**APPH 4238: Ion Channel Structure, Function and Regulation**

Course 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.

**Class location:** 555 14th St Room 1102

**Class times:** TTh 9:35-10:55 am

**Instructors**: Ed Balog

555 14th St Room 1303

894-3957

[ed.balog@ap.gatech.edu](mailto:ed.balog@ap.gatech.edu)

Office hours: By appointment

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

Original research and review articles to be posted to T-square.

Optional Additional Resources: Hille, B. Ion Channels of Excitable Membranes, 3rd edition, Sinauer, 2001.

**Prerequisites**

APPH3755 or BIOL1510 or BIOL1511 or BME3100

**Learning Objectives**

Upon completion of this course students will be able to:

1. Understand the basic biophysical properties of ion channel function and how channel structure imparts these properties.
2. Understand the major technical approaches to study ion channels.
3. Understand the major physiological roles of ion channels and how impaired function causes disease.
4. Develop skills needed for analysis of current research literature and scientific communication.

**Evaluation**

Exams 60%  
 Midterm exam: 30%   
Final exam: 30%

Term Paper 25%

Oral Presentation 15%

Class Participation 5%

Students are not only expected to attend class, but to participate. Participation includes asking questions and taking part in class discussions.

**Oral Presentations:**  
Students enrolled in 6238: Presentation of a recent research article; 30-40 minutes.

Multiple students will present at a time; each will be given all papers to be presented that day. The “primary” paper for one student to present will be the “secondary” paper for the others. After the presentations, presenters will comment on the “secondary’ papers. Comments – how are papers related, do they agree/disagree, if they disagree – why, how do they advance the field, what would you do differently, what should be done next….

*Papers will be posted on T-squre and the entire class will be required to read and comment on all papers!*

Students enrolled in 4238: Presentation on an ion channel disease; 30-40 minutes.

Areas to be covered: Incidence, genetics, symptoms & natural history, molecular/cellular mechanisms, treatment, promising research.

**Term Paper/Article Critique:**

Students enrolled in 6238: Critique of journal article; 20%.

This is ***not a review of the literature*** but a ***critique*** of an ion channel related ***original research*** article, although the introduction to your paper will briefly review relevant related work. Choose a paper and have it approved by October 1.

Students enrolled in 4238: Term Paper 20%.

This **is *a review of the literature*** of a selected ion channel related topic. Broad leeway is give the student in choosing a topic but examples may include an ion channel disease, a mechanism of ion channel regulation, or a physiological function. Choose a topic and have it approved by October 1.

**ACADEMIC HONOR CODE**

Violations of the Georgia Tech academic honor code will not be tolerated. This includes:

* using false excuse to delay completing a test or other assignment
* learning what is on a test from someone who has already taken it
* copying from another student on a test with or without their knowledge
* helping someone else cheat on a test
* using unauthorized notes on a test
* using unauthorized electronic device to obtain information during test
* working with others on an assignment when asked for individual work
* paraphrasing/copying from written or internet source without referencing it
* fabricating/falsifying a bibliography
* turning in work copied from/done by another
* obtaining paper from term paper mill

List adapted from McCabe, Donald. “Cheating among college and university students: a North American Perspective,” International Journal for Educational Integrity, 1.1 (2005).

For any questions involving these or any other Academic Honor Code issues, please consult me or [www.honor.gatech.edu](http://www.honor.gatech.edu)

**Learning Accommodations:**

If needed, classroom accommodations for students with documented disabilities will be made. Accommodations must be arranged prior to the start of class and be in accordance with The Office of Disability Services (http://www.disabilityservices.gatech.edu/).

Lecture Schedule

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| --- | --- | --- |
| Week | Topic | Reading |
| 1 | Introduction to Ion Channels; Biomembranes |  |
| 2 | Bioelectricity and Ions On the Move; Ion Channel Methods | Ashcroft Chapter 4 |
| 3 | Labor day/ Ion Channel Permeability and Selectivity | Ashcroft Chapter 3 |
| 4 | Gating Mechanisms: Voltage and Ligands;  Spider, Snake & Wasp Venoms and other Gating Modifiers | Dutertre & Lewis, Use of Venom Peptides to Probe Ion Channel Structure and Function, *J Biol Chem*. 285: 13315, 2010 |
| 5/6 | Voltage-gated Sodium, Potassium and Calcium Channels; Epilepsy, and Mechanisms of Cardiac Arrhythmia | Ashcroft Chapters 5, 6 & 9 |
| 6 | Voltage-gated Chloride Channels, Hyper-excitable Muscle and Fainting Goats | Ashcroft Chapters 10 |
| 7 | Vision, Olfaction and Cyclic Nucleotide Gated Channels / **MidTerm Exam** | Ashcroft Chapter 11 |
| 8 | Fall Break/ Transient Receptor Potential Channels: Hot Pepper Channels and More | Mickle, Shepherd & Mohapatra. Sensory TRP channels: the key transducers of nociception and pain. *Prog Mol Biol Transl Sci.* 2015;131:73-118 |
| 9 | CFTR, ENaC and Cystic Fibrosis | Ashcroft Chapters 12, 13 & 15 |
| 10 | Neurotransmitter Gated Channels and General Anesthetics | Ashcroft Chapters 16-18 |
| 11 | Intracellular Channels, Hot Dogs and Novel Insecticides; Store-Operated Channels | Ashcroft Chapters 14  Hogan & Rao, Store-operated calcium entry: Mechanisms and modulation. *Biochem Biophys Res Commun*. 460: 40, 2015. |
| 12 | **Student Presentations** |  |
| 13 | **Student Presentations** /Thanksgiving Break |  |
| 14 | Mechanosensitive Channels; Water Channels | Ranade et al. Mechanically Activated Ion Channels. Neuron. 87:1162,2015.  Kitchen et al. Beyond water homeostasis: Diverse functional roles of mammalian aquaporins. *Biochim Biophys Acta*. 1850:2410, 2015. |
| 15 | Toxin Channels  Ion Channel Evolution | Ashcroft Chapter 23  Zakon, H. Adaptive evolution of voltage-gated sodium channels: The first 800 million years. *PNAS* 109:10619, 2012.  Pohorille et al The Origin and Early Evolution of Membrane Channels.  *Astrobiology* 5:1, 2005.  Verkhratsky & Parpura. Calcium signaling and calcium channels: Evolution and general principles. *Eruo J Pharmacol.* 739:1, 2014 |
| 16 | Ion Channel Evolution (continued) |  |