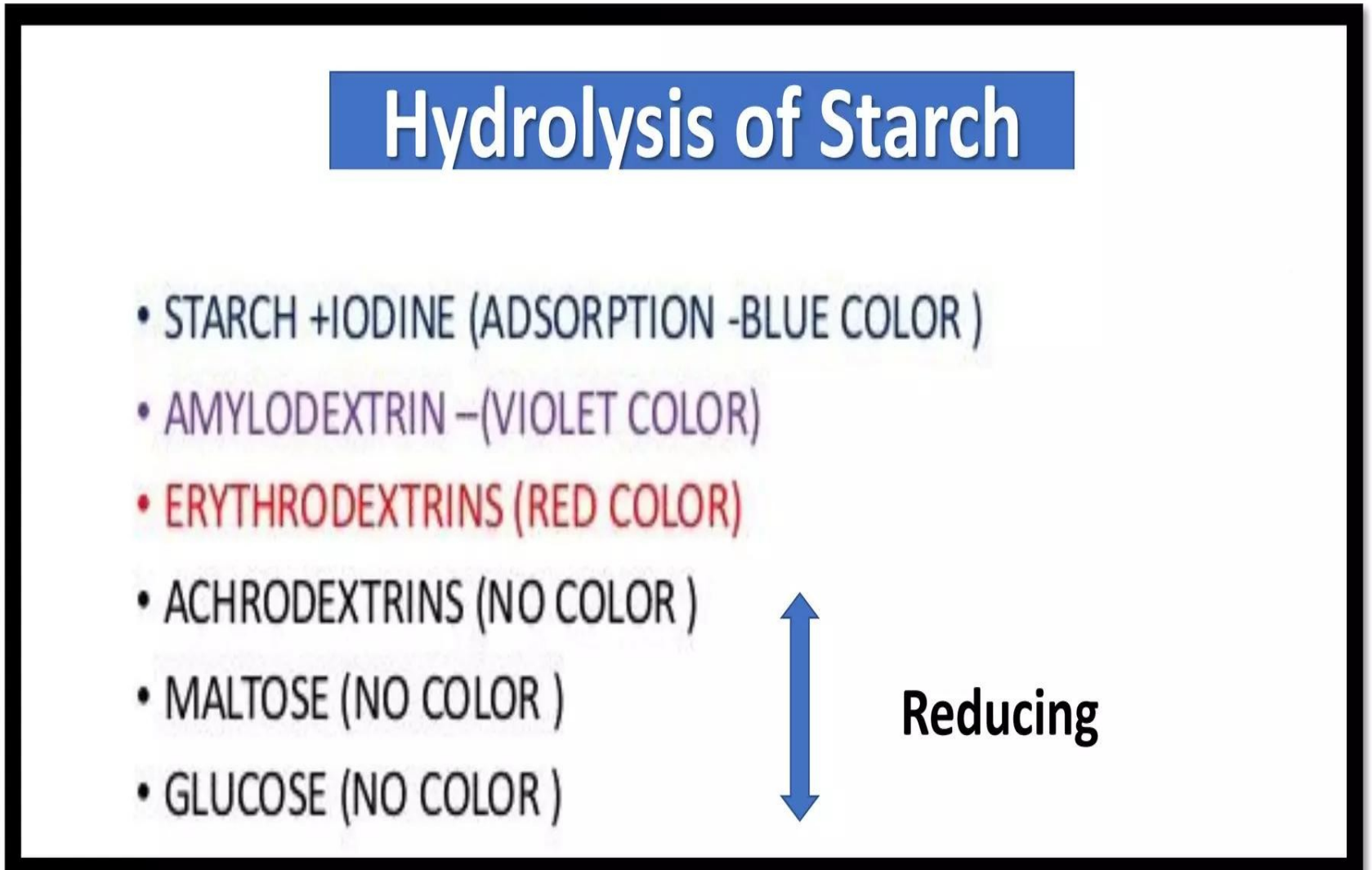
amylose



amylopectin

Dextrins

- The enzyme amylase from saliva or pancreatic juice can hydrolyze starch to smaller units called 'DEXTRIN'S' and finally to maltose.



Action of Amylases on Starch

Salivary and pancreatic amylases are **alpha-amylases**, which act at random on alpha-1,4 glycosidic bonds to split starch into smaller units (dextrins), and finally to alpha-maltose.

Beta-amylases are of plant origin. It acts to release, maltose units from the ends of the branches of amylopectin.The action stops at branching points, leaving a large molecule, called **limit dextrin or residual dextrin.**

Glycogen

It is the reserve carbohydrate in animals. So also called as animal starch.

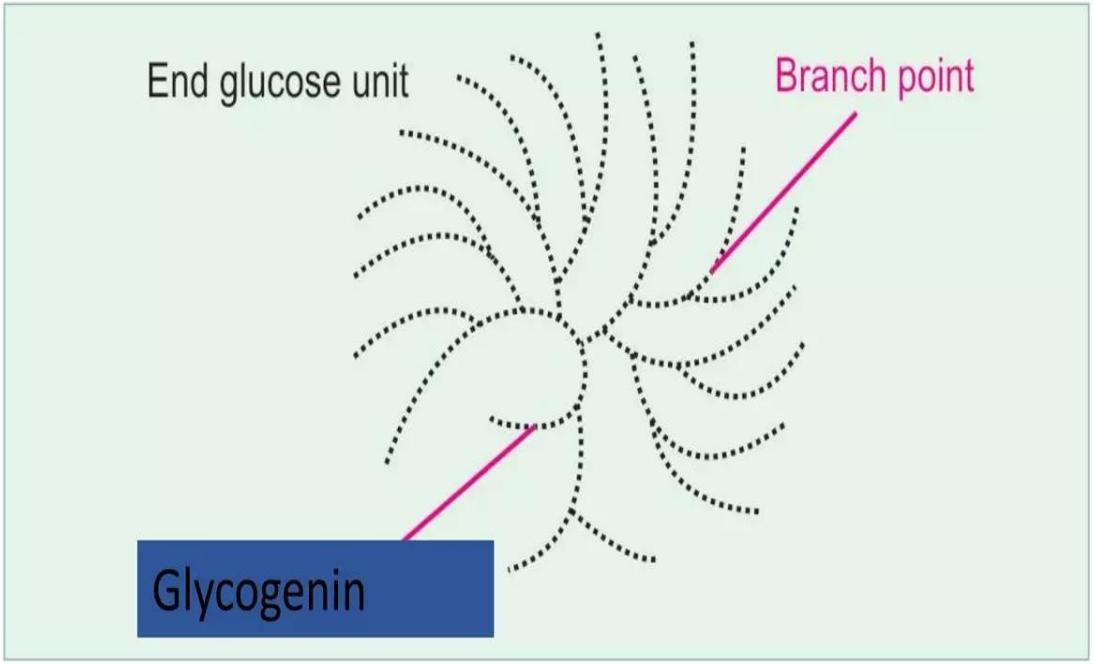
It is stored in liver and muscle.

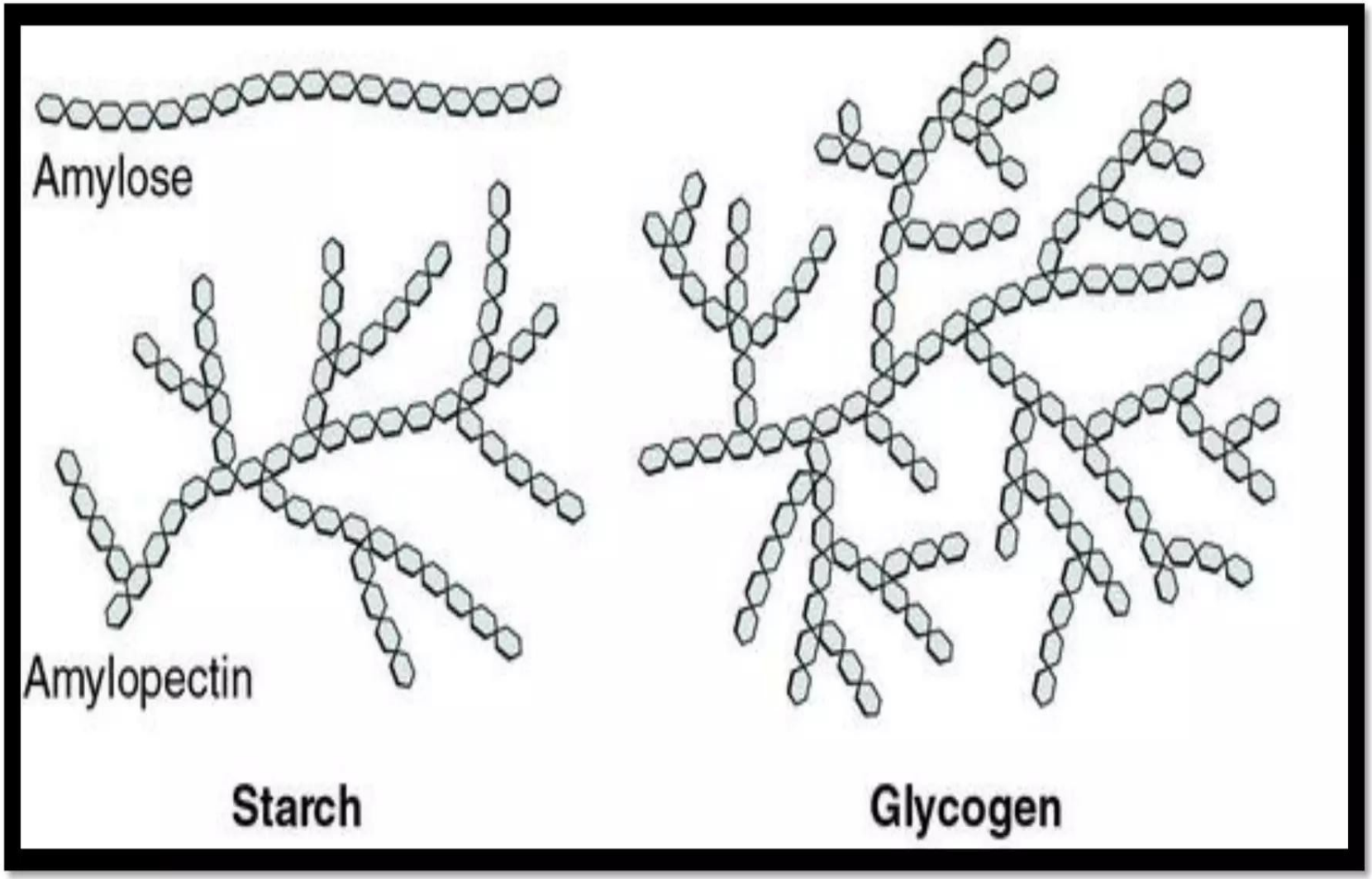
[About 5% of weight of liver is made up by glycogen]

Glycogen is composed of glucose units joined by α-1,4 linkage in the straight chains and branching occurs at α-1,6 glycosidic linkages, and resembles amylopectin.

Glycogen is more branched and more compact than amylopectin.

It gives reddish colour with iodine.


End glucose unit
Branch point
Glycogenin

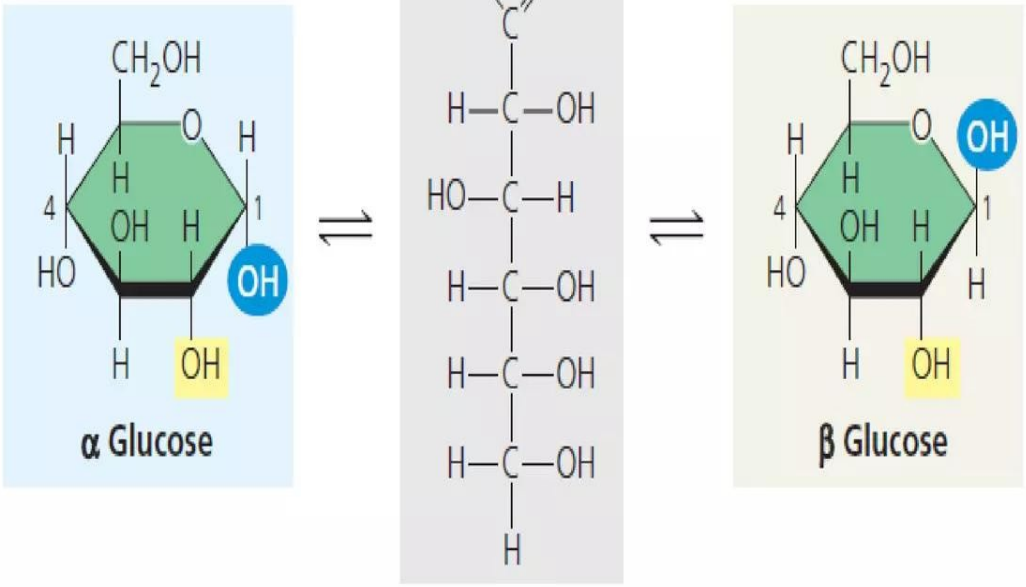

Amylose
Amylopectin
Starch
Glycogen

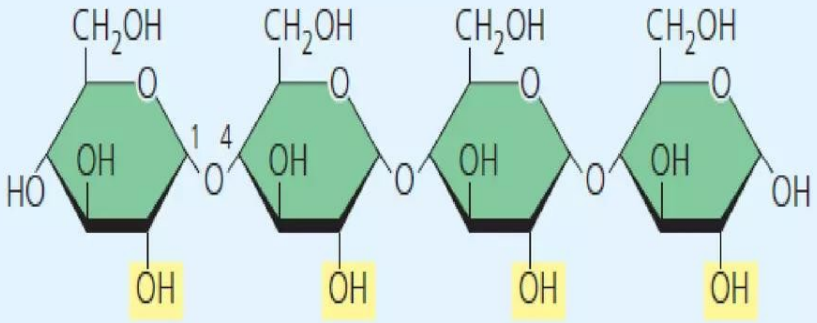
Cellulose

- It is the chief constituent of the woody fibrous portion of plants.
- Most abundant carbohydrates in nature.
- It is a polymer, made up of long chains of glucose molecules united with β-1,4 linkages.
- It has a straight line structure, with no branching points.
- The enzyme 'Cellobiase' can hydrolysed cellulose. But these is absent in humans. Hence cellulose cannot be digested by man, but serves the function of increasing "bulk" in the diet (roughage).

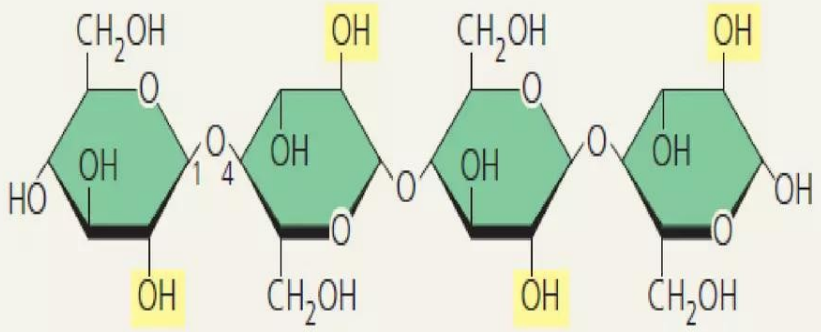
- Herbivorous animals have large caecum, which harbor bacteria. These bacteria can hydrolyse cellulose, and the glucose produced is utilised by the animal.
- Example: Termites (can digest cellulose)

(a) **α and β glucose ring structures.** These two interconvertible forms of glucose differ in the placement of the hydroxyl group (highlighted in blue) attached to the number 1 carbon.





(b) **Starch: 1–4 linkage of α glucose monomers.** All monomers are in the same orientation. Compare the positions of the —OH groups highlighted in yellow with those in cellulose (c).



(c) **Cellulose: 1–4 linkage of β glucose monomers.** In cellulose, every β glucose monomer is upside down with respect to its neighbors. (See the highlighted —OH groups.)

Starch and cellulose structures.

Inulin

- It is a long chain homoglycan composed of D-fructose units with repeating beta-1,2 linkages.
- It is the reserve carbohydrate present in various bulbs and tubers such as chicory, dahlia, onion, garlic.
- It is clinically used to find renal clearance value and glomerular filtration rate.

Dextrans

- These are highly branched homopolymers of glucose units with 1-6, 1-4 and 1-3 linkages.
- They are produced by microorganisms.
- They have molecular weight 1 million to 4 millions. Since they will not easily go out of vascular compartment, they are used for intravenous infusion as plasma volume expander for treatment of hypovolemic shock.

Difference

- **D-glucose** is otherwise called **Dextrose**, a term often used in bed-side medicine, e.g. dextrose drip.
- **Dextrin** is the partially digested product of starch.
- **Dextran** is high molecular weight carbohydrate, synthesized by bacteria.

Chitin

- It is present in exoskeletons of crustacea and insects.
- It is composed of units of N-acetyl-glucosamine with beta-1,4 glycosidic linkages.

Heteropolysaccharides/ Heteroglycans

These are polysaccharides containing more than one type of sugar residues.

Agar and Agarose

- **Agar:**

It is prepared from sea weeds.

It contains galactose, glucose and other sugars.

It is dissolved in water at 100°C, which upon cooling sets into a gel.

Agar cannot be digested by bacteria and hence used widely as a supporting agent to culture bacterial colonies.

Agar is used as a supporting medium for immuno-diffusion and immuno-electrophoresis.

- **Agarose:**

It is made up of galactose combined with 3,6-anhydrogalactose units; it is used as matrix for electrophoresis.

Mucopolysaccharides or glycosaminoglycans (GAG)

- Composed of acetylated glycosamine (amino sugar) and uronic acid units; some are made up of amino sugar and monosaccharide units without the presence of uronic acid.
- Mucopolysaccharides in combination with proteins form mucoproteins or glycoproteins or proteoglycans.

- Acetylated amino groups, sulfate and carboxyl groups are also generally present.

Because of the presence of these charged groups, they attract water molecules and so they produce viscous solutions

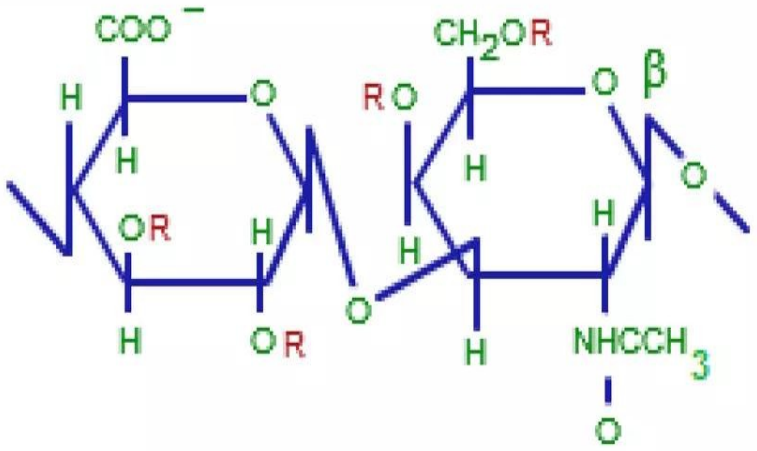
Examples of mucopolysaccharides

- Hyaluronic acid
- Heparin
- Chondroitin sulfate
- Dermatan sulfate
- Keratan sulfate

Mucopolysaccharides	Repeating units	Present in tissues
Hyaluronic acid	N-acetyl- glucosamine and D-glucuronic acid	Skin, connective tissues, synovial fluid and cartilage – • Acts as ground substances , lubricant, and shock absorbent.
Chondroitin Sulphate	N-acetyl galactosamine sulfate and D-glucuronic acid	Cartilage, bone, cornea, arterial wall etc.

Dermatan sulfate	N-acetyl galactosamine in beta, 1,3 linkage and L-iodouronic acid	Skin, aorta, cardiac valves, and loose connective tissues.
Keratan Sulfate	N-acetyl glycosamine and D-galactose (only GAG does not contains any uronic acid.)	Cornea,tendons, intervertebral discs.

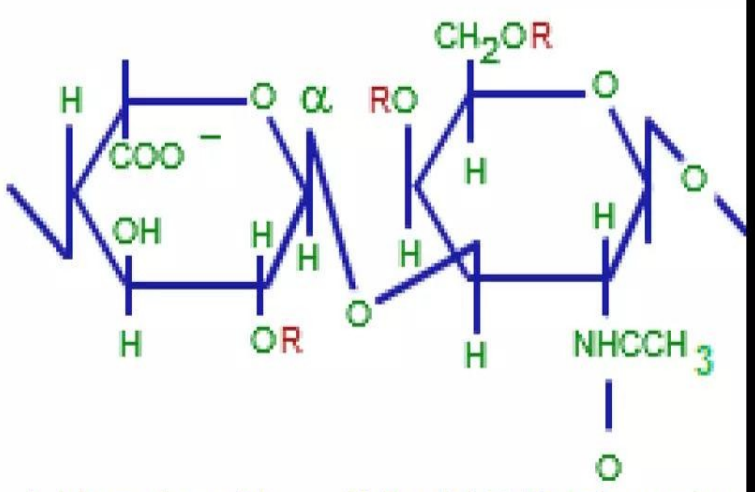
Heparin	D-glucosamine and either of the two uronic acid- D-glucuronic acid or L- iodouronic acid	Liver, skin, and intestinal mucosa. • Acts as anticoagulant. • used *in vivo to* prevent intravascular coagulation. • It activate antithrombin III, which in turn inactivates thrombin, so blood is not clotted.



D - Glucuronic acid (GlcA)

N-Acetyl-D-Galatosamine (GalNac)

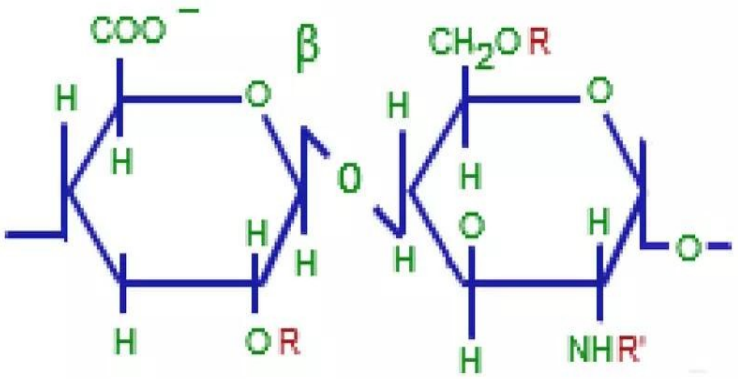
Chonodroitin Sulfate



L-Iduronic acid (IdoA)

N-Acetyl-D-Galatosamine (GalNAc)

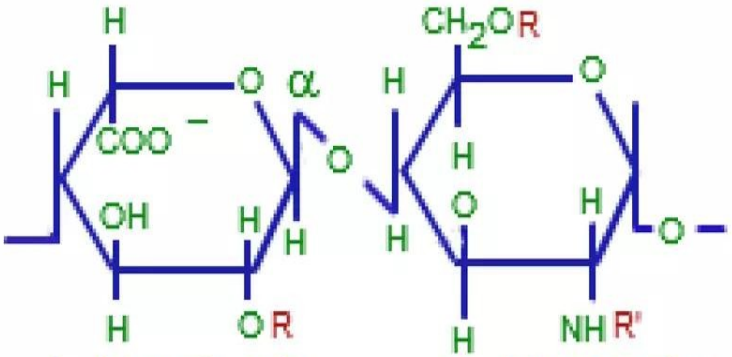
Dermatan Sulfate



D - Glucuronic acid (GlcA)

D - Glucosamine ($GlcNH_2$)

Heparan Sulfate



L - Iduronic acid (IdoA)

D - Glucosamine ($GlcNH_2$)

Heparin

Repeating Units in Polysaccharides

Polysaccharide	Repeating units
Homoglycans	
Inulin	D-fructose, beta-1,2 linkages
Dextran	Glucose, 1-6, 1-4, 1-3 linkages
Chitin	N-acetyl glucosamine; beta 1-4 links
Heteroglycans	
Agar	Galactose, glucose
Agarose	Galactose, anhydrogalactose
Hyaluronic acid	N-acetyl glucosamine, glucuronic acid
Heparin	Sulphated glucosamine, L-iduronic acid
Chondroitin S	Glucuronic acid, Nacetyl galactos-amine
Keratan S	Galactose, N-acetyl glucosamine
Dermatan S	L-iduronic acid, N-acetyl galactos-amine

Glycoproteins & Mucoproteins

- When the carbohydrate chains are attached to a polypeptide chain it is called a **proteoglycan**.

[If the carbohydrate content is less than 10%, it is generally named as a glycoprotein.]

[If the carbohydrate content is more than 10% it is a mucoprotein.]

They are seen in almost all tissues and cell membranes. About 5% of the weight of the cell membrane is carbohydrates; the carbohydrate groups cover the entire surface of the cell membrane, they are called glycocalyx.

Glycophorin is the major membrane glycoprotein of erythrocytes.

It is a transmembrane (spans the whole thickness of the membrane) protein. Carbohydrate chains are attached to the amino terminal portion, outside the cell surface.

The oligosaccharide chains of glycoproteins are composed of varying numbers of the following carbohydrate residues:

The oligosaccharide chains:

Glucose (Glu);
mannose (Man);
galactose (Gal);
N-acetyl glucosamine (GluNAc);
N-acetyl galactosamine (GalNAc);
L-fucose (Fuc) and
N-acetyl neuraminic acid (NANA).

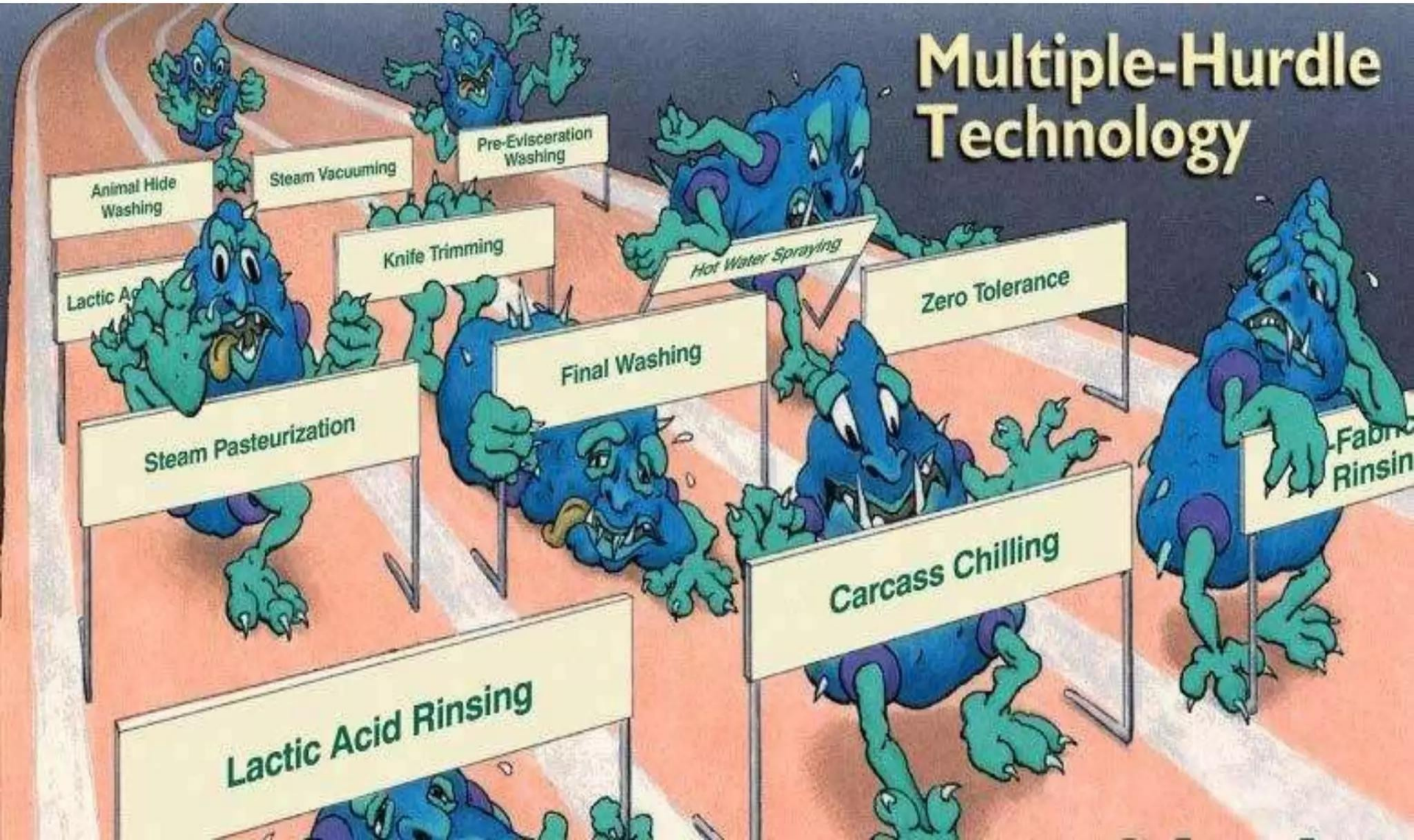
Dietary fiber

- Dietary fiber is contributed by the unavailable carbohydrates in the diet.
- They contribute the bulk and assist in normal bowel movements. Cellulose, semicellulose, pectin, alginates, and gums are the usual glycans which form dietary fiber.
- Cellulose is found in bran, flour, and tubers. Pectins are mixtures of homoglycans found in fruits. Gums and alginates are found in legumes and oatmeal.

Hurdle Technology

Department of Food Technology
Dr. R. Renu

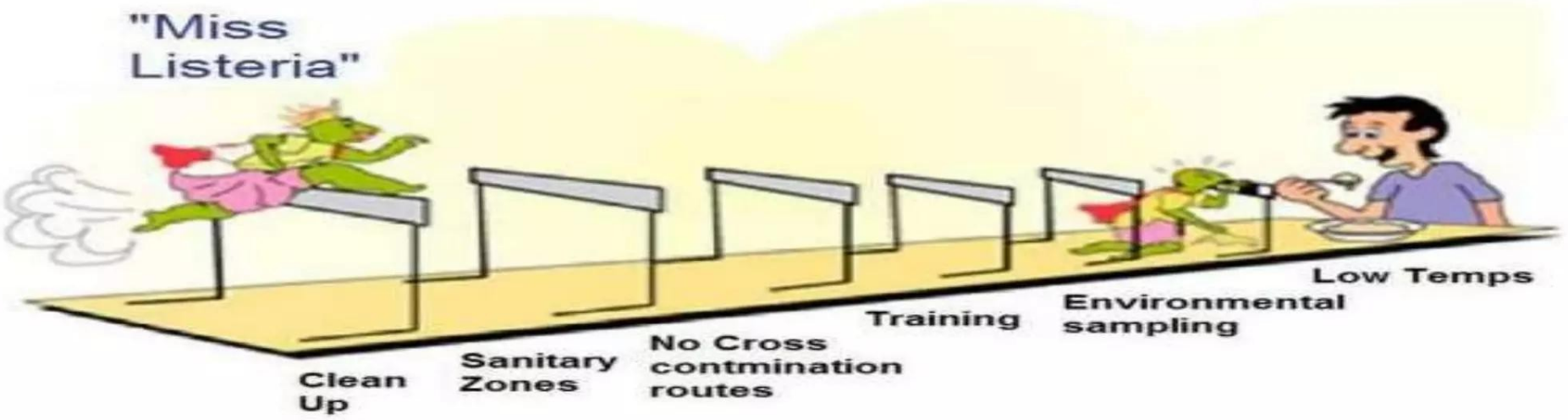
HURDLE TECHNOLOGY IN FOOD INDUSTRY





WHAT IS HURDLE TECHNOLOGY?

- Hurdle Technology is a technology where appropriate type of hurdles are selected and combine to provide microbial safety, stability, sensory, nutritional value and economic viability to products.
- The right combination of hurdles inactivates the pathogens and thereby makes a food products safe for consumption along with an extend shelf life.



HURDLE TECHNOLOGY

- Combination of more than one preservation techniques
- Pro-active and Preventative Tools
- Minimize risk, but not eliminate it
- Synergistic results achieved when hurdles used in combination

NEED OF HURDLE TECHNOLOGY

- Trend of eating out and consume Ready-to-Eat foods
- The need for minimally processed products
- The demand for fresh and natural food products
- Emergence of new routes for the growth of microorganisms

HURDLE EFFECT

- A significant synergistic effect between hurdles for Ex. Gram positive bacteria include some of the most important spoilage bacteria, such as Clostridium, Bacillus.

- A synergistic enhancement occurs if Nisin is used against these bacteria in combination with antioxidants, organic acids or other antimicrobials.

- Depending on the type of product, the type and intensity of the hurdles will vary case by case.

- The effects produced by the combination of hurdles is called **hurdle effect**.

PRINCIPLE

HOW IT WORKS?

1. Homeostasis

- ✓ An organism's ability to stabilize itself

2.Metabolic Exhaustion

- ✓ Organisms completely use up their energy to maintain homeostasis and die.

3. Stress Reactions

- ✓ Some bacteria become more resistant under release stress shock proteins

TYPES OF HURDLES USED IN FOOD PRESERVATION

Some of the most important hurdles used are-

1. High temperature [F]
2. Low temperature [T]
3. Reduce water activity [a_w]
4. Increased acidity [pH]
5. Reduced redox potential [Eh]
6. Preservatives [Pres.]
7. Competitive flora [c.f.]

CLASSIFICATION OF HURDLES

1) Physical hurdles

2) Physico-chemical hurdles

3) Microbially derived hurdles

Physical Hurdles

- High temperature
- Low temperature
- Ultra-high pressure
- Ultrasonication
- Ultraviolet radiation
- Ionizing radiation
- Aseptic packaging
- Packaging films
- Electromagnetic energy

Physicochemical Hurdles

- Carbon dioxide
- Ethanol lactic acid
- Lactoperoxidase
- Low pH
- Low redox potential
- Low water activity
- Organic acids
- Oxygen
- Ozone

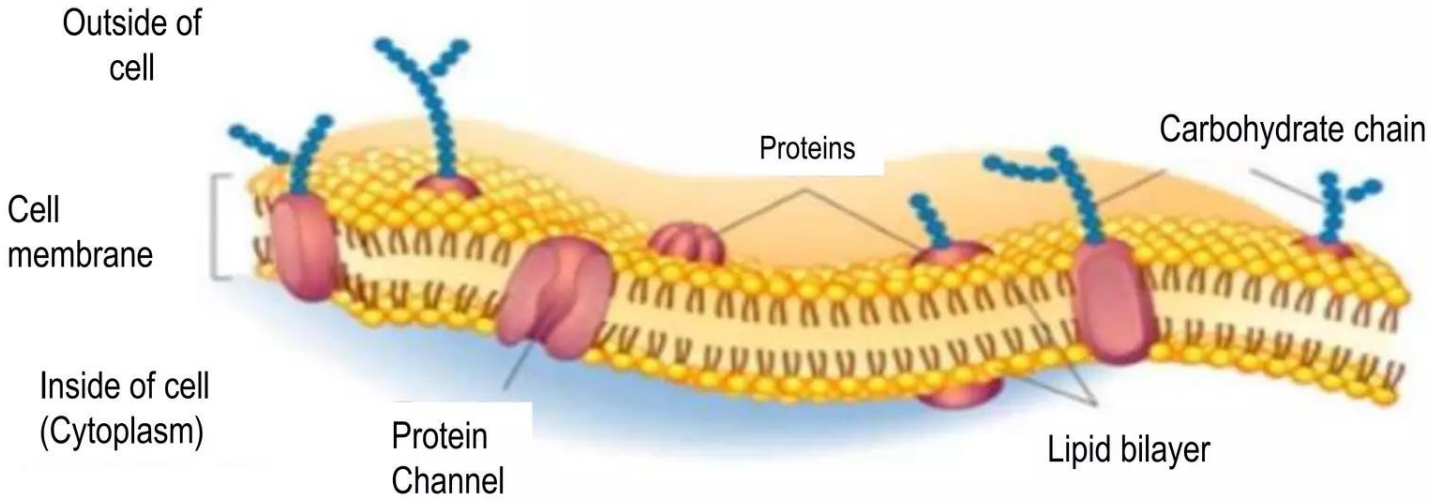
Microbial Hurdles

- Antibiotics
- Biopreservative - Bacteriocin
- Competitive flora

MULTI TARGET PRESERVATION

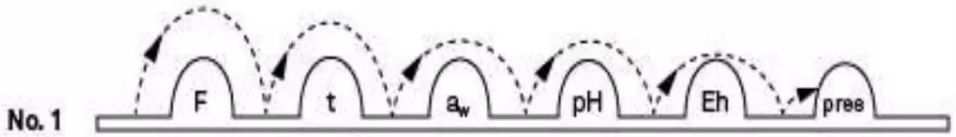
- If the types of hurdles in foods are in right combination, the homeostasis of the microorganisms could be disturbed resulting in a synergistic effect.

- Activation of stress shock proteins and repairing of the homeostasis is more difficult.

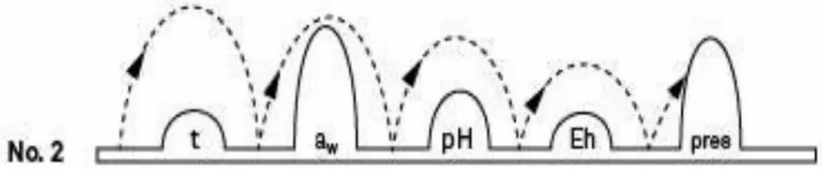


EXAMPLE OF MULTIPLE HURDLE TECHNOLOGY METHOD

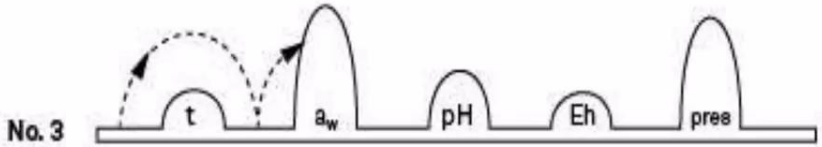
All hurdles
at the same intensity



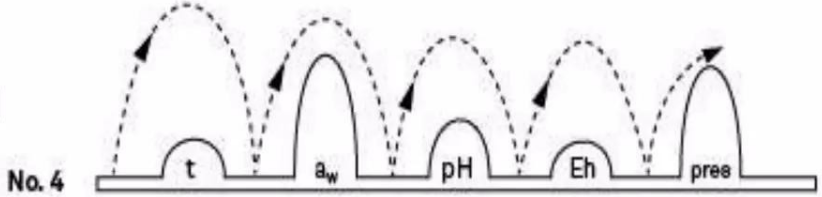
All hurdles
at different intensity



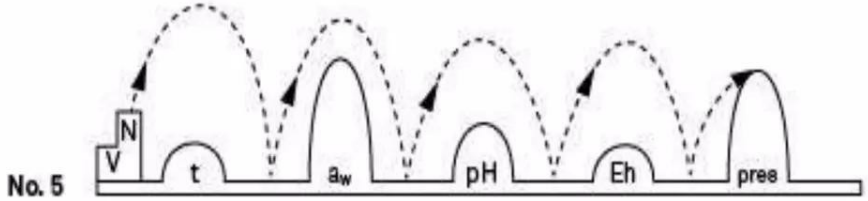
Low initial microbial load
good hygienic practice



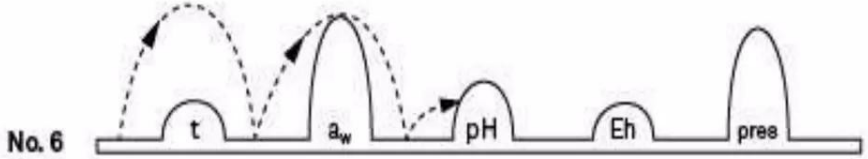
High initial microbial load



Low initial microbial load
more nutrients



Substerilizing treatment
damaged cells



SYMBOLS

F = Heating

t = Refrigeration

aw = Water activity

pH = Acidification

Eh = Redox potential

pres. = Preservatives

K-F = Competitive organisms

V = Vitamins

N = Nutrients

1

GOOD AGRICULTURAL PRACTICES

- GAP Field Audits
- External surface blanching if possible
- Sanitation of cutting equipment



2

FORMULATION HURDLES

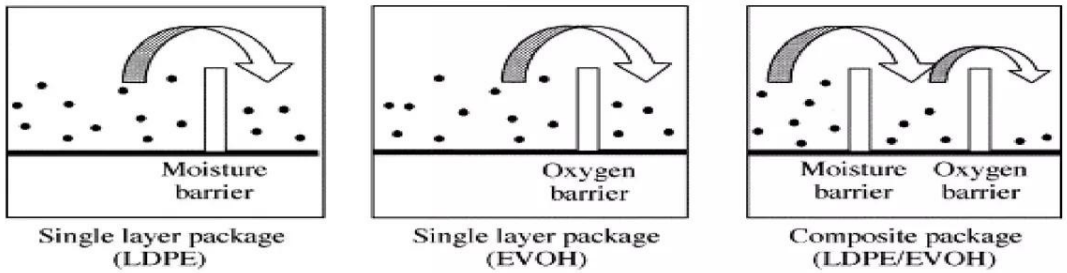
- Antimicrobial agents
- Acidulants
- Pre-treatment of components used in process
- Water activity control
- Antioxidants

3

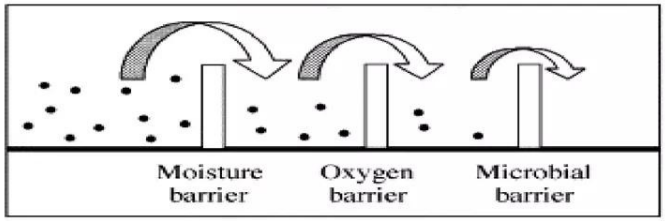
PACKAGING HURDLES

- Clean Room Environment
- Modified Atmosphere Packaging
- Barrier Packaging Materials
- Active Packaging System
- Intelligent Packaging System





(A) Conventional packaging system



(B) Antimicrobial packaging system



4

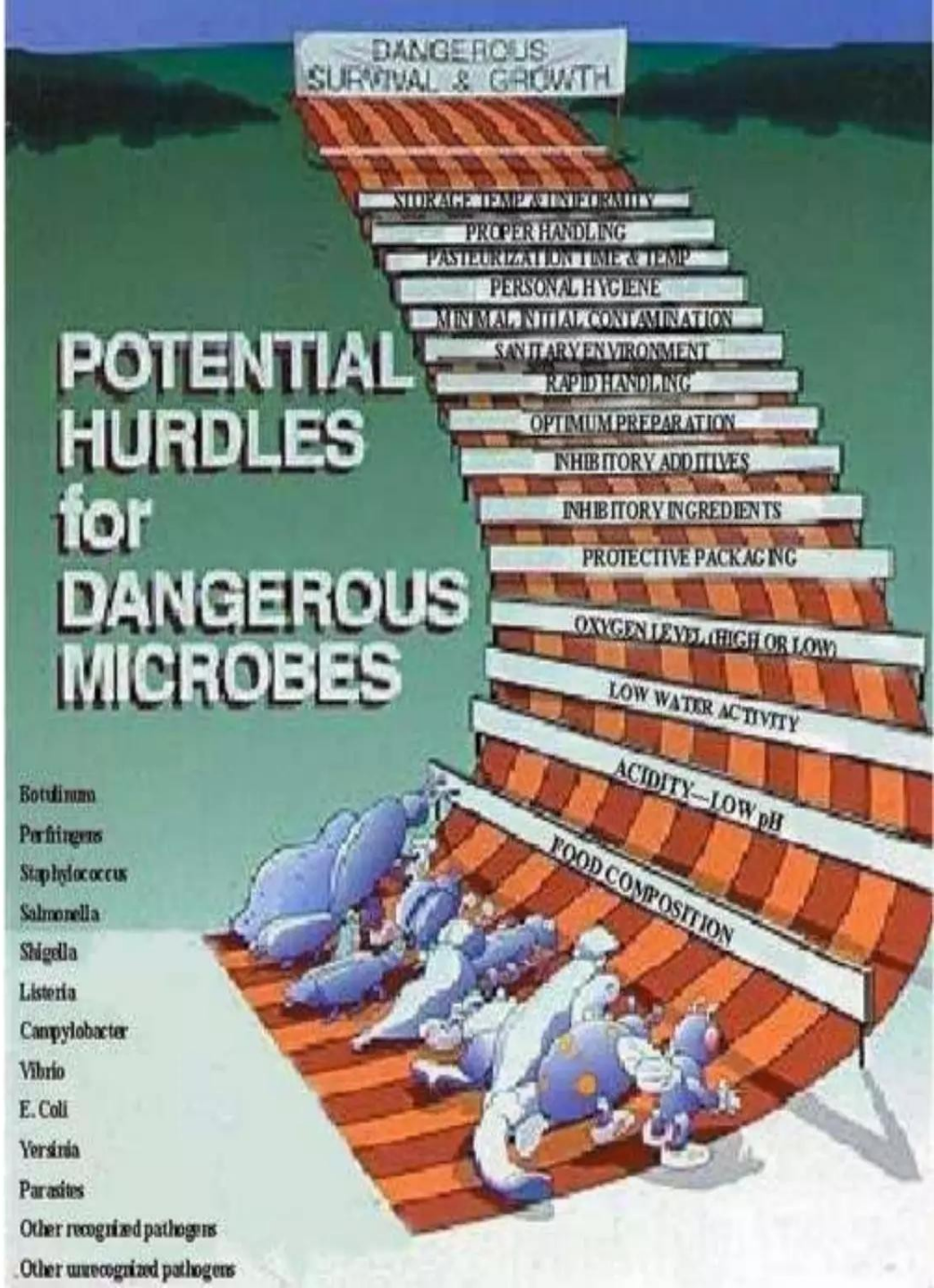
PROCESSING HURDLES

Thermal Processing

- Hot Fill, Quick Chill
- Retort sterilization

Non-Thermal Processing

- Irradiation
- Ultra High Pressure



APPLICATIONS OF HURDLE TECHNOLOGY

FRUIT INDUSTRY









FRUIT INDUSTRY

➢Here, blanching controls the enzymatic activity, soaking the fruits in sugar syrup result in osmotic dehydration of the fruits, where the moisture content is removed from fruits by osmosis





FRUIT INDUSTRY

- Further, the osmo-dehydrated fruit slices are packed in packages to extend the shelf-life of the fruits.

- Along with these traditional methods, UV-light, ultrasound and high hydrostatic pressure can be combined to develop novel fruit based products.

MEAT INDUSTRY

➢Hurdles used in meat industry include combining factors like lowering water activity, acidity in products and use chemical preservatives like nitrite to stop microbial growth.

Important hurdles in meat preservation	
High temperature	Heat treatment
Low temperature	Cooling, Freezing
Water activity	Drying, Salt, Sugar
Acidity (pH)	Acidification
Redox reaction	Decrease oxygen (vacuum, ascorbate)
Preservatives	Sorbate, nitrite etc.
Competitive flora	Fermentation (only applicable for non-heat treated products)

FISH INDUSTRY

➢Fish products can be preserved for long period by combining hurdles like salting and packaging.





DAIRY INDUSTRY

- Dairy products shelf life can be extended using hurdles like surface treatment and using various vacuum packaging techniques for solid products like paneer / tofu.
- Along with these, mild heat treatments, acidification could also be combined.





CONCLUSION

- The disturbance of the homeostasis of microorganisms is the key phenomenon of food preservation

- Since different hurdles have different spectra of antimicrobial action, the combined hurdles could attack microorganisms in different ways and may increase synergistically the effectiveness of preservation (multi-target preservation)

- If all the hurdles operation operating in a particular foods are known, the microbial stability and safety of that food, and its quality, might be optimized by changing the intensity or the character of these hurdles.

- Synergistic effect of different hurdles can lead to enhanced food safety and extended shelf life of food product

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Space Food

Department of Food Technology
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What is space food???

❖**Space food** is a variety of food products, specially created and processed for consumption by astronauts in outer space.

❖<u>Specific requirements for space food</u>

- To provide balanced nutrition
- Easy and safe to store
- Prepare and consume in low gravity environments

- The biggest differences between space food and regular food are in the packaging and design.

- Space food must be carefully contained so it doesn't float around in the low-gravity (microgravity) environment.

- Liquids can float away, so drinks packaged as powders. Astronauts add water to the contained drinks to rehydrate them.

History

- Yuri Gagarin was the first human to experience the sense of weightlessness on Vostok I (1961) mission.
- In Vostok 2, Soviet cosmonaut, German Titov, became the first human to eat in space
- Glenn was the first American to consume food in the space in Mercury capsule

Forms of space food

1. Thermostabilized
2. Irradiated
3. Natural form
4. Rehydratable
5. Extended shelf life
6. Fresh food
7. Beverages

1. Thermostabilized - Heating food to a temperature that renders it free of pathogens, spoilage microorganisms, and enzyme activity. It include pouched soups, desserts, puddings, and entrees.

2. Irradiated – Meat items can be processed for commercially sterility by using radiation doses.

3. Natural Form - This are commercially available, shelf stable foods. This are low to intermediate moisture food having reduced water activity inhibiting microbial growth.

4. Rehydratable -

- The food are freeze-dried, in which it is cooked, quickly frozen and then put in a vacuum chamber to remove the water.
- Freeze-drying preserved the food for the flight without compromising the flavor.
- To rehydrate the food, the simply inject water into the package with a water gun.
- It includes side dishes, such as spicy green beans and cornbread dressing, or cereals.

5. Extended shelf life – It includes cones, waffles, tortillas, and dinner rolls, can be formulated and packaged to give them a shelf life of up to 18 months

6. Fresh Food - Foods such as fresh fruits and vegetables, which have a short shelf life, are provided on a limited basis.

7. Beverages – It Includes freeze-dried beverage mixes (such as coffee or tea) or flavored drinks (such as lemonade or orange drink). After weighing drinks get vacuum sealed inside a beverage pouch.

Packaging of space food

- It should be easy to use, small enough to dispose of in the onboard trash compactor and sturdy enough to keep food fresh for up to a year.

- Rehydratable foods are packaged in flexible bowls with lids.

- Foods can also be kept in cans with pull-off lids, plastic cups or flexible pouches.

Facts…

- All food that is sent to the space station is precooked, exception are the fruit and vegetables stowed in the fresh food locker
- Instead of bowls there are bags and cans
- Seasonings like salt and pepper have to be used in liquid form, otherwise granulated particles would float away

Technological challenges for space food

- Nutrient-dense, shelf stable foods that meet overall sensory acceptability metrics
- Shelf stable items with at least a 5-yr shelf life
- Partial gravity cooking processes with minimization of microbial risk
- Sustained vitamin delivery in shelf stable foods
- A packaging material that meets high-barrier, low-mass, and process-compatibility constraints.

THANK YOU

Digital Disruption in Food Industry

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Dr. R. Renu

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Strategic aspects of Food Technology

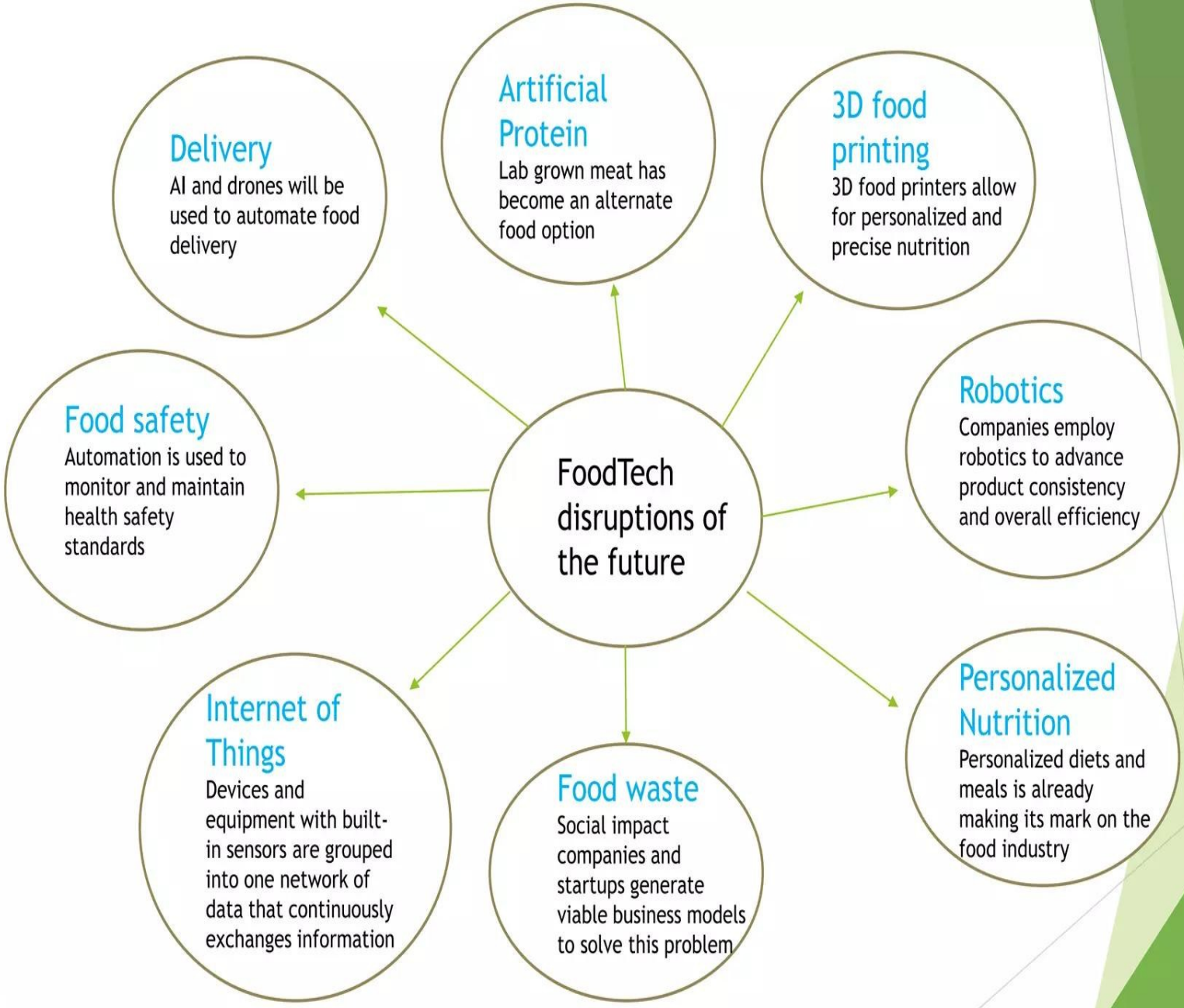
- Market Definition: According to Institute of Food Technologists (IFT), food technology is the application of food science to the selection, preservation, processing, packaging, distribution, and use of safe food. Each stage of the food cycle has a corresponding subcategory within the larger ecosystem of technologies known as “food tech”. Some of the sector under food tech are: 1. Agtech 2.Resturant tech 3. Food and beverages delivery
- The usual practices in the food industry will not be able to feed the world, as demand for agricultural products increases while agricultural land remains limited. Also, consumers’ preferences have shifted with the rise of plant-based and health-first foods. Government regulations have become stricter to better protect public health and ensure total compliance. The COVID-19 pandemic put the supply chains to the test—and in many instances, delays and shortages occurred, making clear the weaknesses in the current models. Meanwhile, innovative technologies like artificial intelligence (AI), Internet of Things (IoT) devices and the blockchain have emerged and are already being applied by food and beverage businesses.
- Market Opportunity: FoodTech innovators have created new ways to harness the power of technology to enhance the world’s food supply. FoodTech innovations are protecting crops and maximizing outputs. As food remains the basic need for humans and the population base has grown to 8 billion in 2023, there remains a huge opportunity for investments in innovative food and beverage technology, or food tech, that better the health of our food ecosystem through novel ingredients and improved diets via better food distribution, preservation and access. According to Pitchbook.com, in second quarter of 2022, startups around the world have raised $5.6 billion across 275 deals. Funding for food tech has skyrocketed from about $60 million in 2008 to more than $1 billion in 2015. And unique investments from VCs and private equity funds have doubled from 223 in 2015 to 459 in 2017, according to CB Insights.
- Key drivers of food tech investments:
- 1. Consumers have increased focus on sustainability, health and fitness causing the food industry to innovate
- 2. Consumers want to know the ingredients of their food, the source and production process.
- 3. Consumers focus on convenience of availability of food, limit the create of waste and prefer on their personal brands of choice.

- Digital Technologies (DTs) can tackle many food production and distribution challenges, such as low productivity, high transaction costs, limited use of inputs and minimal commercialization. For example, Smart farming technology is a technological solution that aims to create highly added value by integrating existing agricultural technologies with cutting-edge ICT solutions. Major technologies causing disruption in the food technology are Internet of Things (IoT), Industrial IoT, Digital Twins, Big Data, Artificial Intelligence (AI), and Drone Technology. The digital disruption of the food industry will impact at multiple points across the food value chain namely Food Production, Supply Chain, and Retail. Since the consumer preferences are changing, CPG companies are more focused towards the wants of their customers. Integrating ingredients informatics with synthetic biology and fermentation-based approaches for food production will transform the food technology industry at food production level.

- In the supply chain, digital tools like soft robotics and digitally driven applications like last-mile transportation will impact the future of food technology. End to end traceability solutions that combine blockchain with IoT sensors will be adopted by food industry players. Digital solutions like AI-enabled sensors, will help in tackling food safety challenges along the supply chain. Digital platforms like Amazon and Alibaba are transforming the food industry. Omnichannel offerings, digitalization of food retails will help create new ways for companies to interact with consumers.

- The digital transformation in the food technology offers several benefits such as better visibility and transparency of important information at several stages, safer products and procedures and greater efficiency and profitability. Although the consumer base for the food and beverage industry is huge, the food industry is facing multiple challenges in production, demand and regulation due to consumer trends.

- FoodTech present trends: 1. Grocery Ordering 2. Meal Ordering 3. Delivery



source: foodware365.com

Future business models

There are 3 keys areas in which food tech innovations will be delivering new approaches along the value chain. The application of technology at various points in the food chain where it is most required, will lead to significant growth and investment attention in future.

- CONSUMER FOOD TECH

Consumer food tech is the segment within food technology investment that focuses on development of technologies primarily marketed toward the consumer. Be it plant-based meats, novel distribution systems or nutrition-based tech, this segment aims to assuage consumer-driven demands. Examples of consumer food tech innovators include alternative protein/diary, nutrition and meal kit distribution companies. As the organic food trend reached its peak and began to commoditize, another food trend has risen to take its place. Plant-based, meatless, animal-free meat are new innovations in the consumer food tech.

- INDUSTRIAL FOOD TECH

Industrial food tech is the sub-segment of food tech that focuses on addressing fundamental business model and B2B pain points within the food industry. The companies include innovators in novel processing and packaging technology and new or functional ingredients that have improved nutritional, labeling or formulation characteristics. Food processing or grading technologies are also included in this segment.

- SUPPLY CHAIN AND PROCUREMENT

This sub segment focuses on increasing food traceability by commercializing new modes of tracking food provenance. Consumer awareness regarding food fraud and requirements for food traceability, as well as records of provenance, are increasing. This has created a strong business case for innovation in the food supply chain to satisfy these demands. Changing consumer preferences for quality, convenience and gourmet products in food service has led to a rise in the category of fast-casual restaurants and placed pressure on fast food restaurants to rethink their delivery models. Innovators in this segment are focused on traceability, sustainability, improving freshness and eliminating food waste.

Hybrid Business Model to grow at a faster rate compared to restaurant chain and cloud kitchen only business models by 2025

By shifting the focus from the core food delivery business, food tech companies are working on slashing costs and serving good quality food. In that quest, the companies have found cloud kitchen as one of the mediums to gain traction of the consumers and offer food at customers' doorstep. A cloud kitchen is the latest modification of low-budget restaurants, who could not offer seating space to the customers. Under this model, an outlet prepares food as per the customer's demand and then, delivers food at the customer's chosen space. The outlet fundamentally works a unit where food is retained, cooked and packed. This kind of model is quite effective as it brings a restaurateur's focus on creating quality food instead of concentrating on dining facilities and space available for customers. This concept is new in the Indian industry while in foreign countries, giant food-tech firms are employing it massively and expanding their footprint in the cloud kitchen niche.

Restaurant chains mostly focus on walk-ins and cloud kitchen focus on food delivery, the hybrid model leverages the best of both. In the hybrid model, the cloud kitchens take care of the delivery demand while café takes care of visitors.

Top funded business models in food tech in 2021

- B2C FRUIT AND VEGETABLES GROUP BUYING PLATFORMS
- FOOD ORDERING PLATFORMS
- ONLINE B2C GROCERY GROUP BUYING
- AUTONOMOUS GROCERY DELIEVERY VEHICLES
- PLANT BREEDING TECHNOLOGY PROVIDERS
- CROP NUTRITION MICROBES
- FUNGI BASED MEAT SUBSTITUTES
- ONLINE B2C SURPLUS FRUIT AND VEGETABLE DELIEVERY
- MANAGED CLOUD KITCHENS
- B2B FRUITS AND VEGETABLES ECOMMERCE MARKETPLACE

source: tracxn technologies

Famous Food delivery business models case studies

- 1. Uber Eats Three-Sided Marketplace Business Model
- 2. Grubhub Two-Sided Marketplace for Restaurants and Diners
- 3. Doordash Business Model
- 4. Instacart Business Model
- 5. Postmates Business Model

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