

Human Physiology I

BIPN 100

Fall 2023

[BIPN 100 Syllabus](#) (Access with UCSD email address)

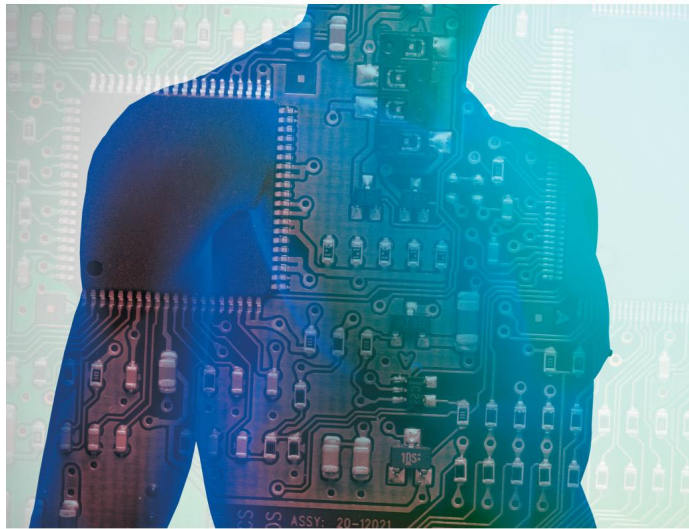
Instructor: Isabella Maita
Email: imaita@ucsd.edu
Student Hours: TBD, 8018 HS&S

Meeting Times:

Lecture	Tu/Th	5:00 PM - 6:20 PM	Peterson Hall 110
Discussion	Tu	7:00 PM - 7:50 PM	Zoom

Course Description

Physiology refers to the functions and mechanisms that support life. BIPN 100 covers the physiology of several organ systems that produce behavior, maintain homeostasis, and promote survival of the human body, including the nervous, endocrine, muscular, cardiac, and excretory systems.



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This course emphasizes the core biological concept of homeostasis at several levels of biological organization- from molecular mechanisms to integration of function between organ systems. Throughout the quarter, we will practice applying concepts in physiology by considering homeostatic dysfunction linked to disease states.

Course Materials

Canvas Website: <https://canvas.ucsd.edu/courses/48781>

Course materials, podcasted class sessions, quizzes, DAs, this syllabus, etc. will be posted on Canvas. Keep an eye out for Canvas announcements and quiz reminders.

Podcast: <https://podcast.ucsd.edu/>

Video & audio recordings can be found at the link above and in the Media Gallery on Canvas.

Recommended textbook: *Human Physiology*, 8th edition by Dee Silverthorn.

Highly recommended, NOT required. BIPN 100 is participating in the BryteWave/RedShelf Inclusive Access (IA) program this term, so you have the opportunity to access our textbook at a discount. Please visit the [bookstore](#) website if you have questions about IA. To avoid the BryteWave charge, you must opt-out of the program by the add/drop deadline on October 13th. You can do this using the [opt-out](#) link on Canvas.

Recommended readings are listed with the [learning outcomes](#), but exams and quizzes will only contain content covered in lecture and discussion sessions, so consistent class attendance is highly recommended. Older versions of the text may be more affordable, though note that chapters may differ.

Recommended Learning Platform: *Mastering A&P*, Pearson

Recommended, NOT required. *Mastering* is an active-learning-based digital tool that guides students through textbook content. I will NOT assign you content on *Mastering*, and have not fully vetted the program. However, *Mastering* guided active-learning activities may be helpful for you.

Evaluation

Learning will be assessed via three types of assignments, DAs, quizzes, and exams.

	Quantity	Due	Weight per assignment	Total Weight
Discussion Activities (DA)	9	Tuesdays at 11:59 PM	1%	9%
Quizzes	8 (Lowest grade dropped)	Fridays at 11:59 PM	3%	21%
Midterm Exams	2 midterms	E1: October 24 E2: November 21	20%	40%
Final Exam	1 final	7-10 PM, December 15	30%	30%

Grading Scale: I do not plan to grade on a curve, though that may change as the semester progresses.

A+	≥97%	B+	87 to <90%	C+	73 to <80%	D	50 to <60%
A	94 to <97%	B	84 to <87%	C	66 to <73%	F	<50%
A-	90 to <94%	B-	80 to <84%	C-	60 to <66%		

Exams

Midterm Exams: Two midterm exams will be administered during our normal lecture session, beginning at the start of class. If you are late for an exam, additional time will not be given. Midterm exams will consist of 70 questions, to be completed in 80 minutes.

Final Exam: One final exam will be administered during the final exam period on December 15th, 7-10 PM. It will consist of 140 multiple choice questions to be completed in 3 hours. The final is cumulative, with questions on material covered throughout the semester, with a focus on more recent material.

Make-Up Exams: Make-up exams can be administered under the following conditions: (1) scheduled prior to the day of the exam, (2) written proof is provided (e.g. doctor's note, email notice of religious observation, court attendance, intercollegiate athletics) or (3) in an emergency and the instructor is promptly updated. Make-up exams will differ from the original exam.

Online Quizzes

- *Due WEEKLY on Fridays at 11:59 PM, except when a midterm is scheduled.*
- **Access & Submission:** Quizzes can be accessed starting on Tuesdays at 6:20 PM (after lecture) under the "Quizzes" tab on Canvas.
- **Content:** 5 multiple choice questions on material from the previous week of lecture. If taking the quiz on Tuesday evening, you can expect questions on content from the lecture that day and the previous Thursday. Question and answer pools are randomized, and should be completed independently.
- **Grading:** Quizzes are graded for accuracy. Your lowest quiz grade will be dropped.
- **Purpose:** Questions are similar to exam questions, and are used as practice and a predictor for exams. Quiz answers will be released on Saturdays at 12 AM. If you are unhappy with your quiz score, consider bringing your questions to Student Hours.

Discussion Section

Discussion sections will meet weekly on Tuesdays, 7-7:50 PM over Zoom. These sessions are *highly recommended* and designed to improve your learning of lecture content. During discussion sections, IAs will lead group discussions, presentations, and Discussion Activities (DAs) to facilitate your learning. Log in to discussion sections ready to ask questions, use lecture content, and actively participate. While not mandatory, attending discussion sections will allow you to submit DAs as a group- see below.

Discussion Activities (DAs)

- *Due WEEKLY on Tuesdays at 11:59 PM.*
- **Access & Submission:** Released on Tuesday mornings at 12 AM under the “Assignments” tab on Canvas. DAs are designed as in-class assignments, completed in groups during our organized discussion section. DAs can be submitted as a group if completed at a discussion section. **If you are unable to attend the discussion section, then you can submit the assignment independently by following the instructions on the Canvas assignment.**
- **Content:** DAs will take a multitude of formats, including problem sets, visual organizers, case studies, and short answer questions about recent lecture content.
- **Grading:** Graded for completion, not accuracy.
- **Purpose:** DAs are designed to help you practice using lecture content: recalling and using information, discussing with classmates, teaching one-another, and presenting improves your learning. You benefit most if you complete DAs during discussion sections, where you will have opportunities to ask questions, present your work, and request feedback.

Surveys

You may be asked to complete an anonymous survey(s) for additional credit on a midterm exam(s). If you prefer not to participate, an alternate assignment for additional credit will be offered. Additional credit, surveys, and alternate assignments are not guaranteed.

Contacting the Instructor

Email: Email me at imaita@ucsd.edu with “BIPN 100” in the subject line and expect a response within 1 business day.

Student Hours: (aka office hours) *Day/time TBD*, 8018 HS&S. Student hours will be determined by a [vote](#) at the start of the quarter, in order to optimize student availability. Student hours are regularly scheduled periods of time for YOU, the student, to pop by my office to discuss lecture material, upcoming assignments/quizzes/exams, grades, and any other comments or concerns. If you cannot attend the decided upon office hours, please email the instructor to schedule an alternative in-person or virtual meeting time.

VOTE HERE on your Student Hour preferences:

<https://forms.gle/HTfseNWRoDJWaEKN6>

Instructional Assistants

Role	Name	Email	Office Hours
Teaching Assistant	Sameeha Rashid	sarashid@ucsd.edu	Virtual Mondays 7-7:50 PM
UGIA	Pallash Desai	p5desai@ucsd.edu	TBD
UGIA	Chloe Lin	iclin@ucsd.edu	TBD
UGIA	Charli MoMo	mmomo@ucsd.edu	TBD

How to Succeed in BIPN 100

Other than the obvious (attending lectures, taking notes).

Practice Learning Outcomes: [Learning outcomes](#) are achievable goals that can be practiced and assessed. Learning physiology requires more than drilling flashcards. In order to learn mechanisms and complex interactions, I recommend organizing lecture information into comprehensive visual organizers- labeled diagrams, flowcharts, and tables. Synthesization and visualization [facilitate](#) learning! Physiologists are often

interested in pathology, so also consider what may go wrong in any given system.

For example:

- Create table [CCing](#) endocrine glands and hormones. Then, add a category to your table that predicts the consequences of hyper/hypo activity of each gland.
- Draw a flowchart [SEQing](#) the opening/closing voltage-gated ion channels during an AP. Next, consider if any one step of the AP is blocked by a neurotoxin.

Once you've created your visual organizers using your notes, recreate them! Recall [strengthens](#) long-term memory, so practice creating organizers both with *and without* your notes. Creating these organizers requires more cognitive energy *at first*, but results in more complete understanding.

Teaching is Learning: Teaching others- or just pretending to- [improves](#) learning outcomes. Once you have created a visual organizer, present it to a classmate, parent, or pet. Make use of discussion sections by talking through mechanisms, asking questions, and quizzing one another with predicted exam questions.

Conduct Gap Analysis: Identifying learning outcomes that you are struggling to achieve is an essential part of learning! Identify gaps in your knowledge and use the resources available to you- discussion sections, student hours, classmates, the textbook. Your instructor/TAs are rooting for your success! Bring up questions and concerns ASAP, so we can do everything in our power to help you succeed.

Course Policies

Plagiarism and Academic Dishonesty: Any violations of academic integrity, according to the UC San Diego policies on academic integrity, will be taken very seriously. Cheating on quizzes and exams will absolutely *not* be tolerated. Violations will be reported to the Academic Integrity (IA) Office.

Disability Services: UC San Diego- including this course and instructor- welcomes students of all abilities. Contact the campus Office for Students with Disabilities (OSD)

to be considered for appropriate accommodations. Please provide the instructor with your accommodation letter (AFA) as early in the semester as possible.

OSD Website: <https://osd.ucsd.edu/students/registering.html>

Inclusivity Statement: I understand and celebrate that students come from a variety of backgrounds and perspectives. I strive to create an inclusive and welcoming classroom environment. To foster this environment, I ask that students maintain a considerate and kind class culture. I encourage students to share their experiences and views, while remaining open and respectful of the experiences and views of others. Disrespectful language and behavior will not be tolerated and may be penalized by reduced grades and/or further intervention.

Health and Well-Being Policy: In accordance with UC San Diego policy at the start of the Fall 2023 semester, masking is optional in the classroom. If you have recently been exposed to COVID or are under the weather, please consider wearing a mask. If you are experiencing symptoms, please do not attend class and take action to prepare alternate learning opportunities (ask a classmate to share their notes, review lectures online, schedule online office hours).

Transfer Students: The Triton Transfer Hub is available to meet transfer students' academic, social, and personal needs. Services include 1:1 involvement and academic success support with professional staff, peer coaching, professional and academic workshops, transfer meetups and more.

Triton Transfer Website: <https://transferstudents.ucsd.edu/>

Subject to Change Policy: The instructor reserves the right to alter the syllabus (i.e. course schedule) as needed to improve student learning.

Campus Policies

- [UC San Diego Principles of Community](#)
- [UC San Diego Policy on Integrity of Scholarship](#)
- [Religious Accommodation](#)

- Nondiscrimination and Harassment
- UC San Diego Student Conduct Code

Other Resources:

Learning and Academic Support	
<p><u>Ask a Librarian: Library Support</u> <i>Chat or make an appointment with a librarian to focus on your research needs</i></p> <p><u>Course Reserves, Connecting from Off-Campus and Research Support</u> <i>Find supplemental course materials</i></p> <p><u>First Gen Student Success Coaching Program</u> <i>Peer mentor program that provides students with information, resources, and support in meeting their goals</i></p> <p><u>Office of Academic Support & Instructional Services (OASIS)</u> <i>Intellectual and personal development support</i></p>	<p><u>Writing Hub Services in the Teaching + Learning Commons</u> <i>One-on-one online writing tutoring and workshops on key writing topics</i></p> <p><u>Supplemental Instruction</u> <i>Peer-assisted study sessions through the Academic Achievement Hub to improve success in historically challenging courses</i></p> <p><u>Tutoring - Content</u> <i>Drop-in and online tutoring through the Academic Achievement Hub</i></p> <p><u>Tutoring - Learning Strategies</u> <i>Address learning challenges with a metacognitive approach</i></p>
Support for Well-being and Inclusion	
<p><u>Basic Needs at UCSD</u> <i>Any student who has difficulty accessing sufficient food to eat every day, or who lacks a safe and stable place to live is encouraged to contact: foodpantry@ucsd.edu basicneeds@ucsd.edu (858) 246-2632</i></p> <p><u>Counseling and Psychological Services</u> <i>Confidential counseling and consultations for psychiatric service and mental health programming</i></p> <p><u>Triton Concern Line</u> <i>Report students of concern: (858) 246-1111</i></p> <p><u>Office for Students with Disabilities (OSD)</u> <i>Supports students with disabilities and accessibility across campus</i></p>	<p><u>Community and Resource Centers</u> <u>Office of Equity, Diversity, and Inclusion</u> <i>As part of the <u>Office of Equity, Diversity, and Inclusion</u> the campus community centers provide programs and resources for students and contribute toward the evolution of a socially just campus (858).822-.3542 diversity@ucsd.edu</i></p> <p><u>Get Involved</u> <i>Student organizations, clubs, service opportunities, and many other ways to connect with others on campus</i></p> <p><u>Undocumented Student Services</u> <i>Programs and services are designed to help students overcome obstacles that arise from their immigration status and support them through personal and academic excellence</i></p>

Course Schedule

The class schedule below is subject to change.

Week	Lecture	Day	Topic	Assessment
1	1	Thursday, September 28	Core concepts in Physiology Nervous System Physiology: neuron structure & function	No discussion section No DA No quiz
2	2	Tuesday, October 3	Nervous System Physiology: membrane potential, GHK, Ohms, Nerst	DA1: Membrane Properties and AP Problem Set DAs are due Tuesdays, 11:59 PM
	3	Thursday, October 5	Nervous System Physiology: action potential	Quiz #1 due Friday, October 6: L1-2. Core concepts, neurons, & membrane properties
3	4	Tuesday, October 10	Nervous System Physiology: synaptic transmission	DA2: Synaptic Transmission Diagram DAs are due Tuesdays, 11:59 PM
	5	Thursday, October 12	Nervous System Physiology: organization and functional anatomy of the CNS	Quiz #2 due Friday, October 13: L3-4. Electrochemical signals
4	6	Tuesday, October 17	Nervous System Physiology: sensory physiology	DA3: Review Qs for Midterm 1 DAs are due Tuesdays, 11:59 PM
	7	Thursday, October 19	Nervous System Physiology: motor pathways	Quiz #3 due Friday, October 20: L5-6. CNS and sensory physiology
5	EX1	Tuesday, October 24	Midterm #1	DA4: Neuromuscular Junction Diagram DAs are due Tuesdays, 11:59 PM
	Midterm #1 Tuesday, October 24 (in-class): Up to motor pathways			
	8	Thursday, October 26	Neuromuscular Physiology: NMJ, E-C coupling, power stroke	No Quiz
6	9	Tuesday, October 31	Skeletal Muscle Physiology: metabolism, muscle types	DA5: Sympathetic vs Parasympathetic Table DAs are due Tuesdays, 11:59 PM
	10	Thursday, November 2	Nervous System Physiology: Autonomic Nervous System	Quiz #4 due Friday, November 3: L7-L9. Nervous system control of skeletal muscle.

Week	Lecture	Day	Topic	Assessment
				Note: 3 topics on this quiz
7	11	Tuesday, November 7	Endocrine Physiology: hormones and receptors	DA6: Hormone Flowcharts DAs are due Tuesdays, 11:59 PM
	12	Thursday, November 9	Endocrine Physiology: hormones and receptors II	Quiz #5 due Friday, November 10 (or BEFORE Veterans Day): L10-11. Endocrinology.
8	13	Tuesday, November 14	Smooth Muscle Physiology: contraction, regulation	DA7: Review Qs for Midterm #2 DAs are due Tuesdays, 11:59 PM
	14	Thursday, November 16	Cardiac Physiology: EC coupling, action potential	Quiz #6 due Friday, November 17: L12-13. Hormones & Receptors, smooth muscle physiology
9	EX2	Tuesday, November 21	Midterm #2	No discussion section No DA
	Midterm #2 Tuesday, November 21 (in-class): Up to Cardiac Physiology: EC coupling and APs			
	THANKSGIVING BREAK- No lecture on Thursday. No quiz.			
10	15	Tuesday, November 28	Cardiac Physiology: the heart, ECG	DA8: ECG Case Study DAs are due Tuesdays, 11:59 PM
11	16	Thursday, November 30	Cardiac Physiology: Wigger's diagram, cardiac performance & regulation	Quiz #7 due Friday, December 1: L14-15. Cardiac physiology.
	17	Tuesday, December 5	Renal Physiology: the kidneys, filtration	DA9: Final Exam Review Qs. DAs are due Tuesdays, 11:59 PM
12	18	Thursday, December 7	Renal Physiology: reabsorption, secretion, excretion, flow rates, endocrine control	Quiz #8 due Friday, December 8: L16-17. Wigger's Diagram & Renal Filtration
Final Exam Friday, December 15, 7-10 PM: Cumulative with emphasis on Lecture 15-21				

BIPN 100 Learning Outcomes

See: [How to Succeed in BIPN 100](#)

APPLY = identify and connect a concept to a real-world example (case study)

CALC = use equations to calculate real-world measures (problem sets)

CC = compare and contrast components of a mechanism (table)

DESC = describe (short answer/combination of visual organizers)

DIAG = draw, label, and identify components of a graph, diagram, physiological reading (diagram/graph)

SEQ = sequence a series of events that make up a mechanism (flowchart)

Lecture 1. Core Concepts & Neuron Physiology

Reading List: Chapters 1.2-1.5, 8.2 up to “Glial Cells Provide...”

Review: Chapters 2- Chemistry; Chapters 3 and 5- Cell Components

1. CC, APPLY themes physiology
2. APPLY, CALC law of mass action
3. CC function and mechanism
4. CC, DIAG neuron structures and functions
5. CC 3 types of neurons
6. Apply review material from BILD 1 and BILD 2

Lecture 2. Membrane Properties

Reading List: Chapter 8.3 up to “Action Potentials Travel...”

1. CC effects of chemical and electrical forces on ion movement across a membrane
2. CALC equilibrium potential for an ion using Nerst equation
3. CALC membrane potential using GHK equation
4. CALC current, resistance, conductance, and voltage using Ohm’s Law
5. CC types of ion channels

6. CC membrane properties: resting potential, conductance, resistance
7. SEQ current flow depending on ion concentration and membrane properties

Lecture 3. Action Potential

Reading List: Chapter 8.3 after "Action Potentials Travel"

1. CC components of axonal membrane: Na⁺/K⁺ pump, Na⁺ and K⁺ voltage-gated ion channels, Na⁺ and K⁺ leak channels
2. SEQ, DIAG membrane potential, ion channel activity and ion flow during an action potential
3. CC absolute and relative refractory period
4. CC activation and inactivation gates of voltage-gated Na⁺ ion channels
5. CC types of conduction
6. CC factors affecting AP

Lecture 4. Synaptic Transmission

Reading List: Chapter 8.4-8.5

1. CC electrical and chemical synapses
2. SEQ neurocrine synthesis, storage, release, termination
3. CC types of NT inactivation
4. DESC link between APs, synaptic transmission, and size of stimulus
5. CC postsynaptic responses
6. CC ionotropic and metabotropic receptors
7. DESC how neurotransmitter can be excitatory at one synapse, inhibitory at another
8. CC, DIAG types of summation
9. APPLY, DIAG principles of summation, PSPs, graded potentials, threshold to determine whether a postsynaptic neuron will fire

Lecture 5. Central Nervous System Physiology

Reading List: Chapter 9.3-9.5, 9.6 (first two sections)

1. APPLY concept of neural network. What functional properties of neurons allow formation of neural networks?

2. CC CNS and PNS
3. CC, DIAG 3 layers of meninges
4. CC, DIAG white and gray matter
5. APPLY properties of BBB. What can pass through?
6. CC functions of forebrain, midbrain, and hindbrain regions
7. DIAG lobes of the brain
8. CC functions of spinal cord
9. DIAG anatomy of spinal cord, CC functions
10. SEQ, CC flow of afferent/efferent information to/from brain via spinal cord
11. SEQ spinal reflex

Lecture 6. Sensory Physiology

Reading List: Chapter 10.1

1. SEQ sensation starting with stimulus
2. CC types of sensory receptors
3. SEQ phototransduction
4. DESC how convergence of sensory neurons affects size of receptive fields
5. CC how brain perceives modality, location, intensity, and duration of stimuli
6. CC tonic and phasic receptors

Lecture 7. Motor Pathways

Reading List: Chapter 13.3, 12.2

1. CC components of skeletal muscle reflex
2. SEQ alpha-gamma coactivation, stretch reflex and withdrawal reflex
3. CC gamma motor neurons and alpha motor neurons
4. DIAG, CC components and structure of muscle spindles
5. CC isotonic and isometric contractions

Lecture 8. Neuromuscular Junction

Reading List: Chapter 11.2, 12.1 up to “Skeletal muscle contraction requires a steady supply of ATP”

1. DIAG, CC components of muscle fibers:
 - a. DIAG neuromuscular junction
 - b. CC myofibrils
 - c. CC regulatory, channel, and receptor proteins
 - d. CC thick and thin filaments
 - e. DIAG, CC regions of the sarcomere (A band, M line, etc)
2. SEQ sliding filament theory and role of ATP in sliding filament model
3. SEQ muscle contraction starting with somatic motor neuron through the power stroke
 - a. SEQ cross bridge formation
 - b. SEQ excitation-contraction coupling and role of calcium channels

Lecture 9. Skeletal Muscle Physiology

Reading List: Chapter 12.1 after “Skeletal muscle contraction requires a steady supply of ATP”

1. CC relationships between length & tension, summation & contraction, and motor units & contraction force
2. CC slow-twitch muscles and 2 types of fast-twitch muscles
3. CC sources of energy for skeletal muscles

Lecture 10. Autonomic Nervous System

Reading List: Chapter 11.1

1. CC, DIAG sympathetic and parasympathetic functions and pathways, SEQ interaction between two branches
2. SEQ, DIAG activity at the neuroeffector junction
3. CC CNS control centers of the ANS
4. CC neurotransmitters, receptors, and receptor subtypes in the ANS
5. SEQ activation of adrenal medulla

Lecture 11 + Lecture 12. Hormones and Receptors

Reading List: Chapter 7.1-7.3

1. APPLY feedback loops to hormone action
2. CC 3 hormone types
 - a. SEQ synthesis, storage, transport in blood, cell mechanism of action for each hormone type
3. APPLY law of mass action to plasma steroid hormone concentration
4. CC endocrine & neuroendocrine structures, SEQ hormone actions
5. CC, SEQ negative feedback in simple endocrine reflexes vs complex pathways
6. CC 3 types of hormone interactions

Lecture 13. Smooth Muscle

Reading List: Chapter 12.3

1. CC tonic and phasic smooth muscle contraction
2. CC types of cell-cell communication in smooth muscle
3. SEQ smooth muscle contraction and relaxation
 - a. CC myosin light chain kinase and myosin light chain phosphatase
4. CC, SEQ effects of calcium sensitivity on smooth muscle contraction
5. CC, DIAG slow wave potentials, pacemaker potentials, pharmacomechanical coupling
6. CC smooth and skeletal muscle anatomy and contraction

Lecture 14. Cardiac Muscle

Reading List: Chapter 14.3

1. SEQ EC coupling in cardiac muscle
2. SEQ, DIAG, CC action potential in contractile and autorhythmic cardiac muscle
3. DESC how tetanus is prevented in cardiac muscle
4. CC skeletal, smooth, cardiac muscle

Lecture 15. Cardiac Physiology 1

Reading List: Chapter 14.4 “Anatomy Summary”, 14.4 until “Pressure-Volume Curves...”

1. CC chambers of the heart and valves
2. SEQ, DIAG blood flow through the heart
3. SEQ electrical conduction in the heart
4. DIAG, CC components of Einthoven’s Triangle
5. DIAG, CC components of ECG
6. SEQ, DIAG cardiac cycle and coinciding ECG readings

Lecture 16. Cardiac Physiology 2

Reading: Chapter 14.2, 14.4 following “Pressure-Volume Curves”

1. SEQ, DIAG Pressure-Volume Curve
2. DIAG Wigger’s Diagram
3. CC, CALC measures of cardiac performance (SV, CO)
4. CC sympathetic and parasympathetic control of HR
5. CC, SEQ relationship between preload, contractility, afterload, SV, CO
6. SEQ catecholamine effects on contractile cells
7. CC factors affecting resistance/flow in blood vessels

Lecture 17. Renal Physiology 1

Reading: Chapter 19.1-19.4

1. CC 6 functions of the kidneys
2. CC, DIAG functional components of renal circulation and tubule systems of kidney
3. CC, SEQ relationship between GFR, filtration pressure, filtration coefficient
4. CALC net filtration pressure
5. CC, SEQ changes to GFR, P_{H_2O} , renal blood flow when arteriole resistance changes
6. CC, SEQ myogenic response and tubuloglomerular feedback
7. CC hormonal and nervous system control of GFR

Lecture 18. Renal Physiology 2

Reading: Chapter 19.5-19.7, 20.2

1. CC functions, process, location of filtration, reabsorption, secretion, excretion
2. CC mechanisms of transepithelial and paracellular transport
3. SEQ, CC reabsorption of Na⁺, anions, H₂O
4. DIAG, APPLY saturation and renal threshold
5. SEQ organic anion secretion
6. CC, APPLY effects of renal handling on clearance
7. SEQ integrated regulation of osmolarity and ion concentration
8. SEQ regulation of medullary interstitial osmolarity and urine concentration
9. SEQ regulation of osmolarity by renal countercurrent multiplier