CARBOHYDRATES

(i) Food - Starch, present in all grain like wheat,
    maize, rice etc.
(ii) Clothing - cellulose present in cotton, linen,
    Rayon etc.
(iii) Shelter - cellulose in wood used in furnitures

Carbohydrates are formed in green plants
by photosynthesis using \( \text{CO}_2 \) and \( \text{H}_2\text{O} \) in the presence
of sunlight

\[
6 \text{CO}_2 + 6\text{H}_2\text{O} \xrightarrow{\text{sunlight}} C_6\text{H}_{12}\text{O}_6 + 6\text{O}_2
\]

Carbohydrates in the form of food
when taken ultimately oxidized back to \( \text{CO}_3 \) and \( \text{H}_2\text{O} \).

Thus, energy with the liberation of energy. This energy
sustain life.

Ex. Glucose, fructose, maltose, mannose \([C_6\text{H}_{12}O_6]\), etc.

Starch, cellulose \([C_6\text{H}_{10}O_5]_n\) etc.
Classical definition: Carbohydrates are the hydrocarbons of carbon having empirical formula $C_x(H_2O)_y$.

Example: $C_6H_{12}O_6$ (Glucose), Fructose]

However, the above definition is not valid in the No. of cases.

(i) The compounds like Formaldehyde ($CH_2O$), Acetic acid and ($C_3H_6O_3$) etc. having formula $C_x(H_2O)_y$ but do not have the characteristics of carbohydrates.

(ii) But some carbohydrates like
- Rhamnose - $C_6H_{12}O_5$
- Rhamnolose - $C_7H_{14}O_6$
- L, D Deoxyribose - $C_5H_{10}O_5$ etc.

are show the properties of carbohydrates but do not show the above empirical formula $C_x(H_2O)_y$.

In the light of the above facts the old definition of carbohydrates lost its significance.

Modern Definition: Carbohydrate are defined as polyhydrony aldehydes or polyhydrony ketones or the compounds which hydrolyse to yield compounds contain atleast one chiral carbon atom.

Example: $CH_2O$

<table>
<thead>
<tr>
<th>CH_{HOH}</th>
<th>(Glyceraldehyde)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH_{2OH}</td>
<td></td>
</tr>
</tbody>
</table>
Carbohydrates are also called as saccharides because the Latin name of sugar is saccharum.

**CLASSIFICATION**

Carbohydrates are generally classified based upon their behaviour towards hydrates.

- Carbohydrates
- Monosaccharides
- Oligosaccharides
- Polysaccharides

1. **Monosaccharides**: The simplest carbohydrates which cannot be hydrolysed further called monosaccharides. These are contain 3 to 8 no. of carbon atoms. All monosaccharides are
   
   (i) Sweet in taste
   (ii) Soluble in water
   (iii) Crystalline in nature

Monosaccharides are further classified into aldose and ketose. Depend upon the presence of aldehyde or keto group.
Monosaccharides

<table>
<thead>
<tr>
<th>Aldose (C(^6))</th>
<th>Ketose (C(^5))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldohexose - Glucose H(_2)C(\text{OH}) - C(H(_2)(\text{OH})) - (\text{CHO})</td>
<td>Ketohexose - D(1) Hydroxy Ketose</td>
</tr>
<tr>
<td>H(_2)C(\text{OH}) - C(H(_2)(\text{OH})) - (\text{CHO})</td>
<td>HOC(\text{H}_2) - CO - CH(_2)O(\text{H})</td>
</tr>
<tr>
<td>Aldopentose - Erythrose</td>
<td>Ketopentose - Erythrose</td>
</tr>
<tr>
<td>H(_2)C(\text{OH}) - C(H(_2)(\text{OH})) - (\text{CHO})</td>
<td>HOC(\text{H}_2) - CO - CH(_2)O(\text{H}) - CH(_2)O(\text{H})</td>
</tr>
<tr>
<td>Aldopentose - Arabinose</td>
<td>Ketopentose - Ribose</td>
</tr>
<tr>
<td>H(_2)C(\text{OH}) - C(H(_2)(\text{OH})) - (\text{CHO})</td>
<td>HOC(\text{H}_2) - CO - (C(H(_2)(\text{OH})) - ((\text{H}_3)O(\text{H}))</td>
</tr>
</tbody>
</table>

2. Oligosaccharides: - These are hydrated to yield two to ten number of monosaccharide molecules. Oligosaccharides are further classified as follows:

(i) Disaccharide: - Sucrose, lactose, Maltose C\(_{12}\)H\(_{22}\)O\(_{11}\)
(ii) Trisaccharide: - Raffinose C\(_{18}\)H\(_{32}\)O\(_{16}\)
(iii) Tetrasaccharide: - Stachyose C\(_{24}\)H\(_{42}\)O\(_{21}\)

3. Polysaccharides: - Complex carbohydrates which are hydrolyzed into 10 no. of monosaccharides are called polysaccharides. All polysaccharides are (i) Tasteless (ii) Insoluble in \(\text{H}_2\text{O}\) and (iii) Amorphous nature.

General formula of polysaccharides are \(\text{C}(\text{H}_2\text{O})_\text{n}\). Polysaccharides are further classified as...
1) Homopolysaccharides: - On hydrolysis gives one kind of monosaccharides e.g. Starch, Cellulose.

2) Heteropolysaccharides: - On hydrolysis gives more than one kind of monosaccharides e.g. Insulin.

Reducing and Non-Reducing Carbohydrates:

Depending upon the reducing nature carbohydrates are further classified as:

Reducing Carbohydrates: - These are reduced by Tollens’ Reagent, feehing solution, Benedict’s solution etc.

e.g. All monosaccharides, most disaccharides (except sucrose)

Non-Reducing Carbohydrates: -

Do not reduce by Tollens’ Reagent, feehing solution etc.

e.g. Sucrose, Cellulose etc.

Mechanism of Carbohydrate Formation:

Glucose on warming with excess of phenyl hydrazine forms a yellow crystalline product known as

Glucorhazine.

\[
\begin{align*}
\text{C}_6\text{H}_5\text{NH}_2 + 3\text{C}_6\text{H}_5\text{NH}_2 \rightarrow \\
\text{C}_6\text{H}_5\text{NH}_2\text{C}_6\text{H}_5
\end{align*}
\]
According to fixation the above reaction occurs through the following steps:

\[ \text{CH}_2 \overset{\text{O}}{=} \text{C} \]

\[ \text{CHOH} + \text{H}_2\text{NNNH}_2 \rightarrow \text{H}_2\text{O} \]

\[ \text{CH}_2\text{OH} \]

\[ \text{(CHOH)}_3 \]

\[ \text{CH}_3\text{OH} \]

\[ \text{(Glucose)} \]

Reduction Mechanism [Amadori Rearrangement]

\[ \text{CH}_2\text{OH} \]

\[ \text{CHOH} \rightarrow \text{CH}_2\text{NNNH}_2 \rightarrow \text{H}_2\text{O} \]

\[ \text{CH} = \text{N} \cdot \text{NHC}_6\text{H}_5 \]

\[ \text{CH} = \text{N} \cdot \text{NHC}_6\text{H}_5 \]

\[ \text{C} = \text{N} \cdot \text{NHC}_6\text{H}_5 \]

\[ \text{(CHOH)}_3 \]

\[ \text{CH}_3\text{OH} \]

\[ \text{Glucosamine} \]
Ozone formation of fucrose:

When heated with an excess of phenyl hydrazine, fucrose forms an ozone which is identical with ozone formation of glucose.

\[ \text{fucrose} \rightarrow \text{CH}_{2} \text{OH} \]
\[ \text{C} = \text{O} \]
\[ (\text{CHOH})_{3} \]
\[ \text{CH}_{2} \text{OH} \]

\[ 3 \text{C}_6 \text{H}_5 \text{NHNNH}_2 \rightarrow \text{CH} = \text{N} \cdot \text{N} \cdot \text{C}_6 \text{H}_5 \]
\[ \text{C} = \text{N} \cdot \text{N} \text{C}_6 \text{H}_5 \]
\[ (\text{CHOH})_{3} \]
\[ \text{CH}_{2} \text{OH} \]

(fucrose)

The ozone reaction occurs in the following steps:
\[ \text{CH}_2\text{OH} \quad \xrightarrow{\text{O}} \quad \text{B}_{2}\text{N.NH}_6\text{H}_5 \]
\[ (\text{CHOH})_3 \quad \text{H}_2\text{O} \]
\[ (\text{CH}_2\text{OH})_n \quad (\text{Fructose}) \]
\[ \text{C} = \text{N} \cdot \text{NH}_6\text{H}_5 \]
\[ (\text{CHOH})_3 \quad \text{H}_2\text{O} \]
\[ (\text{CH}_2\text{OH})_n \quad (\text{Glucose}) \]

\[
\text{Structure of Glucose: - Grape Sugar}
\]

1. Molecular formula: From analytical data molecular weight determination it is found that the molecular formula of glucose is \( \text{C}_6\text{H}_{12}\text{O}_6 \).

2. Presence of Carboxylic group \(-\text{C} = \text{O}:-\): When glucose reacts with HCN, \( \text{NH}_2\text{O} \), and \( \text{CH}_3\text{NH} - \text{NH}_2 \text{H} \) to form cyanohydrin, oxime and phenyl hydrazones respectively. This shows the presence of carboxylic group in glucose.

3. Presence of Aldehyde group \( \text{CHO} \): When oxidised with mild oxidising agent like \( \text{Br}_2 \text{OH} \) water glucose gives gluconic acid having same mol Carbon.
Other four carbon contain H-OH group.

So, the open chain structure of glucose can be written as:

\[ \text{H} \quad \text{O} \quad \text{C} \quad \text{H} \quad \text{O} \quad \text{H} \quad \text{C} \quad \text{H} \quad \text{O} \quad \text{H} \quad \text{C} \quad \text{H} \quad \text{O} \quad \text{H} \quad \text{C} \quad \text{H} \quad \text{O} \quad \text{H} \]

**Configuration of D(+) glucose:**

No. of stereoisomers in glucose = 2^4 = 16.

\[ \text{D}(+)^{\text{H}} \quad \text{D}(+)^{\text{H}} \quad \text{D}(+)^{\text{H}} \quad \text{D}(+)^{\text{H}} \]

\[ \text{D}(+)^{\text{H}} \quad \text{D}(+)^{\text{H}} \quad \text{D}(+)^{\text{H}} \quad \text{D}(+)^{\text{H}} \]

The Fischer projection formula is:

\[
\begin{align*}
\text{CHO} \\
\text{H} & \quad \text{C} \quad \text{O} \\
\text{H} & \quad \text{C} \quad \text{H} \\
\text{H} & \quad \text{C} \quad \text{O} \\
\text{H} & \quad \text{O} \\
\end{align*}
\]

OR

\[
\begin{align*}
\text{CHO} \\
\text{H} & \quad \text{O} \\
\text{H} & \quad \text{H} \\
\text{H} & \quad \text{O} \\
\text{H} & \quad \text{O} \\
\end{align*}
\]

**D (+) glucose**
Limitations of open chain structure of D(+)

1. In spite of presence of -CHO group it does not react with NH₃, NaOH, SO₂ and does not show Schiff’s test.

2. D(+) glucose exists in two forma (enantiomers) i.e. L - D (+) glucose and D - D (+) glucose.

   (i) Crystalline of glucose form alcohols yields L - form with m.p. 119 K and specific rotation 115°

   (ii) Crystalline form pyridine yields B - form with m.p. 119 K and specific rotation +15°

3. Mutarotation: Both α and β are more stable in crystalline form but in aqueous solution in each -form slowly changes into other form to equilibrium mixture, when dissolved in water α - D(+) glucose falls from +112° to 52.7° and B - D(+) glucose rises from +19° to 52.7°

   α - D (+) glucose \( \rightarrow \) Eq. mixture \( \rightarrow \) B - D(+) glucose

   \( [\alpha]_D = 112° \) \( [\alpha]_D = -52.7° \) \( [\alpha]_D = +19° \)

4. Glucose: When heated with mixture of \( \text{CH}_3\text{CHOH} \) and dry HCl glucose forms two isomers - methyl

   \( C_6\text{H}_{12}\text{O}_6 + \text{CH}_3\text{OH} \rightarrow \text{HCl} \)

   \( \text{Methyl - D} \) \( \text{and} \) \( \text{Methyl - L} \) 

   Glucosides
Evidence in favour of ring structure of glucose:

1. Presence of double bond (C=O). 

2. Ring structure of D(-)-glucose.
Each type of diastereomers which differ only in configuration of C-1 are known as Anomers and the carbon atom is called Anomeric carbon.

In the configuration is different whether than C-1 are called C(3), C(3), C(4) etc. Epimers and the C atom is called epimeric carbon.

\[
\begin{align*}
\text{CH}_3 & \\
\text{H} & \text{C} - \text{O} - \text{H} \\
\text{O} & \text{H} \\
\text{H} & \text{C} - \text{O} - \text{H} \\
\text{H} & \text{C} - \text{O} - \text{H} \\
\text{CH}_2 & \text{O} - \text{H}.
\end{align*}
\]

\[
\begin{align*}
\text{CH}_3 & \\
\text{O} & \text{H} - \text{C} - \text{H} \\
\text{O} & \text{H} - \text{C} - \text{H} \\
\text{H} & \text{C} - \text{O} - \text{H} \\
\text{H} & \text{C} - \text{O} - \text{H} \\
\text{CH}_2 & \text{O} - \text{H}.
\end{align*}
\]

2. Mutarotation: - The process of change in special Rotation of an optically active compound in solution with the passage of time to an equilibrium value is called Mutarotation.

When either 2 or 2 form of glucose is dissolved in water and kept for sometime, each form is converted to other form into a equilibrium mixture containing with the isomers 2R (2R,2S) and 2S of R and small amount of open chain form.
Mechanism of Hydrolysis:

$\text{H}_2\text{C} = \text{O} \rightarrow \text{H}_2\text{C} - \text{OH} + \text{H}^+$

Formation of 2,6-Di-O-Methylglucose:

$\text{H}_3\text{C} - \text{C} - \text{OH} \rightarrow \text{H}_3\text{C} - \text{C} - \text{O} - \text{H} + \text{H}_2\text{O}$

$\text{H} - \text{C} - \text{OH} \rightarrow \text{H} - \text{C} - \text{O} - \text{H} + \text{H}_2\text{O}$

$\text{H} - \text{C} = \text{O} \rightarrow \text{H} - \text{C} - \text{OH} + \text{H}^+$

Conc. H$_2$SO$_4$
Conversion of carbohydrates:

(i) Glucose reacts with phenyl hydrazine to form glucoazone

(ii) Glucoxanone reacts with HCl and C6H5 CH3 to form glucozan

(iii) Glucosone reduced with Zn/CH3COOH to give fructose
2. Conversion of Fruuctose into Glucose:

\[
\begin{align*}
\text{CH}_3\text{OH} & \quad \text{CH}_3\text{OH} \\
\text{C} & = \text{O} \\
\text{OH} & - \text{C} - \text{H} \\
\text{H} & - \text{C} - \text{OH} \\
\text{H} & - \text{C} - \text{OH} \\
\text{CH}_3\text{OH} & \\
\text{Na}^{-} - \text{H}_2\text{O} \rightarrow \\
\text{CH}_3\text{OH} & \quad \text{H} - \text{C} - \text{OH} \\
\text{OH} & - \text{C} - \text{H} \\
\text{H} & - \text{C} - \text{OH} \\
\text{H} & - \text{C} - \text{OH} \\
\text{CH}_3\text{OH} & \\
\text{O}_{2} - \text{Hg} \rightarrow \\
\text{COOH} & \\
\text{H} & - \text{C} - \text{OH} \\
\text{OH} & - \text{C} - \text{H} \\
\text{H} & - \text{C} - \text{OH} \\
\text{H} & - \text{C} - \text{OH} \\
\text{CH}_3\text{OH} & \\
\text{Gluconic Acid} & \\
\text{O}_{2} & \rightarrow \\
\text{COOH} & \\
\text{H} & - \text{C} - \text{OH} \\
\text{OH} & - \text{C} - \text{H} \\
\text{H} & - \text{C} - \text{OH} \\
\text{H} & - \text{C} - \text{OH} \\
\text{CH}_3\text{OH} & \\
\text{V} - \text{Hanna Master Reaction} & \\
\text{Na}^{-} - \text{Hg} \rightarrow \\
\text{CH}_3\text{OH} \\
\text{OH} & - \text{C} - \text{H} \\
\text{OH} & - \text{C} - \text{H} \\
\text{H} & - \text{C} - \text{OH} \\
\text{H} & - \text{C} - \text{OH} \\
\text{CH}_3\text{OH} & \\
\text{Dextro Hanaose} &
\end{align*}
\]
Conversion of aldohexose into aldopentose:

[Killian Fischer Synthesis]
\[ \text{CHO} \]
\[ \text{H - C - O - H} \]
\[ \text{O H - C - H} \]
\[ \text{H - C - O - H} \]
\[ \text{H - C - O - H} \]
\[ \text{CH}_3\text{OH} \]

\[ \text{D(+)} \text{ Glucose} \rightarrow \text{D(+)} \text{ Mannose} \]

→ Ketonisation synthesis leads to the formation of epimer (Glucose, Mannose)

→ can be applied converting ketose into next higher Ketose because Ketone is not present in terminal position

**Conversion of higher aldose into lower aldose:**

**The Ruff Degradation**

\[ \text{CHO} \]
\[ \text{H - C - O - H} \]
\[ \text{O H - C - H} \]
\[ \text{H - C - O - H} \]
\[ \text{H - C - O - H} \]
\[ \text{CH}_3\text{OH} \]

**D(+)** Glucose

**Gluconic acid**

**Calcium gluconate**

**D- Arabinose**
**HOHL Degradation:**

CH₂OH

H - C - OH

OH - C - H

NH₂OH → H - C - OH

OH - C - H

H - C - OH

H - C - OH

CH₂OH

D - Glucose

Oxime ↓

CH₃CO - O

CH₃CO

CH₃CO

H - C - COCH₃

H - C - COCH₃

AgNO₃

H - C - COCH₃

NH₄OH

H - C - COCH₃

CH₂OH

D - Arabinose.

Acetated.

5) Conversion of D(+)-Glucose into D(-) Mannose

[EPIMERISATION]

Many carbohydrates which are diffus in their stereochemistry at a single carbon atom at C₃, C₄, etc. Such stereoisomers are known as Epimers.

Glucose and mannose are diffus in their stereochemistry at C-2 position are called C-2 epimers.
Glucose and mannose are different in their stereochemistry at C-2 position and are called C-2 epimers.

\[
\begin{align*}
\text{(+) Glucose:} & \quad \text{Gluconic acid} & \quad \text{(+) Mannose:} & \quad \text{Mannonic acid}
\end{align*}
\]

Equal mixture of Gluconic acid and Mannonic acid

\[
\begin{align*}
\text{(+) Glucose:} & \quad \text{H A W R T H Projection formula:} & \quad \text{2 - Mannose:}
\end{align*}
\]

Harwood projection formula is used for the better representation of cyclic structure of glucose and their carbohydrates.

For six numbered sugars the formula is written as follows.

(i) A hexagon is drawn in which the oxygen atom is written on the right's fourteenth away from the observer.

(ii) The (+) group is written as up for D-Series and down for L-Series.
The numbering is done as shown in the structure.

The OH groups present on R-Hs of the plane sugars are written as down and those on L-Hs are written as up.

The thickened side of the ring indicates that these slopes are nearer to the eye than the others.

(1) The thickness related six numbered rings related to pyrogen and five numbered rings related to furan.

Haworth projection formulae of a-D-P(+) and B-D-P(+) sugars.
1. D-fructose isomerizes in the mammalian liver to form D-gluconate.

2. D-fructose also exists in the mammalian liver as a mixture of D-gluconate and D-fructose.

3. D-fructose is also found in the mammalian liver as a mixture of D-gluconate and D-fructose.

4. D-fructose is also found in the mammalian liver as a mixture of D-gluconate and D-fructose.
Structure of D(+)-Ribose (Aldopentose)

It is an aldopentose with formula C_5H_{10}O_5.

It occurs naturally in plant nucleic acids and liver and brain case nucleic acid.

The open chain and Fischer projection formula of D-Ribose is given below.

\[
\text{CH}_2\text{OH} - \text{CHOH} - \text{CHOH} - \text{CHOH} - \text{CH}_3
\]

D-Ribose also assigned in the Pyranose and furanose forms as follow.

\[
\text{D}(+)-\text{Ribose}.
\]

In aqueous solution D-Ribose contains all the above forms with small amount of open chain form established in NMR study.

\[
\begin{align*}
\alpha - D \text{ Ribofuranose} & \iff \beta - D \text{ Ribofuranose} \\
20\% & \iff 56\% \\
\beta - D \text{ Ribofuranose} & \iff \alpha - D \text{ Ribofuranose} \\
56\% & \iff 20\% \\
\end{align*}
\]
Structure of D-β Deoxyribose:

This is very important aldopentose in which group of C-2 of ribose replaced by H-atom.

It is the fundamental constituent of DNA [deoxyribonucleic acid]

D-β Deoxyribose.

Conformation of Glucose and Fructose:

The cyclic structure of carbohydrates can be represented in conformational structures analogy with cyclohexane.

The chain form of glucose is more stable found by X-ray studies.

α D(+)-Glucopyranose

β D(+)-Glucopyranose
α- or β anomer of glucose β-form is more stable. This is because in β-form all bulky groups are in equatorial position while in α-form one of the bulky groups (OH group) is axial position. Due to this reason β-D-glucose is the predominant form in ordinary D(+)-glucose.

α-D (+) fructopyranose. β-D (+) fructofuranose.

Formation of key-products:

When glucose is treated with CH₃OH in presence of HCl an equilibrium mixture of anemic glycoside [Hether - α-D-glucose, methyl - β-D glucoside are formed]

H₂C \[\text{CH₃OH} \quad \text{HCl} \quad \text{H₂C} \]

Heter - α-D-glucoside

Methyl - β-D-glucoside
Formation of Ethereal:

When methyl glucoside treated with excess of dimethyl sulfate with an NaOH sol it is converted into pentamethyl derivative.
the -OH groups are converted into -OCH₃ groups. This process is called primary methylation or exhaustive methylation.

When above methylated glucoside treated with dil HCl the methyl glucoside bond gets hydrolysed.

But the other methyl groups remain unaffected because ordinary ethyl groups are stable in dil. aqueous acid.

**Formation of Esters**: When mono- or disaccharides treated with acetic anhydride and pyridine (mild base catalyst) all the -OH groups converted into ester group (very useful crystalline compound).

\[
\text{N-Bromoacetamide} \quad \text{N-D Glucopyranose} \\
(\text{CH}_3\text{CO})_6 \text{CH}_2\text{CO}_3 \quad \text{Penta-O acetyl a-D glucopyranoside}
\]
Disaccharides:

Two monosaccharides units joined by glycosidic linkage disaccharides is formed. These are water soluble crystalline solids.

- Lactose: \( \alpha \)-glucose + \( \beta \)-fructose
- Maltose: \( \alpha \)-glucose + \( \alpha \)-glucose
- Sucrose: \( \beta \)-fructose + \( \beta \)-glucose

Sucrose: \( \text{结构图示} \)
Poly saccharides:
when large number of monosaccharide units gained by glucoside linkage poly saccharide is formed.
Poly saccharides are natural polymeric compounds.
Poly saccharides are amorphous, tasteless, and insoluble in water e.g. starch, cellulose, insulin etc.

Structure of Starch:
- Starch is a combination of two compounds a water soluble component called Amylopectin and water insoluble component called Amylose.

Amylose consists of many α-D-glucos units joined by glucosidic units (α-1, 4). It is called helix. It is unbranched molecule containing large number of (α-1, 4) glucos units.

Amylopectin also contains (α-1, 4) glucos units.
- It is highly branched structure contain several short units.
- Each short chain consists of α-1, 6 units by glucos linkage (α-1, 4).
- One end of each chain further joined through α-1, 4 to the other chain.
Structure of Cellulose:

Starch:
(i) It is composed of two complex components, namely, amylose and amylopectin.
(ii) Both amylose and amylopectin are made up of glucose units linked through α-glucosidic linkage.
(iii) It has helical structure.
(iv) It is sensitive to acid hydrolysis.
(v) It turns blue with iodine.
(vi) It is a major food carbohydrate.
(vii) It is stored in plant cells.
**Configuration of Monosaccharides:**

All monosaccharides are optically active having one or more stereocenters in their molecules.

**Ehrlich Fischer:** In 1865, Ehrlich chose a standard reference compound, glyceraldehyde, having one stereocenter to fix the configuration arbitrarily.

(i) OH group right side with specific rotation +13.5° denoted as D

(ii) OH group left side with specific rotation -13.5° denoted as L

By Fischer projection:

(i) By convention the open chain formula of monosaccharide are written vertically with -CHO group at the top and \( \text{CHO} \) group 2nd of the top.

(ii) After written in this way, the benzylic carbon in which -OH group R.H.S is D-saccharide and -OH group on the L.H.S is L-saccharide.

(iii) The benzylic carbon is the highest numbered at carbon in the molecule.
Enzyme and Transition Atom

Enzymes and thymine are characteristic enzymes having two adjacent stereocenters.

(i) If two OH groups are on the same side of the projection formula called Eurythene.

\[
\begin{align*}
\text{CHO} & \quad \text{CHO} \\
\text{OH} & \quad \text{OH} \\
\text{H} & \quad \text{H} \\
\text{C}_2\text{H}_4\text{OH} & \quad \text{C}_2\text{H}_4\text{OH}
\end{align*}
\]

Similarly

\[
\begin{align*}
\text{CHO} & \quad \text{CHO} \\
\text{OH} & \quad \text{OH} \\
\text{H} & \quad \text{H} \\
\text{C}_2\text{H}_4\text{OH} & \quad \text{C}_2\text{H}_4\text{OH}
\end{align*}
\]

(ii) If two similar groups are on the opposite sides in the Fischer projection called thimWasomer.

\[
\begin{align*}
\text{CHO} & \quad \text{CHO} \\
\text{OH} & \quad \text{OH} \\
\text{H} & \quad \text{H} \\
\text{C}_2\text{H}_4\text{OH} & \quad \text{C}_2\text{H}_4\text{OH}
\end{align*}
\]

Ring size of D(+)-Glucose is six-membered.

The cyclic hemiacetal structure involves the aldehyde group (CHO) and hydroxyl group (OH) forming a six-membered ring.

The formation of six-membered rings can be studied because of their instability. But formation of five-membered...
being confirmed by Methylation method and ultimately formation of chbrown acid.

(i) Methyl β-D glucoside (A) treated with dimethyl sulphate and NaOH to convert the free -OH group into ethyl group (C-CH₃) to form compound (C).

(ii) The compound (C) is hydrolysed by dil. HCl, only the -CH₃ group at 1° get hydrolysed more easily than ordinary ethers. By hydrolysis compound (C) is formed (β-tetra-o-methyl-D-glucitol).

(iii) The cyclic compound (C) is in equilibrium with a little of the open chain form.

(iv) The open chain form contains an aldehyde group. -CHO group and one -OH group.

The position of free -OH group in the open chain structure mediates the carbon atom more than being formation.

\[
\begin{align*}
\text{Methyl β-D glucoside} & \xrightarrow{\text{H}_3\text{C}-\text{C}=\text{H}} \quad \text{(CH}_3\text{)}_2\text{SnCl}_4, \text{N,N,N,N} \\
& \xrightarrow{\text{H}_3\text{C}-\text{C}=\text{H}} \quad \text{H}_3\text{C}-\text{C}=\text{H} \\
& \xrightarrow{\text{H}_3\text{C}-\text{C}=\text{H}} \quad \text{H}_3\text{C}-\text{C}=\text{H} \\
& \xrightarrow{\text{H}_3\text{C}-\text{C}=\text{H}} \quad \text{H}_3\text{C}-\text{C}=\text{H} \\
& \xrightarrow{\text{H}_3\text{C}-\text{C}=\text{H}} \quad \text{H}_3\text{C}-\text{C}=\text{H} \\
\end{align*}
\]

\text{β-tetra-o-methyl-D glucoside}