

Molecular Literacy for All

$C_6H_{12}O_6$ to CO_2 : Glycolysis

Why, to write down the stuff
and people of every day,
must poems be dressed up in gold,
in old and fearful stone?

[...]

I want poems stained
by hands and everydayness.

Sweetness, Always
Pablo Neruda

Session 8

Today's Outline

Breaking Bread

- Yeast: Man's Best Microscopic Friend
- Glycolysis
- Citric Acid Cycle

Carbonyls: Keys to the Kingdom

- Nucleophiles and Electrophiles
- Carbonyl Chemistry
- Glycation of Hb_{A1c}
- Amadori Rearrangement

Be Careful What You Crave For


- Alkylation: A Dark History
- Alkylation: A Bright Future

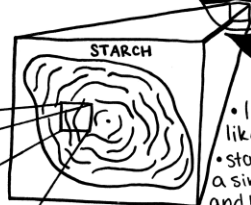
Questions from Session 7

- Why does COVID-19 disable our sense of smell?
 - Some viruses disable sense of smell by triggering congestion. COVID-19 can disable sense of smell without nasal obstruction
 - *ACE2* and *TMPRSS2* genes encode the enzymes that are targeted by SARS-CoV-2 to enter the cell. These genes are found in sustentacular cells and basal cells.
 - There must be an indirect mechanism for taste & smell deactivation, but that mechanism is not yet known.

STARCH

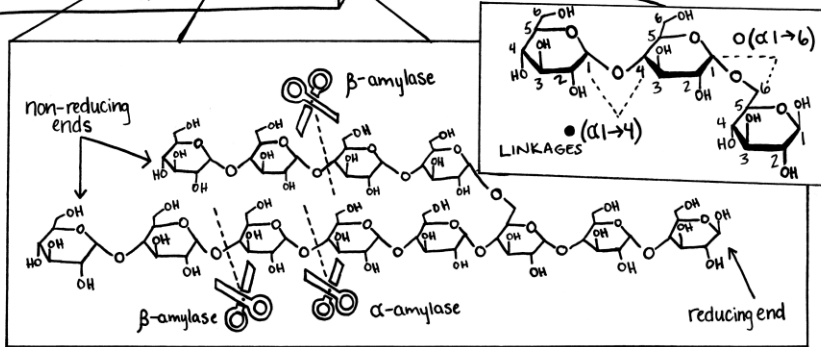
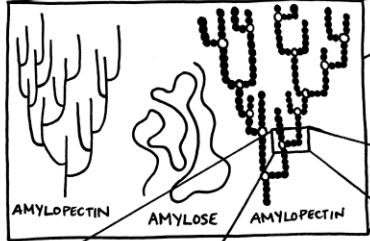


- alpha linked polymer of glucose
- most abundant biomolecule after cellulose
- $\uparrow 60^\circ\text{C}$ helix unravels in water
- helical structure 



- layered like an onion
- starts from a single glucose and branches out

- Amylopectin - highly branched polymer of glucose
- Amylose - long unbranched polysaccharide chain



Breaking Down Starch

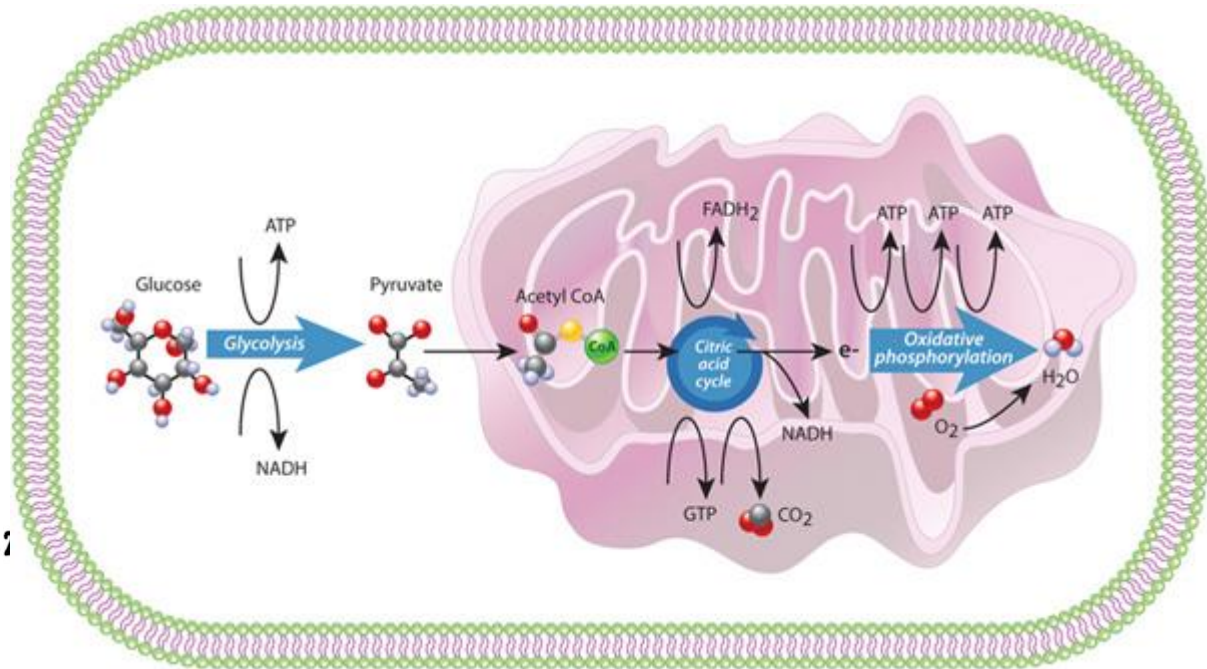
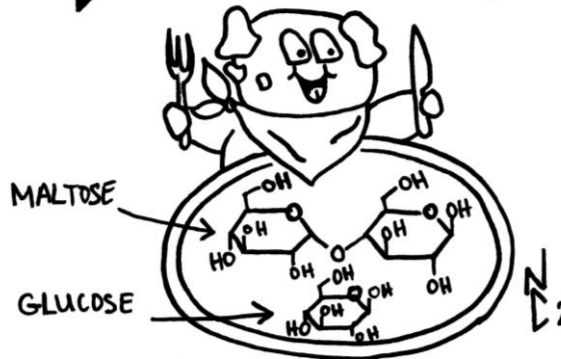


- Amylase enzymes catalyze the hydrolysis of starch into smaller sugars
- Alpha-amylase (α -amylase)
 - randomly breaks ($\alpha 1 \rightarrow 4$) glycosidic linkages
 - o but not near branchpoints or non-reducing ends
- Beta-amylase (β -amylase)
 - breaks ($\alpha 1 \rightarrow 4$) glycosidic linkages near non-reducing ends

Yeast – Man’s Best Microscopic Friend

STARCH

BREAKS APART INTO
FOOD FOR YEAST!



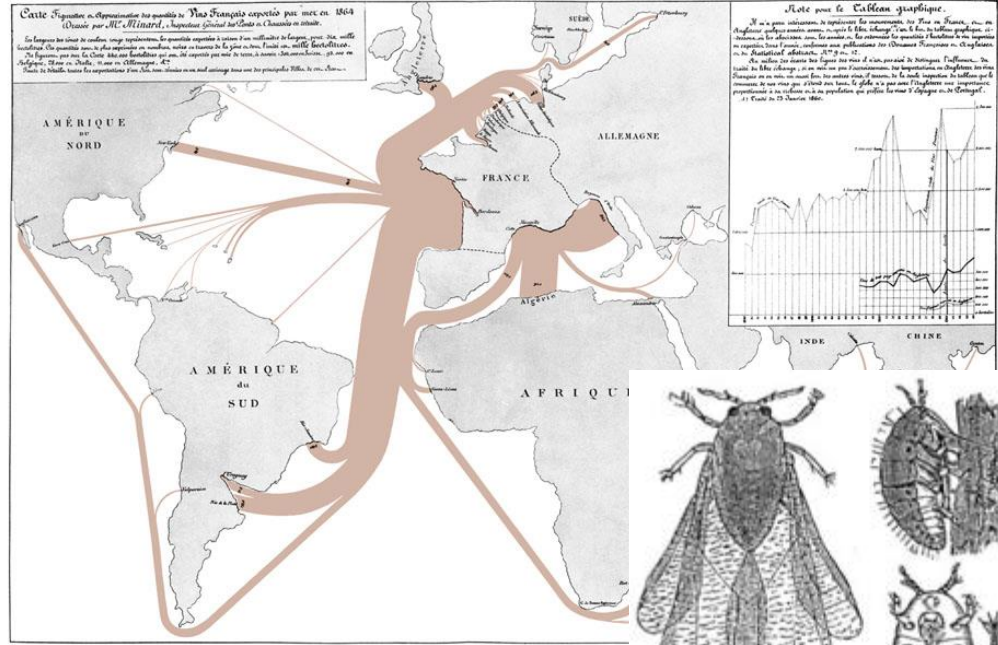
Crash Course in History of French Wine



"Day of 21 January 1793 the death of Louis Capet on the Place de la Révolution" – French engraving.



As Minister of the Interior, Jean-Antoine Chaptal played an important role in helping the French wine industry recover from the French Revolution.



Charles Joseph Minard, *Tableaux Graphiques et Cartes Figuratives de M. Minard*, 1845-1869, a portfolio of his work held by the Bibliothèque de l'École Nationale des Ponts et Chaussées, Paris.

By the mid-1800's, French wine industry reaches a golden age. The golden age soon collapses as a result of various diseases.

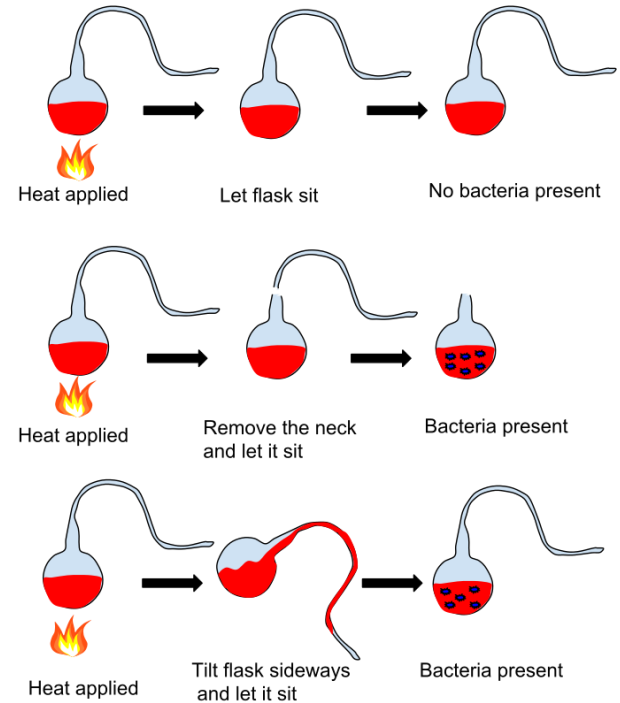
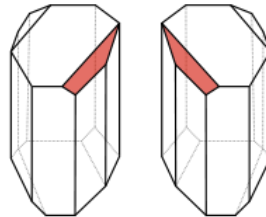
Louis Pasteur to the Rescue



In 1850's, Louis Pasteur makes significant progress toward the germ theory of disease.

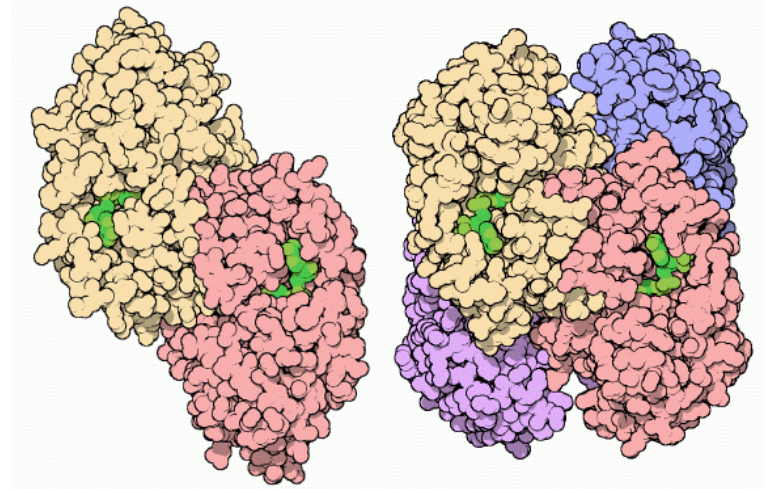
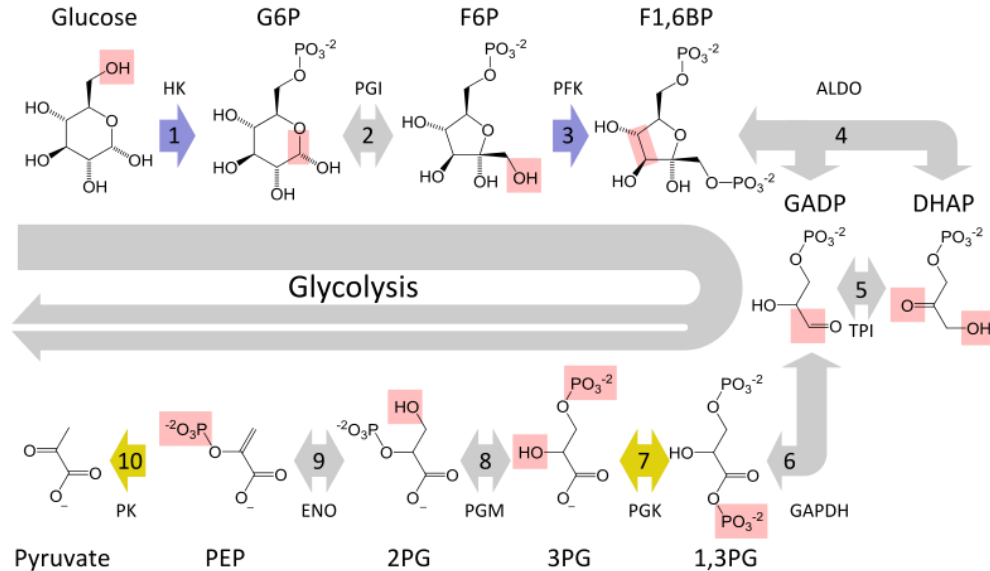


Pasteur made contributions to our understanding of racemization!

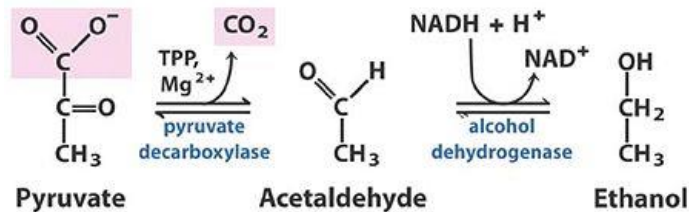


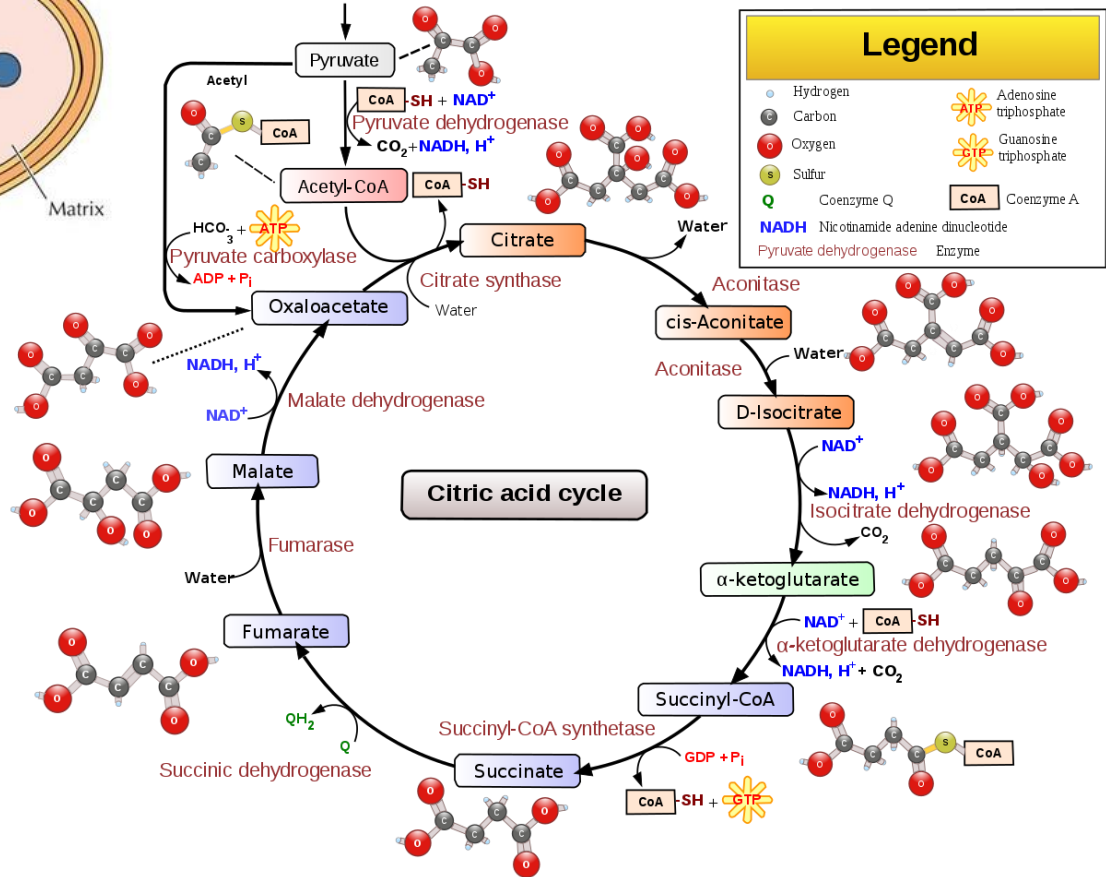
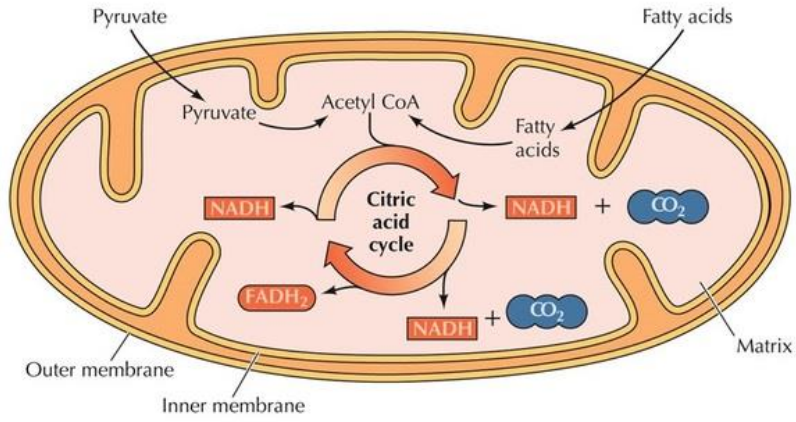
Patents process of wine pasteurization in 1865.

Yeast – Man’s Best Microscopic Friend



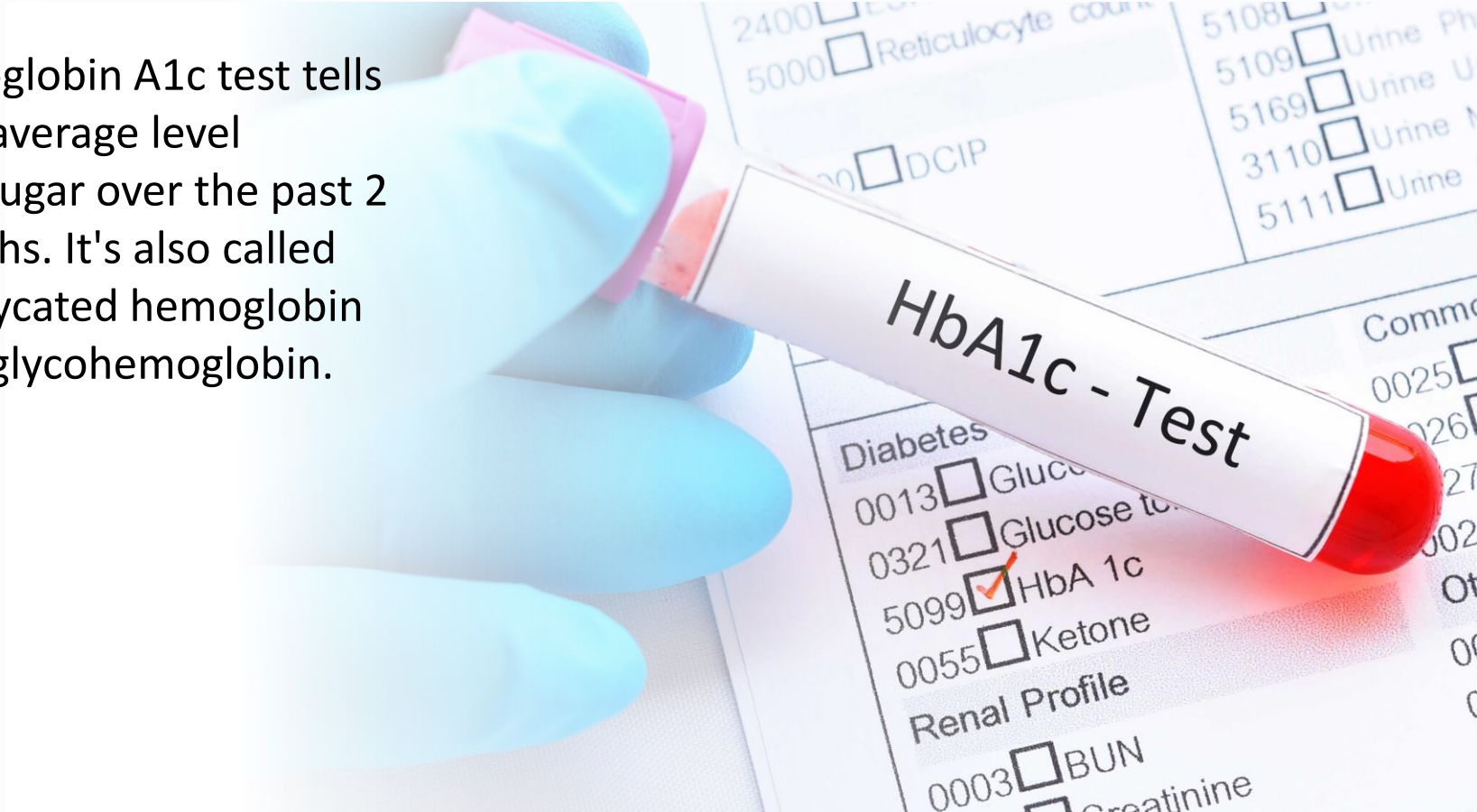
Alcohol Dehydrogenase (ADH)
Human ADH (left) and bacterial ADH (right)





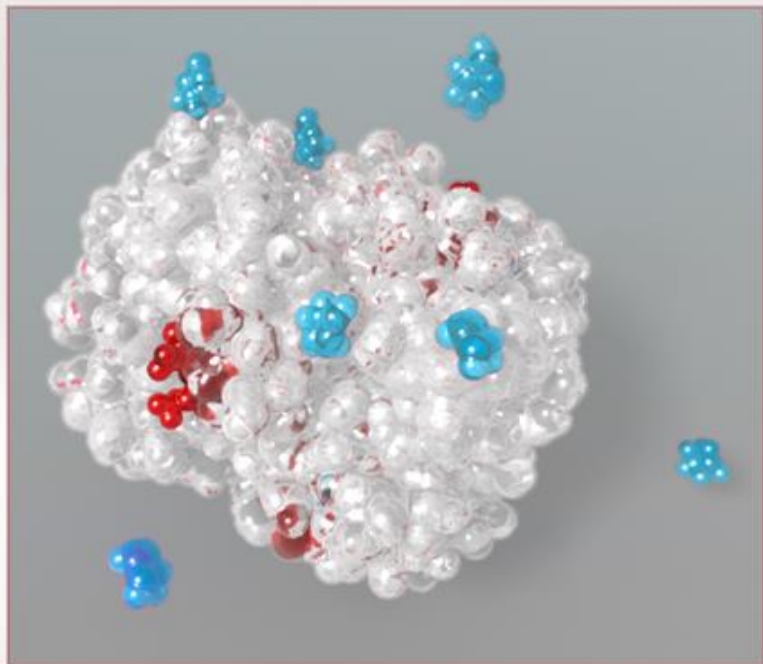
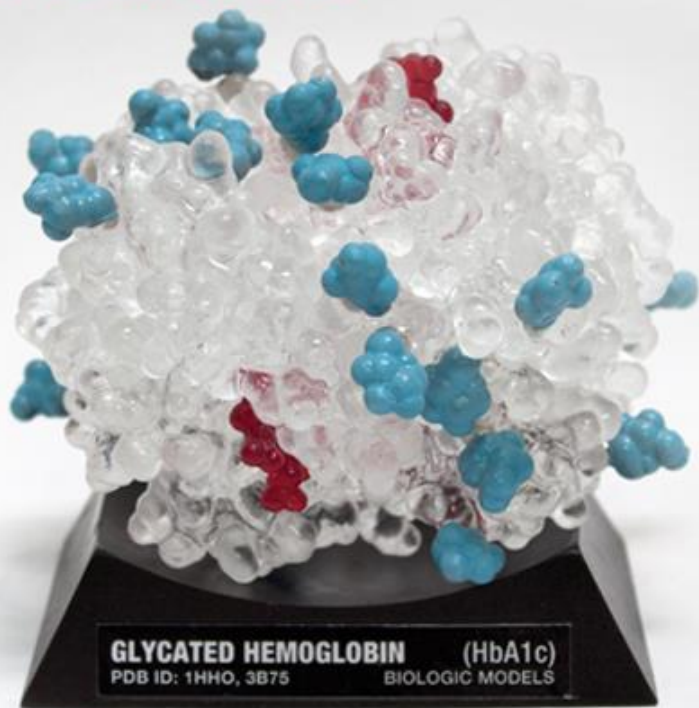
Testing blood sugar – HbA1c

The hemoglobin A1c test tells you your average level of blood sugar over the past 2 to 3 months. It's also called HbA1c, glycated hemoglobin test, and glycohemoglobin.

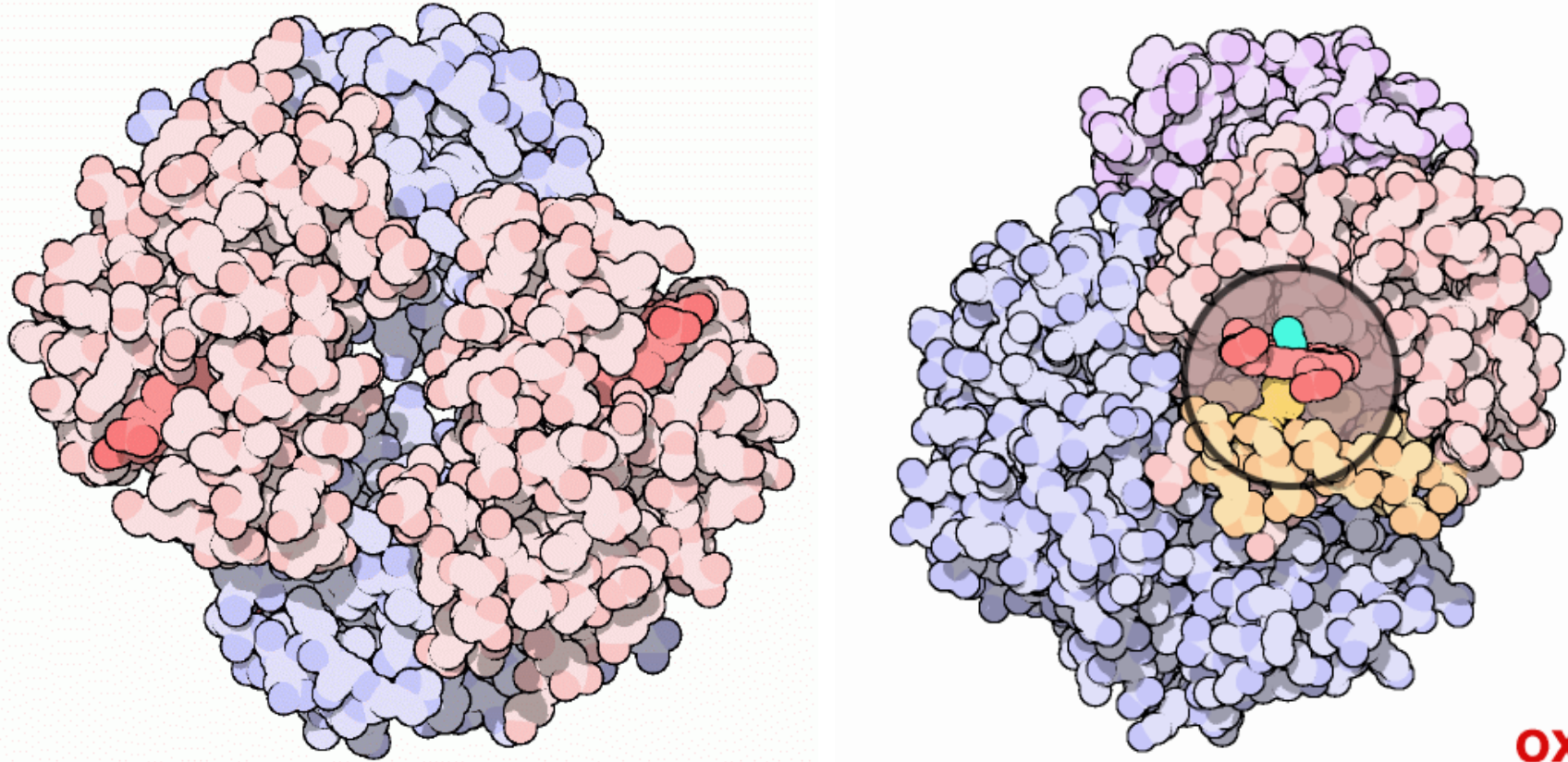


Glycated Hemoglobin HbA1c

PDB ID: 1HHO, 3B75

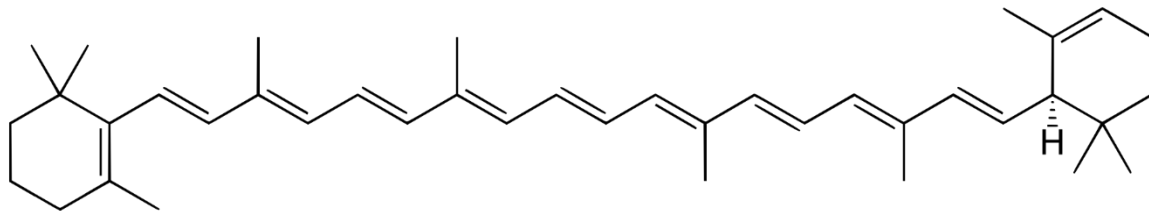
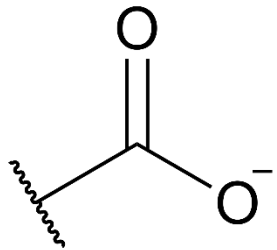


Hemoglobin – Molecule of the Month

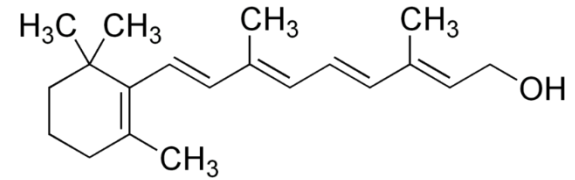
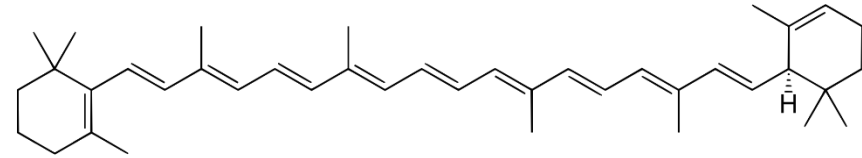
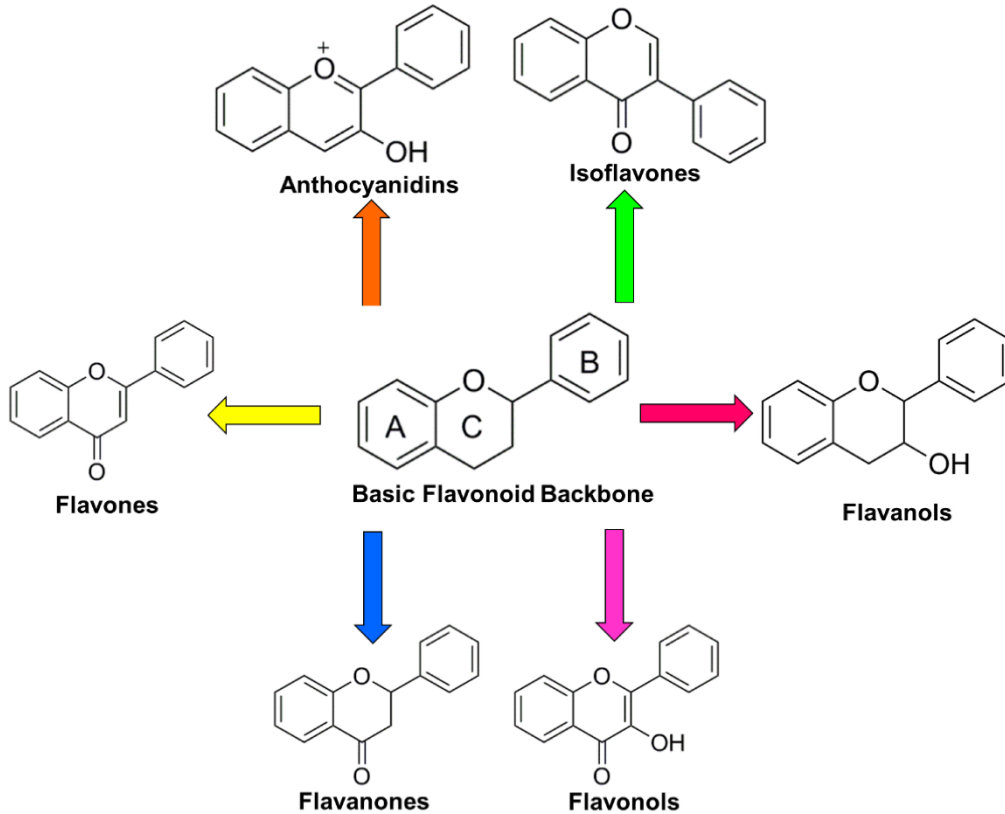


oxy

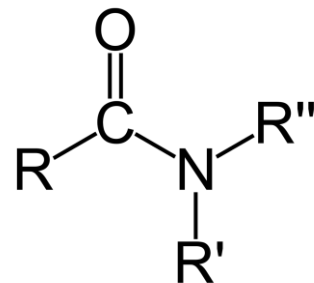
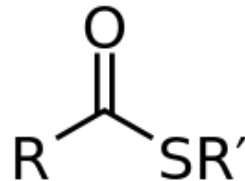
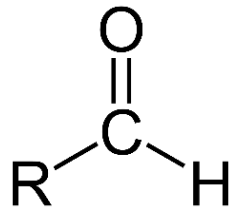
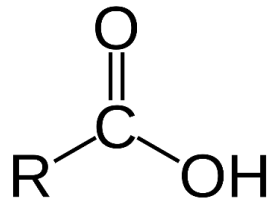
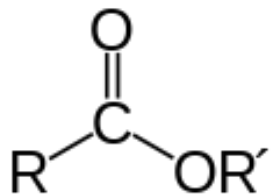
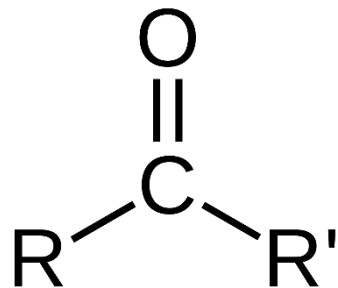
Resonance



Colorful Conjugated Systems



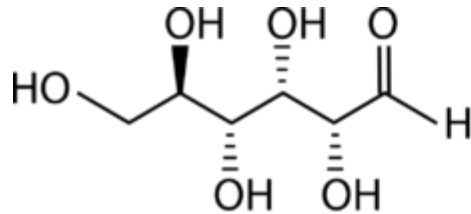
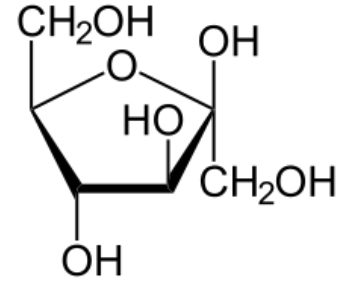
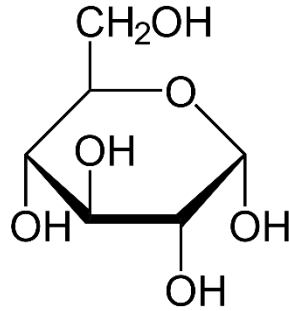
Carbonyls: Keys to the Kingdom



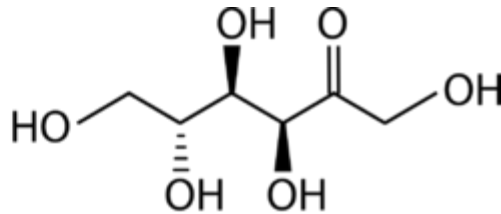
Nucleophiles vs Electrophiles

Attacking Carbonyls

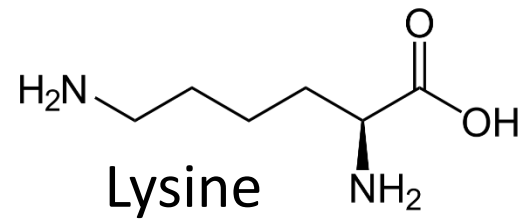
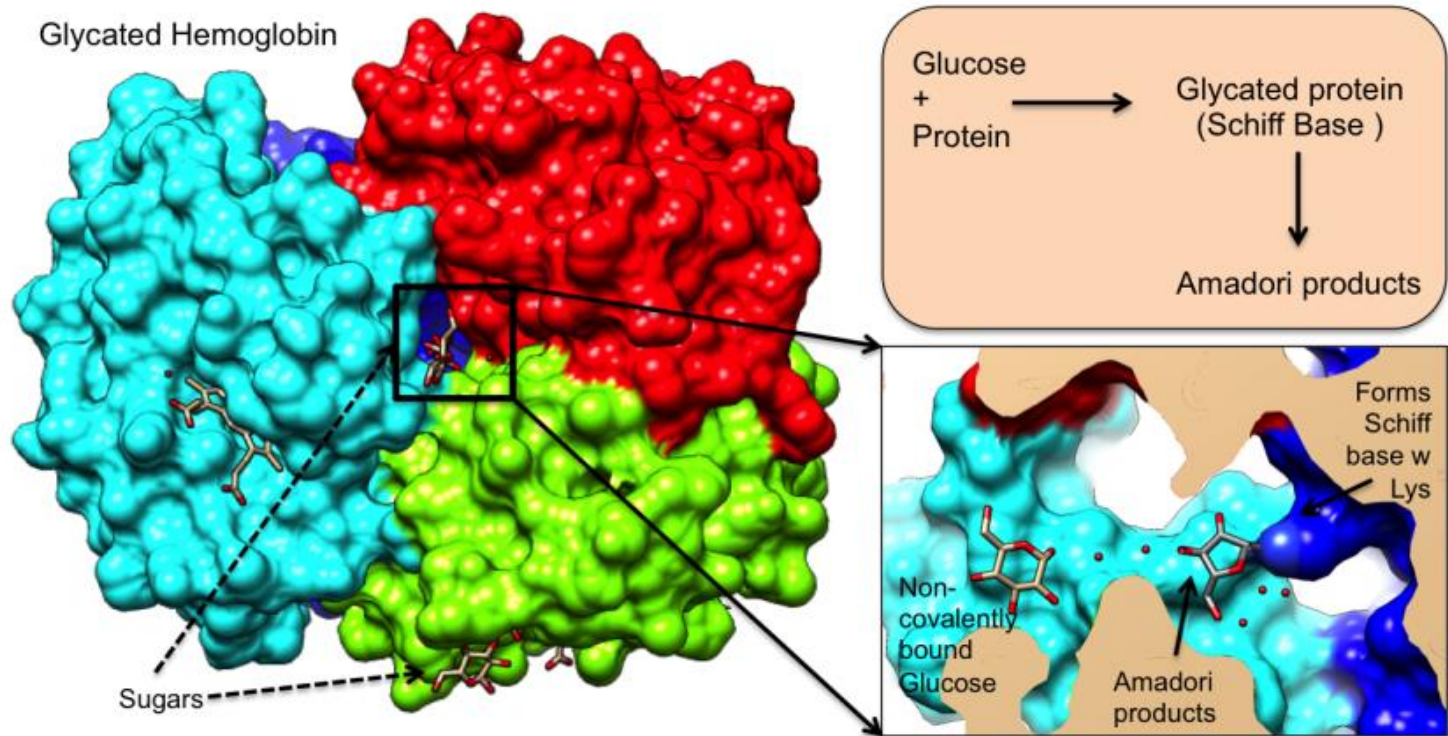
Anomeric Carbon



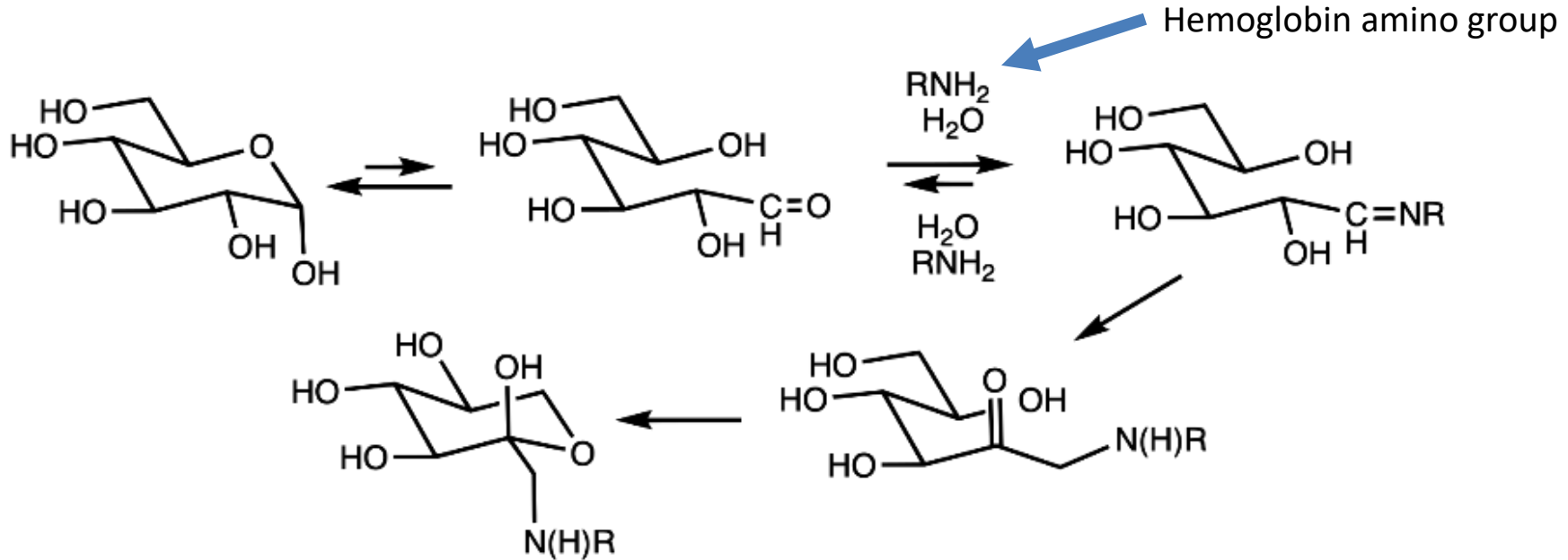
glucose



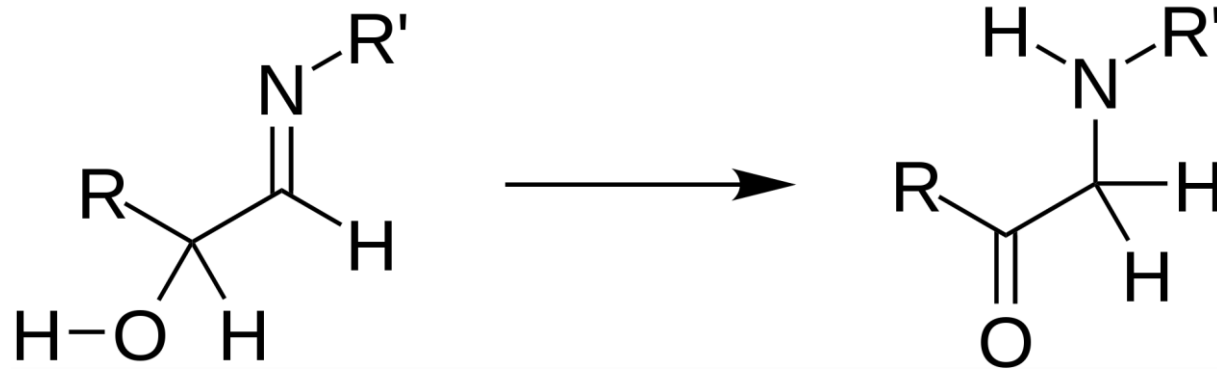
fructose



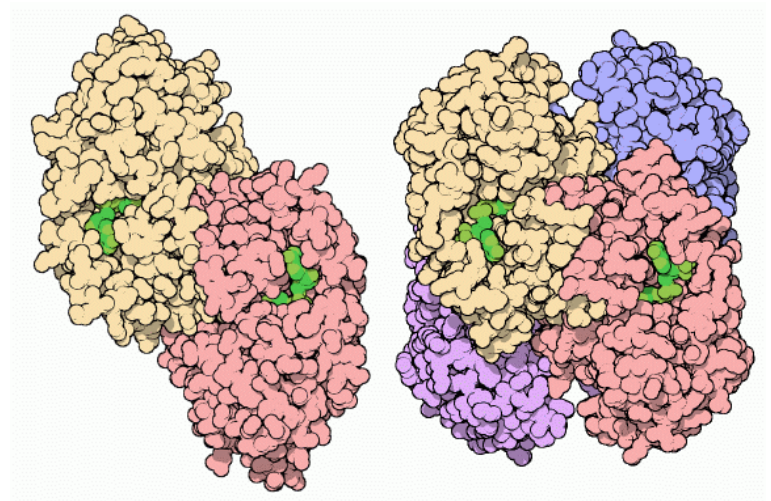
Hemoglobin Glycation



Amadori Rearrangement



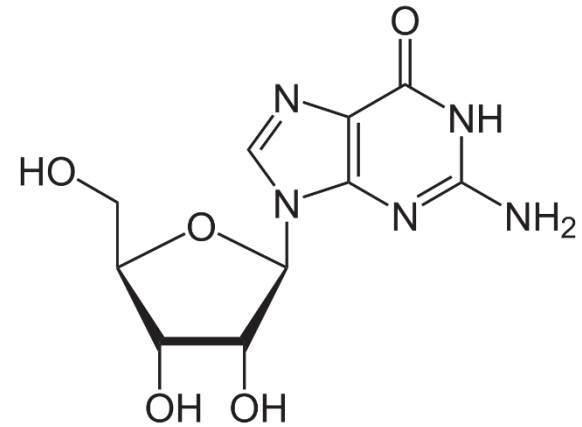
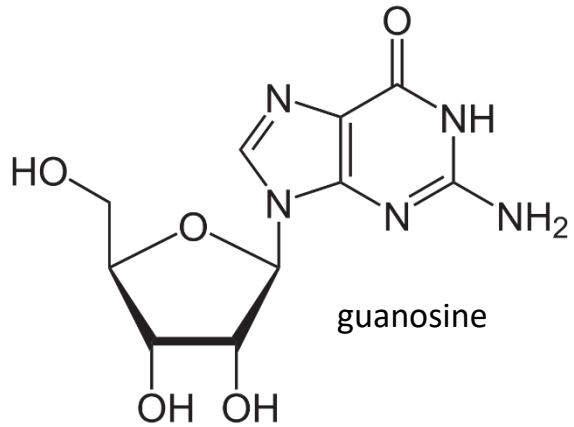
Alcohol Metabolism



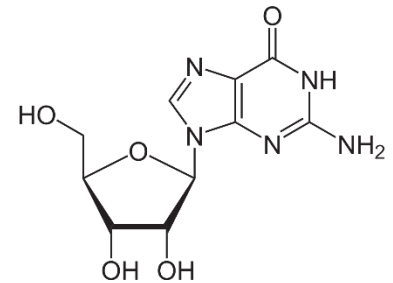
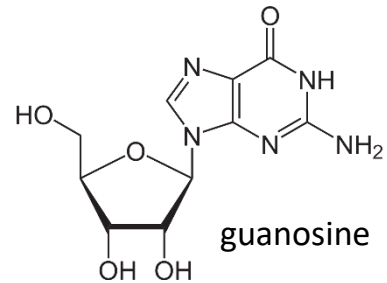
Human ADH (left) bacteria ADH (right)

<https://pdb101.rcsb.org/motm/13>

Aldehyde Alkylation



Acrolein Alkylation



Discovering Sulfur Mustard



In 1860, Francis Guthrie isolates the compounds and records its irritating properties, especially in tasting.



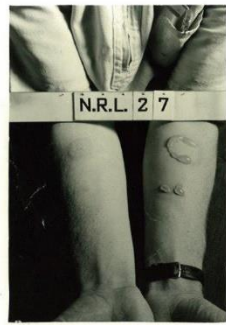
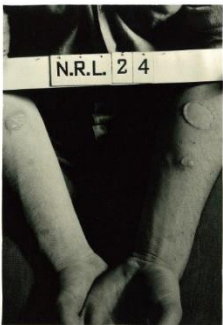
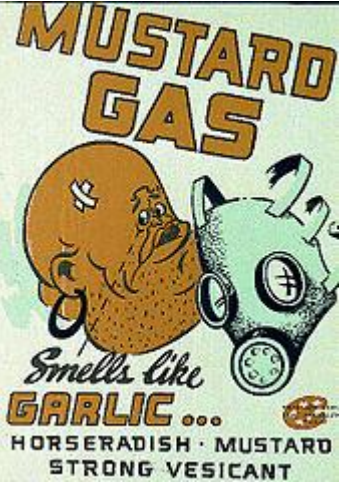
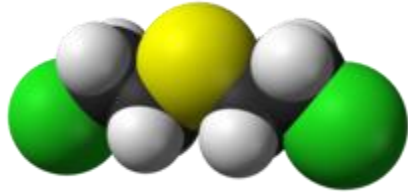
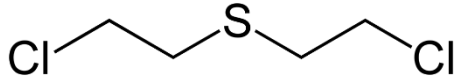
Also in 1860, Albert Niemann synthesizes and records blistering-effect of mustard



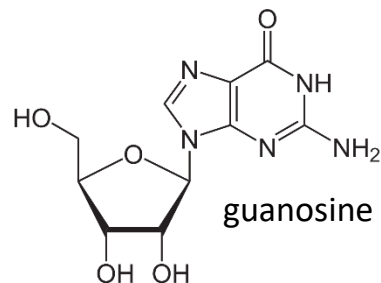
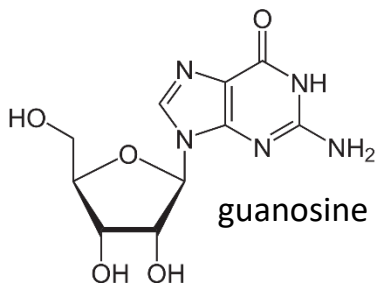
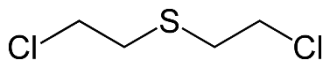
In 1886, Viktor Meyer produced sulfur mustard in high yield

Militarizing Sulfur Mustard

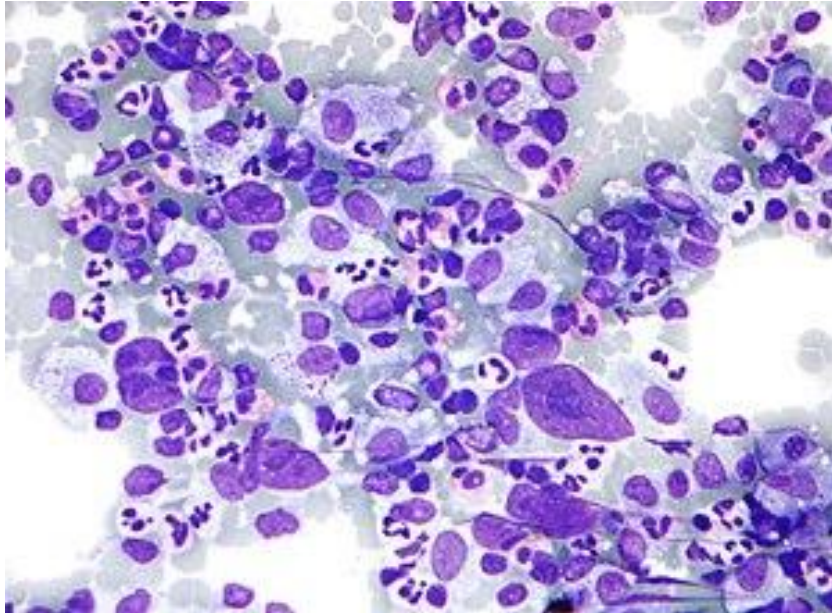
First use in 1917, Battle of Ypres.
Sometimes this chemical is called yperite.



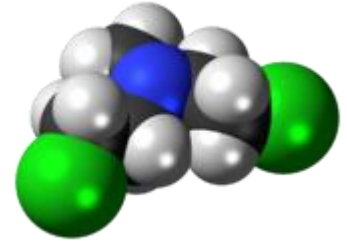
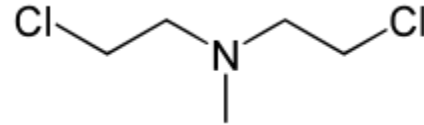
Chemical Mechanism of Sulfur Mustard



The first cancer chemotherapy drug



Hodgkin lymphoma (HL) is a type of lymphoma in which cancer originates from a specific type of white blood cells called lymphocytes.



In 1919, it became apparent that people exposed to mustard gas had decreased white blood cell counts.

In 1946, research on nitrogen mustards was declassified. Chlormethine became the first chemotherapy drug to be used in clinics.