คณะวิทยาศาสตร์ มหาวิทยาลัยมหิดล

FACULTY OF SCIENCE, MAHIDOL UNIVERSITY

Course Syllabus

SCBM 261: Physiology for Medical Sciences 1

Course coordinator: Dr Chonlawan Saengjaroentham, Ph.D.

Credit Hour: 2(2-0-4)

Program: B.Sc. Program in Biomedical Science

Semester I, Academic Year: 2022

August 9, 2022 – December 9, 2022

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Course Syllabus and Lesson plan

SCBM 261: Physiology for Medical Sciences 1

Academic Year 2022 (1st semester)

August 9, 2022 – December 9, 2022

Course Title	:	Physiology for Medical Sciences 1
Course Code	:	SCBM 261
Total credit	:	2 (2-0-4)
Prerequisite	:	None

Course Description

Basic mechanisms underlying the function of the nervous and muscular systems including cell physiology, membrane potential and signal transmission, sensory and motor systems, autonomic nervous system, special sensory system, higher brain, muscular system; interaction of several systems in the body in order to maintain homeostasis.

Course Objectives

After completing this course, students should be able to:

1. Explain functional principles, regulation and factors influencing on homeostasis, feedback control systems, body fluids
2. Explain functional principles, regulation and factors influencing on cell, membrane transport, membrane potential and synaptic transmission
3. Explain functional principles, regulation, co-ordination and factors influencing on sensory system
4. Explain functional principles, regulation, co-ordination and factors influencing on motor system
5. Explain functional principles, regulation, co-ordination and factors influencing on autonomic nervous system
6. Explain functional principles, regulation, co-ordination and factors influencing on higher brain
7. Explain functional principles, regulation, co-ordination and factors influencing on muscular system

Course Overview

This course is designed to provide students with the fundamental concept and principles of various systems mentioned above. For an assessment, students are tested through theory exam and their participation

performance during lecture and group discussion sessions. Therefore, students are expected to actively participate in these activities both individually and team work.

Course Organization

The course was designed to use two types of learning processes, including lectures and group discussion.

1. Lectures: Lectures are primarily focused on the concepts/principles of organ system functions. Each lecturer will provide a transcript of his/her lecture. When appropriate, the lecturer will assign the students to read the suggested textbooks and original articles.
2. Group discussion: These include sessions of cell and neuronal physiology, sensory and motor system, autonomic nervous system and higher function of the nervous system, and muscular system. The questions, scenario and problems will be provided to students for preparation in advance. This session is designed to help students to develop analytical thinking. Students are expected to actively participate in class. The knowledge from each session will be included in the examination.

Teaching Materials

1. Text-books
2. Print copies of power point presentation
3. Lecture notes

Student Assessment

1. Examinations

The written examination will be conducted during midterm and final exam. The 70% or the 2.8 grade point of the total weight of score has been assigned for lectures. The examinations are short essay writing.

	% COUNT
Midterm Exam	35
Final Exam	35
SUM	**70% of TOTAL**

2. Quiz & Performance for Activities

The 30% or 1.20 grade point of the total weight of score has been set for these activities as following:

	% COUNT
Participation and attention	10

Group discussion 1: Cell and neuronal physiology	5
Group discussion 2: Sensory and motor system	5
Group discussion 3: ANS and higher brain function	5
Group discussion 4: Muscular system	5
SUM	**30% of TOTAL**

Student achievement will be graded according to the faculty and university standard using the symbols: A, B^+, B, C^+, C, D^+, D, and F.

Recommended Textbooks:

1. Boron WF, and Boulpaep EL. Medical Physiology, 2nd ed., Elsevier, 2009.
2. Berne PM, Levy MN, Koeppen BM and Stanton BA. Physiology, 5th ed., 2004.
3. Guyton AC and Hall JE, Textbook of Medical Physiology, 12th ed., Elsevier, 2011

Course co-ordinator	**E-mail**	**Room**	**Tel.**
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Course Lecturers

Physiology, Faculty of Science	**E-mail**
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Asst. Prof.Nattapon Panupinthu	nattapon.pan@mahidol.ac.th
Dr. Ratchaneevan Aeimlapa	ratchaneevan.aei@mahidol.ac.th
Dr. Chonlawan Saengjaroentham	chonlawan.sae@mahidol.ac.th
Dr. Ioannis Papadimitrou	ioannis.pap@mahidol.ac.th

Group discussion coordinators

Group Discussion 1	Dr. Ratchaneevan Aeimlapa
Group Discussion 2	Dr. Chonlawan Saengjaroentham
Group Discussion 3	Prof. Narattaphol Charoenphandhu
Group Discussion 4	Dr. Ioannis Papadimitrou

Department of Physiology, Faculty of Science, Mahidol University

Physiology for medical sciences I (SCBM 261) Semester 1/2022 for SCBM year 2

Date: Aug 9th, - Nov 22nd, 2022 (Tuesday) Room: SC1-152 Time: 9:00 am – 11:00 am

Course coordinator: Chonlawan Saengjaroentham, Ph.D. Tel: 02-201-5514

LESSON PLAN OF THE COURSE (SCBM 261/2022)

Date	Time	Topics	h	Instructor
Tue Aug 9	9:00-9:15 9:15–11:00	Course orientation L1: Homeostasis/body fluid	2	Chonlawan Nattapon
Tue Aug 16	9:00–11:00	L2: Cell & membrane physiology	2	Ratchaneevan
Tue Aug 23	9:00–11:00	L3: Synaptic transmission	2	Ratchaneevan
Tue Aug 30	9:00–11:00	*Group Discussion 1:* Cell physiology (2 groups)	2	Ratchaneevan (TA)
Tue Sep 6	9:00–11:00	L4: Somatosensory system	2	Chonlawan
Tue Sep 13	9:00–11:00	L5: Motor system	2	Chonlawan
Tue Sep 20	9:00–11:00	L6: Vision, L7: Hearing and balance	2	Narattaphol
Tue Sep 27	9:00–11:00	*Group discussion 2:* Sensory/motor system	2	Chonlawan (TA)
Oct 3-7		**Midterm exam**	3	**SIM**
Tue Oct 11	9:00–11:00	L8: Autonomic Nervous System	2	Narattaphol
Tue Oct 18	9:00–11:00	L9: Higher functions of the nervous system	2	Narattaphol
Tue Oct 25	9:00–11:00	*Group discussion 3:* ANS and higher functions of the NS	2	Narattaphol (TA)
Tue Nov 1	9:00–11:00	L10: Skeletal muscle	2	Ioannis
Tue Nov 8	9:00–11:00	L11: Cardiac and smooth muscle	2	Ioannis
Tue Nov 15	9:00–11:00	*Group discussion 4:* Muscle	2	Ioannis (TA)
Tue Nov 22	9:00–11:00	Wrap up/Q&A	2	Chonlawan/Ioannis
Nov 28 – Dec 9		**Final exam**	3	SIM

Lecture 1 **Homeostasis and body fluid**

Date/Time August 9th, 2022, 9:00 a.m. – 11:00 p.m. (2h)

Lecturer Nattapon Panupinthu, M.D., Ph.D.

Department of Physiology, Faculty of Science, Mahidol University

E-mail: nattapon.pan@mahidol.ac.th

Background & Synopsis:

Human body is a complex living organism organized from molecules, cells, tissues, organs and systems to the whole body. These levels of organization require controlling mechanisms as one functional individual. Our bodies also experience changes throughout the lifetime from the processes of development, growth, puberty and aging. In addition, external environment influences our behaviors and interactions. Coordination of regulatory processes inside the body is an important tool for maintaining the stability of our physical and mental health. Our internal environment must be monitored and corrected to achieve the steady state called homeostasis.

Learning Objectives:

Students should be able to:

1. Define homeostasis and describe its importance
2. Describe internal and external environments
3. Explain the composition of body fluid
4. Describe principles and application of feedback control systems

Contents Outlines:

1. Concept of homeostasis
2. Parameters related to internal and external environments
3. Composition of body fluid
4. Feedback control systems and disturbances

Learning Organization:

1. Read learning materials before the lecture
2. 100 minutes lecture using visual presentation
3. 20-minute questions & answers

Learning Materials Provided:

1. Lesson plan including the objectives and lecture outline

2. Handout of the lecture presentation

References:

1. Sherwood Human Physiology: From Cells to Systems. 2013. 8th Edition. Chapter 1: Introduction to Physiology and Homeostasis. Brooks/Cole Cengage Learning.
2. Boron and Boulpaep Medical Physiology. 2017. 3rd Edition. Chapter 1: Foundation of Physiology. Elsevier Saunders.

Student Assessment:

Written examination in short-answer type

Updated July 3rd, 2022

Lecture 2 **Cell and membrane physiology**

Date/Time August 16th, 2022; 9:00–11.00 a.m. (2 h)

Lecturer Ratchaneevan Aeimlapa, Ph.D.

Department of Physiology, Faculty of Science, Mahidol University

E-mail: ratchaneevan.aei@mahidol.ac.th

Background & synopsis

Membrane transport is essential to cellular functions and is divided into several modes including endocytosis, exocytosis, simple diffusion, facilitated diffusion, and active transport (primary and secondary). In addition to mediating substance exchange, membrane transport is important for regulation of resting membrane potential, which in turn controlling excitability of excitable cells including neurons and muscle cells.

Learning objectives

Students should be able to:

1. Describe different types of membrane transport.
2. Differentiate between passive and active transport and between passive diffusion and transport protein-mediated transport processes.
3. Use Nernst equation to calculate equilibrium potential and predict direction of ion flow.
4. Describe mechanisms generating resting membrane potential.
5. Describe importance of resting membrane potential
6. Describe mechanisms of action potential generation
7. Discuss factors affecting action potential propagation

Lecture outline

1. Membrane transport
2. Membrane potential
3. Nernst equation
4. Mechanisms generating resting membrane potential
5. Action potential
6. Factors affecting action potential propagation

Learning organization

1. Read learning materials before the lecture
2. 110 minutes lecture using visual presentation
3. 10 minutes questions and answers

Learning materials

1. Lesson plan, including the behavioral objectives
2. Lecture outline
3. Handout of the lecture presentation

Presentation materials

1. Visual presentation
2. Personal computer
3. LCD projector

Suggested readings

1. Koeppen BM, Stanton BA. BERNE & LEVY Physiology. Updated 6th ed., 2010.

Student assessment

MCQ and/or short essay writing

Updated July 15th, 2022

Lecture 3 **Synaptic transmission**

Date/Time August 23rd, 2022; 9:00–11:00 a.m. (2 h)

Lecturer Ratchaneevan Aeimlapa, Ph.D.

Department of Physiology, Faculty of Science, Mahidol University

E-mail: ratchaneevan.aei@mahidol.ac.th

Background & synopsis

Synaptic transmission is essential for the process of communication between two neurons. Synaptic transmission involves the release of the neurotransmitter, the binding of the neurotransmitter to the postsynaptic receptor, which trigger the functional response of the postsynaptic cell. The molecular mechanisms of neuronal synapses are similar, but not identical, to those of the neuromuscular junction.

Learning objectives

Students should be able to:

1. Describe the types of synapses
2. Explain the mechanisms of synaptic transmission
3. Differentiate the difference between excitatory postsynaptic potential (EPSP) vs. inhibitory postsynaptic potential (IPSP)
4. Explain the mechanism of postsynaptic neuronal integration
5. Explain the mechanism of how toxins and drugs affecting synaptic transmission

Lecture outline

1. Structural component of synapses
2. Mechanisms of synaptic transmission
3. Electrical events in postsynaptic neurons
4. Postsynaptic neuronal integration
5. Synaptic transmission at the neuromuscular junction
6. Toxins and drugs affecting synaptic transmission

Learning organization

1. Self-study of suggested reading materials before class
2. 110 minutes lecture using visual presentation
3. 10 minutes questions and answers

Learning materials

1. Lesson plan, including the behavioral objectives

2. Handout of the lecture presentation

Suggested readings

2. Koeppen BM, Stanton BA. BERNE & LEVY Physiology. Updated 6th ed., 2010.
3. Sherwood L, Human Physiology: From Cells to System, 9th ed., 2015.

Student assessment

MCQ and/or short essay writing

Updated July 15th, 2022

Group discussion 1 **Cellular physiology**

Date/Time August 30th, 2022; 9:00–11:00 a.m. (2 h)

Organizer Ratchaneevan Aeimlapa, Ph.D.

Department of Physiology, Faculty of Science, Mahidol University

Background & synopsis

Membrane transport is essential to cellular functions and is divided into several modes including endocytosis, exocytosis, simple diffusion, facilitated diffusion, and active transport (primary and secondary). In addition to mediating substance exchange, membrane transport is important for regulation of resting membrane potential, which in turn controlling excitability of excitable cells including neurons and muscle cells.

Learning objectives

Students should be able to:

1. Discussion modes of transports and their characteristics
2. Use Nernst equation to calculate equilibrium potential and predict direction of ion flow.
3. Describe mechanisms generating resting membrane potential.
4. Describe importance of resting membrane potential under physiological and pathological conditions
5. Discuss factors affecting action potential propagation

Discussion outline

1. Membrane transports and their properties
2. Membrane potential and Nernst equation
3. Mechanisms generating resting membrane potential and implications in physiological and pathological contexts
4. Action potential, factors affecting action potential propagation and implications in physiological and pathological contexts

Learning organization

1. Read learning materials and study assigned questions before the discussion
2. 110 minutes discussion
3. 10 minutes questions and answers

Learning materials

1. Lesson plan, including the behavioral objectives
2. Discussion outline

3. Handout of the lecture presentation

Presentation materials

1. Visual presentation
2. Personal computer
3. LCD projector

Suggested readings

4. Koeppen BM, Stanton BA. BERNE & LEVY Physiology. Updated 6th ed., 2010.
5. Sherwood L, Human Physiology: From Cells to System, 9th ed., 2015.

Student assessment

MCQ and/or short essay writing

Pre/post-class quiz

Updated July 15th, 2022

Lecture 4 **Somatosensory system**

Date/Time September 6th, 2022, 9:00 a.m. –11:00 p.m. (2h)

Lecturer Chonlawan Saengjaroentham, Ph.D.

Department of Physiology, Faculty of Science, Mahidol University

E-mail: chonlawan.sae@mahidol.ac.th

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.

Learning 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).

Contents Outlines:

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 learning materials before the lecture
2. Two 50-minute lecture sessions using visual presentations with a 10-minute break.
3. 10-minute questions & answers

Learning Materials Provided:

1. Lesson plan including the objectives and lecture outline

2. Handout of the lecture presentation

References:

1. Boron, W., & Boulpaep, E. L. (2016). Medical physiology. 3rd Edition, Chapter 15: Sensory Transduction, pp 924–935, Elsevier Health Sciences.
2. Koeppen, B. M., & Stanton, B. A. (2017). Berne and levy physiology. 7th Edition Chapter 7: The Somatosensory System Sensory, pp. 108–125, Elsevier Health Sciences.

Student Assessment:

MCQ and/or short written examination

Updated July 15th, 2022

Lecture 5 **Motor system**

Date/Time September 13th, 2022, 9:00 a.m. –11:00 p.m. (2h)

Lecturer Chonlawan Saengjaroentham, Ph.D.

Department of Physiology, Faculty of Science, Mahidol University

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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.

Learning 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

Contents Outlines:

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.

Learning Organization

1. Read the learning materials before the lecture.
2. Two 50-minute lecture sessions using visual presentations with a 10-minute break.
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. Boron, W., & Boulpaep, E. L. (2016). Medical physiology. 3rd Edition, Chapter 16: Circuits of the Central Nervous System, Elsevier Health Sciences.
2. Koeppen, B. M., & Stanton, B. A. (2017). Berne and levy physiology. 7th Edition Chapter 9: Organization of Motor Function, Elsevier Health Sciences.

Student Assessment

MCQ and/or short written examination

Updated July 15th, 2022

Lecture 6: **Vision**

Date/Time: Tue 20th August 2022 09.00–10.00 AM (1.0 h)

Lecturer: Prof. Narattaphol Charoenphandhu, M.D., Ph.D.

Department of Physiology, Faculty of Science, Mahidol University

E-mail: narattaphol.cha@mahidol.ac.th

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.

Learning 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.

Content Outlines:

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. 55 minutes lecture using visual presentation with in-class discussion
3. 5 minutes questions & answers

Learning Materials Provided:

1. Lesson plan
2. Handout of the visual presentation

Reference:

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

Student Assessment:

MCQ and/or short written examination

Updated: July 1st, 2022

Lecture 7 **Hearing and Balance**

Date/Time August 20th, 2022 10.00–11.00 AM (1.0 h)

Lecturer Prof. Narattaphol Charoenphandhu, M.D., Ph.D.

Department of Physiology, Faculty of Science, Mahidol University

E-mail: narattaphol.cha@mahidol.ac.th

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.

Learning 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.

Content Outlines:

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. 55 minutes lecture using visual presentation with in-class discussion
3. 5 minutes questions & answers

Learning Materials Provided:

1. Lesson plan
2. Handout of the visual presentation

Reference:

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

Student Assessment:

MCQ and/or short written examination

Updated: July 1st, 2022

Group discussion 2 **Sensory/motor system**

Date/Time September 27th, 2022, 9:00 a.m. –11:00 p.m. (2h)

Lecturer Chonlawan Saengjaroentham, Ph.D.

Department of Physiology, Faculty of Science, Mahidol University

E-mail: chonlawan.sae@mahidol.ac.th

Background & Synopsis:

The sensory system and motor system have coordinate functions to maintain balance of the body. The neural circuit in the higher brain centres and spinal cord coordinately control involuntary movement. The vestibular system is also play an important role in the body balance. The clinical examination in sensory system and motor system is necessary to detect the pathophysiology of neurological disorders.

Learning Objectives:

Students should be able to:

1. Discuss physiology of sensory systems and motor systems
2. Discuss coordination of sensory and motor system
3. Explain the clinical examination related to sensory and motor system defects

Discussion outline:

1. Fundamental concept of sensory systems and motor systems
2. Fundamental concept of sensory and motor system coordination
3. Fundamental concept of body balance

Learning organization:

1. Review lectures and related references.
2. Read and discuss the assigned questions before class.
3. Discuss and answer the leading questions.
4. Prepare for presentation and group discussion.

Learning materials and reference

1. Leading questions
2. Boron WF, Boulpaep EL. Medical Physiology, 2nd ed., Elsevier 2009.

Student assessment

1. Group's performance
2. In-class participation

3. In-class discussion
4. Post class quiz

Lecture 8: Autonomic Nervous System

Date/Time: October 11th, 2022 09.00–11.00 AM (2.0 h)

Lecturer: Prof. Narattaphol Charoenphandhu, M.D., Ph.D.

Department of Physiology, Faculty of Science, Mahidol University

E-mail: narattaphol.cha@mahidol.ac.th

Background & Synopsis:

Autonomic nervous system (ANS) mainly consists of the sympathetic and parasympathetic nervous system. It controls several functions of the visceral organs, such as heart, lung, stomach, intestine, kidney, etc. as well as certain tissues such as blood vessels and smooth muscle cells. Normally, signals from ANS originate from the brain stem or sacral spinal cord and are conveyed through preganglionic and postganglionic neurons. Several neurotransmitters, e.g., acetylcholine, norepinephrine, nitric oxide and ATP, are involved in ANS.

Learning Objectives:

Students should be able to:

1. Explain the organization of the visceral control system, including the sympathetic, parasympathetic and enteric nervous system.
2. Explain the synaptic physiology of ANS, for example acetylcholine from preganglionic neurons, norepinephrine from postganglionic sympathetic neurons, etc.
3. Explain the signaling pathways of nicotinic, muscarinic, adrenergic and dopaminergic receptors
4. Explain how central nervous system (CNS) controls the functions of visceral organs.
5. Explain the fight-or-flight response and interactions between cortical and autonomic function.

Lecture Outline:

1. Organization of the visceral control system
2. Sympathetic and parasympathetic system
3. Synaptic physiology of ANS
4. Signaling pathways of autonomic receptors
5. CNS control of the functions of visceral organs
6. Fight-or-flight response
7. Interactions between cortical and autonomic function

Learning Organization:

1. Read learning materials before the lecture
2. 110 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

References:

1. Boron WF, Boulpaep EL. Concise Medical Physiology (Chapter 14. The Autonomic Nervous System). Elsevier, Philadelphia. 2021.

Student Assessment:

MCQ and/or short written examination

Updated: July 1, 2022

Lecture 9 **Higher Functions of the Nervous System**

Date/Time October 18th, 2022 09.00–11.00 AM (2.0 h)

Lecturer Prof. Narattaphol Charoenphandhu, M.D., Ph.D.

Department of Physiology, Faculty of Science, Mahidol University

E-mail: narattaphol.cha@mahidol.ac.th

Background & Synopsis:

The higher functions of the nervous system often refer to learning, memory, numerical ability, calculation and most mental activities, such as reasoning, thinking and remembering. Certain volitional motor tasks, including purposeful movement, speaking, singing, etc. are parts of the higher functions. Some functions are connected to complex psychosocial behaviors (e.g., maternal behavior), sleep-wake cycle and mood. The present lecture also focuses on the plasticity of central synapses and its relevant electrophysiological and molecular events, e.g., long-term potentiation and hippocampal glutamate receptors

Learning Objectives:

Students should be able to:

1. Explain the term “higher functions” and give examples of higher cerebral functions.
2. Explain how the cerebral cortex organizes learning and memory.
3. Describe the mechanisms of long-term potentiation and synaptic plasticity.
4. Describe the motor speech and language functions of the cortex.

Lecture Outline:

1. Overview of higher cerebral functions
2. Learning and memory
3. Long-term potentiation (LTP) and hippocampal glutamate receptors
4. Motor speech and language

Learning Organization:

1. Read learning materials before the lecture
2. 110 minutes lecture using visual presentation with in-class discussion
3. 10 minutes questions & answers

Learning Materials Provided:

1. Lesson plan
2. Handout of the visual presentation

References:

1. Boron WF, Boulpaep EL. Concise Medical Physiology (Chapter 13. Synaptic Transmission in the Nervous System). Elsevier, Philadelphia. 2021.

Student Assessment:

MCQ and/or short written examination

Updated: July 1, 2022

Group discussion 3 ANS and Higher Functions of the Nervous System

Date/Time October 25th, 2022; 09.00–11.00 AM (2.0 h)

Lecturer Prof. Narattaphol Charoenphandhu, M.D., Ph.D.

Department of Physiology, Faculty of Science, Mahidol University

E-mail: narattaphol.cha@mahidol.ac.th

Background & Synopsis:

The forebrain—as the central center of higher functions—often influences autonomic nervous system (ANS) and vice versa. For example, a learning of stressful situation not only affects the limbic system in the forebrain but also modulate an autonomic outflow, leading to excessive gastric acid secretion and peptic ulcer. On the other hand, viscerosensory inputs from the internal organs—mostly through autonomic neurons profoundly alter a number of cortical functions, particularly those related to emotion and memory.

Learning Objectives:

Students should be able to:

1. Create a comprehensive presentation related to ANS and higher brain functions.
2. Explain and discuss the physiological roles of ANS.
3. Explain and discuss the higher functions of the nervous system.
4. Explain and discuss how the ANS influences the cortical functions and vice versa.

Lecture Outline:

1. Autonomic nervous system (ANS)
2. Higher functions of the nervous system

Learning Organization:

1. Read learning materials.
2. Students are divided into 6 group (11–12 students/group).
3. Each group is assigned to prepare a 15-min presentation before class (the leading questions and keywords are given at least 15 days before class).
4. In the class, delegate(s) of each group presents the contents (15 min/group).
5. After presentation, students are encouraged to ask questions and participate in discussion (5-min discussion).

Learning Materials Provided:

1. Lesson plan
2. Leading questions and keywords for preparation of presentation

References:

1. Boron WF, Boulpaep EL. Concise Medical Physiology (Chapters 13 and 14). Elsevier, Philadelphia. 2021.
2. Critchley HD, Harrison NA. Visceral influences on brain and behavior. Neuron. 2013;77(4): 624–638.

Student Assessment:

1. In-class assessment

Updated: July 1, 2022

Lecture 10 **Skeletal muscle**

Date/Time November 1st, 2022, 9.00 a.m. –11.00 a.m. (2 h)

Lecturer Ioannis Papadimitrou, Ph.D.

Department of Physiology, Faculty of Science, Mahidol University

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Background & synopsis

Skeletal muscle constitutes approximately 35% of total body mass. As skeletal muscle works under voluntary control, its function is essential in numerous activities such as locomotion, maintaining posture, speech and respiration. Under resting conditions, approximately 20% of cardiac output flows to skeletal muscle. During exercise this can increase to as much as 70%. Skeletal muscle is the most highly evolved form of muscle.

Learning Objectives:

Students should be able to:

1. Explain the functions and functional characteristics of skeletal muscle
2. Describe the sequence of skeletal muscle activation
3. Explain the excitation-contraction coupling process
4. Describe factors affecting muscle force production
5. Describe the energy sources for muscle contraction
6. Compare the properties of the three different skeletal muscle fiber types and their relationship to the activities
7. Explain how fatigue, hypertrophy and atrophy occur

Lecture outline:

1. Functional Charascteristics of Skeletal Muscle
2. Sequence of Skeletal Muscle Activation
3. Excitation Contraction Coupling
4. Biophysical Properties of Skeletal Muscle
5. Skeletal Muscle Types
6. Energy Sources and Metabolism
7. Skeletal Muscle Physiology in Health and Disease

Learning organization

1. Read learning materials before the lecture
2. 3 sessions of 50-minute lecture using visual presentation
3. 15 minutes questions and answers

Learning materials

1. Lesson plan, including the behavioral objectives
2. Lecture outline
3. Handout of the lecture presentation

Presentation materials

1. Visual presentation
2. Personal computer
3. LCD projector

Suggested readings

1. Berne and Levy Physiology. Koeppen, B.M., Stanton, B.A. 6th edition, 2008, Mosby Elsevier Science, Philadelphia, PA, Chapter 12, p. 233-255.
2. Medical Physiology. Boron, W.F., Boulpaep, E.L. Updated edition, 2005, Elsevier Saunders, Philadelphia, PA, Chapter 9, p. 230-254.
3. Medical Physiology: Principles for Clinical Medicine. Rhoades, R.A., Bell, D.R. 4th edition, 2013, Lippincott Williams & Wilkins, Baltimore, MD, Chapter 8, p. 138-157.

Student assessment

MCQ and/or short essay writing

Updated: 14 July 2022

Lecture 11 **Cardiac and smooth muscle**

Date/Time November 8th, 2022 9.00 a.m. –11.00 a.m. (2 h)

Lecturer Ioannis Papadimitrou, Ph.D.

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Background & synopsis

Contraction of cardiac muscle is involuntary, but the function of the highly organized cardiac muscle cells is essential for the pumping action of the heart. Smooth muscle is a non-striated muscle whose activity is controlled in a non-voluntary fashion. It lines the walls of hollow organs, blood vessels and ducts of secretory glands. Given the diversity of functions these various tissues fulfill, it is not surprising that there are many physiological differences between smooth muscle cells of different origins.

Learning Objectives:

Students should be able to:

5. Describe the characteristics of cardiac muscle as well as multiunit and unitary smooth muscles
6. Describe the differences in actomyosin regulation of cardiac, smooth and skeletal muscle and indicate the structural similarities in their respective contractile units
7. Explain the sequence of events leading to contraction of cardiac and smooth muscle
4. Explain the biophysical properties in cardiac and smooth muscle
5. Discuss the factors affecting contraction force in cardiac and smooth muscle

Lecture outline:

1. Control of cardiac and smooth muscle activity
2. Regulation of myoplasmic [Ca^{2+}]
3. Regulation of cardiac and smooth muscle contraction
4. Biophysical properties of cardiac and smooth muscle
5. Determinants of contractile force in cardiac and smooth muscle

Learning organization:

1. Read learning materials before the lecture
2. 3 sessions of 50-minute lecture using visual presentation
3. 15 minutes questions and answers

Learning materials:

1. Lesson plan, including the behavioral objectives
2. Lecture outline

3. Handout of the lecture presentation

Presentation materials:

1. Visual presentation
2. Personal computer
3. LCD projector

Suggested readings:

1. Berne and Levy Physiology. Koeppen, B.M., Stanton, B.A. 6th edition, 2008, Mosby Elsevier Science, Philadelphia, PA, Chapters 13-14, p. 256-285.
2. Medical Physiology. Boron, W.F., Boulpaep, E.L. Updated edition, 2005, Elsevier Saunders, Philadelphia, PA, Chapter 9, p. 230-254.
3. Medical Physiology: Principles for Clinical Medicine. Rhoades, R.A., Bell, D.R. 4th edition, 2013, Lippincott Williams & Wilkins, Baltimore, MD, Chapter 8, p. 158-165 and Chapter 13, p. 248-250.

Student assessment:

MCQ and/or short essay writing

Updated 14 July 2022

Group Discussion 3 Muscle

Date/Time November 25th, 2022, 9.00 a.m. –11.00 a.m. (2 h)

Lecturer Ioannis Papadimitrou, Ph.D.

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Background & synopsis

Skeletal muscles are heterogeneous, composing of different fiber types- 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 dependent on many factors such as activity pattern, age, and muscle fiber type composition. Experimental conditions provide examples of scientific evidence that help to understand how the physiological properties of mammalian muscle fibers could be modified.

Learning Objectives:

Students should be able to:

1. Describe adaptive changes in skeletal muscle contractile properties following compensatory overload and discuss the underlying mechanisms responsible for such changes
2. Discuss structural and physiological alterations in aging human skeletal muscle

Content outline

1. Physiological responses to compensatory overloaded skeletal muscle
2. Skeletal muscle adaptation to disuse and aging

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

Presentation materials

1. Visual presentation
2. Personal computer

3. LCD projector

Suggested readings

1. Berne and Levy Physiology. Koeppen, B.M., Stanton, B.A. 6th edition, 2008, Mosby Elsevier Science, Philadelphia, PA, Chapter 12, p. 233-255.
2. Medical Physiology. Boron, W.F., Boulpaep, E.L. Updated edition, 2005, Elsevier Saunders, Philadelphia, PA, Chapter 9, p. 230-254.
3. Medical Physiology: Principles for Clinical Medicine. Rhoades, R.A., Bell, D.R. 4th edition, 2013, Lippincott Williams & Wilkins, Baltimore, MD, Chapter 8, p. 138-157.

Student assessment

1. Pre- and post-discussion quizzes
2. Accuracy of the information that the students provide in class
3. Student participation & presentation