Porphyrins
Structure & Function

By lecturer:

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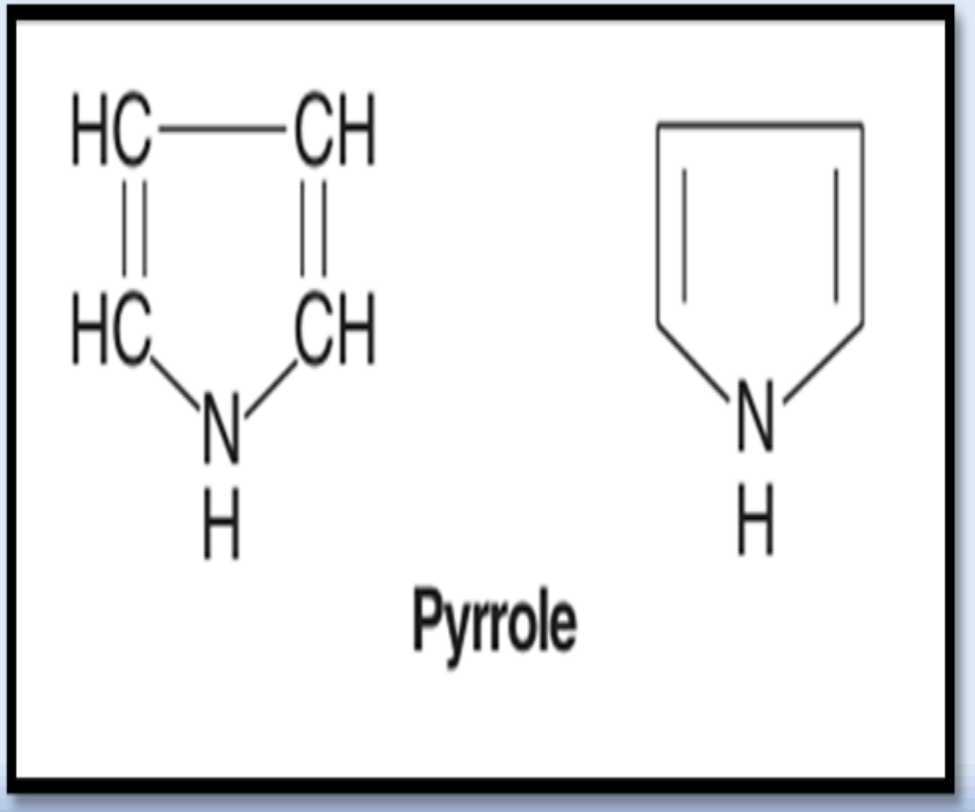
Porphin

- **Porphin:** is a cyclic compound formed by the linkage of 4 **pyrrole rings** (1, II, III and IV) through **methenyl bridges** (-CH=).

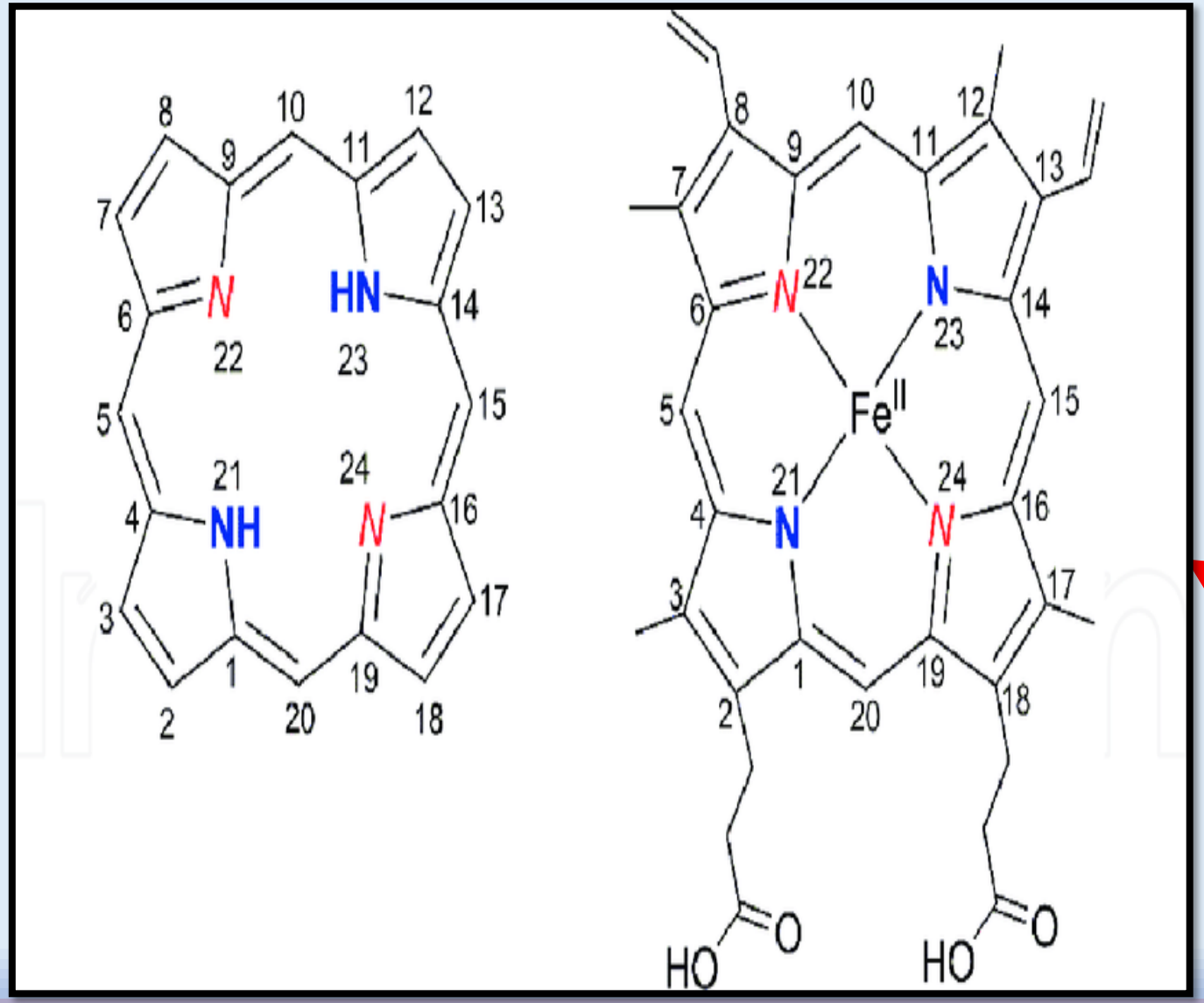


Porphyrins

- **Porphyrins:** are cyclic compounds composed of **4 pyrrole rings** held together by **methenyl (-CH=) bridges** + **Metal ions**
- Porphyrins absorbing light strongly in the visible spectrum and having deep colors (the name comes from the Greek word for "purple").

Porphin & Porphyrins

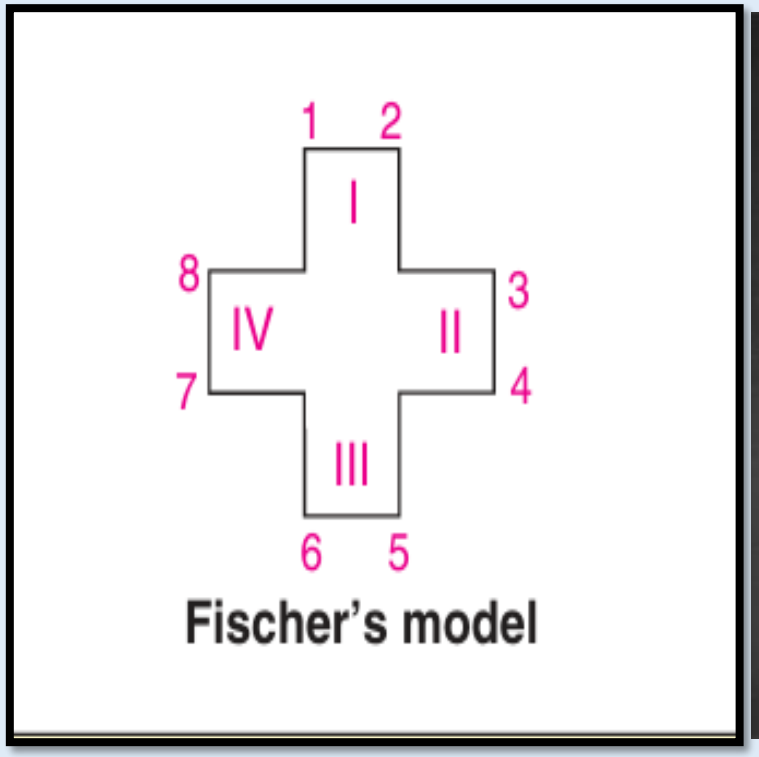
Porphin



Porphyrin

Porphyrins structure

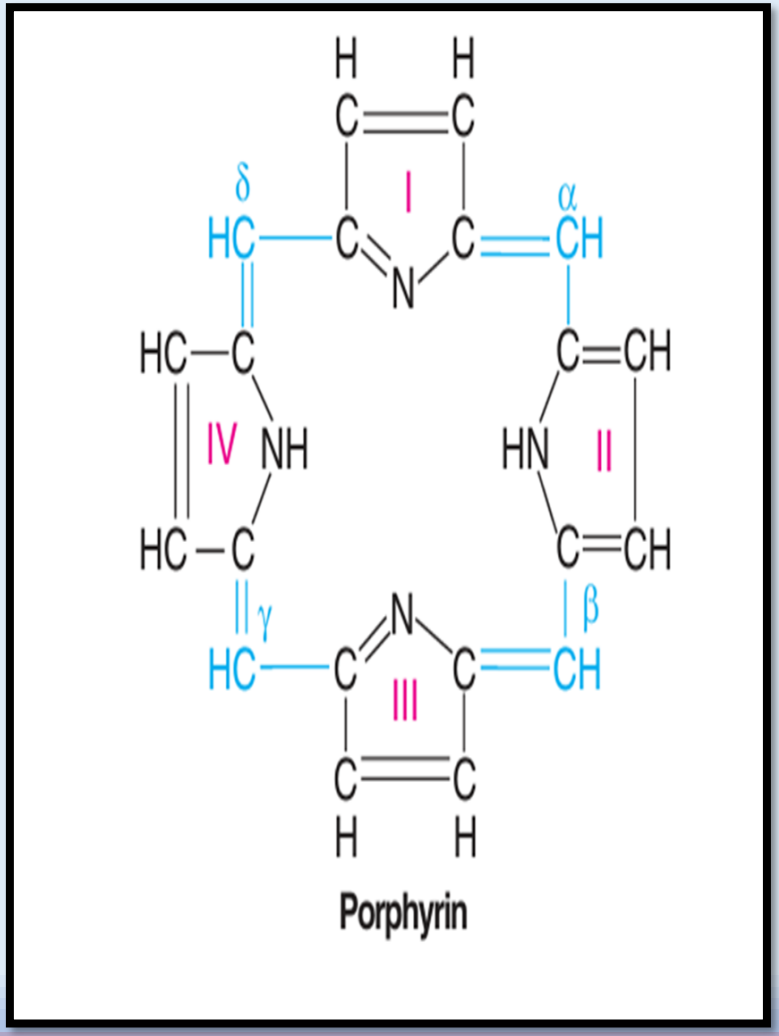
- Hans Fischer, the father of porphyrin chemistry, proposed a shorthand model for presentation of porphyrin structures.





Porphyrins structure

- The structure of porphyrins ($C_{20}H_{14}N_4$) has four pyrrole rings namely (I, II, III and IV).
- Porphyrins differ from each other in the type and arrangement of side chains attached to numbered positions.



Porphyrins structure

The side chains which may be substituted in numbered positions are:

1. A = Acetate = -CH2-COOH

2. P = propionate= -CH2 -CH2 -COOH

3· M = Methyl = -CH3

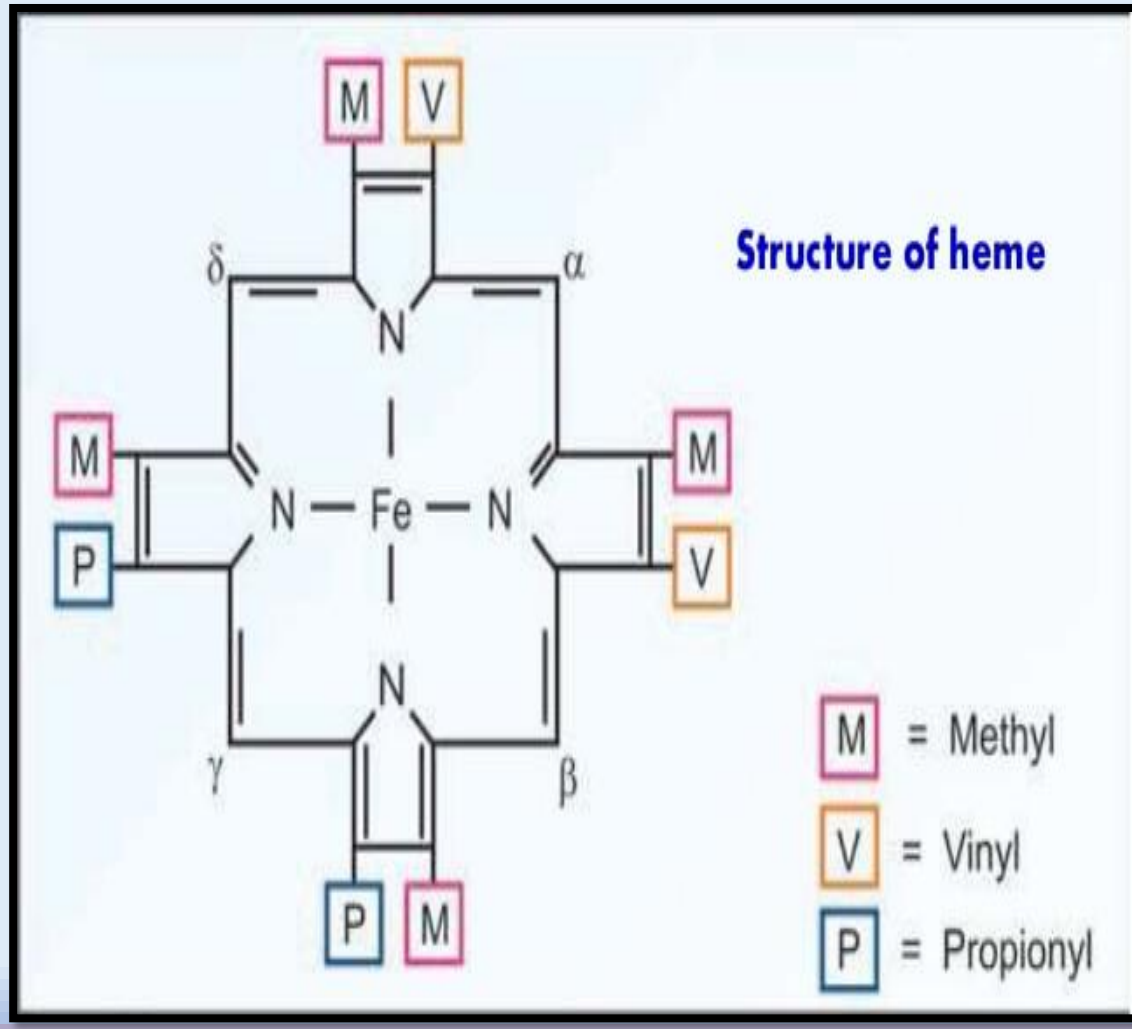
4· V = Vinyl = -CH=CH2

Porphyrins functions

- **Oxygen transport:** Hb
- **Photosynthesis**: Chlorophyll, mg-containing porphyrin (plants pigment)
- **Electron carrier**: prosthetic groups in cytochromes facilitate electron transfer.
- **Enzyme catalysis**: part of active site of the enzymes
- **Vitamin B-12 synthesis**: cobalt-containing porphyrin derivative is a key part of vitamin B-12

Structure of heme

- Heme is an iron-containing porphyrin, a complex of one of porphyrins called: protoporphyrin IV + iron (in ferrous state, Fe++} and iron is held in the centre of heme molecule by bonds to the 4 nitrogen atoms of protoporphyrin of pyrrole rings



Haemoproteins

- These are a group of specialized proteins that contain heme as a prosthetic group.

a) Hemoglobin.

b) Myoglobin.

c) Respiratory cytochromes.

d) Cytochrome P450.

e) Catalase and peroxidase.

f) Tryptophan oxygenase.

Cytochromes

- The cytochromes are conjugated proteins containing heme group.
- Consists of a porphyrin ring with iron atom.
- The heme group of cytochromes differ from that found in the structure of hemoglobin and myoglobin.

Cytochromes

- The iron of heme in cytochromes is alternately oxidize (Fe2+ ⟷ Fe3+) and reduce (Fe3+ ⟷ Fe2+), which is essential for the transport of electrons in the ETC.
- This is in contrast to the heme iron of hemoglobin and myoglobin which remains in the ferrous (Fe2+) state.

Discovery of cytochromes

- **Three cytochromes were initially discovered from the mammalian mitochondria.**

Types of cytochromes are :

1. **Cytochrome a**
2. **Cytochrome b**
3. **Cytochrome c**

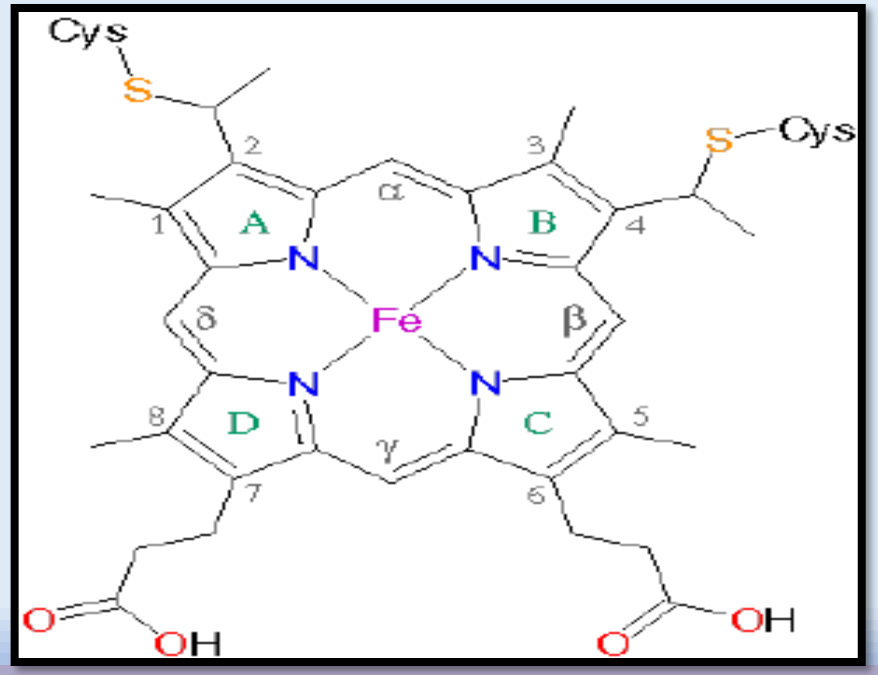
Functions of Cytochromes

- The property of reversible oxidation- reduction of heme iron

$Fe^{2+} \longleftrightarrow Fe^{3+}$ present in cytochromes allows them to **function as effective carriers of electrons in ETC.**

Cytochrome C

- It is a central member of ETC with an intermediate redox potential.
- Loosely bound to inner mitochondrial membrane and can be easily extracted.
- **In cytochrome c:** Protein is attached to the heme by **covalent bond**



Cytochrome a and a3

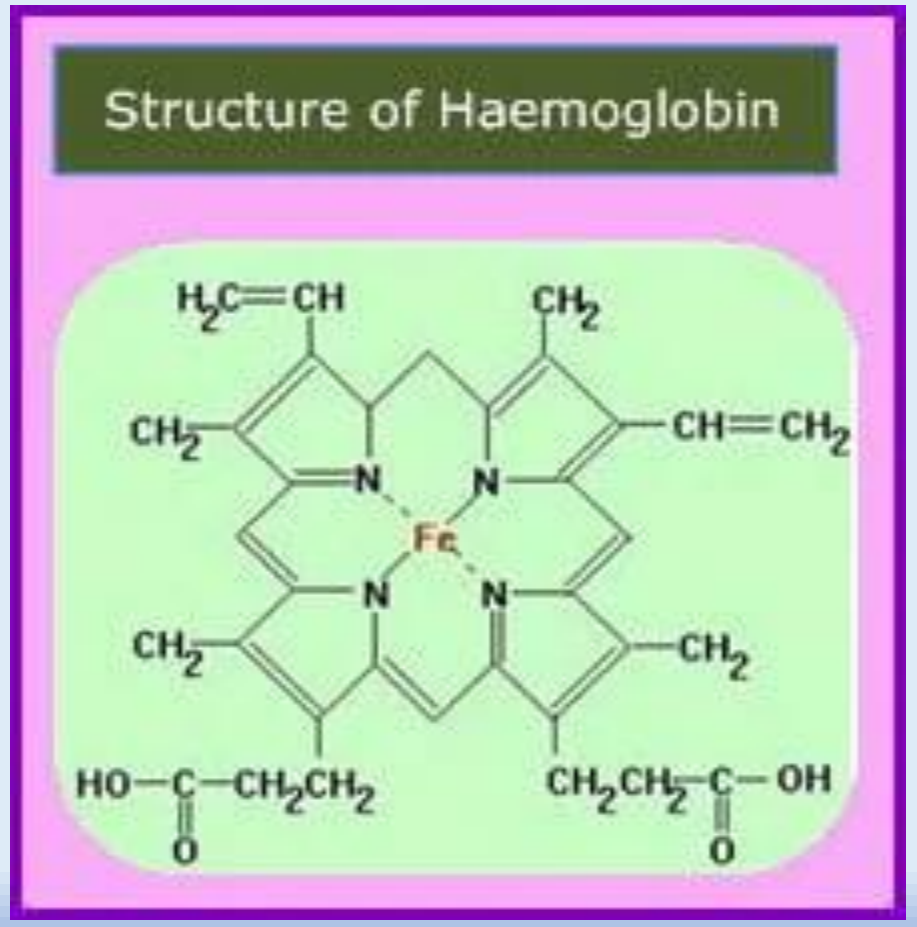
- **Cytochrome oxidase represent cytochrome a and a3 (**the terminal component of ETC).
- **Cytochrome oxidase is the only electron carrier**, the heme iron of which can directly react with molecular oxygen.
- Besides heme (with iron), this oxidase also contains **copper** that undergoes oxidation reduction (Cu2+ ⟷ Cu+) during the transport of electrons.

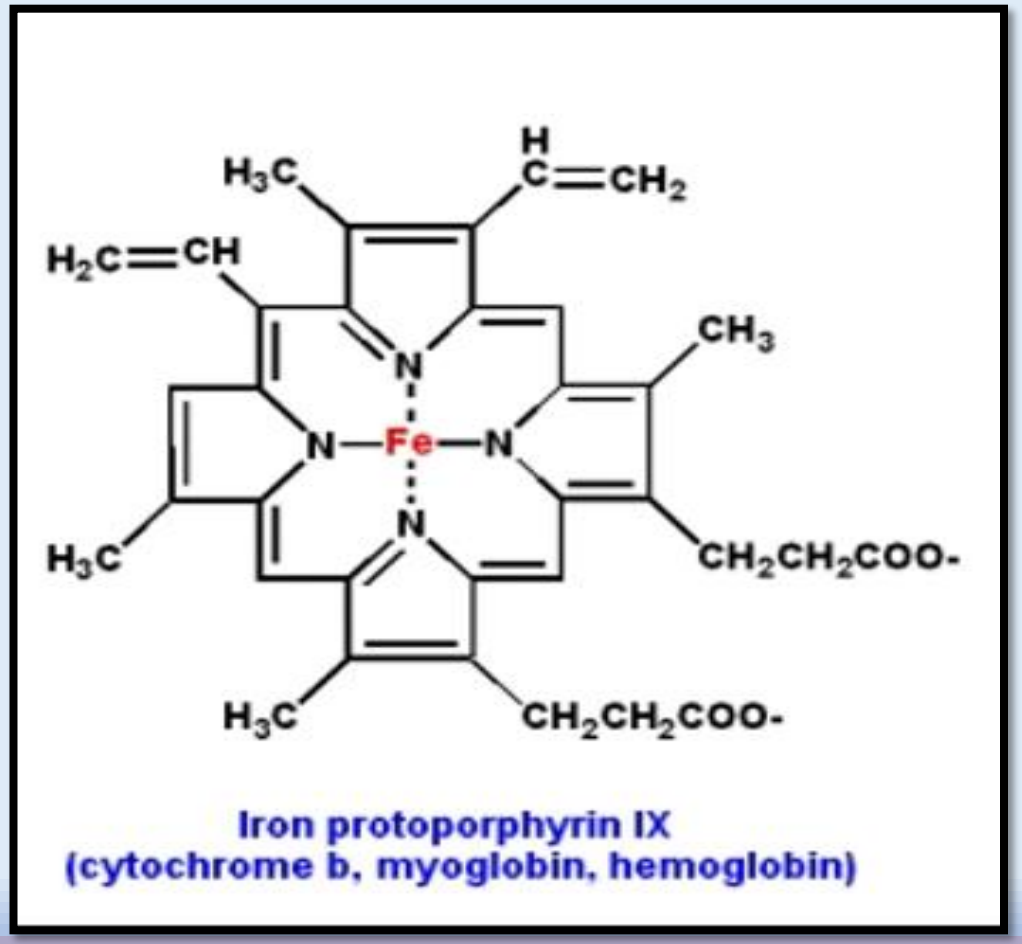
Cytochrome a and a3 function

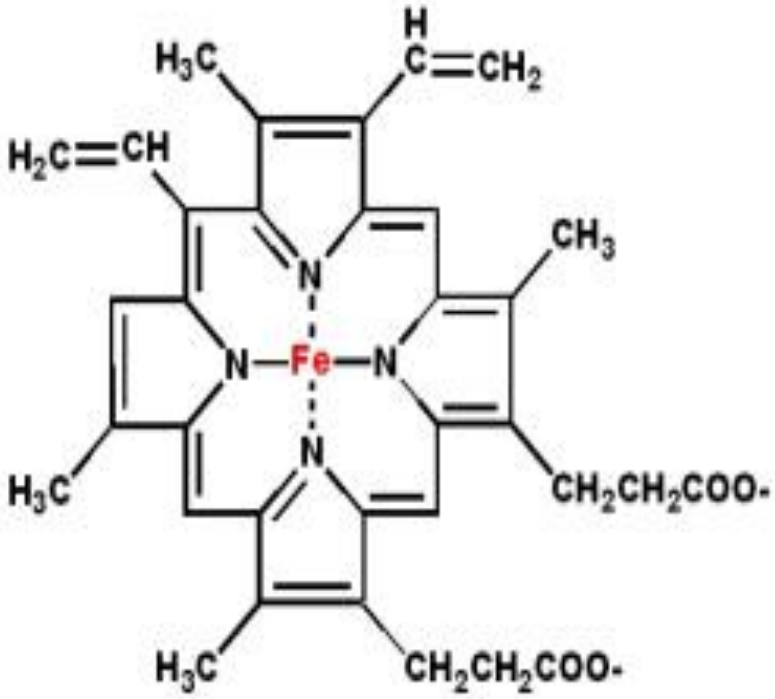
- Cytochrome oxidase, the terminal component of electron transport chain, **transfers electrons** (obtained from the oxidation of substrate molecules) **to the final acceptor, oxygen to** form **water.**

Cytochrome b

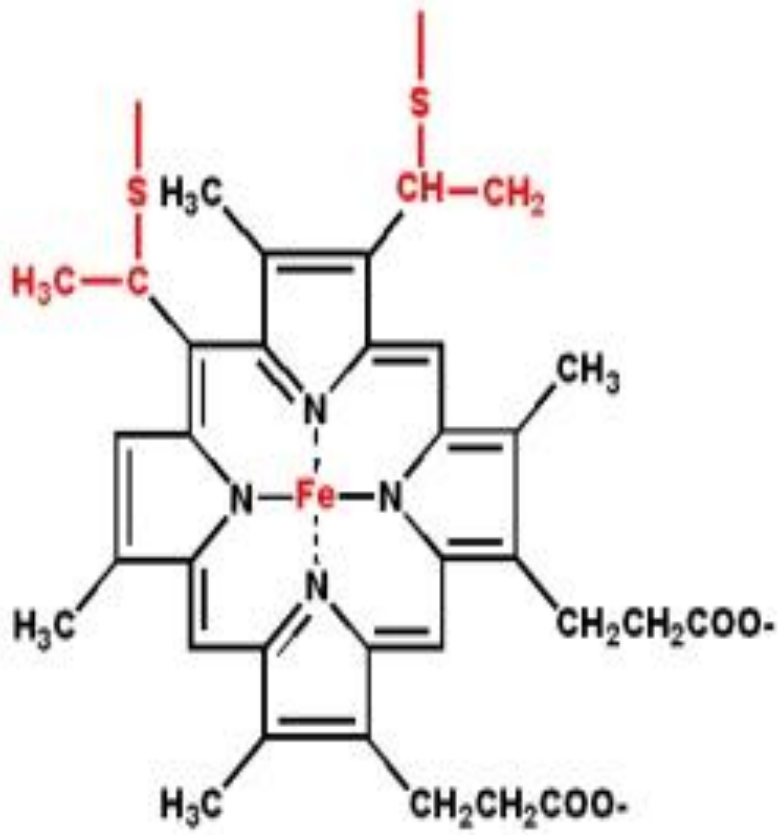
- The heme group is similar to hemoglobin and myoglobin.



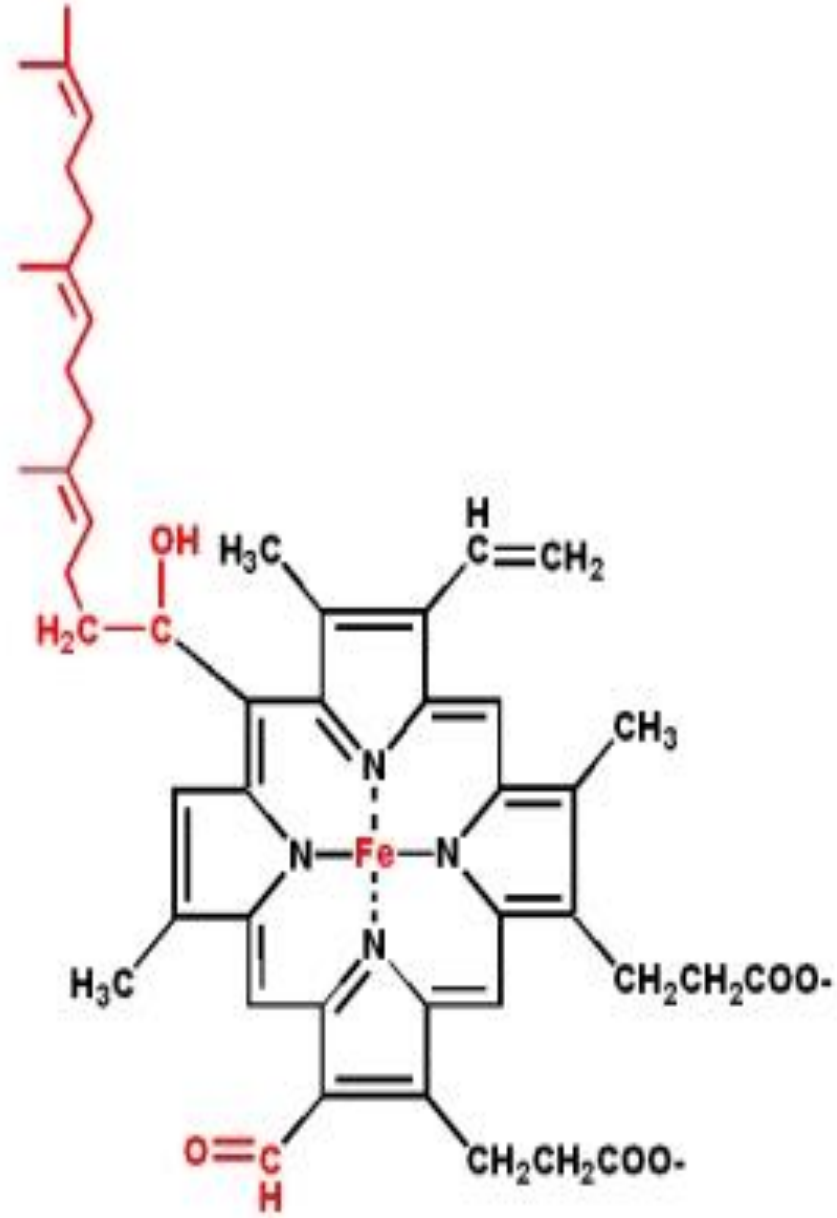




Iron protoporphyrin IX
(cytochrome b, myoglobin, hemoglobin)



Heme C
(cytochrome c)



Heme A
(cytochrome A)


THANK
YOU