**BIOCHEMISTRY II lectures - Learning objectives**

**Clinical relevance and therapeutic targeting of DNA repair mechanisms**

1. Describe the different types of DNA repair mechanisms.
2. Compare and contrast different DNA repair mechanisms.
3. Associate DNA repair defects with human pathologies.
4. Provide examples of DNA repair-related therapeutic targets.

**Basic principles of regulation of the transcription of eukaryotic cells**

1. Describe the role of the transcription initiation complex.
2. Define control elements and explain how they influence transcription.
3. Distinguish between general and specific transcription factors.
4. Describe the function of transcription factors and their protein partners.
5. Explain the role of promoters, enhancers, activators, and repressors in

transcriptional control.

1. Explain how eukaryotic genes can be coordinately expressed.

**Mechanisms of cell cycle regulation and apoptosis**

1. Describe the roles of checkpoints, cyclins, and Cdks in the cell cycle control system.
2. Describe the internal and external factors that influence the cell cycle control system.
3. Explain how the abnormal cell division of cancerous cells escapes normal cell cycle controls.
4. Describe the molecular mechanisms of apoptosis.
5. Explain how cancer cells evade apoptosis.
6. Provide examples of therapeutic targeting of cell cycle deregulation and apoptosis inhibition in cancer cells.

**Carcinogenicity and nuclear receptors/ Carcinogenicity and cell signaling**

The learning objectives for studying the relationship between carcinogenicity, nuclear receptors, and signaling pathways include:

* Understanding the fundamentals of carcinogenesis and the factors that contribute to the development of cancer.
* Understanding the mechanisms of action of carcinogens and how they cause DNA damage and mutations.
* Understanding the different stages of carcinogenesis, including initiation, promotion, and progression.
* Understanding the role of nuclear receptors in regulating gene expression and cellular function, as well as their involvement in the development and progression of cancer.
* Students will also learn about the various environmental and genetic factors that can activate or disrupt nuclear receptor signaling, and how these changes can contribute to carcinogenesis.
* Understanding the mechanisms underlying the interaction between cell signaling pathways and carcinogenesis.
* Understanding the principles of cell signaling and how they relate to cancer development and progression.

 By gaining a deeper understanding of these concepts, students can develop the knowledge and skills needed to identify potential carcinogens, assess their risks, and develop effective strategies for preventing or treating cancer.

**Characteristics of cancer cells**

The learning objectives include:

* understanding the characteristics of cancer cells
* understanding the differences in their growth patterns, characteristics, and behavior, as well as the underlying causes of these differences
* the genetic and environmental factors that contribute to development of cancer cells
* the mechanisms of cancer cell growth and metastasis

By gaining a deeper understanding of these concepts, students can develop the knowledge and skills needed to effectively distinguish between cancer cells and healthy cells, and to develop targeted treatment strategies that improve patient outcomes.

**Immuno-Oncology and Cell Signaling**

* Understanding the basics of cancer biology and the role of the immune system in cancer development and progression.
* Understanding the signaling pathways involved in cell growth, differentiation, and death
* Understanding how these pathways are altered in cancer.
* Understanding the mechanisms underlying the interaction between cancer cells and the immune system.
* Understanding the challenges and opportunities associated with the development of immunotherapeutic agents and their clinical implementation.

**THEMATIC SECTION - Introduction to hormone biochemistry and the hormonal cascade system. Hormone receptors and signaling (M. Dalamaga)**

* Definition and functions of hormones
* Neuroendocrine system and endocrine glands
* Classification of hormones
* Hormone Receptors and Signaling
* Hormonal Properties
* Hormonal Cascade System
* Autoregulation and feedback mechanisms
* Circadian rhythms
* Determination of hormones in blood

**General Educational Goals: Students should be able to:**

* Understand the role of hormones and neuroendocrine system.
* Understand how hormones are classified based on their biochemical structure, their action to the target tissues and their molecular mechanism of action.
* Understand hormonal receptors and signaling.
* Understand the hormonal cascade system and important hormonal properties.

**Learning Objectives: Students should be able to answer the following questions OR to:**

* What are hormones?
* What are hormonal functions and effects on humans?
* What are endocrine glands?
* What are the differences between endocrine and exocrine glands?
* Which system coordinates metabolism in mammals?
* What is a neurotransmitter?
* How can hormones be classified?
* How can hormones be classified based on the way they get from their point of release to their target tissues?
* How can hormones be classified based on their chemical structure?
* How can hormones be classified based on their molecular mode of action?
* How do hormones act through cellular receptors?
* What are metabotropic and ionotropic surface receptors?
* What are the differences between water soluble and water insoluble hormones?
* Explain and interpret the main hormonal properties.
* How do autoregulation and feedback mechanism function?
* What are the neuroendocrine origins of hormone signals?
* What are hormonal cascades?
* What is a circadian rhythm? Provide examples.
* How do we measure hormones in the blood?

**THEMATIC SECTION - Calcium metabolism and homeostasis. Calciotropic hormones. Metabolic actions. Receptors and signaling (M. Dalamaga)**

* Role and distribution of calcium in the organism
* Calcium balance and circulation in blood
* Calcium metabolism, homeostasis and hormonal regulation
* Calciotropic hormones: parathyroid hormone, calcitonin and vitamin D
* Calciotropic hormones: biosynthesis, metabolic actions, receptors and signaling

**General Educational Goals: Students should be able to**

* Understand the role and distribution of calcium in the organism.
* Understand how calcium is regulated by hormones.
* Understand the metabolic actions and molecular mechanisms (receptors and signaling) of calciotropic hormones.

**Learning Objectives:** **Students should be able to answer the following questions OR to:**

* How is calcium distributed in the organism?
* What is the role of calcium?
* What are the food sources of calcium?
* What are the suggested daily calcium needs?
* What is calcium balance?
* How does calcium circulate in blood?
* How is calcium homeostasis achieved?
* Which hormones regulate calcium?
* What is the general chemical structure of parathyroid hormone (PTH)?
* Where is PTH synthesized?
* What are the main PTH circulating forms?
* How is PTH Secretion and Biosynthesis regulated?
* How do Calcium Sensing Receptors function?
* What are the main metabolic actions of PTH?
* How does PTH act on bone?
* How does PTH act on target tissues (receptors-signaling)?
* What are the role and function of Parathyroid Hormone related Protein (PTHrp)?
* What is the general chemical structure of calcitonin?
* Where is calcitonin synthesized?
* What are the main metabolic actions of calcitonin?
* How does calcitonin act on target tissues (receptors-signaling)?
* What is vitamin D?
* Where is vitamin D produced?
* Recognize the main sources of vitamin D.
* How is vitamin D synthesized and activated?
* Explain the main metabolic actions of calcitriol.
* What are calbindins?
* How does calcitriol act on target tissues (receptors-signaling)?
* Who are at risk of vitamin D deficiency?

**THEMATIC SECTION - Obesity - Biochemical regulation of body mass - Biochemistry of adipose tissue hormones. Receptors and signaling (M. Dalamaga)**

* Obesity: prevalence, definition, determination, classification, health risks
* Biochemical regulation of body mass
* Adipose tissue and adipocytes
* Main adipose tissue hormones
* Role of AMPK in Maintaining Energy Homeostasis
* Role of Peroxisome proliferator-activated receptors
* Gut hormones in short-term eating behavior
* Gut microbiome and obesity

**General Educational Goals: Students should be able to:**

* Understand the main aspects of obesity and the biochemical regulation of body mass.
* Understand the role and function of adipose tissue and adipose tissue hormones.
* Understand the role of critical enzymes and transcription factors in energy homeostasis.
* Understand the function of gut hormones in short-term eating behavior.
* Understand the role of gut microbiome in obesity.

**Learning Objectives:** **Students should be able to answer the following questions OR to:**

* Recognize the obesity pandemic.
* What are the causes of obesity?
* How is obesity defined?
* How is body mass measured?
* How is weight status classified based on WHO?
* What are the health risks associated with obesity?
* Is BMI a perfect measure for obesity?
* Are there other measures/indices of body mass?
* Explain the role of white and brown adipose tissue.
* Describe the function of white, brown and beige adipocytes.
* What is the fate of excess dietary calories?
* Which hormones are produced by the adipose tissue?
* Explain the metabolic role of leptin and its molecular mechanism of action (receptor and signaling).
* Which are the main neuropeptides that control appetite?
* Explain the metabolic role of adiponectin and its molecular mechanism of action.
* What is the role of AMPK in maintaining energy homeostasis?
* Explain how the mTORC1 Pathway Coordinates Cell Growth with the Supply of Nutrients and Energy.
* How does diet Regulate the Expression of Genes Central to Maintaining Body Mass?
* How do PPAR Isoforms Regulate Lipid and Glucose Homeostasis?
* What is the molecular mode of action of PPARs?
* How is short-term eating behavior influenced? Which are the main gut hormones in short-term eating behavior? Explain their function.
* What is the gut microbiome and its role?
* How do gut microbes influence Energy Metabolism and Adipogenesis?
* How can we alter gut microbiome and promote weight reduction?

**THEMATIC SECTION: Hypothalamic, pituitary and pineal hormones (M Katsianou)**

**Hypothalamic, pituitary and pineal hormones**

**Hypothalamus**

**Growth hormones**

**Lactation hormones**

**General Educational Goals: Students should be able to**

* Understand the structure of hypothalamic, pituitary and pineal hormones.
* Understand their biosynthesis and metabolism.
* Understand the mechanism of action and regulation of the hormones’ secretion.
* Understand their function in tissues and organs.
* Understand clinical correlations.

 **Learning Objectives**

* Define the hormones of the hypothalamus, pituitary gland and pineal gland.
* What is the molecular mechanism of action of hypothalamic-pituitary hormone?
* Which pituitary hormones are glycoproteins and what is their structure?
* What is the role of the growth hormone?
* What do you know about IGF-1?
* What are lactation hormones? Where are they produced and what are their actions?
* Which hormones play an important role in spermatogenesis?
* Describe the cellular mechanisms for T3 and T4 release into bloodstream.
* How FSH/LH secretion is regulated in women and in men?
* On which hormones does the ovarian cycle depend?
* Where is progesterone produced and what are its effects?
* Describe the molecular mechanism of action of ADH. What is the stimulus for its secretion?
* Where is melatonin biosynthesized and produced? Explain its functions.
* Explain hypopituitarism and precocious puberty.

**THEMATIC SECTION: Adrenal hormones (M Katsianou)**

**Cortex and adrenal medulla hormones Hypothalamus**

**Catecholamines**

**Cortisol secretion**

**Aldosterone**

**Androgens and estrogens**

**General Educational Goals: Students should be able to**

* Understand the structure of the cortex and adrenal medulla hormones.
* Understand their biosynthesis and metabolism.
* Understand their molecular mechanism action and regulation.
* Understand their action on tissues and organs.
* Understand their function through clinical examples.

**Learning Objectives**

* Which are the hormones of the cortex and marrow of adrenal glands?
* From which amino acids do catecholamines originate and describe their biosynthesis.
* What is the role of catecholamines?
* How does cortisol contribute to the synthesis of catecholamines?
* Define the molecular mechanism of action of catecholamines as well as the function of the catecholamine receptor.
* How is the action of catecholamines terminated?
* How is cortisol secretion regulated?
* What is the molecular mechanism of action of cortisol in the cell?
* Describe the metabolic and anti-inflammatory role of cortisol?
* Describe the renin-angiotensin-aldosterone axis.
* Which is the main stimulator of aldosterone secretion?
* Describe aldosterone?
* What is the vaginal natriuretic peptide?
* Explain the molecular mechanism of action of ANF.
* Define adrenal androgens. Where are androgens and estrogens produced in the organism.
* Which hormones regulate the water and electrolyte balance?
* Which hormones can cause arterial hypertension in hypersecretion?

**THEMATIC SECTION: Steroid hormones (M Katsianou)**

**Steroid Hormones**

**Steroid hormone receptors**

**Estrogens**

**General Educational Goals: Students should be able to**

* Understand the structure and biosynthesis of steroid hormones.
* Understand the molecular mechanism of action of steroid hormones in cells.
* Understand and identify receptors for steroid hormones.
* Understand their function through clinical examples.

**Learning Objectives**

* What are steroid hormones? Describe their biosynthesis.
* How are steroid hormones classified based on the number of their carbons?
* Explain StAR protein.
* Describe the molecular mechanism of action of steroid hormones.
* Explain the formation and secretion of 5α-reductase, aromatase and 18- aldosterone hydroxylase/synthase, 21-hydroxylase and 11-hydroxylase.
* Describe the main estrogens, their biosynthesis and function.
* Explain the transport of steroid hormones. How do steroid hormones circulate in the blood?
* Describe the model of steroid hormone action/the steroid receptor gene superfamily.
* Explain oral contraception.
* Define the categories of nuclear receptors. Which receptors belong to the extended family of receptors of steroid hormones?
* Explain the non-genomic effects of steroid hormones.
* Explain the action of glucocorticoids in suppressing immune and inflammatory responses mediated by cytokines.
* What you know about 11β-hydroxysteroid type 1 and 2 dehydrogenase?
* Explain the mechanisms of PCOS (Polycystic Ovarian Syndrome) in women.

**Metabolic correlations:**

**- Starve-feed cycle**

**- Mechanisms involved in the transduction of hepatic metabolism between well-fed and fasting states.**

**Learning Objectives**

* Understand and describe how glucose, amino acids and fat are disposed by various tissues in a well-fed state
* Understand and describe how diet supplies provide energy requirements in a well-fed state
* Understand and describe how blood glucose is maintained in the early fasting state through hepatic glycogenolysis
* Understand and describe how blood glucose is maintained in the early fasting state through hepatic glycogenolysis
* Understand and describe how gluconeogenesis occurs in the fasting state
* Describe metabolic interrelationships of major tissues in early fasting state
* Describe metabolic interrelationships of major tissues in fasting state
* Understand and describe how glucose homeostasis is maintained during different nutritional states
* Describe how allosteric effectors control hepatic metabolism in the well-fed state
* Describe how allosteric effectors control hepatic metabolism in the fasting state
* Describe how covalent modifications control hepatic metabolism in the well-fed state
* Describe how covalent modifications control hepatic metabolism in the fasting state
* Understand and describe how gene transcription is regulated in the well-fed and fasting state in the liver

**Metabolic correlations: Interrelationships of tissues in nutritional and hormonal states.**

**Learning Objectives**

* Understand and describe metabolic interrelationships of tissues in various nutritional, hormonal and disease states
* Understand and describe metabolic interrelationships of tissues in obesity
* Understand and describe metabolic interrelationships of tissues in dieting
* Understand and describe metabolic interrelationships of tissues in cancer
* Understand and describe metabolic interrelationships of tissues in exercise
* Understand and describe metabolic interrelationships of tissues in pregnancy
* Understand and describe metabolic interrelationships of tissues in lactation
* Understand and describe metabolic interrelationships of tissues in stress and injury
* Understand and describe metabolic interrelationships of tissues in liver disease
* Understand and describe metabolic interrelationships of tissues in kidney failure
* Understand and describe metabolic interrelationships of tissues in consumption of alcohol
* Understand and describe metabolic interrelationships of tissues in acidosis

**Metabolic correlations: Type 1 and 2 diabetes mellitus. Hyperglycemic-hyperosmotic coma.**

* Understand and describe metabolic interrelationships of tissues in type 2 diabetes mellitus
* Understand and describe metabolic interrelationships of tissues in type 1 diabetes mellitus
* Describe mechanisms of obesity and the metabolic syndrome
* Describe hyperglycemic-hyperosmotic coma

**Metabolic correlations: Polyol pathway and complications of Diabetes Mellitus**

* Understand and describe the polyol pathway
* Describe multi-organ complications of diabetes mellitus

**Lipid digestion:**

At the end of this lesson student should be able to define:

* Different kinds of dietary lipids
* Dietary sources of lipids
* The different sites of lipids digestion in the human body
* Hormones and/or enzymes involved in lipids digestion
* Role of Bile salts in lipids digestion
* The clinical significance of lipids digestion and absorbance

**Protein digestion:**

At the end of this lesson student should be able to define:

* Protein structure and dietary sources
* The different sites of protein digestion
* What is the Amino acids linkage?
* Classification of enzymes involved in proteins digestion
* How amino acids, Polypeptides and intact proteins are absorbed in the human body?
* The clinical significance of proteins digestion and absorbance.

**Carbohydrate digestion:**

At the end of this lesson student should be able to define:

* Dietary sources of carbohydrates
* To classify the carbohydrates present in human nutrition
* The different sites of carbohydrates digestion in the human body
* Classification of enzymes involved in the carbohydrates digestion and their site of action.
* The clinical significance of carbohydrates digestion and absorbance.