CAPS 423
Mammalian Renal & Gastrointestinal Physiology
Renal Physiology Section – Course Outline
Academic Year 2019 -2020

Academic Calendar Entry

CAPS 423 (3) Mammalian Renal and Gastrointestinal Physiology
Control of mammalian renal and gastrointestinal systems. Role in homeostasis. Intended for Honours students in Cellular, Anatomical and Physiological Sciences or other life sciences. [3-0-0] *Prerequisite:* A cumulative average of 75% over at least 90 credits attempted in the first three years of a student's program and a minimum mark of 75% in CAPS 301 or PHYL 301. Permission of the course director is also required.

Attendance Policy:
All students are expected to attend all lectures, exercise discussions and presentations.

Instructor Contact Information for Renal Physiology Section

Kenny Kwok PhD
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Office hour: Monday, Wednesday and Friday from 2:30 to 3:30 pm most of the time. Please email to the instructor to confirm or make an appointment at both the instructor and your convenience.

Course Format

The course consists of lectures, problem-solving exercises and student presentations

Course Schedule and Lecture Materials

Schedule of Renal Physiology:
Time: 2:00 – 4:00 p.m.
Location: Life Sciences Centre 1410

Sept. 3	*No Class – Imagine UBC day*	
Sept. 5	Overview of Functional Anatomy & Circulation of the Kidney	Kwok
Sept. 10	Glomerular Filtration I	Kwok
Sept. 12	Glomerular Filtration II/Quantification of Urinary Excretion	Kwok
Sept. 17	Renal Transport I & Problem-Solving Exercise	Kwok
Sept. 19	Renal Transport II & Problem-Solving Exercise	Kwok
Sept. 24	Acid Base Balance I	Kwok
Sept. 26	Acid Base Balance II	Kwok
Oct. 1	Water Homeostasis I	Kwok
Oct. 3	Water Homeostasis II	Kwok
Oct. 8	Functions of the Urinary Bladder & Body Fluids Exercise	Kwok
Oct. 10	Student Presentation I	Kwok

Oct. 15 Student Presentations II Kwok
Oct. 17 ***No Class – CAPS 422 Mid-Term Examination***
Oct. 22 **Renal Physiology Examination**
** The schedule may be changed depending on the progress of the lectures*

Lecture Materials:
Presentations (PowerPoints in pdf formats) of all lectures are posted in CANVAS. Individual chapters of materials presented are also available in CANVAS.

Reference Texts: Please see individual topics related to the lectures in
Boron WF& Boulpaep EL. Medical Physiology. 2nd Ed, updated Edition, 2012, Elsevier;
Alpern RJ, Moe OW, & Caplan M. Seldin and Giebisch's the Kidney. Physiology and Pathophysiology, 5th Edition, 2013, Elsevier;
Skorechi K, Chetow GM, Marsden PA, Taal MW & Yu ASL. Brenner & Rector's The Kidney. 10th Edition, 2016, Elsevier .

Please Check Canvas regularly for any changes or additional information

ALL POSTED MATERIALS WILL BE DELETED IMMEDIATELY AFTER EXAMINATION

Evaluation Criteria and Grading

The Renal Physiology section contributes to 50% of the course grade (100%)

Problem Solving Exercises:	10% of Renal grade
Presentations:	10% of Renal grade
Written Examination:	80% of Renal grade

There is no scaling of the renal course grade.
Both Problem Solving Exercises and Presentations may be works of a group or individual students depending on the numbers of students enrolled in the course. Topics of the exercises and presentation are determined during the first two weeks of lectures.
The examinable materials of the written examination are included in the PowerPoint presentations in pdf formats provided and posted in CANVAS
The written examination is marked/graded by the instructor.
The exercises and presentations are marked/graded by both students and instructor at equal weight.
The day of Deferral Examination of the written Examination is scheduled to be on the last week of lectures of the course. Please confirm the day/time of the deferral examination with instructor no later than Nov. 8, 2019.

Course Overview, Content, and Objectives

Renal Physiology Overview and Content:

1. ***Anatomy of the kidney*** – Gross features; functional unit (nephron) with emphasis on glomerulus and filtration barrier; tubular cell types.
2. ***Circulation of the kidney*** – Arterial and venous blood supply and renal vasculatures; cortical and medullary blood supply architectures; peritubular capillaries and vasa recta; hydrostatic and transcapillary pressure dynamic profiles of renal vasculatures; measurement of renal blood flow and clearance of para-aminohippuric acid (PAH); renal handling of PAH;

regulation of renal circulation, including neural, hormonal, modulatory and intrinsic factors; mechanisms involved in autoregulation of renal blood flow.

3. ***Glomerular filtration*** – Glomerular filtration rate (GFR) and its determination by clearance of inulin and creatinine; relationship between plasma creatinine concentration and GFR; Cockroft & Gault equation and Starling's forces in estimation of GFR; single nephron GFR (SNGFR) ; transcapillary hydrostatic and oncotic pressure difference during ultrafiltration equilibrium and disequilibrium; mathematic analysis of alternation of SNGFR; regulation of SNGFR, including selective biophysical changes and autoregulation; mechanisms involved in the tubuloglomerular feedback in autoregulation of GFR/SNGFR; factional clearance of solutes; selective biophysical changes on fractional clearance; fractional excretion, delivery and reabsorption of water and solutes.
4. ***Renal transport*** – Introduction and overview; transport mechanisms involved in tubular transport of sodium, chloride, potassium, proteins, oligopeptides and amino acids; factors involved in the regulation of these transport systems; glomerular balance; pressure diuresis.
5. ***Acid-Base Balance*** – Acid load and body pH; source of acid; buffering system; transport mechanisms and alternating factors involved in tubular reabsorption of bicarbonate; excretion of acid and its quantification; mechanisms involved in formation of titratable acid and ammonia/ammonium; role of diffusion trapping on ammonium cycling and excretion; involvement of liver in acid base balance; acid base disturbances and their determinations; Davenport diagram; plasma anion gap.
6. ***Body fluids (BF) and water homeostasis*** – Compartments of BF; estimation of compartmental BF volume; Gibbs-Donnan effect on BF osmolality; estimation of plasma osmolality; effect of alterations of volume and solute concentration in various BF compartments on overall distribution of BF; posterior pituitary and water balance; arginine vasopressin (AVP) biosynthesis and its receptors; role of AVP receptor subtypes on renal transport of water and other renal related functions; aquaporins and their relationship to water transport and AVP; AVP induced reabsorption of water (shuttle theory); osmotic, volume and chemical regulation of AVP secretion; osmoreceptor and volume receptors; abnormalities of water balance, including diabetes Insipidus and syndrome of inappropriate AVP secretion.
7. ***Function of the bladder*** – Bladder anatomy and its innervations; passage and storage of urine; micturition reflex and its supra-spinal control.

Renal Physiology Objectives:
Please refer to objectives of individual topics in lecture notes/presentations for any revisions

At the end of the lectures, students are expected to understand and/or describe

1. ***Anatomy of the kidney***
    - Gross features of the kidney
    - Characteristics of the functional units, Nephrons
    - Types and roles of nephrons
    - Composition of a nephron, including cell types
    - Characteristics of the filtration barrier
    - Different features of tubular epithelial cells

2. ***Circulation of the kidney***
    - Renal blood supply and related vasculatures
    - Hydrostatic pressure profiles along renal vasculatures
    - Transcapillary pressure dynamics on filtration and reabsorption
    - Use of PAH to estimate renal plasma flow & blood flow
    - Tubular secretion of PAH
    - Various factors that alter renal vascular resistance
    - Interaction of prostaglandins & AII on vascular resistance
    - Effect of selective alteration of arteriolar resistance on RBF
    - Autoregulation of RBF & mechanisms involved
3. ***Glomerular filtration***
    - Glomerular filtration rate (GFR) & filtration fraction
    - Various methods of determining GFR
    - Single nephron GFR (SNGFR) & associated hemodynamics
    - Ultrafiltration/filtration equilibrium & disequilibrium
    - Mathematic model in predicting changes in SNGFR
    - Selective biophysical changes on SNGFR
    - Significance and mechanisms involved in autoregulation of GFR
    - Fractional clearance and solute filtration
    - Effect of selective hemodynamic changes on fractional clearance
    - Determination of fractional excretion, delivery & reabsorption
4. ***Renal transport***
    - Characteristics of membrane integrated proteins & carrier-mediated transport
    - Driving forces & route of active & passive transport
    - Renal handling of Na^+ & Cl^-, including transport carriers
    - Extra-renal & renal regulation of K^+ transport
    - Handling of K^+ following a meal, & different dietary intake
    - Renal transport of K^+, including both reabsorption & secretion
    - Factors that may alter K^+ transport
    - Aldosterone paradox and proposed mechanisms
    - Significance & mechanisms of glomerulotubular balance
    - Significance & mechanisms of pressure diuresis
5. ***Acid-Base Balance***
    - Plasma pH & Henderson-Hasselbalch equation
    - Overall handling of acid base balance by the body
    - Sources of acid load & buffering systems in the body
    - Bicarbonate reabsorption & transporters involved in various tubular segments
    - Factors that may alter bicarbonate reabsorption
    - Quantification & titratable acid excretion
    - Ammonium handling in various tubular segments &
    - ammonia/ammonium cycling
    - Diffusion trapping & cycling of ammonia/ammonium
    - Role of liver in acid base balance

- Simple acid base disturbances; primary cause & compensation
- Composition & use of Davenport diagram in acid base disturbances
- Analysis of acid base disorders
- Distinguish between simple & mixed acid base disorders
- Measurement of plasma anion gap & its application

6. ***Body fluids (BF) and water homeostasis***
   - Characteristic of body fluids, their compartments & [solute]
   - Distribution of body fluids and osmolality (Gibbs-Donnan effect)
   - Estimation of body fluid volumes & their distributions after alterations in volume & [solute] (osmolality) in various compartments
   - Characteristic of water handling in the kidney
   - Synthesis and distribution of posterior pituitary hormones
   - Neural input & output of neurohypophysis
   - Classification & localization of AVP receptors in the kidney
   - Classification, localization & regulation of AQPs
   - Various functions of AVP receptors
   - Shuttling of AQPs & water reabsorption
   - Osmotic receptor & osmotic regulation of AVP secretion
   - Pathophysiology of Diabetes Insipidus
   - Pathophysiology of SIADH
7. ***Function of the bladder***
   - Functional anatomy of the bladder
   - Innervation of the bladder
   - Nerve activities during filling & voiding
   - Bladder tone & Cystometrogram
   - Initiation of Micturition Reflex
   - Nerve activities associated with Micturition Reflex
   - Supraspinal nerve input during emptying & voiding
   - Characteristics of Micturition

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. A more detailed description of academic integrity, including the University's policies and procedures, may be found in the Academic Calendar at http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3,54,111,958