
# ESSENTIAL TRACE ELEMENT

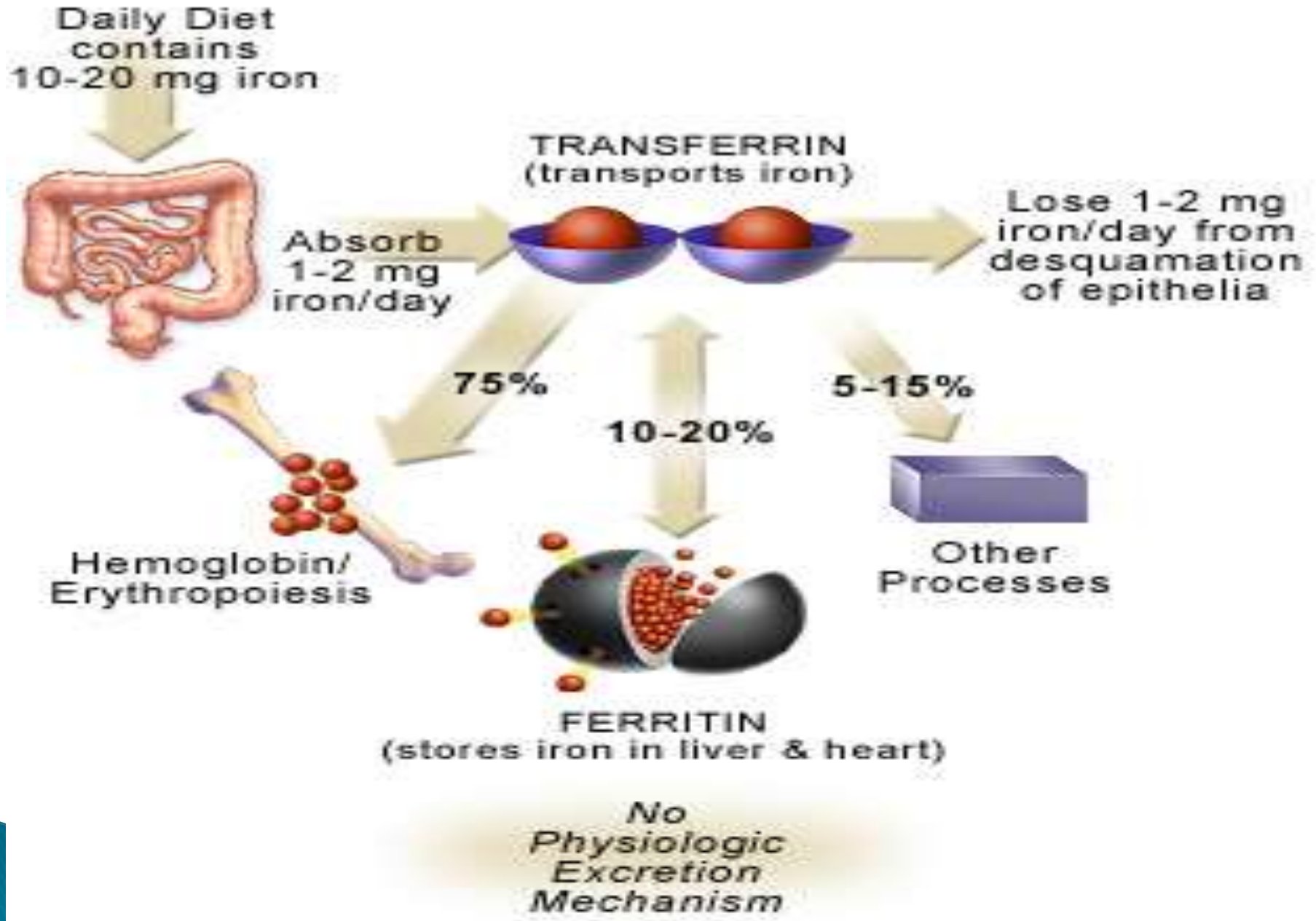
# *IRON*

# INTRODUCTION

- Total I**RON** content -adult body - 3-5 gms
- 70% **-erythrocytes** of blood - **hemoglobin**
- 5% of body iron **-myoglobin** of muscle
- Blood hemoglobin level:

**Male**: 13-18 gm/dl

**Female**: 12-16 gm/dl


Daily Diet contains 10-20 mg iron
TRANSFERRIN (transports iron)
Absorb 1-2 mg iron/day
Lose 1-2 mg iron/day from desquamation of epithelia
75%
10-20%
5-15%
Hemoglobin/ Erythropoiesis
Other Processes
FERRITIN (stores iron in liver & heart)
No Physiologic Excretion Mechanism

# BIOCHEMICAL FUNCTIONS


- IRON -exerts its function through the compounds in which it is present , **hemoglobin and myoglobin** - transport of O2 and CO2
- **Cytochromes & non heme proteins** - ETC and oxidative phosphorylation
- **Peroxidase** (lysosomal enzyme) -phagocytosis - killing bacteria by neutrophils
- **IRON** associated - immunocompetence of the body

## Sources:

- **Rich source** – jaggery and organ meat (liver,heart,kidney)
- **Good sources-**

  Green leafy vegetables, pulses, cereals, fish, apples, dry fruits.
- **Poor sources-**milk, wheat, polished rice
- Cooking in **iron utensils improves iron content in diet**

## RDA

- Adult man = 20 mg/day
- Children  = 20-30 mg/day
- Menstruating woman = 15-20 mg/day
- Pregnant and lactating woman = 40mg/day

# Absorption, transport and storage

- **IRON** – absorbed-in stomach, duodenum
- In normal people 10% of dietary **IRON** - absorbed
- In anemic (**IRON** deficient) individuals - growing children - higher proportion - dietary **IRON** is absorbed.
- **IRON** found in foods in ferric form $Fe^{3+}$ bound to proteins- organic acids

- In - acidic medium - gastric HCL - $Fe^{3+}$ released from foods.
- Reducing substances - ascorbic acid (vitamin c) - cysteine - ferric ion to ferrous.
- IRON - ferrous form - readily absorbed.
- Inhibitors are phytates (cereals) and oxalates (leafy vegetables)
- Calcium, copper, lead and phosphates will inhibit iron absorption.

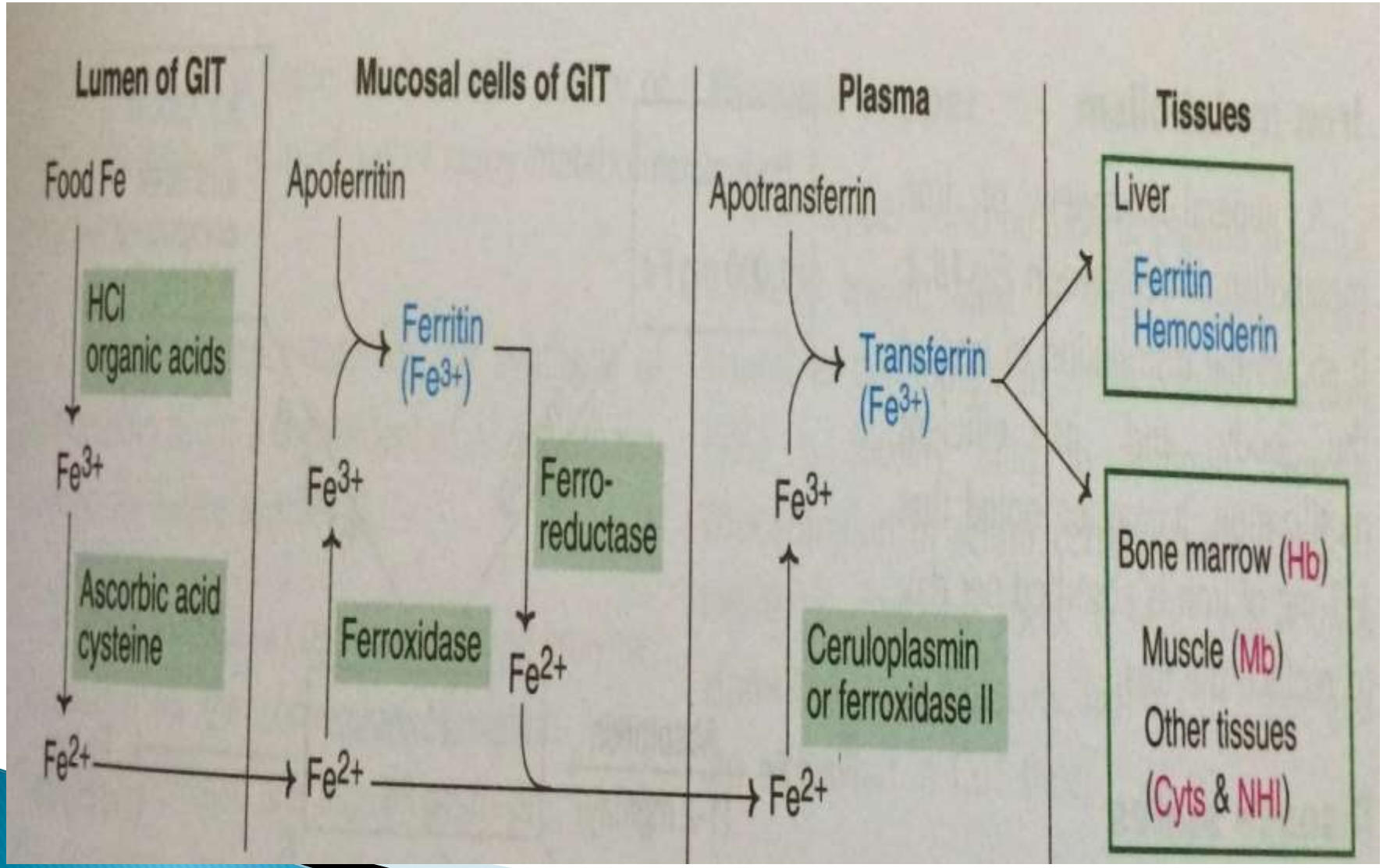
## Trasferrin :

- Glycoprotein, beta-1 globulin
- M. W. 76,000 Daltons
- N. R. 250mg/dl
- Half life is 7-10 days and useful index of nutritional status.
- In iron deficiency it increases but serum iron level decreases.
- Total iron binding capacity(TIBC) : 400mg/dl, this is provided by transferrin.
- In blood Ceruloplasmin or ferroxidase converts ferrous to ferric state.
- Apo- trasferrin ------Transferrin

- Transferrin receptors are present on body cells which synthesise heme.
- Iron transferrin receptors gets internalised
- Reticulocyte can internalise about 1 million atoms of iorn per minutes.

| Parameters of iron status | | | | | |
|---|---|---|---|---|---|
| | Normal | Pregnancy | Infection | Hemolytic anemia | Hemo-siderosis |
| Transferrin (mg/dl) | 250 | 300 | 150 | 200 | 1000 |
| Serum iron (mg/dl) | 120 | 50 | 50 | 200 | 250 |
| TIBC (mcg/dl) | 400 | 500 | 200 | 300 | 300 |
| Iron store (mg) | 1000 | 500 | 1000 | 2000 | 25000 |
| Absorption (mg/day) | 1 | 2 | 2 | 2 | 2 |
| RBC, lifespan, days | 120 | 120 | 100 | 75 | 75 |

# IRON ABSORBTION AND TRANSPORT



# Mucosal Block Theory

- Duodenum and jejunum are the sites of absorption.
- Iron metabolism is unique because homeostasis is maintained by regulation at the **level of absorption** and not by excretion.
- When iron stores in the body are depleted, absorption is enhanced.
- When adequate quantity of iron is stored, absorption is decreased.
- This is referred to as **Mucosal block** of regulation of absorption of iron. **Only ferrous (and not ferric)** form of iron is absorbed.

- **Ferrous iron** in the intestinal lumen binds to mucosal cell protein, called divalent metal transporter-1 **(DMT-1)** is then transported into the mucosal cell.
- Inside the mucosal cell, the ferric iron is formed and is complexed with apoferritin to form **ferritin**.
- This mechanism of iron absorption from intestinal lumen to the mucosal cell is different from the iron release from intestinal cell to the bloodstream.
- Iron in the ferritin is released, then crosses the mucosal cell with the help of a transport protein called, **ferroportin**.
- Iron crosses the cell membrane as ferrous form. In the blood it is reoxidized to ferric state, and transported by **transferrin**

# Storage of iron

- Iron –stored- liver, spleen - bone marrow - form of Ferritin.
- In the mucosal cell, ferritin - **temporary storage** form.
- A molecule of apoferritin (molecular wt.5,00,000) - combine with 4,000 atoms of iron
- The maximum iron content -ferritin - is around 25%

- Hemosiderin

- Iron storage protein - 35% of iron by weight

- Hemosiderin accumulates in the body(spleen,liver)-supply of iron is in excess of body demands.

# Factors affecting absorption

Enhancers:-

- Vitamin C
- Cooking in iron vessels
- Gastric acid
- Cysteine
- Amino acid
- Lactate
- Pyruvate

Inhibitors:-

- Tannins
- Phosphates
- Oxalates
- Pancreatic secretions
- Antacids
- Calcium

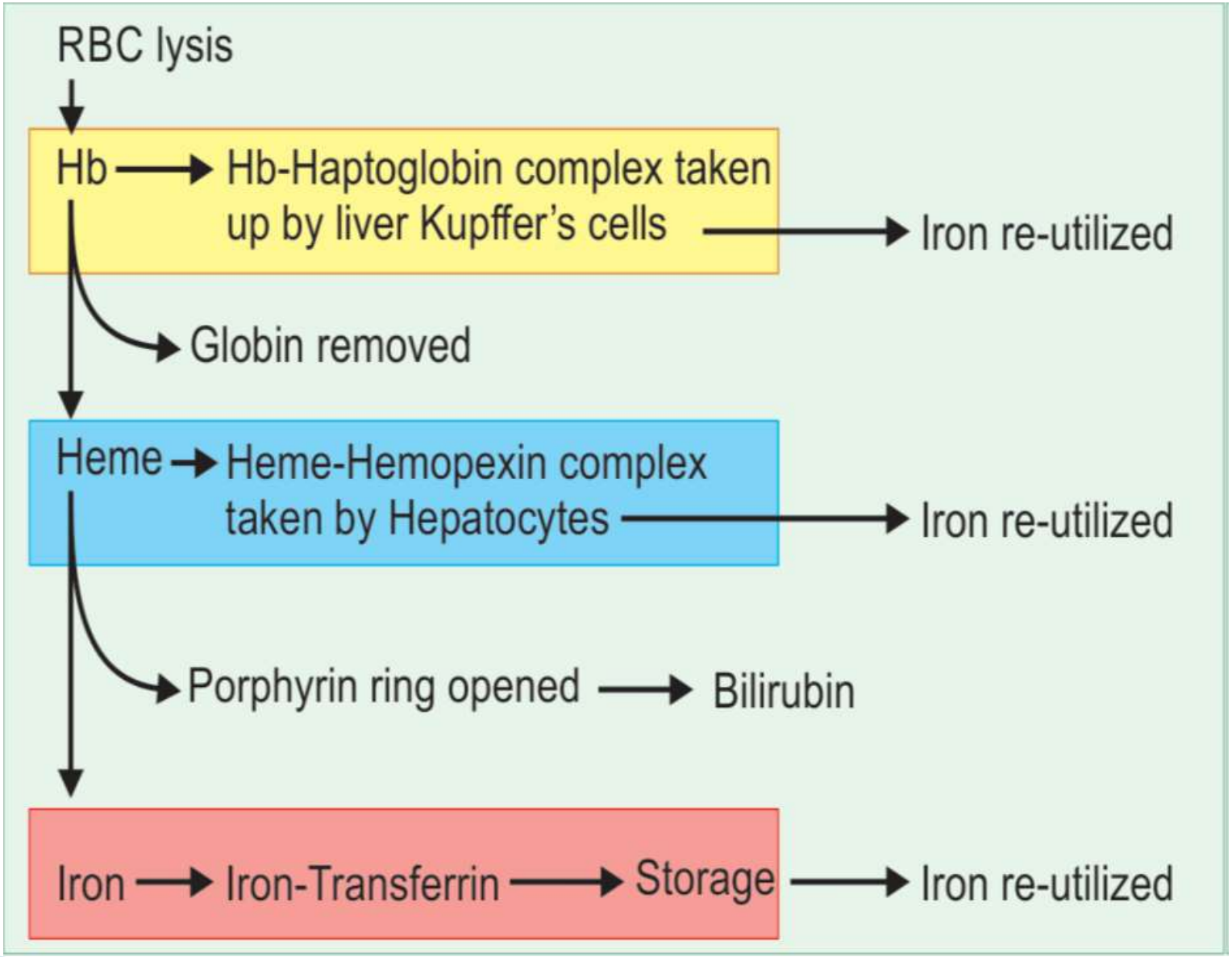
# IRON IS A ONE WAY SUBSTANCE

- **IRON** metabolism -unique -operates in closed system.
- Very efficiently utilized - reutilized by the body.
- **IRON** losses - minimal(<1mg/day) which may occur through bile,sweat,hair loss etc.

- **IRON** - not excreted - urine. Iron differs from vitamins  other organic/ inorganic substances which are either inactivated or excreted during the course of metabolic function. Hence **IRON** - regarded -one way substance.

- I**RON** entry - controlled at the absorption level, depending on body needs. Thus the periodical blood loss menstruating women increases -requirements.

- Increased **IRON** demands - observed  in pregnancy, lactation,growing children.


RBC lysis
Hb
Hb-Haptoglobin complex taken up by liver Kupffer's cells
Iron re-utilized
Globin removed
Heme
Heme-Hemopexin complex taken by Hepatocytes
Iron re-utilized
Porphyrin ring opened
Bilirubin
Iron
Iron-Transferrin
Storage
Iron re-utilized

**Causes of iron deficiency**

1. Nutritional deficiency of iron.
2. **Lack of absorption:** Subtotal gastrectomy and hypochlorhydria.
3. **Hookworm infection:** One hookworm will cause the loss of about 0.3 mL of blood per day. Calculation shows that about 300 worms can produce a loss of 1% of total body iron per day.
4. **Repeated pregnancies:** About 1 g of iron is lost from the mot
5. her during one delivery.
6. **Chronic blood loss:** Hemorrhoids (piles), peptic ulcer, menorrhagia.
7. **Nephrosis:** Haptoglobin, hemopexin and transferrin are lost in urine, along with loss of iron.
8. **Lead poisoning:** Iron absorption and hemoglobin synthesis are reduced. In turn, iron deficiency causes more lead absorption. It is a vicious cycle.

# Classification of Anemias

**1.Impaired production of RBCs**

**a.Defect in heme synthesis:** Deficiency of iron, copper, pyridoxalphosphate, folic acid, vitamin B12 or vitamin C. Lead
will inhibit heme synthesis.

**b.Defect in regulators:** Lack of erythropoietin due to chronic renal failure.

**c.Defect in stem cells:** Aplastic anemia due to drugs, infections

**2.Intracorpuscular defects**

**a.Hemoglobinopathies:** HbS, HbC, HbM

**b.Thalassemias,** Spherocytosis, glucose-6-phosphate dehydrogenase deficiency.

**3.Extracorpuscular causes**

**a.Infections:** Malaria, *streptococcus*

**b.Autoimmune hemolysis,** Isoimmune hemolysis, Rh incompatibility

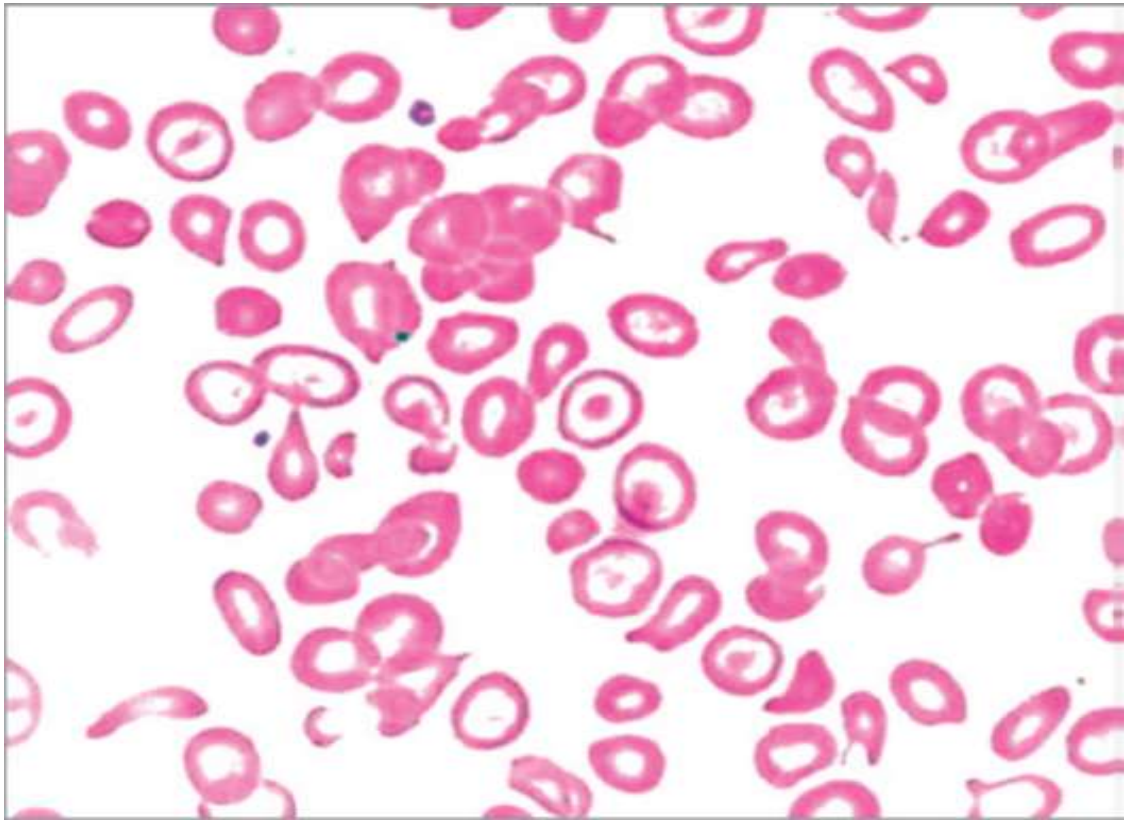
**c.Hemolysis due to drug sensitization:** Alpha-methyldopa, quinine, etc.

**4.Hemorrhage:** Hematuria, hematemesis, hemoptysis, menorrhagia, hemophilia (absence of AHG), thrombocytopenia


# DISEASE STATES

- Most prevalent nutritional disorder
- Factors - inadequate intake - defective absorption - iron,chronic blood loss,repeated pregnancies - hookworm infections nephrosis, lead poisoning
- Strict vegetarians - prone - iron deficiency anemia.
- Presence of inhibitors- iron absorption in vegetarian foods,besides - low content of iron.
- Occurs –growing children,adolescent girls,pregnant – lactating women
- Characterised by MICROCYTIC HYPOCHROMIC ANEMIA reduced blood hemoglobin level(<12g/dl)

# Peripheral blood smear. Iron deficiency manifests as microcytic hypochromic anemia



Koilonychia or “spoon nail” in chronic iron deficiency anemia

- Clinical manifestations:
- Apathy
- Achlorhydria –less absorption
- Irritability
- Lowered memory
- Poor sclolastic performance

- Anemia results when hemoglobin level  less than 12 gm/dl

- **TREATMENT**
- Supplementation of iron along with folic acid and vitamin C.

# Treatment of Iron Deficiency

•Oral iron supplementation is the treatment of choice. 100 mg of **iron** + 500 μg of **folic acid** are given to pregnant women, while 20 mg of iron + 100 μg folic acid to children.

•Iron tablets are usually given along with **vitamin C,** to convert it into ferrous form, for easy absorption.

•Administration of iron-zinc combinations are beneficial to correct deficiency of both.

•There are different pharmaceutical preparations. Ferrous sulfate is the first choice, as it is easily absorbed and has maximum bioavailability. If that is not tolerated, ferrous fumarate or ferrous gluconate may be tried. If that is also not tolerated, then iron polymaltose or iron bisglycinate may be tried.

# Iron Toxicity

***Hemosiderosis***

Iron excess is called hemosiderosis. It occurs in persons receiving repeated blood **transfusions**. So, the regulation at the level of intestine is circumvented leading to iron overload.

**Primary Hemosiderosis**

It is also called hereditary hemochromatosis. Iron absorption is increased and transferrin level in serum is elevated. Excess iron deposits are seen.

***Iron Vessels***

Cooking in iron vessels increases the availability of iron.

***Bantu Siderosis***

Bantu tribe in Africa is prone to hemosiderosis because the staple diet, corn, is low in phosphate content

# HEMOSIDEROSIS

- Less common disorder- excessive iron in body.
- Observed in  subjects receiving repeated blood transfusions  eg. Patients of hemolytic anemia,hemophilia.
- As iron - one way compound - excessive iron -deposited as ferritin & hemosiderin.
- Hemosiderosis -commonly observed among the Bantu tribe in south africa.Attributed to a high intake of iron from their staple diet corn and habbit of cooking foods in iron pots.

# HEMOCHROMATOSIS

- Rare disease- iron - directly deposited in the tissues(liver,spleen,pancreas,skin)
- Hemosiderosis -sometimes accompanied by hemochromatosis.
- Bronzed pigmentation of the skin,cirrhosis of liver,panceatic fibrosis.
- In pancreas excess iron - damage the beta cells - cause diabetes mellitus.later condition termed as bronze disease

Bronze diabetes

# TREATMENT

- Repeated phlebotomy.
- Only disease in which the use of leech(hirudo sp.) is treatment of choice.
- Iron chelating agents eg.desferrioxamine used.

# THANK YOU