Blood Biochemistry
BCH 577

By

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Part I

- Introduction
- Types of White Blood Cells
- Genesis of the White Blood Cells
- Life Span of the White Blood Cells

Leucocytes

Introduction:

- **Infectious agents are capable of causing serious abnormal physiologic function or even death if they invade the deeper tissues.**
- **Highly infectious bacteria and viruses can cause acute lethal diseases such as pneumonia, streptococcal infection, and typhoid fever.**

- **Our bodies have a special system for fighting the different infectious and toxic agents.**
- **Blood leucocytes (white blood cells) work in two ways to prevent disease:**

  (1) Destroying invading bacteria or viruses by phagocytosis.

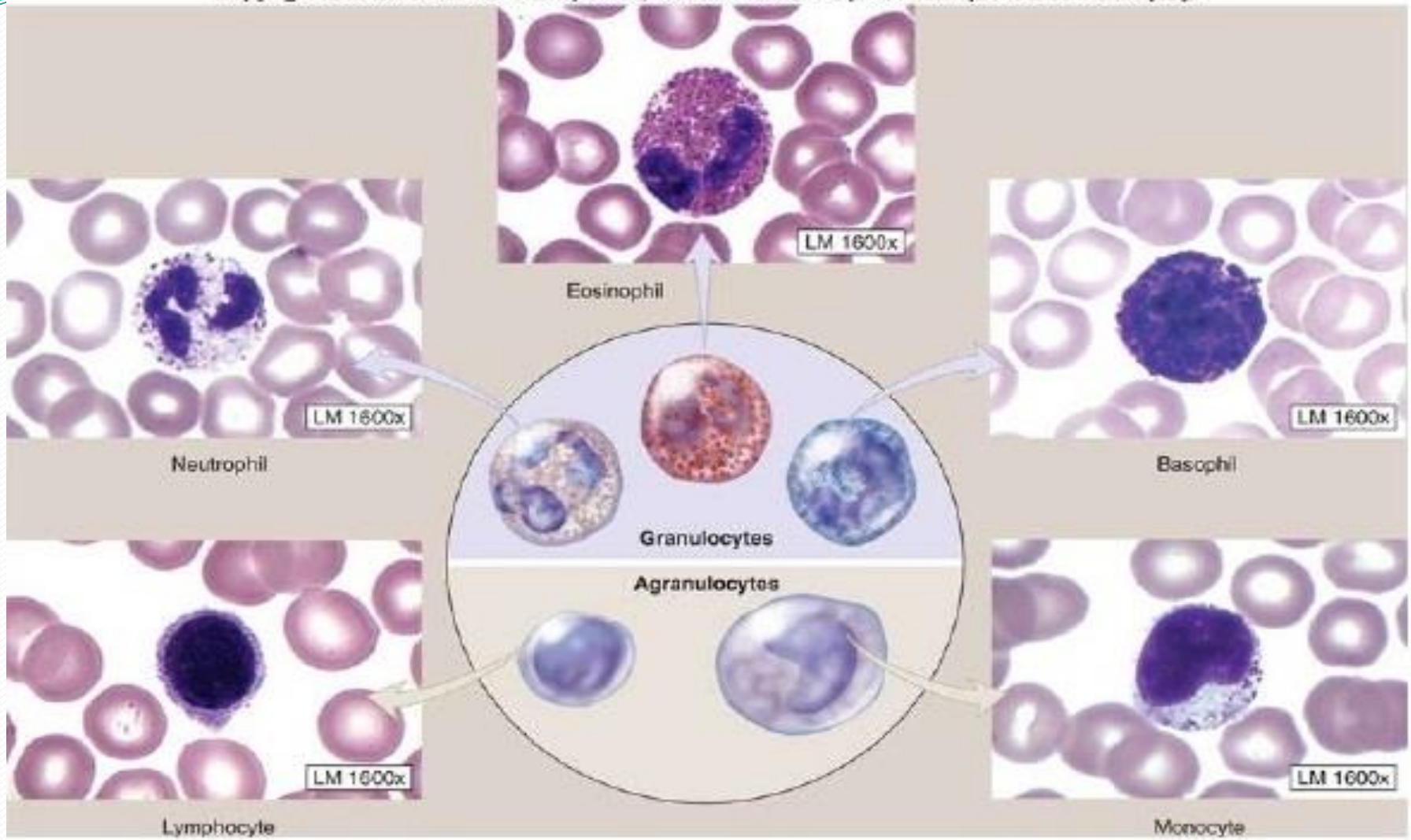
  (2) Forming antibodies and sensitized lymphocytes, one or both of which may destroy or inactivate the invader.

Leucocytes (White Blood Cells):

- **Leucocytes (white blood cells): Mobile units of the body's protective system.**
- **Formed in the bone marrow (granulocytes and monocytes and a few lymphocytes) and in the lymph tissue (lymphocytes and plasma cells).**
- **After formation, they are transported in the blood to different parts of the body where they are needed.**

Types of White Blood Cells.

- **Five types of white blood cells are normally present in the blood. (neutrophils, eosinophils, basophils, monocytes and lymphocytes).**
- **Neutrophils, eosinophils, basophils, all have a granules (granulocytes).**
- **The granulocytes and monocytes protect the body against invading organisms mainly by ingesting them (phagocytosis). The lymphocytes function mainly in connection with the immune system.**



Normal range of WBC

- At birth, in full term infant: 10,000-25,000/µl of blood.
- Infants up to 1 year of age:6000-16,000/µl of blood.
- Adults: 4000-11,000/µl of blood.

Abnormal variations in WBC count:

TLC > 11,000/µL (Leucocytosis)

Physiological causes: Age – Exercise - Mental stress – Pregnancy - After food intake – Exposure to low temperature.

Pathological causes: Acute bacterial infections (pyogenic organisms) – Burns - Post-operative period – Tuberculosis - Glandular fever.

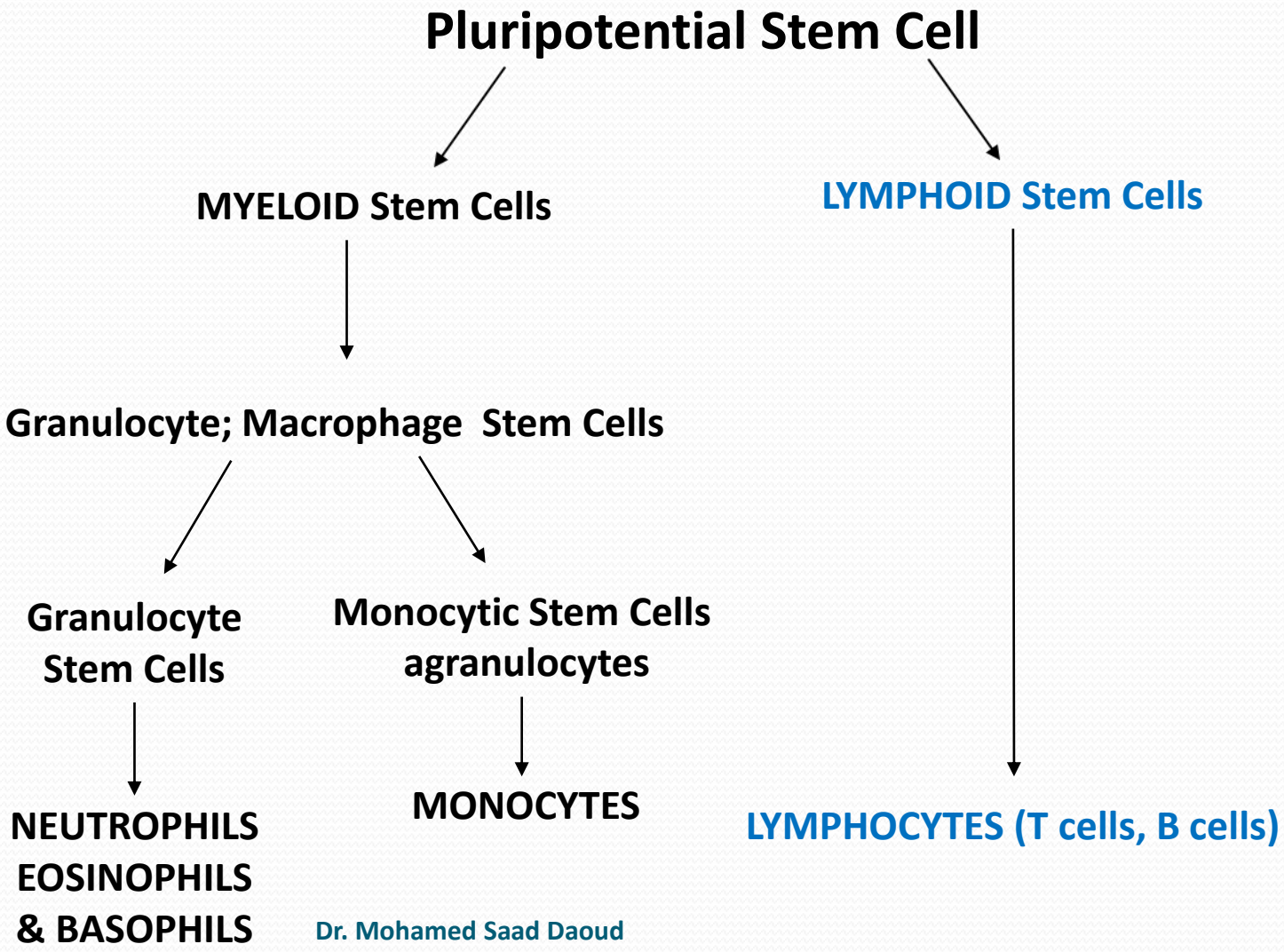
TLC < 4000/µL(Leucopenia)

- Infections by non-pyogenic organisms e.g. typhoid fever
- Viral infections, influenza, smallpox, mumps, etc
- Protozoal infections
- Starvation & malnutrition
- Aplasia of bone marrow
- Bone marrow depression

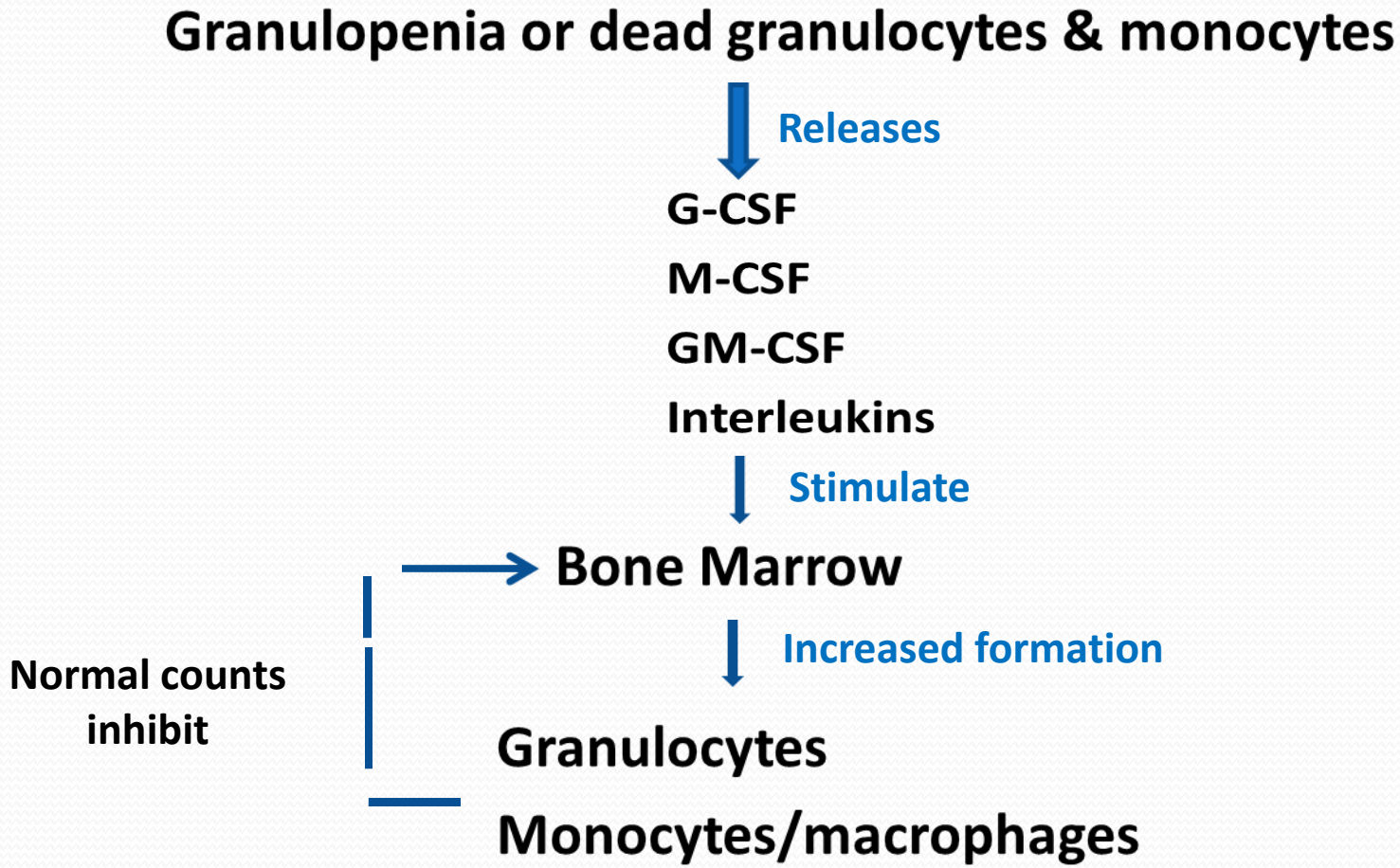
Leucopoiesis

- The process of development and maturation of white blood cells (leucocytes).
- White blood cells originates in bone marrow.
- Each type of cell has parent cells (stem cell).

Leucopoiesis



Regulation of leucopoiesis



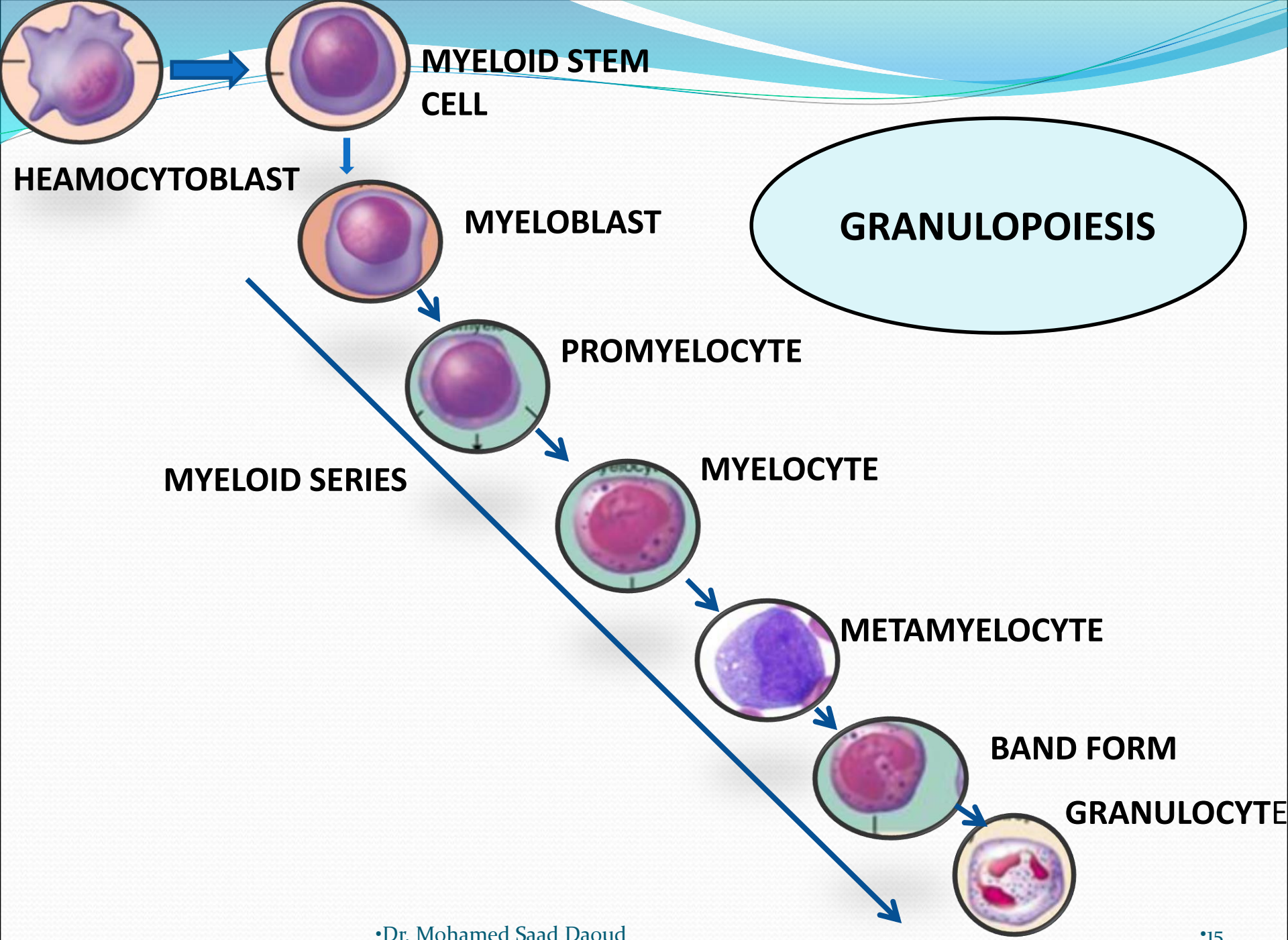
- **Small portion of cell reproduce remains like the original pluripotential cells and is retained in the bone marrow to maintain a supply of these.**
- **Most of the reproduced cells, differentiate to form the other cell types. The intermediate stage cells are very much like the pluripotential stem cells.**
- **Growth and reproduction of the different stem cells are controlled by multiple proteins (four growth inducers).**

1- Granulocyte-colony stimulating factor (G-CSF).

2- Macrophage colony-stimulating factor (M-CSF).

3- Granulocyte-macrophage colony-stimulating factor (GM-CSF).

4- Interleukins.


MYELOID STEM CELL
HEAMOCYTOBLAST
MYELOBLAST
GRANULOPOIESIS
PROMYELOCYTE
MYELOID SERIES
MYELOCYTE
METAMYELOCYTE
BAND FORM
GRANULOCYTE

Granulocyte Lineage:

Myeloblast:

- Large cell (18 µm) with pale basophilic cytoplasm without any granules.
- It has a large round nucleus and prominent nucleoli which appear as lightly staining spheres within the nucleus.
- Normal myeloblasts have no granules but abnormal myeloblasts may have a few granules. Myeloblasts undergo one cell division and mature into promyelocytes.

Promyelocytes:

The most characteristic features of the promyelocyte are:

- **its large overall cell size**
- **its large rounded nucleus with prominent nucleoli**
- **the presence of purple-staining nonspecific azurophilic granules.**

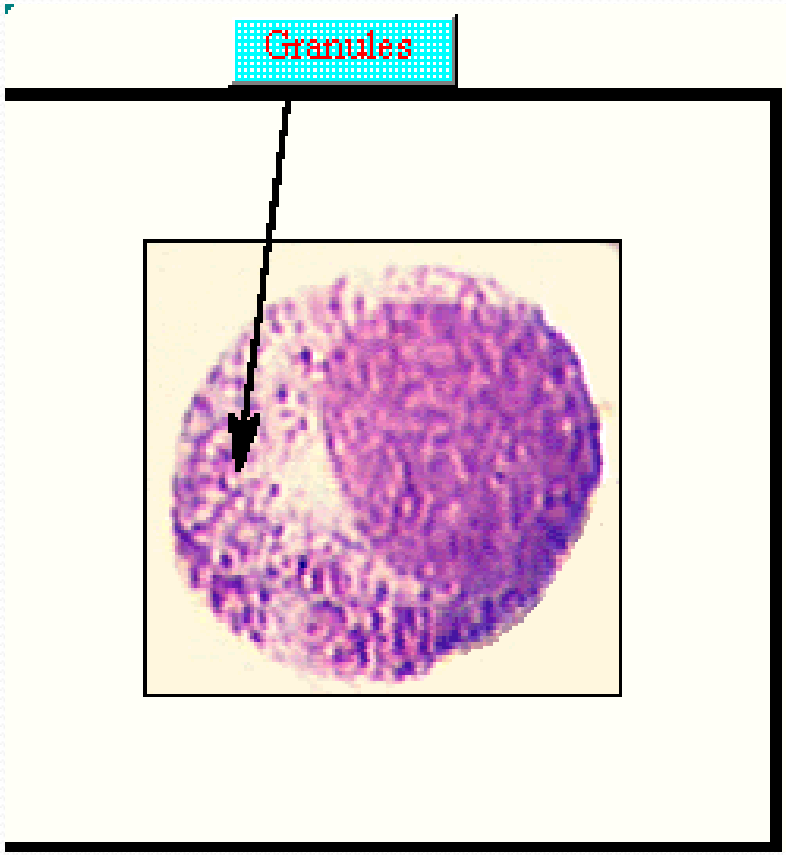
Myelocyte:

The most characteristic features of the myelocyte stage are:

- **The range in cell size - early myelocytes are as large as promyelocytes, whereas late**

  myelocytes are closer in size to metamyelocytes .
- **The shape and size of the nucleus - more condensed than that of a promyelocyte and frequently indented**
- **The presence of both the purplish-staining azurophilic and lilac-staining linear-specific granules.**

- **the number of linear-specific granules per cell increases and the number of azurophilic granules per cell decreases.**

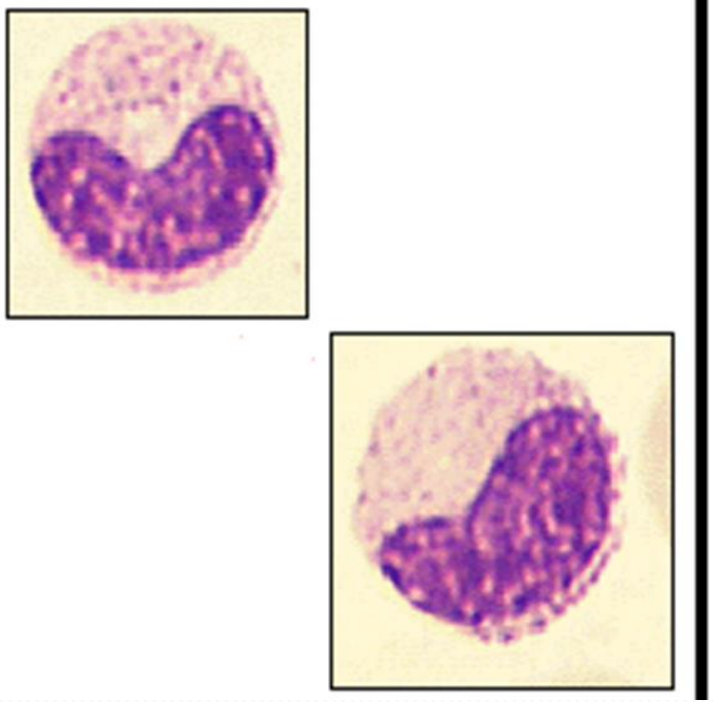


The nuclear chromatin of the myelocyte is coarse and a nucleolus is rarely seen. The cytoplasm is pale and contains lineage-specific granules:

1. Violet-brown:
   Neutrophilic myelocyte.
2. Orange-red:
   Eosinophilic myelocyte.
3. Dark-blue:
   Basophilic myelocyte.

Metamyelocyte:

When the nucleus becomes flattened and the chromatin further condensed, the cell is called a metamyelocyte.



The metamyelocyte **nucleus is bean or kidney shaped,** and contains compact chromatin, especially at both poles.

The cytoplasm is similar to that of a myelocyte, but with less granules.

Band (Stab or juvenile):

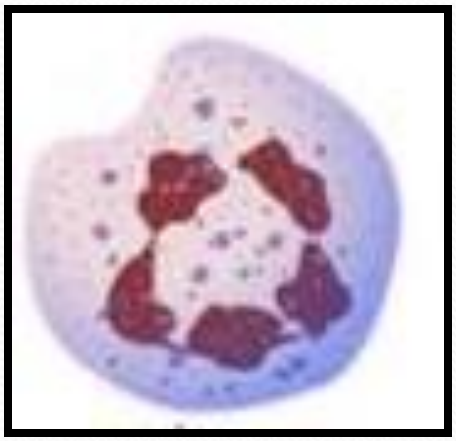
When the nucleus becomes horseshoe-shaped, it is called a band cell.

- **The shape can also be described as C or S shaped.**
- **A band cell can also be referred to as a stab cell.**

There are smaller numbers of cells of neutrophil lineage with non-segmented nuclei. They are referred to as neutrophil band cells or band forms. They are less mature than segmented neutrophils.

Cell	Size	Nucleus	Cytoplasm
Myeloblast	12-20µ	Round, fine chromatin, nucleoli	Blue usually without granules. Some azurophilic granules may be present
Promyelocyte	15-25µ	Slightly indented nucleus often eccentrically placed. Chromatin coarser than a myeloblast. Nucleoli seen	Blue cytoplasm with numerous azurophilic granules
Myelocyte	10-20µ	Round to oval, indented, chromatin more coarse than promyelocyte, no nucleoli	Most immature forms have less basophilia than the promyeloblast. Basophilia disappears as cell matures. Secondary granules appear.
Metamyelocyte	12-18µ	Indented, coarse clumped chromatin	Pink with secondary granules.
Band Form	10-12µ	Band shaped. Borders are parallel for most of the length. May be folded	Pink with secondary granules

Neutrophils



1. **Cell size-** 10-14µm
2. **Nucleus-** central or eccentric; 2-6 lobes; deep purplish blue
3. **Cytoplasm-** faint pink
4. **Granules-** fine (pin-point); violet-pink in color

Normal values

- Differential:40 -75%
- Absolute:2000 -7500/µl of blood

Neutrophils

- 1st line of defense
- Granules contain enzymes like

  Nucleotidases

  Catalases
- Antibody like substances -> Defensins

Eosinophils

1. **Cell size-** 10-14µm
2. **Nucleus-** central or eccentric; 2-3 lobes; purplish blue; "spectacle shaped"
3. **Cytoplasm-** acidophilic;bright pink in color
4. **Granules-** large; coarse; crimson red

Normal values

- Differential: 1-6%
- Absolute:40-440/µl of blood

Eosinophils

- Defense (specially against parasites)
- Role in allergic reactions
- Substances present in granules

1. Major basic protein
2. Eosinophilic cationic proteins
3. Eosinophil peroxidase
4. Aryl sulphatase B

Basophils

1. **Cell size-** 10-14µm
2. **Nucleus-** central; 2-3 lobes; purplish blue; overlaid with granules
3. **Cytoplasm-** basophilic; full of granules
4. **Granules-** very coarse,deep purple or blue

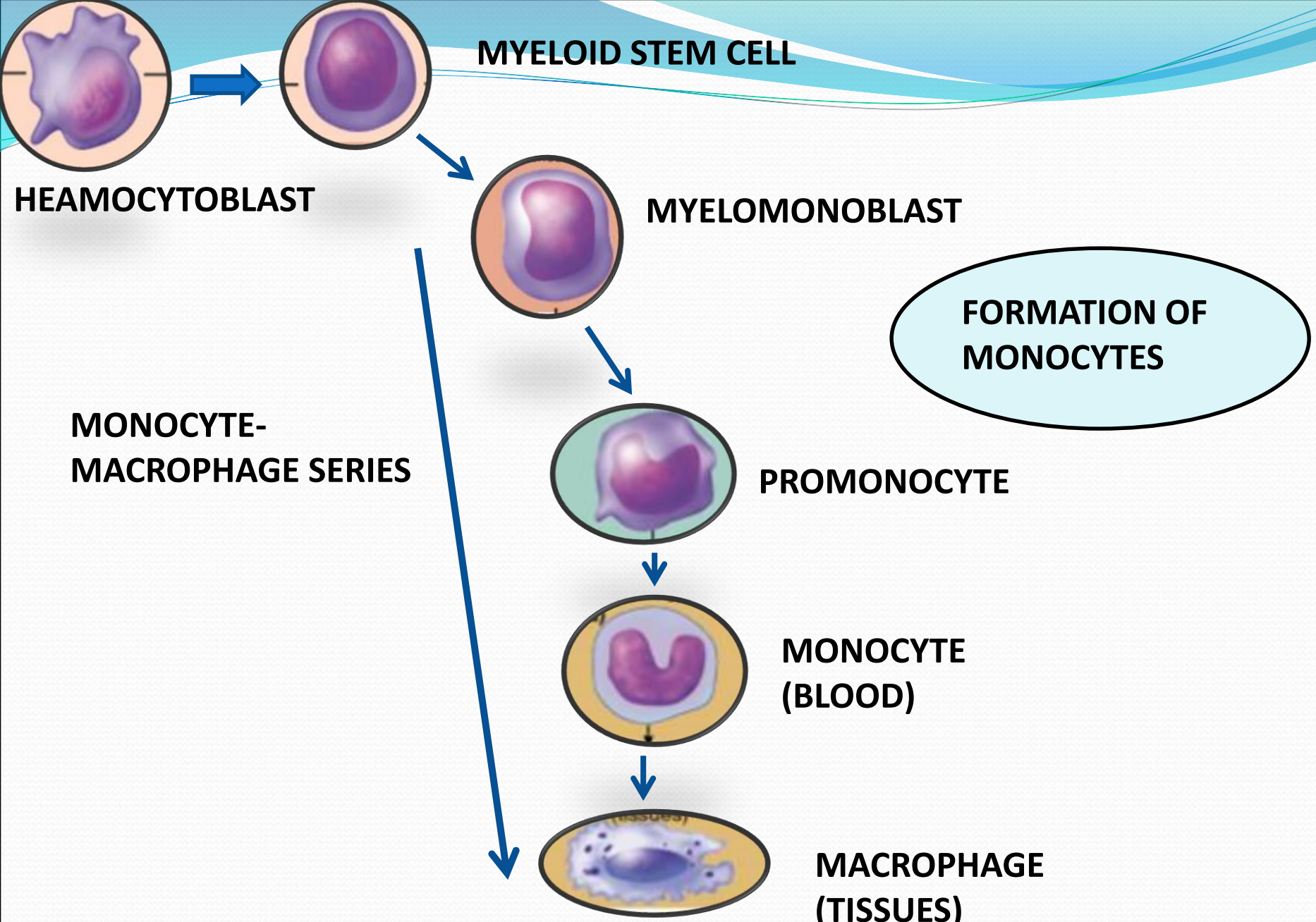
Normal values

- Differential: 0-1%
- Absolute: 0-100/µl of blood

Basophils

- Role in allergic responses
- Substances present in granules

1. Histamine
2. Heparin
3. Hyaluronic acid
4. Proteases & Myeloperoxidase


MYELOID STEM CELL
HEAMOCYTOBLAST
MYELOMONOBLAST
FORMATION OF MONOCYTES
MONOCYTE-MACROPHAGE SERIES
PROMONOCYTE
MONOCYTE (BLOOD)
MACROPHAGE (TISSUES)

Monocyte Lineage

Monoblast:

- Morphologically, the monoblastis undistiguishable from the myeloblast. That is, it is a very large cell of up to 20 µ in size.
- The nucleus occupy more than 85% of the cell with very smooth chromatin, and 1 to 3 nucleoli could be seen.
- The very scant cytoplasm present is usually light to slightly dark blue in color, with no granules or vacuoles of any type.

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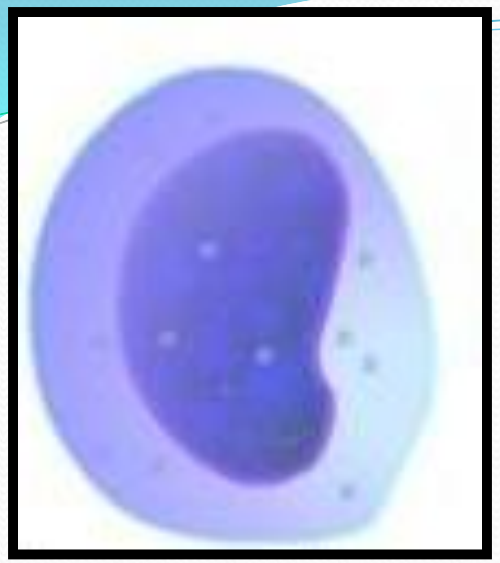
- **Only CD markers, biological assays, and advanced molecular techniques can differentiate between monoblast and myeloblast**

Promonocyte:

- **Similar to the promyelocyte in everything, except they don't have the typical primary (reddish pink) granules of the promyelocytes.**
- **Their shape, size, chromatin quality, and cytoplasm are very much similar to that of promyelocytes. They also resemble myeloblasts but they might not have nucleoli.**

Monocyte



1. **Cell size-** 12-20µm
2. **Nucleus-** eccentric or central; round or oval; pale bluish violet
3. **Cytoplasm-** abundant; pale blue; clear

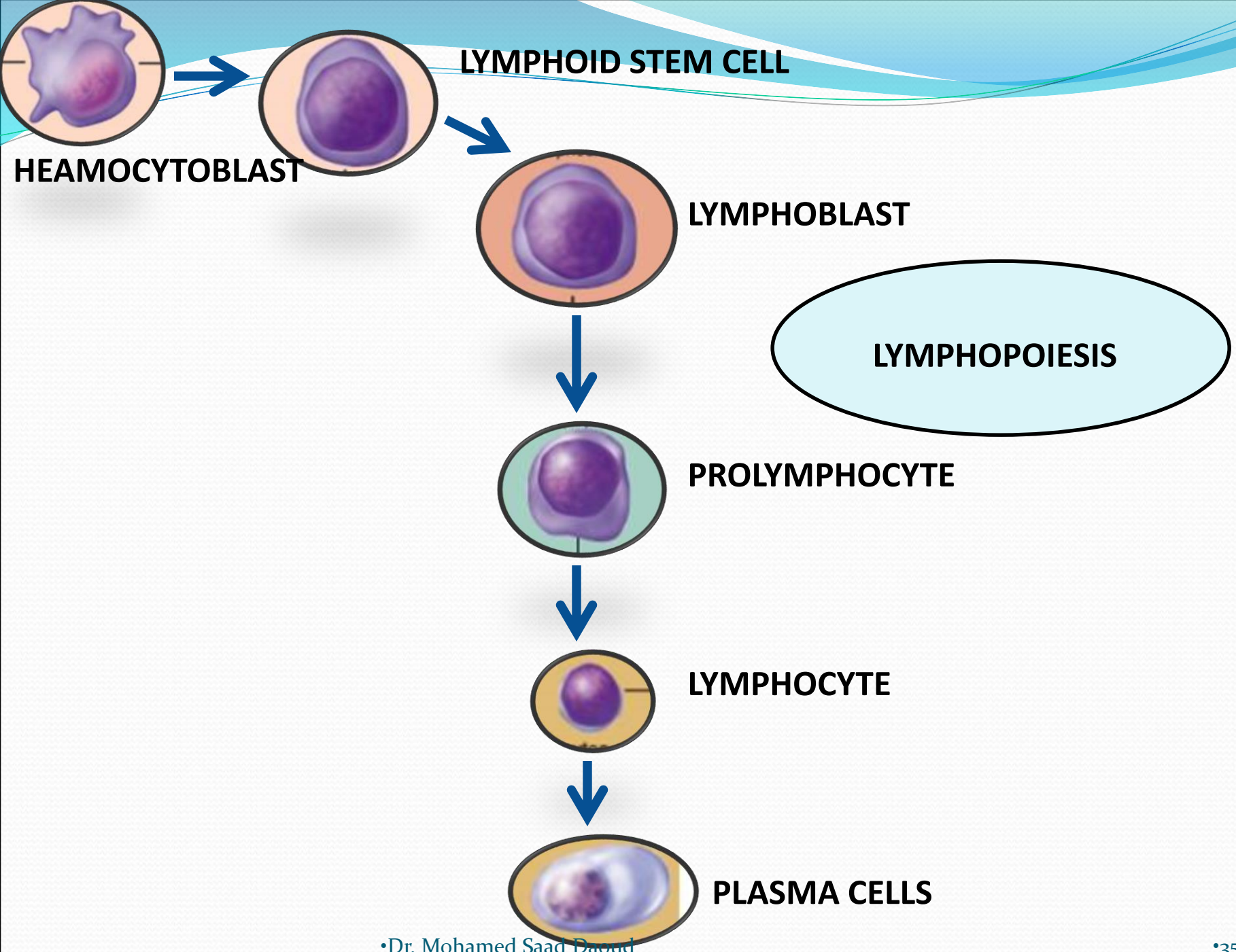
Normal values

- Differential: 2-10%
- Absolute:500 -800/µl of blood

Monocytes

- 1st line of defense
- Motile & phagocytic
- Precursors of tissue macrophages secrete:

1. Interleukin 1
2. Colony stimulating factor
3. Platelet activating factor


LYMPHOID STEM CELL
HEAMOCYTOBLAST
LYMPHOBLAST
LYMPHOPOIESIS
PROLYMPHOCYTE
LYMPHOCYTE
PLASMA CELLS

Lymphocyte Lineage

- **Lymphocytes are the cornerstone of the adaptive immune system.**
- **They are derived from common lymphoid progenitors. The Lymphocytes is primarily composed of T-cells, B-cells and natural killer cells (NK)**

Lymphoblast:

All in contrast to the myleoblast the lymphoblast is a small blast with a scant cytoplasm, dense chromatin, indistinct nucleoli.

Prolymphocytes:

It is a medium sized cell with variable amount of non granular basophilic cytoplasm, round, oval or irregular nucleus. Coarse chromatin and single prominent nucleoles.

Lymphocyte

1. **Cell size-** LL:12-16µm; SL:7-10µm
2. **Nucleus-** eccentric; large round nucleus; deep purplish blue
3. **Cytoplasm-** scanty; light blue color

Normal values

- Differential:20-40%
- Absolute: 1500-4000/µl of blood

Lymphocytes

- Immunity

1. T- Lymphocyte -> Cellular Immunity

2. B- Lymphocyte -> Humoral Immunity

Life Span of the White Blood Cells

Not constant

- **Neutrophils -> 2-5 days**
- **Eosinophils -> 7-12 days**
- **Basophils -> 12-15 days**
- **Monocytes -> 2-5 days**
- **Lymphocytes -> ½-1 day**