CAPS 422 Course Syllabus

Welcome to CAPS 422, a lecture series on the control and integration of cardio-pulmonary function in mammals. Intended for Honours students in Cellular, Anatomical & Physiological Sciences or other life sciences offered online on **Tuesdays** and **Thursdays from 8:00-9:30 am PST**. The lecturers will be available for 30 minutes after each class to answer questions; these are their office hours. This is the first online offering of this course. Come ready and prepared to participate in lively exchange early in the morning. Have your cup of morning coffee ready! Keep in mind that the success of this course depends in good measure on your input, readiness, keen preparation and respect for netiquette. Course material and communications are accessible through the UBC Canvas LMS. The course is in two parts, each assessed separately.

Course Coordinators

Respiratory:	Sally Osborne	sally.osborne@ubc.ca
Cardiovascular:	Ed Moore	ed.moore@ubc.ca

Instructors Drs. Accili, Courneya, Moore, & Osborne

Assessment, Evaluation & Grading

Distribution of Marks

Resp. Assignment	10%
Resp. Quizzes (2X5%)	10%
Resp. Midterm Exam	30%
CV Quizzes/Assignments (4X5%)	20%
CV Final Exam	30%
Total Mark	100%

Classes will be held synchronously using Collaborate Ultra. Please turn your video /camera setting to off to save bandwidth while in the main room. Use the chat function to communicate with your instructor. If you run into difficulty during the break out sessions, use the raise hand function. You may wish to have your video on during the breakout sessions.

Quizzes are scheduled during class time, designed to test your comprehension of lecture material. The formats include MCQ, True/False and fill in the blank. Failure to complete a quiz during the scheduled window will result in a mark of zero.

Assignments Respiratory: Students work in teams of 4-5 to create a 20 minutes voice-over slide presentation based on an assigned paper. Teams are paired and are required to submit four questions based on the presentation of their matched team. Each team is required to provide answers to the supplied matched team questions. For more details see the assignments section in Canvas. Cardiovascular: TBA

Midterm/Final Exams The respiratory physiology content of the course will be examined mid term during scheduled class time. The cardiovascular physiology content will be examined during the December final exam period. Format includes short answer, long essay, or both. Each exam is 1.5 hour in duration.

Academic Concession Academic concessions (regarding participation, assignments, quizzes) are not guaranteed and are at the discretion of your instructor.

Missed Classes/ Attendance Regular attendance is expected of students in all their classes as specified by UBC's Academic Regulations. Students missing lectures may have access to recordings (if available) at the discretion of the lecturer.

Missed Quizzes Students can request concession to miss **one quiz** without penalty during the entire term for valid medical and compassionate grounds only. Missed quizzes will receive a mark of zero.

Late Assignments There will be a 25% mark reduction per day for late assignments.

Missed Midterm Exam Students may request an academic concession from the course coordinator along with supporting documentation for valid medical and compassionate grounds only. If concession is granted, the midterm exam must be completed within term. Be aware that students are not granted concession for conflicting responsibilities for this course. Students must resolve such conflicting matters in advance of the midterm exam. Missed exams that are not granted concession will receive a mark of zero.

Missed Final Exam Concessions for the final exam are granted through request for deferred standing from Faculty of Science Advising **no later than 48 hours after the missed final exam**. The exam will be rescheduled during the Deferred Standing Exam period (late July to early August). Missed exams that are not granted concession will receive a mark of zero.

Course Schedule 2020W

Date	Topic	Lecturer
Sept. 8	IMAGINE DAY NO CLASS	
Sept. 10	Eupnea: A Review	Osborne
Sept. 15	Mechanics of Breathing	Osborne
Sept. 17	Mechanics of Breathing	Osborne
Sept. 22	Quiz Mechanics of Breathing	Osborne
Sept. 24	Ventilation & Perfusion Distribution & Mismatch	Osborne
Sept. 29	Mechanisms of Hypoxemia	Osborne
Oct.1	Control of Breathing	Osborne
Oct. 6	Quiz Control of Breathing	Osborne
Oct.8	Control of Breathing	Osborne
Oct. 13	Respiratory Assignment Due Diving	Osborne
Oct. 15	High Altitude / Sleep	Osborne
Oct. 20	Sleep / Review Match Team Presentation Q&A	Osborne
Oct. 22	**Respiratory Midterm Exam**	Osborne
Oct. 27	No Class [scheduled CAPS 423 exam]	
Oct. 29	Introduction/ Ionic Basis of the Action Potential I	Accili
Nov. 3	Autonomic Regulation of Heart Rate I	Accili
Nov. 5	Autonomic Regulation of Heart Rate	Accili
Nov. 10	Cardiac Cycle	Courneya
Nov. 12	ECG/Arrhythmia	Courneya
Nov. 17	Excitation-Contraction Coupling: The Basics	Moore
Nov. 19	Ryanodine Receptors: Centre Stage	Moore
Nov. 24	Quiz Regulation of Cardiac Contraction I	Moore
Nov. 26	Regulation of Cardiac Contraction II	Moore
Dec. 1	Regulation of Cardiac Contraction III	Moore
Dec. 3	Quiz Integration – Heart Failure	Moore
TBA December	**Cardiovascular Final Exam**	Moore

Objectives - Respiratory Physiology

Recommended Textbook Pulmonary Physiology by Michael G. Levitzky, 2018 Full text online with electronic access through UBC library with your CWL login.

1. **Mechanics of Breathing (Statics)** [Ch. 1 & 2]

1.1 Define and be able to identify the following lung volumes and capacities on a spirogram: tidal volume (V_T), residual volume (RV), inspiratory reserve volume (IRV), expiratory reserve volume (ERV), vital capacity (VC), total lung capacity (TLC) and functional residual capacity (FRC).

1.2 Describe the two-compartment model of the lungs and define FRC in relation to the elastic recoil of the lungs and the chest wall and in relation to the transmural pressure across these two compartments. Specify the alveolar, intrapleural and atmospheric pressures at FRC under static conditions when there is no airflow in or out of the lungs.

1.3 Describe the changes in alveolar pressure (P_A), intrapleural pressure (P_{pl}), atmospheric pressure (P_{atm}) and transpulmonary pressure (P_L) during a single respiratory cycle during normal quiet breathing (eupnea) and relate swings in intrapleural pressure to the two forces the inspiratory muscles must overcome to inflate the lungs.

1.4 Describe the generation of a pressure gradient between the atmosphere and alveoli. In your description state the relevance of Boyle's Law and include the function of the main respiratory muscles involved both during a normal quiet tidal breath and during forced expiration.

1.5 Describe how static lung compliance is measured with reference to the pressure-volume curve of the lung obtained during deflation of the lungs from TLC to FRC. Contrast this relationship to the pressure-volume curve of a stiff lung (low compliance) and the pressure-volume curve of a highly distensible lung (high compliance) encountered in disease states. Describe the effect of changes in lung compliance in disease states on FRC.

1.6 Discuss the factors that influence the static compliance of the lungs.

1.7 Distinguish between static and specific compliance and describe what information can be derived knowing both values in an individual.

1.8 Discuss the key findings that have led to our understanding of the role of surface tension and pulmonary surfactant in the mechanics of breathing.

1.9 Specify the components of pulmonary surfactant and summarize our understanding of their function.

1.10 List conditions where chest wall compliance is altered.

1.11 Draw the static PV curves of the lungs, chest wall and respiratory system from RV to TLC and how interactions between the chest wall and the lungs determine lung volume.

1.12 Explain why FRC is reduced when moving from the sitting to supine position; in pregnancy; in obesity and in bilateral paralysis of the diaphragm.

2. Mechanics of Breathing (Dynamics) [Ch. 2]

2.1 Identify the key resistive force opposing movement of air in and out of the lungs and describe its overall value as well the contribution of airway generations to total resistance in healthy individuals.

2.2 Describe the three patterns of airflow typically found in the airways and their characteristics.

2.3 Compare the relationship between driving pressure, flow and airway resistance in laminar and turbulent flow conditions and specify the physiologic significance of the different relationships.

2.4 Define the Reynolds number and specify its significance to pattern of airflow.

2.5 Describe both active and passive control of the airway caliber. In your description, include the key neural pathways controlling airway function.

2.6 Describe how resistance to airflow is indexed clinically by measuring maximal airflow during a forced vital capacity.

2.7 Define the variables obtained from the expiratory flow volume curve and their significance in determining airway function.

2.8 Using the equal pressure point hypothesis, apply the concept of dynamic compression of airways during forced expiration to explain the concept of "flow limitation" and "effort independence" of expiratory flow.

2.9 Specify the determinants of maximal expiratory flow and describe how each of these factors can be affected by a disease state.

2.10 Describe the "normal" flow volume loop profile and the profiles found in fixed and variable intra and extra-thoracic airway obstructions. Provide the physiologic basis for the abnormal profiles.

3. **Distribution of Alveolar Ventilation** [Ch. 3]

3.1 Describe the relationship between minute ventilation, alveolar ventilation, anatomic dead space and physiologic dead space.

3.2 Describe two methods used to measure dead space and explain why a discrepancy in the value of dead space obtained between the two methods is significant.

3.3 Distinguish between physiologic and alveolar dead space.

3.4 Define the respiratory quotient [RQ] and the respiratory exchange ratio [RER] and explain the basis for difference found in RER in healthy subjects at rest, during exercise and in patients on intravenous glucose.

3.5 List the partial pressure of oxygen and carbon dioxide in the alveoli and predict the change in them under the following conditions 1) no perfusion to the alveolar unit. 2) no ventilation to the alveolar unit.

3.6 Derive the alveolar ventilation equation and discuss the factors determining alveolar PCO_2.

3.7 Distinguish between hypoventilation, hyperventilation, hypopnea, and hyperpnea.

3.8 Use correct terminology when describing factors that define ventilation and breathing patterns.

3.9 State the Alveolar-Air equation and discuss the factors that determine alveolar PO_2.

3.10 Using the alveolar-air equation predict the alveolar PO_2 at 8,000 ft.

3.11 Describe the regional distribution of ventilation.

3.12 Explain how the intrapleural pressure gradient in the upright lung and the shape of the static pressure volume curve of the lungs results in differences in regional alveolar size and alveolar compliance and greater ventilation to the base of the lungs when breathing from FRC. How does this differ if the lungs were inflated from RV? How would this differ in a subject breathing while in lateral decubitus position?

4. Distribution of Pulmonary Blood Flow- Ventilation Perfusion Mismatch [Ch. 4 & 5]

4.1 Specify the two sources of blood flow to the lungs; specifically the conductive versus respiratory zones/airways.

4.2 Compare and contrast the vascular pressures in the pulmonary and systemic circulations. Provide an anatomic explanation for the lower pressures found in the pulmonary circulation.

4.3 Explain how pulmonary vascular resistance (PVR) is measured and calculated.

4.4 Describe the effect of increasing lung volume on the alveolar and extra alveolar vessel contribution to PVR.

4.5 Describe the role of distention and recruitment in determining PVR.

4.6 Summarize the role of passive factors (lung inflation, pulmonary vessel distention and recruitment) in determining PVR.

4.7 Compare the effect of low alveolar oxygen on pulmonary vessels versus low blood oxygen on systemic vessels and the physiologic significance of this difference.

4.8 Define hydrostatic pressure and the relative arterial, alveolar and venous pressures in the three zones of the upright lung.

4.9 Specify the driving pressure for blood flow in each of the three zones of the lungs and describe the regional distribution of this blood flow at rest, during exercise and in conditions where mean arterial pressure is low [acute hemorrhage or during PEEP].

4.10 Describe graphically the relationship between lung height and 1) ventilation 2) perfusion and 3) the V/Q ratio in the up right lungs.

4.11 Compare the partial pressure of respiratory gases in an "ideal alveolar unit" to 1) a shunt unit (V/Q=0) and 2) dead space unit (V/Q= ∞) and predict the consequences of the regional differences in the ventilation and perfusion ratio on PA_{CO2} and PA_{O2} in the normal upright lung.

4.12 Distinguish between regional variations in partial pressure of respiratory gases in the alveoli in the upright lung and regional variations in the quantity of blood and airflow.

5. Mechanisms/Causes of Hypoxemia [Ch.6, Ch. 8]

5.1 Distinguish between hypoxia, hypoxemia, anoxia and asphyxia.

5.2 Specify the normal range for $P(A\text{-}a)O_2$ and specify how this A-a gradient is calculated and what it quantifies.

5.3 Discuss the five major causes of hypoxemia: hypoventilation, low inspired PO_2, right to left shunt, diffusion impairment and ventilation-perfusion mismatch and explain how they may be distinguished from one another in a clinical setting.

6. Control of Breathing [Ch.9]

6.1 Describe the chemoreceptors involved in the control of breathing, including the site of the receptors, their adequate stimulus and the effect of their stimulation.

6.2 Describe how the cerebrospinal fluid (CSF) is formed and secreted, its buffering properties, and its role in control of ventilation.

6.3 Describe and illustrate graphically the effects of hypercapnia and hypoxia on minute ventilation and discuss the factors that modify these relationships.

6.4 In historic context, discuss the development of hypotheses regarding signal transmission by the glomus cell.

6.5 List the major mechanoreceptors in the lungs; identify their location, major properties and reflex effects.

6.6 List the major sensory receptors in the upper airways; identify their location, afferent pathway, and reflex effects.

6.7 Identify the muscles of respiration, their innervation, and when these muscles are typically activated.

6.8 Describe the central organization of the respiratory control system referring to the locations of the respiratory-related (RRN) neurons and their potential axonal projections.

6.9 A dual control system one voluntary and the other automatic regulates breathing. Provide three examples that reveal the role of a voluntary system.

7. Lung Development & Respiratory Physiology: Fetus & Pregnancy (If time permits this lecture will be included in the course)

7.1 Describe the key structural phases associated with the prenatal development of the lungs and the importance of development of the trachea-esophageal septum

7.2 Describe the embryonic development of the lungs and the pleural cavity.

7.3 Describe the milestones of prenatal lung development and differentiation in terms of the pseudoglandular, canalicular, saccular and alveolar periods.

7.4 List the key steps for transition to independent breathing and the main factors governing normal lung development during this period.

7.5 Identify the factors affecting static lung volumes. Specify the changes in lung volume during normal pregnancy caused by the enlarging uterus and explain the underlying factors associated with changes in inspiratory capacity (IC) and functional residual capacity (FRC).

7.6 Know the partial pressures of oxygen where the Hb molecule is 100% saturated, 90% saturated, 75% saturated and 50% saturated and relate these to the oxygen environment of the alveoli of the lungs, mixed venous blood arriving at the lungs for gas exchange, arterial blood leaving the lungs upon completion of gas exchange and the average partial pressure of oxygen in tissues.

7.7 Describe the physiologic significance of the sigmoidal shape of the oxyhemoglobin dissociation curve in terms of oxygen transport. Consider both Hb loading of oxygen at the lungs and unloading of oxygen and its release at the tissues.

7.8 Specify the effect of temperature, carbon dioxide, pH and 2,3 BPG in affinity of the Hb molecule for oxygen. Provide examples related to the exercising muscle, hypothermia and placental gas exchange.

7.9 Explain the role of 2,3 BPG molecule in placental gas exchange.

7.10 Compare and contrast the oxyhemoglobin dissociation curve of the adult Hb, fetal Hb and myoglobin and explain the physiologic benefic of their relative Hb affinities.

7.11 Explain why during the first few months of life, the affinity of blood for oxygen is closer to adult despite presence of very high amounts of fetal hemoglobin

8. Breathing During Sleep [class notes]

8.1 Describe the pattern of breathing during NREM and REM sleep in healthy adults.

8.2 Describe the change in the ventilatory response to CO_2 and in the reflex response to airway irritants that takes place during sleep.

8.3 Identify the arousal mechanisms that protect the sleeper.

8.4 Explain why the upper airway patency may become compromised during sleep.

8.5 Distinguish between apnea, hypopnea, and sleep apnea.

8.6 Explain how you can distinguish between central, obstructive, and mixed sleep apneas in using polysomnography.

9. Diving & The Respiratory System [class notes]

9.1 Describe the major physiological stresses associated with diving.

9.2 State the effect of barometric pressure on ambient pressure with stepwise increases in diving depth.

9.3 Explain and provide examples of barotraumas that can occur during descent and ascent while diving.

9.4 Explain why divers can suffer decompression sickness and discuss its prevention and treatment.

9.5 Describe the symptoms of nitrogen narcosis.

9.6 Describe the key physiologic changes associated with the diving reflex and the lessons learned from study of comparative physiology.

10. Breathing During Ascent To High Altitude [class notes]

10.1 Explain why inspired levels of oxygen decrease with increased elevation.

10.2 Describe the effects of decreased inspired levels of oxygen on the sensory and mental function of individuals with gradual ascent.

10.3 Describe the symptoms of Acute Mountain Sickness (AMS), Chronic Mountain Sickness and High Altitude Pulmonary Edema (HAPE).

10.4 Describe the physiologic changes that take place during long-term acclimatization to high altitude.

10.5 Distinguish between three patterns of adaptation in native highlanders from the Andes, Tibet, and Ethiopia.

Objectives - Cardiovascular Physiology

1. Understand the electrical underpinnings of the ventricular action potential and the primary ion channel genes.
2. Differentiate between voltage-time, current-time and current voltage relations.
3. Understand the general equation for macroscopic membrane current.
4. Know the Nernst equation and the approximate concentrations of Na+ and K+ ions inside and outside of cardiac cells, and these are maintained.
5. To know the anatomy of the cardiac conduction system and that of the sino-atrial node.
6. To understand the currents underlying the action potential of sino-atrial (SA) "pacemaker" myocytes.
7. To understand how repetitive activity in the SA node is regulated by the autonomic nervous system at the cellular level.
8. Describe Cardiac Functional Anatomy (including a review of blood flow and valves)
9. Discuss the consequences of disruptions in flow through the heart
10. Use Wiggers Diagram to explain how the heart functions in health and disease
11. Differentiate between heart sounds and murmurs
12. Describe Systolic and Diastolic Murmurs
13. When provided with a single lead ECG tracing estimate heart rate, identify the rhythm (regular or irregular $\pm$ pattern), measure PR and QRS intervals and discuss their significance.
14. Differentiate between mechanisms for narrow and wide QRS on an ECG

15. Identify and discuss the basis for the absolute refractory period in the cardiac action potential.
16. Describe re-entry circuits and relate them to the genesis of tachyarrhythmias.
17. Compare and contrast the mechanisms for changing the force of contraction in skeletal and cardiac muscle.
18. Discuss the molecular mechanisms for regulating Ca^{2+} concentration in a myocardial cell.
19. Define a Ca^{2+} spark and discuss its relevance to excitation-contraction coupling.
20. Discuss how myocardial ryanodine receptors function.
21. Discuss the effect of β-agonists on pacemaker cells and on ventricular cells considering both action potentials and force production.
22. Discuss cardiac actions associated with parasympathetic activation
23. Discuss the heart's intrinsic mechanisms for altering force.
24. Analyze cardiac performance using pressure-volume loops.
25. Critique the physiological response to heart failure.

UBC Statement of 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 work done 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 is your 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.

The information contained in the course syllabus, other than the grade and absence policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor.