The American Physiological Society
Medical Curriculum Objectives Project
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Endocrinology and Metabolism

General Principles

EN 1. Explain the principle of negative feedback control of hormone secretion.

EN 2. Explain the principles of positive feedback and feed forward control of hormone secretion.

EN 3. Explain the bases of hormone measurements; e.g., radio-immuno assay, ELISA.

EN 4. Contrast the terms endocrine, paracrine, and autocrine based on the site of hormone release and the pathway to the target tissue. Provide an example of each, and describe major differences in mechanisms of action of peptides working through membrane receptors and steroids, vitamin D, and thyroid hormones working through nuclear receptors.

EN 5. Define hormone, target cell, and receptor.

EN 6. Compare and contrast hormone actions that are exerted through changes in gene expression with those exerted through changes in protein phosphorylation.

EN 7. Understand the effects of plasma hormone binding proteins on access of hormones to their sites of action and degradation and on the regulation of hormone secretion.

EN 8. Explain the effects of secretion, excretion, degradation, and volume of distribution on the concentration of a hormone in blood plasma.

Pituitary Gland - Posterior

EN 9. Contrast the anterior and posterior pituitary lobes with respect to cell types, vascular supply, development, and innervation.

EN 10. List the target organs or cell types for oxytocin and describe its effects on each.

EN 11. Name the stimuli for oxytocin release during parturition or lactation.

EN 12. List the target cells for vasopressin and explain why vasopressin is also known as antidiuretic hormone.

EN 13. Describe the stimuli and mechanisms that control vasopressin secretion

EN 14. Identify disease states caused by a) over-secretion, and b) under-secretion of vasopressin

and list the principle symptoms of each.

Pituitary Gland - Anterior

EN 15. Describe the biosynthesis, structure, and actions of the glycoprotein hormones FSH, LH, and TSH.

EN 16. Describe the biosynthesis, structure, actions, and metabolism of the GH/prolactin family.

EN 17. Describe the biosynthesis, structure, and actions of the POMC family: ACTH, MSH, β-lipoprotein, β-endorphin.

EN 18. Identify appropriate hypothalamic factors that control the secretion of each of the anterior pituitary hormones, and describe their route of transport from the hypothalamus to the anterior pituitary.

EN 19. Diagram the short-loop and long-loop negative feedback control of anterior pituitary hormone secretion. Predict the changes in secretory rates of hypothalamic, anterior pituitary, and target gland hormones caused by over-secretion or under-secretion of any of these hormones or receptor deficit for any of these hormones.

EN 20. Explain the importance of pulsatile and diurnal secretion.

Thyroid Gland

EN 21. Identify the steps in the biosynthesis, storage, and secretion of tri-iodothyronine (T_3) and thyroxine (T_4) and their regulation.

EN 22. Define "iodine pool". Describe the distribution of iodine and the iodide metabolic pathway. Relate the distribution of radioiodide in the body to thyroid hormone synthesis, metabolism, and excretion.

EN 23. Describe factors that control the synthesis, storage, and release of thyroid hormones. Explain the importance of thyroid hormone binding in blood on free and total thyroid hormone levels.

EN 24. Understand the significance of the conversion of T_4 to T_3 and reverse T_3 (rT_3) in extra-thyroidal tissues.

EN 25. Describe the actions of thyroid hormones on development and metabolism.

EN 26. Understand the causes and consequences of a) over-secretion and b) under-secretion of thyroid hormones. Explain why either condition can cause an enlargement of the thyroid gland.

Parathyroid Gland

EN 27. Know the cells of origin for parathyroid hormone, its biosynthesis, and mechanism of transport within the blood (bound or free).

EN 28. List the target organs and cell types for parathyroid hormone and describe its effects on each.

EN 29. Describe the functions of the osteoblasts and the osteoclasts in bone remodeling and the factors that regulate their activities.

EN 30. Identify the time course for the onset and duration for each of the biological actions of parathyroid hormone.

EN 31. Describe the regulation of parathyroid hormone secretion and the role of the calcium-sensing receptor.

EN 32. Understand the causes and consequences of a) over-secretion, and b) under-secretion of parathyroid hormone.

EN 33. Identify the sources of vitamin D and diagram the biosynthetic pathway and the organs involved in modifying it to the biologically active $1,25(OH_2)D_3$ (1-25 dihydroxy cholecalciferol).

EN 34. Identify the target organs and cellular mechanisms of action for vitamin D.

EN 35. Describe the negative feedback relationship between the parathyroid hormone and the biologically active form of vitamin D [$1,25(OH_2)D_3$].

EN 36. Describe the consequences of vitamin D deficiency and vitamin D excess.

EN 37. List the cell of origin and target organs or cell types for calcitonin.

EN 38. Name the stimuli that can promote secretion of calcitonin.

EN 39. Describe the actions of calcitonin and identify which (if any) are physiologically important.

Adrenal Gland

EN 40. Identify the functional zones (one medullary and three cortical zones), innervation, and blood supply of the adrenal glands and the principal hormones secreted from each zone.

EN 41. Describe the biosynthesis of the adrenal steroid hormones (glucocorticoids, mineralocorticoids, and androgens) and the key structural features that distinguish each class.

EN 42. Understand the cellular mechanism of action of adrenal cortical hormones.

EN 43. Identify the major actions of glucocorticoids on metabolism and the target organs on which they are produced.

EN 44. Describe the actions of glucocorticoid hormones in injury and stress.

EN 45. Describe the components of the neuroendocrine axis that control glucocorticoid secretion and describe how factors in the internal and external environment influence the neuroendocrine axis.

EN 46. Identify the causes and consequences of a) over-secretion and b) under-secretion of glucocorticoids and adrenal androgens.

EN 47. List the major mineralocorticoids and identify their biological actions and target organs or tissues.

EN 48. Name the physiological stimuli that cause increased mineralocorticoid secretion. Relate these stimuli to regulation of sodium and potassium excretion. List the factors can modulate the secretory response and explain how they are detected.

EN 49. Identify the causes and consequences of a) over-secretion and b) under-secretion of mineralocorticoids.

EN 50. Diagram the negative feedback control of aldosterone secretion.

EN 51. Identify the chemical nature of catecholamines, their biosynthesis, mechanism of transport within the blood, and how they are degraded and removed from the body. Identify how the structure of norepinephrine differs from epinephrine.

EN 52. Describe the biological consequences of activation of the adrenal medulla and identify the target organs or tissues for catecholamines along with the receptor subtype that mediates the response. Understand the mechanism by which epinephrine and norepinephrine can produce different effects in the same tissues. Explain the change in the ratio of epinephrine to norepinephrine release from the adrenal medulla during sympathetic activation (fight and flight), or in prolonged food deprivation.

EN 53. Name the key stimuli causing catecholamine secretion. List the factors that can modulate

a) the secretory response and b) the responses of target tissues.

EN 54. Describe the interactions of adrenal medullary and cortical hormones in response to stress.

EN 55. Identify disease states caused by an over-secretion of adrenal catecholamines.

Pancreas

EN 56. Identify the major hormones secreted from the endocrine pancreas, their cells of origin, and their chemical nature.

EN 57. List the target organs or cell types for glucagon and describe its principal actions on each.

EN 58. Identify the time course for the onset and duration of the biological actions of glucagon.

EN 59. Describe the control of glucagon secretion.

EN 60. List the major target organs or cell types for insulin, the major effects of insulin on each, and the consequent changes in concentration of blood constituents.

EN 61. Identify the time course for the onset and duration for the biological actions of insulin.

EN 62. Understand the relationship between blood glucose concentrations and insulin secretion. Describe the roles of neural input and gastrointestinal hormones on insulin secretion. List the factors that modulate the secretory response.

EN 63. Identify disease states caused by: a) over-secretion, b) under-secretion of insulin, or c) decreased sensitivity to insulin, and describe the principal symptoms of each.

Growth

EN 64. Describe the relationship between growth hormone and the insulin-like growth factors and their binding proteins in the regulation of growth.

EN 65. Understand the regulation of growth hormone secretion. Identify the roles of hypothalamic factors and IGF-I.

EN 66. Identify the target organs or cell types for insulin-like growth factors that account for longitudinal growth.

EN 67. Explain how thyroid, gonadal, and adrenal hormones modulate growth.

EN 68. Understand the nature and actions of local growth factors: epidermal growth factor, nerve growth factor, platelet-derived growth factor, and angiogenic and antiangiogenic factors.

Endocrine Integration of Energy and Electrolyte Balance

EN 69. Identify the normal range of plasma glucose concentrations, and list the chemical forms and anatomical sites of storage pools for glucose and other metabolic substrates.

EN 70. Identify the hormones that promote the influx and efflux of glucose, fat, and protein into and out of energy storage pools and their impact on the uptake of glucose by tissues. Establish specific roles for insulin, glucagon, glucocorticoids, catecholamines, growth hormone, and thyroid hormone.

EN 71. Describe the changes in metabolic fuel utilization that occur in long- and short-term fasting and in acute and sustained exercise. Understand how increases or decreases in hormone secretion produce these changes.

EN 72. Describe the role of appetite and metabolic rate in the maintenance of long-term energy balance and fat storage. Identify the factors that regulate appetite and fuel oxidation.

EN 73. Identify the normal range of dietary sodium intake, sodium distribution in the body, and routes of sodium excretion. Explain the roles of antidiuretic hormone, aldosterone, angiotensin, and atrial natriuretic hormone in the regulation of sodium balance.

EN 74. Identify the normal range of dietary potassium intake, potassium distribution in the body, and routes of potassium excretion. Explain how acute changes in aldosterone, insulin, and acid/base concentrations affect the plasma potassium concentration and the movement of potassium into and out of the intracellular compartment. Explain the chronic regulation of body potassium balance and plasma potassium levels by aldosterone through its actions on renal excretion, intestinal excretion, and dietary appetite/absorption.

EN 75. Identify the normal range of dietary calcium intake, calcium distribution in the body, and routes of calcium excretion. Explain the regulation of the plasma calcium concentration by parathyroid hormone, vitamin D, and calcitonin based on exchange with bone, renal excretion, and intestinal excretion and/or absorption.

EN 76. Identify the normal range of dietary phosphate intake, phosphate distribution in the body, and routes of phosphate excretion. Explain the regulation of the plasma phosphate concentration by parathyroid hormone, vitamin D, and calcitonin based on exchange with bone, renal excretion, intestinal excretion and/or absorption.

Reproductive Physiology - Male

EN 77. Describe the physiological functions of the major components of the male reproductive tract.

EN 78. Describe spermatogenesis and the role of different cell types in this process.

EN 79. Describe the endocrine regulation of testicular function: the role of the GnRH pulse generator, FSH, LH, testosterone, and inhibin.

EN 80. Identify the cell of origin for testosterone, its biosynthesis, mechanism of transport within the blood, how it is metabolized and how it is eliminated. List other physiologically produced androgens.

EN 81. List the target organs or cell types for testosterone and describe its effects on each.

EN 82. Describe the cellular mechanisms of action for testosterone.

EN 83. List the neural, vascular, and endocrine components of the erection and ejaculation response.

EN 84. Identify the causes and consequences of over-secretion and under-secretion of testosterone for a) prepubertal and b) postpubescent males.

EN 85. Compare and contrast the actions of testosterone, dihydrotestosterone, estradiol, and Müllerian inhibitory factor in the development of the male and female reproductive tracts.

Reproductive System - Female

EN 86. Describe oogenesis and its relationship to changes in the ovarian follicle. Explain the roles of FSH, LH, estradiol, inhibin, and paracrine agents in oogenesis and follicular maturation.

EN 87. Describe ovulation and the formation and decline of the corpus luteum and the roles of pituitary hormones in each of these processes.

EN 88. Describe the hormonal regulation of estrogen and progesterone biosynthesis and secretion by the ovary. Identify the cells responsible for their biosynthesis, the mechanism of their transport in the blood, and how they are degraded and removed from the body.

EN 89. List the target organs or cell types for estrogen action and describe its effects on each.

EN 90. Describe the cellular mechanisms of action for estrogen.

EN 91. List the principal physiological actions of progesterone, its target organs or cell types, and describe its effects on each and the importance of "estrogen priming."

EN 92. Describe the cellular mechanisms of action for progesterone.

EN 93. With time on the x-axis, diagram the changes in the endometrium and the ovary seen during the menstrual cycle and correlate these changes with changes in blood levels of FSH, LH, estradiol, progesterone, and inhibin. Describe how the changes in ovarian steroids produce the proliferative and secretory phases of the uterine endometrium and menstruation and the changes in basal body temperature during the menstrual cycle.

EN 94. Trace the pathways of sperm and egg transport that can result in fertilization and the movement of the fertilized embryo to the uterus.

EN 95. List the protein hormones secreted by the placenta and describe the role of human chorionic gonadotropin (hCG) in the rescue of the corpus luteum in maintaining pregnancy early post-implantation.

EN 96. Describe the interactions between the placenta and the fetal adrenal cortex in the production of estrogens during pregnancy.

EN 97. Discuss the roles of oxytocin, relaxin, and prostaglandins in the initiation and maintenance of parturition.

EN 98. Explain the role of estrogens, progesterone, placental lactogen, prolactin, and oxytocin in mammary gland development during puberty, pregnancy, and lactation.

EN 99. Explain the basis for the inhibition of milk secretion during pregnancy and the initiation of lactation after parturition.

EN 100. Differentiate between milk secretion and milk ejection, and describe the hormonal regulation of both during lactation, including the role of suckling.

EN 101. Explain the physiological bases for the antifertility actions of contraceptive steroid hormones.

EN 102. Describe the age-related changes in the male and female reproductive systems, including the mechanisms responsible for these changes, at the following times:

a. In utero development
b. Puberty
c. Senescence