Chemistry and Life

Life is impossible without chemistry

Biochemistry is the study of the chemistry of life

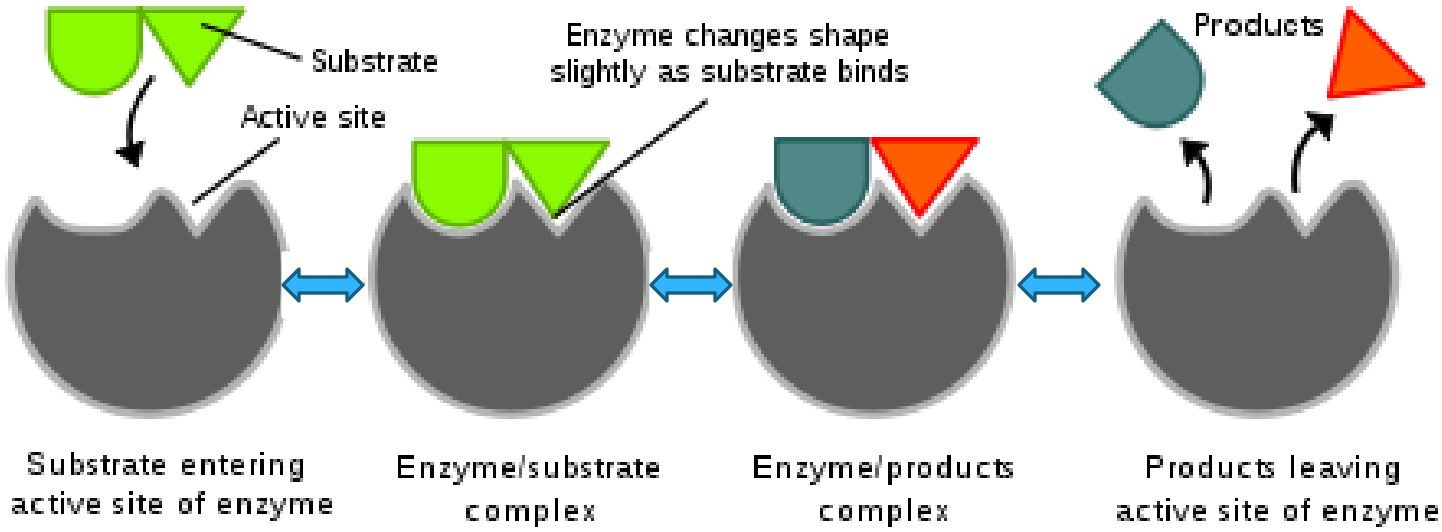
Atoms and molecules

* All substances are made up of ***atoms*** of the elements
* Such as hydrogen, oxygen, carbon and nitrogen, all of which are found in biological organisms
* These atoms are combined into ***molecules***, such as water H_2O, sugar $C_6(H_2O)_6$ and urea $CO(NH_2)_2$
* These molecules are three-dimensional in space
* Many ***biomolecules*** can be extremely complex and form long chain polymers, such as proteins, collagen and DNA

All chemical reactions that occur in the body can occur in a test tube

* The difference between life and a test tube is that proteins have evolved as enzymes to catalyze and speed up chemical reactions
* The way they do this is by bringing the compounds together in close proximity, thus enhancing their reaction

Diagram of enzyme action



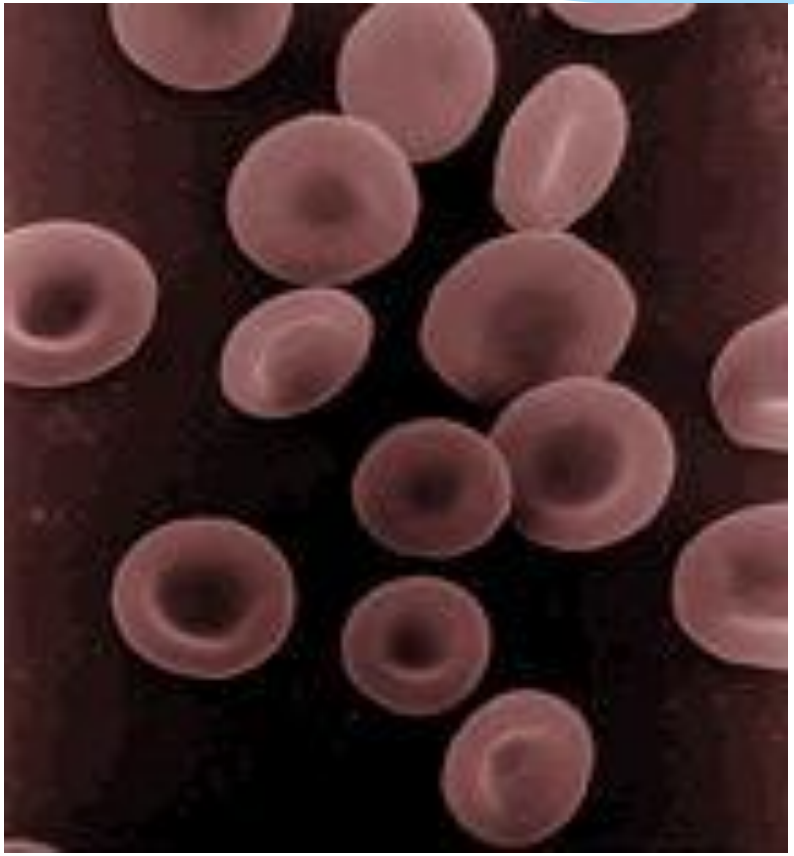
Most enzyme reactions are reversible

Common biological substances

* Proteins (enzymes and structural proteins)
* Carbohydrates (sugars)
* Fats (long-chain fatty acids)
* Nucleic acids (DNA and RNA)
* Co-factors (heme, hormones, growth factors)

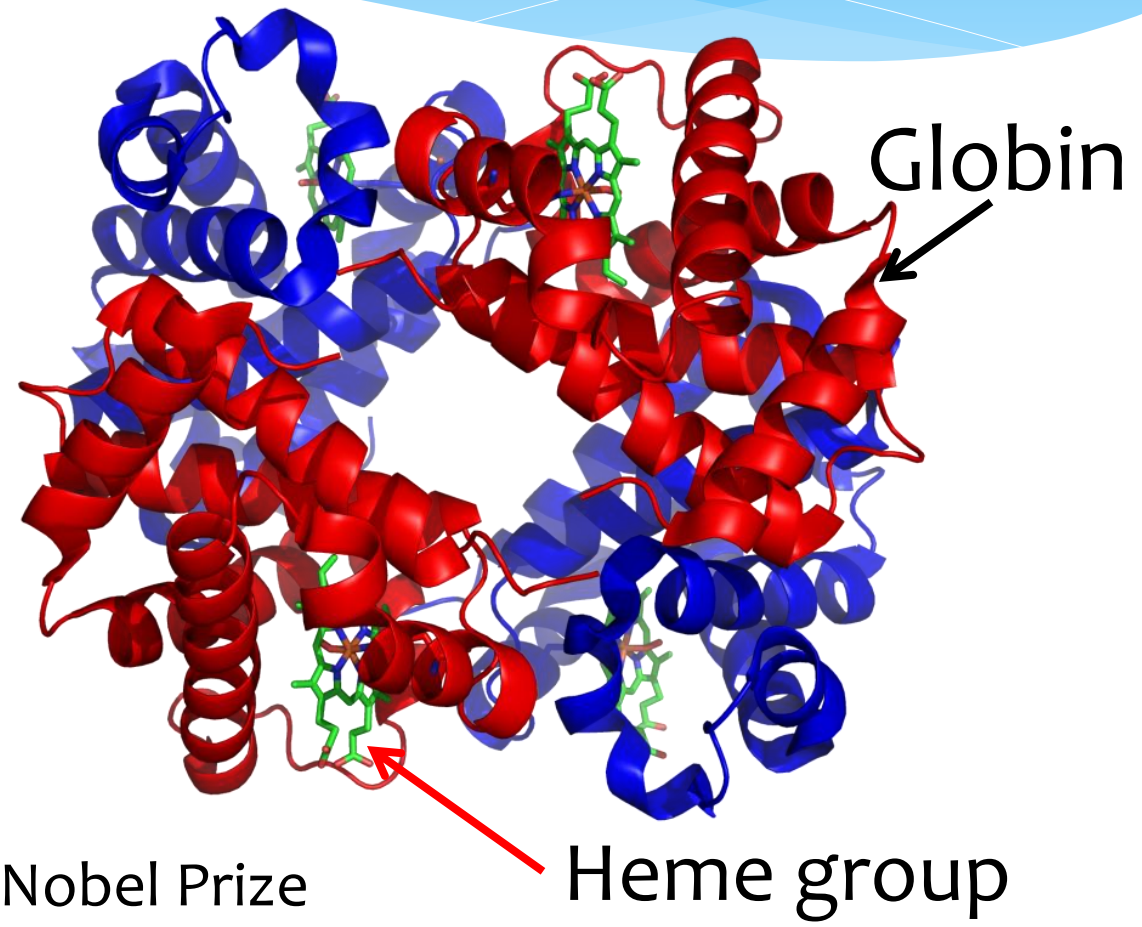
Blood contains red blood cells

The red blood cells get their red color from ***Hemoglobin***



The structure of hemoglobin

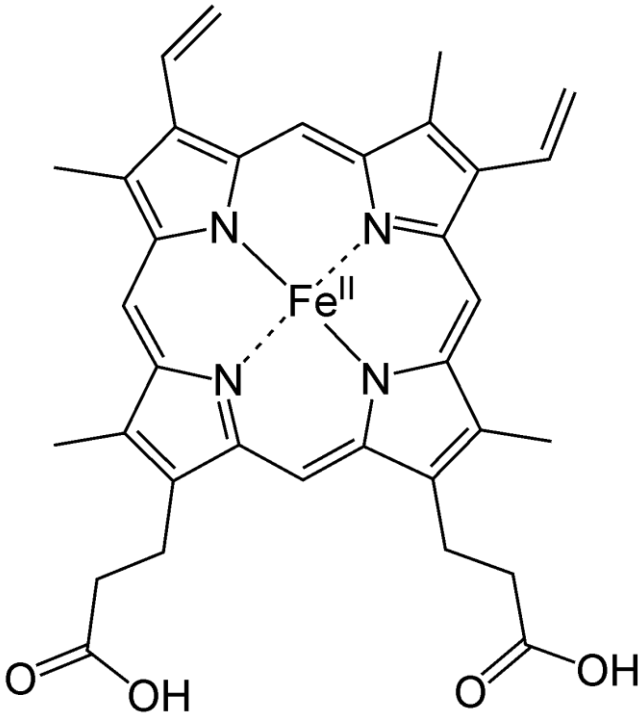
Hemoglobin consists of a complex between two kinds of globin proteins and heme groups



Structure determined in 1959 by Max Perutz for which he won the Nobel Prize

The heme group

The red color actually comes from a complex between a ***porphyrin*** ring and an ***iron atom*** to form the ***heme*** group that is red. This group binds oxygen



Mutations of hemoglobin I

* A single mutation of ***heme*** synthesis partially resulted in the independence of the USA
* It causes the genetic disease of ***Porphyria***, that caused King George III to go mad and urinate red urine

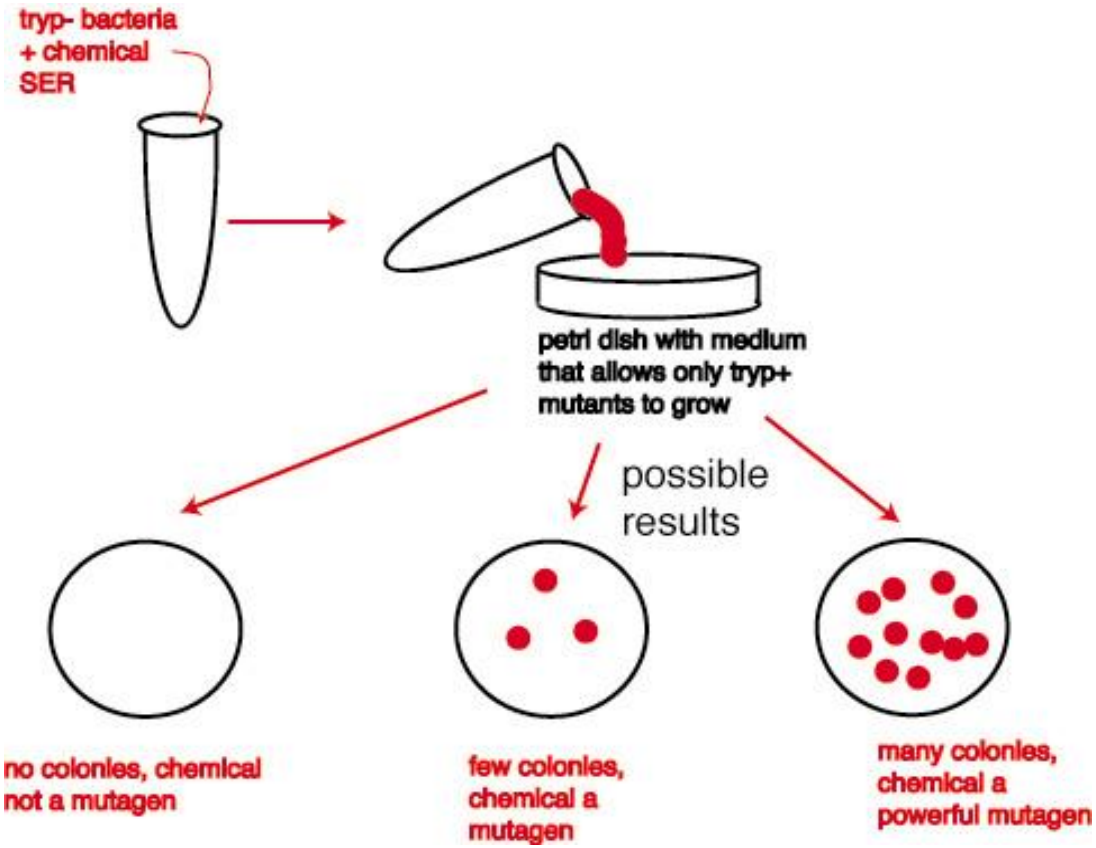
Mutations of hemoglobin II

* A single mutation in the ***globin*** portion was recognized by Linus Pauling as the first genetic disease
* It affects the binding of the α–β dimers and causes them to form long stacks and results in ***Sickle Cell Anemia***

The Ames Test

* In 1986 Bruce Ames at Cal Tech devised the ***Ames test for mutagenicity***
* This works as follows: *Take a bacterium that has a mutation that prevents it growing. Add a mutagen that causes mutations. Eventually this will cause a reversal of the mutation, allowing the bacteria to grow. Then count colonies*
* This gives a measure of ***mutagenicity*** which is equivalent to carcinogenicity

Diagram of Ames Test



The Ames test applied to food

* When the Ames test was applied to many food substances it was found surprisingly that the most mutagenic/ carcinogenic food was ***peanut butter*** !
* This was shown to be due to a specific toxic substance named ***Aflatoxin***

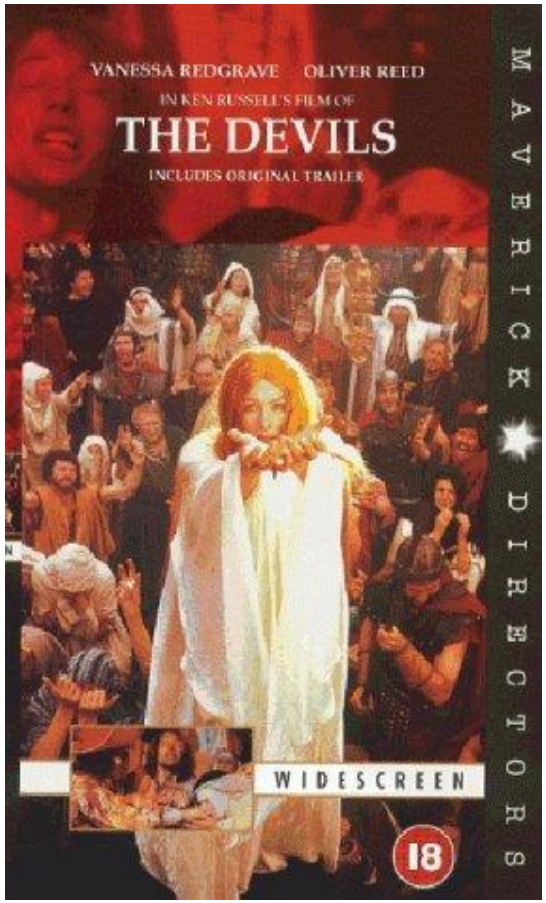
Peanut husks contain aflatoxin

The peanut husk has a white fungus growing on it – *Aspergilius flavus*, that contains the Aflatoxin. When the peanuts are stored in damp conditions more fungus grows

The Devils of Loudun

* In 1632 a famous incident of ***mass hysteria*** occurred in the central French town of Loudun
* The whole town went mad and the nuns accused their priest of rape, there was a trial that was even attended by the Dauphin
* Since we have a transcript of the trial the incident is well documented and was the subject of a book by Aldous Huxley (1953) and a movie directed by Ken Russell (1972)

A notorious story



The priest Father Grandier was tried, tortured and burnt on the grounds that he was an agent of the Devil!

This was a notorious story that has lasted for centuries and the film itself was banned in many countries

The origin of the mass hysteria?

* A natural explanation of the mass hysteria is that the town had one granary and the year before was very rainy.
* It is now known that when wheat is stored in wet conditions a specific fungus grows that produces ***lysergic acid (LSD)***
* ***So the whole town was high on LSD from bread, a medieval Woodstock!***

Conclusion

* Chemistry has a direct impact on all our lives both as an integral part of life itself and as a result of unexpected and sometimes surprising outcomes of genetic or environmental conditions