CAPS 310 Course Syllabus

CAPS 310. Modern Biomedical Research Techniques and their Application (3 Credits)

Academic Calendar Description:
This course covers core and advanced biomedical research techniques which have hugely impacted our current understanding of health and disease. The course will be also be critical to being able to read, understand and critique the primary research literature. [3-0-0]

Prerequisites:
CAPS 205, CAPS 206.

Corequisites:
None

Student Expectations
Students are required to read all online modules, using session objectives to guide learning topics. Students are expected to complete all examinations and achieve an overall grade of 50% to pass the course.

Learning Activities
All classes are in person. Lectures and relevant materials will be provided prior to the start of the term. All students are expected to read the material for each class. Short quizzes at the beginning of each class will test the content covered in the assigned readings. These quizzes will be administered through CANVAS.

Learning Materials
All learning and reading material will be provided in PDF format on Canvas prior to the start of term. Recent reviews that cover some of the major concepts and techniques will be provided at the beginning of the term.

Course Structure
There will be three 50-min sessions per week. Each session consists of an online module accessed via the course CANVAS site, and both asynchronous and in-person classes.

Course Co-Directors
Dr. T. Michael Underhill tunderhi@brc.ubc.ca.
Dr. Kurt Haas kurt.haas@ubc.ca

Course Instructors
Dr. T. Michael Underhill, Professor, Dept. of Cellular and Physiological Sciences,

Biomedical Research Centre; tunderhi@brc.ubc.ca. Dr. Underhill is a developmental and stem cell biologist who uses a variety of advanced techniques to study embryology, tissue renewal and regeneration and cancer.

Dr. Kurt Haas, Professor, Dept. of Cellular and Physiological Sciences, DMCBH; kurt.haas@ubc.ca. Dr. Haas is a developmental neuroscientist with expertise in imaging and genetics of autism.

Dr. Francis Lynn, Associate Professor, Dept of Cellular and Physiological Sciences, BC Children's Research Institute, and School of Biomedical Engineering. Dr. Lynn is a stem cell biologist that studies the development of pancreatic beta cells.

Dr. Nozomu Yachie, Associate Professor, School of Biomedical Engineering, Biomedical Research Centre; nozomu.yachie@ubc.ca. Dr. Yachie is a genome engineering specialist is developing advanced genome editing tools for studying health and disease.

Dr. Douglas Allan, Professor, Dept. of Cellular and Physiological Sciences, Life Sciences Institute, DMCBH; doug.allan@ubc.ca. Dr. Allan is a geneticist who studies the role of major signaling pathways in neural development and homeostasis, and modeling human disease variants in *Drosophila*.

Land Acknowledgements

UBC's Point Grey Campus is located on the traditional, ancestral, and unceded territory of thexwməθkwəy̓ əm (Musqueam) people. The land it is situated on has always been a place of learning for the Musqueam people, who for millennia have passed on in their culture, history, and traditions from one generation to the next on this site.

Learning Outcomes

Module 1 – Imaging and Electrophysiology

- The basic principles of microscopy.
- The advantages and disadvantages of various fluorescence-based imaging strategies (i.e., wide-field, confocal, two-photon, etc.).
- More advanced imaging methods that are used to follow intracellular signaling pathway activity and/or membrane channel activity.
- How super resolution microscopy has revolutionized microscopy and our understanding of molecular and cellular biology.
- The basic principles of electrophysiology
- The advantages and disadvantages of various electrophysiological recording technologies
- Advanced patch-clamp recording (including: whole-cell, cell-attached, perforated, inside-out patching)

Module 2 – Genomics, genome editing and next generation sequencing

- The meaning of the terms genome, transcriptome and proteome
- The methods that are being used to advance our understanding of various omes.
- The advanced methods that are being used to characterize various omes at the single cell level.
- The methods are being used to modify the genome and their advantages and disadvantages.
- How some of the described methods are now being used to treat animal and human disease.

Module 3 – Model Organisms and Experimental Systems

- How various model organisms have advanced our understanding of animal and human biology.
- The methods used to study gene and cell function in various experimental models.
- How some of the described methods are now being used to treat animal and human disease.

Schedule of Topics (36 50-min Sessions Total):

Module 1: Imaging

1. Introduction (Underhill and Haas)

2. Overview of imaging technologies topics (Haas)

    - Basic concepts of microscopy and imaging used in experiments and medicine to advance our understanding of animal and human health.

3. Mechanisms of fluorescence (Haas)

- The basics of fluorescence.
- Fluorescence microscopy
- The basics of fluorescence microscopy and its applications.

4. Fluorophores and Biosensors (Haas)

- The basics of genetically-encoded and molecular fluorophores, and how their properties impact applications.
- Active learning in microscopy
- Advantages and disadvantages of the various microscopy modalities and how these can be applied to address specific scientific questions.

5. *In vivo* imaging and calcium imaging (Haas)

- How genetics and advanced labelling combined with imaging technologies allows direct imaging within intact animals.
- Calcium Imaging
- The properties and applications of genetically-encoded and molecular dye calcium biosensors for detecting neuronal activity and non-neural signaling.
- Optogenetics
- The properties and applications of genetically-encoded light-activated channels and pumps to regulate membrane potential.

6. Advanced imaging technologies

- Super-resolution microscopy (Haas)
- Approaches to increase resolution below the diffraction limit of light.
- Flow cytometry and spectral umixing
- Approaches to application of fluorescence imaging for high-throughput experimentation.
- Active learning in advanced imaging
- The advantages and disadvantages of various advanced imaging methodologies and how these can be applied to address specific scientific questions.

7. Introduction to electrophysiology (Haas)

- How cells generate electrical signals
- Multiple methods for recording electrical potentials

8. Patch-clamp electrophysiology (Haas)

- Multiple patch clamp technologies, including whole-cell, cell-attached, inside-out and perforated patch recording

9. Module 1 Review (Haas)

- Review all content from the Imaging and electrophysiology section and integrate this knowledge.

10. Module 1 Exam (50mins in class time).

Module 2: Genomics, genome editing and next generation sequencing

11. Overview of genomics, gene editing and related topics (Underhill)

- The basic concepts of genomics and methods used to manipulate the genome and their role in advancing our understanding of animal and human health.

12. The genome and its analysis (Underhill)

- Standard techniques used to study the genome and identify disease-causing alterations.

13. The transcriptome and its analysis (Underhill)

- The transcriptome and some of the methods used to characterize and study the transcriptome.

14. The proteome and its analysis (Underhill)

- The proteome and some of the cutting-edge methods used to characterize and study the proteome.

15. Active learning in omics (Underhill)

- Advantages and disadvantages of the various omics methodologies and how these can be applied to address specific scientific questions.

16. Study of the genome, transcriptome and proteome at the single cell level (Underhill)

- Recent cutting-edge methods that have enabled characterization of the omes of single cells.

17. Advanced techniques in single cell omics (Underhill)

- The most recent advancements in single cell omics.

18. Methods used to manipulate the genome (Yachie)

- Some of the methods used to modify the genome including methods that span the last couple of decades, such as TALENS, CRISPR, etc.

19. Advanced methods for genome modification (Yachie)

- Some of the most recent advancements in genome manipulation including more sophisticated approaches to modifying single bases (i.e., base editing).

20. Clinical applications of genome modification methods

- The development and use of genome editing methods to treat human disease.

21. Active learning in genome modification (Underhill and Yachie)

- The advantages and disadvantages of the various genome modification methodologies and how these can be applied to address specific scientific questions.

22. Wrap-up, discussion and review (Underhill and Yachie)

- How these various methods have advanced our understanding of human biology along with an overview of what is on the near and far horizon.

23. Module 2 exam (50mins. in class time)

Module 3: Model Organisms and Experimental Systems

24. Overview of model organisms and systems and their importance (Underhill)

- How various model organisms including evolutionary divergent animals have advanced our understanding of animal and human health and disease. Get an understanding of the underlying concepts of experimental research which is typically gene and/or cell centric.

25. Yeast as a model organism – benefits, challenges and drawbacks (Allan)

- Some of the standard techniques used to study gene and cell function in yeast

26. *C.elegans* as a model organism – benefits, challenges and drawbacks (Allan)

- Some of the standard techniques used to study gene and cell function in *C.elegans.*

27. *Drosophila* as a model organism – benefits, challenges and drawbacks (Allan)

- Some of the standard techniques used to study gene and cell function in *Drosophila*.

28. Zebrafish as a model organism - benefits, challenges and drawbacks (Allan)

- Standard techniques used to study gene and cell function in Zebrafish.

29. Mouse as a model organism - benefits, challenges and drawbacks (Underhill)

- The major techniques used to study gene and cell function in mice.

30. Humans as a model organism - benefits, challenges and drawbacks (Underhill - others)

- The methods used to identify and study gene function in humans.

31. Active learning in experimental model systems (Underhill and Allan)

- Interpretation and discussion of studies using model organisms.

32. *In vitro* and *ex vivo* culture models - benefits, challenges and drawbacks (Underhill)

- Standard techniques used to study gene and cell function in cell culture including, cell lines, primary and tissue explants, organoids and organs-on-a-chip.

33. Embryonic stem cells (ESCs) and induced pluripotent stem cells (iPSCs) - benefits, challenges and drawbacks (Lynn)

- How the use of ESCs and iPSCs has transformed our understanding of animal and human health.

34. Clinical use of ESCs and iPSCs to treat disease (Lynn)

- The methods being developed to use ESCs and iPSCs for the treatment of human disease.

35. Active learning in stem cell biology (Underhill and Lynn)

- Interpretation and discussion of studies using model organisms.

36. Wrap-up, discussion and review-1 (Underhill, Allan and Lynn)

- Discussion of how integration of data from these various model organisms and systems is accelerating our understanding of animal and human biology, along with next steps in the evolution of these methods.

Final exam (covering material in Module 3 only)

Assessments of Learning

Assessment is in the form of two invigilated exams, distributed through term time, and covering lectures not covered by a prior exam. Exam marking will be weighted based on the number of lectures being examined. Each student will be responsible for preparing a short summary of one technique (no more than 2 pages) including a general introduction to the method, its implementation, utility, advantages and disadvantages, and how it has transformed our study of animal and/or human biology, in addition to potential future advances. The student is expected to demonstrate a clear understanding of the method and its relevance to research and they will be evaluated on the overall clarity and quality, as well as their assessment of the technology. In this way, the students will get an understanding of how technology development has advanced our knowledge of animal and human biology.

Grading scheme

Write-up on each student's paper	15%
Module 1 exam	25%
Module 2 exam	30%
Module 3 exam	30%

University Policies

UBC provides resources to support student learning and to maintain healthy lifestyles but recognizes that sometimes crises arise and so there are additional resources to access including those for survivors of sexual violence. UBC values respect for the person and ideas of all members of the academic community. Harassment and discrimination are not tolerated nor is suppression of academic freedom. UBC provides appropriate accommodation for students with disabilities and for religious observances. UBC values academic honesty and students are expected to acknowledge the ideas generated by others and to uphold the highest academic standards in all their actions. Details of the policies and how to access support areavailable at the Policies and Resources section of the UBC Senate website.

Academic Integrity

The academic enterprise is founded on honesty, civility, and integrity. As members of this enterprise, all students are expected to know, understand, and follow the codes of conduct regarding academic integrity. At the most basic level, this means submitting only original workdone by you and acknowledging all sources of information or ideas and attributing them to others as required. This also means you should not cheat, copy, or mislead others about what isyour work. Violations of academic integrity (i.e., misconduct) lead to the breakdown of the academic enterprise, and therefore serious consequences arise and harsh sanctions are imposed.For example, incidences of plagiarism or cheating may result in a mark of zero on the assignment or exam and more serious consequences may apply if the

matter is referred to the President's Advisory Committee on Student Discipline. Careful records are kept in order to monitor and prevent recurrences.

A more detailed description of academic integrity, including the University's policies and procedures, may be found in the Discipline for Academic Misconduct section of the UBCAcademic Calendar.

- No assignment may be submitted to any other instructor of any course for a grade.
- The minimum penalty for plagiarism in any assignment is a zero for the paper; themaximum penalty is a zero for the course.

UBC Grading Standards

Undergraduate Grading Scale

Percentage (%)	Letter Grade
90-100	A+
85-89	A
80-84	A-
76-79	B+
72-75	B
68-71	B-
64-67	C+
60-63	C
55-59	C-
50-54	D
0-49	F

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