GLOBULAR PROTEINS

Color index:

- Important
- Extra explanation

"LIVE A LIFE YOU ARE PROUD OF"

Hemoglobin Structure:

This slide is Extra ..

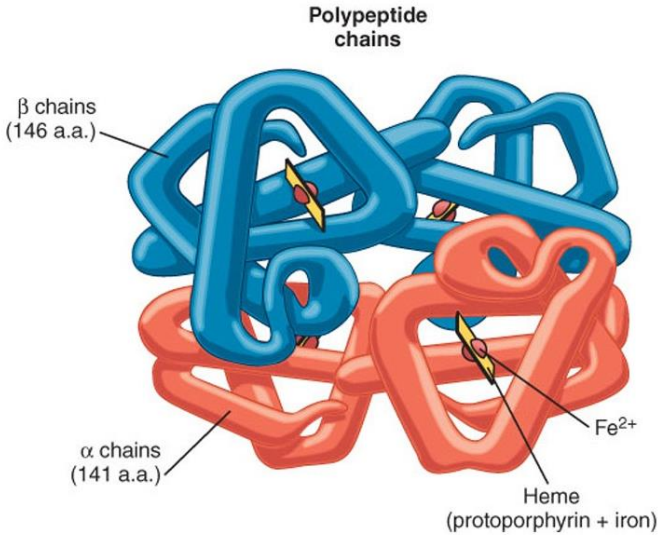
Hemoglobin A structure:

Composed of four polypeptide chains (two α chains and two β chains) and 4 Heme groups:
One α chain and one β chain held together by covalent bond to form DIMER, two Dimers (α and β subunit) held together by non-covalent interaction.

Hydrophobic amino acid residues are localized not only in the interior of the molecule, but also in a region on the surface of each subunit. Multiple interchain hydrophobic interactions form strong associations between α-subunits and β-subunits in the dimers.

Note:

-Covalent bond is stronger than non-covalent
-Non-covalent could be Ionic or Hydrogen bond



HEME STRUCTURE:

This slide is Extra ..

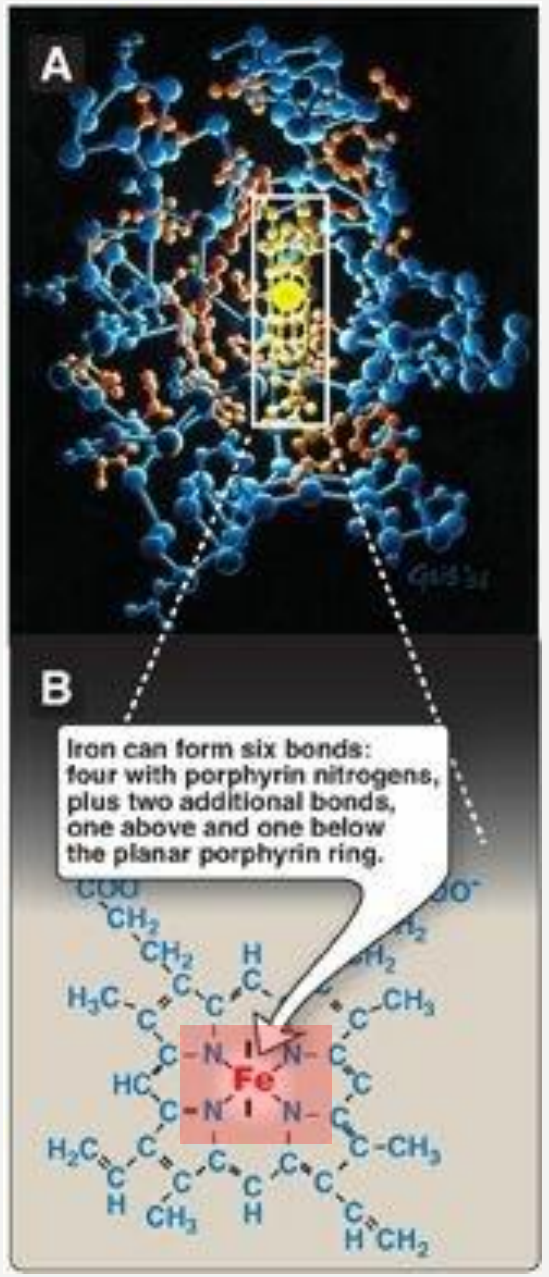
Heme is a complex of protoporphyrin IX and ferrous iron (Fe^{2+}).

Portoporphyrin IX in metabolism of porphyrin created by protoporphyringen oxidase, porphyrins are cyclic compounds that readily bind to metal ions, Ferrous is the+2 oxidation state of Iron, while Ferric is the +3 oxidation state of Iron.

Iron:
can form 6 bonds

Is held in the center of the heme molecule by bonds to the four nitrogens of the porphyrin ring.

Can form **two additional bonds**, one on each side of the planar porphyrin ring, one of these positions is coordinated to the side chain of a histidine residue of globin , whereas the other position is available to bind oxygen.



Note:
Each heme attached to 1(O2) molecule

OBJECTIVES:

- ✓ To describe the globular proteins using common examples like hemoglobin and myoglobin.
- ✓ To study the structure and functions of globular proteins like:
  - Hemoglobin (a major globular protein)
  - Myoglobin, and
  - g-globulins (immunoglobulins)
- ✓ To know the different types of hemoglobin and difference between normal and abnormal hemoglobin.
- ✓ To understand the diseases associated with globular proteins.

Globular proteins

- **What are globular proteins ?**

- Proteins which their Amino acid chains are folded into shapes that resemble "spheres".

- **Benefit of that folding :**

That type of folding increase the solubility of proteins in water.

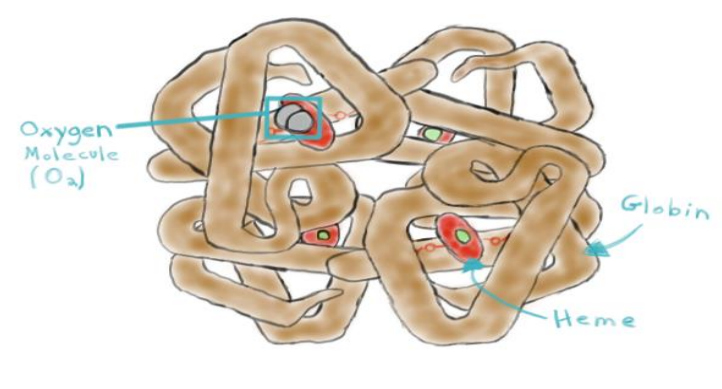
- Polar groups → on the protein's surface
- Hydrophobic groups → in the interior

Note: Fibrous protein : are mainly insoluble structural proteins. *Found in muscles and bone matrix.

Examples

- **Hemoglobin** → - oxygen transport function.
- **Myoglobin** → - oxygen storage/supply function in heart and muscle.
- **α1, α2, β-globulins** → - various functions.
- **γ-globulins (immunoglobulins)** → - immune function.
- **Enzymes** → - catalysis of biochemical reactions.

Hemoglobin: A major globular protein in humans



Heme is the non- protein part of the hemoglobin

١-الهيموجلوبين يتكون من أربعة سلاسل polypeptides :2B و 2a.
٢-كل سلسلة تحتوي على مجموعة هيم مرتبطة بالحديد(+٢ Ferrous-Fe).
٣-كل سلسلة a ترتبط بسلسلة B و تكون جزيء نسميه dimer
٤- وسط كل dimer يوجد مجموعة الهيم المرتبطة بالحديد(بيكون وسط الهيم)
٥- ترتبط سلسلة a بسلسلة B عن طريق interactions hydrophobic
٦- يرتبط dimer ب dimer آخر عن طريق bond non-covalent

Dimer

Ferrous — Heme — a — hydrophobic bond — B — Heme — Ferrous
(intradimer bond)

strong

Ionic and hydrogen bonds
(interdimer bond)

weak

Dimer

Ferrous — Heme — a — hydrophobic bond — B — Heme — Ferrous
(intradimer bond)

strong

Notes:

- Each Hemoglobin has 2 dimers. Each dimer consist of 1 a chain an 1 B chain.
- Between the two dimers of Hb (interdimer bonds) → non covalent(ionic,hydrogenic).
- Hb consists of 2 parts : Heme group + globin chains(a or B)

HEMOGLOBIN

Function of Hb:

Carries oxygen from the lungs to tissues

↓

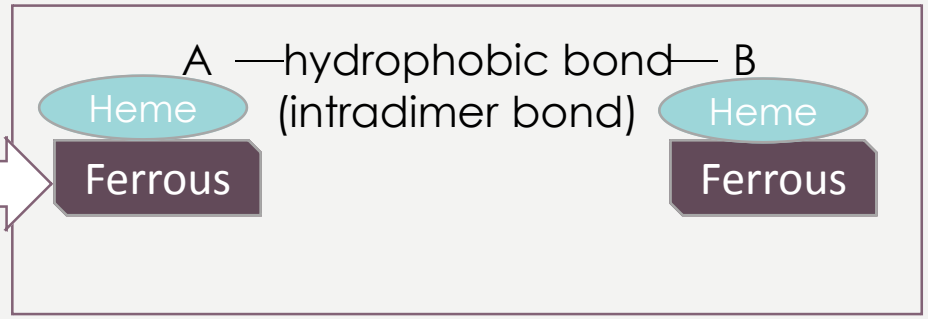
Carries carbon dioxide from tissues back to the lungs (not the main way of delivering the co2 to the lung)

Normal HB Range (g/dL):

- Males: 14-16
- Females: 13-15

Oxygen binds to iron in each globin chain.
Since we have 4 globin chains = 4 iron molecules = 4 oxygen atoms can bind

تكافؤ الحديد 6 . يمكنه الارتباط ب6 ذرات.
4 روابط ترتبط بالهيم (تحديدا protopophyrin)
ويبقى رابطتين ، رابطة ترتبط بالهستدين من القلوبين
ورابطة ترتبط مع الاكسجين.



Note:

-Each Hb can carry 4 oxygen molecules while each myoglobin can carry 1 oxygen molecule.
-**Hb that carry oxygen** appears red and called oxyhemoglobin.
-**Hb that doesn't carry oxygen(but co2)** appears blue and called carbahemoglobin.

Hemoglobin.

Types of Hemoglobin

- **Normal**
  - HbA (97%)
  - HbA_2 (2%)
  - HbF (1%)
  - HbA_{1c}
- **Abnormal**
  - Carboxy Hb
  - Met Hb
  - Sulf Hb

Note: abnormal Hemoglobin is any kind of hemoglobin that cannot carry oxygen

Note: HbA1c is Present in all people but it's elevated in diabetic people

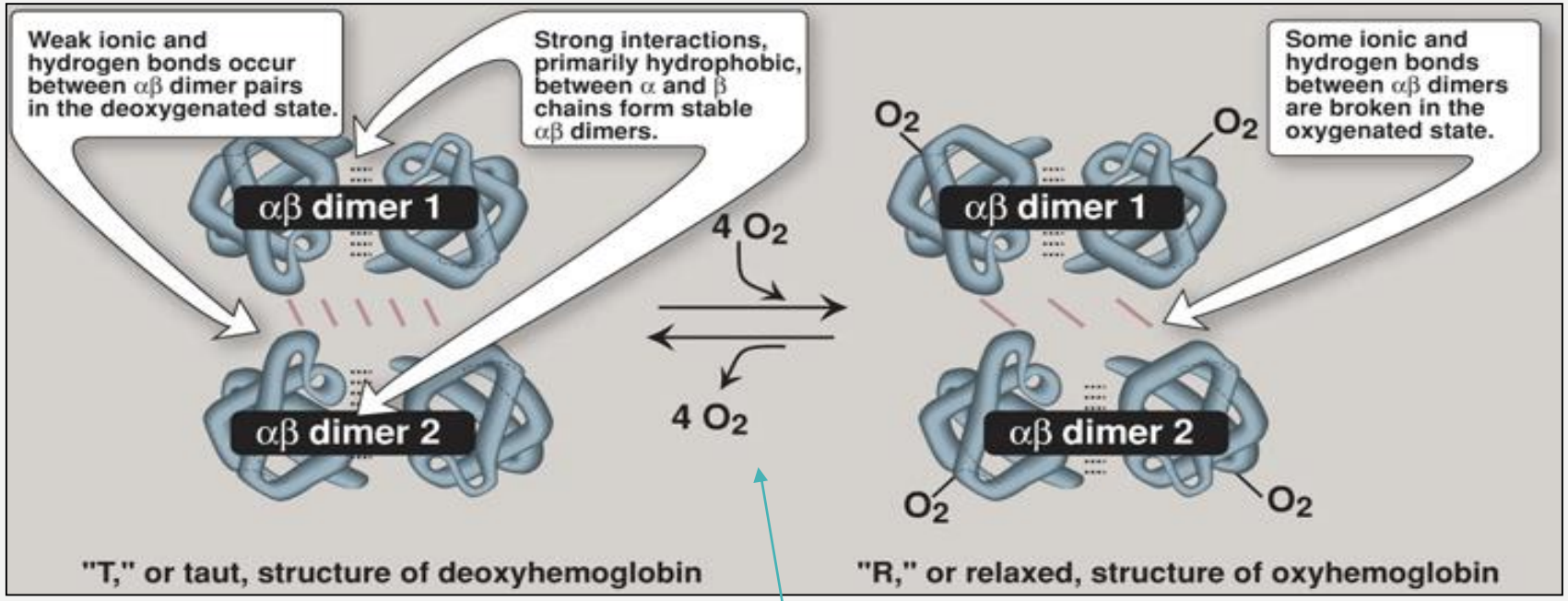
Notes: -We can see Carboxy-Hb in carbon monoxide poisoning and it's reversible.
-Treatment: Spending time in a pressurized oxygen chamber.

HbA structure

Structure of HbA is made up by: (composed of two identical dimers,$(\alpha\beta)_1$ and $(\alpha\beta)_2$,)

1- strong Interchain hydrophobic interactions between α-subunit and β-subunit which will form a very stable dimer.

2- weak ionic and hydrogen bonds between the 2 dimers (αβ dimer). (it allows the two dimers to move with respect to one other)



The binding of oxygen to hemoglobin causes the rapture of some of the polar bonds between the two dimers, the movement will lead to a structure called " R" or "relaxed" structure.

The structure of hemoglobin has flexibility so it will give us 2 conformations:

tense hemoglobin

(T or taut hemoglobin or deoxyhemoglobin)

-constrains the movement of the polypeptide chains.

-It is the low-oxygen-affinity form of hemoglobin.

relaxed hemoglobin

(R hemoglobin or oxyhemoglobin)

- some of the ionic and hydrogen bond are broken because of Oxygen binding so the polypeptide chains have more freedom of movement

-It is the high-oxygen-affinity form of hemoglobin.

Note:

-when one oxygen binds to hemoglobin, it facilitates the binding of the second oxygen and then the second oxygen will facilitate the binding of the third oxygen and so on.

*** The binding of the last oxygen is much easier than the first one because the binding of oxygen to hemoglobin will lead to conformational changes**

(cooperative binding)

HEMOGLOBIN

Types of normal hemoglobin:

The type of chains (globin protein chains) that compose the hemoglobin

Type	Composition	Characteristic
HbA	α2β2	1) It is the most common human hemoglobin. 2) comprising over 97% of the total red blood cell hemoglobin.
HbA1c	α2β2-Glucose	1) What is it? It is the glycosylated form of HbA. 2) How it gets glycosylated ? β chain in HbA undergoes non-enzymatic glycosylation, The glycosylation depends on plasma glucose levels . 3) IHbA1c is found in high levels in patients with diabetes mellitus
HbA2	α2δ2	1) Appears approximately 12 weeks after birth . 2) Constitutes 2% of total Hb .
HbF fetal hemoglobin	α2γ2	1) found in: the fetus and newborn 2) Has higher affinity to O2 than HbA 3) Transfers O2 from maternal to fetal circulation across the placenta 4) "γ" chain belong to the same family of "β" chain

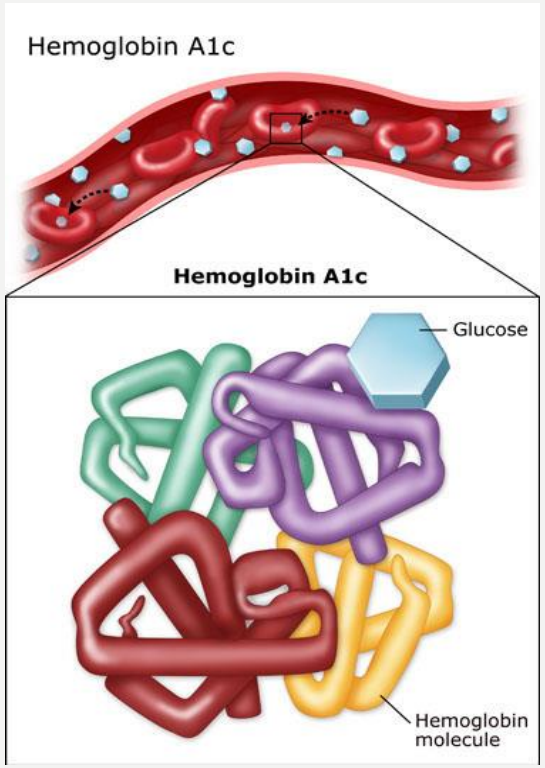
نوع الهيموجلوبين عند الأم هو أي ، بينما نوع الهيموجلوبين عن الطفل هو اف ، حتى يأخذ الجنين الأكسجين من أمه لابد ان يكون لديه افينتي عاليه للاكسجين حتى يستطيع «سرقة» الأكسجين من أمه

MORE EXPLANATION

- Composition of different types of hemoglobin

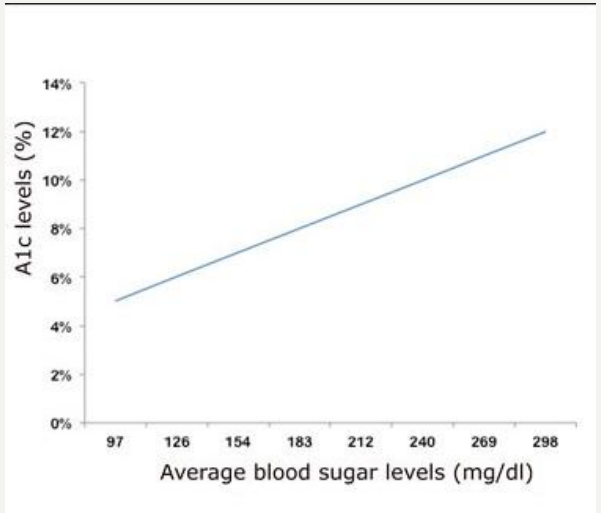
All types of hemoglobin are composed of 4 polymers,
Each polymer is a globin protein chain
As these polymers differ the hemoglobin- differs.

Type	Composition
HbA	α2β2
HbA1c	α2β2-Glucose
HbA2	α2δ2
HbF fetal hemoglobin	α2γ2



HbA1c test is an accurate indicator of blood sugar over prolonged period. It detects glucose levels of blood in the preceding 30 days or even before, unlike regular glucose test.

For example:
HbA1c
Is composed of two alpha globins & two beta globins + one glucose molecule attached to a beta globin.



Abnormal Hbs

Carboxy-Hb

- Hemoglobin that has carbon mono-oxide instead of the normal oxygen bound to it.
- In smokers .
- CO binds 200x tighter then O2 .

- Extra information: Carboxyhemoglobin is formed in carbon monoxide poisoning and leads to oxygen deficiency in the body. The source of the carbon monoxide may be exhaust (such as from a car, truck, boat, or generator), smoke from a fire, or tobacco smoke. The level of carboxyhemoglobin is a measure of the degree of carbon monoxide exposure.

Met-Hb

- Hemoglobin that Contains oxidized (ferric) Fe^{3+} (~2 %) which cannot carry O2.

Sulf-Hb

- formed when the sulfur level in blood is high.

- Extra information: This can be caused by taking medications that contain sulfonamides under certain conditions

Note: The Carboxy-Hb & Met-Hb are reversible , while sulf-Hb is irreversible.

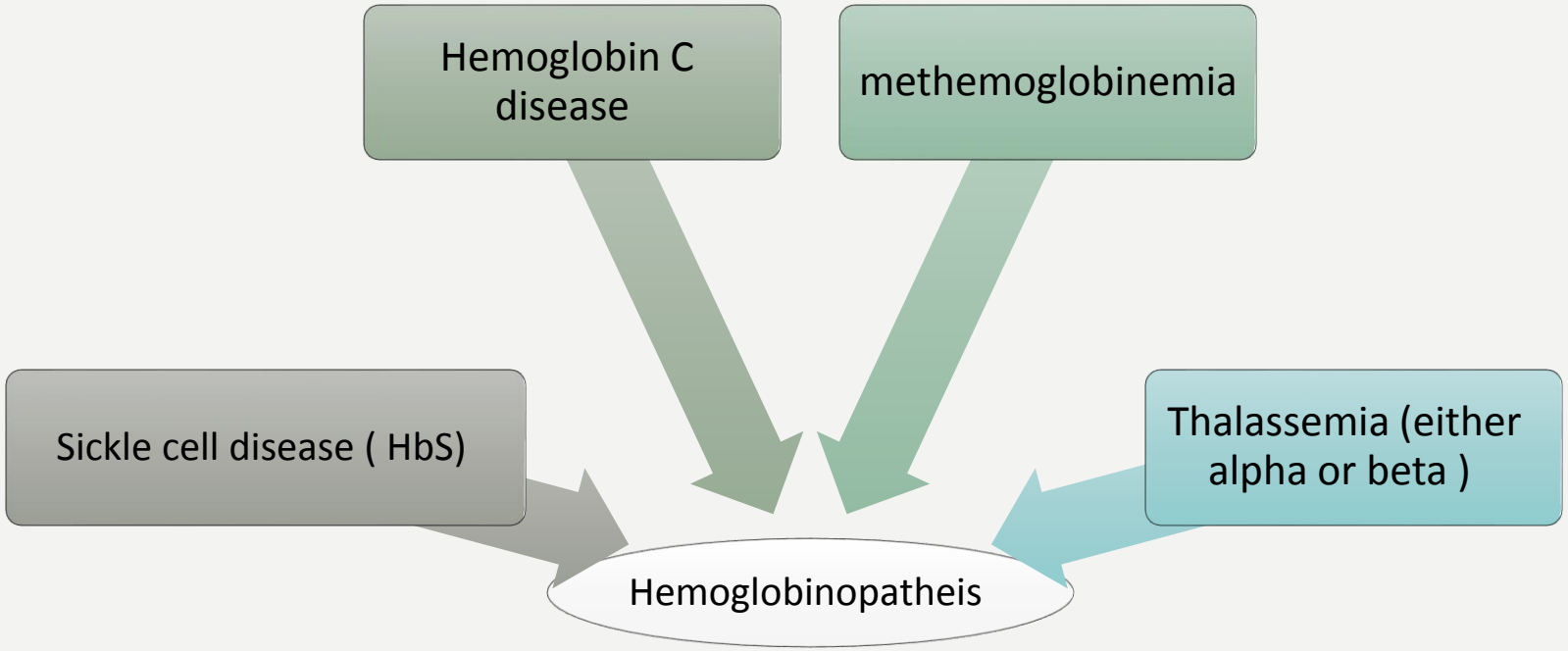
Hemoglobinopathies

Disorders of hemoglobin are caused by :

1- synthesis of structurally abnormal Hb (previous slide) . (qualitative disorders)

2- synthesis of insufficient quantities of normal Hb . (quantitative disorders)

3- combination of both (1&2) .



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Hemoglobinopathies

1- Sickle cell (HbS) disease

- **Caused by:**
  a single (point) mutation in β-globin gene.

- Glutamic acid at position 6 in HbA is replaced by valine.

- The mutant HbS contains β^s chain.
- The shape of RBCs become sickled.
- **Causes** sickle cell anemia

- Homozygous ,autosomal recessive disorder.
- RBCs life span decreased to 20 days or less.

Difference

2- Hemoglobin C disease

- **Caused by:**
  a single (point) mutation in β-globin gene.

- Glutamic acid at position 6 in HbA is replaced by lysine.

- **Causes** a mild form of hemolytic anemia

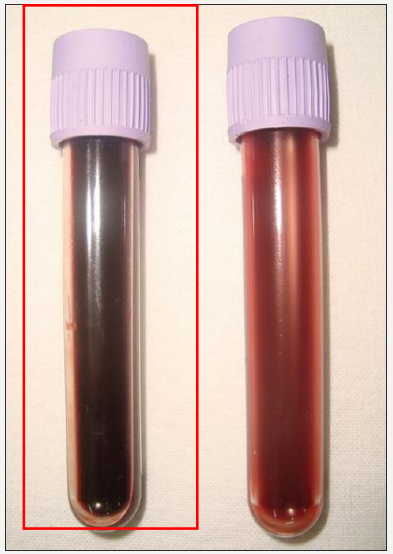
Note: Basically what happens in Sickle disease is : The beta chain within the RBCs start polymerizing making fibrous (rigid)RBCs → The bigger RBCs fail to move into the small blood vessels → can't deliver oxygen → hypoxia → cell death ' infraction '

3- Methemoglobinemia:

oxidation of Hb to ferric (Fe^{3+}) due to NADH-cytochrome b5 reductase deficiency

Caused by

oxidation of Hb to ferric (Fe^{3+}) due to certain drugs, reactive oxygen species



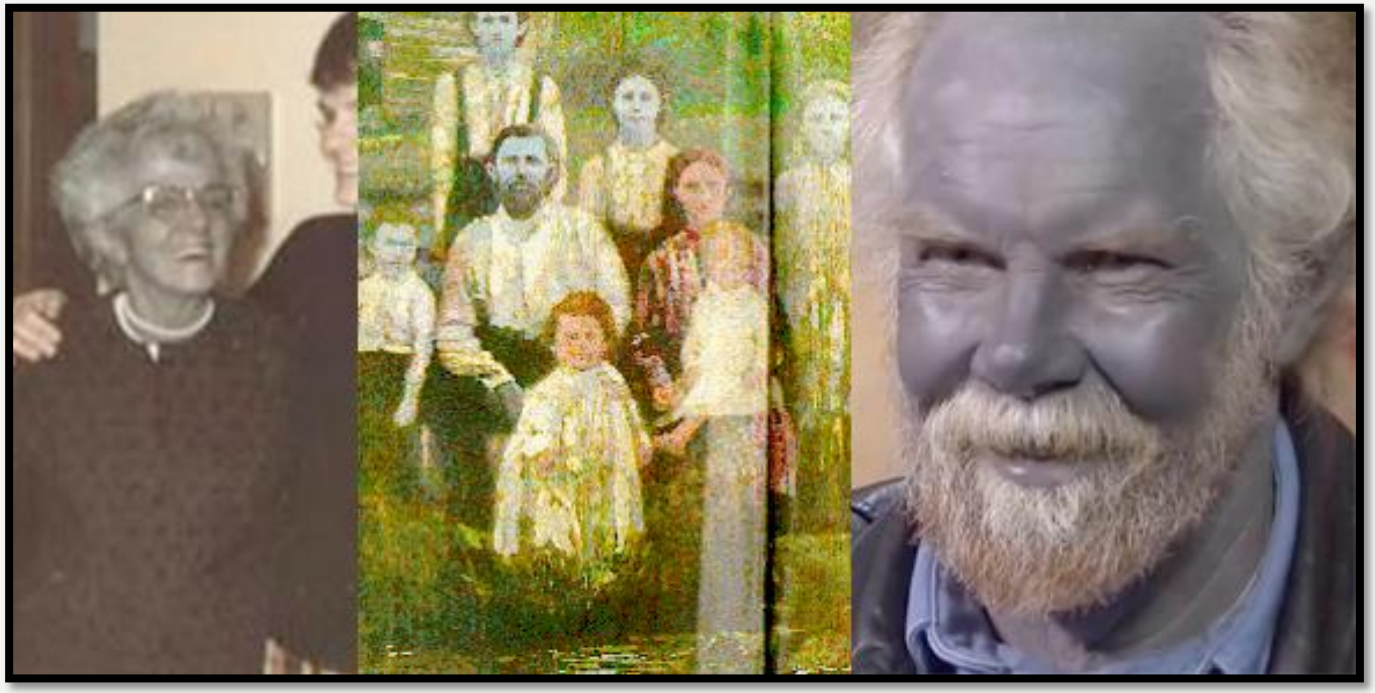
Features:

- HB cannot bind oxygen .
- Chocolate cyanosis: brownish-blue color of the skin and blood

Note: the oxidation to ferric occur spontaneously

- NADH-cytochrome b5 reductase is the enzyme that converts ferric back to ferrous. (by reducing it), so if there's any deficiency of it the iron won't get reduced, instead of that it will get oxidized.

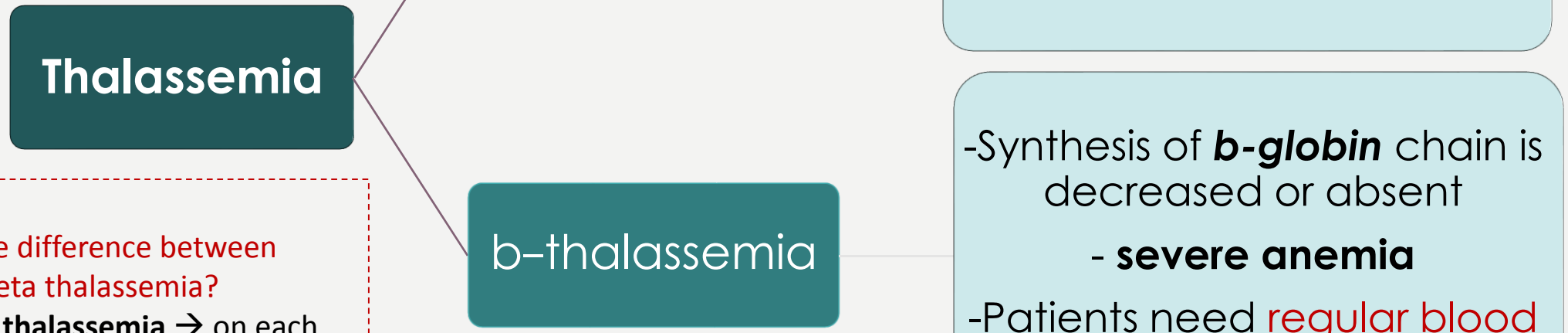
This slide is Extra ..



The Blue People of Kentucky became famous in the mid-1800s for, as the name implies, being blue. A rare recessive genetic condition called **methemoglobinemia** caused many members of this family to have blue skin - but were otherwise, essentially, pretty healthy. Methemoglobinemia causes higher levels of methemoglobin, which reduces the oxygen-carrying capacity of the blood of affected individuals, causing cyanosis - or blue skin. blood does not become blue when it is low in oxygen - in fact, in people with this condition, their blood becomes chocolate-colored. But because cyanosis develops, these people often have blue-tinged lips and fingers, and in the more extreme case of the Kentucky family, their entire bodies can appear blue.

4- Thalassemia

Thalassemia is Defective synthesis of either α or β-globin chain due to gene mutation



Note:

- What is the difference between alpha and beta thalassemia?
  - **In alpha thalassemia** → on each allele → there's a single mutation.
  - **In beta thalassemia** → on each allele→ there're four mutation.

Because of that : beta thalassemia is more severe than alpha thalassemia.

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Myoglobin

Myoglobin - Structure and Function.

A globular hemeprotein in **heart** and **skeletal muscle**

Function

- **Stores** and **supplies** O_2 to the heart and skeletal muscle only.
  + Acts as O_2 carrier that increases the rate of transport of O_2 within muscle cell.
- It found only in heart and skeletal muscle, therefore when we found it in blood in high amount, means there is abnormalities in heart or skeletal muscle.
  Note: it's not a specific marker im heart injury.
- Gives **red** color to skeletal muscles.
- Supplies O_2 during **aerobic** exercise.

<< Flash back

Skeletal muscle fiber **type I** has a large amount of **myoglobin** ⟶ makes its color appear as **Red and dark**.
+ muscle fiber **type I** depends mainly on **aerobic metabolism** to produce energy.

The structure of myoglobin is stabilized by hydrophobic interaction.

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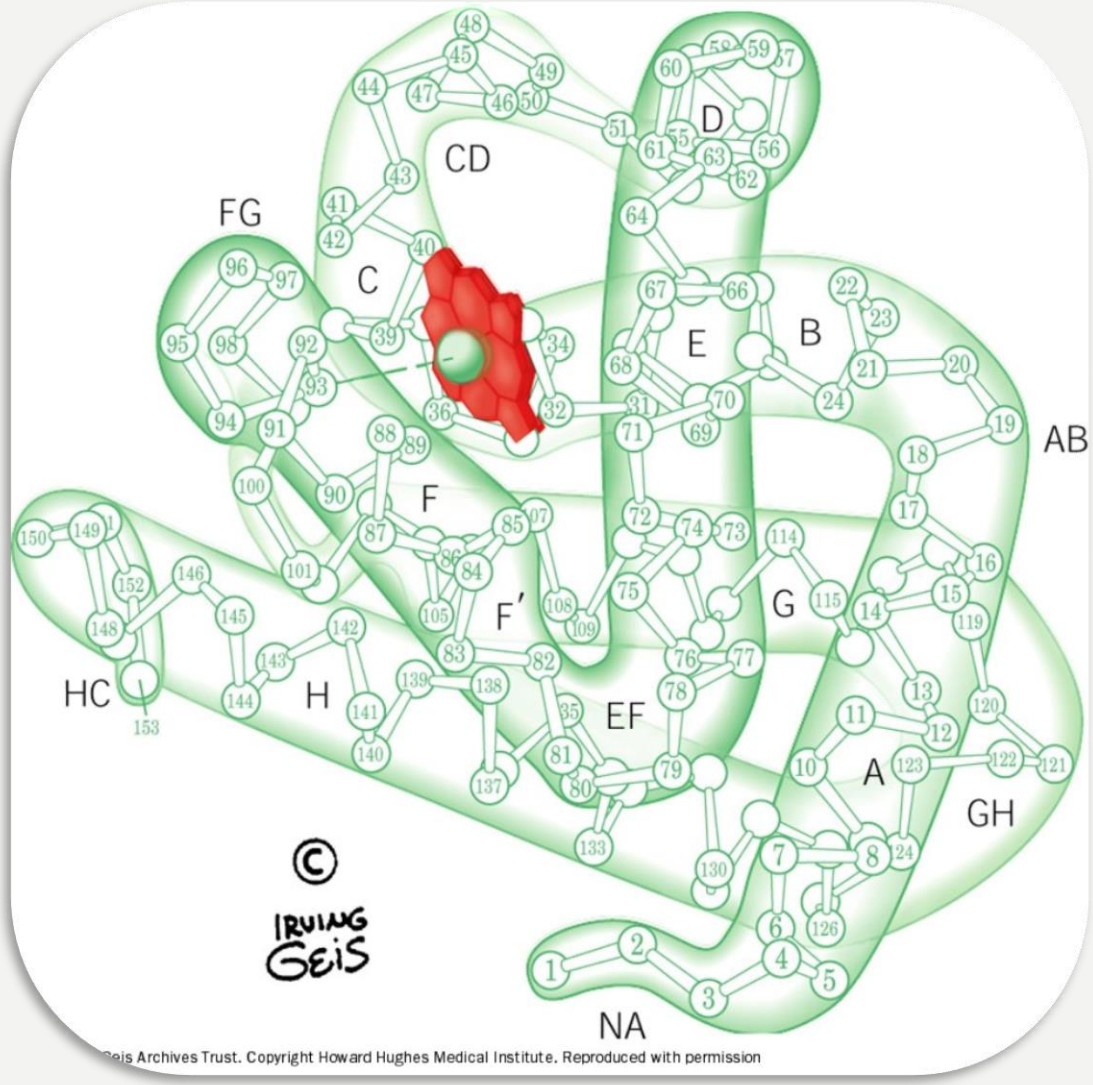
Structure

- Contains a **single** polypeptide chain forming single subunit with **8 α- helix** structure
- single chain will bind to **one Heme**
- So Myoglobin molecule will bind to **one O_2**
- As mentioned previously, globular proteins are **water-soluble** and **sphere** in shape.
  We conclude that:
  - The charged amino acids are located on the **surface**.
  - The **interior** of the subunit is composed of nonpolar amino acids.
- The heme group is present at the **center** of the molecule.

Extra



تركيب المايوجلوبين:

في البداية المايوجلوبين عبارة عن جُزيْء مدمج مع بعضه بإحكام، ويساعده في هالصفة شكله: Sphere .

بما إن شكله كروي، وبما إن عنده قابلية للذوبان في الماء، فأكيد الsurface حقه مكوّن من polar amino acids وعشان يحافظ البروتين على شكله الكروي، لازم يمتلك في باطنه non-polar amino acids ما تذوب في الماء.

جزيء المايوجلوبين يكوّن سلسلة واحدة فقط من الpolypeptide وهذي السلسلة منثنية على بعضها البعض بواسطة ثمانية stretches of alpha helix.

قد يتساءل البعض، كيف ينتهي تكوين جزيء واحد من المايوجلوبين؟

ينتهي تكوينه بواسطة أمينو أسيد : Proline، لأنه يملك في تركيبته حلقة خماسية تعيق تكوين الalpha helix مثل ما أخذناه سابقًا.

بالنسبة للـ Heme group فهو واحد فقط، موجود في قلب البروتين (داخل مع non-polar amino acids)

وبما إن عندنا مجموعة Heme واحدة فقط، إذن راح يرتبط الحديد بجزيء واحد من الأكسجين فقط،

المايوجلوبين = سلسلة واحدة + مجموعة Heme واحدة + جزيء أكسجين واحد

COMPARISON BETWEEN HEMOGLOBIN & MYOGLOBIN

	Hemoglobin	Myoglobin
Type	**Globular proteins**	
Shape	**Sphere shape**	
Function	Transport O_2 from lung to tissue	Store and supplie O_2 to the heart and skeletal muscle
Structure	4 chains (2α, 2β)	Single polypeptide chain
No. of Heme group	Four Heme	One Heme
No. of O_2 molecules	4 O_2	One O_2

Myoglobine in disease

Myoglobinuria :

- **Myoglobin is excreted in urine due to muscle damage** " heart or skeletal muscles " **(Rhabdomyolysis)**
- **May causes acute renal failure.**

Note:

If anything the level goes up in **blood** → it called (emia) as a suffix , like ANEMIA

If anything the level goes up in **urine** → **i**t called (uria) as a suffix , like MYOGLOBINURIA

Myoglobine in disease

Myoglobinuria (Extra) :

- Rhabdomyolysis is the breakdown of muscle tissue that lead to the release of muscle fiber contents into the blood. These substances are harmful to the kidney and often causes kidney damage.
- Myoglobinuria is usually the result of rhabdomyolysis or muscles destruction. Any process that interferes with the storage or use of energy by muscle cells can lead to myoglobinuria.
- The most common causes of myoglobinuria in adults are : trauma , alcohol and drugs.
- In children and adolescents the most common causes of myoglobinuria and rhabdomyolysis are viral myositis , trauma , exertion , drug overdose, seizures , metabolic disorders and connective tissue disease.

Note:

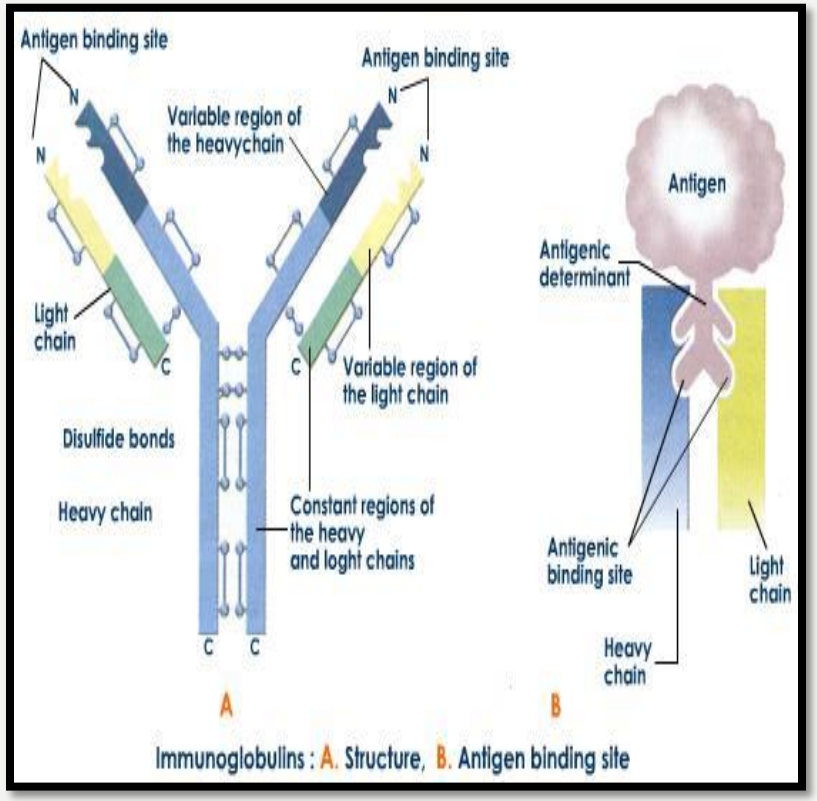
What is the causes of acute renal failure in myoglobinurei ?

When myoglobin metabolism it produces Nephrotoxic molecules and these molecules causes damage to the kidney.

Immuno-globulins

Note:

الـ antibody بيمسك في الـ antigen الصغير في الحجم عشان يخليه أكبر وأوضح و يشوفه الـ immune system عن طريق الـ macrophage



Immunoglobulins : A. Structure, B. Antigen binding site

Y- shaped structure with 2 heavy and 2 light polypeptide chains.

Function : neutralize bacteria and viruses.

Defective proteins produced by B-cells (plasma cell) of the immune system.

Types : IgG , IgM , IgI , IgD , IgE

Immuno-globulins

Antibodies and Immunoglobulin Function.

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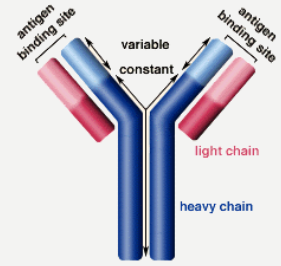
Summary

Globular proteins	
What is it ?	Amino acid chains fold into shapes that resemble spheres
features	↑ solubility of in water (Polar groups on surface/Hydrophobic groups in the interior)
Note !	Fibrous proteins("wire" or "rod" –like)are mainly insoluble structural proteins
Examples	1. Hemoglobin. 2. Myoglobin. 3. a_1, a_2, b-globulins. 4. γ-globulins (immunoglobulins) 5. Enzymes: catalysis of biochemical reactions
Myoglobin (hemeprotein in heart and muscles)	
Composed of	single polypeptide chain forming a single subunit with eight a-helix structures * contains 1 chain → 1 heme group → it can carry 1 molecule of O_2
functions	• Stores and supplies oxygen to the heart and muscles(during aerobic exercise) • it gives red color to skeletal muscles
In disease	* Myoglobinuria: it is excreted in urine due to muscle damage (rhabdomyolysis) * Myoglobin is very toxic for the kidney so it may cause acute renal failure * It is a specific marker for muscle injury & Less specific marker for heart attack
Immunoglobulins	
Function	Defensive proteins, they neutralize bacteria and viruses
Produced by	the B-cells of the immune system
Structure	Y-shaped structure with 2 heavy and 2 light polypeptide chains
Types	IgA, IgD, IgE, IgG, IgM



Hemoglobin (heme= protoporphyrin + Iron "ferrus=Fe^{2+}") (globin= protein)			
Composed of	4 polypeptide chains: (2 α chains + 2 β chains)		
Function	Carries O_2 from the lungs to tissues (as an oxyhemoglobin) Carries CO_2 from tissues back to the lungs (as a carbaminohemoglobin) * A Hb molecule contains 4 chains → 4 heme groups → it can carry 4 molecules of O_2		
Bonds	Strong hydrophobic interactions between α and β chains → stable dimers two dimers of αβ subunits held together by <u>non-covalent</u> interactions <u>(weak ionic and H bond)</u> So: (intradimers→ strong hydrophobic interactions),(interdimers→ weak ionic and H bond) Note that: some ionic and H bonds are broken in the oxygenated state		
Normal levels	Males→ 14-16(g/dL) & Females→ 13-15(g/dL)		
Types	Normal	HbA (97%)	Adult hemoglobin, composed of 2α chains + 2β chains
		HbA_2 (2%)	Appears ~12 weeks after birth, composed of 2α chains + 2δ chains
		HbA_{1c}	• high in patients with diabetes mellitus • HbA undergoes non-enzymatic glycosylation "depends on plasma glucose levels"
		HbF	• Fetal hemoglobin, composed of 2a chains + 2γ chains • Higher affinity for O_2 than HbA → transfers O_2 from maternal to fetal circulation across placenta
	Abnormal	Carboxy Hb	CO replaces O_2 and binds 200X tighter than O_2 (in smokers)
		Met Hb	Contains oxidized Fe^{3+} (~2%) that cannot carry O_2
		Sulf Hb	Forms due to high sulfur levels in blood (irreversible reaction)

Hemoglobinopathies		
Disorders of Hb caused by synthesis of structurally abnormal Hb and/or insufficient quantities of normal Hb.		
Sickle cell (HbS) disease	• Single mutation in β-globin gene • Glutamic acid at position 6 in HbA is replaced by valine • Mutant HbS contains β^S • The shape of RBCs become sickled • Causes sickle cell anemia	
Hemoglobin C disease	• Single mutation in b-globin gene • Glutamic acid at position 6 in HbA is replaced by lysine • Causes a mild form of hemolytic anemia	
Methemoglobinemia	• Caused by oxidation of Hb to ferric (Fe^{3+}) state • Methemoglobin cannot bind oxygen • Caused by : ✧ certain drugs ✧ reactive oxygen species ✧ NADH-cytochrome b5 reductase deficiency • It leads to chocolate cyanosis "brownish-blue color of the skin and blood"	
Thalassemia	α-thalassemia	• Synthesis of a-globin chain is decreased or absent • Causes mild to moderate hemolytic anemia
	β-thalassemia	• Synthesis of b-globin chain is decreased or absent • Causes severe anemia • Patients need regular blood transfusions

MCQS

1-which of the following characteristic is not true for globular protein?

A. Soluble
B. Spheres shape
C. Hydrophobic group on the protein's surface

2-Which one of the following is the function of myoglobin ?

A. carrying the oxygen in blood
B. storage of oxygen
C. various function

3-Hemoglobin represent following structural organization of protein:

A. Primary
B. Secondary
C. Tertiary
D. Quaternary

- **4-The porphyrin present in heme is:**

A. Protoporphyrin III
B. Uroporphyrin
C. Cobroporphyrin

5-Gamma polypeptide chain is present only in:

A. Hb S
B. Hb A
C. Foetal Hb

6-Diabetic patient has higher levels of which hemoglobin:

A. HbA2
B. HbF
C. HbA1c

7- The type of hemoglobin which is composed of 2 alpha globin proteins & 2 delta globin protein, is:

A. HbA
B. HbA2
C. HbF

8-which one of the following can be consider as hemoglobinopathy :

A. Rhabdomyolysis.
B. myoglobinuria .
C. polycythaemia Vera .
D. thalassemia

8-D
7-B
6-C
5-C
4-A
3-D
2-B
1-C

MCQS

9-Glutamic acid at position 6 in HbA is replaced by lysine in which hemoglobinpathies ?

A- Sickle cell disease

B- thalassemia

C- hemoglobin C disease

D- methemoglobinemia

10-In sickle cell disease Glutamic acid at position 7 in HbA is replaced by valine:

A. T

B. F

11-Which on of the following cause severe anemia :

A - α Thalassemia

B - β Thalassemia

C – hemoglobin c disease

12-NADH-cytochrome b5 reductase deficiency converts ..... to .....

13- Myoglobinuria causes :

A. Hemolytic anemia
B. Heart attack
C. Muscles injury
D. Acute renal failure

14- Immunoglobulins have five types :

A. T
B. F

15- Myoglobin in the urine is a specific marker of renal failure:

A. T
B. F

16- what is the bond that held a and B chains together ?

A. Hydrogen bond.
B. Covalent bond.
C. Ionic bond
D. Glycoside bond.

17- how many O2 molecules are attached to 1 hemoglobin ?

A. 3
B. 4
C. 2

9- C
10- B
11- B
12-
Fe+2
to
Fe3+
13- D
14-A
15-B
16- B
17-B

MCQS:

18-…. Is an abnormal hemoglobin:

A. HbA

B. HbF

C. Hb1c

D. sulf Hb

19- Hemoglobin is made up from:

A. 4 dimers

B. 2 polypeptide chains

C. 2 dimers

D. 5 polypeptide chains

20-The intradimer bond is stronger than the interdimer bond:

A. T

B. F

18- D
19- C
20- A

SAQs

1) NAME 2 EXAMPLES OF GLOBULAR PROTEIN:

2) WHAT IS THE DEFERENS BETWEEN HEMOGLOBIN & MYOGLOBIN?

hemoglobin	myoglobin

3) TALK ABOUT THALASSEMIA.

4) WHAT IS THE MAIN FEATURES OF SICKLE CELL DISEASE ?

5) TALK ABOUT MYOGLOBINURIA:

6) DESCRIBE THE STRUCTURE OF HEMOGLOBIN

Answers

1) NAME 2 EXAMPLES OF GLOBULAR PROTEIN:

a-hemoglobin.
b-myoglobin.
c-globulines (gamma – alpha one – alpha two – beta)
d-enzymes.

2) WHAT IS THE DEFERENS BETWEEN HEMOGLOBIN & MYOGLOBIN?

hemoglobin	myoglobin
• Found in RBCs • Has 4 polypeptide chains. • Carries 4 molecules of O2. • Has low O2 affinity. • Carries O2 from our lungs to our cells and CO2 from our cells to our lungs.	• Found in heart & skeletal muscles. • Has a single polypeptide chain . • Carries one molecules of O2. • Has high O2 affinity. • Stores and supplies O to the heart and muscles only. • Supplies O2 during aerobic exercise.

3) TALK ABOUT THALASSEMIA :

- It's a hemoglobinopathies that has 2 types
- a-thalassemia: defective synthesis of a-globin chain, and causes mild to moderate hemolytic anemia.
- B-Thalassemia: defective synthesis of B-globin chain, and causes sever anemia.

4) WHAT IS THE MAIN FEATURES OF SICKLE CELL DISEASE ?

- Mutation in B-globin gene.
- Glutamic acid is replaced be valine.
- The RBCs shape becomes sickled.

5) TALK ABOUT MYOGLOBINURIA:

- It's a myoglobin disease that the myoglobin gets excreted in the urine due to muscle damage.
- It can cause acute renal failure.
- It's a specific marker for muscle injury but less specific for heart injury.

6) DESCRIBE THE STRUCTURE OF HEMOGLOBIN

IT IS A GLOBULAR PROTEIN WHICH IS COMPOSED OF TWO IDENTICAL DIMERS,$(AB)_1$ AND $(AB)_2$,)

1- strong Interchain hydrophobic interactions between a-subunit and β-subunit which will form a very stable dimer.
2- weak ionic and hydrogen bonds between the 2 dimers (aβ dimer).

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- أثير النشوان.
- علا النهير.
- أفنان المالكي.
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- دلال الحزيمي.
- رهف بن عباد.
- منيره السلولي.
- غاده القصيمي.
- نوف الرشيد.
- مي العقيل.
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