

VORLESUNG 4

Vorlesung
Humboldt-Universität zu Berlin
Institut für Physik

Biologische Physik

Die Dynamik biologischer Prozesse im menschlichen Körper

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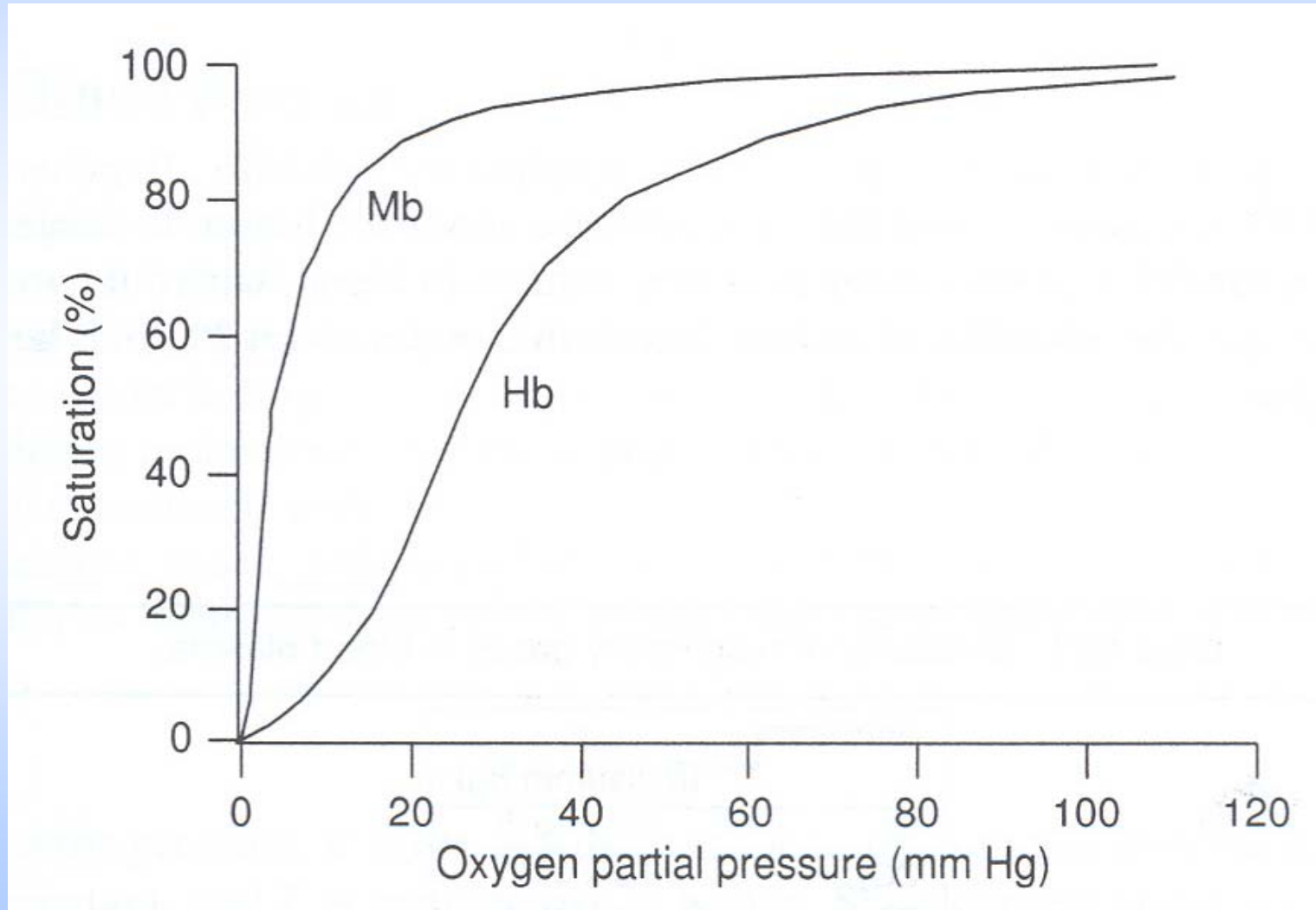


Max Planck Institute
of Colloids and Interfaces



2.2 Myoglobin vs Hemoglobin

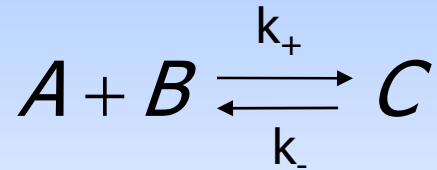
uptake of oxygen by myoglobin and hemoglobin:





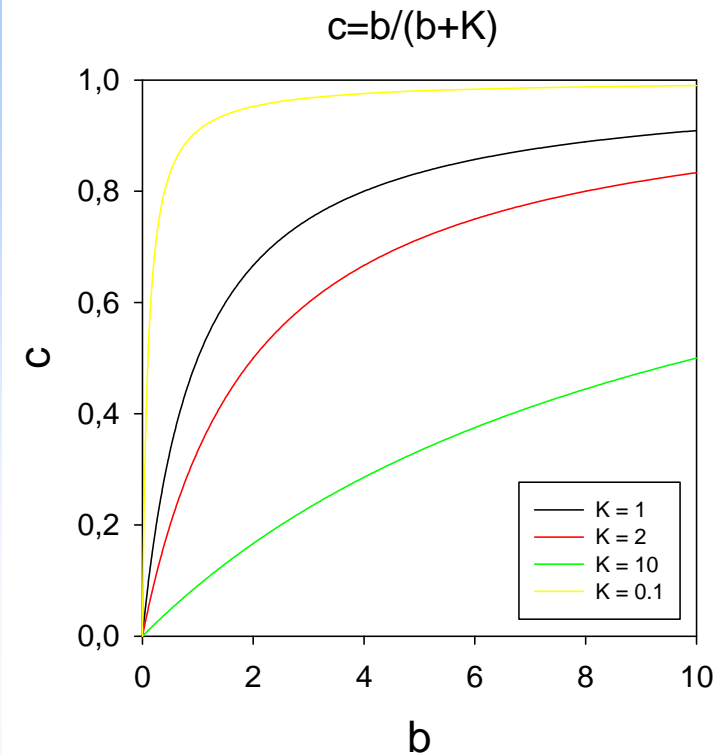
Chemical Reactions

simple reaction:

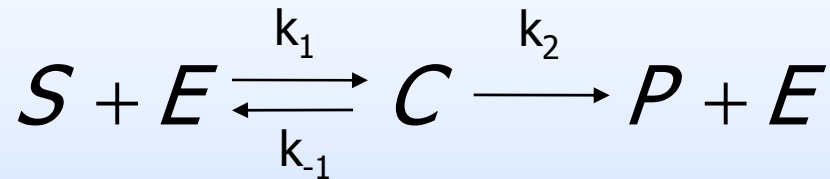


law of mass action: $\frac{da}{dt} = k_- c - k_+ a b$

$$c = a_0 \frac{b}{b + K_{eq}}$$



enzyme reaction:

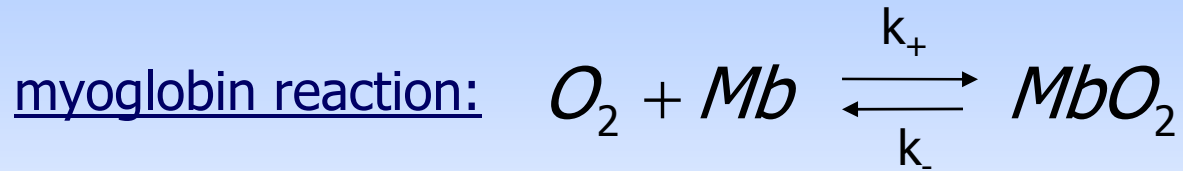


Michaelis-Menten law: $V = \frac{dp}{dt} = V_{\max} \frac{s}{s + K_m}$

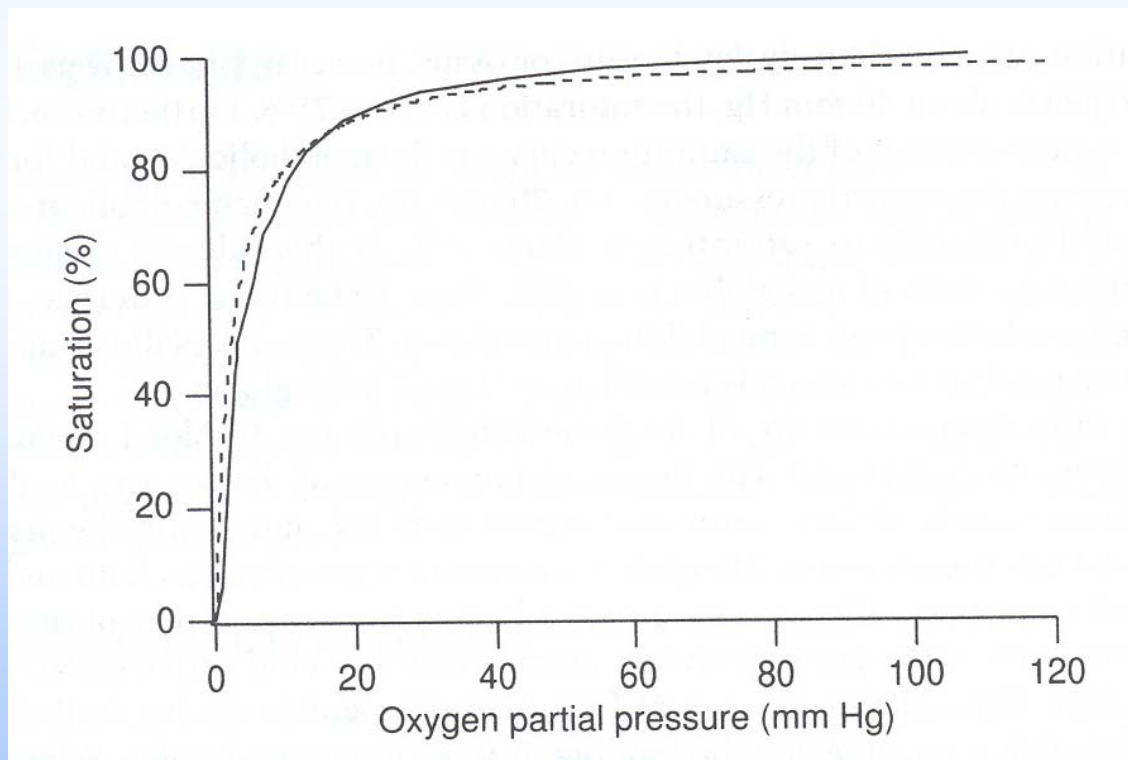
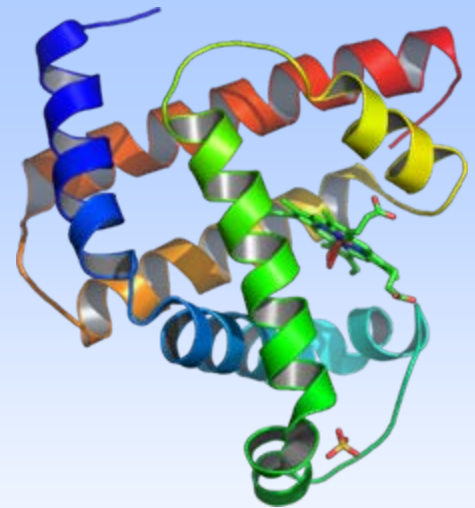




2.2 Myoglobin vs Hemoglobin

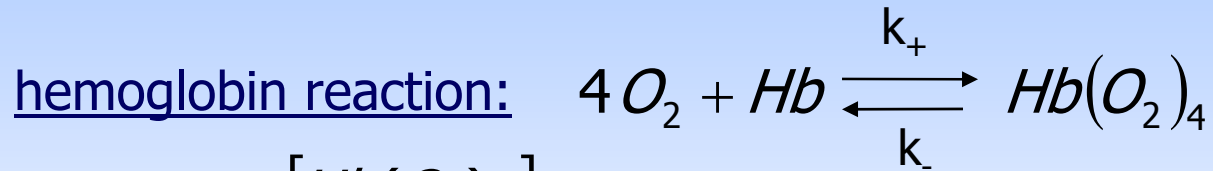


$$Y = \frac{[MbO_2]}{[Mb] + [MbO_2]} = \frac{P_{O_2}}{K_P + P_{O_2}}$$



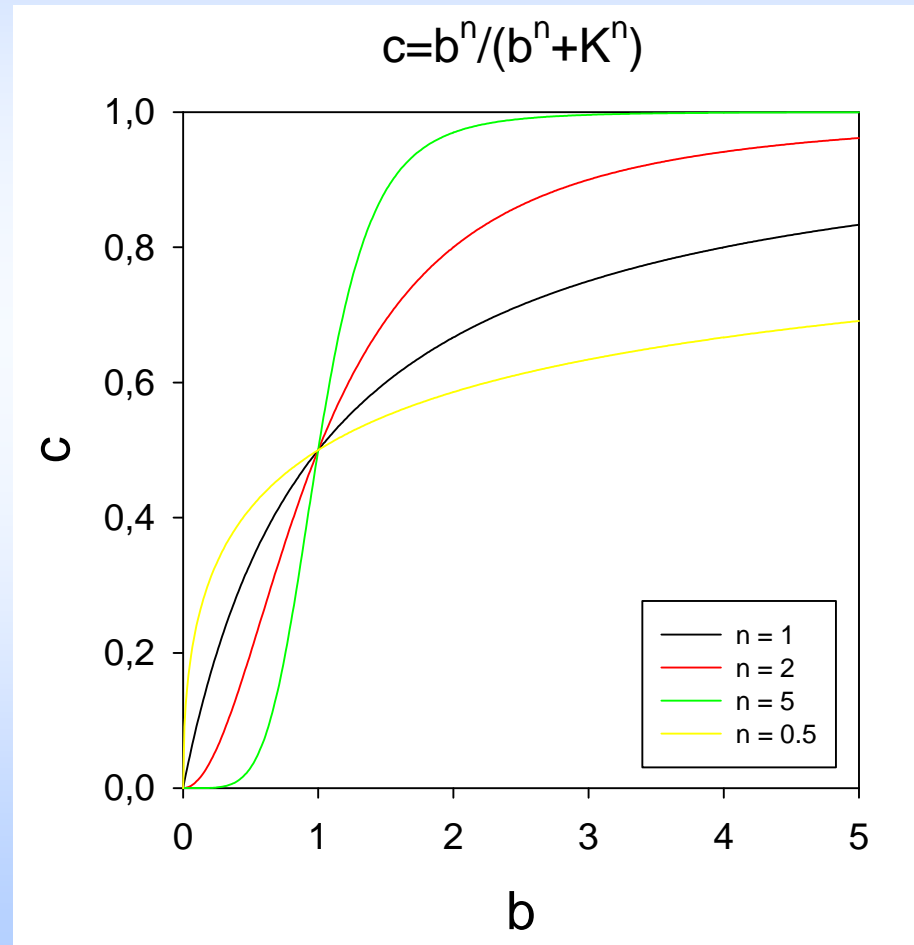
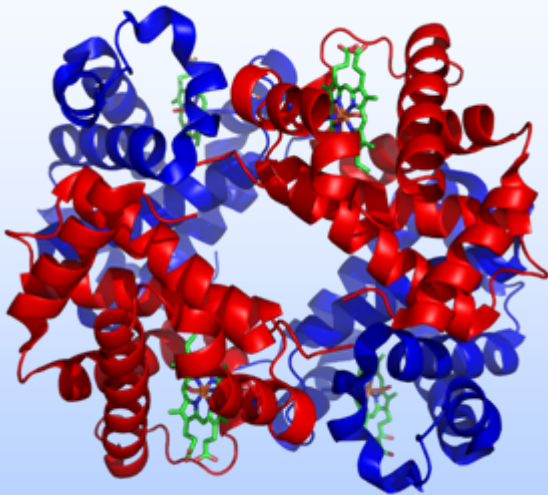


2.2 Myoglobin vs Hemoglobin



Hill equation:

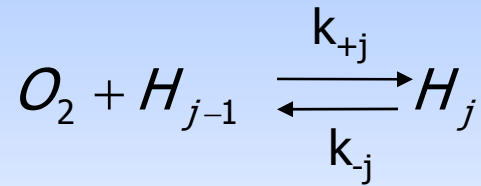
$$Y = \frac{[Hb(O_2)_4]}{[Hb] + [Hb(O_2)_4]} = \frac{[O_2]^4}{[O_2]^4 + K^4}$$





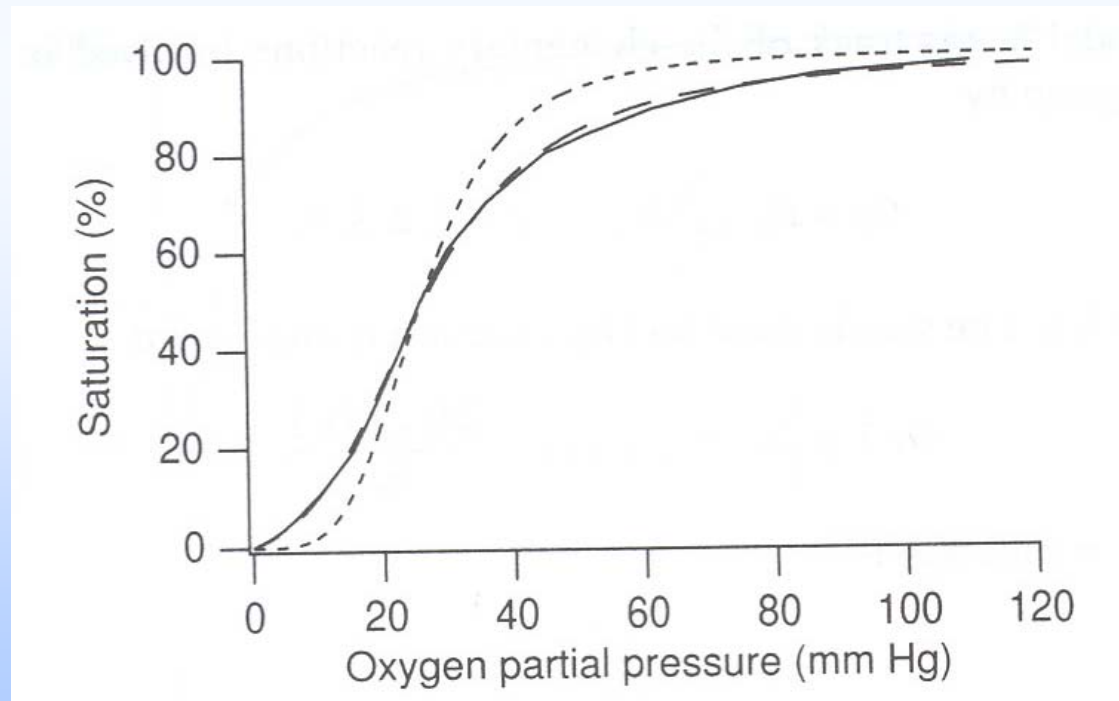
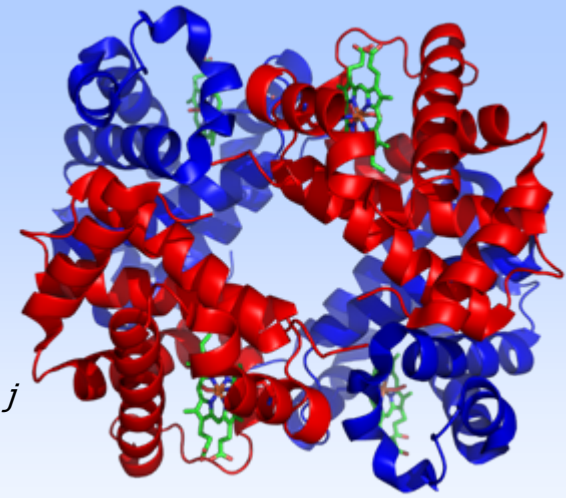
2.2 Myoglobin vs Hemoglobin

hemoglobin reaction:
(improved model)



$$Y = \frac{\sum_{j=0}^4 j H_j}{4 \sum_{j=0}^4 H_j} = \frac{\sum_{j=0}^4 j \prod_{i=1}^j K_i^{-1} [O_2]^j}{4 \sum_{j=0}^4 \prod_{i=1}^j K_i^{-1} [O_2]^j}$$

where $H_j = Hb(O_2)_j$



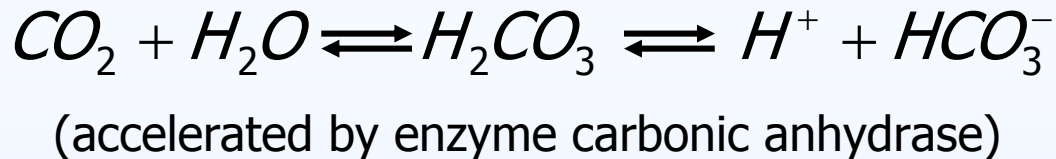


2.2 Myoglobin vs Hemoglobin

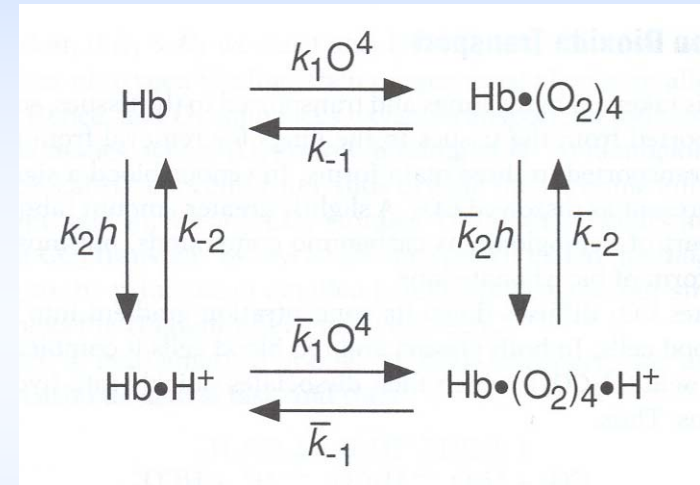
coupling between carbon dioxide and oxygen transport:

hydrogen ion is an allosteric inhibitor of oxygen binding

$$Y = \frac{O^4 T_{Hb}}{O^4 + \Phi(h)} \quad \text{where } h \text{ denotes concentration of } H^+$$



simple 4 state model:



in the tissue:

high local CO_2 concentration \Rightarrow high H^+ concentration

\Rightarrow right-shift of hemoglobin saturation curve for O_2 (lower O_2 affinity)

\Rightarrow O_2 release

in the lungs: opposite


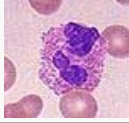
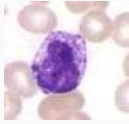

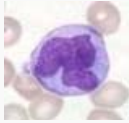
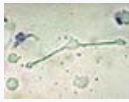
BOHR EFFECT \longleftrightarrow HALDANE EFFECT





2.3 Leukocytes

overview:

Type	Microscopic Appearance	Approx. % in adults	Diameter (μm)	Main targets
Neutrophil		54-62% ^[6]	10-12	<ul style="list-style-type: none"> • bacteria • fungi
Eosinophil		1-6%	10-12	<ul style="list-style-type: none"> • parasites • in allergic reactions
Basophil		<1%	12-15	<ul style="list-style-type: none"> • in allergic reactions
Lymphocyte		25-33%	7-8	<ul style="list-style-type: none"> • B cells: various pathogens • T cells: <ul style="list-style-type: none"> ◦ CD4+ (helper): extracellular bacteria broken down into peptides presented by MHC class 2 molecule. ◦ CD8+ cytotoxic T cells: virus-infected and tumor cells. ◦ $\gamma\delta$ T cells: • Natural killer cells: virus-infected and tumor cells.
Monocyte		2-8%	14-17	various
Macrophage			21 (human) ^[8] 13 (rat) ^[9]	





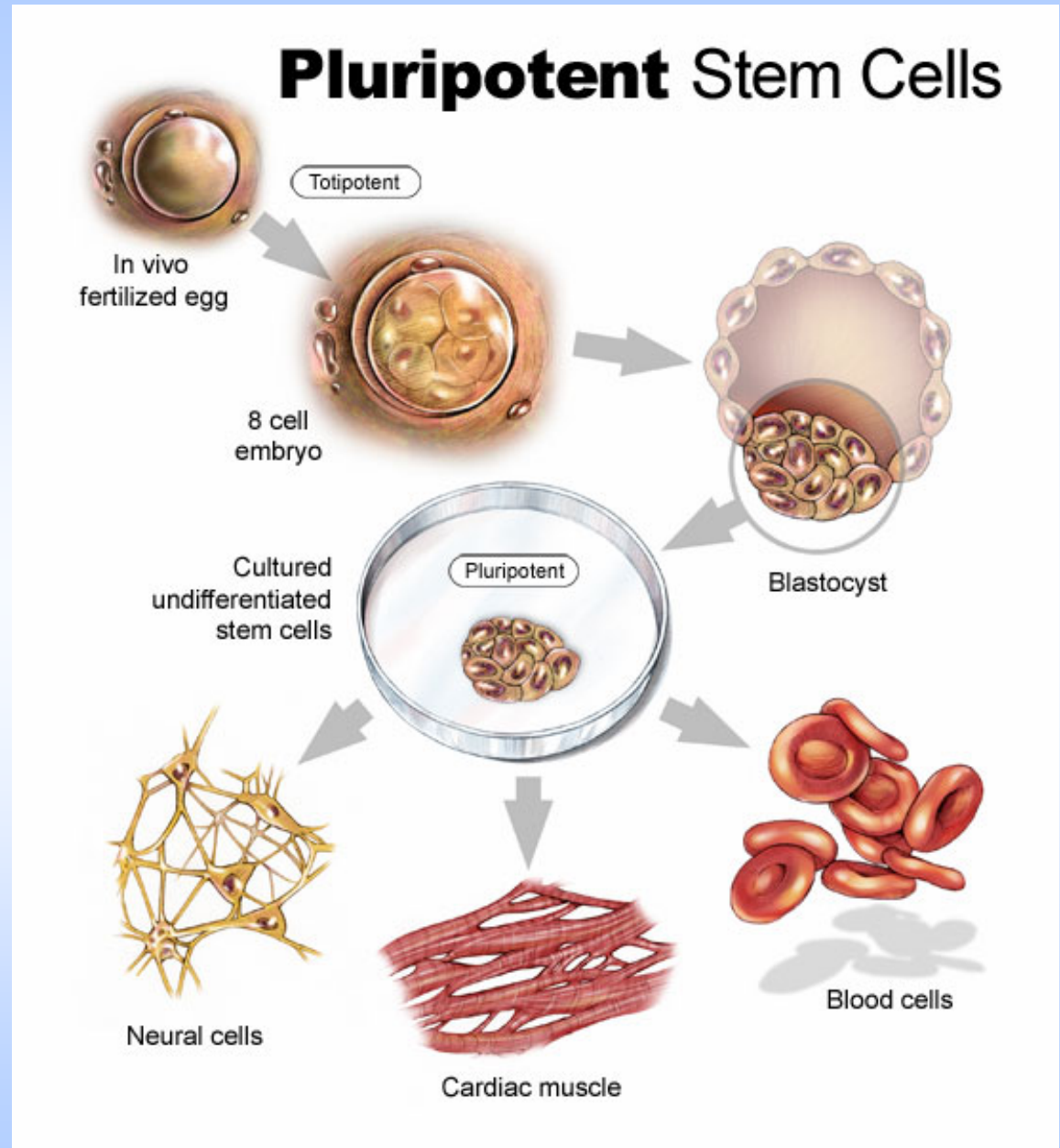
Stem Cells

two characteristic properties:

- self-renewal
- potency
- totipotent
- pluripotent
- multipotent
- unipotent

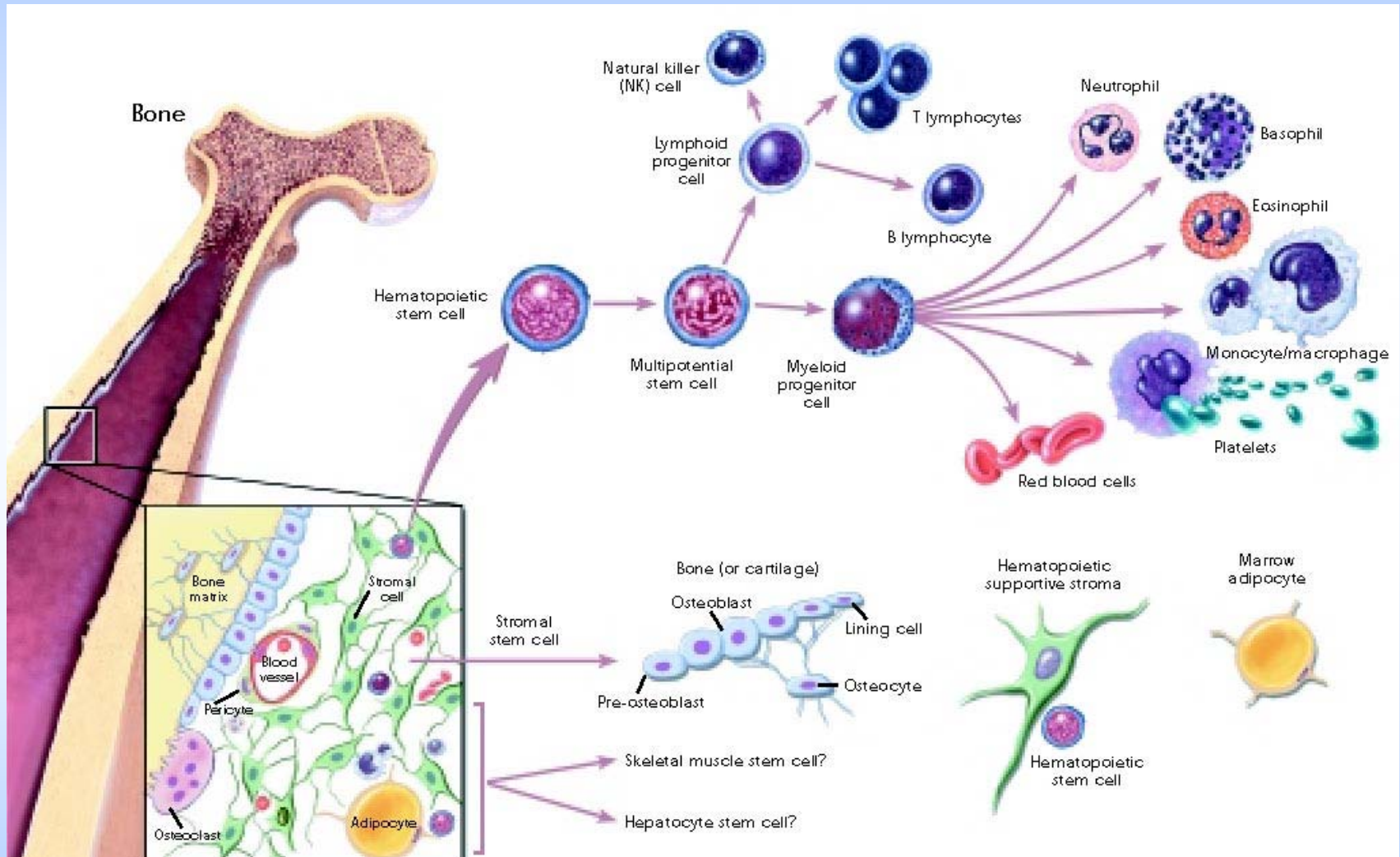
3 germ layers:

- ectoderm
(nerves, epidermis, ...)
- mesoderm
(muscle, skeleton, blood, ...)
- endoderm
(lungs, stomach, bladder, ...)





Hematopoietic and Mesenchymal Stem Cells



red marrow (source of red blood cells and most of white blood cells) and yellow marrow

