Syllabus for BME 307
Bioelectricity

- Instructor: Dr. Walter G. Besio
- Phone: 401-874-4738, Office Kelly 107
- Office Hours: M,W 10am-11am,
- Class Time: 11:00 am– 12:15 pm, TR, Kelly Hall 203
- Email: besio@ele.uri.edu
- **Course Concept**
- This course will present a quantitative description of electrical activity in excitable cells. We will analyze microscopic and macroscopic mechanisms that generate membrane potentials; the Core Conductor theory; voltage-current characteristics of the cell membrane; time-independent and time-dependent solutions to the Cable Equation; the Hodgkin-Huxley model of action potential in the squid giant axon; and cell-to-cell and tissue-level propagation of action potentials as well as potentials generated on the body surface from these sources. Many of the jobs in the fields of biomedical engineering and electrical engineering require extensive physiological modeling backgrounds. This course should help meet those requirements. After successfully completing this course you will be able to:

- **Understand**
  - **state how diffusion and the electromotive force contribute to the cell resting potential;**
  - **compute the resting potential from intra- and extracellular ion concentrations;**
  - **develop an analog model of an excitable cell membrane;**
  - **describe the ionic currents that constitute the action potential;**
- **Question**
  - **interpret how changes in ionic conductivities affect the action potential;**
  - **analyze simulated electrophysiology recordings;**
- **Design**
  - **design software scripts to simulate an action potential waveform;**
  - **design software scripts to simulate potentials on a body surface due to action potentials;**
  - **implement a finite difference algorithm to integrate a differential equation;**
- **Lead**
  - **work with a team to complete a software design project;**
- **Communicate**
  - **present simulation results in written and oral reports.**

- **Textbook- R Plonsey and RC Barr. Bioelectricity: A Quantitative Approach, third edition Springer 2007**
  - **This textbook may be a little difficult to follow at times and I will be using several other reference books and give handouts as necessary.**
- **Course Policies**
  - **1. It is to your benefit to read ahead. A 5 minute quiz may be given at the beginning of each class. These quizzes will not be counted against you, but will be added as bonus points.**
  - **2. There will be three exams, two midterm and one final. The midterm exams should be taken during class times on the days specified. The only allowable reason for missing an exam is a medical excuse signed by a physician or other specific URI allowable absence. Missing an exam without a medical excuse or prearranged accommodation due to other URI approved absence will result in taking a comprehensive exam during the final week of class as well as the comprehensive final.**
  - **3. Grading will be based on:**
    - **Midterm Exam 1 (15%)**
    - **Midterm Exam 2 (15%)**
    - **Final Exam (20%)**
    - **Homework assignments (10%)**
    - **Simulation Project (35%)**
    - **Class participation (5%)**
    - **Quizzes (5% Bonus)**

- **Homework is an integral part of this course and must be turned in. Late homework (15 minutes after due date and time is 5% off if submitted before the end of class) will be reduced 10% for each day. However, any missing homework assignments will impact the course grade by 1 grade level. Therefore, even if an assignment is late, it is in your best interest to turn it in. The grading scale will be:**
- **92-100: A, 80-91: B, 70-79: C, 60-69: D, <60: F**
- **Neatness and legibility are factors in the grading of the exams and homework since they make it easier if I can read and follow your work. Where appropriate, put a box around your final answer.**
- **Please use engineering paper at the top of the page, put your name, the course number, and the number of the homework set, and the due date. For example, see the layout to the right.**
- **Also mark each page with your name and the page number on the bottom right corner (e.g. John Doe, page 1 of 4).**

- **4. *Attendance regulations:* There will be a grade penalty of 1 grade level if more than 2 lectures are missed unless the absence is a University of Rhode Island authorized absence. Inform the instructor by email if you must miss a lecture.**
- **5. *Office Hours:* I do hope you will visit during my office hours. Come individually or with friends. It's a chance to talk about the course, assignments, exams, study strategies, or whatever else you'd like to discuss. You don't have to have a problem to visit. If these office hours are impossible for you, please let me know so that we can make an appointment for another time.**
- **6. No calculators will be allowed for examinations. Any tables or supporting material for questions will be provided.**
- **7. Selected course documents and the course announcements will be made available to all the students through http://www.ele.uri.edu/courses/bme307/f08.**

- **8. If you are caught breaking the URI honor code, you could be given an F for the class.**
  - **Being a student of higher standards, you pledge to embody the principles of academic integrity.**
  - **You may work with other students on your homework assignments, and you are encouraged to discuss concepts, principles and methods with each other; however, you must prepare your own final submission unless a group solution is specifically called for. You are not to copy another student's homework.**
  - **Collaboration among students is not permitted during examinations.**
- **9. Extra credit is often given for learning endeavors beyond contemporary class work.**
- **10. Any student with a documented disability should contact me early in the semester so that we may make reasonable accommodations to support your success in this class; you should also contact Disability Services for Students, Office of Student Life, 330 Memorial Union, 874-2098.**
- **11. Special dates:**
  - **9/12/2008 Last day to drop "Early Drop" courses**
  - **9/17/2008 Last day to ADD and to ADD Pass/Fail Option (Last day to drop with billing adjustment)**
  - **10/29/2008 Last day to DROP courses (billing adjustment not applicable after add period).**
  - **10/4/2008 Election Day (make up class Wednesday 11/12/08)**
  - **11/11/2008 Veteran's Day**
  - **11/27-30/2008 Thanksgiving Recess, classes do not meet**
  - **12/9/2008 Classes end**

Week	CHP		Date	Lecture Topic	HW	DUE
1	3	R	**9-4**	Introduction, review syllabus, Lipid bilayer,		
2	3	T	**9-9**	diffusion		
2	3	R	**9-11**	diffusion	HW1	
3	3	T	**9-16**	diffusion		HW1
3	3	R	**9-18**	diffusion		
4	3	T	**9-23**	Active transport	HW2	
4	3	R	**2-25**	Nernst equation		HW2
5		T	**9-30**	Midterm 1		
5	4	R	**10-2**	Channels		
6	4	T	**10-7**	Channels		HW4
6	4	R	**10-9**	Channels	HW3	
7	5	T	**10-14**	Action potentials		HW3
7	5	R	**10-16**	Action potentials	HW4	
8	5	T	**10-21**	Action potentials		HW4
8	5	R	**10-23**	Action potentials		
9		T	**10-28**	Midterm 2		
9	1	R	**10-30**	Vector review		
10		T	**11-4**	No Class Election Day (make up Wednesday 11/12)		
10	1	R	**11-6**	Vector review		
11	2	T	**11-11**	No class Veterans Day		
11	2	W	**11-12**	Sources & Fields		
11	2	R	**11-13**	Sources & Fields (Make up class)	HW5	
12	2	T	**11-18**	Sources & Fields		HW5
13	2	R	**11-20**	Sources & Fields		
13	2	T	**4-25**	Sources & Fields		
		R	**11/27**	Thanksgiving Break		
14		T	**12-2**	STUDENT PRESENTATIONS		
14		R	**12-4**	STUDENT PRESENTATIONS		
15		T	**12-9**	Review		
16		R	**12-18**	11:30-2:30 FINAL EXAM		

BME 307

Walter G Besio

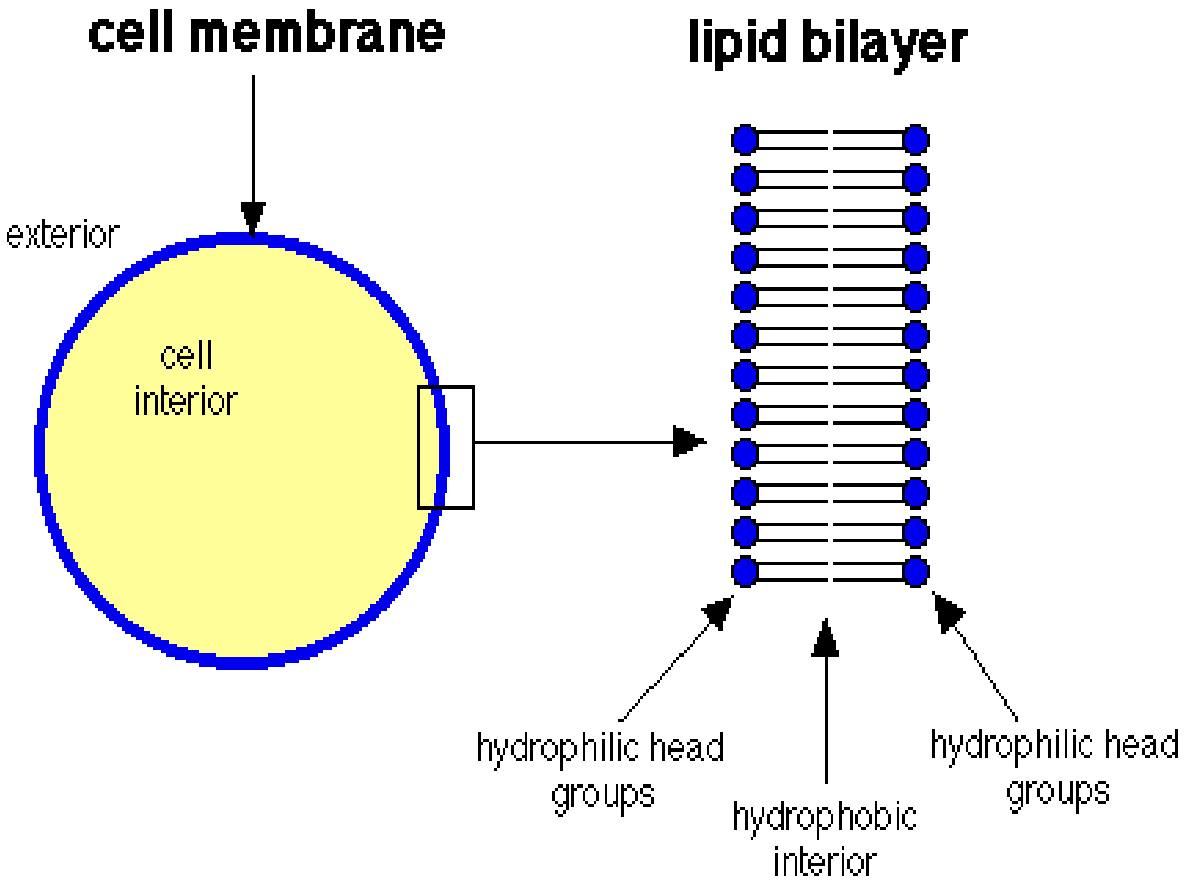
Course Outline

- Structure of cell Membranes
  - Lipid Bi-layers & Protein Molecules
- Diffusion
  - Simple and Facilitated Diffusion, Osmosis
- Active Transport
  - Primary & Secondary
- Membrane Potentials
- Nernst Equation
- Resting Potential of Nerves
- Nerve Action Potential
- Propagation Of Action Potential
- Hodgkin-Huxley model
- Electrostatics modeling

Functions & Features of the Cell membrane

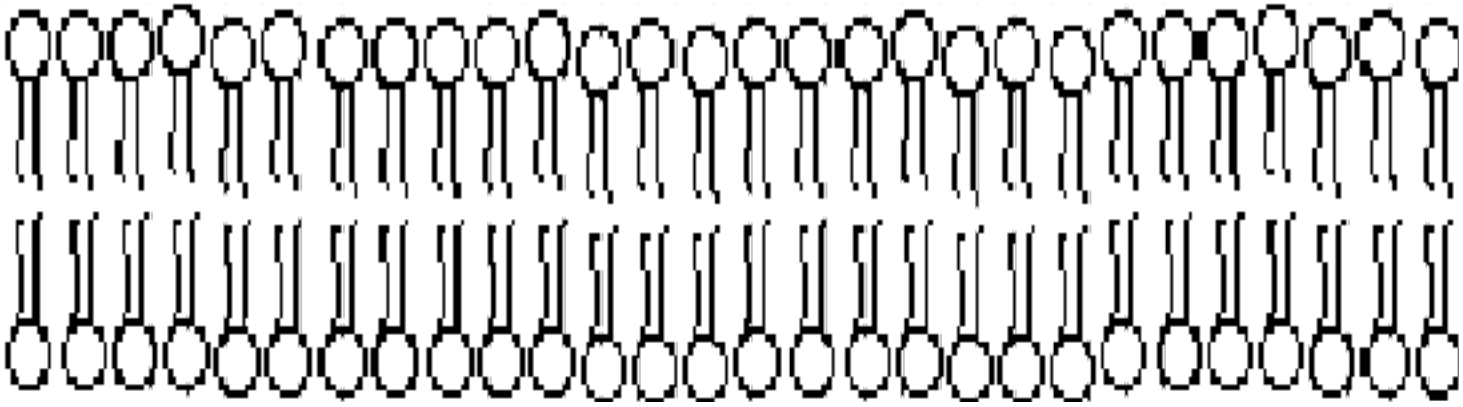
- Gives the cell shape and strength
- It is fluid in nature allowing cell mobility
- The cell membrane is differentially permeable, allowing some materials to pass through while preventing others from doing so.
- With regard to molecules, the cell membrane is very permeable to water, certain lipid-soluble substances, amino acids, and sugars,
- Relatively impermeable to large molecules such as proteins and polysaccharides.
- Although more permeable to uncharged than to charged particles, with regard to ions, the cell membrane is more permeable to negative ions than to positive ions.

Simplified Structure Of Cell Membrane

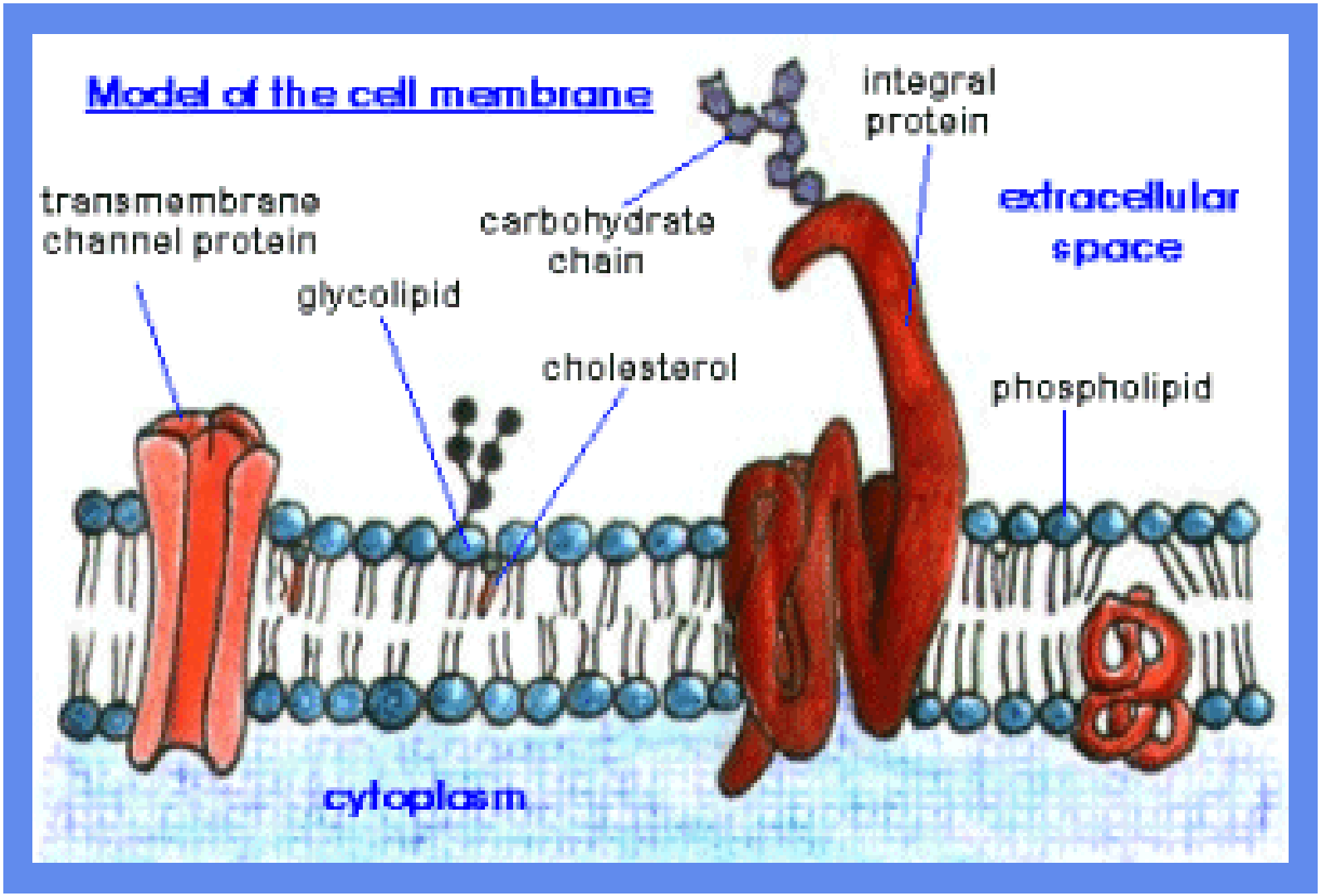


Structure of the Cell membrane

- The cytoplasm of cells is bounded by a membrane referred to as the **cell membrane** or **plasma membrane**.
- The outer cell membrane and the membranes surrounding inner cell organelles are bilipid layers.
- In a real cell, the membrane phospholipid molecules create a spherical three dimensional lipid bilayer shell around the cell. However, they are often represented two-dimensionally as:



The Fluid Mosaic Model



Composition of Cellular Fluids

	Intra Cellular	Extra cellular
K^+	140	5
Na^+	5–15	145
Cl^-	4	110
Ca^{2+}	0.0001	2.5–5

Substances can pass through the cell membrane in four ways.

- If a favorable concentration gradient is present, substances such as water or those soluble in lipids can pass through the membrane via **Simple diffusion**.
- Substances, such as simple sugars or amino acids, that are too big to move through the membrane's pores and are non-lipid soluble, can pass through the membrane through a process called **facilitated diffusion** or **passive transport**.
- Substances can even pass through the membrane against the concentration gradient via a process called **active transport**.
- Substances can enter a cell without ever passing through the cell membrane through the process of **Endocytosis**.

- Next class we start Diffusion
- Homework
  - Send me an email with your name, major, academic year, and 3 sentences maximum of why you are taking this class.
  - Evaluation of syllabus due Tuesday.