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INVESTMENTS IN EDUCATION DEVELOPMENT

Innovation and Development of Study Field Nanomaterials at the Technical University of Liberec

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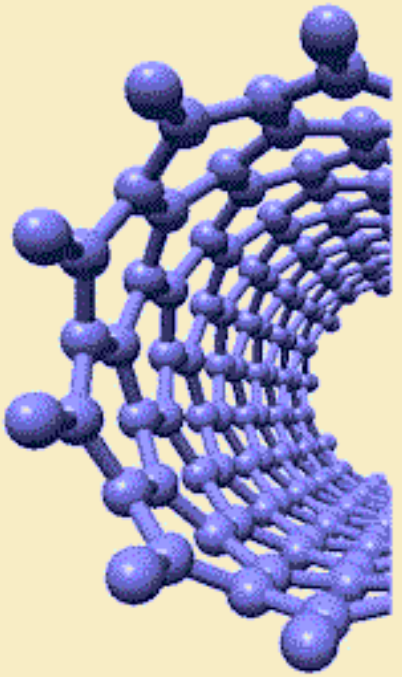

These materials have been developed within the ESF project: Innovation and development of study field Nanomaterials at the Technical University of Liberec

TECHNICAL UNIVERSITY OF LIBEREC
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BIOPHYSICS

prof. RNDr. Evžen Amler, CSc.
RNDr. Lucie Koláčná, Ph.D.

LITERATURE

- **Study sources at Moodle**
  http://dl1.cuni.cz/course/category.php?id=98
- **Evžen Amler et al.: Chapters from biophysics**, 2006
- **Vojtěch Mornstein: Biophysical Principles of Medical Technology,** Masaryk university Brno, 2000
- **František Vítek: Lectures on Medical Biophysics,**
  Charles University in Prague – The Karolinum Press, 2004
- **Bruce Alberts et al.: Essential Cell Biology,**
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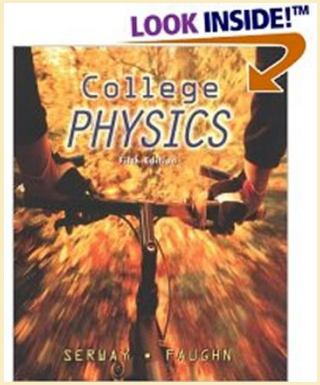
- **General Physics Overview**
  e.g. Sears, FW: University physics
- **http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html**

LITERATURE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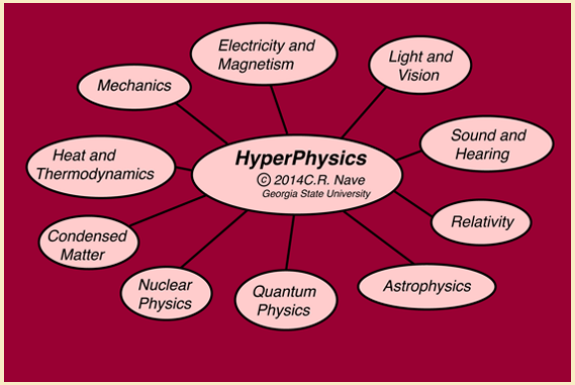
Electricity and Magnetism
Light and Vision
Mechanics
Sound and Hearing
Heat and Thermodynamics
HyperPhysics
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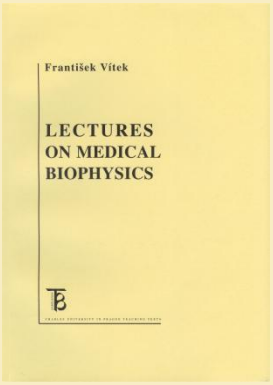
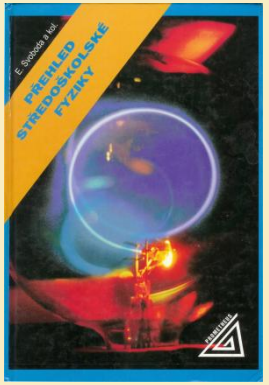
Relativity
Condensed Matter
Nuclear Physics
Quantum Physics
Astrophysics


František Vítek
LECTURES
ON MEDICAL
BIOPHYSICS


PŘEHLED
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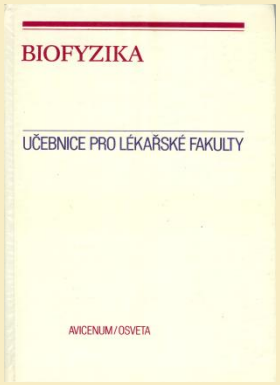
FYZIKY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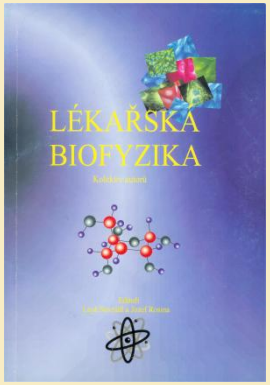
UČEBNICE PRO LÉKAŘSKÉ FAKULTY
AVICENUM/OSVETA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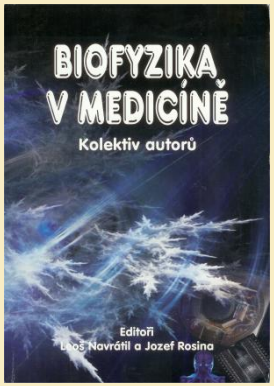
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MEDICÍNSKÁ
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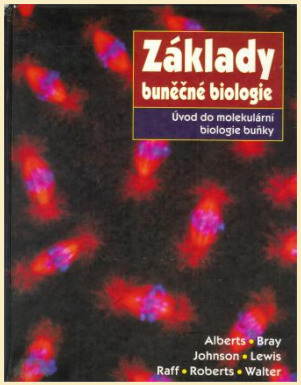

Základy
buněčné biologie
Úvod do molekulární biologie buňky
Alberts • Bray
Johnson • Lewis
Raff • Roberts • Walter

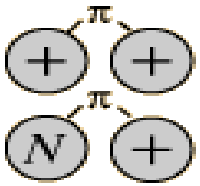
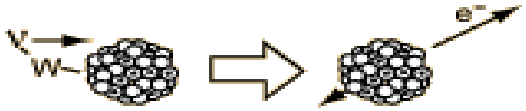
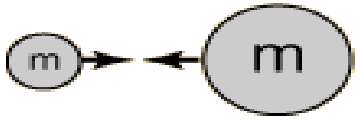
BIOMECHANICS

prof. RNDr. Evžen Amler, CSc.
RNDr. Lucie Koláčná, Ph.D.

FUNDAMENTAL SI UNITS

QUANTITY (SYMBOL)	NAME OF UNIT (SYMBOL)
Length *(l)*	**meter (m)**
the length of path traveled by light in vacuum during a time interval of 1/299 792 458 of a second	
Mass *(m)*	**kilogram (kg)**
the mass of the international prototype created by the Third General Conference on Weights and Measures in 1901 . (Attempts are under way to define the kilogram proceeding from Planck's constant; another then from the mass of of ^{12}C atoms.)	
Time (*t*)	**second (s)**
duration of 9 1 92 63 1 770 radiation periods corresponding to the transition between the two hyperfine levels of the ground state of cesium atom ^{133}Cs	
Electric current *(I)*	**ampere (A)**
the current that, if maintained in two straight parallel conductors of infinite length and of negligible circular cross section, placed 1 meter apart in vacuum, will produce a force between these conductors equal to 0.2 micronewton per meter	
Temperature *(T)*	**kelvin (K)**
the fraction 1/273 .16 of the thermodynamic temperature of the triple point of water at a pressure of 101.325 pascal	
Amount of substance (*n*)	**mole (mol)**
amount of substance containing as many elementary entities (atoms, molecules, ions, electrons, photons, etc.) as there are atoms in 12 grams of carbon isotope ^{12}C	
Luminous intensity *(I)*	**candela (cd)**
luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 0.54 petahertz and that has a radiant intensity in that direction of 1/683 watt per steradian	

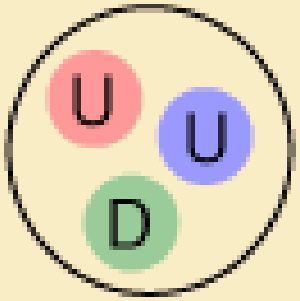
FUNDAMENTAL FORCES

		Strength	Range (m)	Particle
Strong	 Force which holds nucleus togeher	1	10^{-15} (diameter of a medium sized nucleus)	gluons, π(nucleons)
Electro-magnetic		$\frac{1}{137}$	Infinite	photon mass = 0 spin = 1
Weak	 neutrino interaction induces beta decay	10^{-6}	10^{-18} (0.1% of the diameter of a proton)	Intermediate vector bosons W^+, W^-, Z_0, mass > 80 GeV spin =1
Gravity		6×10^{-39}	Infinite	graviton ? mass = 0 spin = 2

Proton

- Along with neutrons, protons make up the nucleus, held together by the strong force. The proton is a baryon and is considered to be composed of two up quarks and one down quark.
- It has long been considered to be a stable particle, but recent developments of grand unification models have suggested that it might decay with a half-life of about 1032 years. Experiments are underway to see if such decays can be detected. Decay of the proton would violate the conservation of baryon number, and in doing so would be the only known process in nature which does so.

Proton structure



Proton

U = "up" quark $+\frac{2}{3}$ e

D = "down" quark $-\frac{1}{3}$ e

$m_p = 1836.15\ m_e$

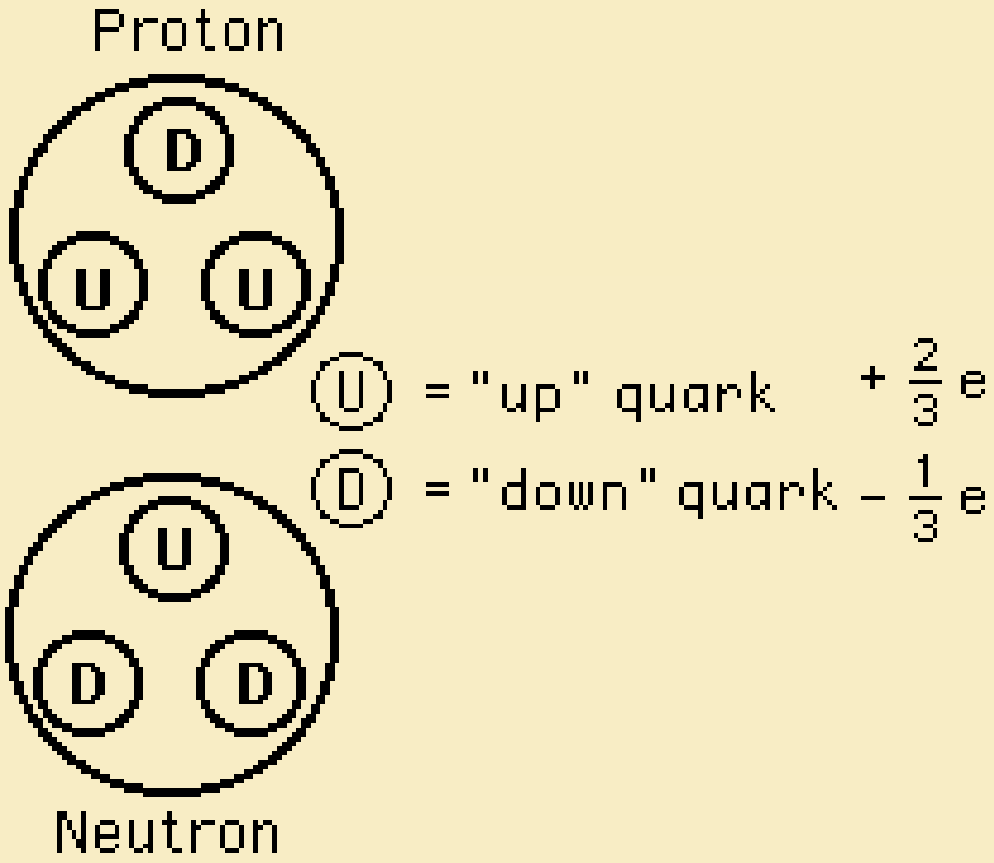
Mass = 1.6726×10^{-27} kg

$= 938.27231$ MeV/c^2

$= 1.00727647$ u

- The up and down quarks are the most common and least massive quarks, being the constituents of protons and neutrons thus of most ordinary matter.
- The fact that the free neutron decays and nuclei decay by beta decay in processes like is thought to be the result of a more Fundamental quark process

Structure proton and neutron



BIOMECHANICAL PROPERTIES OF TISSUES

BIOMECHANICS

Leonardo da Vinci (1452-1519) - structure of the human body as it relates to performance, center of gravity and the balance and center of resistance

Modern concept of locomotion
Giovanni Alfonso Borelli (1608-1679)
Etienne-Jules Marey (1830-1904) – movement is the most important of human functions and that all other functions are concerned with its accomplishment

Break of 19th and 20th centuries

center of gravity of the human body, concept of bone architecture

BIOMECHANICS

Biomechanics deals with application of mechanical principles on living organisms.

Macrobiomechanics

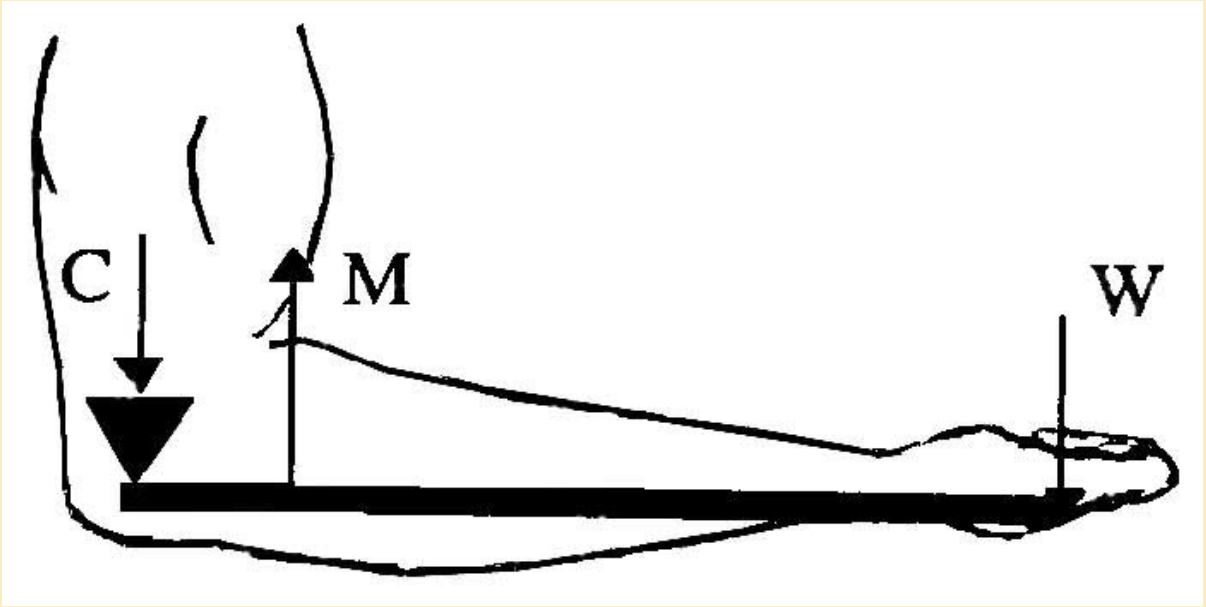
Organism

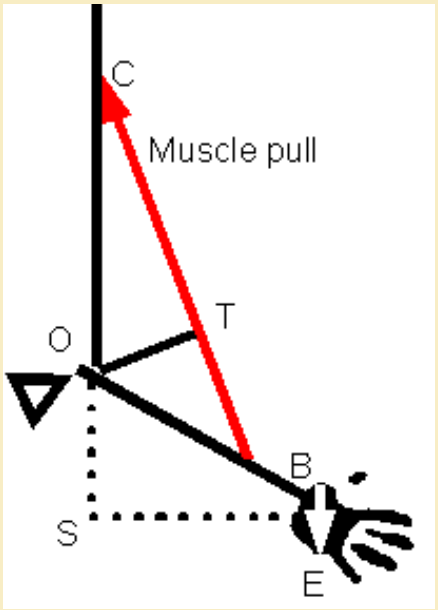
Microbiomechanics

tissue, cell, subcellular level

CONNECTIVE TISSUES

MUSCLE - LEVER





CONNECTIVE TISSUE

Composition and structure

- **fibroblasts**
- **collagen fibers**
- **elastic fibers**
- **reticular fibers**
- **extracellular matrix**
- **dense connective tissue (collagenous)**
- **loose connective tissue (collagenous)**

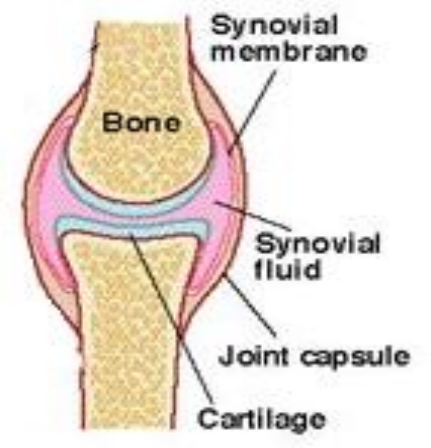
CARTILAGE

COMPOSITION

Cells – chondrocytes – principal cartilage cells, synthesize and produce extracellular matrix

Extracellular matrix – collagen, hyaluronic acid, proteoglycans, glycoproteins

TYPES: Hyaline – articular
Elastic
Fibrocartilage

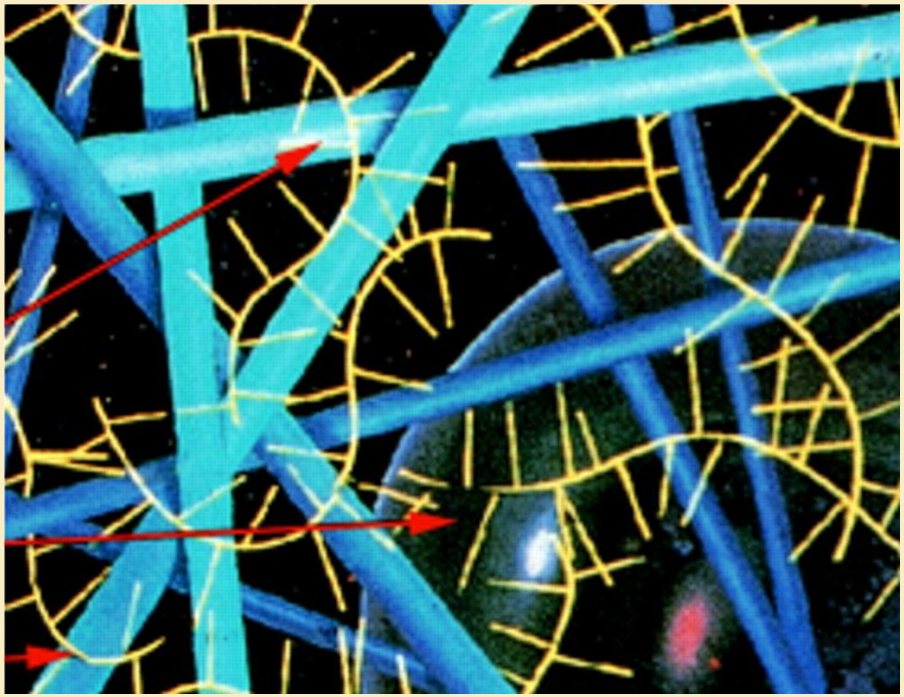


ARTICULAR CARTILAGE

- **„Non-loaded“ articular cartilage is submitted to permanent pressure (6-8 kg/cm^2)**
- **Non-loaded articular cartilage (e. g. joint immobilization) – broken metabolism of deeper cartilage zones → chondrocyte degeneration**
- **Alternate loading → cartilage regeneration**

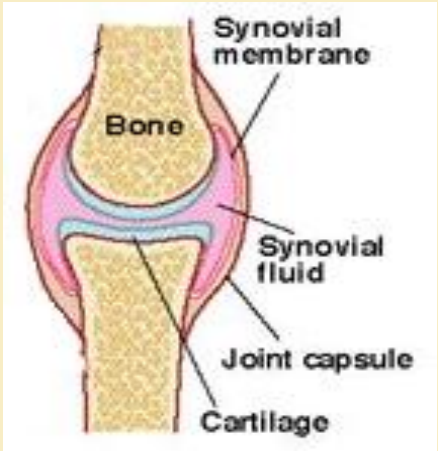
ARTICULAR CARTILAGE
structure and composition

- **Cells**
  chondrocytes (synthesize fibers and matrix)
- **Extracellular matrix**
  collagen fibers + amorphous matrix
  collagen
  hyaluronic acid
  proteoglycans
  glycoproteins



ARTICULAR CARTILAGE

- **Hyaline cartilage**
- **Specialized connective tissue**
- **Strong and elastic matrix**
- **Pressure-resistant**
- **Supplies smooth surfaces for articulating bone movement**
- **Compensation of jolts**
- **Thickness 0.5–6 mm**
- **Aging: elasticity reduction**
  thickness reduction



ARTICULAR CARTILAGE

- **porous** (spongy)
  submicroscopic slots (~ 6 nm)
- **loading → elastic deformation**
  changes of synovial fluid content
- **loading properties determined by synovial fluid saturation**

  loading – synovial fluid expelled from the matrix into the joint cavity, extracellular-matrix density increases

  unloading – cartilage absorbs synovial fluid (taken in by proteoglycan osmotic pressure)