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# A novel projection for anomers of glucose

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**ABSTRACT**

There are many monosaccharides, which are considered as a monomeric unit of polysaccharides. The glucose is one main monosaccharide that have paramount importance in our daily life. Actually, glucose is an optically active polyhydroxy aldehyde, which has four chiral centers in open chain form, and five chiral centers in cyclic form. Due to the presence of stereogenic centers, it becomes very important to write a correct representation showing its stereochemistry/chirality. Many scientists have given their ideas to write a correct representation/projection of a glucose molecule. Tollens/Fischer, Haworth projection, chair conformation, and stereochemical view, are one of them. The current paper presents another projection for glucose in an easy and understandable depiction, and is named as a novel projection. The projection that was used for gaining the presented representation was the stereochemical view of glucose, which was rotated horizontally at 90°. The main thing to be kept in the mind, was to preserve the stereochemistry of each carbon as it is, and the positions of -OH groups above and below the plane of glucose ring. The current projection is applicable not only for alpha glucose but also for beta glucose. Besides, the presented projection will also be very helpful in representing the chiral molecules having a cyclic structure.



**Capsule Summary:** A new and easy representation of glucose, a novel projection is presented without disturbing the stereochemistry of the glucose molecule. This projection will be very helpful in representing the molecules that exist in the cyclic form.

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## INTRODUCTION

The smallest carbohydrates are those molecules that cannot be hydrolyzed further. The molecular formula of monosaccharides, is $C_6H_{12}O_6$. There are many isomers that have the same molecular formula. Some of them have four chiral centers. The number of chiral centers determines the total number of stereoisomers (Suhail and Ali, 2020a) and called as optical isomers. Glucose with the molecular formula $C_6H_{12}O_6$ having four chiral centers in acyclic form, and five chiral centers in cyclic form. is the smallest carbohydrate i.e. monosaccharide (Domb et al., 1998). Glucose is listed in the biologically important molecules. It has great importance in providing the energy to all living beings. The reason behind it, is the presence of such elements in glucose, which are very crucial for life. Of course, hydrogen, oxygen, and carbon have different

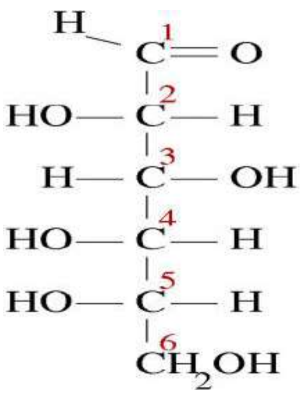

**Fig. 1:** Open chain form of glucose

properties (Suhail and Ali, 2020b; Ali et al., 2017a), but these elements are used by many autotrophs in preparing glucose, during photosynthesis.

Glucose exists in two forms i.e. D-glucose and L-glucose. The naturally occurring form of glucose is D-glucose, while L-glucose is produced synthetically in comparatively small amounts and is of lesser importance. Glucose is a monosaccharide containing six carbon atoms, an aldehyde group and is therefore referred to as an aldohexose. There are many reactions with the help of which, a straight chain of glucose was confirmed. After that, it was considered that glucose exists in an open-chain (acyclic) form (Fig. 1).

Besides the reactions proving the arrangement of carbon atoms in the straight chain of glucose, some other reactions/tests were also noted, which created ambiguities in the open-chain form of glucose. These reactions/tests are as follows:

1. Glucose does not give 2,4 DNP test, and Schiff`s test.
2. It does not give an addition product with sodium bisulfite ($NaHSO_3$).
3. The pentaacetate of glucose does not react with hydroxylamine ($NH_2OH$).

The above behaviour could not be explained by the open-chain form for glucose. It was found that glucose exists in a six-membered cyclic form, and -CHO group is not free in glucose. Actually, in a six-membered ring, –OH at C-5, is involved in a ring formation. This explains the absence of free –CHO group, and also the existence of glucose in a cyclic form (Fig. 2a).

There are many representations of cyclic form of glucose in different perspectives (Fig. 2a-2d). In Fischer projection, devised by Emil Fischer in 1891 (John McMurry 2008) a two-dimensional structure of glucose is represented (Fig. 2a). On the other hand, the cyclic structure of glucose with a simple three-dimensional perspective, is represented in a Haworth projection (Fig. 2b). Fig. 2c shows the projection/representation of glucose in the chair form, while Fig. 2d shows the stereochemistry of each carbon atom of glucose in stereochemical view i.e. chirality. Organic chemistry and especially biochemistry are the areas of chemistry that use the Haworth projection the most. The Haworth projection was named after the English chemist Sir Norman Haworth. A Haworth projection (Fig. 2b) has the following characteristics (Nic and Znamenacek, 2005).

1. Carbon is the implicit type of atom. In Fig. 2d, the atoms numbered from 1 to 6 are all carbon atoms. Carbon 1 is known as the anomeric carbon.
2. Hydrogen atoms on carbon are implicit. In the example, atoms 1 to 6 have extra hydrogen atoms, which are not depicted.
3. A thicker line indicates the atoms that are closer to the observer. In Fig. 2d, atoms 2 and 3 (and their corresponding -OH groups) are the closest to the observer. Atoms 1 and 4 are farther from the observer. Atom 5 and the other atoms are the farthest.
4. The groups below the plane of the ring in Haworth projections correspond to those on the right-hand side of a Fischer projection.

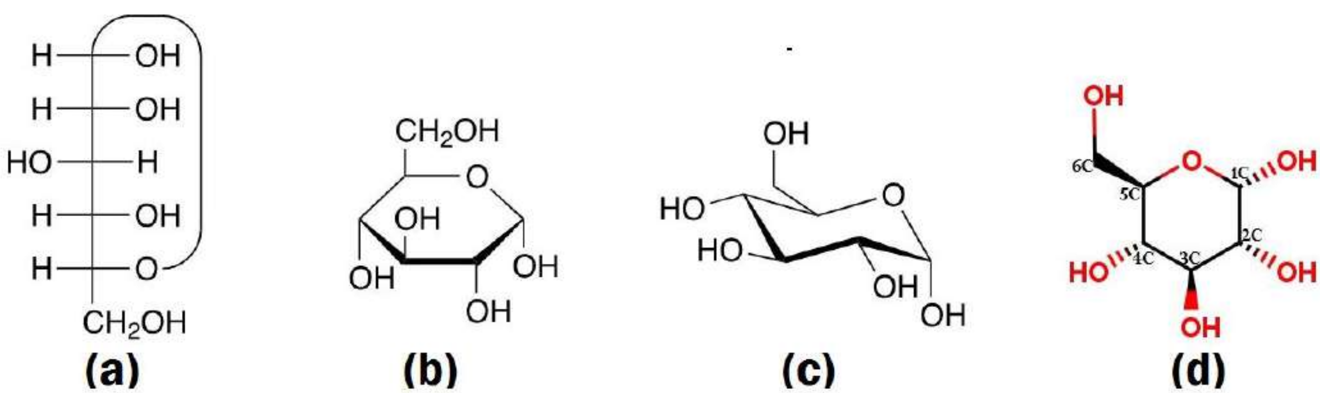


**Fig. 2**: α-D-Glucopyranose in (a) Tollens/Fischer (b) Haworth projection (c) chair conformation (d) stereochemical view

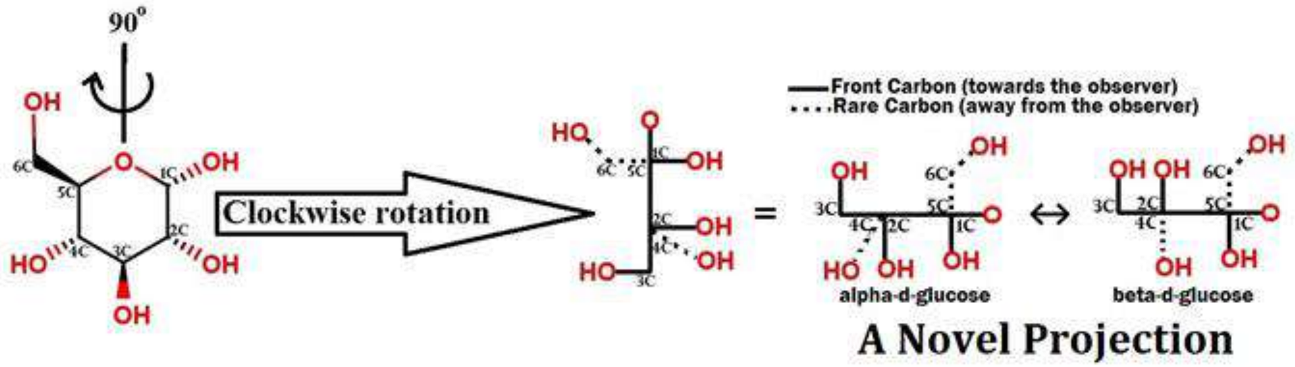


**Fig. 3**: A new representation for alpha and beta-d-glucose

Having found and read the data on the projections of glucose, we presented a new one, which can show the positions of -OH groups as they are i.e. above and below the plane as shown in Fig 2b and 2d. Hence, the presented projection (Fig. 3) was obtained by the rotating stereochemical view of the glucose molecule (Fig. 2d) at a 90° angle horizontally. After doing this, it was noted that no need to draw a cyclic structure of glucose. Besides, this projection is also able to show the positions of -OH groups in both forms of glucose i.e. alpha and beta-d-glucose. These two forms have already been confirmed experimentally by knowing their specific rotations (Manfred el. 2011) using polarimeter. The presented projection has the following characteristics:

1. Like in Haworth projection, carbon and hydrogen atoms are the understood type of atom. Of course, the first carbon atom is known as the anomeric carbon because the variation in the arrangement of this carbon, offers the anomers of glucose.
2. A straight line, drawn from the oxygen atom, shows the plane of a cyclic ring of glucose, in which 6 carbon atoms are arranged. Dotted and undotted lines touching this plan, are the chiral centers.
3. Undotted lines indicate the atoms that are closer to the observer. In alpha glucose, 1st, 2nd, and 3rd carbon atoms are the closest to the observer. On the other hand, the dotted lines indicate the atoms that are farther from the observer. Hence, 4th, 5th, and 6th carbon atoms are farther from the observer in alpha glucose.
4. The -OH groups below the plane of the ring as shown in stereochemical view (Fig. 2d), are shown below the straight line i.e. plane of a cyclic ring of alpha glucose in the presented projection. On the other hand, the -OH groups above the plane of the ring, are shown above the straight line drawn from oxygen atom.
5. The most significant fact to be noted in this projection, is the stereochemistry of the groups in glucose, which is not disturbed because chirality has great importance in representing the chiral molecule (Alajmi et al., 2016) (Ali, et al., 2016a; 2016b; 2016c; 2017b; 2017c; 2018a; 2018b; 2018c;2019;2020).

## CONCLUSIONS

The representation of glucose has been made easy and simple in the current projection without changing the position of -OH groups as well as the stereochemistry of chiral carbons. Besides, this projection also opens the doors for more work to be done in the same fields of representation of chiral compounds existing in both cyclic from in a simple way, as we did. The projection of glucose, given in the present paper, will very be useful to the scientific community. The proposed projection of glucose will be valuable in the learning process, as it is free of drawbacks, because we made the presented projection easy, just by rotating the Haworth projection at 90° horizontally.

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