Biosynthesis of peptide and steroid hormones

Science, Biology

Biosynthesis of Peptide and Steroid Hormones - Biosynthesis of Peptide and Steroid Hormones Introduction: Hormones are chemical messengers synthesized by endocrine organs and released directly into the blood stream and are carried to distant target organs. Hormones are classified into hydrophilic and lipophilic molecules on the basis of their solubility. Hormones are also classified on the basis of their chemical structures into steroids, peptides and amines. Peptide Hormones: The majority of hormones synthesized in the body are polypeptides and proteins. The number of amino acids constituting the hormones can range from three to up to 50. Peptide hormones mediate diverse effects on the body and have a range of target areas and sites of synthesis. The first step involved in the formation of peptide hormones is transcription which results in the formation of a heterogeneous nuclear RNA that is spliced and translated into a peptide chain having a characteristic amino acid sequence. The inactive precursors formed have a single sequence on their N-terminus which binds to signal recognition particles in a GTP dependent process and thereby direct the ribosomes to the rough endoplasmic reticulum. A prohormone is formed by splitting off a single peptide by a single peptidase when the growing peptide chain is transferred to the ER. After formation, the prohormone is folded and undergoes post translational modifications such as disulphide bond formation and glycosylation. At this stage, the cleavage of certain substrates of prohormone convertases occurs however, a major portion of post translational processing occurs in the trans-Golgi network or in the secretory pathway. The folded prohormones are packed in vesicles and are transferred from the ER to the Golgi apparatus. In trans cisternae of the Golgi apparatus,

processes such as phosphorylation and sulphation occur. The process of sulphation is mediated by a tyrosyl protein sulphotransferase. The resulting prohormones are packed into secretory vesicles. Once inside the vesicles, the prohormones are converted into biologically active hormones which are released into the blood stream upon the arrival of an appropriate stimulus. (HUGHES 2009). Steroid Hormones: The precursor of all classes of steroid hormones is cholesterol. Glucocorticoids, mineralocorticoids, and sex hormones are all synthesized from cholesterol. The adrenal cortex, ovaries, testes, and placenta are the sites of synthesis and secretion of steroid hormones. The first step in the synthesis of steroid hormones is the shortening of the cholesterol chain and its subsequent hydroxylation. The conversion of cholesterol into 21-carbon pregnenolone is the initial and the rate limiting step in the formation of steroid hormones. The reaction is catalyzed by a cytochrome P450 mixed function oxidase present in the inner mitochondrial membrane and is known as cholesterol side-chain cleavage enzyme complex (desmolase, P450scc). The movement of cholesterol substrate into the inner mitochondrial membrane is mediated by steriodogenic acute regulatory protein. The next step in the formation of steroid hormones involves oxidation and isomerization of pregnenolone to progesterone. Hydroxylation of progesterone in ER and mitochondria results in the formation of steroid hormones. The enzymes involved in hydroxylation are CYP proteins. Once formed, the steroid hormones owing to their lipid solubility diffuse through the cell membrane and enter the blood stream. (HARVEY et al 2011). Similarities: The synthesis of peptide and steroid hormone is not a direct process and involves a series of inter depended

enzymatically controlled reactions. Both classes of hormones are initially synthesized as biologically inactive molecules which are later converted into biologically active molecules. The biosynthesis of peptide and steroid hormones involves a set of complex reactions and each of these reactions is controlled by enzymes. Differences: The biosynthesis of peptide and steroid hormones is as different as the composition and function of the respective hormones. The major difference between the synthesis of peptide and steroid hormones is their site of formation, the former is synthesized on the ribosomes of the ER while the latter is formed through stepwise modification of cholesterol in various intracellular compartments. The synthesis of peptide hormones involves the transcription of DNA and translation of the formed heterogeneous RNA. On the other hand, the synthesis of steroid hormones does not involve the processes of transcription and translation. The core molecules from which the peptide hormones are synthesized are amino acids whereas the steroid hormones are synthesized from cholesterol. The peptide hormones are segregated from intracellular proteins within membrane enclosed compartments from the time the hormones are synthesized until their secretion. On the other hand, steroid hormones are lipid soluble so cannot be segregated in membrane bound compartments. The peptide hormones are synthesized as larger proteins known as preprohormones which are not biologically active. The preprohormones are cleaved smaller proteins called prohormones in the ER. Prior to their secretion, the prohormones are converted into biologically active molecules inside storage vesicles. The synthesis of steroid hormones does not involve such processes. Another major difference between the biosynthesis of steroid and peptide

hormones is the excessive modification which occurs in the case of peptide hormones. The prohormones undergo excessive post translational modification in the Golgi apparatus, while the synthesis of steroid hormones involves only minor modification processes. The peptide hormones are secreted from the cell of origin through exocytosis while, steroid hormones simply diffuse across the cell membrane. Lastly, the biosynthesis of steroid hormones is regulated by the demand of the hormone because unlike peptide hormones, steroid hormones are not stored within the steriodogenic cells. On the other hand, the rate of synthesis of hydrophilic peptide hormones is depended upon the release of presynthesized stored hormone. Lipophilic steroid hormones mediate their physiological effects by either entering the target cells or interacting with the nucleus to modulate gene expression or they act by interacting with ligand gated ion channels present in the cell membrane. The peptide hormones mediate the activities of the target cells through interaction with characteristic membrane receptors which activates second messenger systems. (GARRETT et al 2009).

References: HUGHES, A. B. (2009). Amino acids, peptides, and proteins in organic chemistry. Weinheim, Wiley-VCH. HARVEY, R. A., & FERRIER, D. R. (2011). Lippincott's illustrated reviews: Biochemistry. Philadelphia, Wolters Kluwer Health. GARRETT, R. H., & GRISHAM, C. M. (2009). Biochemistry. Australia [u. a.], Brooks/Cole, Cengage Learning.