COURSE SYLLABUS

Course: SYSTEMS PHYSIOLOGY I
Code: SCPS 680 **Credit:** 3 (3-0-6)
Prerequisite: –
Academic year: 2024 **Semester:** 1st

Course Organizer: Tai Chaiamarit, Ph.D., D.Phil.
Room: B. 522/1, Department of Physiology, Faculty of Science, Mahidol University
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Course Description

Mechanisms underlying the functions of the nervous, muscular, and cardiovascular systems as well as the coordination of these systems to maintain homeostasis of the body internal environment in response to disturbances from the external environment

Course Objectives

After completion of this course, students should be able to:

1. Explain the fundamental concepts of the neural, muscular, and cardiovascular physiology
2. Explain the interactions among the various parts of neural, muscular and cardiovascular systems in response to stimuli or disturbances
3. Discuss how these systems work to maintain the body homeostasis

Course Organization

The course is composed of three units as shown in the attached schedule. The first unit covers an introductory overview of the body functional systems, so called homeostasis (Lecture 1), following by neurophysiology (L2-7 & 1 Discussion). The second unit covers muscular system (L8-9, 1 Discussion, and 1 Lab & Conference), and the third unit covers the function and mechanisms of the cardiovascular system (L10-18, 2 Discussion, 1 Lab Preview, and 1 Lab & Conference). The total lecture and activity hours for each unit are as follows:

	Lecture Hours	Activity Hours
Unit I: Neurophysiology	10.5	3
Unit II: Muscular System	3	5
Unit III: Cardiovascular System	14.5	9 & 0.5 (Lab Preview)
TOTAL	**28 (~62%)**	**17 (~38%)**

The lesson plans of each lecture/activity (lab & conference/ small group discussion) gathering the background & synopsis, learning objectives, lecture outline, learning organization,

learning materials, suggested readings and student assessment are included in this syllabus. For the classes of discussion/lab & conference, the responsible instructor will evaluate the student performance based on an appropriate rubric form attached herein as well as a post-quiz session.

Teaching & Learning Methods

1. On-site lecture together with WebEx or Zoom online
2. Lab & conference
3. Small group discussion
4. Self-study
5. Video records
6. Examination, participation & quiz

Teaching media

1. Textbooks: various physiology textbooks and reading materials essential for each study unit individually suggested by the responsible instructor of the topic
2. Digital media (CDs) are available in the library of the Department of Physiology, including
   - Essentials of human physiology
   - Muscular system
   - Cardiovascular system

Classroom

Room Pr. 401

Course Assessment

There are three written examinations taken after the completion of each unit as scheduled. The examination mainly covers the contents from lectures and assigned materials with the weight score of 10 points per each lecture hour. The weight score for each activity hour is also 10 points with 50% contribution from participation/discussion and another 50% from post-quiz right after the end of each class as summarized:

	EXAMINATION			ACTIVITY (points)	
	Date	Duration (hrs)	Score (points)	Participation	Quiz
UNIT I	Friday Aug 16, 2024	3.5	105	15	15
UNIT II	Monday Aug 26, 2024	1	30	25	25
UNIT III (Part I)	Monday Sep 16, 2024	2.0	55	-	-
UNIT III (Part II)	Thursday Sep 19, 2024	3.0	90	45	45
			280 (~62%)	170 (~38%)	

The score range for grading is set as follows:

Grade	Score
A	≥ 80
B+	≥ 70
B	≥ 60

The minimum passing grade for the course completion is "B" for the graduate student from both the MS and PhD Programs in Physiology.

Grade	Score
C+	≥ 55
C	≥ 50
F	< 50

Tentative Date for Re-examination: October 11, 2024

List of Instructors:

Lecturer	E-mail	Room	Phone
Prof. Narattaphol Charoenphandhu, MD, PhD (NC)	narattaphol.cha@mahidol.ac.th	Pr. 409	0–2201–5629
Prof. Vitoon Saengsirisuwan, PhD (VS)	vitoon.sae@mahidol.ac.th	B. 506	0–2201–5504
Assoc. Prof. Ratchakrit Srikuea, PhD (RS)	ratchakrit.sri@mahidol.ac.th	B. 502/2	0–2201–5518
Assoc. Prof. Tepmanas Bupha-Intr, DVM., PhD (TB)	tepmanas.bup@mahidol.ac.th	B. 508	0–2201–5506
Asst. Prof. Nattapon Panupinthu, MD, PhD (NP)	nattapon.pan@mahidol.ac.th	Pr.420	0-2201-5620
Lecturer Benjamin Ongnok, PhD (BO)	benjamin.ong@mahidol.ac.th	Pr. 416	0–2201–5616
Lecturer Chonlawan Saengjaroentham, PhD (CS)	chonlawan.sae@mahidol.ac.th	B. 520	0–2201–5514
Lecturer Tai Chaiamarit, PhD, DPhil (TC)	tai.chm@mahidol.ac.th	B. 522/1	0–2201–5515

Course Attainment Evaluation

Program Learning Outcomes (PLOs) for MS in Physiology

1. Demonstrate moral and professional ethics
2. Evaluate physiological concepts for knowledge transfer/innovation and problem solving
3. Apply knowledge and research skills in physiology or related fields to produce publications/innovation
4. Demonstrate responsibility, leadership, and ability to work with others
5. Transfer/disseminate knowledge by using various means of communications

Program Learning Outcomes (PLOs) for PhD in Physiology

1. Demonstrate moral and professional ethics
2. Integrate knowledge in physiology and related fields for knowledge transfer/innovation and problem solving
3. Create research in physiology and related fields to produce international publications, patents or innovations
4. Demonstrate responsibility, leadership, and the ability to work with the others
5. Deliver specific and generalizable knowledge effectively by using various means of communication

Course Learning Outcomes (CLOs) for SCPS 680

1. Explain the fundamental concepts of the neural, muscular, and cardiovascular physiology
2. Explain the interactions among the various organs of neural, muscular and cardiovascular systems in response to stimuli or disturbances
3. Discuss how these systems maintain the body homeostasis

Measurement of ELO Achievement for SCPS 680 by Students

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5
CLO 1					
CLO 2					
CLO 3					
Attainment Score					

SCPS 680: Systems Physiology I – 3(3-0-6)
Academic Year 2024
Department of Physiology, Faculty of Science, Mahidol University

Date	Act. #	Time	Topics	h	Instructors
Mon Aug 5, 24		09.00–09.30	Course orientation	0.5	TC
Unit I: Homeostasis & Neurophysiology **Total 13.5 h: Lecture (L) = 10.5, Discussion (D) = 3**					
Mon Aug 5, 24	L1	10.00–11.00	L: Homeostasis	1	NP
	L2	13.00–15.00	L: Membrane potential and nerve physiology	2	TC
Tues Aug 6, 24	L3	09.00-10.30	L: Somatosensory system	1.5	CS
	L4	10.30-12.00	L: Motor system and autonomic nervous system	1.5	CS
Thurs Aug 8, 24	L5	10.30-12.00	L: Higher function of the nervous system	1.5	BO
Thurs Aug 8, 24	L6	13.00-14:30	L: Special sense I - Vision	1.5	NC
	L7	14.30-16.00	L: Special sense II – Hearing and balance	1.5	NC
Tues Aug 13, 24	**D1**	13.00-16.00	D: Nervous system	3	CS
Fri Aug 16, 24	***Ex. I***	***09.00-12.30***	***Exam Unit I (105 points)***	***3.5***	***JW & TC***
Unit II: Muscular System **Total 8 h: Lecture (L) = 3, Discussion (D) = 2, Laboratory (Lab) & Conference (Conf) = 3**					
Mon Aug 19, 24	L8	09.00-11.00	L: Muscular system I	2	RS
	L9	11.00-12.00	L: Muscular system II	1	RS
Tues Aug 20, 24	**L&C 1**	09.00-12.00	Lab & Conf.: Skeletal muscle functions	3	RS
Fri Aug 23, 24	**D2**	09.00-11.00	D: Property of skeletal muscle	2	RS
Mon Aug 26, 24	***Ex. II***	***09.00-10.00***	***Exam Unit II (30 points)***	***1***	***JW & TC***
Unit III: Cardiovascular System **Total 23.5 h: Lecture = 14.5, Discussion = 6, Lab Preview = 0.5, Lab & Conference = 3**					
Mon Aug 26, 24	L10	11.00-12.00	L: Principle of CVS	1	TB
Tues Aug 27, 24	L11	09.00-10.00	L: Hemodynamics	1	TB
	L12	10.00-12.00	L: Electrophysiology of the heart	2	VS
Thurs Aug 29, 24	L13	09.00-10.30	L: Electrocardiography	1.5	VS
Fri Aug 30, 24	**D3**	09.00-12.00	D: Electrophysiology & Hemodynamics	3	VS
Mon Sep 2, 24	L14	09.00-11.00	L: Cardiac pump dynamics	2	BO
Tues Sep 3, 24	L15	09.00-11.00	L: Resistance, capillary and capacitance vessels	2	TB
	—	11.30-12.00	**Lab Preview:** Mechanical Heart Model	0.5	TB
Thurs Sep 5, 24	**L&C 2**	09.00-12.00	Lab & Conference: Mechanical heart model	3	TB

Date	Act. #	Time	Topics	h	Instructors
Fri Sep 6, 24	L16	09.00-11.00	L: Cardiovascular control	2	BO
Mon Sep 9, 24	L17	09.00-10.30	L: Cardiovascular response to exercise	1.5	VS
Tues Sep 10, 24	L18	09.00-10.30	L: Body response to hemorrhagic hypotension	1.5	TB
Fri Sep 13, 24	**D4**	09.00-12.00	D: Factors affecting CVS function	3	TB
Mon Sep 16, 24	*Ex. III*	*09.00-11.00*	*Exam Unit III-part I (L10-13; 55 points)*	*2*	*JW & TC*
Thurs Sep 19, 24	*Ex. III*	*09.00-12.00*	*Exam Unit III-part II (L14-18; 90 points)*	*3*	*JW & TC*
Tentative Date for Re-examination: October 11, 2024					

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Assessment Rubric

SCPS 680 & 681: Systems Physiology I & II

Academic Year 2024

Student Name .....

Instructor: ..... Date ..... Time .....

Evaluation Rubric for Class Participation						
Criteria of Performance Assessment	Inadequate (0 point)	Developing (below expectations) (1 point)	Accomplished (meets expectations) (2 points)	Exemplary (shows leaderships) (3 points)	SCORE	FINAL POINT
Preparation (20%)	- Lack of preparation in advance	- Insufficient preparation for the assigned materials before class	- Sufficient preparation for the assigned materials before class	- Well preparation for class - Having questions or comments on materials beyond the assignment		
Active Participation (60%)	- No class contribution & discussion - No response to direct questions	- Less class contributions & discussion - Seldom volunteers in response to direct questions	- Proactive class contributions & discussion - Asking questions & response to direct questions	- Proactive with regular class contribution & discussion - Initiate discussion on topic related issues		
Listening Skills (20%)	- No listening attention to others - Non-responsive comment to discussion	- Less listening attention - Less comments to discussion	- Appropriate listener - Appropriate response to others	- Good listener without inappropriate interruption - Incorporate & expand response to others		
TOTAL SCORE OF CLASS PARTICIPATION & DISCUSSION						

ACTIVITIES	ASSIGNED SCORE	EARNED SCORE (point)
PERFORMANCE	50% = pt	..... /3 x ..... (assigned score) =
QUIZ	50% = pt	
TOTAL		

INSTRUCTOR SIGNATURE.....

DATE OF SUBMISSION .....

Exam I: Neurophysiology
Date: Friday August 16, 2024
Time: 09:00 – 12:30 (3.5 h)

Instructors/ Activities	Lectures (hrs)	Exam Score (points)	Exam Time (mins)	Due Date for Exam Question Submission
NP	1	10	20	Friday August 9, 2024
CS	3	30	60	
TC	3.5	35	70	
NC	3	30	60	
Total	10.5	105	210	
CS / SGD I	3	30	In class: Dis/Quiz = 15/15	

Exam II: Muscular System
Date: Monday August 26, 2024
Time: 09:00 – 10:00

Instructors/ Activities	Lectures (hrs)	Exam Score (points)	Exam Time (mins)	Due Date for Exam Question Submission
RS	3	30	60	Monday Aug 19, 2024
Total	3	30	60	
Lab & Conf.	3	30	In class: Dis/Quiz = 25/25	
SGD II	2	20		

Exam III: CVS (part 1 & 2)
Date: Part I (Monday Sep 16, 2024) Time: 09:00 – 11:00
Part II (Thursday Sep 19, 2024) Time: 09:00 – 12:00

Instructors/ Activities	Lectures (hrs)	Exam Score (points)	Exam Time (mins)	Due Date for Exam Question Submission
TB	2 (L10 & 11)	20	45	Monday Sep 9, 2024
VS	3.5 (L11, 13) 13)	35	75.0	
Total (I)	5.5	55	120	
BO	4	40	80.0	
VS	1.5	15	30.0	
TB	3.5	35	70.0	
Total (II)	9	90	180	
VS / SGD III	3	30	In class: Dis/Quiz = 45/45	
TB / SGD IV	3	30		
Lab & Conf.	3	30		

Exam : Activities = 280 :170 → ~ 62% : 38%

SCPS 680: System Physiology I
Lesson Plan 2024

Topic **Lecture 1: Homeostasis**
Date/Time Mon Aug 5, 2024; 10:00 – 11:00 AM
Room Pr.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Asst. Prof. Nattapon Panupinthu, M.D., Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
(E-mail: nattapon.pan@mahidol.ac.th)
Student Graduate students in the Program of Physiology and related Programs

Background & Synopsis

The human body is a complex living organism, organized from molecules, cells, tissues, and organs into systems, all functioning together as one individual. Throughout a lifetime, our bodies continue to operate despite constant internal and external challenges and disturbances. The coordination of important regulatory mechanisms is essential for maintaining the stability of the body's internal environment. This dynamic process, known as homeostasis, involves various feedback systems that monitor and adjust physiological activities to keep conditions within an optimal range.

Objectives

Students should be able to:

1. Identify and discuss the significance of the internal environment of an organism
2. Explain the concept of homeostasis and how it is achieved
3. List the factors of the internal environment that must be maintained
4. Identify the types of control systems and explain how they function

Lecture Outline

1. The external and internal environments of the body
2. The concept of homeostasis
3. Contributions of body systems to homeostasis
4. Control systems for maintaining homeostasis
5. Disruption of homeostasis and its consequences

Learning Organization

1. Read learning materials before the lecture
2. 50-min lecture presentation
3. 10-min questions and answers

Learning Materials

1. Lesson plan including the objectives and lecture outline
2. Handout of the lecture presentation

Suggested Readings

1. Boron and Boulpaep (2017) Medical Physiology, 3rd Edition, Chapter 1: Foundations of physiology, Elsevier Saunders.
2. Koeppen B.M. and Stanton B.A. (2018) Berne and Levy Physiology: 7th Edition, Chapter 2: Homeostasis, Mosby, PA, USA.
3. Sherwood (2013) Human Physiology: From Cells to Systems, 8th Edition, Chapter 1: Introduction to Physiology and Homeostasis, Brooks/Cole Cengage Learning.

Student Assessment

1. Student participation in class
2. Written examination 10 points

Topic **Lecture 2: Membrane potential and nerve physiology**
Date Monday Aug 5, 2024 **Time** 01:00 – 03:00 PM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Tai Chaiamarit, PhD, DPhil
Department of Physiology, Faculty of Science, Mahidol University
E-mail: tai.chm@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

Excitable cells, such as neurons, utilize membrane potential at the resting state versus the excited states for electrical signal transduction. These electrical signals could spread passively or actively and could propagate from one cell to the next via synaptic transmission. Electrophysiological measurement and mathematical description of neuronal properties are fundamental tools to understand the basics of nerve physiology.

Objectives

Students should be able to:

1. Describe the mechanisms generating the resting membrane potential via ion channels
2. Interpret the mathematical description of neuronal properties
3. Understand the electrophysiology methods and measurement results
4. Discuss factors affecting passive and active signal propagation
5. Explain the mechanisms of synaptic transmission and integration

Lecture Outline

1. The resting membrane potential and ion channels
2. The functional properties of the neurons as electrical equivalent circuit
3. The passive electrical signaling and factors that determine signal conduction
4. The active electrical signaling and the Voltage clamp studies
5. Synaptic transmission and integration

Learning Organization

1. Read learning materials before the lecture
2. Lecture using visual presentation 110 min
3. Questions and answers 10 min

Learning Materials

1. Lecture outlines
2. Handout of the lecture presentation
3. Video record for review

Suggested Readings

1. Kandel *et al.* **Principle of Neural Science**. 5th edition, 2012, McGraw Hill Education
2. Sherwood. **Human Physiology: From Cells to Systems**. 9th edition, 2015, Brooks/Cole Cengage Learning
3. Koeppen & Stanton. **Berne & Levy Physiology**. 6th edition, 2009, Mosby/Elsevier

Student Assessment

Writing examination 20 points

Updated June 20, 2024

Topic **Lecture 3: Somatosensory system**
Date Tuesday Aug 6, 2024 **Time** 09.00-10.30 AM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Dr. Chonlawan Saengjaroentham, Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: chonlawan.sae@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

The somatosensory system is involved with the conscious perception, for example, mechanical force, pressure, temperature, and pain. These perceptions consist of the specific pathways that delivers sensations detected in the periphery receptors and then conveys through the spinal cord, brainstem, and relay thalamic nuclei to the primary sensory cortex. In addition, proprioceptors located in muscle spindles and tendon are responsible for convey information about body position and movement to the brain.

Objectives **Students should be able to:**

1. Describe the sensory modalities of somatosensory information such as temperature, pressure, pain, and mechanical force.
2. Explain the corresponding pathways that deliver each sensory information to the primary somatosensory cortex.
3. Explain the receptive fields, spatial discrimination of skin receptor and two-point discrimination.
4. Explain the importance of proprioceptors (muscle spindles and Golgi tendon organs).

Lecture Outline

1. General sensory modalities (e.g., mechanical force/pressure, temperature, and pain)
2. Functions of mechanoreceptors, thermoreceptors, and nociceptors
3. Corresponding pathways of each sensory information
4. Receptive fields and spatial discrimination
5. Proprioceptive functions of muscle spindles and Golgi tendon organs

Learning Organization

1. Read the learning materials before the lecture.
2. 80-minute lecture sessions using PowerPoint presentations
3. 10-minute questions & answers session

Learning Materials

1. Lecture plan including the objective and lecture outlines
2. Handout of the lecture presentation
3. Video record for review

Suggested Readings

1. Kandel, E. R., Koester, J. D., Mack, S. H., Siegelbaum, S. A. (2021). Principles of Neural Science, Sixth Edition. United States: McGraw Hill LLC.
2. Purves, D., et al. (2018). Neuroscience. United Kingdom: Oxford University Press.
3. Koeppen, B. M. (2017). Berne and Levy Physiology: Berne and Levy Physiology E-Book. Mayotte: Elsevier Health Sciences.

Student Assessment

Writing examination 15 points

Updated June 18, 2024

Topic **Lecture 4: Motor system and autonomic nervous system**
Date Tuesday Aug 6, 2024 **Time** 10:30 – 12:00 PM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Dr. Chonlawan Saengjaroentham, Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: chonlawan.sae@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

Body movement is an important behaviour, and it involves motor control. The coordination of voluntary movement is controlled by various higher brain centres while the neural circuit in the spinal cord control involuntary movement, both of which regulate the contraction of skeletal muscles. The coordinate contraction of the skeletal muscles functions to maintain a posture and transition of movement through the several descending motor pathways. The autonomic nervous system function in maintaining the body's homeostasis relate to control of the viscera. It is divided into the sympathetic and parasympathetic divisions.

Objectives

Students should be able to:

1. Describe the components and mechanisms of reflex (Stretch reflex, Golgi tendon reflex, and Flexion reflex)
2. Describe the pathway of descending motor control from the cortex to the skeletal muscles.
3. Explain physiology of pyramidal and extrapyramidal systems.
4. Describe the roles of primary motor cortex, brain stem, cerebellum, and basal ganglia in controlling motor function
5. Describe the control of the autonomic nervous system related to neurotransmitters and their receptors.

Lecture Outline

1. Reflex and control of reflex (Stretch reflex, Golgi tendon reflex, and Flexion reflex).
2. Fundamental concept of descending pathways consists of pyramidal and extrapyramidal systems.
3. The function of cortical, basal ganglia, brain stem, and cerebellum in motor control.
4. Organization and function of sympathetic and parasympathetic nervous system.

Learning Organization

1. Read the learning materials before the lecture.
2. 80-minute lecture sessions using PowerPoint presentations
3. 10-minute questions & answers session

Learning Materials

1. Lecture plan including the objective and lecture outlines
2. Handout of the lecture presentation
3. Video record for review

Suggested Readings

1. Kandel, E. R., Koester, J. D., Mack, S. H., Siegelbaum, S. A. (2021). Principles of Neural Science, Sixth Edition. United States: McGraw Hill LLC.

2. Purves, D., et al. (2018). Neuroscience. United Kingdom: Oxford University Press.
3. Koeppen, B. M. (2017). Berne and Levy Physiology: Berne and Levy Physiology E-Book. Mayotte: Elsevier Health Sciences.

Student Assessment

Writing examination 15 points

Updated June 18, 2024

Topic **Lecture 5: The Higher function of the nervous system**
Date Thursday Aug 8, 2024 **Time** 10:30 AM – 12:00 PM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Benjamin Ongnok, Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: Benjamin.ong@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

Sleep-wakefulness cycle and memory formation require integrative function of several brain regions. Furthermore, primary sensory information is integrated into complex concepts such as language. Understanding in-depth neural mechanisms of sleep-wakefulness, memory, and language is crucial in understanding how the brain works at the fundamental level.

Objectives

Students should be able to:

1. Describe the mechanisms of sleep-wakefulness and their disorders
2. Discuss the mechanisms of neural plasticity in the basis of learning and memory
3. Describe how language is processed in the brain

Lecture Outline

1. The physiology of sleep, sleep-wakefulness cycle, and the neural mechanisms
2. Synaptic plasticity, Long-term potentiation, and different forms of memory
3. Higher cortical function and language processing

Learning Organization

1. Read the learning materials before the lecture.
2. 80-minute lecture sessions using PowerPoint presentations
3. 10-minute questions & answers session

Learning Materials

1. Lecture plan including the objective and lecture outlines
2. Handout of the lecture presentation
3. Video record for review

Suggested Readings

1. Koeppen, B. M., & Stanton, B. A. (2017). Berne and levy physiology. 7th Edition Chapter 10: Integrative Functions of the Nervous System, Elsevier Health Sciences.
2. Purves, D., Augustine, G. J., Fitzpatrick, D., Hall, W., LaMantia, A. S., & White, L. (2019). Neurosciences. 6th Edition Chapter 5: Complex Brain Functions and Cognitive Neuroscience, Sinauer.
3. Kandel *et al.* Principle of Neural Science. 5th edition, 2012, McGraw Hill Education.

Student Assessment

Writing examination 15 points

Updated June 20, 2024

Topic: **Lecture 6: Special Sense I – Vision**
Date: Thursday August 8, 2024 **Time:** 1:00–2:30 PM
Room: PR 401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer: Prof. Narattaphol Charoenphandhu, M.D., Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: narattaphol.cha@mahidol.ac.th Tel. 5975
Students Graduate students in the Program of Physiology and related Programs

Background & synopsis:

The visual system is composed of the eyes and parts of the central nervous system, which allow us to sense, perceive and interpret electromagnetic signals within visible light spectrum (~400–800 nm). This system requires photoreceptors (cones and rods) in the retina, the 2nd cranial nerve (optic nerve), lateral geniculate body, and visual cortex (the occipital lobe). Visual transduction also requires a number of photon-sensitive proteins, the abnormalities of which (e.g., from genetic mutation) may lead to color blindness.

Objectives:

Students should be able to:

1. Describe the organization of the visual system, e.g., how the visual information is conveyed from the eyes to the brain.
2. Describe structures of the eyes, including cornea, lens, sclera, iris, choroid and retina.
3. Describe physiological significance of each layer of the retina.
4. Describe the mechanism of visual signaling and retinal metabolism.
5. Explain how to translate related basic science to biomedical application, e.g., transforming cells to express photon-sensitive protein or gene therapy/precision medicine for certain eye diseases.
6. Describe how the retina and brain process images.
7. Describe principal visual pathways, including connections to the visual cortex, superior colliculus, pretectum and suprachiasmatic hypothalamic nucleus.
8. Explain abnormal conditions related to the visual system, such as night blindness, hemianopsia, scotoma, and achromatopsia.

Lecture Outline:

1. Organization of the visual system
2. Structures of the eyes
3. Retina and photoreceptors
4. Visual signal transduction
5. Color vision
6. Visual pathways
7. Abnormal conditions related to the visual system

Learning Organization:

1. Read learning materials before the lecture
2. 80 minutes lecture using visual presentation with in-class discussion
3. 10 minutes questions & answers

Learning materials:

1. Lesson plan
2. Handout of the visual presentation

Suggested reading:

Boron WF, Boulpaep EL. Concise Medical Physiology (Chapter 15. Sensory Transduction). Elsevier, Philadelphia. 2021.

Student assessment:

1. In-class participation
2. Essay writing 15 points

Updated: July 1, 2022

Topic **Lecture 7: Special sense II - Hearing and balance**
Date Thursday August 8, 2024 **Time:** 2:30–4:00 PM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer: Prof. Narattaphol Charoenphandhu, M.D., Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: narattaphol.cha@mahidol.ac.th Tel. 5975
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis:

Auditory and vestibular systems—also known as hearing and balance systems—have very similar transduction mechanisms at both cellular and molecular levels because of similar mechanical receptors in the inner ear. Sound is transmitted through the tympanic membranes and ossicles before reaching the cochlear, which is the most important auditory portion in the inner ear where the sound pressure is converted to the neural signals. The vestibular apparatuses are composed of the semicircular canals for perception of angular acceleration, and the otolith organs (i.e., utricle and saccule) for perception of linear acceleration. Auditory and vestibular signals are conveyed through vestibulocochlear nerve (the 8th cranial nerve) to the brainstem and cerebral cortex.

Objectives:

Students should be able to:

1. Describe the organization of the auditory and vestibular systems, e.g., how the signal is transmitted from the peripheral vestibuloacoustic organs to the central nervous system.
2. Explain physics of sound transmission and audition as well as biomedical applications, e.g., cochlear implant.
3. Describe physiological significances of external ear, middle ear and inner ear.
4. Describe cellular mechanism of sound transduction.
5. Describe central auditory pathways and related cortical organization.
6. Describe the structure and function of semicircular canals and otolith organs.
7. Describe the mechanism of vestibular transduction and control of body balance.
8. Describe central vestibular pathways and related cortical organization.

Lecture Outline:

1. Organization of auditory and vestibular systems
2. Audition and sound transmission
3. External ear, middle ear and inner ear
4. Mechanism of sound transduction
5. Central auditory system
6. Semicircular organs and otolith organs
7. Mechanism of vestibular transduction
8. Central vestibular system

Learning Organization:

1. Read learning materials before the lecture
2. 80 minutes lecture using visual presentation with in-class discussion
3. 10 minutes questions & answers

Learning Materials:

1. Lesson plan
2. Handout of the visual presentation

Suggested reading:

Boron WF, Boulpaep EL. Concise Medical Physiology (Chapter 15. Sensory Transduction). Elsevier, Philadelphia. 2021.

Student assessment:

1. In-class participation
2. Essay writing 15 points

Updated: July 1, 2022

Topic **Discussion 1: Nervous system**
Date Tuesday Aug 13, 2024 **Time** 09:00 – 12:00 PM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Dr. Chonlawan Saengjaroentham, Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: chonlawan.sae@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Objectives

Students should be able to:

1. Explain physiology of the somatosensory system
2. Explain physiology of motor system
3. Explain physiology of autonomic nervous system
4. Explain the function of vestibular system and related pathology

Discussion Outline

1. Fundamental concept of somatosensory system
2. Fundamental concept of the motor system
3. Fundamental concept of the autonomic nervous system
4. Clinical investigation in neurological disorders
4. Pathophysiology of the vestibular system

Learning Organization

1. Review lectures and related references before class
2. Problem based learning (PBL)
3. Group discussion and presentation on the leading questions

Learning Materials

1. Leading questions, Case study
2. Handout of the lecture presentation

Suggested Readings

1. Kandel, E. R., Koester, J. D., Mack, S. H., Siegelbaum, S. A. (2021). Principles of Neural Science, Sixth Edition. United States: McGraw Hill LLC.
2. Purves, D., et al. (2018). Neuroscience. United Kingdom: Oxford University Press.
3. Koeppen, B. M. (2017). Berne and Levy Physiology: Berne and Levy Physiology E-Book. Mayotte: Elsevier Health Sciences.

Student Assessment

1. Student performance 50% (15 points)
2. Quiz 50% (15 points)

Updated June 18, 2024

Topic **Lecture 8 & 9: Muscular System I & II**
Date Monday Aug 19, 2024 **Time** **L8:** 09:00 – 11:00 AM
Time **L9:** 11:00 – 12:00 PM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Assoc. Prof. Ratchakrit Srikuea, Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: ratchakrit.sri@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

The study of muscular system serves as a basis for understanding the mechanical events that related to physiological functions of many organs. Locomotor movement is a characteristic of living systems which is responsible by skeletal muscle. Skeletal muscle accounts for approximately 40-45% of body weight and works to provide a structural framework for movement and postural maintenance. Cardiac muscle contracts to exert pressure in pumping blood out of the heart to the vascular system. Smooth muscle, a component in the wall of hollow viscera, acts by developing pressure to regulate blood flow in blood vessel, generating the movement of alimentary tract, and voiding the urine from the urinary bladder. Cardiac and smooth muscles, although regulated by the autonomic nervous system, contract automatically to perform intrinsically rhythmic contraction in response to internal environmental changes. The muscular system is, therefore, an important factor in maintenance of the body homeostasis.

Objectives

Students should be able to:

1. Describe the physiological properties of skeletal muscle, cardiac muscle, and smooth muscle
2. Compare and contrast the mechanisms of contraction and relaxation of skeletal muscle, cardiac muscle, and smooth muscle
3. Explain the factors that regulate functions and adaptations of skeletal muscle, cardiac muscle, and smooth muscle

Lecture Outline

1. Physiological properties
2. Regulation of contraction and relaxation
3. Contractile properties and force generation
4. Factors that regulate functions and adaptations

Learning Organization

1. Self-study before the class
2. Two-sessions of 2 h and 1 h lectures
3. 10 min questions and answers

Learning Materials

1. PowerPoint presentation/handout
2. Video record for review

Suggested Readings

1. Boron WF, Boulpaep EL. Medical Physiology. 3rd ed., 2016.

2. Barrett KE, Barman SM, Yuan J, Brooks HL. Ganong's Review of Medical Physiology. 26th ed., 2019.
3. Hall JE, Hall ME. Guyton and Hall Textbook of Medical Physiology. 14th ed., 2020.
4. Koeppen BM, Stanton BA. BERNE & LEVY Physiology. 8th ed., 2023.

Student Assessment

Written Examination 30 points

Updated June 18, 2024

Topic **Lab & Conference 1: Skeletal muscle functions**
Date Tuesday Aug 20, 2024 **Time** 09.00-12.00 PM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Assoc. Prof. Ratchakrit Srikuea, Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: ratchakrit.sri@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

Skeletal muscle contraction is controlled by nerve impulse sending from motor cortex located in the central nervous system. Nerve impulse is transmitted in the form of action potential to control skeletal muscle contraction. However, skeletal muscle contraction can be directly stimulated via electrical stimulation that mimic the generation of action potential as demonstrated in this laboratory to study skeletal muscle functions.

Objectives

Students should be able to:

1. Describe the effects of stimulation intensity and frequency on skeletal muscle tension
2. Define the factors that affect skeletal muscle fatigue
3. Explain the concept of force-length relationship on skeletal muscle tension

Laboratory Outline

1. Overview of skeletal muscle function study
2. Laboratory report and conference

Learning Organization

1. Study laboratory demonstration video clip and laboratory manual
2. Writing lab report on provided experimental data
3. Laboratory conference

Learning Materials

1. Laboratory demonstration video clip
2. Laboratory manual

Suggested Readings

Laboratory manual

Student Assessment

1. Student performance 50% (15 points)
   - In-class performance 7.5 points
   - Laboratory report 7.5 points
2. Post-conference Quiz 50% (15 points)

Updated June 18, 2024

Topic **Discussion 2: Property of skeletal muscle**
Date Friday Aug 23, 2024 **Time** 09:00 – 11:00 AM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Assoc. Prof. Ratchakrit Srikuea, Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: ratchakrit.sri@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

Skeletal muscles are heterogeneous, composing of different fiber types including slow, fast-oxidative, and fast-glycolytic. Each of which is characterized by a set of contractile and molecular properties. One of the remarkable features of skeletal muscle is its adaptability. The adaptation of skeletal muscle is diverse, and the magnitude of change is depended on many factors such as activity pattern, age, and muscle fiber type composition. This topic will provide the scientific evidence that help to understand how the physiological properties of skeletal muscle could be modified.

Objectives

Students should be able to:

1. Explain the fundamental knowledge of skeletal muscle properties and adaptation
2. Discuss the changes of skeletal muscle properties under overloading, disuse atrophy, and aging conditions

Discussion outline

1. Overview of skeletal muscle properties and adaptation
2. Skeletal muscle adaptation to overloading, disuse atrophy, and aging

Learning Organization

1. Self-study before the class
2. Two-hour of group discussion on the assigned topics

Learning Materials

Handout of the assigned topics

Suggested Readings

Schiaffino and Reggiani. Fiber types in mammalian skeletal muscles. Physiol Rev 91: 1447–531, 2011. (Read on page 1447-1453)

Student Assessment

1. In-class performance 50% (10 points)
2. Post-discussion quiz 50% (10 points)

Updated June 18, 2024

Topic **Lecture 10: Principle of CVS**
Date Wednesday August 26, 2024 **Time** 11.00 – 12.00 PM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Assoc. Prof. Tepmanas Bupha-Intr, DVM., PhD
Department of Physiology, Faculty of Science, Mahidol University
E-mail: tepmanas.bup@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

The cardiovascular system transports and distributes essential substances to tissues and removes metabolic byproducts. It plays the central mechanism in maintaining body homeostasis, such as regulation of body temperature, maintenance of fluid balance, and adjustment of O_2 and nutrient supply under various physiological states. Blood flow to every organ is essentially operated through the transport processes performed by the heart and blood vessels with the focus on maintenance of arterial blood pressure as a homeostatic parameter.

Objectives

Students should be able to:

1. Discuss the role of cardiovascular system in maintaining body homeostasis.
2. Discuss the structure-function relations of the circulatory system.
3. Discuss the arrangements of organ systems and the operating concept of cardiovascular system to achieve its main objective.
4. Explain the homeostatic concept of cardiovascular system.

Lecture Outline

1. Significance of the cardiovascular system in body homeostasis.
2. The structure-function relations of the circulatory system.
3. Operation concepts:
   3.1 Homeostasis of Mean Arterial Blood Pressure:
   3.2 Balance concept
   - Cardiac output
   - Total peripheral resistance
4. Cardiovascular control:
   - Negative feedback mechanism

Learning Organization

1. Lecture 40 min.
2. Question and answer 10 min.

Learning Materials

1. Transcript of lecture objectives and outline
2. Textbooks and References
3. Power point presentation of the lecture
4. Video record for review

Suggested Readings

1. Koeppen B.M. and Stanton B.A. (2018) Berne & Levy Physiology, 7th edition, Chapter 15: Overview of Circulation, pp. 301-303, MOSBY Elsevier, Philadelphia, PA, USA.

2. Rhoades RA and Bell DR. (2018) Medical Physiology: Principles for Clinical Medicine, 5th ed., Chapter 11: Overview of the Cardiovascular System and Hemodynamics, pp. 766-777, Wolters Kluwer/Lippencott Williams & Wilkins, China.

Student Assessment

Written Exam with short to moderate answer 10 points

Topic **Lecture 11: Hemodynamics**
Date Tuesday August 27, 2024 **Time** 09.00 – 10.00 AM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Assoc. Prof. Tepmanas Bupha-Intr, D.V.M., Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: tepmanas.bup@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

Hemodynamics are the dynamics of blood flow regulated by control systems to meet body homeostasis. Hemodynamics explains the physical laws that govern the flow of blood in the blood vessels. Disturbance in physical and physiological properties of blood flow can lead to cardiovascular abnormality.

Objectives

Students should be able to:

1. Discuss the relationship between pressure gradient, fluid flow, and resistance to flow
2. Describe factors determining the blood flow in terms of the Poiseuille's equation
3. Describe the pressure changes that occur as blood flows through a simple vascular network and relate them to the vascular resistance of the various vascular segments

Lecture Outline

1. Blood flow
    a. Pressure gradient and resistance
    b. Poiseuille's equation
    c. Reynold's number
2. Bernoulli's principle
3. Elastic properties of blood vessel
    a. Compliance
    b. Wall tension

Learning Organization

1. Flip-Class: Study the suggested reading materials in advance
2. 50-min class discussion

Learning Materials

1. Video clips: Fluid dynamics (By strong medicine)
2. PowerPoint: case discussion
3. Video record for review

Suggested Readings

1. Guyton AC and Hall JE. Textbook of Medical Physiology. 11th ed. Philadelphia: Elsevier Saunders, 2006.
2. Levick JR. An Introduction to Cardiovascular Physiology 4th ed. Arnold, London, 2003.

Student Assessment

Written Examination 10 points

Topic **Lecture 12: Electrophysiology of the heart**
Date Tuesday August 27, 2024 **Time** 10:00 AM – 12.00 PM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Assoc. Prof. Vitoon Saengsirisuwan, Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: vitoon.sae@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

The function of the heart is to pump blood through the vasculature. To serve as a pump, the ventricles must be activated by the proper electrical activation which includes the cardiac action potentials; the conduction of action potentials along specialized conducting tissues; excitability and the refractory periods; the modulating effects of the autonomic nervous system on heart rate, conduction velocity, and excitability. This lecture covers the processes that involve in the electrical activation of the heart.

Objectives

Students should be able to:

1. Explain the ionic basis of cardiac resting membrane potential, fast response action potential, and slow response action potential
2. Describe the mechanism and significance of action potential duration, diastolic depolarization, refractory periods, and conduction velocity
3. Identify the components and propagation pathway of cardiac electrical signals
4. Describe the sequence of activation of the heart and indicate the importance of timing of the various events to efficient function

Lecture Outline

1. Cardiac resting membrane potentials
    - Ionic gradients
    - Role of pumps and exchangers
2. Cardiac cell action potentials
    - Ionic basis of the fast response
    - Ionic basis of the slow response
3. Cardiac excitability
4. Conduction velocity
5. Propagation pathway of cardiac action potentials
6. Physiological changes in action potentials of the heart

Learning Organization

1. Study the suggested reading materials in advance
2. Two sessions of 50-min lecture
3. A session of 15-min class discussion

Learning Materials

1. Transcripts of lecture outline
2. PowerPoint lecture presentation
3. Video record for review

Suggested Readings

1. Koeppen BM and Stanton BA. Berne & Levy Physiology. 7th ed. Philadelphia: Elsevier, 2018.
2. Levick JR. An Introduction to Cardiovascular Physiology. 4th ed. Arnold: London, 2003.
3. Costanzo LS. Physiology. 6th ed. Philadelphia: Elsevier, 2018.
4. Hall JE. Guyton and Hall Medical Physiology. 13th ed. Philadelphia: Elsevier, 2016.

Student Assessment

Written Examination 20 points

Topic **Lecture 13: Electrocardiography**
Date Friday August 30, 2024 **Time** 09:00 – 10.30 AM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Assoc. Prof. Vitoon Saengsirisuwan, Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: vitoon.sae@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

Based on the sequence and the timing of the spread of depolarization and repolarization in the myocardium, small potential differences established between different portions of the heart. The electrocardiogram (ECG) is a measurement of potential differences, which can be detected by electrodes placed on the body surface and reflect the electrical activity of the heart.

Objectives

Students should be able to:

1. Describe the principle of dipole and apply the dipole principle for ECG recording
2. Draw a typical ECG record labeling the waves and indicate the timing of the electrical activation of cells following the sequence of activation of the heart
3. Indicate the ECG conventions of leads I, II and III as well as determine the mean electrical axis of a heart

Lecture Outline

1. Principles of Electrocardiography
2. Vectors and the sequence of activation
3. Electrodes and recording leads
4. Recording the dipole in a specific lead
5. ECG, the conduction system, and timing

Learning Organization

1. Study the suggested reading materials in advance
2. Two sessions of 40-min lecture
3. 10-min class discussion

Learning Materials

1. Transcripts of lecture outline
2. PowerPoint lecture presentation
3. Video record for review

Suggested Readings

1. Koeppen BM and Stanton BA. Berne & Levy Physiology. 7th ed. Philadelphia: Elsevier, 2018.
2. Hall JE. Guyton and Hall Medical Physiology. 13th ed. Philadelphia: Elsevier, 2016.

Student Assessment

Written Examination 15 points

Topic **Discussion 3: Electrophysiology & Hemodynamics**
Date Thursday August 29, 2024 **Time** 09.00 – 12.00 PM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Assoc. Prof. Vitoon Saengsirisuwan, Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: vitoon.sae@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Learning Objectives:

Students should be able to

1. Describe the relationships among the factors affecting blood flow.
2. List and describe the functions of the major ion channels participated in the excitability of cardiac muscle and nodal cells.
3. Explain the principle of electrocardiogram and discuss the factors that modulate the formation of an eletrocardiogram.
4. Explain how a pathological condition, myocardial ischemia, leads to changes in electrocardiogram.

Discussion Outline:

1. Relationships among the factors affecting blood flow.
2. Factors affecting the functions of cardiac muscle and nodal cells
3. Components of an electrocardiography
4. Modulation of an electrocardiography

Learning Organization:

1. Study & prepare the materials provided in advance
2. Review the leading questions, lecture handouts and suggested references before attending the class
3. Make a presentation to class on the assigned leading questions.
4. Participate in the discussion session

Learning Materials:

1. Leading questions
2. Textbooks and lecture handouts

Suggested Readings

Koeppen BM and Stanton BA. Berne & Levy Physiology. 7th ed. (Chapter 16: Elements of Cardiac Function) Philadelphia: Elsevier, 2018.

Student Assessment

1. Post-discussion quiz 50% (15 points)
2. Accuracy of the information that the students provide in class
3. Student participation & presentation 50% (15 points)

Topic **Lecture 14: Cardiac pump dynamics**
Date Monday Sep 2, 2024 **Time** 09.00 – 11.00 AM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Benjamin Ongnok, Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: Benjamin.ong@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

The heart serves as a dynamic and intricate pump, essential for maintaining circulatory homeostasis. Cardiac pump dynamics refer to the coordination between the mechanical and electrical processes that take place in all four chambers of the heart. Comprehending the way in which the structure, mechanical, and electrical activities of the heart are interconnected is essential for understanding how it carries out its vital function. A key aspect of the basal contractile force is length-dependent activation of cross-bridges by increasing the length of the individual sarcomere via Frank-Starling mechanism which is typically achieved during the end of diastole when the ventricles are filled with blood. The contractile capacity of the heart can be altered by either the hemodynamic loading conditions or the cellular inotropic state. The ability to alter muscle performance by modifying the inotropic state of individual cells is a characteristic feature of the physiological regulation of cardiac contraction.

Objectives

Students should be able to:

1. Explain the phases of the cardiac cycle and their physiological significance.
2. Describe the mechanical properties of cardiac muscle and their influence on heart function.
3. Interpret pressure-volume loops and their relevance to cardiac performance.
4. Analyze the determinants of cardiac output and factors affecting it.
5. Discuss the regulatory mechanisms involved in maintaining cardiac function.
6. Understand and interpret the cardiac function curve (Starling curve) and its implications.

Lecture Outline

1. Overview of the heart as a pump
2. Anatomical structure of the heart and mechanical properties of cardiac muscle
    a. Structure and function of the heart and cardiac muscle fibers
    b. Frank-Starling mechanism
    c. Excitation-contraction coupling
    d. Length-tension relationship and its impact on cardiac output
    e. Myocardial contractile machinery and contractility
3. Phases of the Cardiac Cycle
    a. Atrial and ventricular systole and diastole
    b. Pressure changes during the cardiac cycle
    c. Heart sounds
4. Determinants of cardiac output
    a. Stroke volume and heart rate
    b. Regulation of cardiac output
        i. Heterometric autoregulation

ii. Homeometric regulation

5. The ventricular pressure-volume relationship in the cardiac cycle
   a. Construction and interpretation of pressure-volume loops
   b. Key phases and their significance in cardiac performance
6. The cardiac function curve (Starling curve)
   a. Definition and significance of the Starling curve
   b. Relationship between preload and cardiac output
   c. Clinical implications of the Starling curve

Learning Organization

1. Read learning materials before the lecture
2. Two sessions of 50-min lecture
3. A session of 15-min class discussion
4. Osmosis video: Cardiac cycle

Learning Materials

1. Lesson plan including the objectives and lecture outline
2. Handout of the lecture presentation
3. Video record for review

Suggested Readings

1. Koeppen B.M. and Stanton B.A. (2018) *Berne & Levy Physiology*, 7th edition, Chapter 16: Elements of Cardiac Function, pp. 317-328, MOSBY Elsevier, Philadelphia, PA, USA.
2. Rhoades RA and Bell DR. (2018) *Medical Physiology: Principles for Clinical Medicine*, 5th ed., Chapter 13: Cardiac Muscle Mechanics and the Cardiac Pump, pp. 885-952, Wolters Kluwer/Lippencott Williams & Wilkins, China.

Student Assessment

Written Exam with short to moderate answer 20 points

Updated 18 June 2024

Topic **Lecture 15: Resistance, capillary and capacitance vessels**
Date Tuesday Sep 3, 2024 **Time** 09.00 – 11.00 AM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Assoc. Prof. Tepmanas Bupha-Intr, D.V.M., Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: tepmanas.bup@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

In the circulation, vascular system is made up of the vessels that carry blood through the body. The arteries and veins carry blood throughout the body, delivering oxygen and nutrients to the body tissues and taking away tissue waste matter. At the tissue, arteries bench into small vessel called capillary. Capillary is a small blood vessel from 5 to 10 micrometres (μm) in diameter, and having a wall one endothelial cell thick. These microvessels are the site of exchange of many substances with the interstitial fluid surrounding them.

Objectives

Students should be able to:

1. Discuss the basic relationships between cardiac output, systemic arterial pressure, and total peripheral resistance to the flow of blood
2. Discuss the relationships between stroke volume, heart rate, systemic vascular resistance, mean arterial pressure, pulse pressure, and vascular compliance
3. Describe the significance of capillary network on capillary flow
4. List the modes of transcapillary exchange
5. Discuss the physical factors governing fluid movement across the capillary membrane
6. Discuss the vasoactive substances generated from endothelial cells
7. Describe the function of the venous system as the blood reservoir
8. Explain the effects of external pressures on venous return
9. Explain the basis of the vascular or systemic function curve and factors affecting the curve

Lecture Outline

1. Where do the pressure and pressure gradients come from?
   Dissipation of energy across resistance vessels
   Hydrostatic pressure (weight of columns of blood)
   Recoil pressure and active changes in wall tension
2. Arterial elasticity
3. Determinants of the arterial blood pressure
   Mean arterial pressure
   Pulse pressure
4. Capillary network
5. Capillary blood flow
6. Transcapillary exchange
   a. Diffusion
   b. Capillary filtration
      - Balance of hydrostatic and osmotic forces
      - Disturbances in hydrostatic-osmotic balance
   c. Pinocytosis

7. Other functions of the endothelial lining
8. Basic features of the venous system
9. Factors that alter venous pressure and venous return
    a. Factors that influence blood flow in and out of the venous system
    b. Changes in blood volume
    c. External Pressures
10. The vascular or systemic function curve

Learning Organization

1. Study the learning materials provided in advance
2. Lecture 100 min.
3. Questions and answers 10 min.
4. Self-study

Learning Materials

1. Transcript of lecture objectives and outline
2. Textbooks and References
3. Power point presentation of the lecture
4. Video record for review

Suggested Readings

1. Koeppen BM and Stanton BA. *Berne & Levy Physiology*. 7th ed. (Chapter 17: Properties of the Vasculature, pp. 345-367, Philadelphia: Elsevier, 2018.
2. Boron WF and Boulpaep EL. *Medical Physiology*. 3rd Ed. Chapter 19: Arteries and Veins & Chapter 20: The Microcirculation, pp. 1066-1164. Philadelphia: Elsevier, 2017.
3. Rhoades R.A. and Tanner G.A. (2004) *Medical Physiology*, 2nd edition, Chapter 15: The Systemic Circulation, pp. 252-261, Lippencott Williams & Wilkins, Baltimore, MD, USA.

Student Assessment

Written Examination 20 points

Updated June 25, 2024

Topic **Lab & Conference 2: Mechanical heart model**
Date Thursday Sep 5, 2024 **Time** 09:00 – 12:00 PM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Assoc. Prof. Tepmanas Bupha-Intr, D.V.M., Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: tepmanas.bup@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

In order to understand the mechanism in regulating blood flow by cardiovascular system, study the function of cardiovascular system without the regulatory function of autonomic nervous system will provide the necessary knowledge. In this class, the student will observe the change in cardiovascular parameter during various factor changes in the mechanical heart model that mimic cardiovascular system but no homeostatic regulation.

Objectives

Students should be able to:

1. Explain the principle hemodynamic variables in determining the performance of the heart
2. Explain the changes in the cardiac performance when each variable is individually altered
3. Describe the significance of those variables on the function of the heart.
4. Differentiate the direct and indirect factors affecting the mean arterial blood pressure
5. Explain the relationship between mean arterial blood pressure and total blood flow under various simulated pathologic conditions

Laboratory Outline

1. Normal circulatory function, cardiac performance and blood pressure
2. Effect of changes in heart rate, contractility, venous pressure and total peripheral resistance on cardiac function and blood pressure
3. Effect of change in compliance of the artery on blood pressure
4. Effect of valvular lesions on cardiac performance

Learning Organization

1. Study the laboratory manual provided in advance
2. Lecture on experimental objectives for 50 min.
3. Laboratory exercise for 3.5 hours
4. Laboratory conference for 3 hours

Learning Materials

1. Mechanical Heart Model
2. Laboratory manual
3. Video record for review

Student Assessment

1. Pre-laboratory quiz 25 % (7.5 points, 15 mins)
2. Participation and performance 50 % (15 points)
3. Post lab & conference quiz 25 % (7.5 points, 15 mins)

Topic **Lecture 16: Cardiovascular control**
Date Fri Sep 6, 2024 **Time** 09.00 – 11.00 AM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Benjamin Ongnok, Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: Benjamin.ong@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

Cardiovascular control is a critical area of study in physiology, focusing on the mechanisms that regulate heart rate, blood pressure, and blood flow to ensure adequate perfusion of tissues under various physiological conditions. It involves complex interactions between neural, hormonal, and local factors that adjust cardiovascular function in response to internal and external stimuli. Neural and hormonal mechanisms are primarily involved in the control of central blood volume and arterial pressure. In addition to cardiac autoregulation, blood volume and arterial pressure are continuously monitored by stretch receptors located in the heart and major arteries which can further convey afferent signals to the cardiovascular center in the medulla oblongata. This center integrates the incoming sensory information with other afferent inputs, subsequently modulating the activity of the sympathetic and parasympathetic nervous systems. Furthermore, local vascular control systems also play a role in cardiovascular control. These mechanisms involve the reactions of vascular smooth muscle cells that surround arterioles and venules to different physical and chemical stimuli, resulting in changes in vascular resistance.

Learning Objectives

Students should be able to:

1. Describe the components and functions of the cardiovascular control system.
2. Explain the role of the autonomic nervous system in cardiovascular regulation.
3. Explain the mechanisms of baroreceptor and chemoreceptor reflexes.
4. Discuss the hormonal regulation of cardiovascular function.
5. Discuss the interaction between neural, hormonal, and local factors in cardiovascular control.

Content Outline

1. Introduction to Cardiovascular Control
    a. Overview of cardiovascular control
    b. Importance in maintaining homeostasis
2. Components of Cardiovascular Control
    a. Extrinsic control
        i. Neural influences on circulatory **control**
        ii. Humoral factors
    b. Intrinsic or local control
        i. Autoregulation and myogenic regulation
        ii. Endothelial factors: nitric oxide and endothelin
        iii. Metabolic regulation
3. Balance between extrinsic and intrinsic factors in regulation of peripheral blood flow
4. Coupling between the heart and the blood vessels
5. How does the cardiovascular control operate?

Learning Organization

1. Read learning materials before the lecture
2. Two sessions of 50-min lecture
3. A session of 15-min class discussion
4. Osmosis video: Baroreceptor

Learning Materials

4. Lesson plan including the objectives and lecture outline
5. Handout of the lecture presentation
6. Video record for review

Suggested Readings

1. Koeppen B.M. and Stanton B.A. (2018) *Berne & Levy Physiology*, 7th edition, Chapter 18: Regulation of the Heart and Vasculature & Chapter 19: Integrated Control of the Cardiovascular System, pp. 386-426, MOSBY Elsevier, Philadelphia, PA, USA.
2. Boron WF and Boulpaep EL. *Medical Physiology*. 3rd Ed. Chapter 25: Integrated Control of the Cardiovascular System, pp. 1370-1409. Philadelphia: Elsevier, 2017.
3. Rhoades RA and Bell DR. (2018) *Medical Physiology: Principles for Clinical Medicine*, 5th ed., Chapter 17: Control Mechanisms in Cardiovascular Function, pp. 1119-1172, Wolters Kluwer/Lippencott Williams & Wilkins, China.

Student Assessment

Written Exam with short to moderate answer 20 points

Updated 18 June 2024

Topic **Lecture 17: Cardiovascular response to exercise**
Date Monday Sep 9, 2024 **Time** 09.00 – 10.30 AM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Assoc. Prof. Vitoon Saengsirisuwan, Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: vitoon.sae@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

The cardiovascular system always operates in an integrated manner. One of the most enduring examples to understand the integrative functions of the cardiovascular system is by describing its responses to exercise. This lecture explains the mechanisms by which the body responds to exercise including changes in the autonomic nervous system and the local responses to modulate blood flow and oxygen delivery to several vascular beds.

Objectives

Students should be able to:

1. State the relationships between exercise intensity and major cardiovascular parameters.
2. Discuss the effects of dynamic exercise on the cardiovascular system and mechanisms involved.
3. Compare the cardiovascular responses to dynamic exercise with those to isometric exercise.
4. Indicate the effects of chronic exercise and physical conditioning on cardiovascular variables.

Lecture Outline

1. Definition of maximal oxygen consumption
2. Cardiovascular effects of dynamic exercise
3. Cardiovascular effects of isometric exercise
4. Effects of exercise training on cardiovascular variables

Learning Organization

1. Study the suggested reading materials in advance
2. 45-min lecture
3. 5-min class discussion

Learning Materials

1. Transcripts of lecture outline
2. PowerPoint lecture presentation
3. Video record for review

Suggested Readings

1. Boron WF and Boulpaep EL. *Medical Physiology*. 3rd Ed. Chapter 25: Integrated Control of the Cardiovascular System, pp. 1390-1402. Philadelphia: Elsevier, 2017.
2. Laughlin MH. *Cardiovascular response to exercise*. Am. J. Physiol. 277 (Adv. Physiol. Educ. 22): S244-S259, 1999.
3. Opie LH. *Heart Physiology: From cell to circulation*. 4th ed. Chapter 15: Cardiac Output and Exercise, pp. 460-484. Philadelphia: Lippincott Williams & Wilkins, 2004.

Student Assessment

Written Examination 15 points

Topic **Lecture 18: Body response to hemorrhagic hypotension**
Date Tuesday Sep 10, 2023 **Time** 09.00 – 10.30 AM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Assoc. Prof. Tepmanas Bupha-Intr, D.V.M., Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: tepmanas.bup@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Background & Synopsis

Hemorrhagic shock is a clinical syndrome resulting from decreased blood volume (hypovolemia) caused by blood loss, which leads to reduced cardiac output and organ perfusion. The reduction in blood volume during acute blood loss causes a fall in central venous pressure and cardiac filling. This leads to reduced cardiac output and arterial pressure. The body has a number of compensatory mechanisms that become activated in an attempt to restore arterial pressure and blood volume back to normal. However, severe loss of blood without proper treatment can lead to irreversible tissue failure.

Objectives

Students should be able to:

1. Differentiate hemorrhagic shock from other types of shock
2. Classify the different states of hemorrhage
3. Describe the pathophysiology during the early phase of different classes of hemorrhage
4. Explain the major organ systems involved in the compensatory mechanisms to blood loss
5. Explain the decompensatory mechanisms that are evident during hemorrhage

Lecture Outline

1. Types of shock
2. Hemorrhagic hypotension: classes and severity
3. Compensatory mechanisms (negative feedback mechanisms):
    - The baroreceptor reflexes
    - The chemoreceptor reflexes
    - Cerebral ischemia responses
    - Reabsorption of tissue fluids
    - Release of endogenous vasoconstrictor substances
    - Renal conservation of salt and water
4. Decompensatory mechanisms (positive feedback mechanisms):
    - Depression of the reticuloendothelial system
    - Cardiac failure
    - Acidosis
    - Central nervous system depression
5. Interactions of positive and negative feedback mechanisms

Learning Organization

1. Discussion 50 min.
2. Self-study

Learning Materials

1. Transcript of lecture objectives and outline
2. Textbooks and References
3. Power point presentation of the lecture
4. Video record for review

Suggested Readings

1. Koeppen BM and Stanton BA. Berne & Levy Physiology. 7th ed. (Chapter 19: Integrated Control of the Cardiovascular System, pp. 427-432, Philadelphia: Elsevier, 2018.
2. Boron WF and Boulpaep EL. *Medical Physiology*. 3rd Ed. Chapter 25: Integrated Control of the Cardiovascular System, pp. 1400-1408. Philadelphia: Elsevier, 2017.
3. Rhoades R.A. and Tanner G.A. (2004) *Medical Physiology*, 2nd edition, Chapter 15: The Systemic Circulation, pp. 252-261, Lippencott Williams & Wilkins, Baltimore, MD, USA.

Student Assessment

Written Examination 15 points

Updated June 25, 2024

Topic **Discussion 4: Factors affecting CVS function**
Date Friday Sep 13, 2024 **Time**; 09.00 – 12.00 PM
Room PR.401, Department of Physiology, Faculty of Science, Mahidol University
Lecturer Assoc. Prof. Tepmanas Bupha-Intr, D.V.M., Ph.D.
Department of Physiology, Faculty of Science, Mahidol University
E-mail: tepmanas.bup@mahidol.ac.th
Students Graduate students in the Program of Physiology and related Programs

Objectives

Students should be able to:

1. Correlate the cardiodynamics in term of the ventricular volume-pressure relationship
2. Differentiate between Heterometric Autoregulation (Starling law of the heart) and Homeometric Regulation
3. Discuss the different factors affecting the ventricular pressure-time curve
4. Discuss the postural effect on cardiovascular function and control
5. Correlate the relationship of stroke volume, heart rate and cardiac output and discuss the factors affecting each variable

Discussion Outline:

1. The cardiac pump cycle and the volume-pressure relationship
2. Starling law of the heart
3. Homeometric regulation of the heart
4. The cardiac function curve (the ventricular pressure-time curve)
5. Factors affecting the cardiac function curve
6. Relationships of stroke volume, heart rate and cardiac output

Learning Organization

1. Study & prepare the answers/discussion/presentation for the listed discussion questions/assignments provided in advance
2. Review the leading questions, lecture handouts and references before class
3. Class presentation and participation during the session

Learning Materials

1. Case scenarios with leading questions provided one week before the class
2. Textbooks and lecture handouts

Suggested Readings

1. Koeppen B.M. and Stanton B.A. (2018) *Berne & Levy Physiology*, 7th edition, Chapter 19: Integrated Control of the Cardiovascular System, pp. 410-432, MOSBY Elsevier, Philadelphia, PA, USA.
2. Boron WF and Boulpaep EL. *Medical Physiology*. 3rd Ed. Chapter 25: Integrated Control of the Cardiovascular System, pp. 1370-1409. Philadelphia: Elsevier, 2017.
3. Rhoades RA and Bell DR. (2018) *Medical Physiology: Principles for Clinical Medicine*, 5th ed., Chapter 17: Control Mechanisms in Cardiovascular Function, pp. 1119-1172, Wolters Kluwer/Lippencott Williams & Wilkins, China.

Student Assessment:

1. Student participation & presentation as listed in the rubric form 15 points
2. 15-20 minutes post-discussion quiz 15 points

Updated June 25, 2024