BMEN 4001: Quantitative Physiology I
Molecules and Cells

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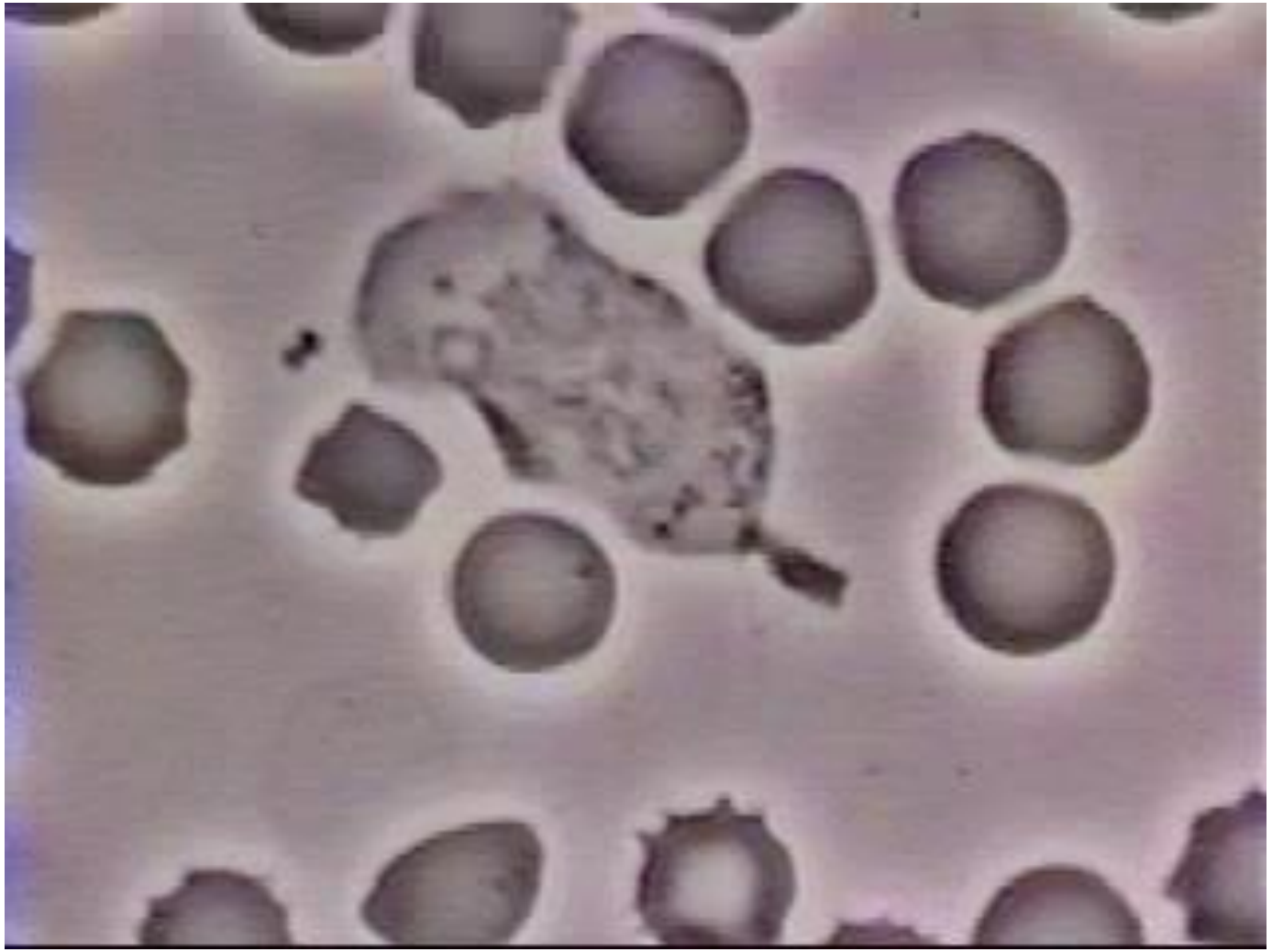
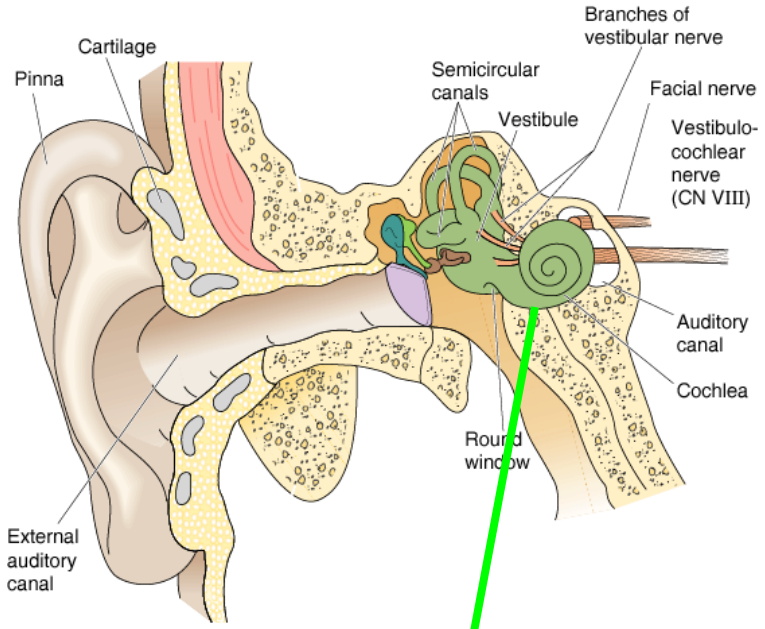
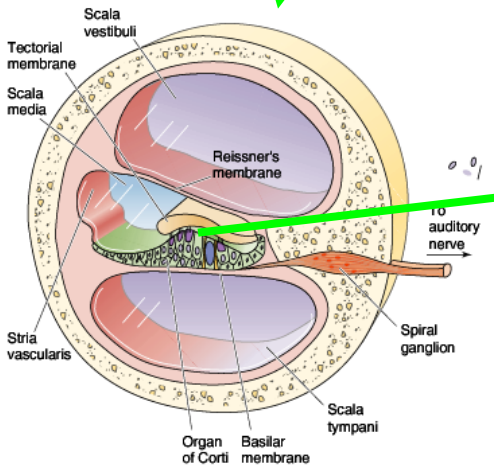
- Overview of course content
- Texts and resources
- Evaluation and grading
- Schedule
- Tips for success

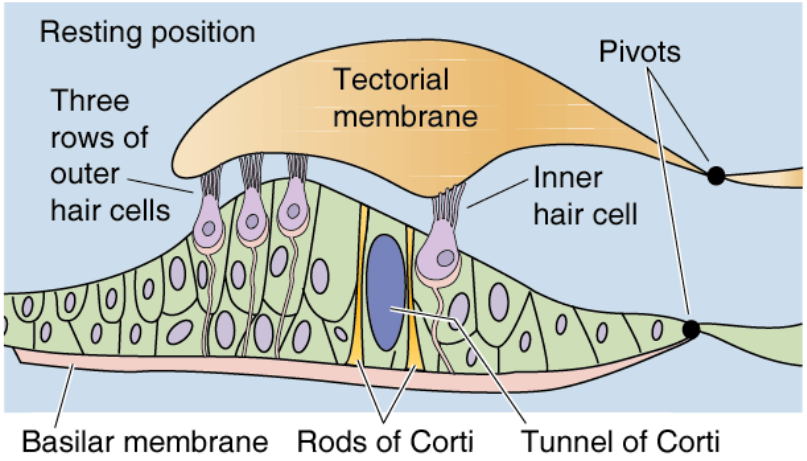


Crawling Neutrophil chasing a bacterium

David Rogers, Vanderbilt University, 1950’s







movie from: http://www.physiol.ucl.ac.uk/ashmore/

Overview of content

- Chemical/biochemical Reactions
  - Affinity and Binding
  - Enzyme Kinetics
  - Modelling reaction dynamics
- Diffusive Transport

- Membrane Physiology
  - Bioelectricity / membrane potential
  - Active Membranes
- Cell Cytoskeleton and Molecular Motors

- Cellular Engineering

Class composition and Grading

- Class composition
  - 3rd year undergraduates
  - Graduate students
  - Columbia Video Network
- Numerical score will be based on
  - 40% Homeworks (5 assigned, 4 best counted)
  - 30% Mid-term Exam 1
  - 30% Mid-term Exam 2
- One extension of four days will be allowed for one homework assignment. This does not have to be arranged in advance of the deadline. It will be applied to one of the counted HWs.
- Final grades for undergraduate, graduate, and CVN students will be on separate scales.
- Violations of academic honesty will be addressed with the appropriate Dean.
- Scheduling and modalities for all assessments will be subject to University, School, and Department policies in place at that time.
- Concerns of academic misconduct can be brought to Prof. Kam or Prof. Clark Hung, DBME Vice-chair.

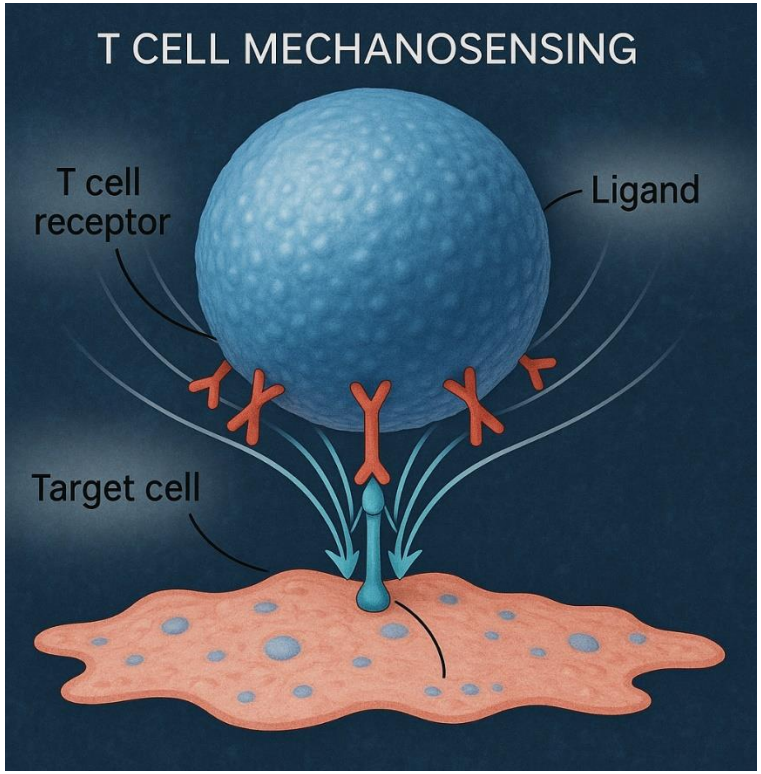
Homeworks

- Each student is required to submit an individual solution for each assignment. While students are encouraged to discuss the homeworks, submitted solutions must reflect individual effort.
- Solutions to be done neatly in 8.5” X 11”, portrait orientation. Assignments will be submitted electronically, and initial grading will be anonymous;
  do not include your name or identifying information
- Homeworks are due by 11:00PM (Eastern Time) of the assigned due date. Unless other arrangements are made 24 hours in advance, late homework will discounted 25% per day.

Midterm exams

- Two in-class, in person midterm exams.
- Open book, open notes. Some excluded materials as will be detailed later.

Generative AI



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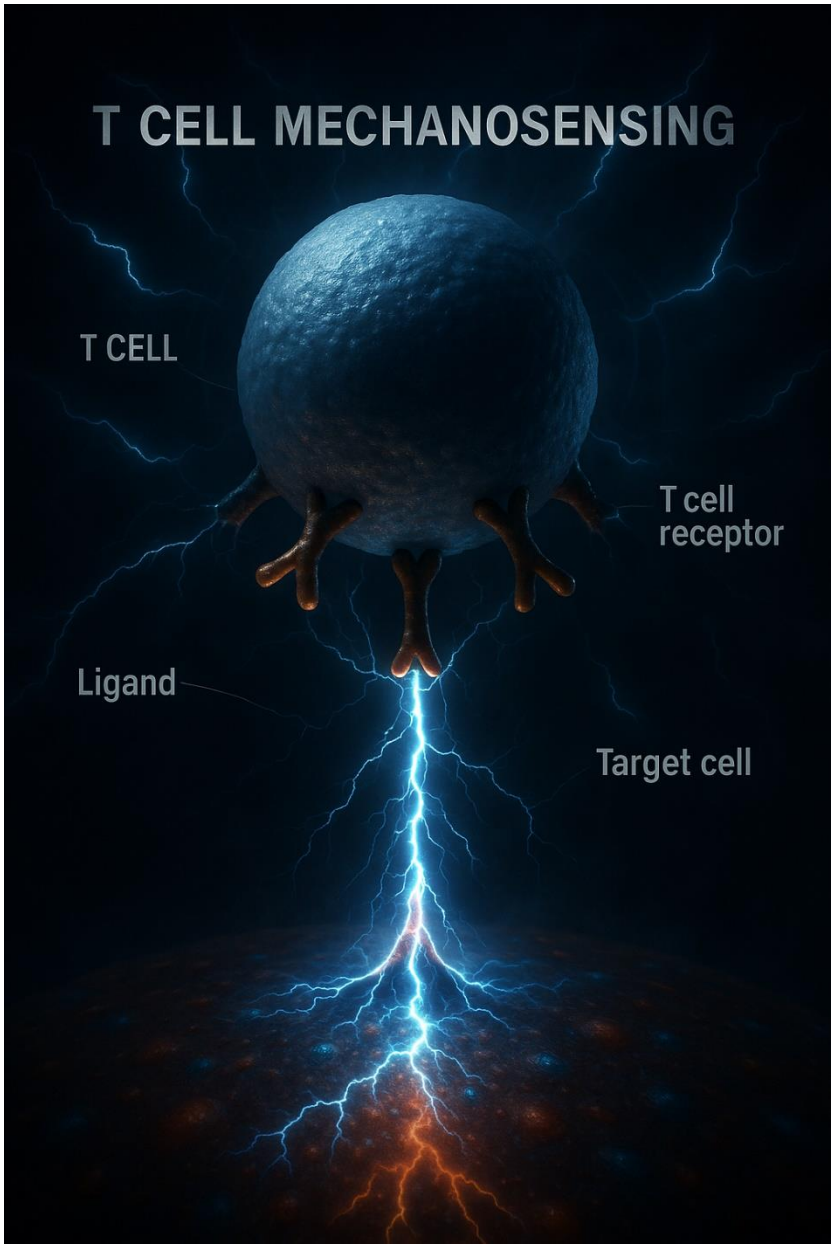


Generative AI

- Submitted materials are an individual's original work.
- Homework assignments: Generative AI can be used to approach questions and explore.
- Exams: Generative AI / Search are not allowed.
- We will also follow the University's Generative AI Policy
  https://provost.columbia.edu/content/office-senior-vice-provost/ai-policy

Texts

- WF Boron and EL Boulpaep, “Medical Physiology”, Elsevier, 3e edition, 2016.
- Course pack, consisting of chapters from
  - J Keener and J Sneyd, “Mathematical Physiology”, Springer, 1998, Ch. 1 & 2. ISBN: 0387983813
  - P Nelson, “Biological Physics”, Freeman and Company, 2004, Ch. 4 & 12. ISBN: 0716743728
- Calculator/computer, some numerical steps can use Excel, Sheets, MATLAB, Python, etc.
- Exams require scientific calculators (graphing calculators are allowed but not needed).
- Access to MATLAB for one assignment; https://www.mathworks.com/login/verification/tah/new

Teaching Assistants

TAs:

- Terry Fang, hf2505@columbia.edu
- Yuyao Wang, yw4398@columbia.edu
- Justin Yun, jy3200@cumc.columbia.edu
- Office hours
  - Monday, 5:15 – 7:15 PM, 343 Mudd
  - Tuesday, 5:00 – 7:00 PM, 343 Mudd
  - Thursday, 9:00 – 11:00 AM, zoom
  - Friday, 10:00 - 11:00 AM; 363D ET / zoom - L Kam
- TAs and office hours are not assigned to specific students. This arrangement will be revisited if needed.

Tentative Schedule

Dates	Topics/Event	Reading
Sept. 3 (week 0)	Course overview	
Sept. 8 (week 1)	01 – Chemical Kinetics	K&S Chap. 1 (Coursepack)
Sept. 10	02 – Enzymes part 1	K&S Chap. 1 (Coursepack), B&B Chap. 58
Sept. 15 (week 2)	02 – Enzymes part 2	
Sept. 17	03 – O2 transport part 1 – HW1 assigned	K&S Chap. 1 (Coursepack), B&B Chap. 28/29
Sept. 22 (week 3)	03 – O2 transport part 2	
Sept. 24	04 – Diffusion 1 – HW1 due	Nelson Chap. 4 (Coursepack)
Sept. 29 (week 4)	04 – Diffusion 2	
Oct. 1	04 – Diffusion 3 – HW2 assigned	
Oct. 6 (week 5)	04 – Diffusion 4	
Oct. 8	05 – Entropy – HW2 due	
Oct. 13 (week 6)	06 – Computational Modeling – HW3 assigned	K&S Chap. 1 (Coursepack), MATLAB
Oct. 15	07 – Membranes and carriers	K&S Chap. 2 (Coursepack), B&B Chap. 5
Oct. 20 (week 7)	Midterm Exam 1	
Oct. 22	08 – Bioelectricity and Nernst potential	Nelson Chap. 7 (Coursepack), K&S Chap. 2 (Coursepack), B&B Chap. 6
Oct. 27 (week 8)	09 – Resting potential – HW3 due	K&S Chap. 2 (Coursepack)
Oct. 29	10 – Excitable membranes – HW4 assigned	B&B Chap. 7
Nov. 3/4	Academic Holiday / Election Day	
Nov. 5 (week 9)	Cell culture	
Nov. 10 (week 10)	11 – Cell cytoskeleton	Boal, B&B Chap. 2
Nov. 12	12 – Motors and muscle 1 – HW4 due, HW5 assigned	B&B Chap. 9
Nov. 17 (week 11)	12 – Motors and muscle 2	
Nov. 19	Mechanobiology – HW5 due	
Nov. 24 (week 12)	Microscopy	
Nov. 26 – 28	Holiday / Thanksgiving break	
Dec. 1 (week 13)	Experiment analysis with computers	
Dec. 3	Midterm Exam 2	
Dec. 8 (week 14)	Microscale physiology	Last day of classes
Dec. 9 – 11	Study Days	
Dec. 12 – 19	Final Exam Week	

Communication

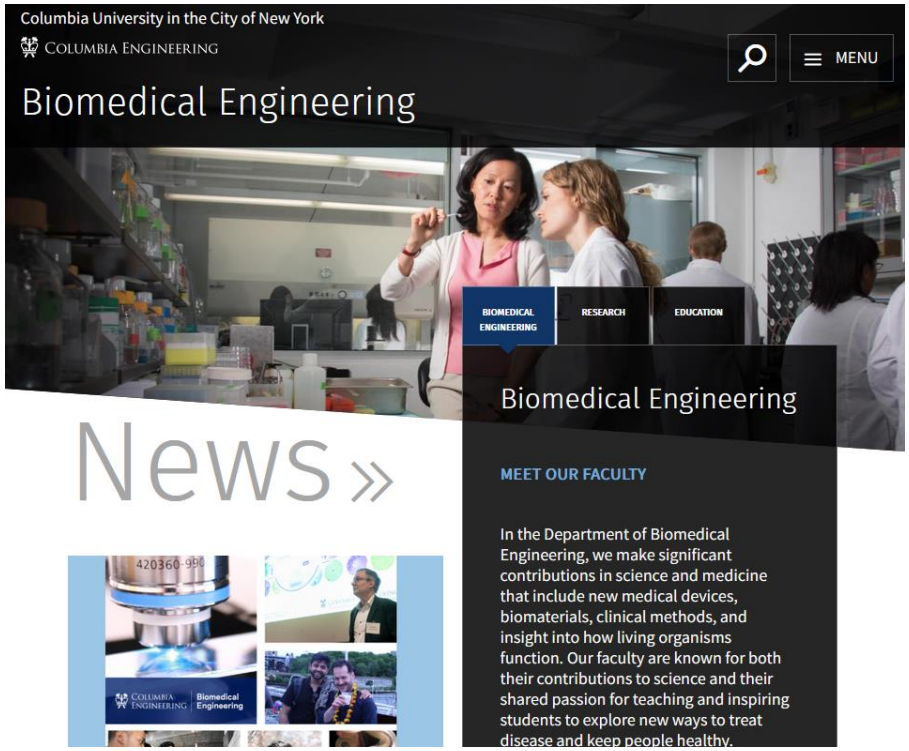
- Courseworks
  - Lecture notes and slides are available on the Modules section. These are allowed for exams.
  - Homeworks and grading through Gradescope
  - Discussion section will be available to post general questions / answers
- Class sessions
  - In-person
  - Recorded videos will be available on Courseworks

Strategy

- Reach out with questions
- Don’t wait until the last night for HWs. These take time.
- Have your chemistry, physics, biology, mathematics texts and notes in hand and in mind.
- Collaborate (appropriately) with other students. Network!

Welcome! From the BME Faculty

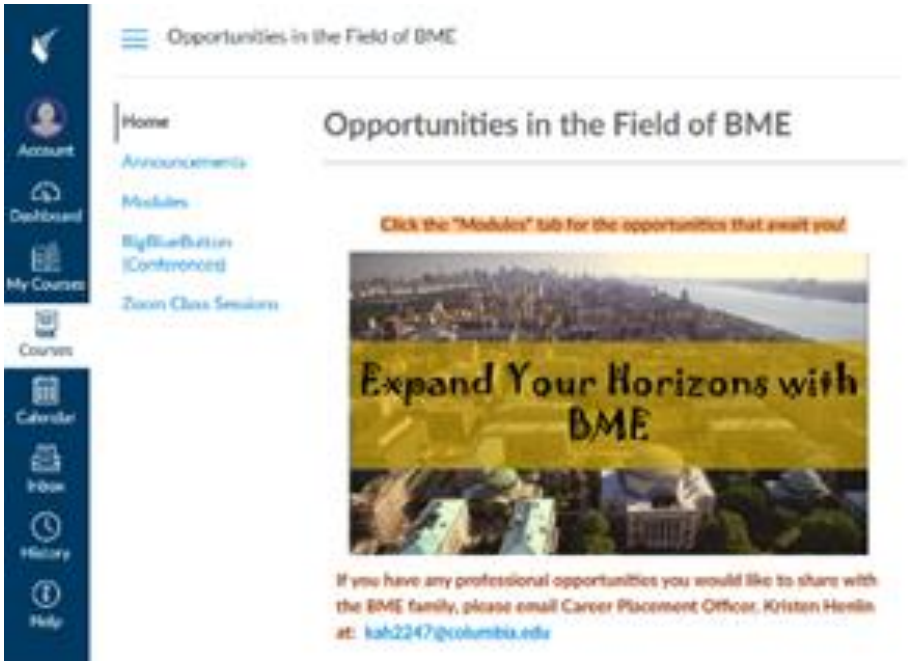
Explore !



https://bme.columbia.edu

Talks and News

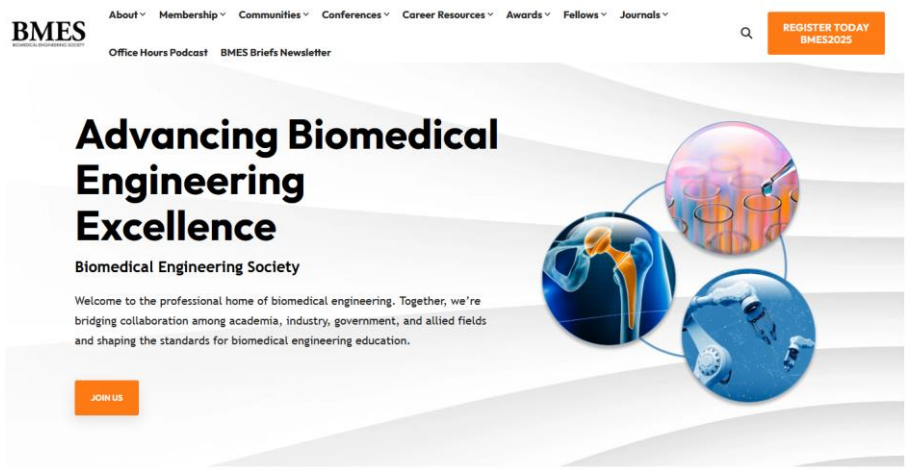
- Tissue Talks – Wednesdays
- BME Seminars – Thursdays
- People Profiles
- Faculty Profiles



Opportunities in the Field of BME

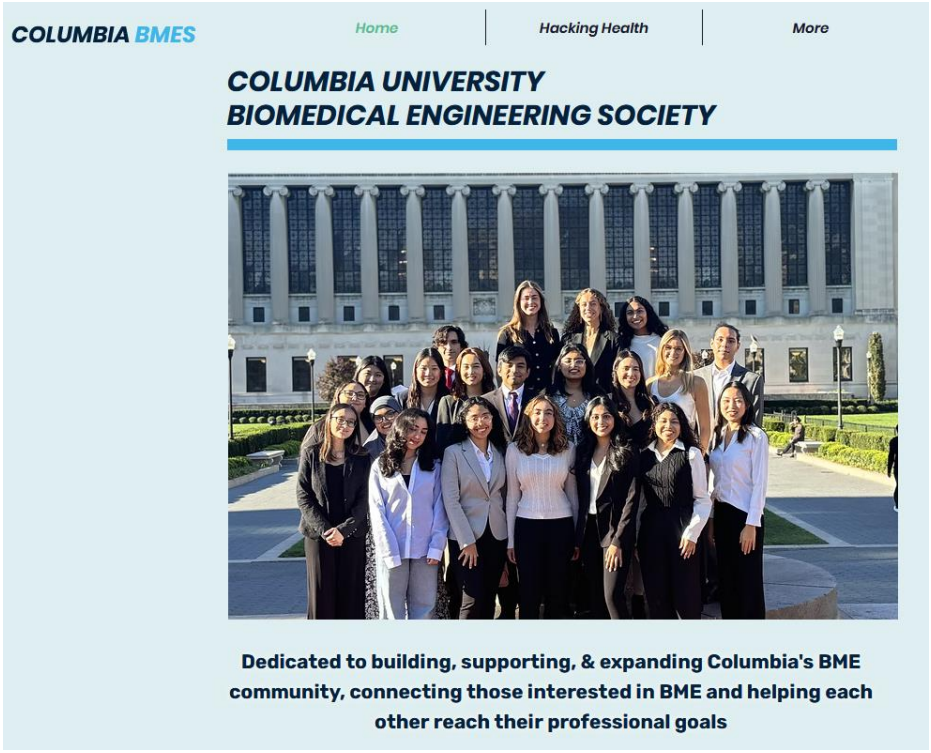
- For both Graduate and Undergraduate communities
- Job postings
- Announcements and recordings of workshops
- Links to additional resources, guidance

https://www.bme.columbia.edu/studentprofessional-organizations-and-awards



GoBME

Graduate Organization of Biomedical Engineers



@cu_gobme

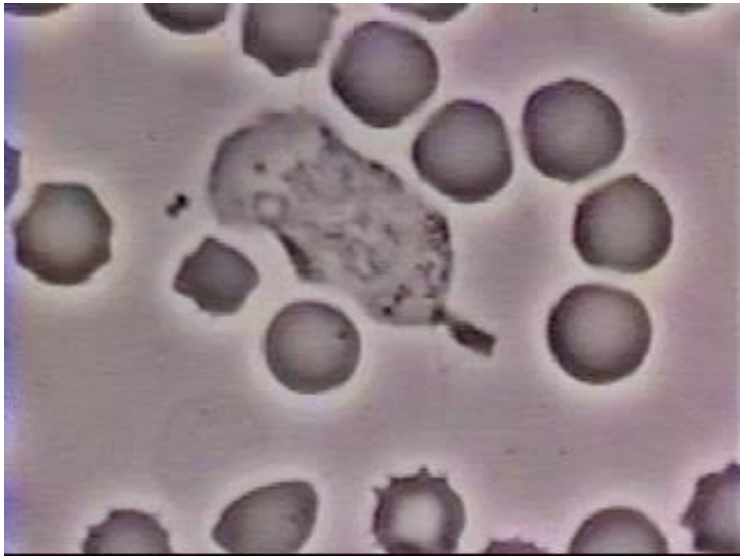
gobme.columbia@gmail.com

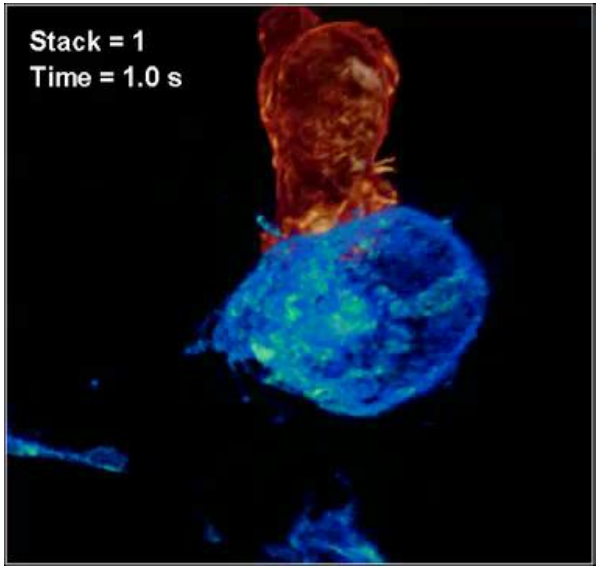
Columbia GoBME

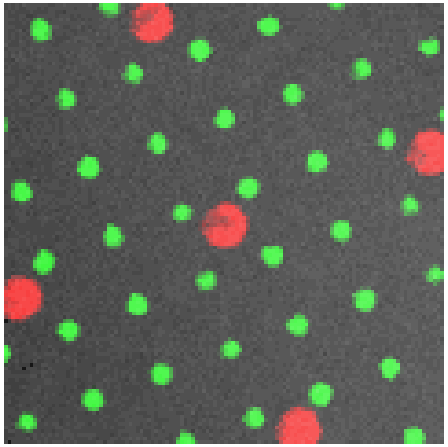
https://bmesatcolumbia.wixsite.com/columbia-bmes

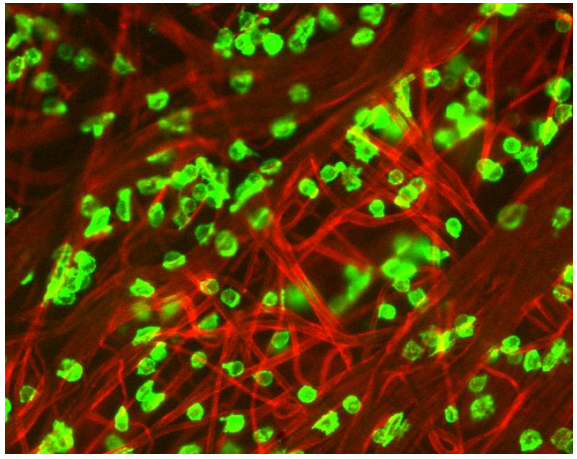
Microscale Biocomplexity Laboratory

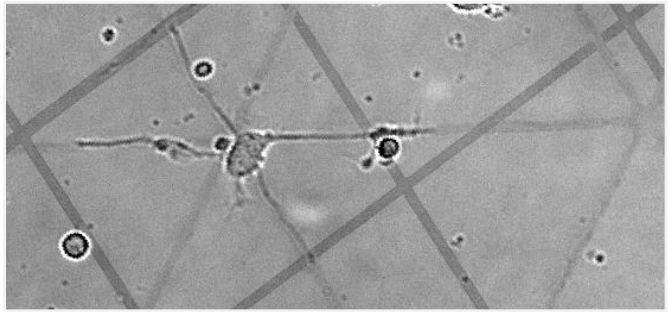
Department of Biomedical Engineering
Columbia University in the City of New York

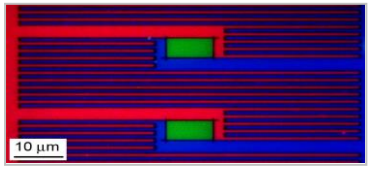


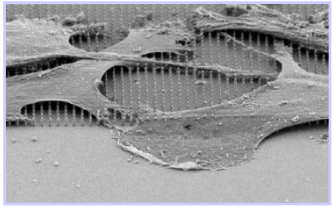


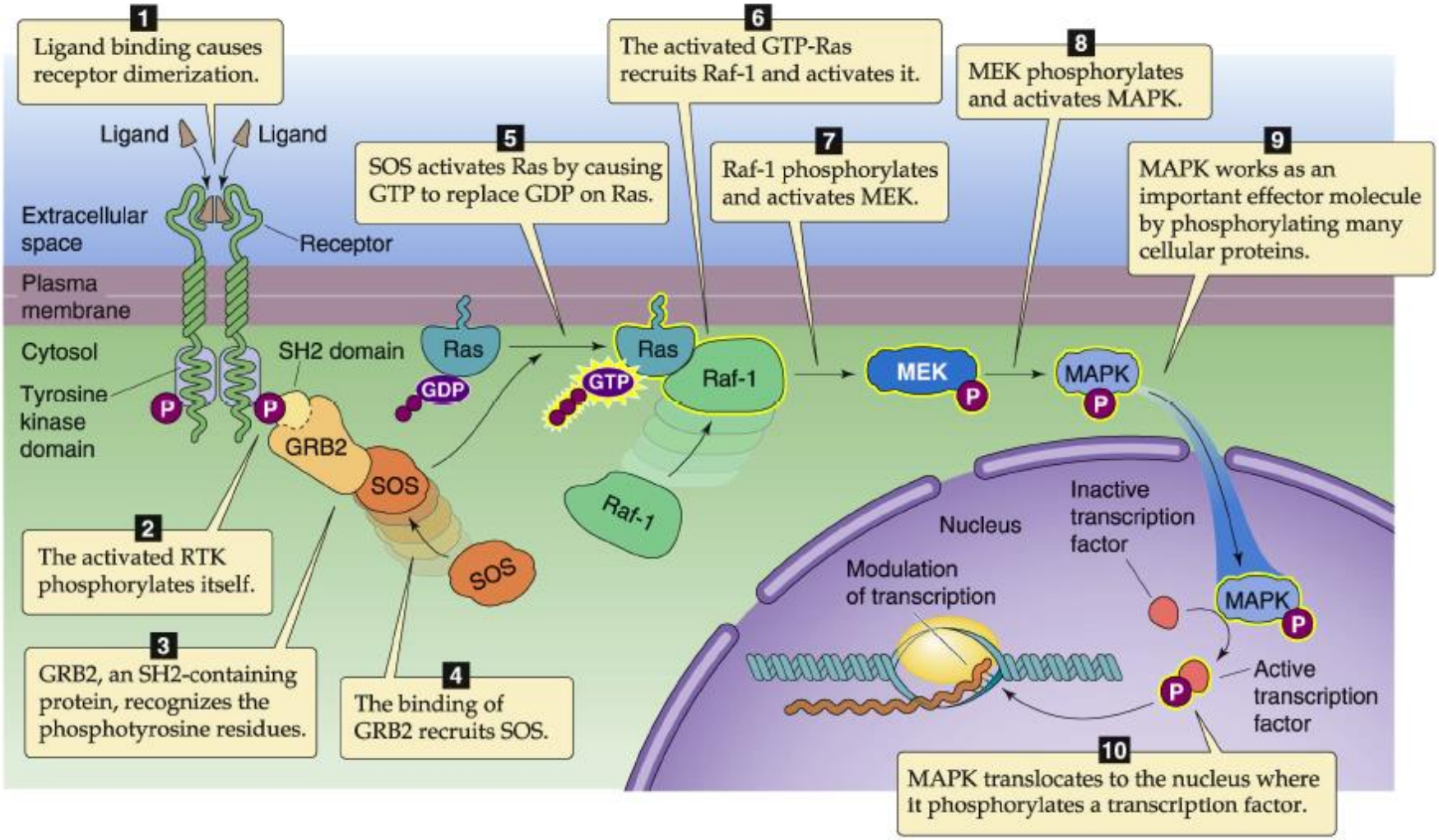











1
Ligand binding causes receptor dimerization.
Ligand
Ligand
Extracellular space
Receptor
Plasma membrane
Cytosol
Tyrosine kinase domain
P
P
2
The activated RTK phosphorylates itself.
SH2 domain
GRB2
3
GRB2, an SH2-containing protein, recognizes the phosphotyrosine residues.
SOS
4
The binding of GRB2 recruits SOS.
5
SOS activates Ras by causing GTP to replace GDP on Ras.
Ras
GDP
SOS
6
The activated GTP-Ras recruits Raf-1 and activates it.
Ras
GTP
Raf-1
Raf-1
7
Raf-1 phosphorylates and activates MEK.
MEK
P
8
MEK phosphorylates and activates MAPK.
MAPK
P
9
MAPK works as an important effector molecule by phosphorylating many cellular proteins.
Nucleus
Inactive transcription factor
Modulation of transcription
MAPK
P
P
Active transcription factor
10
MAPK translocates to the nucleus where it phosphorylates a transcription factor.