University of Debrecen, Faculty of Medicine
Department of Biophysics and Cell Biology, director: János Szöllősi, professor

• Biophysics Division (1st semester)
  ➢ head: György Panyi, professor

• Biomathematics Division (1st and 2nd semester)
  ➢ Head: László Mátyus, professor

• Cell Biology Division (2nd semester)
  ➢ head: Gábor Szabó, professor

General Education manager: Zsolt Fazekas, assistant professor

What is biophysics?

- An interdisciplinary science
- Provides a quantitative description of the physical principles of biology and medicine
- What did biophysics give to medicine?
  - Understanding the pathomechanism of diseases (e.g. formation of amyloid plaque in Alzheimer’s disease)
  - Development of novel therapeutic approaches (e.g. photodynamic therapy, US therapy)
  - Development of novel diagnostic tools: e.g. ECG, MRI, PET
  - Understanding the operation of cells, tissues and organs at the molecular level
The Biophysics Program at Stanford

The major areas of modern biophysics are represented in the Program, principally in the molecular basis of macromolecular function including computational biology, single molecule analysis, and structural biology. The quantitative relationship between molecular properties and higher-level cell and tissue properties, and research in emerging areas of quantitative cell and organ biology, are also well represented. Methodologies include single-molecule analysis, x-ray diffraction, electron microscopy, NMR and other spectroscopic methods, and computation. Outstanding facilities are available within research groups, as well as major facilities including the Stanford Synchrotron Radiation Laborator, the Stanford Magnetic Resonance laboratory featuring an 800 MHz spectrometer, and the Lucas center for MRI imaging.

Inquiries may be directed to biophysics@med.stanford.edu or (650) 721-4175.
What do you get from studying biophysics?

• Introduction to natural sciences
• Medical physics (e.g. physical principles of diagnostic procedures)
• Molecular biophysics (e.g. diffusion, membrane biophysics)
• Organ biophysics (e.g. vision, hearing, circulation)
• Link to other subjects
  • Physiology
  • Clinical physiology
  • Radiology

Classes (GM ONLY, DENTISTRY SEE NEXT PAGE):

• 2 lectures every week in the F.015-016, Life Science Building (LSB) from week 1 to week 15
• 1×2 biophysics seminars every week (seminar room of the Department of Biophysics and Cell Biology, ground floor, Life Science Building F.102) from week 1 to week 15
• 1×3 biophysics practicals on weeks 2 and 15, biophysics practical rooms in the LSB (a total of 22 hours), every other week, see schedule on the web
What do you get from studying biophysics?

- Introduction to natural sciences
- Medical physics (e.g. physical principles of diagnostic procedures)
- Molecular biophysics (e.g. diffusion, membrane biophysics)
- Organ biophysics (e.g. vision, hearing, circulation)
- Link to other subjects
  - Physiology
  - Clinical physiology
  - Radiology

Classes (DENTISTRY ONLY):

- 2 lectures every week in the F.015-016 or F. 003-004 of the Life Science Building (LSB) from **week 1 to week 13**
- 1×2 biophysics seminars every week (seminar room of the Department of Biophysics and Cell Biology, ground floor, Life Science Building F.102) from **week 1 to week 13**
- 1×3 biophysics practicals on weeks 2 and 14, biophysics practical rooms in the LSB (a total of 16 hours), every other week, see schedule on the web
Seminar room F102

Biophysics lab F401

Life Science building
Ground floor
Office hours of the education manager (Dr. Zsolt Fazekas) from the 2nd week:

- Three times in a week, in the F.402 seminar room.
- The same time for foreign and Hungarian students.

<table>
<thead>
<tr>
<th>Day</th>
<th>Time</th>
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<tbody>
<tr>
<td>Monday</td>
<td>15:45-16:30</td>
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<tr>
<td>Thursday</td>
<td>14:45-15:30</td>
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<td>Friday</td>
<td>14:45-15:30</td>
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Exceptions: the table above is not valid for the 1st week. Dates on the 1st week:

- Tuesday, 8:45 AM to 9:30 AM, LSB F.402 sem. room
- Thursday, 14:45 to 15:30, LSB F.402 sem. room
- Other exceptions and changes will be posted in the News section of the Biophysics web page
Contacting the Manager of Education

- The primary tool for contacting the Department is the e-mail:
  
  biophysedu@med.unideb.hu

Advantages:

- If your problem (or question) can be solved by e-mail, you don’t need to go to the office hours.
- Beside posting on the web site, we usually send Neptun messages about important educational events (test writings, timetable changes, etc.). You will receive them as an email as well, if you have a valid, working email address registered in the Neptun system (and you check it regularly…).

The only place and time we deal with students is the room F.402 and during the office hours. Do not go to the 1st or 2nd floor and disturb the teachers with your problems.
Welcome to the webpage of the Department of Biophysics and Cell Biology

Medical and Health Science Center, University of Debrecen
Department of Biophysics and Cell Biology

Head of department:
Prof. Dr. János Szélösi

Address:
4032 Debrecen, Egyetem tér 1. Life Science Building

Mailing address:
4012 Debrecen, Nagyerdei ut 99. PO Box 39

Phone:
+36/52/412-623

Fax:
+36/52/252-251

E-mail:
biophys@med.unideb.hu

Please write to the educational manager, dr. Zsolt Fazekas to the further email addresses in connection with any educational questions:

biophysedu@med.unideb.hu or
cellbiocell@med.unideb.hu

Consultation with the manager of Education: during office hours only.

Office hours:
Monday and Wednesday, 8:00-11:00
The two login methods to the biophysics web site:

Federated login:
User name: your Neptun login name
password: your Neptun password

General login as a student:
User name: students
password: geta5
Questions can be posted after **Federated login** (logging in with your Neptun user name and password) only.

Before posting the question, you must choose (from the rolling down list) the type of your education (student_med, students_den), and the number and title of lecture. Then please post your question. It will appear under the „Questions about lecture materials” link. Questions will appear anonymously, so the teacher will not see the student’s personal data (name, Neptun code, etc.).
Self control tests:

Week 8, 30th October (Monday) 7:30 AM

Week 12, 27th November (Monday) 7:30 AM
Topics of Biophysics lectures and seminars

1st semester of the academic year 2016-17

Lecture:
Med., MB_E Monday 13:00-14:00 LSB F.015-016
Med. Friday 12:00-13:00 LSB F.015-016
Dent Monday 12:00-13:00 LSB F.015-016 (weeks 1-13)
Dent. MB_E Friday 10:00-11:00 LSB F.003-004 (weeks 1-13)

<table>
<thead>
<tr>
<th>Week</th>
<th>Number</th>
<th>Title</th>
<th>Lecturer</th>
<th>English biophysics seminar</th>
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<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Introduction. Electromagnetic waves, the properties of light (interference, photoelectric effect, photon theory), Matter waves.</td>
<td>PGY</td>
<td>Intro</td>
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<tr>
<td></td>
<td>2-12</td>
<td>X-ray, X-ray crystallography.</td>
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<td>FZS</td>
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<tr>
<td>2</td>
<td>3</td>
<td>Thermal radiation, light absorption and emission. Atomic and molecule spectra, absorption spectroscopy.</td>
<td>PGY</td>
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<td>19-23 Sept</td>
<td>4</td>
<td>Fluorescence spectroscopy, applications of fluorescence.</td>
<td>JA</td>
<td>1,2</td>
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<td>Semmelweis University</td>
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<td>University of Pecs</td>
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Understanding biophysical equations and their application: sample problems and exercises

Moodle e-learning module is coming during the week

Introduction. Electromagnetic waves, the proton (interference, photoelectric effect, photon theory)

1. Photoelectric effect

By Dr. György Panyi

1.1 The formula, definition of the variables

Photoelectric effect is the most important experimental evidence of the quantum nature of light which influenced the formation of the concept of wave-particle duality. The explanation of the phenomenon was given by Albert Einstein awarded with the Nobel Prize in 1921 for his discovery.

1.3.2 Exercise

The value of the "stopping" potential in a photoelectric experiment is \( U = -0.49 \text{V} \).

A. What is the maximum kinetic energy (given in eV) and speed of the photoelectrons?

B. Given the work function characteristic of the metal used in the experiment is 2eV, what was the wavelength of the illuminating light?

C. What is the limiting wavelength (above which photoelectron emission does not occur) characteristic for the metal? The mass of the electron: \( m = 9.1 \times 10^{-31} \text{kg} \)

Solution

A. 

\( eU = E_{e,\text{kin, max}} = (0.49 \text{V} \times 1.6 \times 10^{-19} \text{C})/(1.6 \times 10^{-19} \text{J}) = 0.49 \text{ eV} \). The maximum speed of the photoelectron:

\[
E_{e,\text{kin, max}} = \frac{1}{2} m v_{\text{max}}^2
\]

\[
v_{\text{max}} = \sqrt{\frac{2E_{e,\text{kin, max}}}{m}} = \sqrt{\frac{2 \times 0.49 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31}}} \approx 4.15 \times 10^5 \text{ m/s}
\]

1.4 Exercises

1. Zinc is illuminated by ultraviolet light of wavelength \( \lambda = 248.63 \text{ nm} \). What is the energy of photons in eV?

   a) \( 8 \times 10^{-19} \text{ eV} \)
   b) 5 eV
   c) \( 1.28 \times 10^{-17} \text{ eV} \)
65% passing only in 2015/2016

This direwolf will guard the door so that late comers are not allowed in the practicals!!!

BRACE YOURSELF

WINTER IS COMING

Guide to biophysics course at a glance - guide to success

Practicals
- Repeat during spare lab
- \( QG < 2.5 \)
- \( LG = 0 \)
- >0 for all labs

Seminar
- <=7 absences

SCT
- \( SCT_{ave} \geq 66 \)
- \( SCT_{ave} \geq 85 \)

Passage to the final exam
- PE: practical exam
- \( PE \) on the day of FE
- exempt of FE part I
- signature granted

FAIL

PASS

Bonus points towards the Final Exam → see requirements point 7
Seminar bonus: 3 points max. → see requirements point 2
PG: 5 points max., calculated as \( (QG_{ave} + LG_{ave}) / 2 \) → see requirements point 3
0 if \( QG < 2.5 \) two times!
SCT bonus: 11 points max → see requirements point 6

\( QG: \) lab quiz grade
\( LG: \) lab grade
\( PG: \) practical grade

\( PE: \) practical exam
\( FE: \) final exam
\( SCT: \) self-control test

\( Subscript ave: \) average
65% passing only in 2015/2016

BRACE YOURSELF

WINTER IS COMING

65% passing only in 2015/2016

EARN A LOT OF BONUS POINTS!!!!!
The nature of light

velocity in vacuum: \( c = 3 \times 10^8 \) m/s

in other materials: \( v = \frac{c}{n} \), \( (\lambda = \frac{c}{f}) \) where \( n \) is the index of refraction

End of the 19\(^{\text{th}}\) century

electromagnetic wave

transversal wave propagating with the speed of light \( (c) \), having two components, electric and magnetic

proof for the wave nature of light: interference phenomena

Beginning of the 20\(^{\text{th}}\) century

particle (photon)

\( E = hf \), where \( h = \text{Planck's constant} = 6.63 \times 10^{-34} \) Js

proof for the particle nature of light: photoelectric effect

\( 1\text{eV}=1.6\times10^{-19} \) J \( E=hf=hc/\lambda \)
Interference: property of waves

Two-slit experiment

Constructive interference: waves are in phase

Destructive interference: waves are out of phase

Alternating bright and dark bands are observed (interference) in accordance with the predictions of wave theory.

Intensity distribution according to the particle theory (one bright spot in the middle.)
The photoelectric effect can be adequately explained only by the photon concept.

- For λ = 700 nm, $E_{\text{photon}} = 1.77$ eV. 
- For λ = 550 nm, $E_{\text{photon}} = 2.25$ eV. 
- For λ = 400 nm, $E_{\text{photon}} = 3.1$ eV.

The kinetic energy of the ejected photoelectrons is analyzed with an electric field.

\[ \frac{1}{2}mv^2 = eU \]

<table>
<thead>
<tr>
<th>Photon Energy</th>
<th>KE of Electron</th>
<th>Stopping Potential</th>
<th>ΔE (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.25 eV</td>
<td>0.25 eV</td>
<td>-0.25V</td>
<td>2 eV</td>
</tr>
<tr>
<td>3.1 eV</td>
<td>1.1 eV</td>
<td>-1.1V</td>
<td>2 eV</td>
</tr>
</tbody>
</table>

- According to the wave theory, the kinetic energy of photoelectrons is proportional to light intensity.
- Since this is not the case, the photon theory has to be used for the interpretation of the photoelectric effect.

Electrode made of potassium, 2 eV needed to eject an electron. $A = 2$ eV (A – work function, ionization energy).

\[ hf = A + E_{\text{el,kin}} = A + \frac{1}{2}mv^2 \]

1 eV = 1.6 x 10^{-19} J
The wave nature of matter

- electromagnetic radiation has both wave- and matter-like properties
- Davisson and Germer succeeded in generating interference with electrons classically regarded as particles → electrons have wave-like properties too
- certain properties of elementary particles can only be explained by the wave model
- a wavelength (called de Broglie wavelength) can be assigned to any elementary particle:

\[ \lambda = \frac{h}{p} \]

Planck’s constant

The de Broglie wavelength of an electron:

\[ \frac{6.63 \cdot 10^{-34} \text{ Js}}{9.1 \cdot 10^{-31} \text{ kg} \cdot \text{ m/s}} = \frac{0.000729 \text{ m}}{\text{ m/s}} = 729000 \text{ nm} \]
The electromagnetic spectrum

400 nm

750 nm