APPH 6238/BIOS 4238 Syllabus

**Fall 2024**

**Ion Channels in Health and Disease, 3 credit hours**

**Lecture time: Tuesday and Thursday 12:30 – 1:45 am**

**Location: Cherry Emerson 320**

**Instructor Information**

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| Instructor | Email | Office |
| Edward M. Balog, Ph.D. | ed.balog@ap.gatech.edu | 555 14th St Engineering Center Rm 1303 |

**General Information**

**Description**

This class will examine the structure, function, and regulation of ion channels from both excitable and non-excitable cells. Topics to be covered include the basic biophysical properties of ion channels including conductance, selectivity, gating and voltage sensing; structure-function relationships; cell physiology of ion channels; physiological regulation and pharmacological manipulation of channel function; and ion channel diseases. Although the textbook will provide background, there will be a heavy reliance on more recent literature.

## Learning Objectives:

By the end of this class you will understand

* the fundamental biophysical properties of ion channel function, including gating, selectivity and permeability;
* the relationship between ion channel structure and function;
* the physiological role of ion channels in controlling the cell membrane potential, ion transport across membranes and in cell signaling;
* how impaired ion channel function can lead to a number of important human diseases and how pharmaceutical agents targeting ion channels ameliorate these disorders.

**Prerequisites:**

 BIOS 3450: Cell and Molecular Biology OR

 BIOS 3755: Human Physiology OR

 BMED 3100: Systems Physiology OR

 NEUR 3100: Cell and Molecular Neuroscience OR

 Graduate Standing

**Course Materials**

**Required textbook:** Ashcroft, F. Ion Channels and Disease. Academic Press 2000.

 Original research and review articles to be posted to Canvas.

**Optional Additional Resources**: Hille, B. Ion Channels of Excitable Membranes, 3rd edition, Sinauer, 2001. A copy of this book is on reserve at the library. Ask at INFODesk - Grove Level, Price Gilbert; QH603.I54 H54 2001

**Required Software**: Two free software programs, *Electrophysiology of the Neuron* and *ChimeraX* will be used for class homework.

Download Electrophysiology of the Neuron at: <https://www.eotnprogram.org/>

Download ChimeraX at :<https://www.rbvi.ucsf.edu/chimerax/>

## Course Website and Other Classroom Management Tools

All course assignments, readings and grades will be posted and submitted via Canvas.

**Course Requirements & Grading**

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| Those enrolled in BIOS 4238 |
| Assignment  | Date | Weight (Percentage) |
| Exam 1 | September 19 | 20% |
| Exam 2 | October 29 | 20% |
| Final Exam | Thursday, Dec 12 11:20 AM - 2:10 PM | 20% |
| Homework & Quizes |  | 20% |
| Poster | November 7 | 20% |

**BIOS 4238**

**Exams:**

Exams will in class and consist of both multiple choice and short answer questions. The final exam is not cumulative, it will cover only material from the last section of the course.

**Homework:**

There will be 5 homework projects. Three projects will use the program *Electrophysiology of the Neuron* to simulate the electrical response of the neuron membrane to various interventions. Two projects will use the molecular visualization program *ChimeraX*to exam the structure of a voltage-gated and a ligand-gated ion channel. Homework must be submitted via Canvas by midnight the due date

**Quizzes:**

There will be three quizzes given shortly before each exam. The quizzes are online, out side of class and are open book but must be completed individually. They are intended to help students review material from the upcoming exam. Quizzes must be submitted via Canvas by midnight the due date.

**Poster:**

The poster will be in the format of a posters presented at scientific meeting, a template will be provided. Students will choose an ion channel topic such as a disease, a basic mechanism or physiological function. **Submit the topic of your poster the Dr. Balog via email by October 1.** After reviewing the literature, the topic will be summarized on the poster. Components of the poster will include a title, abstract, introduction, methods, results, conclusion and references. Students will give 10-minute poster presentations to the class.

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| Exam 2 | October 29 | 20% |
| Final Exam | Thursday, Dec 12 11:20 AM - 2:10 PM | 20% |
| Homework & Quizzes |  | 10% |
| Oral Presentation | October 8 & Nov 12 | 10% |
| Research Article Critique | November 7 | 20% |

**Description of APPH 6238 Graded Components**

**Oral Presentations:**
Students enrolled in APPH6238: Presentation of a recent research article; 20-30 minutes. This should be similar to a journal club presentation. Chose a paper and send a copy to me. I will post it on Canvas.

Your talk should provide a brief introduction to the problem addressed in the paper, a description of the methods and results. Describe the author’s conclusions and state whether you agree with them and why or why not. Point out any improvements that could be made in the experimental design, methods, results and/or interpretation. Make sure to address the significance of the work and what questions remain. ***The class will be required to read and comment on all papers!***

The final exam will be given during the final exam period. The format will be the same as the mid-term exam and will only address material from the second half of the course.

**Article Critique:**

Students enrolled in APPH 6238: This is ***not a review of the literature*** but a ***critique*** of an ion channel related ***original research*** article. The goals of journal article critique are to foster critical analysis of the scientific literature and promote effective written communication. The paper should be 7-10 double spaced pages including references. Students will choose an original research article from a reputable peer-reviewed journal and *send a PDF of the paper to me for approval prior to beginning work. I will simply make sure it is a research article is from a reputable journal*. The topic of the journal article should be broadly related to an area covered in class. The critique should begin with a brief review of the literature leading to the reason why the work described in the article was performed and the hypothesis. The review of the literature will require that you read articles in addition to the one you will analyze. Included these articles in your references. The critique should also include a summary of the methods, results and the author’s interpretation and conclusion. Your critique should include a discussion of whether the problem was significant, whether the experimental design and methods appropriate, do you agree with the author’s interpretation of the results, is the work likely to have a significant impact on the field, what (if anything) would you have done differently and what should be done next. **Choose a paper and have it approved by October 1.**

**Homework and Quizzes:**

Graduate and undergraduate students will do the same homework projects and quizzes.

**Grading Scale**

Your final grade will be assigned as a letter grade according to the following scale:

A 90-100%

B 80-89%

C 70-79%

D 60-69%

F 0-59%

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**Course Expectations & Guidelines**

## Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit http://www.catalog.gatech.edu/policies/honor-code/ or <http://www.catalog.gatech.edu/rules/18/>.

Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

## Extensions, Late Assignments, & Re-Scheduled/Missed Exams

Rescheduling an exam must be done in advance and receive approval from the instructor. An exam missed without prior approval will receive a zero.

## Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or <http://disabilityservices.gatech.edu/>, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter.

## Student-Faculty Expectations Agreement

At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See <http://www.catalog.gatech.edu/rules/22/> for an articulation of some basic expectation that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

**Course Schedule (tentative – subject to change)**

|  |  |  |
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| Date | Topics | Reading |
| Aug 20 | Introduction |  |
| Aug 22 | Review of membranes, proteins, diffusion and transport |  |
| Aug 27 | Review of Electricity and circuits |  |
| Aug 29 | Resting membrane and action potential | Hodgkin & Huxley A quantitative description of membrane current and its application to conduction and excitation in nerve *J Physiol.* 117:500-544, 1952. |
| Sept 3 | Resting membrane and action potential |
| **Sept 5** | Ion Channel Methods: Biochemical and electrophysiological techniques**Homework 1 Due: EOTN - Passive Membrane Properties** **submitted via Canvas by midnight** | Ashcroft Chapt 4 |
| Sept 10 | Guest Lecturer: Monneh Diggs – Methods of protein structure determination |  |
| **Sept 12** | Ion Channel Methods**Quiz 1 Due** | Ashcroft Chapt 4 |
| Sept 17 | Whole cell and single channel data analysis | Ashcroft Chapt 3 |
| **Sept 19** | **Exam 1** |  |
| Sept 24 | Ion Channel Properties: Voltage, Ligand and Mechanical Gating |  |
| **Sept 26** | Ion Channel Properties: Permeability; Channel Inactivation & Block**Homework 2 Due: EOTN – Ionic Currents submitted via Canvas by midnight** |  |
| Voltage-Gated Ion Channels |
| **Oct 1** | Epilepsy and Voltage-Gated Sodium Channels**Graduate students: Deadline to send copy of article to be critiqued to Dr Balog.****Undergraduates: Deadline to send poster topic to Dr Balog** | Ashcroft Chapt 5Huang J, et al Structural biology ahnd molecular pharmacology of voltage-gated ion channels. *Nature Reviews: Molecular Cell Biology* 2024 |
| Oct 3 | Voltage-Gated Potassium Channels | Ashcroft Chapt 6 |
| **Oct 8** | **Grad Student Presentations** |  |
| Oct 10 | Inward Rectifying, Ca2+- and ATP-dependent Potassium Channels**Homework 3 Due: ChimeraX – Voltage-gated Potassium Channel Kv1.2 submitted via Canvas by midnight** | Ashcroft Chapts 7, 8, & pages 405-407 |
| Oct 15 | **Fall Break** |  |
| Oct 17 | Voltage-Gated Calcium Channels | Ashcroft Chapt 9 |
| Oct 22 | Myotonia Congenita, Fainting Goats and Voltage-Gated Chloride Channels**Quiz 2 Due** | Ashcroft Chapt 10 |
| Oct 24 | Chloride Channels and Cystic Fibrosis | Ashcroft Chapt 12 |
| **Oct 29** | **Exam 2** |  |
| Oct 31 | Modulation of Action Potential Form and Frequency | Bean, B.P. The action potential in mammalian central neurons. *Nature Reviews: Neuroscience* 8:451, 2007. |
| Ligand-Gated Ion Channels |
| **Nov 5** | Myasthenia Gravis, the Neuromuscular Junction and Nicotinic Acetylcholine Receptor Channels**Homework 4 Due: EOTN – Action Potential Frequency Modulation submitted via Canvas by midnight** | Ashcroft Chapt 15 |
| **Nov 7** | Anesthetics; Neurotransmitter-Gated Channels**Undergraduate Posters Due****Graduate Critique Papers Due** | Ashcroft Chapt 16 |
| **Nov 12** | **Grad Student Presentations** |  |
| Nov 14 | Inhibitory Neurotransmitter-Gated Channels | Ashcroft Chapt 17 & 18 |
| **Nov 19** | **Poster Presentations** |  |
| **Nov 21** | **Poster Presentations** |  |
| Nov 26 | Malignant Hyperthermia, Catecholaminergic Polymorphic Ventricular Tachecardia, Intracellular Calcium Release & Store Operated Channels**Homework 5 – ChimeraX: Ligand-gated Channel submitted via Canvas by midnight** | Ashcroft Chapt 14 |
| **Nov 28** | **Thanksgiving Holiday** |  |
| Dec 3 | Proprioception & PIEZO Channels; Transient Receptor Potential Channels**Quiz 3 Due** |  |

**Final Exam: Thursday, Dec 12**

**11:20 AM - 2:10 PM**