The Blood

A generalized collection of handouts and illustrations to accompany lecture

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Erythrocyte Metabolism: Glycolysis

During the ejection stage of erythropoiesis, the mitochondria are eliminated, and with them, the ability to do cellular respiration (transition stage, kreb's cycle, and electron transport chain).

Therefore, the only metabolic pathway remaining for ATP production is that which occurs in the cytoplasm: glycolysis. Although ATP production through glycolysis is modest, the net gain of two ATP per one glucose is adequate for the required metabolic activity of the erythrocyte.

Due to the absence of mitochondria, oxygen is not required nor can it be used. This is beneficial as the erythrocyte does not use its cargo: oxygen and can deliver the goods to the cells that do require oxygen.

In this case, in order for glycolysis to proceed anaerobically, NAD+ must continue to be available to pick up electrons and deposit them somewhere in order to keep this anaerobic pathway going. Therefore, NADH will be oxidized to NAD+ by reducing pyruvate to lactate.

Erythrocyte metabolism is anaerobic. They do not use the oxygen that they carry.
Erythropoiesis

Hemopoietic (or Hematopoietic) Stem cells are Multipotent

*Multipotent Stem Cells* give rise to Many cell lines

*Oligopotent Stem Cells* give rise to a Few Cell lines

*Unipotent Stem Cells* give rise to only One Cell line.

Committed Cell - Cell is committed be differentiating into an erythrocyte

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Erythrocyte Development

Stage #1 - *Ribosome Production* (for protein synthesis, ie hemoglobin, enzyme systems, etc.)

Stage #2 - *Hemoglobin Synthesis* (as well as other proteins)
Hemoglobin accumulates in the cell.

Stage #3 - *Ejection Stage* (Nucleus, mitochondria are ejected)

Mature Erythrocyte - Ejection stage results to collapse of cell, taking on a Biconcave shape. This increases the surface area for gas diffusion.

Loss of Mitochondria results is loss of ability to do cellular respiration. Respiration is therefore **anaerobic**. RBC will not use it’s cargo (oxygen)

Physiological Stress due to a decreased oxygen carrying capacity of blood may be caused by:

- Reduced $O_2$ is atmosphere
- Inadequate hemoglobin
- Low red blood cell (erythrocyte) count
- ETC . . .

**Regulation of Erythropoiesis**

**Afferent Pathway**
(Blood by way of its oxygen carrying capacity)

**Efferent Pathway**
(Blood Stream) $(Erythropoietin \ (\square) \ Secreted)$

- a glycoprotein hormone
- (In Adult: sternum, ribs vertebrae, pelvis and proximal ends of humerus and femur)
- (Hematopoietic Stem Cells in Red Bone Marrow stimulated)

**Effect**:
(Erythrocyte Count increases)

- Erythropoiesis rate increase

**Effect**:
($O_2$ Carrying Capacity of blood increases)

**Homeostasis Restored**

- **Stress HYPOXIA**
  (Reduced $O_2$ in blood)
  (-)
**CO₂ Transport in Blood**

- **Interstitial Tissues** generate CO₂, which is transported in the blood to lungs.
- From the blood, CO₂ diffuses into air spaces of the lung.

**Erythrocyte**
- 10% Dissolved in Plasma
- 30% Attached to globin as Carbaminohemoglobin
- 60% CO₂ + H₂O → H₂CO₃ → H⁺ + HCO₃⁻
- Chloride Shift: Cl⁻ → HCO₃⁻

**CO₂ increase lowers the pH**
(blood is acidified)

**CO₂ decrease raises the pH**
(blood becomes more alkaline)

**CO₂ Transport**
- Alveoli of Lungs
- Interstitial Tissues
- Erythrocyte
- CO₂ Diffusion
- pH Changes

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Hemoglobin Breakdown

Red Blood Cell damaged → Hemoglobin Released

Amino Acids reused for protein synthesis in body

Protein Globins broken down into amino acids

Bilirubin complexed with albumin enters bloodstream

Liver retrieves the bilirubin and it is put into the bile, and temporarily stored in the gall bladder

Iron complexed with Transferrin is transferred through the blood to other organs

In red bone marrow, iron will be incorporated into hemoglobin during hemopoiesis

The liver is the primary storage organ of the body for iron

During digestion bile (with bilirubin) enters digestive tract. Bacterial activity creates “bilirubin derivatives” which color feces.

Some of these derivatives are absorbed into the blood but will be eliminated in the urine, giving the characteristic yellow color

Macrophages in spleen and liver etc. ingest hemoglobin
Iron does not normally exist in the body unaccompanied by a protein. Within cells Ferritin (and hemosiderin) are the intracellular storage proteins. As Ferritin is limited within intestinal cells, the intestine limits the amount of iron that can be absorbed. Once ferritin within intestinal cells is saturated, additional iron within intestinal lumen will be excreted.

Transport of iron within the blood is accompanied by a protein called Transferrin. Transferrin will carry the iron to organs such as the liver or spleen or to the red bone marrow for incorporation into hemoglobin. Once the transferrin-iron complex reaches its destination, the iron must then be complexed with ferritin at the new cell site.

**IRON TRANSPORT**

Excreted

Iron stored in cells is complexed with Ferritin

Transferral of Iron within the blood occurs with a protein called Transferrin

Storage of Iron occurs in liver and spleen, complexed with Ferritin

Spleen processes cells and hemoglobin. Iron complexes with Ferritin.

LIVER

Red Blood Cell Count Goes Up. Iron incorporated into erythrocytes

Erythrocyte longevity is 80 - 120 days

Spleen
Introduction to Lymphocytes
Hemostasis

Platelet Plug - Exposed collagen due to endothelia damage allows for platelet adhesion, enlargement, and aggregation. Platelets soon release serotonin and clotting factors.

Platelet-released clotting factors initiate a complex cascade of reactions culminating in Factor X activation and the, therefore, the “common pathway”.

Common Pathway leads to polymerization of Fibrinogen into fibrin fibers. These fibrin fibers will be cross-linked to form a secure adhesive mesh that can effectively stop bleeding.

Synergist operation of both pathways results in both a quick and prolonged response that will efficiently stop blood flow in almost all cases.

Damaged tissues release “tissue factor,” which bypasses several reactions of the Intrinsic pathway prompting quick activation of the common pathway.