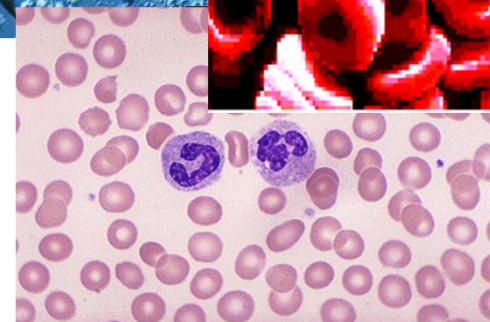
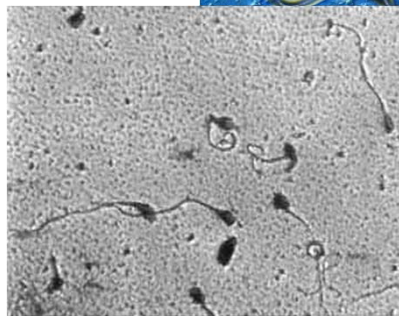
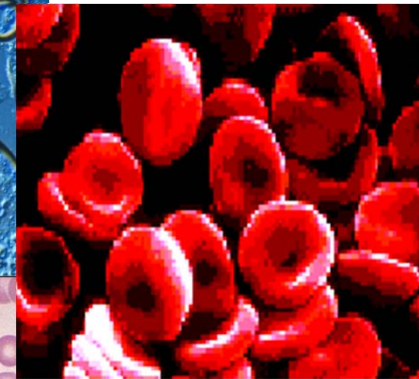
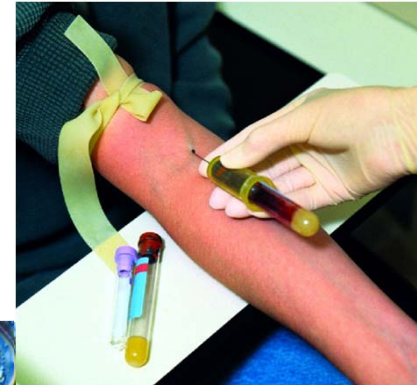


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4. Microfabrication Technologies
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11. Microreactors
12. Analytical Chips
13. Particle-Laden Fluids
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 - b. Fundamentals of Biotechnology
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2. Fluids

- 2.1. General Characteristics
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- 2.4. Transport Phenomena
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- 2.9. Biological Fluids**



2.9. Biological Fluids

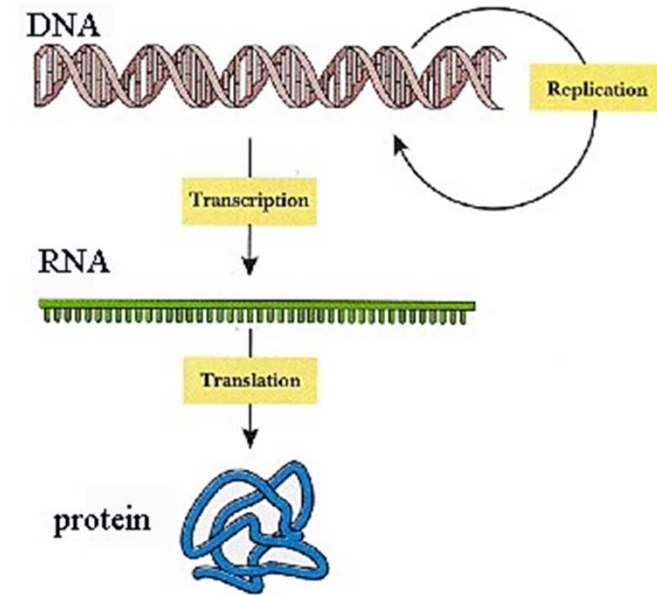
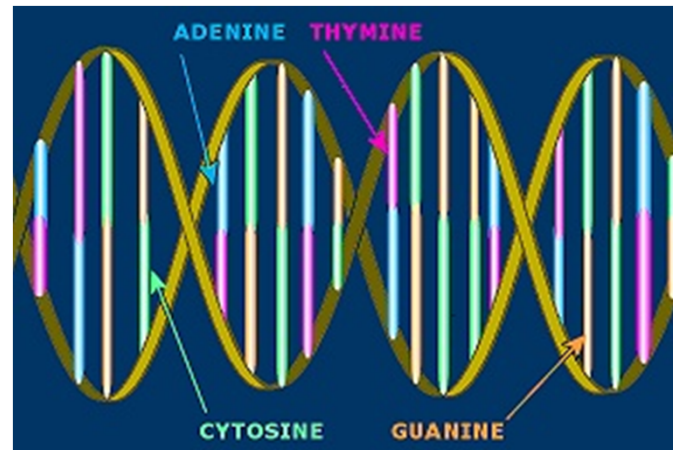
1. DNA

2. Proteins

3. Cells

4. Dispersions of Biopolymers and Cells

5. Human Blood



2.9.1. DNA

- Structure
 - Deoxyribonucleic acid or DNA
 - Organic chemical
 - Complex and **highly stable double-helix** configuration
 - 2 DNA strands wound around each other

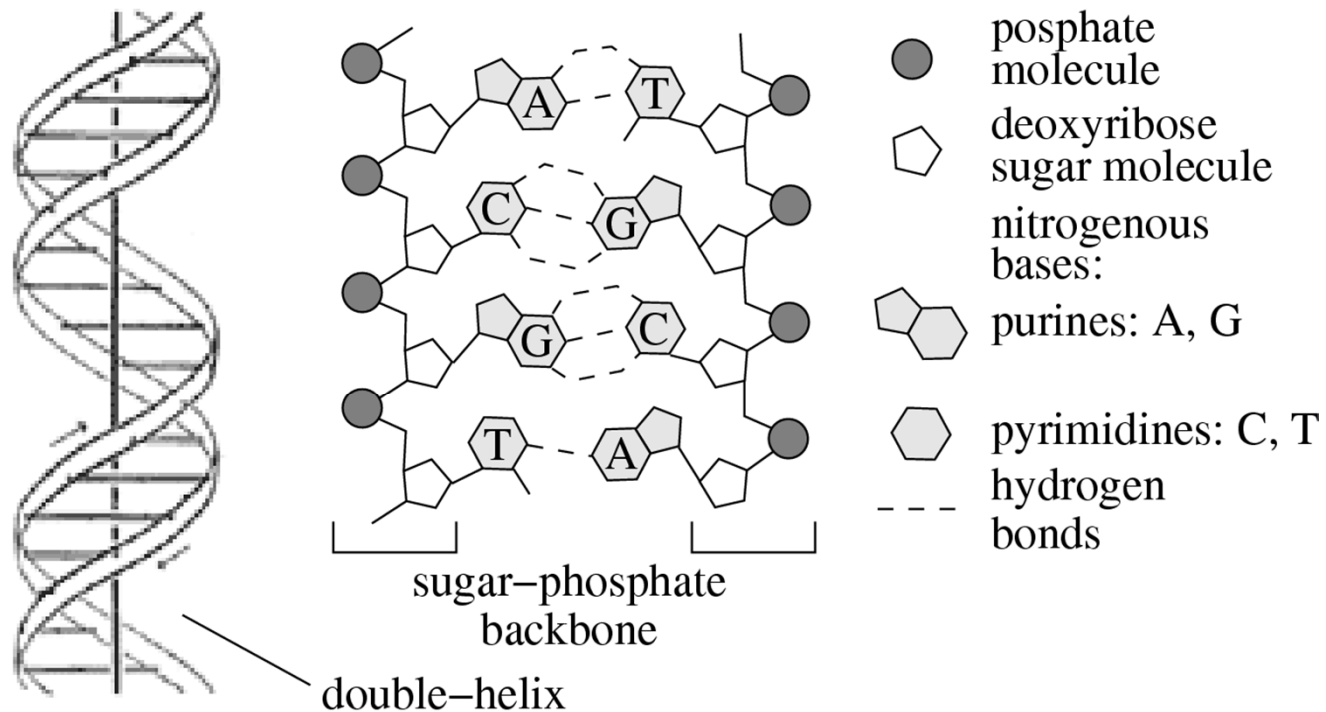


Fig. 2.34. Double-Helix structure of DNA and its molecular constituents

2.9.1. DNA

- Molecular Constituents

- Long **chain** of monomer **nucleotides** consisting of

- Deoxyribose sugar molecule
- Phosphate group
- 1 of 4 nitrogenous bases

- **Adenine (A)**

- **Guanine (G)**

- **Cytosine (C)**

- **Thymin (T)**

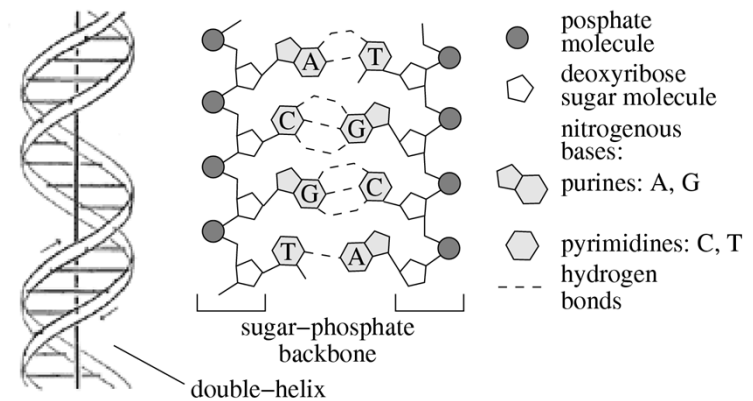


Fig. 2.34. Double-Helix structure of DNA and its molecular constituents

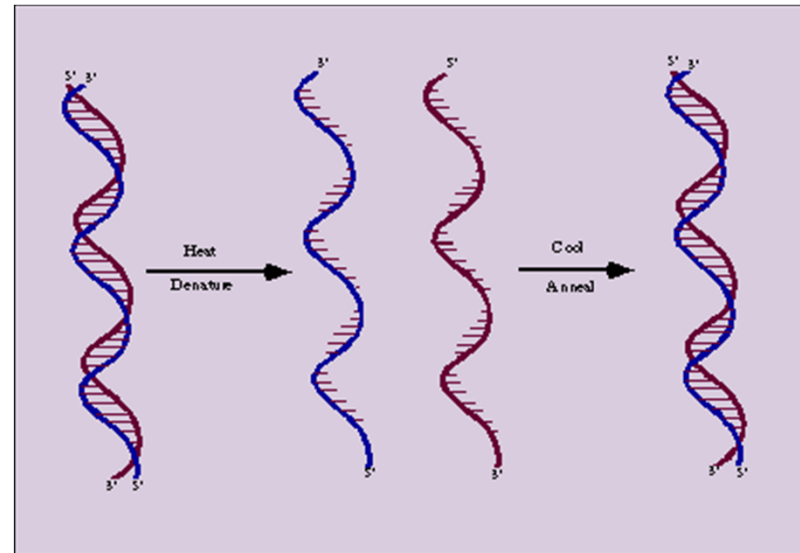
- **Covalent phosphate-sugar bonds** connect adjacent nucleotides

- Base-specific **hydrogen bonds**: **A-T** and **C-G**

- Stabilized double-helix structure

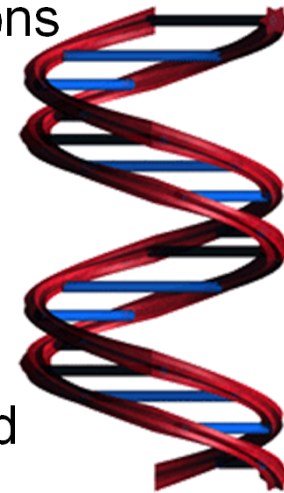
2.9.1. Viscosity of DNA

- Related to asymmetry and size
→ DNA very viscous
- **Heat**
 - **Denaturing**
 - Destruction of hydrogen bonds
 - Double-helix splits in 2 strands
 - Markedly decreased viscosity



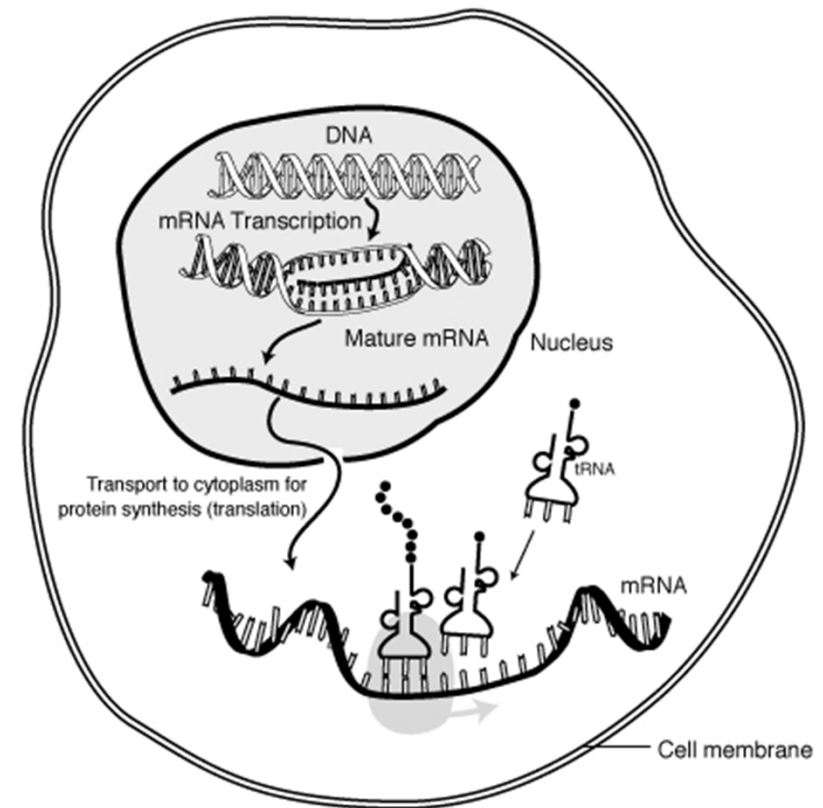
2.9.1. Physico-Chemical Properties of DNA

- **Dissolves well** in water
- **Negatively charged** in neutral solutions
- **Chemically stable** in mild acidic and alkaline solutions
- **Renaturing possible**
- A-T bonds weaker than C-G
 - 2 vs 3 hydrogen bonds
 - Regions with more A-T bonds melt first
- Covalent bonds between nucleotides on same strand
 - Hard to break
 - Enzymes
 - Mechanically (shearing, pipetting, sonication)
- Nucleic acids exhibit distinct light absorption in UV-region
 - Strong absorption at 260 nm



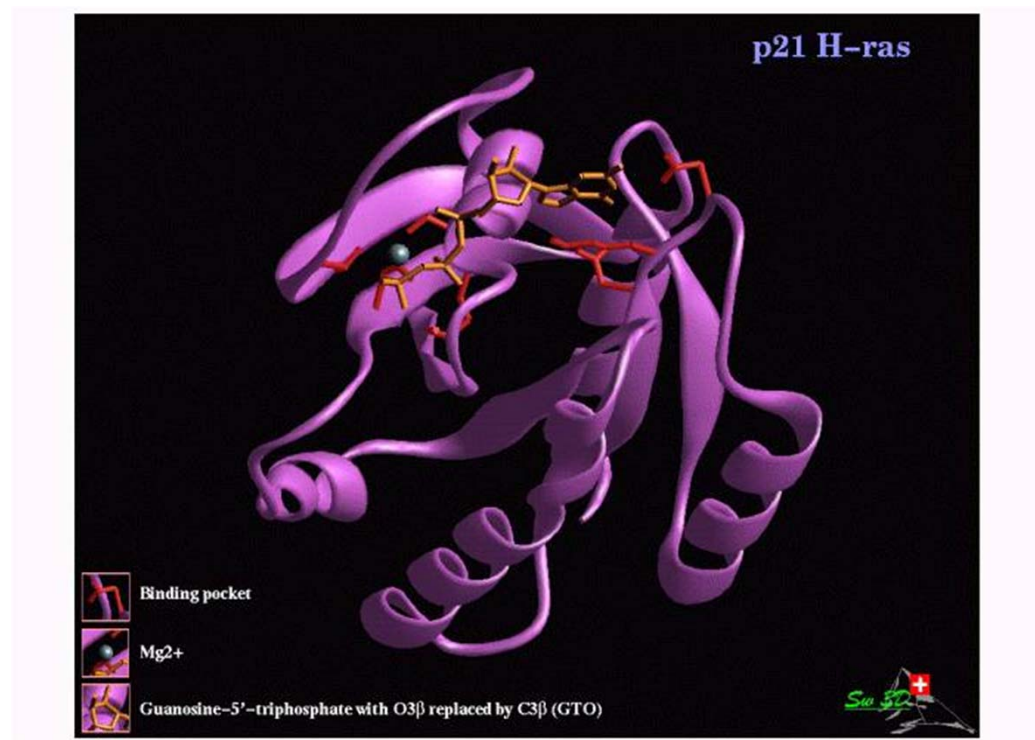
2.9.1. RNA

- RNA
 - Ribonucleic acid
 - Structure similar to ssDNA
 - Found in nucleus and cytoplasm
 - Degrades rapidly in alkaline solution
- Several classes
 - Messenger: mRNA
 - Template for protein synthesis
 - Transfer: tRNA
 - Ribosomal: rRNA
 - Other small RNAs
 - Serving for different purposes



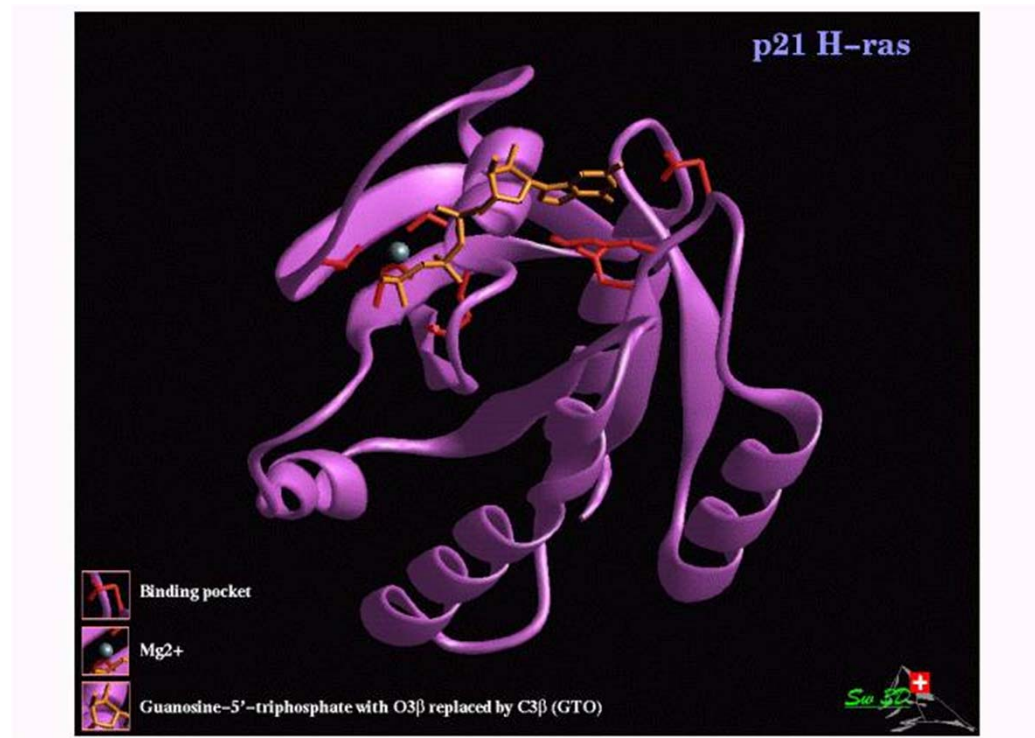
2.9. Biological Fluids

1. DNA
- 2. Proteins**
3. Cells
4. Dispersions of Biopolymers and Cells
5. Human Blood



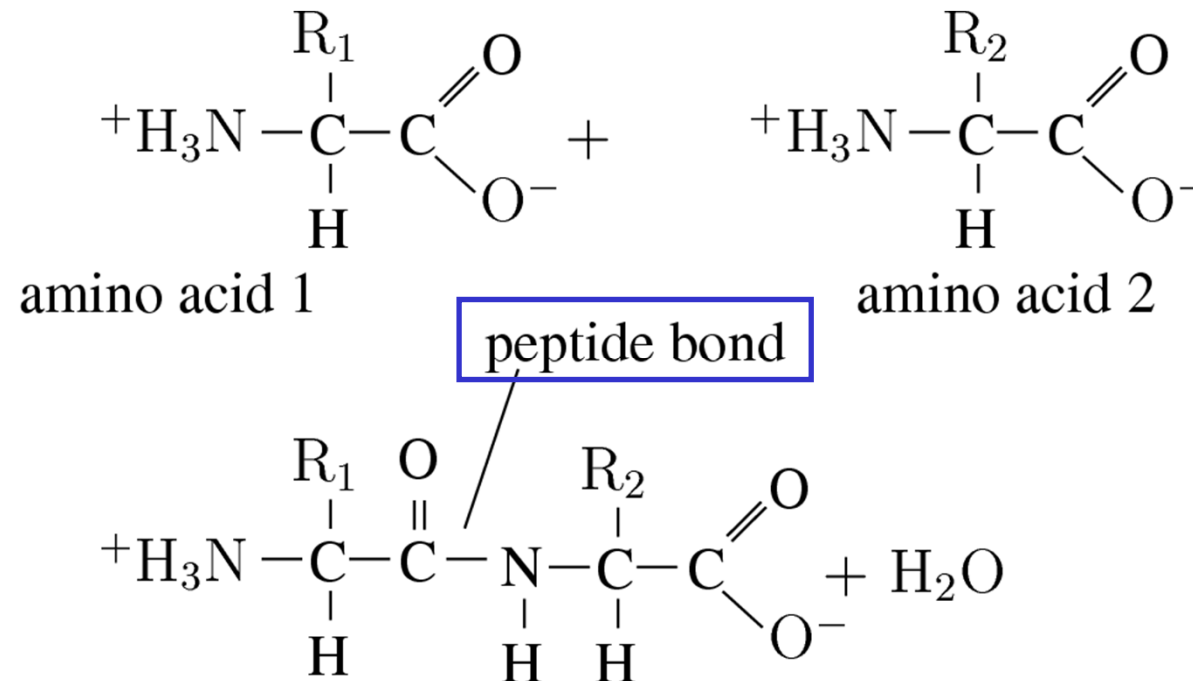
2.9.2. Proteins

- **Large molecule** composed of **one or more chains of amino acids**
- **Diverse class** regarding
 - Structure
 - Biological functions
 - Properties



2.9.2. Peptides

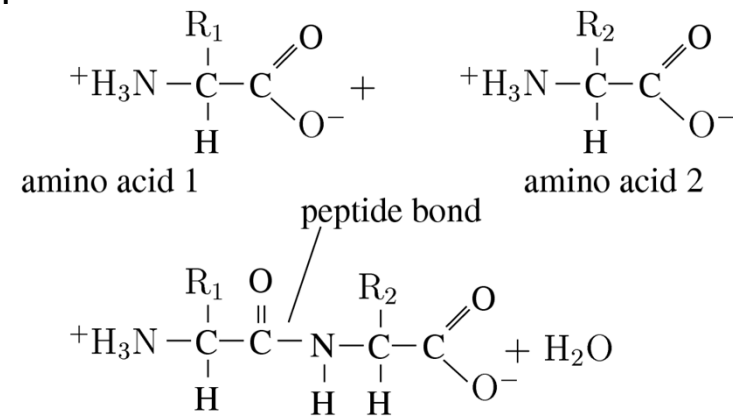
- Short polymer
- Subclass and building block of proteins
- Peptide bonds
 - Linking amino acids
- Proteins in nature
 - Synthesized from set of 20 amino acids



2.9.2. Proteins

- Function

- Necessary for chemical processes in living organisms
 - E.g., hormones, enzymes and antibodies
- Necessary for structure, function, regulation of cells, tissues, organs
- Each protein has unique functions
- Interaction by protein binding,
 - I.e., by physicochemical affinity to protein



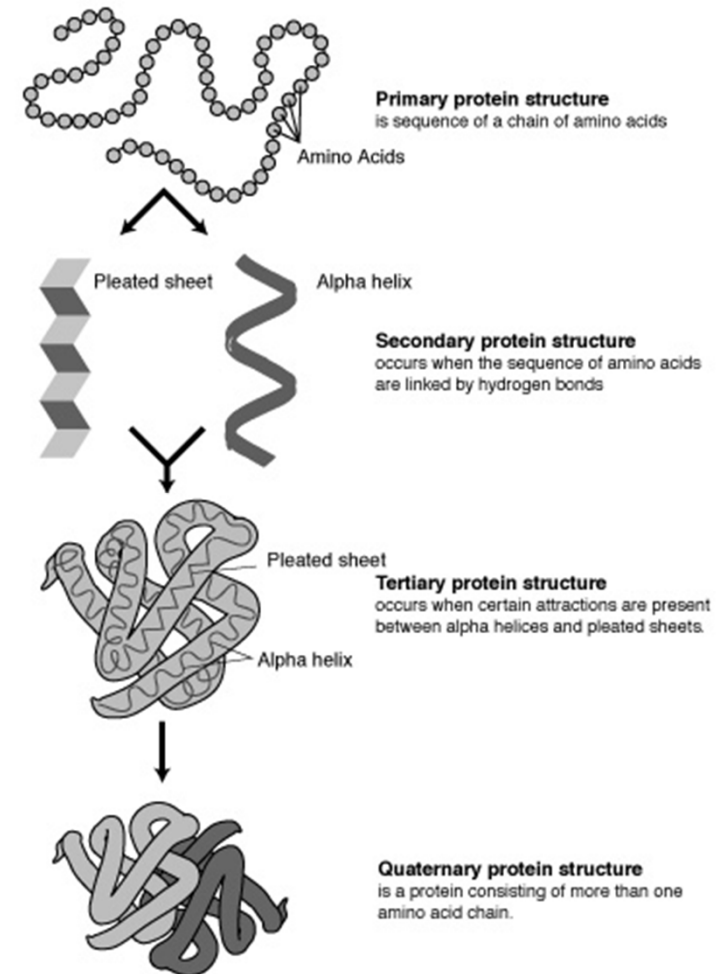
- Size

- Varies strongly
- Size
 - Often specified by number of amino acids
 - Daltons (d or Da)
 - 1Da = $1.66 \cdot 10^{-27}$ kg, 12th fraction of $^{12}\text{C} \approx m(\text{proton})$
- Weight up to some MDa (oligomers)

2.9.2. Molecular Structure of Biopolymers

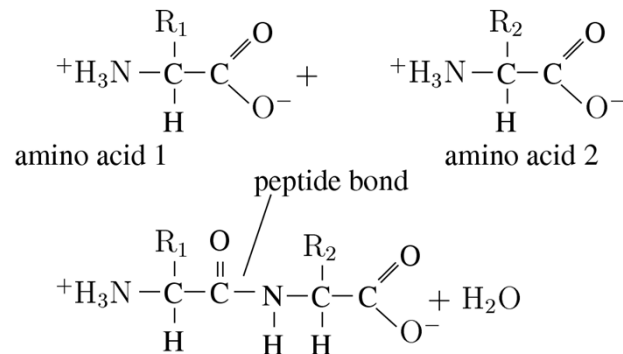
Analogy: curled phone wire

- **Primary Structure**
 - Set by covalent backbone of macromolecule
 - Order of subunits, like nucleotides in DNA
- **Secondary Structure**
 - Folded, coiled or twisted shape of chains when hydrogen bonds form between adjacent parts of the molecule
- **Tertiary Structure**
 - Three-dimensional structure of a polypeptide in its normal, folded state
- **Quaternary Structure**
 - Three-dimensional structure of complex protein
 - Way polypeptide subunits fit together



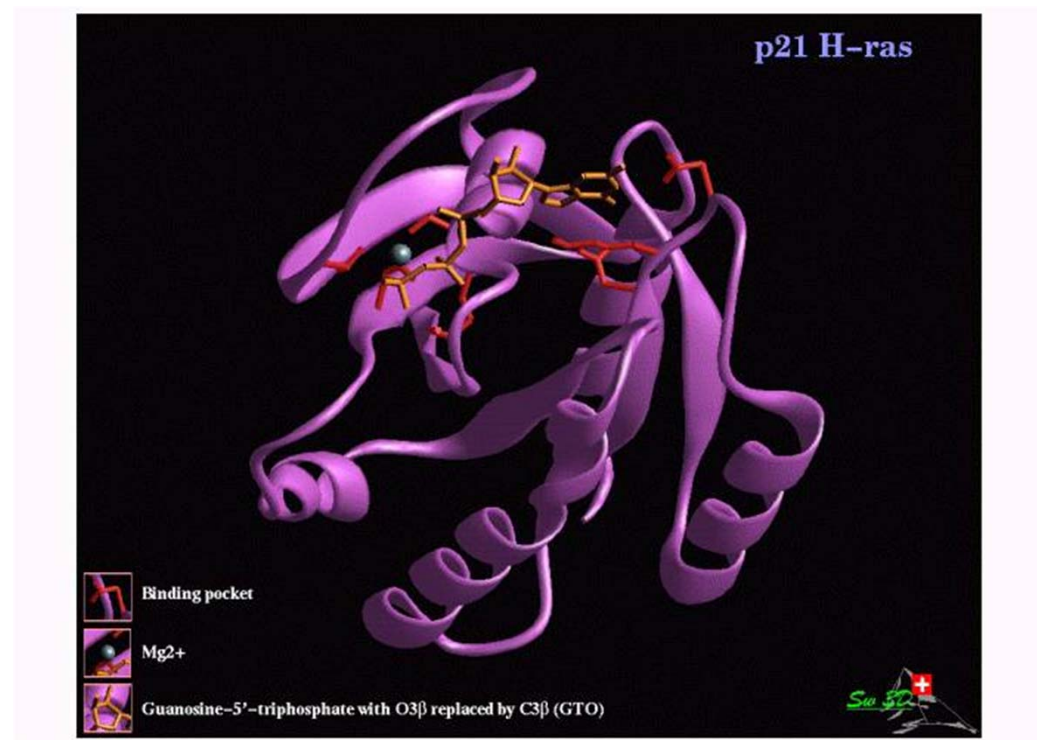
2.9.2. Proteins

- **Biological Activity**
 - Determined by **molecular composition** and **spatial structure**
 - Change in structure stops activity („denaturing“)
 - E.g., by heat, pH-value, contact with unphysiological surfaces (glass, etc.)
 - Stability of untreated protein samples often very poor
 - Addition of protease inhibitors
- **Available Amounts**
 - Vary strongly
 - Between few copies per cell and some thousands



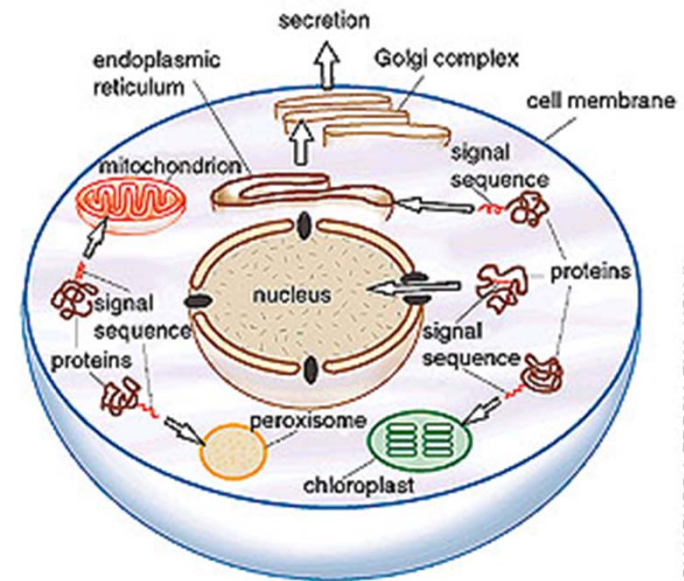
2.9. Biological Fluids

1. DNA
2. Proteins
- 3. Cells**
4. Dispersions of Biopolymers and Cells
5. Human Blood



2.9.3. Cells

- **Smallest structural units** of living matter
 - Plants
 - Animals
 - Single cell organisms
- Capable of functioning **autonomously**
- Complex systems incorporating
 - Energy production
 - Reproduction /self-repair
 - Operation in various domains
 - Chemical
 - Biochemical
 - Mechanical /physical
 - Electrical
 - Optical
- **Engineering of sophisticated functionality still far out of reach**



2.9. Biological Fluids

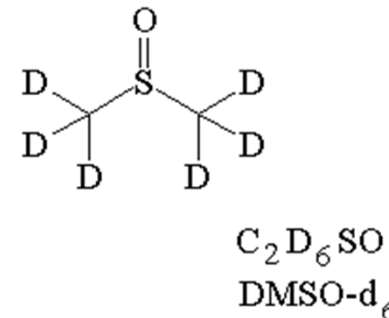
1. DNA
2. Proteins
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- 4. Dispersions of Biopolymers and Cells**
5. Human Blood

2.9.4. Dispersions of Biomolecules and Cells

- Vast variety of solvents for biomolecules
 - For storage, dehydration, precipitation and cell lysis
 - Here: only two examples
- Aqueous Solutions
 - Basic and most frequent solvent in nature
 - Accommodation of DNA and proteins
 - DNA usually in very dilute, buffered, aqueous solutions

- DMSO

- Dimethylsulfoxide (C_2H_6OS)
- Cryoprotective
 - Preventing damage of cells
 - Usually stored frozen



2.9. Biological Fluids

1. DNA
2. Proteins
3. Molecular Structure of Biopolymers
4. Solutions of Biomolecules
- 5. Human Blood**

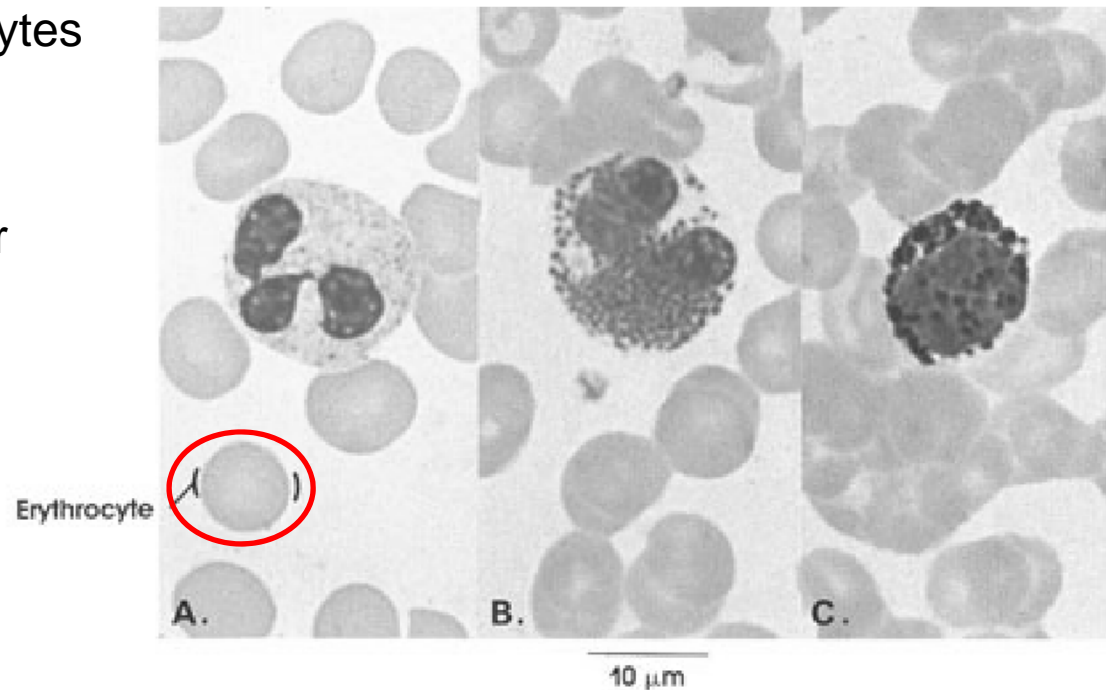
2.9.5. Human Blood

- Suspension in plasma matrix
 - Cells
 - Other biological particles
- Multi-cellular animals
- Homeostasis
 - Constancy of internal environment
- Transport medium pumped by heart
 - Oxygen
 - Nutrients
 - Hormones
 - Disease-fighting substances
 - Carries away waste products
- pH = 7.4
 - Slightly alkaline
- Volume of blood in human adults
 - $V = 4.6 - 5.6 \text{ l}$

2.9.5. Human Blood - RBCs

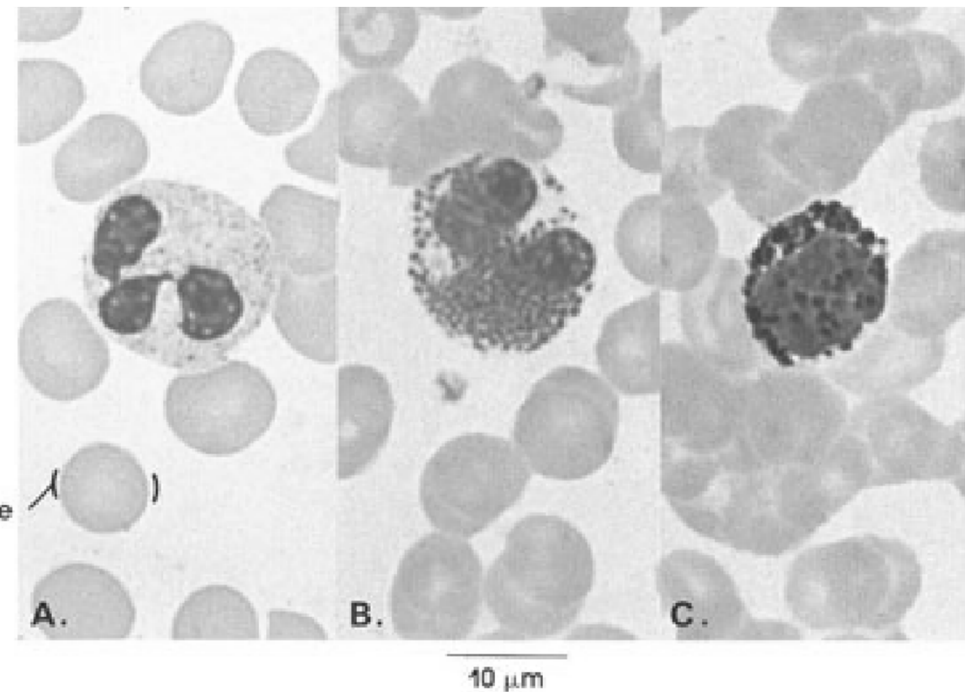
- Erythrocytes

- Red Blood Cells (RBC)
- Biconcave disks
 - Length 7 - 8 μm , width 2 μm
 - Large surface/volume ratio for absorption of O_2 , release of CO_2
- No nucleus
- 4.5 – 5 million erythrocytes per mm^3
- Life time 3 – 4 months
- Contain hemoglobin for efficient O_2 transport



2.9.5. Human Blood- WBCs

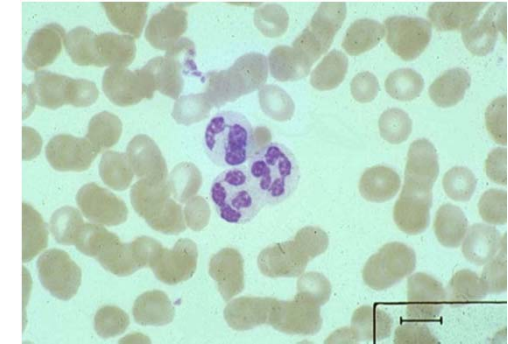
- Leukocytes
 - White Blood Cells (WBC)
 - Cellular nucleus
 - Spherical shape
 - Alters during amoeboid movement
 - Independently motile
 - Defense mechanisms and reparative activity
 - Phagocytosis
 - Process of ingesting or engulfing other cells or particles
 - 4,500 – 11,000 per mm³
 - Lifetime approx. 10 days
 - Different types



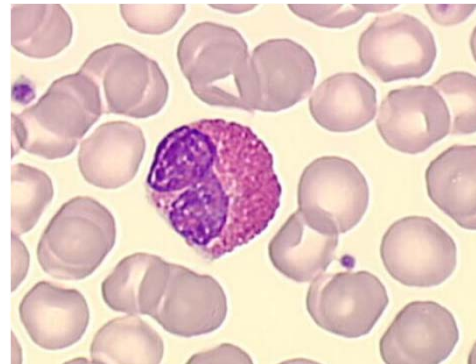
2.9.5. Leukocytes

- Granulocytes

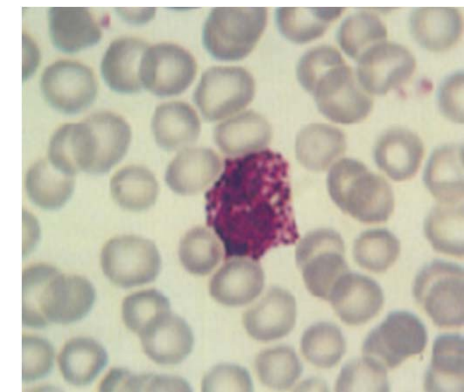
- Also „polymorphonuclear leukocytes“
- Leukocytes with white granules in their cytoplasm
- A. Neutrophil
 - 60 – 70 % of all leukocytes
 - Phagocytes



- B. Eosinophil
 - 2 – 4 %
 - Phagocytes
 - Antiparasite agents

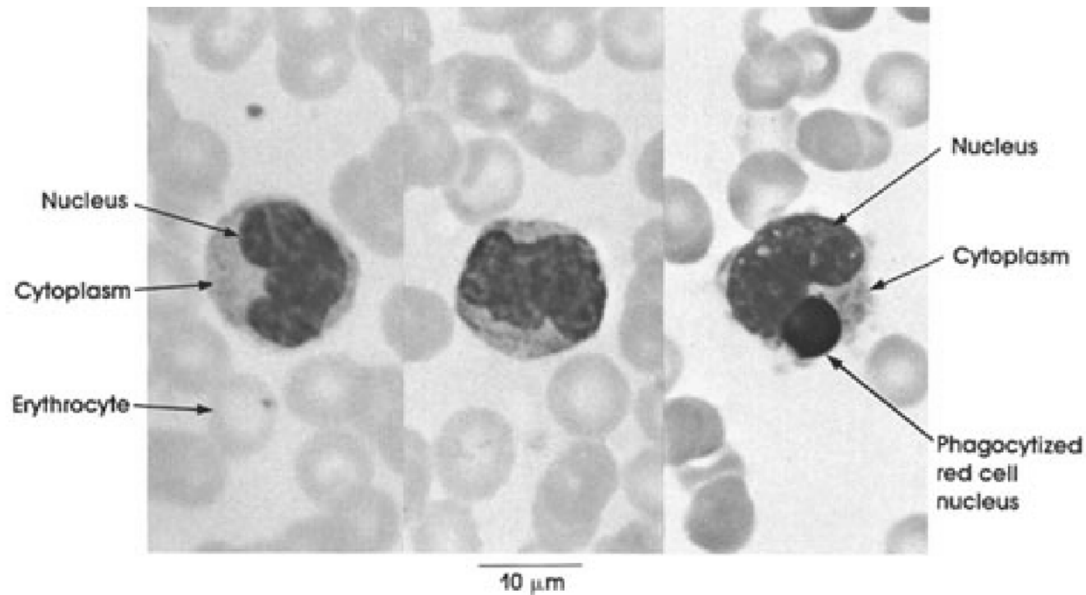
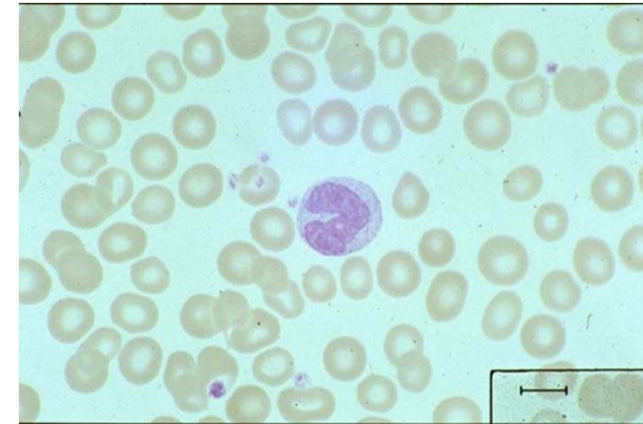


- C. Basophil
 - 0.5 – 1 %
 - Contain heparin
 - Prevent coagulation



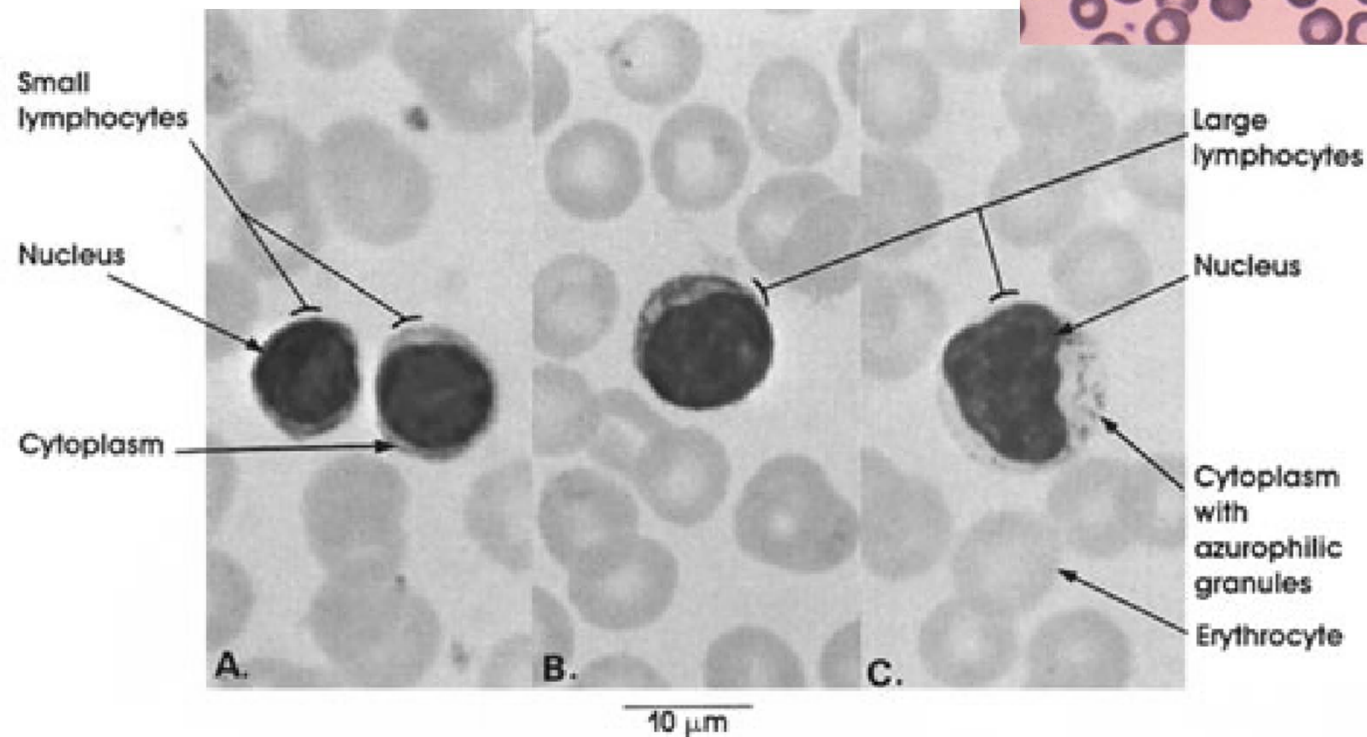
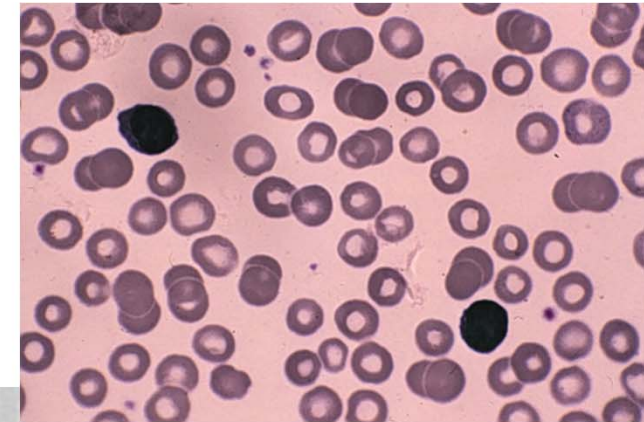
2.9.5. Leukocytes

- Monocytes
 - Largest cells found in human body
 - 15 – 25 μm
 - 3 – 8 % of all leukocytes
 - Kidney-shaped
 - Voracious phagocytes digesting microorganisms as well as cellular debris



2.9.5. Leukocytes

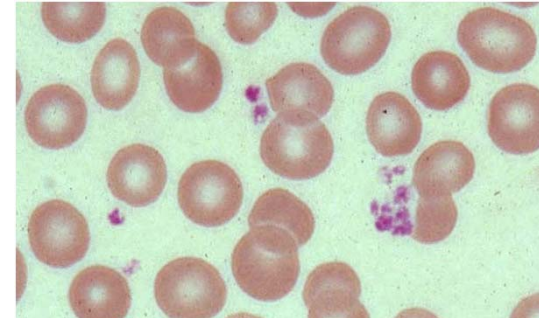
- Lymphocytes
 - 20 - 40 % of all leukocytes
 - Providing immunity to diseases producing antibodies
 - Between 7 – 20 μm



2.9.5. Human Blood

- Platelets

- Also „thrombocytes“
- Fragments of cytoplasm of megakaryocytes
- Shape of small disks about 2 – 4 μm in diameter
- 200,000 – 350,000 platelets per mm^3 blood
- Coagulation by sticking to wound



- Plasma

- 55 % of whole blood (45 % by cells described above)
- 90 – 92 % of plasma are water
- 6 – 8 % proteins
- Transport matrix
- Maintains blood pressure
- Distributes heat
- Controls pH-value
- Water and dissolved salt (sea-water)

