The University of British Columbia

Faculty of Education, School of Kinesiology

KIN 438: Muscle Physiology: From Generation to Regeneration (Term II, 2021) Previously KIN 462

3 Credits

UBC's Vancouver Campus is located on the traditional, ancestral, and unceded territory of the xwməθkwəy̓əm (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.

Course Structure: Online

Your Instructor: Dr. Cameron Mitchell

Contact Information: cameron.mitchell@ubc.ca Email if question relates to only to you. **Please use the discussion forums for questions about course material.** More focused questions will be answered directly in the online discussion forms while broader more open ended questions will be answered during the weekly Zoom Q&A session.

Response time: I aim to respond to emails/ discussion posts within 24 hours but will not respond on evenings or weekends. Response times may be slower in the days immediately before the midterm and final exam due to last minute questions so please ask questions early!

Instructor Bio

Dr. Cameron Mitchell Ph.D., School of Kinesiology

Dr. Mitchell has been an Assistant Professor in the school of Kinesiology since 2019, his research focuses on how and why we lose muscle mass as we age and what we can do about it. His lab uses techniques which range from resistance exercise and nutrition interventions to molecular biology techniques. He is a former rugby player who enjoys being active in the mountains and cycle commuting to work.

Course Description

This course will explore the cellular and molecular response of human muscle to exercise aging and inactivity. Muscle cells sense a number of contraction related events which control the transcription of genes and protein translation resulting in altered muscle phenotype. In addition to muscle fibers, muscle tissue contains a number of other cell types including stem cells,

endothelial cells and fibrotic cells which work together to allow muscle to adapt to stimuli such as exercise training. In this course you will lean about the similar and divergent adaptions to muscle injury, aerobic training, resistance training, old age and inactivity. We will also addressed some possible explanations for interindividual variability in response to exercise training. You will also have the opportunity to practice criticality reading and evacuating recent primarily literature as well as claims made by so called 'experts' on the internet.

High Level Learning Objectives:

- Understand the similarities and differences in the muscular response to different exercise modes
- Contrast muscular responses to aging and inactivity
- Discuss the relationship between exercise and inactivity/ aging, are they opposites?
- Critically evaluate recent literature and discuss its practical applications
- Use evidence to respond to media claims related to muscle

Specific Learning Objectives:

- Identify the different cell types within muscle and their functions
- Explain how aerobic and resistance exercise initiate different signaling events
- Apply basic molecular biology to understanding exercise adaptation
- Understand the regulations of mitochondrial biogenesis
- Understand the role of angiogenesis in exercise adaptation
- Explain the role of satellite cells in human muscle
- Explain the relationship between ribosomes, translational capacity and exercise adaption
- Understand how protein turnover regulates muscle size
- Discuss possible mechanisms which allow for extreme levels of muscle hypertrophy
- Identify common age related changes in muscle as well as the response to exercise
- Explain the negative effects of inactivity on muscle function and metabolism

Additional Materials

Online Communications

In this course, and throughout your program, you are expected to communicate in a respectful and professional manner. You may find it helpful to review UBC's Distance Learning Communication Online: Netiquette web page.

Web Conferencing

Zoom

Your class may be meeting virtually using Zoom. Some class sessions may be recorded and posted for you to view. Before recording you will have the option to off your video and/or mute your audio, change your name if you wish not to be in the recording. The recordings will be shared with you in this course.

Review the Zoom Student Guide. If you are experiencing technical issues then contact the UBC IT help desk for support.

Course Assignments

This is an overview of the assignments for this course. For more information about each of these assignments, use the ASSIGNMENTS link in the course navigation to read the details and expectations for each assignment.

Assessment Title	**Grading**
Module quizzes X 4 (lowest mark is dropped)	30 %
Journal club presentation	15 %
Video Response proposal	1 %
Video Response assignment	14 %
Final exam	40 %

Course Schedule

The course will be divided into 6 modules, with a quiz the Wednesday after modules 2-5 during class time (2-3pm PST).

Each Monday there will be a live question and answer session during class time (2-3pm PST).

Each Friday during class time (2-3pm PST) starting January 22 there will be a Journal Club presentation over Zoom where students will discuss a recent article relevant to course material. The content testable on module quizzes. The Journal Club presentations will be recorded for students to watch asynchronously if they cannot join live. If you do not want you presentation recorded inform Dr. Mitchell in advance.

Modules and Dates

Module	Notable Dates
MODULE 1: Introduction/ Muscle Regeneration *January 11-22*	• Practice quiz • Live lecture January 11th
MODULE 2: Adaptation to Aerobic Exercise *January 25-Febuary 5th*	• Quiz Feb 10th • Video proposal due Feb 5th
MODULE 3: Adaptation to Resistance Exercise *February 8-26*	• Quiz March 3rd
MODULE 4: Responders and Non-Responders to Exercise March 1- *March 12*	• Quiz March 17th
MODULE 5: Aging Muscle *March 15-26*	• Quiz March 31 • Video Response assignment due March 19
MODULE 6: Adaptions to Inactivity *March 29- April 14*	

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 and cultural 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 of their actions. Details of the policies and how to access support are available from the UBC Senate Website.

Online Learning for International Students

During this pandemic, the shift to online learning has greatly altered teaching and studying at UBC, including changes to health and safety considerations. Keep in mind that some UBC courses might cover topics that are censored or considered illegal by non-Canadian governments. This may include, but is not limited to, human rights, representative government, defamation, obscenity, gender or sexuality, and historical or current geopolitical controversies. If you are a student living abroad, you will be subject to the laws of your local jurisdiction, and your local authorities might limit your access to course material or take punitive action against you. UBC is strongly committed to academic freedom, but has no control over foreign authorities (please visit the UBC Academic Calendar 2020/21 for an articulation of the values of the University conveyed in the Senate Statement on Academic Freedom). Thus, we recognize that students will have legitimate reason to exercise caution in studying certain subjects. If you have concerns regarding your personal situation, consider postponing taking a course with manifest risks, until you are back on campus or reach out to your academic advisor to find substitute courses.

Course Policies

Please make sure you are familiar with the academic policies and procedures.

Academic Integrity

Students are expected to follow UBC policies for academic integrity and academic misconduct, which includes practices around plagiarism, referencing and citation, and copyright. For more see, UBC's Learning Commons Academic Integrity resources.

Accessibility

If you have any challenges accessing materials that will impact your success in this course, UBC's Centre for Accessibility can support your needs by providing appropriate accommodations to support you.

- Web: UBC's Centre for Accessibility website
- Email: accessibility@ubc.ca

Learning Analytics

Some of the learning technologies used for this course collect data to support the improvement of teaching and learning. This includes the collection of data related to overall class progress to provide personalized feedback, engagement in discussion forums to support the fostering of community within the course, and how resources are being accessed to support improvements to the course design. To learn more about learning analytics at the Faculty of Education and at UBC, see the What is Learning Analytics? page.

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obscenity, gender or sexuality, and historical or current geopolitical controversies. If you are a student living abroad, you will be subject to the laws of your local jurisdiction, and your local authorities might limit your access to course material or take punitive action against you. UBC is strongly committed to academic freedom, but has no control over foreign authorities (please visit http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3,33,86,0 for an articulation of the values of the University conveyed in the Senate Statement on Academic Freedom). Thus, we recognize that students will have legitimate reason to exercise caution in studying certain subjects. If you have concerns regarding your personal situation, consider postponing taking a course with manifest risks, until you are back on campus or reach out to your academic advisor to find substitute courses. For further information and support, please visit: http://academic.ubc.ca/support-resources/freedom-expression

Reading List

MODULE 1: Introduction/ Muscle Regeneration
January 4-15

Review: Egan, B., & Zierath, J. R. (2013). Exercise metabolism and the molecular regulation of skeletal muscle adaptation. Cell metabolism, 17(2), 162-184.

Review: Wosczyna, M. N., & Rando, T. A. (2018). A muscle stem cell support group: coordinated cellular responses in muscle regeneration. *Developmental cell*, *46*(2), 135-143.

Journal club: Mackey, A. L., & Kjaer, M. (2017). The breaking and making of healthy adult human skeletal muscle in vivo. *Skeletal muscle*, *7*(1), 24.

MODULE 2: Adaption to Aerobic Exercise
January 18-29

Review: Perry, C. G., & Hawley, J. A. (2018). Molecular basis of exercise-induced skeletal muscle mitochondrial biogenesis: historical advances, current knowledge, and future challenges. *Cold Spring Harbor Perspectives in Medicine*, *8*(9), a029686.

Journal club: Granata, C., Oliveira, R. S., Little, J. P., Renner, K., & Bishop, D. J. (2017). Sprint-interval but not continuous exercise increases PGC-1α protein content and p53 phosphorylation in nuclear fractions of human skeletal muscle. *Scientific reports*, *7*, 44227.

Journal club: Larsen, F. J., Schiffer, T. A., Ørtenblad, N., Zinner, C., Morales-Alamo, D., Willis, S. J., ... & Boushel, R. (2016). High-intensity sprint training inhibits mitochondrial respiration through aconitase inactivation. *The FASEB Journal*, *30*(1), 417-427.

Journal club: Joanisse, S., Gillen, J. B., Bellamy, L. M., McKay, B. R., Tarnopolsky, M. A., Gibala, M. J., & Parise, G. (2013). Evidence for the contribution of muscle stem cells to nonhypertrophic skeletal muscle remodeling in humans. *The FASEB Journal*, *27*(11), 4596-4605.

Journal club: Hoier, B., Olsen, K., Hanskov, D. J., Jorgensen, M., Norup, L. R., & Hellsten, Y. (2020). Early time course of change in angiogenic proteins in human skeletal muscle and vascular cells with endurance training. *Scandinavian Journal of Medicine & Science in Sports*.

MODULE 3: Adaptation to Resistance Exercise
February 1-12

Review: McGlory, C., & Phillips, S. M. (2015). Exercise and the regulation of skeletal muscle hypertrophy. In *Progress in molecular biology and translational science* (Vol. 135, pp. 153-173). Academic Press.

Journal Club: Damas, F., Phillips, S. M., Libardi, C. A., Vechin, F. C., Lixandrão, M. E., Jannig, P. R., ... & Tricoli, V. (2016). Resistance training-induced changes in integrated myofibrillar protein synthesis are related to hypertrophy only after attenuation of muscle damage. *The Journal of physiology*, *594*(18), 5209-5222.

Journal club: Song, Z., Moore, D. R., Hodson, N., Ward, C., Dent, J. R., O'Leary, M. F., ... & Hornberger, T. A. (2017). Resistance exercise initiates mechanistic target of rapamycin (mTOR) translocation and protein complex co-localisation in human skeletal muscle. *Scientific reports*, *7*(1), 1-14.

Journal club: Figueiredo, V. C., Caldow, M. K., Massie, V., Markworth, J. F., Cameron-Smith, D., & Blazevich, A. J. (2015). Ribosome biogenesis adaptation in resistance training-induced human skeletal muscle hypertrophy. *American Journal of Physiology-Endocrinology And Metabolism*, *309*(1), E72-E83.

Journal club: Snijders, T., Smeets, J. S., Van Kranenburg, J., Kies, A. K., van Loon, L. J. C., & Verdijk, L. B. (2016). Changes in myonuclear domain size do not precede muscle hypertrophy during prolonged resistance-type exercise training. *Acta physiologica*, *216*(2), 231-239.

MODULE 4: Responders and Non-Responders to Exercise
February 22- March 5

Review: Roberts, M. D., Haun, C. T., Mobley, C. B., Mumford, P. W., Romero, M. A., Roberson, P. A., ... & McCarthy, J. J. (2018). Physiological differences between low versus high skeletal muscle hypertrophic responders to resistance exercise training: current perspectives and future research directions. *Frontiers in physiology*, *9*, 834.

Journal club: Marsh, C. E., Thomas, H. J., Naylor, L. H., Scurrah, K. J., & Green, D. J. (2020). Fitness and strength responses to distinct exercise modes in twins: S tudies of T win R esponses to U nderstand E xercise as a TH erapy (STRUETH) study. *The Journal of Physiology*, *598*(18), 3845-3858.

Williams, C. J., Williams, M. G., Eynon, N., Ashton, K. J., Little, J. P., Wisloff, U., & Coombes, J. S. (2017). Genes to predict VO 2max trainability: a systematic review. *BMC genomics*, *18*(8), 831.

Journal club: Stec, M. J., Kelly, N. A., Many, G. M., Windham, S. T., Tuggle, S. C., & Bamman, M. M. (2016). Ribosome biogenesis may augment resistance training-induced myofiber hypertrophy and is required for myotube growth in vitro. *American Journal of Physiology-Endocrinology and Metabolism*, *310*(8), E652-E661.

Petrella, J. K., Kim, J. S., Mayhew, D. L., Cross, J. M., & Bamman, M. M. (2008). Potent myofiber hypertrophy during resistance training in humans is associated with satellite cell-mediated myonuclear addition: a cluster analysis. *Journal of applied physiology*, *104*(6), 1736-1742.

MODULE 5: Aging Muscle
March 8-19

Review: Wilkinson, D. J., Piasecki, M., & Atherton, P. J. (2018). The age-related loss of skeletal muscle mass and function: Measurement and physiology of muscle fibre atrophy and muscle fibre loss in humans. *Ageing research reviews*, *47*, 123-132.

Journal club: Snijders, T., Nederveen, J. P., Bell, K. E., Lau, S. W., Mazara, N., Kumbhare, D. A., ... & Parise, G. (2019). Prolonged exercise training improves the acute type II muscle fibre satellite cell response in healthy older men. *The Journal of physiology*, *597*(1), 105-119.

Journal club: Phillips, B. E., Williams, J. P., Greenhaff, P. L., Smith, K., & Atherton, P. J. (2017). Physiological adaptations to resistance exercise as a function of age. *JCI insight*, *2*(17).

Journal club: Distefano, G., Standley, R. A., Zhang, X., Carnero, E. A., Yi, F., Cornnell, H. H., & Coen, P. M. (2018). Physical activity unveils the relationship between mitochondrial energetics, muscle quality, and physical function in older adults. *Journal of cachexia, sarcopenia and muscle*, *9*(2), 279-294.

Journal club: Robinson, M. M., Dasari, S., Konopka, A. R., Johnson, M. L., Manjunatha, S., Esponda, R. R., ... & Nair, K. S. (2017). Enhanced protein translation underlies improved metabolic and physical adaptations to different exercise training modes in young and old humans. *Cell metabolism*, *25*(3), 581-592.

MODULE 6: Adaptions to Inactivity
March 22- April 7

Review: Rudrappa, S. S., Wilkinson, D. J., Greenhaff, P. L., Smith, K., Idris, I., & Atherton, P. J. (2016). Human skeletal muscle disuse atrophy: effects on muscle protein synthesis, breakdown, and insulin resistance—a qualitative review. *Frontiers in physiology*, *7*, 361.

Journal club: Stokes, T., Timmons, J. A., Crossland, H., Tripp, T. R., Murphy, K., McGlory, C., ... & Baker, S. K. (2020). Molecular Transducers of Human Skeletal Muscle Remodeling under Different Loading States. *Cell reports*, *32*(5), 107980.

Journal club: Oikawa, Sara Y., et al. "A randomized controlled trial of the impact of protein supplementation on leg lean mass and integrated muscle protein synthesis during inactivity and energy restriction in older persons." *The American journal of clinical nutrition* 108.5 (2018): 1060-1068.

Journal club: Dirks, M. L., Miotto, P. M., Goossens, G. H., Senden, J. M., Petrick, H. L., van Kranenburg, J., ... & Holloway, G. P. (2020). Short-term bed rest-induced insulin resistance cannot be explained by increased mitochondrial H2O2 emission. *The Journal of Physiology*, *598*(1), 123-137.

Journal club: Hafen, P. S., Abbott, K., Bowden, J., Lopiano, R., Hancock, C. R., & Hyldahl, R. D. (2019). Daily heat treatment maintains mitochondrial function and attenuates atrophy in human skeletal muscle subjected to immobilization. *Journal of applied physiology*, *127*(1), 47-57.