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2. Fluids

2.1. General Characteristics

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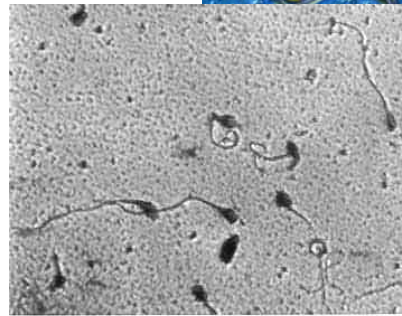
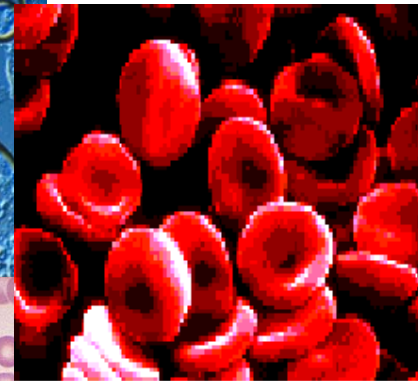
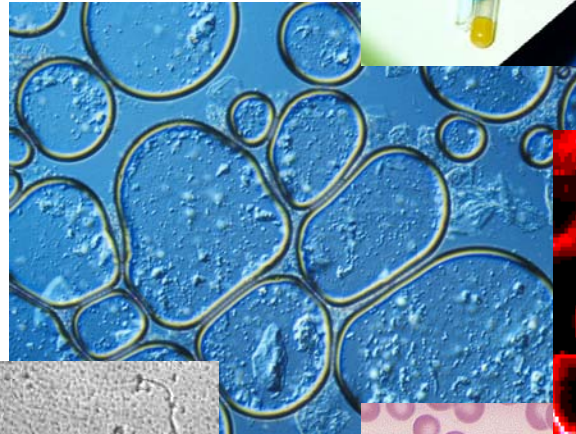
2.5. Solutions

2.6. Surface Tension

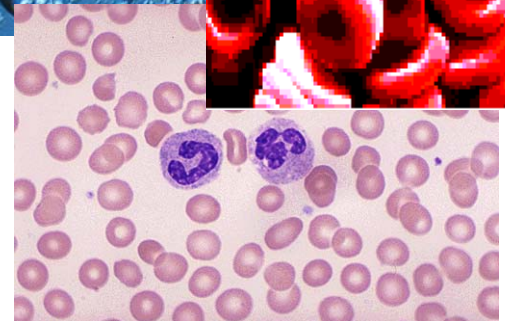
2.7. Electrical Properties

2.8. Optical Properties

2.9. Biological Fluids

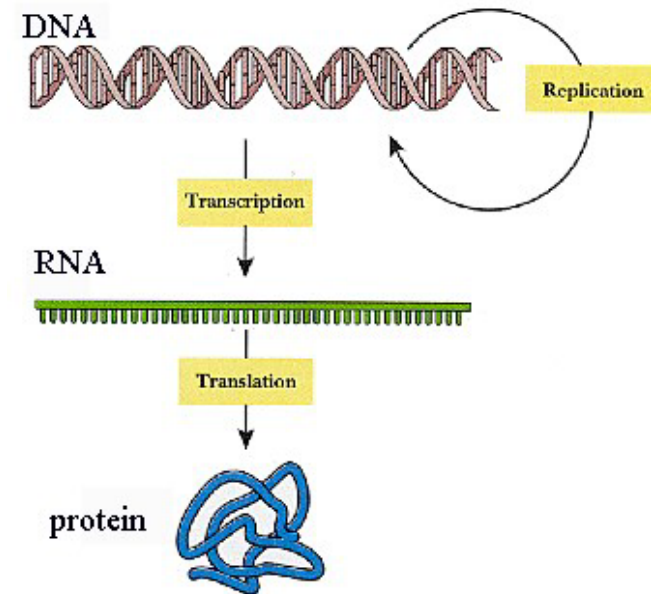
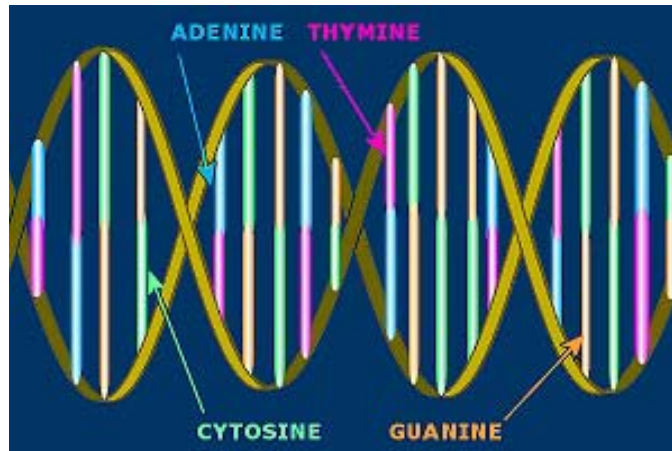


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2.9. Biological Fluids

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

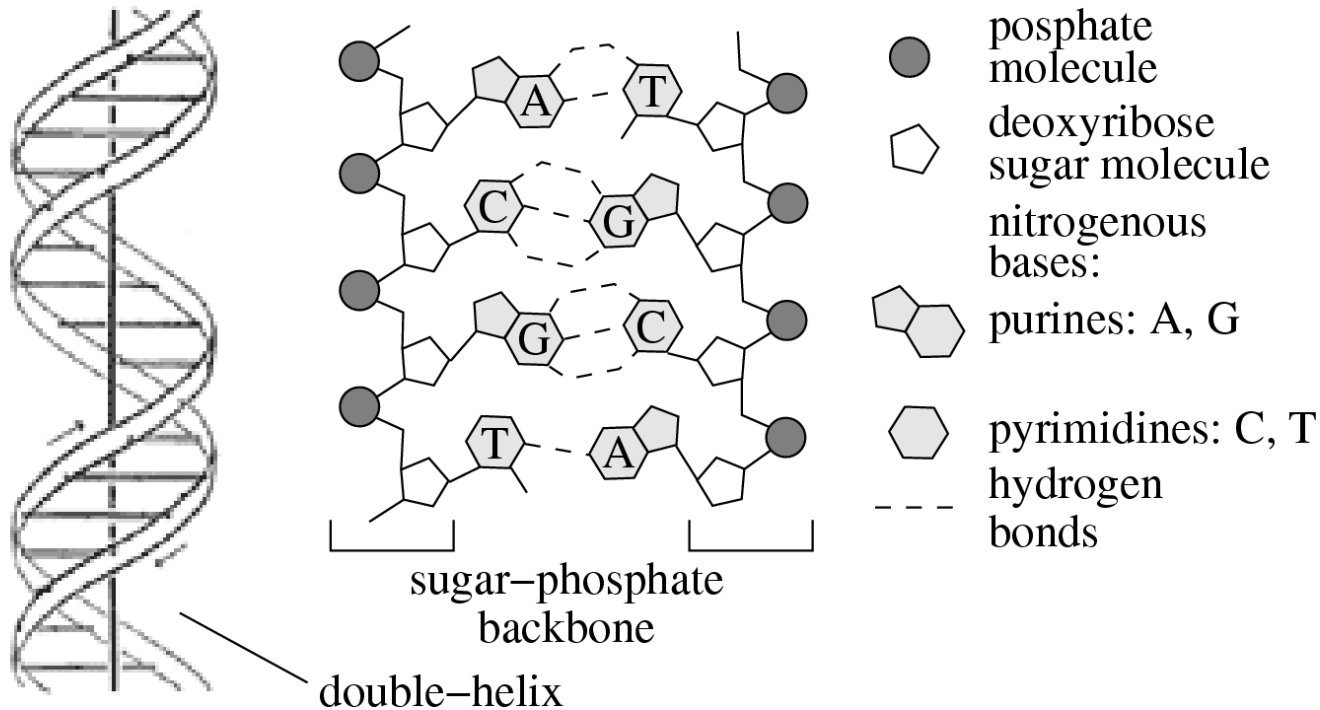


Fig. 2.34. Double-Helix structure of DNA and its molecular constituents

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)**

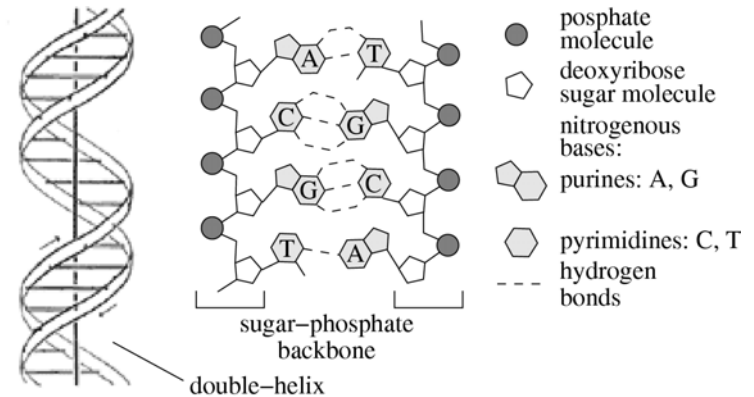


Fig. 2.34. Double-Helix structure of DNA and its molecular constituents

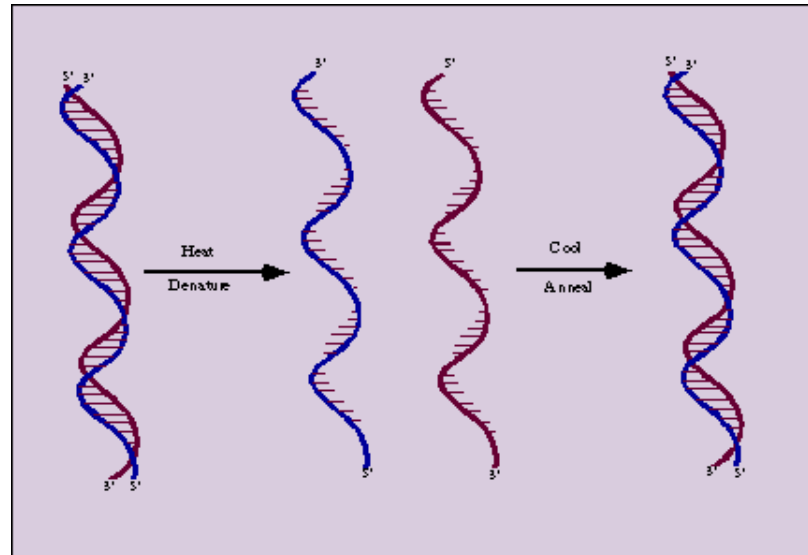
- **Covalent phosphate-sugar bonds** connect adjacent nucleotides

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

- Stabilized double-helix structure

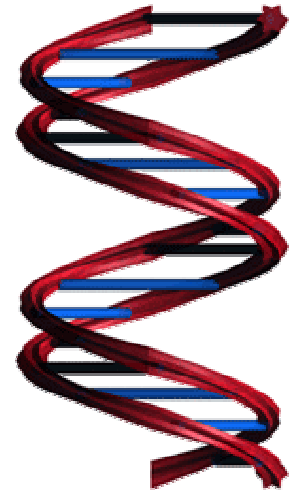
2.9.1. Viscosity of DNA

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



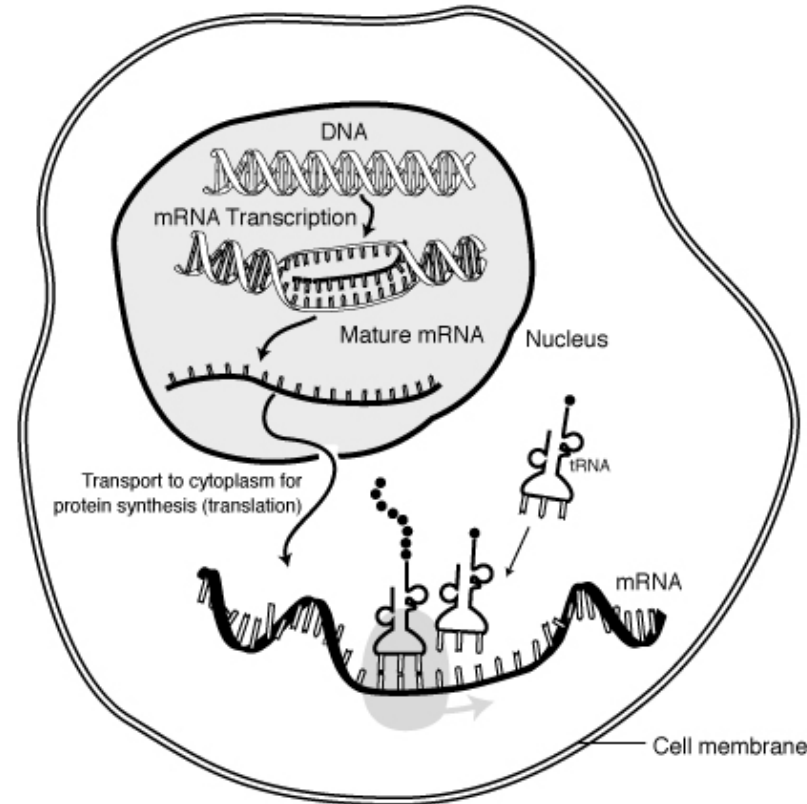
2.9.1. Physico-Chemical Properties of DNA

- **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



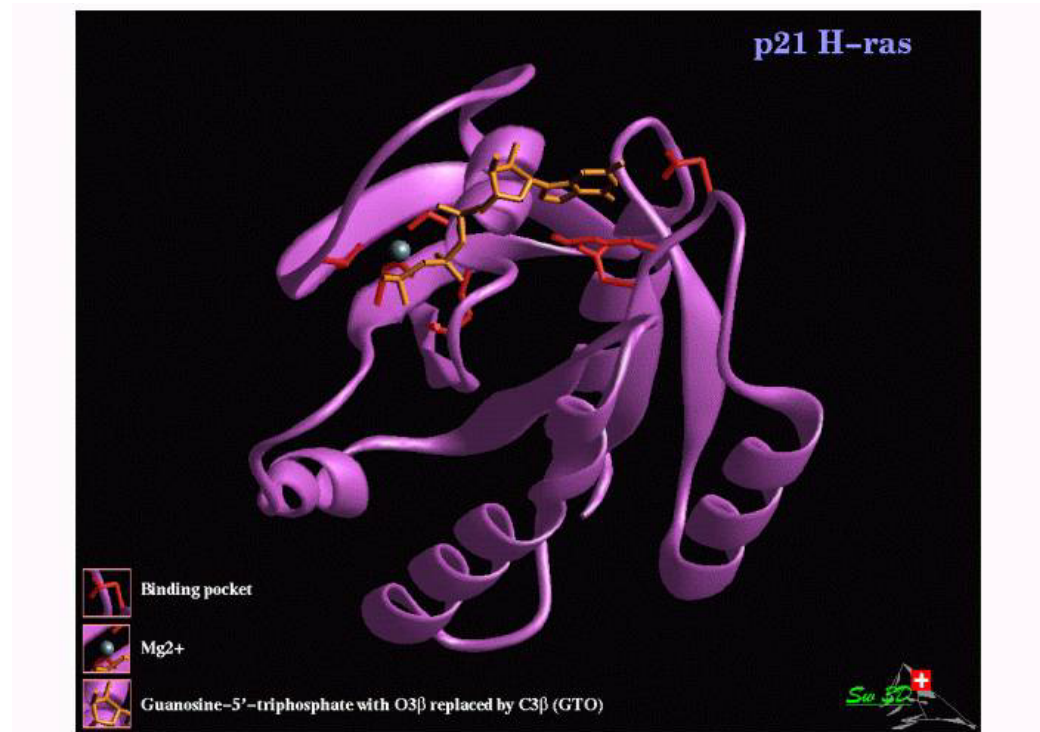
2.9.1. RNA

- 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



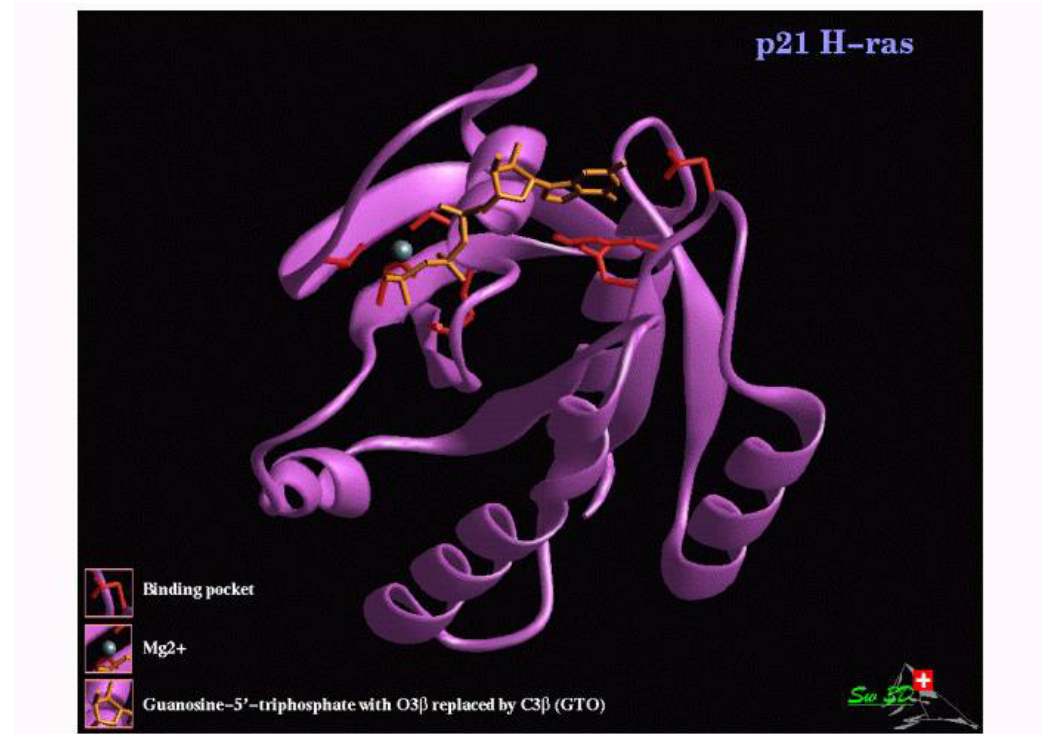
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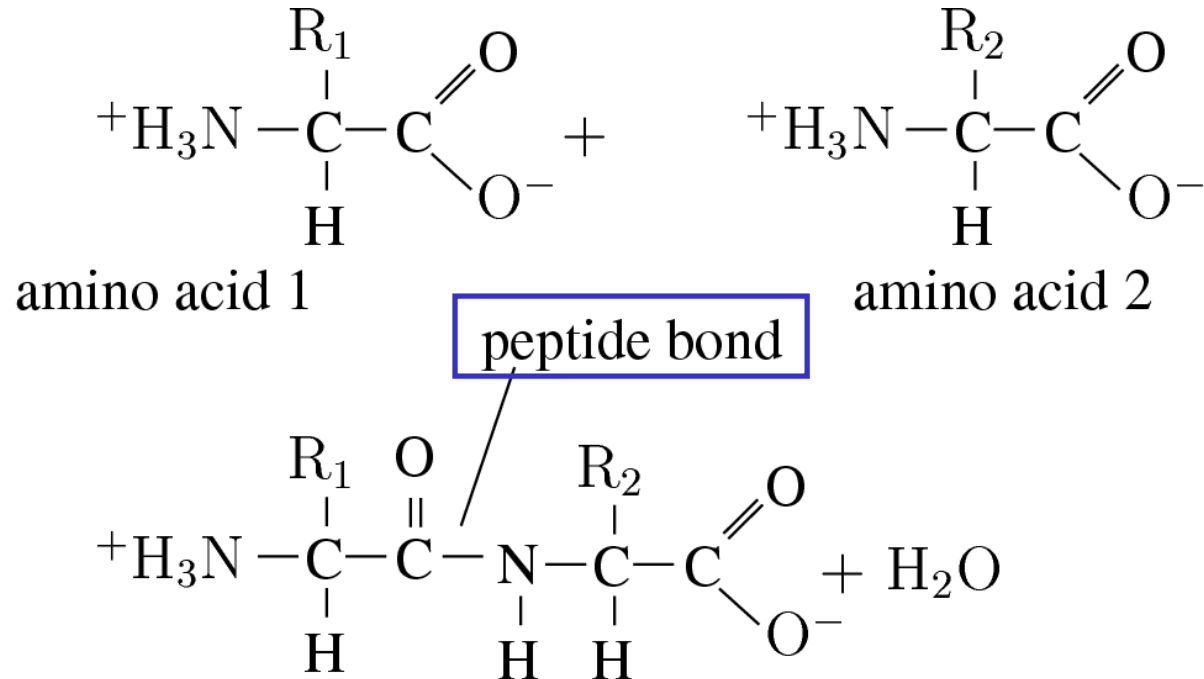
2.9.2. Proteins

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



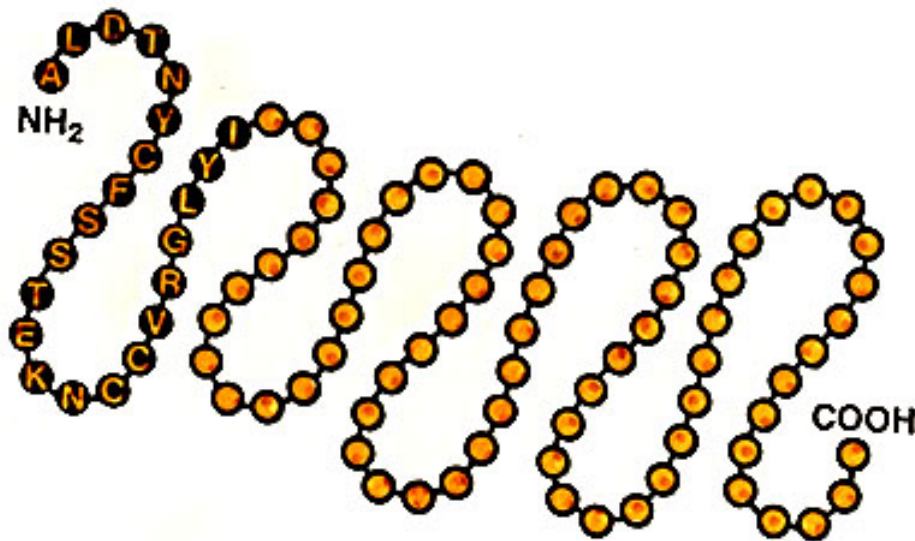
2.9.2. Peptides

- 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. Polypeptides

- Chain of peptides or amino acids
- Usually less than 100 amino acids long
- One or more polypeptides required to form protein



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**

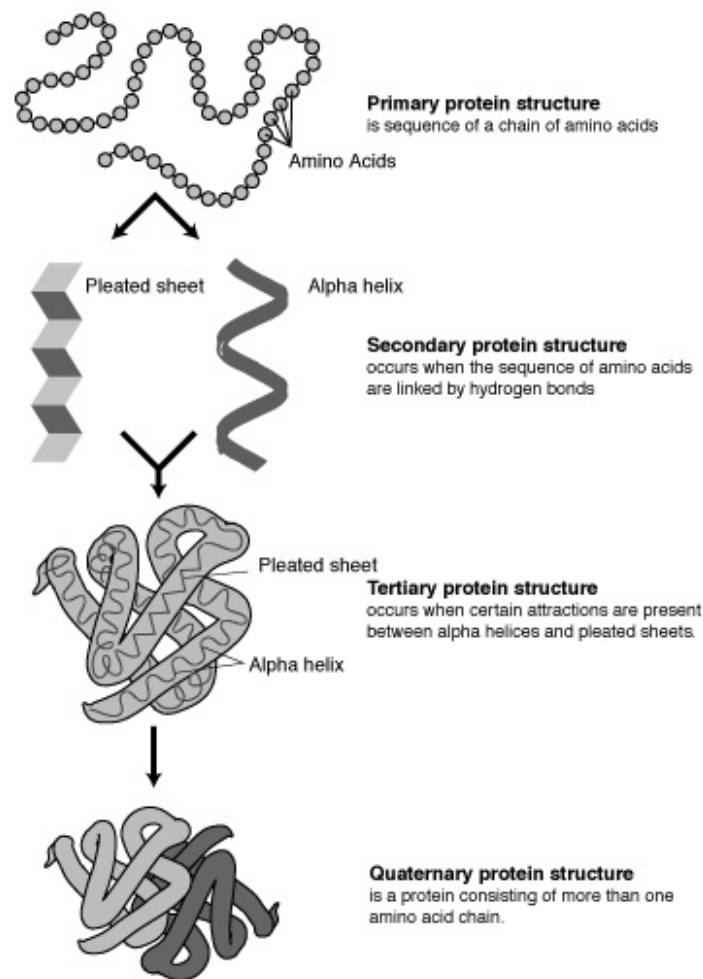
- Folded, coiled or twisted shape of chains when hydrogen bonds form between adjacent parts of the molecule

- **Tertiary Structure**

- Three-dimensional structure of a polypeptide in its normal, folded state

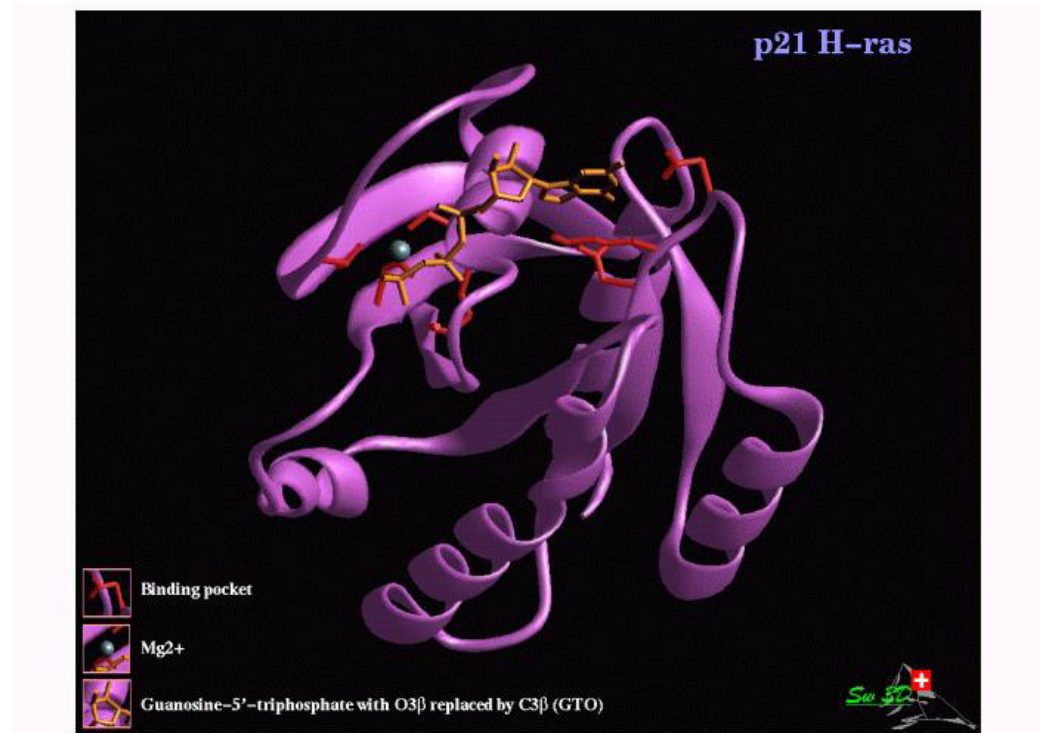
- **Quaternary Structure**

- Three-dimensional structure of complex protein
- Way polypeptide subunits fit together



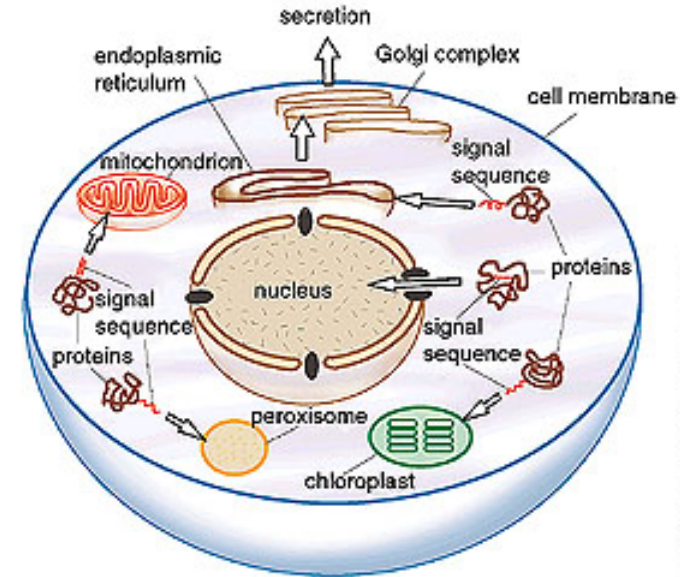
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4. Dispersions of Biopolymers and Cells
5. Human Blood



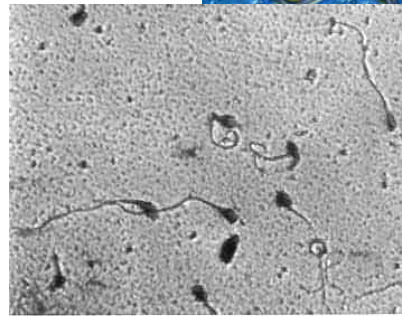
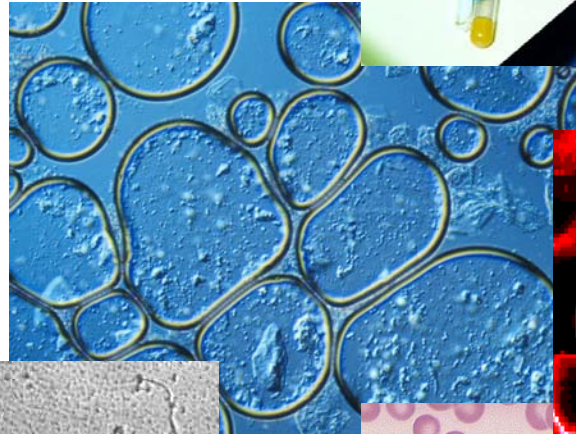
2.9.3. Cells

- **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**

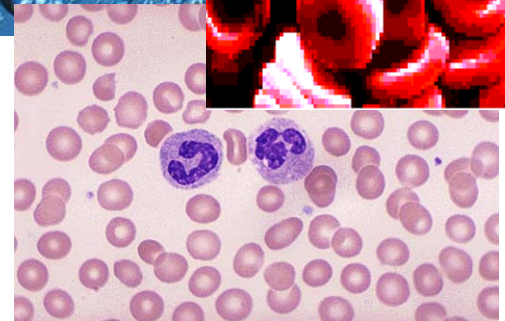
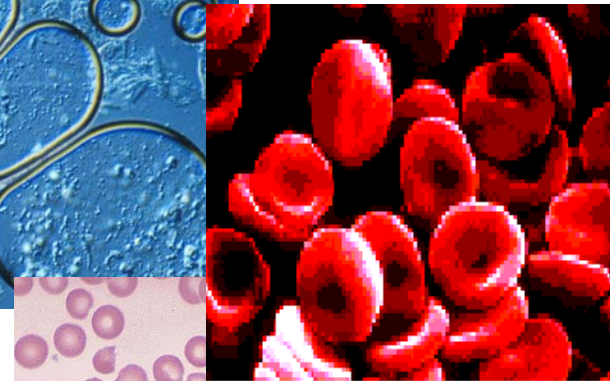


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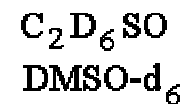
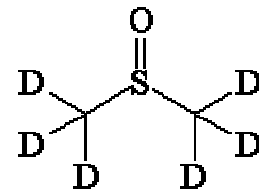


2.9.4. Dispersions of Biomolecules and Cells

- 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

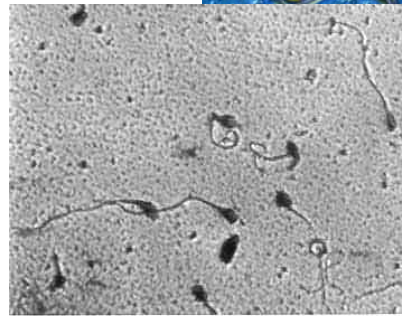
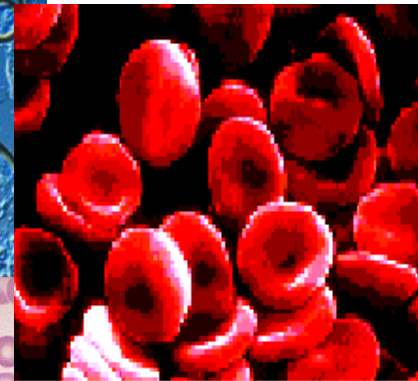
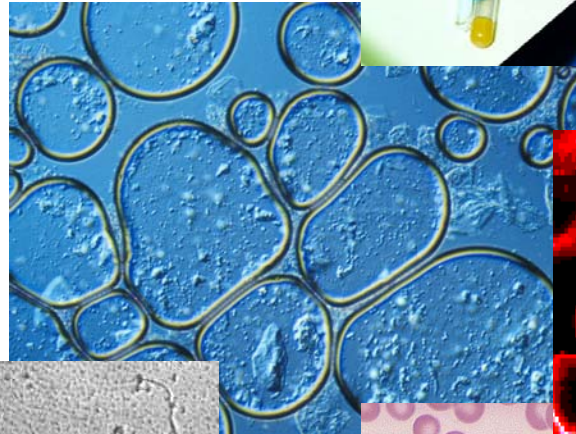
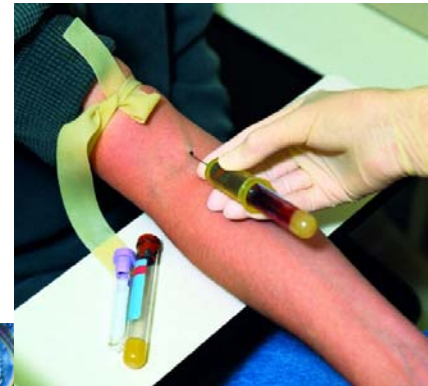
- DMSO

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

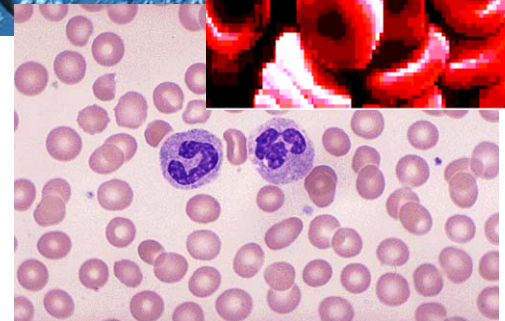


2.9. Biological Fluids

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

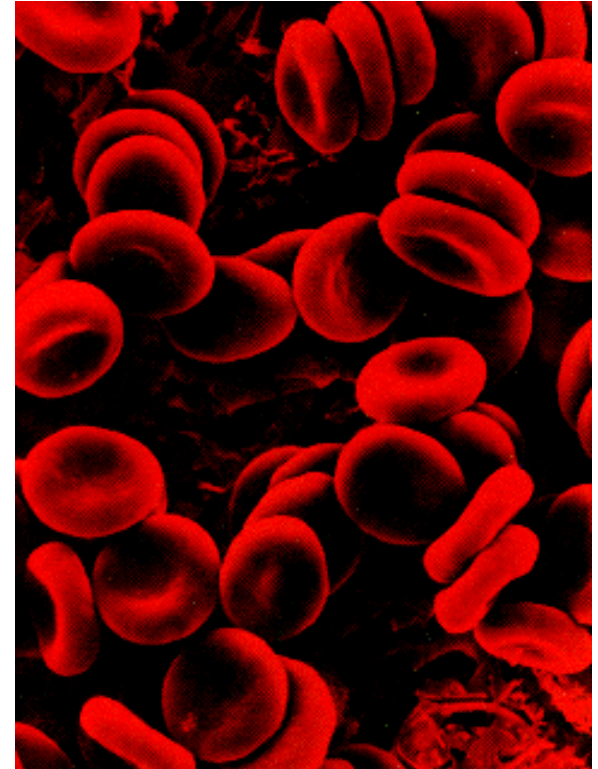


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2.9.5. Human Blood

- 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

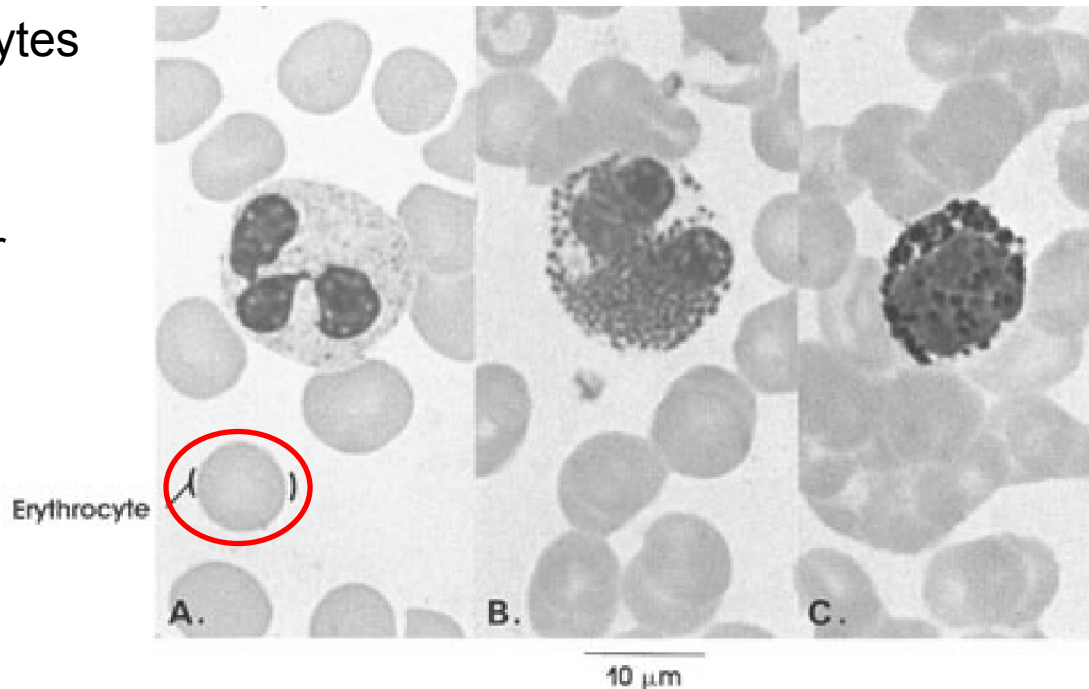
- Large surface/volume ratio for absorption of O_2 , release of CO_2

- No nucleus

- 4.5 – 5 million erythrocytes per mm^3

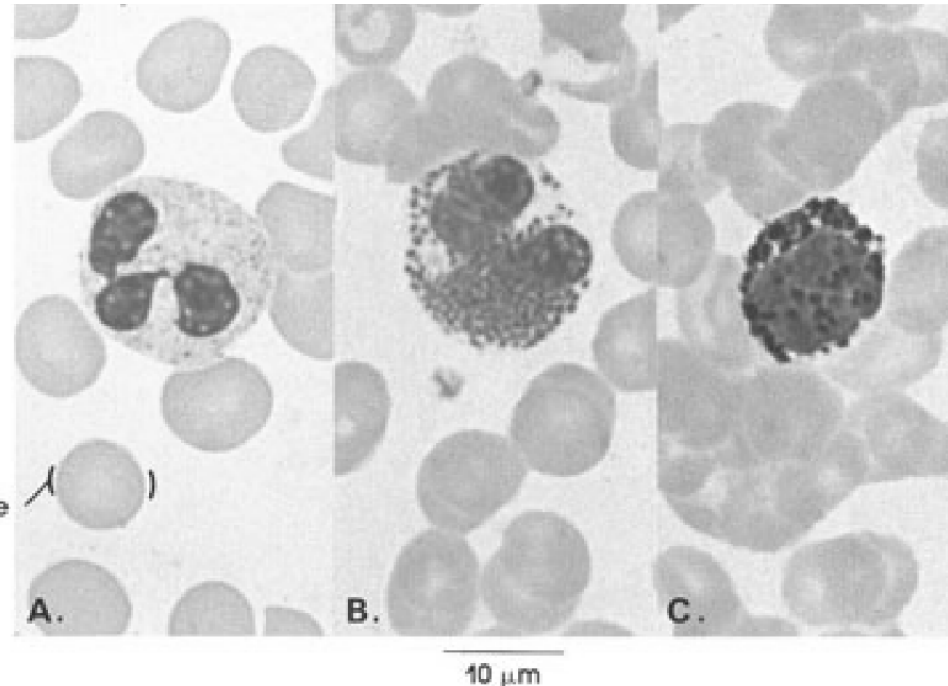
- Life time 3 – 4 months

- 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 mm^3
 - Lifetime approx. 10 days
 - Different types



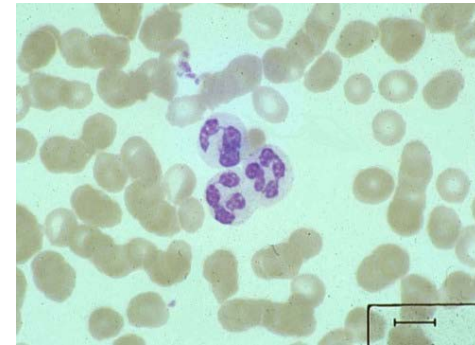
2.9.5. Leukocytes

- Granulocytes

- Also „polymorphonuclear leukocytes“
- Leukocytes with white granules in their cytoplasm

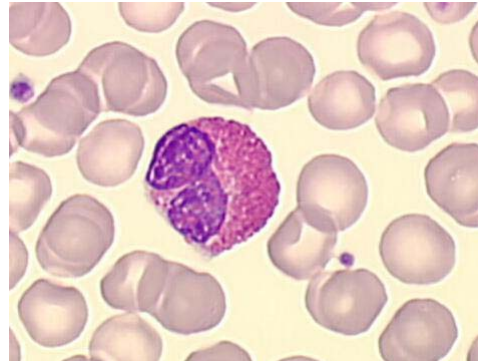
- A. Neutrophil

- 60 – 70 % of all leukocytes
- Phagocytes



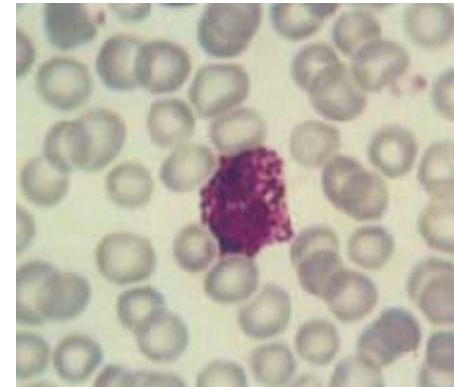
- B. Eosinophil

- 2 – 4 %
- Phagocytes
- Antiparasite agents



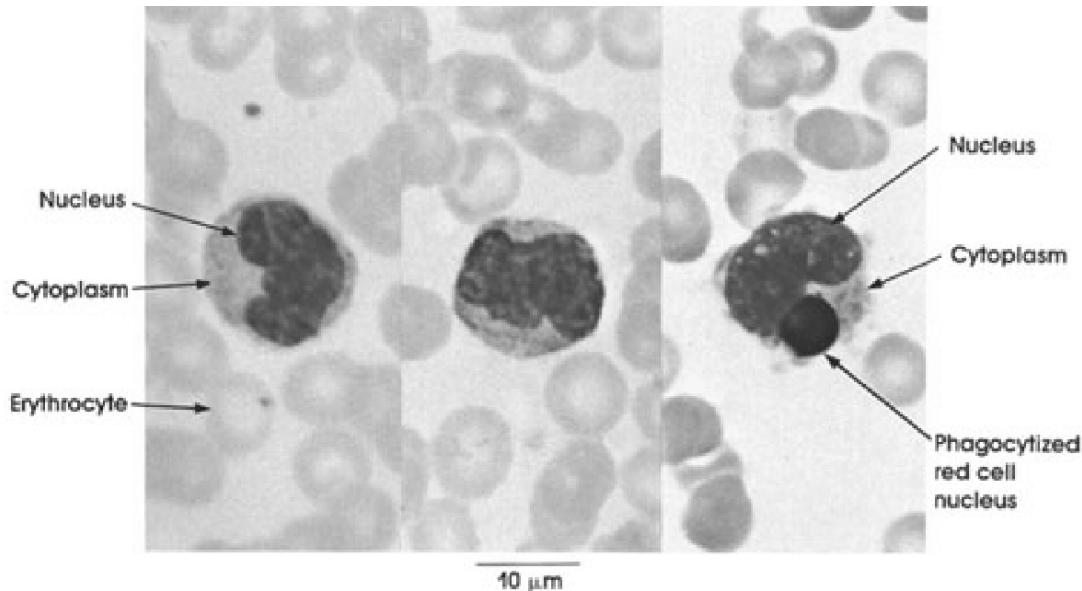
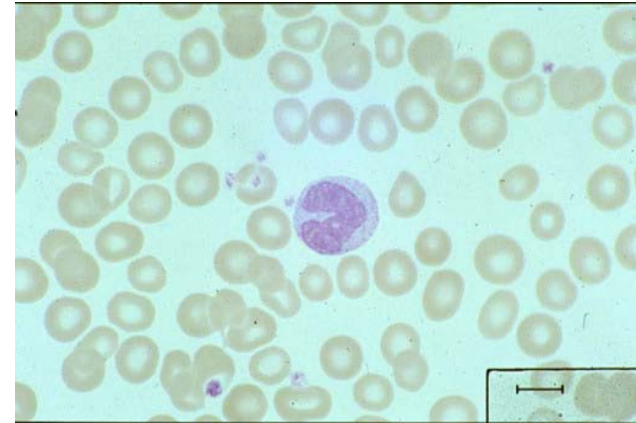
- C. Basophil

- 0.5 – 1 %
- Contain heparin
- Prevent coagulation



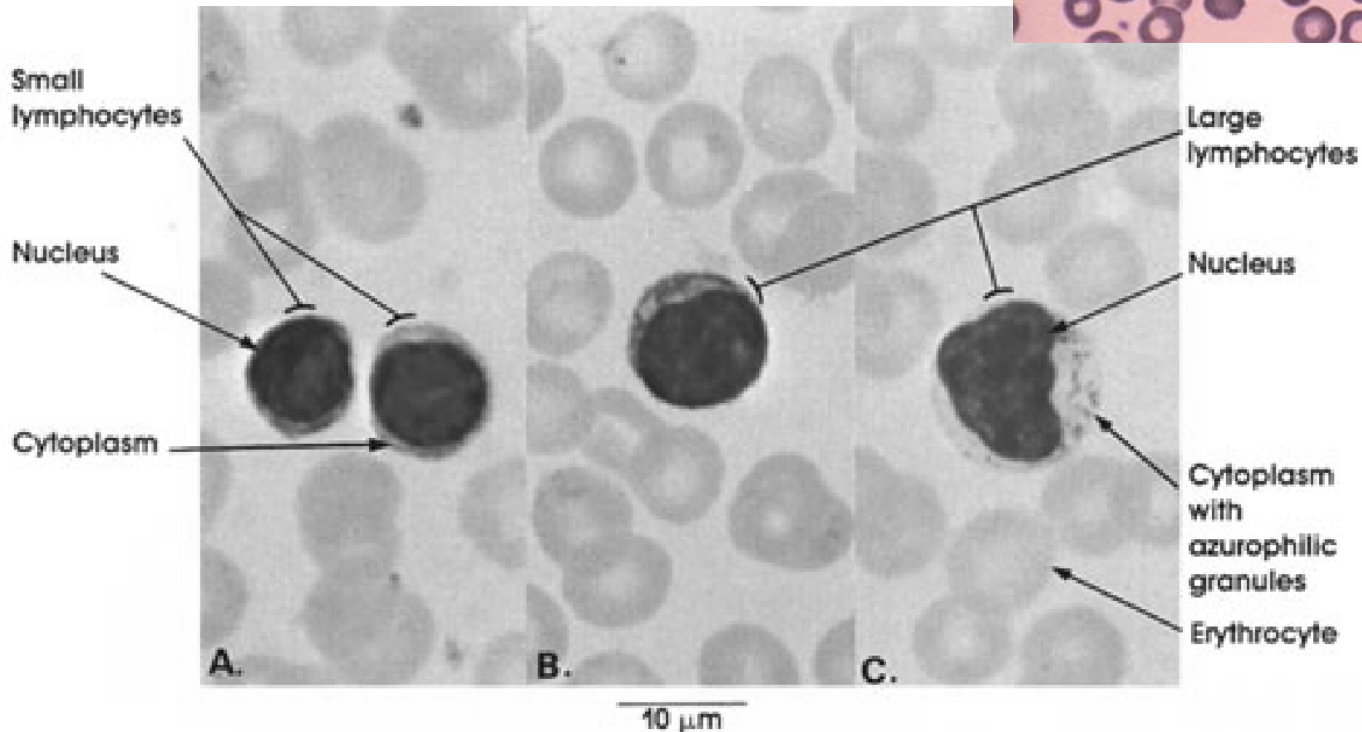
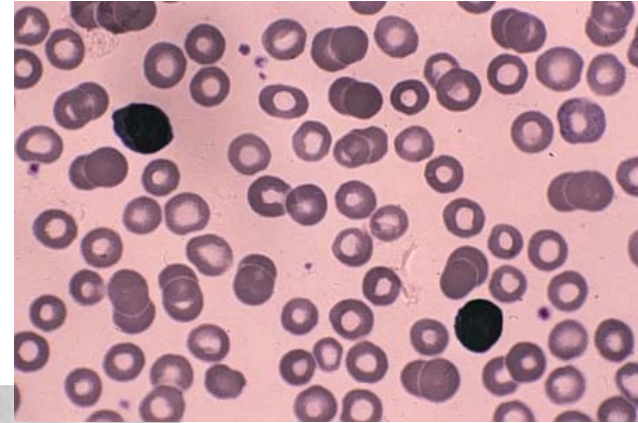
2.9.5. Leukocytes

- 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)

