IOSR Journal Of Pharmacy And Biological Sciences (IOSR-JPBS)
e-ISSN:2278-3008, p-ISSN:2319-7676. Volume 16, Issue 2 Ser. I (Mar. – Apr. 2021), PP 71-78
www.iosrjournals.org

An Introduction to Developmental Cognitive Neuroscience and the Origin to Neuroendocrinology

Dr. Prahalad Kumar Meena
Assistant Professor
Department of Zoology, Government College Karauli, Rajasthan

ABSTRACT- *The study of interactions between the neurological and endocrine systems is known as neuroendocrinology. The brain, spinal cord, ganglia, and nerves make up the nervous system. Neurotransmitters are the primary means of direct communication between neural cells and the cells of sensory and effector tissues. The endocrine system is made up of ductless glands that produce hormones with systemic effects. Therefore, neuroendocrinology studies the mutual effects of local and extensive signalling systems in animals. The progression of neuroendocrinology study will be described in this article, starting with an examination of the pituitary's regulation as a nervous system output and moving on to other hormone affects on the neurological system. Neuroscientists concentrate on the brain and how it affects behavior and mental processes. Neuroscience is not only interested in how the nervous system works normally, but also in how the nervous system behaves in cases of neurological, psychiatric, and neurodevelopmental problems. The term "neurosciences"—plural for neuroscience—is frequently used.*

Keywords- *Neuroscience, endocrine systems, Hormone, Neural cells, neurological, Neuroendocrinology*

I. INTRODUCTION

The study of how the nervous system grows, is structured, and functions is known as neuroscience, commonly referred to as neural science. Neuroscientists are interested in how the brain affects behaviour and cognitive processes. Neuroscience is concerned not only with how the nervous system normally functions but also with what occurs to the nervous system in cases of neurological, psychiatric, and neurodevelopmental problems. The term "neurosciences" is frequently used to refer to neuroscience [1]. Traditionally, neuroscience has been categorised as a branch of biology. These days, it is an interdisciplinary field of study that works closely with other academic fields like languages, engineering, computer science, chemistry, philosophy, psychology, and medicine. According to many academics, neuroscience and neurobiology have the same meaning. Neuroscience, on the other hand, covers everything relating to the nervous system, whereas neurobiology examines the biology of the nervous system [2]. Today, neuroscientists work in a far broader range of disciplines than in the past. They research the nervous system's cellular, functional, evolutionary, computational, molecular, cellular, and medicinal aspects.

THE PRINCIPAL FIELDS OF CONTEMPORARY NEUROSCIENCE

Based on research areas and fields of study, the following branches of neuroscience can be generally divided into the following disciplines (neuroscientists typically work in multiple branches concurrently):

Research on affective neuroscience, which focuses on how neurons act in connection to emotions, is typically conducted on laboratory animals. Neuroscience of behaviour is the study of the biological underpinnings of behaviour. examining the impact of the brain on behaviour. The study of neurons, including their structure and physiological characteristics at the cellular level, is known as cellular neuroscience [3]. Clinical neuroscience examines neural system problems, whereas psychiatry, for instance, examines mental disorders.

The study of higher cognitive processes in humans and the brain mechanisms that underlie them is known as cognitive neuroscience. Linguistics, neurology, psychology, and cognitive science are all incorporated within cognitive neuroscience. With the goal of understanding the nature of cognition from a neurological perspective, cognitive neuroscientists can go in one of two general directions: behavioral/experimental or computational/modeling. Computational neuroscience is the study of brain function utilising methods from physics, mathematics, and other computational sciences in an effort to comprehend how brains process information. Cultural neuroscience examines how the brain, mind, and genes change over time and influence beliefs, practises, and cultural values. Developmental neuroscience investigates the underlying mechanisms that underlie the cellular development of the nervous system [4]. The study of how certain molecules function in the neurological system is known as molecular neuroscience.

Neuroengineering is the application of engineering principles to replace, enhance, or better understand neural systems. A subfield of medical imaging that focuses on the brain is called neuroimaging. Neuroimaging is employed in the diagnosis of illness and the evaluation of brain health. Additionally, it can be helpful in the study of the brain, how it functions, and how certain activities influence it. In order to better understand the brain and treat disorders, neuroinformatics incorporates data from various branches of neuroscience. Data collection, sharing, publication, archiving, analysis, modelling, and simulation are all part of neuroinformatics. Neurolinguistics is the study of the neurological processes in the brain that govern language learning, comprehension, and expression [5].

The study of neurophysiology examines the connections between the functions of the brain and the body's various organs. the examination of the nervous system's operation using physiological methods, such as stimulation with electrodes, light- or voltage-sensitive dyes, or light-sensitive channels. Paleoneurology is the study of the fossilised brain. An interdisciplinary field called social neuroscience is devoted to comprehending how biological systems carry out social processes and behaviour [6]. Social neuroscience assembles biological ideas and techniques to support and improve social behaviour theories. It improves theories of neuronal organisation and function using information and concepts from social and behavioural sciences. Systems neuroscience aims to characterise the types of processing taking place in the CNS (central nervous system) by tracking the data flow channels within that system. It explains behavioural functions using that data.

HUMAN BEHAVIOUR AND NEUROSCIENCE

The study of the anatomy and operation of the nervous system and the brain is known as neuroscience. To map the brain mechanistically, neuroscientists draw on cellular and molecular biology, anatomy and physiology, human behaviour and cognition, and other fields. Each neuron, or brain cell, in an adult human has an estimated 100 billion connections to other neurons. The mapping of all the cell-to-cell communication networks—the brain circuits that process all ideas, feelings, and behaviors—remains one of the major difficulties of contemporary neuroscience. The resulting image that gradually forms is referred described as "the connectome." All learning is based on the brain's capacity to build new neural circuits and connections, or neuroplasticity.

In the study of neuroscience, biology and psychology come together to address issues like the brain's function in pain perception and the fundamental causes of Parkinson's disease. Researchers and medical professionals now have a better understanding of the physical makeup of the brain, its five million kilometres of wiring, and how it interacts with the rest of the body and mind thanks to computer simulations, imaging, and other techniques.

APPLICATIONS OF DEVELOPMENTAL COGNITIVE NEUROSCIENCE

Developmental cognitive neuroscience has gained recognition from numerous national and international grant funding agencies as a crucial field within the neurosciences. This recognition stems, in part, from the understanding that human functional brain development has far-reaching implications for social, educational, and clinical policies and strategies. Several chapters in this book have highlighted how certain developmental disorders can be characterized as deviations from the typical trajectory of postnatal human brain development [7]. One notable perspective, known as the Interactive Specialization (IS) view, proposes that biases in attention and processing during early infancy are reinforced by differential patterns of experience. Consequently, these patterns contribute to the observed specialization in cortical function among adults. This implies that certain patterns of cortical specialization are a natural outcome of the interaction between various factors in typical development [8]. Conversely, disruption of one or more of these factors can impede the development of typical degrees or patterns of cortical specialization. Furthermore, even minor deviations from the norm can accumulate and result in compounded patterns of deviance as individuals in the affected individual's surroundings adapt their own behavior accordingly. However, a positive aspect of the IS view is that remediation strategies may be effective in alleviating some symptoms in certain cases, particularly when initiated early in life, before symptoms become more complex. Consequently, one of the key priorities for the next decade will be exploring interventions that can influence the trajectory of development, particularly in disorders such as autism, before symptoms become compounded.

The application of developmental cognitive neuroscience in the field of school education has garnered significant interest. However, the challenges arise from the fact that education involves transmitting others' knowledge, while neuroscience primarily focuses on individual interaction with the environment. Bridging this gap, neuroscience urges education to incorporate research on neural and genetic factors that influence learning effectiveness. Historically, these disciplines lacked collaboration, leading to commercial products based on a simplified understanding of the brain [9]. Nonetheless, recent advancements in both fields offer a more precise understanding of key issues, paving the way for the emerging discipline of "educational neuroscience." Moving forward, it is essential to witness examples where developmental cognitive neuroscience laboratories address educational needs, utilizing the revealed principles and processes to inform classroom practices.

FUTURE OF TECHNOLOGY IN COGNITIVE NEUROSCIENCE

In line with the pursuit of advancing intelligent machines, President Obama initiated the BRAIN initiative, which focuses on innovative neurotechnologies. Remarkable technological advancements over the past decade have provided new opportunities for studying and comprehending the brain. Through interdisciplinary convergence, ground-breaking discoveries are anticipated to reshape our understanding of the brain, reminiscent of Ramon y Cajal's establishment of the "neuron doctrine" facilitated by the invention of the microscope. Neuroscience aims to unravel the complexities of the human brain, encompassing molecules, cells, circuits, and systems that underlie behavior, perception, thought, and emotion [10].

The BRAIN Initiative aims to deepen our understanding of the brain's generation of complex thoughts and behaviors, leading to advancements in the diagnosis, treatment, and potential cure of neurological and psychiatric diseases [11]. The initiative was spearheaded by the National Institutes of Health (NIH), seeking to catalyze an interdisciplinary effort in developing and applying new technologies for constructing a dynamic picture of brain function at the neuronal and circuit levels. Collaborations with specialists from various fields, including chemical and molecular methodologies, recording techniques, neurobiology, computation, theory, data analysis, and human neuroscience, were essential. Partner organizations, such as the Howard Hughes Medical Institute Janelia Research Campus, National Science Foundation, Defense Advanced Research Projects Agency, Allen Institute for Brain Science, Kavli Foundation, and Food and Drug Administration, also played key roles due to the broad applicability of the technology.

The advancement of neuroscience now allows for high-resolution studies of the brain at various levels, including genes, synapses, molecules, and neurons. Whole-brain imaging enables the examination of large brain areas. Circuit analysis emerges as a crucial area of investigation, with the potential for technological advancements to revolutionize multiple domains of neuroscience. The focus of the BRAIN Initiative is to gain a fundamental understanding of the nervous system's behavior in health and disease, rather than solely advancing technology. The initiative's main challenges are accelerating the development of brain circuit mapping technologies, measuring electrical and chemical activity within circuits, and comprehending the interactions that underlie cognitive and behavioral abilities.

During the BRAIN initiative, a working group identified seven key areas of investigation to achieve the initiative's goals. Each area presents opportunities for conceptual and technological advancements that can lead to remarkable progress. The first area, "Discovering Diversity," aims to establish objective classification schemes combining electrophysiological, gene expression, anatomical, and connectional data. This approach facilitates the characterization of different types of nervous system cells, the development of techniques to record, mark, and manipulate these neurons in living brains, and the assessment of molecular properties' stability across various time scales and dimensions, along with standardizing laboratory procedures [11].

The second target area of the BRAIN Initiative focuses on mapping brain connectivity at multiple scales, utilizing technologies such as macro-connectomic measurements and meso-connectomic approaches. These advancements enable the segmentation of normal and diseased human brains, integrating diverse datasets into a unified framework. The third target area, "The Brain in Action," emphasizes electrical and optical methods for studying brain activity, facilitating the mapping of electrical and chemical activity during cognitive processes and behaviors [12]. The fourth target area, "Demonstrating causality," involves circuit manipulation using tools like optogenetics and chemogenetics to establish causal relationships between brain activity and behavior. Advancements in technology and the development of new tools hold promise for further understanding brain connectivity, activity, and causal mechanisms.

The BRAIN Initiative encompasses several target areas aimed at advancing our understanding of the brain. The fifth target area focuses on identifying fundamental principles through the utilization of spatial scales, new analytical and computational methods, and theoretical frameworks. Rigorous theory, modeling, and statistics are enhancing our comprehension of complex, nonlinear brain activities. As new data types emerge, the development of novel techniques for data analysis and interpretation becomes imperative. The sixth target area, "Advancing human neuroscience," emphasizes the integration of established brain analysis technologies such as magnetic resonance imaging, electroencephalography, and magnetoencephalography. The goal is to combine multiple measurement and manipulation capabilities to optimize data gathering for both patient care and scientific purposes. Lastly, the seventh target area emphasizes the integration of technological and conceptual approaches from the previous target areas, employing a systems engineering approach to maximize overall system performance. The ultimate outcome of the BRAIN Initiative will be a comprehensive understanding of brain function through the coordinated use of novel technologies and conceptual frameworks. With advancements in neuroscience technology, we can gain new perspectives on ourselves, improve disease treatment, enhance education, inform law and governance, and foster greater empathy and understanding for individuals with diverse brain experiences [11]. The significance of technology becomes evident as we strive to advance our knowledge and comprehension of the brain.

UPCOMING TECHNOLOGY IN IN COGNITIVE NEUROSCIENCE

A novel technological tool called Neuromaps, introduced as the Python package, has garnered attention for its potential in providing a broader context for human neuroimaging data. By facilitating the integration of diverse data types, this tool aids in developing comprehensive theories regarding brain functioning, cognition, and diseases. While data-driven methodologies have faced criticism for reflecting researcher biases, the fidelity of these maps is expected to improve as more data is accumulated, allowing for finer-scale connections across different domains. Additionally, the future of Neuromaps holds promise for incorporating additional maps, such as electrophysiological features of single neurons, laminar profiles of neuron and glial cell types, and dendritic geometry, further enhancing our ability to contextualize findings and advancing our understanding of the brain and human behavior.

'NEUROENDOCRINOLOGY'

Neuroendocrinology is a word made up of many morphemes. The term "nerve" or "sinew" are the roots of the prefix "neuro-," which designates a neurological system with physical connections between its components. The word "endocrine" is a combination of the Greek words "endo-," which means "within," and "-crine," which means "separate." As a result, the glands that make up the endocrine system are distinct from the bodily tissues they affect. Of course, the word "ology" denotes a body of knowledge. Thus, the study of the interconnections between the neurological and endocrine systems is the most literal definition of neuroendocrinology. It is important to note that both the neurological and endocrine systems emit chemical messengers that bind to sensitive cells as part of their common signalling tasks. Only target cells with the proper receptors get a response upon binding of the chemical messengers. The chemical messenger in the case of the nervous system is a neurotransmitter, which is produced and operates principally at a synapse, an area of tight cellular contact. The nervous system's cells are concentrated in centralised organs like the brain and spinal cord, where they form a large number of synapses with other cells as well as with other cells by long cellular processes called axons and dendrites [13]. When it comes to the endocrine system, hormones are released from glandular cells and circulated throughout the body to operate on cells there. The distinction between the domains of neurology and endocrinology is no longer as clear-cut as originally believed, and it is now understood that the brain and endocrine systems share many traits and activities.

SCOPE OF NEUROENDOCRINOLOGY

This embraces major body functions – reproduction, growth and metabolism, water and electrolyte balance, diurnal and seasonal rhythms and resilience to stress. Control by the brain has three elements – receiving external environmental signals, in all sensory modalities, and then organising neuroendocrine responses appropriate to meet challenges (stressors), to accommodate opportunities (to eat, drink, reproduce) and to harmonise with the natural day and sea- sons on planet earth; processing internal signals to maintain or restore homeostasis through neuroendocrine adjustments (osmo- regulation, balancing energy supply and use, or coping with infection[14]; detecting hormonal signals from peripheral endocrine glands the brain regulates that mainly act as negative (but some can be positive) feedback signals which automatically adjust the neuroendocrine output from the brain to keep the output from the controlled endocrine gland within set limits. Feedback may be on the anterior pituitary as well as on neurons in the brain

HISTORICAL EVOLUTION OF NEUROENDOCRINOLOGY RESEARCH

The original focus of neuroendocrine research was on the endocrine system as a specific nervous system output. More recent work has focused on the complex feedback affects of endocrine glands on the neurological system [15]. Analysing the regulatory interactions between the hypothalamus, pituitary, and other bodily glands has been a major focus of neuroendocrinology. The direct neural control of glands other than the pituitary has also been studied by neuroendocrinology. The study of hormonal effects on brain and behavioural systems has advanced.

Neurosecretion

Studies on invertebrates have long suggested that neural cells exude chemicals throughout the body. The term "neurosecretion" was used to describe the hormonal activity of neural cells, and the notion that neurosecretory cells serve as a link between the endocrine and neurological systems gave rise to the subject of neuro-endocrinology [16]. The pituitary gland's activity was discovered to be significantly affected by lesions of the median eminence of the hypothalamus, and the consequences of the lesions could be reproduced by cutting off the blood supply to the pituitary. According to these findings, hypothalamic neurons are neurosecretory because they directly release substances into the blood.

It is now known that the hypothalamus is the source of a large number of hormonal variables, the majority of which are short peptides. There are two separate systems for neuropeptide secretion related to pituitary function. Characterization of the release of neuropeptides became an early primary focus of neuroendocrinology (see Table 1). The neurohypophysis, or posterior lobe of the pituitary, is made up of neuro-secretory cell terminals with somas in the hypothalamus. Neuropeptides that enter the bloodstream are released by the posterior pituitary gland. An endocrine gland is the pituitary's anterior lobe, often known as the adenohypophysis. The anterior pituitary receives neuropeptides from the median eminence through the portal blood supply, which regulates the anterior pituitary hormone release. Several of the anterior pituitary hormones in turn control how certain glands in different sections of the body operate. As in, for instance, the "hypothalamo-pituitary-thyroid axis," such glands are stated to be a component of a hypothalamo-pituitary axis of hormonal regulation.

NEUROENDOCRINOLOGY LINKING ENDOCRINOLOGY WITH NEUROSCIENCE

System of Sympathetic Nerves

The somatic portion of the nervous system's output, which regulates voluntary muscular contractions, and the autonomic division, which controls visceral activity, are standard descriptions of the nervous system's output. Effects associated with the "fight-or-flight" response are produced when the sympathetic nervous system is activated as a result of injury or a perceived threat. The heart rate, breathing rate, blood pressure, and glucose mobilisation all increase as a result of these impacts [17]. The sympathetic branch of the autonomic nervous system's axons leaves the spinal cord and connects with nearby vertebrae or prevertebral ganglia that are closer to the innervated tissue. The synapses in smooth muscle, cardiac muscle, or exocrine glands are where the postganglionic cells release norepinephrine.

Anterior pituitary hormone production in humans typically occurs in a sequence of spikes spaced 90–120 minutes apart, with the maximal concentration of the spikes changing consistently with the time of day. It is believed that the pattern of activity of the neurosecretory cells in the hypothalamus determines the temporal pattern of pulsatile and circadian hormone secretions. The timing of hormonal variations may therefore be a key way that the brain controls the endocrine system. There are likely additional circadian and ultradian clocks in the brain in addition to the suprachiasmatic nucleus of the hypothalamus, which serves a clock-like role in the brain.

The pineal gland plays the unusual job of fusing endocrine and sensory processes. The pineal in lower vertebrates functions as a photosensitive third eye. Despite the apparent loss of photoreceptive ability in mammals, photic input is still important for the pineal's function. Multi-synaptic inputs from the retina, particularly through the suprachiasmatic nucleus of the hypothalamus, are used to innervate the mammalian pineal, and the hormone released by the pineal, melatonin, is mainly active at night.

Table 1. Summary of roles of some neurosecretory peptides in relation to pituitary function

Hypothalamic Neuropeptide(s)	Pituitary Hormones(s)	Lobe	Peripheral Target Tissue	Process Regulated at Peripheral Target Tissue	Process Regulated by Peripheral Hormone
prolactin inhibitory factor (PIF), dopamine	prolaction	Ant.	mammary glands	Lactation	
growth hormone-releasing hormone	growth hormone (GH or somatotropin)	Ant.	Various	Growth	
(GHRH); somatostatin (SS or SRIH)			Liver	secretion of insulin-like growth factor-I (IGF-I)	Growth
Thyrotropin-releasing hormone (TRH)	thyroid-stimulating hormone (TSH or thyrotropin)	Ant.	thyroid gland	secretion of thyroid hormones	basal metabolic rate; development
Corticotropin-releasing hormone (CRH)	adrenocorticotropic hormone (ACTC or corticotropin)	Ant.	adrenal cortex	secretion of adrenal steroids	reaction to stress; electrolyte balance
Gonadotropin-releasing hormone (GnRH)	gonadotropins: luteinizing hormone (LH); follicle-stimulating hormone (FSH)	Ant.	Gonads	gamete formation; secretion of sex steroids	Reproduction
Melanocyte-stimulating hormone releasing factor (MRF); inhibiting factor (MIF)	Melanocyte-stimulating hormone (MSH);	Inter-med.	Melano-cytes	skin pigmentation	
antidiuretic hormone (ADH or vasopressin)	Same	Post.	Kidneys	Fluid retention	
Oxytocin	Same	Post.	mammary glands,	milk letdown; labor	

uterus

Oxytocin and vasopressin neurons

The magnocellular oxytocin and vasopressin neurons, found in the PVN and SON, are regarded as exemplar neuroendocrine cells with properties that other neurosecretory neurons should be expected to match (Figure 1): their cell bodies are in the hypo- thalamus; the neurons have excitatory and inhibitory synapses on their dendrites and soma, and appropriate specific receptors; the neurons produce and secrete peptides that mediate their functions (except that tubero-infundibular dopaminergic neurons use dopa- mine); their axon terminals are on fenestrated capillaries (in the posterior pituitary for magnocellular neurons; in the median eminence for releasing factors/ hormones); secretion is stimulated by arrival of action potentials that increase Ca^{2+} entry into the terminals, triggering exocytosis; frequency and pattern of action potentials generated in the cell bodies determine amount and pattern of peptide released; pre-terminal modulation of stimulus-secretion coupling is likely [18].

Feedback Peripheral Hormones and Nervous System Regulation

In addition to examining the endocrine outputs from the neurological system, neuroendocrinology also looks at how hormones from the periphery affect the brain. The significance of negative feedback mechanisms, whereby one output of a system inhibits the system's controller, is a fundamental theme of neuroendocrinology. There is evidence that the hormone of the peripheral gland has an impact on the neurosecretory cells in the hypothalamus in the majority of hypothalamo-pituitary axis [19]. For instance, growth hormone (GH) promotes the release of somatostatin while inhibiting the production of growth hormone-releasing hormone (GHRH). GH's feedback on the hypothalamus causes its secretion to decrease as its levels rise, which in turn regulates its circulating levels. In a similar way, thyroid hormone levels in the bloodstream that are unbound have a big impact on how much thyrotrophin-releasing hormone (TRH) is released. The response of sex steroids on gonadotrophin-releasing hormone (GnRH) release from the hypothalamus is incredibly complex and switches from inhibitory to stimulatory immediately before female ovulation.

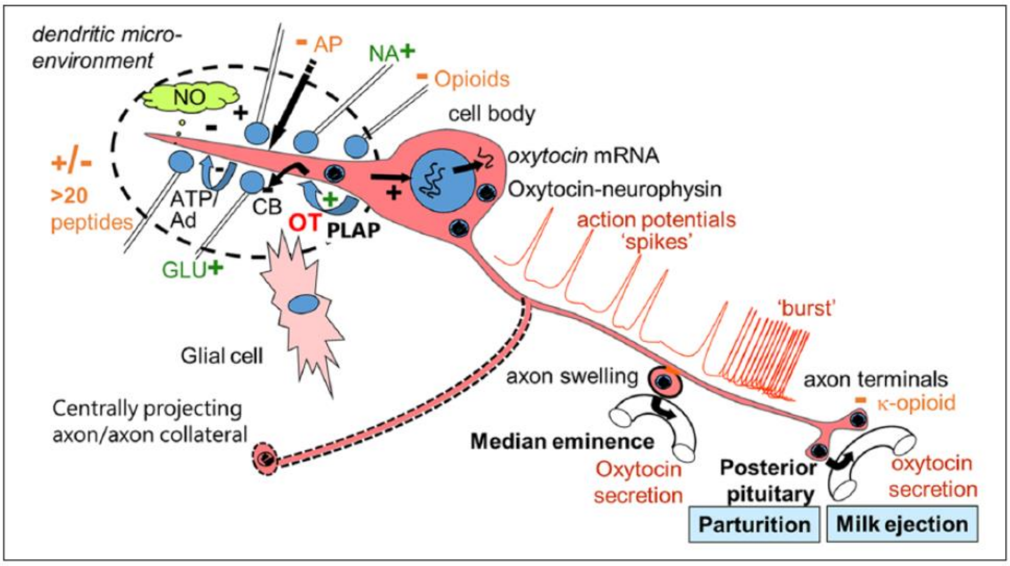

Figure1. Features of a magnocellular oxytocin neuron (MCN): a model peptidergic neuron. Oxytocin is synthesised in the cell body, as a higher molecular weight precursor, translated from the mRNA transcribed from the OXT gene; precursor peptides are processed to oxytocin-neurophysin and packaged into secretory granules in the Golgi apparatus; secretory granules are moved by axonal transport to the axon terminals; some are transported into dendrites; precursor is processed further during transport; the axon terminals are on fenestrated capillaries in the posterior pituitary (some axon swellings release into portal capillaries in the median eminence, like releasing factors – oxytocin can stimulate prolactin secretion); a few magnocellular oxytocin neuron axons (dashed) project centrally (e.g. to amygdala). Secretion is via exocytosis, stimulated by action potentials (APs) that increase Ca+ entry; frequency and pattern of action potentials generated in the cell bodies determine amount and pattern of peptide released; stimulus-secretion coupling can be modulated by pre-terminal action of κ-opioid peptide. Under most conditions, oxytocin neurons fire APs irregularly but during parturition or suckling they fire in brief high-frequency bursts, co-ordinated among the oxytocin neurons, resulting in

secretion of a pulse of oxytocin after each burst. Major excitatory inputs use noradrenaline (NA) or glutamate (GLU); major inhibitory input is via GABA; allopregnanolone (AP; progesterone neurosteroid metabolite) potentiates GABA action via GABAA receptors; more than 20 neuropeptides have excitatory or inhibitory (e.g. opioid) actions on magnocellular oxytocin neurons. Dendritic secretion of oxytocin drives burstsn – auto-stimulating endocannabinoid (CB) release, which presynaptically modulates inputs (GLU); placental leucine aminopeptidase (PLAP) from oxytocin dendrites limits local oxytocin action; ATP/adenosine (Ad) and nitric oxide (NO) from dendrites also have local inhibitory actions. Adapted From Russell and Brunton (2017). With permission**.**

Hormone Effects on the Developing Brain

During development, the endocrine system has a significant impact on the brain. Long recognized to have a crucial role in brain development, thyroid hormones, hypothyroidism throughout development can result in severe abnormalities such cretinism. Certain types of brain neurons have structural impairments as a result of these actions. Gender differences in brain anatomy and function can be determined in part by perinatal hormones, particularly androgens [20].

Hormonal Control of Behavior As it has become increasingly obvious that hormones affect a range of adult brain functions, behavioral neuroendocrinology has developed into a thriving field of study. Gonadal steroids have an impact on both genders' reproductive behaviors since they have direct effects on the brain. There are many clinical signs and symptoms of thyroid disease that show how thyroid hormones affect the adult brain, and there are several clues that thyroid hormones are significant in the aetiology of depression. Peptide hormones such as corticotrophin-releasing factor (CRF), GHRH, SS, GnRH, arginine vasopressin, oxytocin, and vasotocin can affect a variety of behaviors, including eating, getting pregnant, and responding to stress in a particular way.

Trends in Neuroendocrine Research Recently: New Mechanisms of Hormone Action in the Brain

A family of nuclear receptors that change gene expression is the well-established mechanism by which thyroid and steroid hormones operate in brain and peripheral organs. Numerous steroids have been shown to influence the binding and activation of membrane receptors for neurotransmitters like gamma-aminobutyric acid (GABA), according to recent studies.

It has also been demonstrated that thyroid hormones have an impact on GABA membrane receptors. The functional significance of numerous unique mechanisms of a particular hormone's brain effects is a current area of neuroendocrine research attention. The lines separating hormones and neurotransmitters have gradually blurred. Some neuroactive steroids are known to be produced in the brain by the synthesis of cholesterol and may have significant direct signalling roles in brain tissue [21]. Thyroid hormones may also function in the brain similarly to neurotransmitters, according to a number of lines of evidence. It is now known that a number of brain locations contain neuropeptides, which were previously only known to be present in connection with pituitary function. In addition to the hypothalamus, many other neuropeptides that were once categorized as stomach hormones are also present in the brain. These neuropeptides probably do not enter the bloodstream as hormones, but they may be released locally and function like neurotransmitters within the brain tissue. These neuropeptides, which are frequently referred to as "neuromodulators," appear to affect the effects of other, more normal neurotransmitters functioning on the same cell.

II. CONCLUSION

Interleukins and tumor necrosis factors are two peptides known as cytokines that play significant roles in immune response. These chemicals may play neuromodulatory effects and are also present in the brain. The function of cytokines in the control of sleep is a field of study that is now undergoing significant development. It appears plausible that other signalling agents whose actions have been thoroughly studied in one system will end up having broad impacts on brain tissue. Neuroendocrine Research in the Future Numerous elements have been discovered to transmit signals from the brain to the endocrine system and from the endocrine system to the brain over the history of neuroendocrinology. Molecular biology methods have aided in the identification and cataloguing of factors and their receptors, and it appears that this process will quicken as information from human and other genome sequences becomes widely accessible. Neuroendocrine research should focus on the challenging problem of how the effects of these factors could be integrated inside distinct tissues as the list of signalling factors and their receptors closes in. The examination of the processes and functional roles of the pulsatile and circadian rhythms of hormone secretions, for instance, is perhaps one future research area that will be of interest. Surprisingly many signalling factors function similarly in immunological, endocrine, neurological, and other systems. Instead of categorizing signals and receptors according to the secretory or target tissues, future researchers may one day study chemical signals in biological systems as a single, integrated discipline, classifying signals and receptors according to their structure, gene family, or hypothesized evolutionary origins.

ACKNOWLEDGEMENT

I acknowledge to Prof. Maheep Bhatanagar, Retd. Professor and Dean, Department of Zoology, M.L.S. University for his guidance and support. I also acknowledge to DST GO Rajasthan and DBT GO India for their financial support.

REFERENCES

[1]. Johnson, M. H. (2005). *Developmental cognitive neuroscience: An introduction* (2nd ed.). Blackwell Publishing.
[2]. Mark H. Johnson ; with Michelle de Haan. (2011), Developmental cognitive neuroscience : an introduction, Chichester, West Sussex, U.K. ; Malden, MA : Wiley-Blackwell .
[3]. Vaidya AR, Pujara MS, Petrides M, Murray EA, Fellows LK. Lesion Studies in Contemporary Neuroscience. Trends Cogn Sci. 2019 Aug;23(8):653-671.
[4]. Cara M. Altimus et.al. (2020), The Next 50 Years of Neuroscience, Journal of Neuroscience, 40 (1) 101-106
[5]. Ereifej ES, Shell CE, Schofield JS, Charkhkar H, Cuberovic I, Dorval AD, Graczyk EL, Kozai TDY, Otto KJ, Tyler DJ, Welle CG, Widge AS, Zariffa J, Moritz CT, Bourbeau DJ, Marasco PD (2019). Neural engineering: the process, applications, and its role in the future of medicine. J Neural Eng.
[6]. Nir Y, Tononi G. (2010), Dreaming and the brain: from phenomenology to neurophysiology. Trends Cogn Sci.,14(2):88-100.
[7]. Karmiloff- Smith, A. (1998). Development itself is the key to understanding developmental disorders. Trends in Cognitive Sciences, 2, 389–398.
[8]. Johnson, M. H. (2001). Functional brain development in humans. Nature Reviews Neuroscience, 2, 475–483.
[9]. Johnson, M. H. (2011). Interactive specialization: A domain- general framework for human functional brain development? Developmental Cognitive Neuroscience, 1(1), 7–21.
[10]. Howard MD, John. "Artificial Intelligence: Implications for the Future of Work." Wiley Online Library, 22 Aug. 2019,
[11]. Jorgenson (2015). The BRAIN Initiative: Developing technology to catalyze neuroscience discovery. Philosophical Transactions of the Royal Society B: Biological Sciences, 370(1668),.0164
[12]. David A. Borton,(2020), Developing Collaborative Platform to Advances Neurotechnology and its Translation, 108 (2), 286-301.
[13]. Malcolm J. Low (2016), Neuroendocrinology, Williams Textbook of Endrocrinology(13 Eds.).
[14]. A. C. Kentner, Q. J. Pittman (2010), Minireview: Early-Life Programming by Inflammation of the Neuroendocrine System, 151(10), 4602-4606.
[15]. Kreier F, Swaab DF. Chapter 23: history of neuroendocrinology "the spring of primitive existence". Handb Clin Neurol. 2010;95:335-60.
[16]. William E Armstrong (2007), The neurophysiology of neurosecretory cells, J. Physics, 585(3), 645-647.
[17]. Georg Pongratz and Rainer H Straub (2014), The sympathetic nervous response in inflammation, Arthritis Res Ther, 16, 504.
[18]. Russell JA and Brunton PJ (2017) Oxytocin: Control of secretion by the brain and central roles. In: Reference Module in Neuroscience and Biobehavioral Psychology. Amsterdam: Elsevier.
[19]. Fink G (1979) Feedback action of target hormones on the hypothalamus and pituitary with special reference to gonadal steroids. Annual Review of Physiology 41: 571–80
[20]. Hackman, D. A., & Farah, M. J. (2009). Socioeconomic status and the developing brain. Trends in Cognitive Neuroscience, 13, 65–73.
[21]. Kriegsfeld LJ, Silver R. (2006) The regulation of neuroendocrine function: Timing is everything., Horm Behav., 49(5), 557.