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INTRODUCTION TO CELL SIGNALING AND PRINCIPLE PATHWAY

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ABSTRACT

Cell signaling is an important aspect of biological life. It enables cells to sense and respond to the extracellular environment, enabling development, growth, immunity, etc. Furthermore, errors in cell signaling can lead to cancer growth and diabetes. Understanding the processes that control these pathways allows scientists to understand the flow of information and transmission, allowing people to treat disease and manipulate tissues. Here we look at how the message is transmitted from the initial messenger (ligand) to the receptor. Signal transduction is a biochemical reaction along a signaling pathway. It is the process of transmitting signals by organisms, specifically across or through cells. This report aims to describe the components of cell signaling. Ligands and receptors are key components of signal transduction. These components complete the cell signaling process. When signals are transmitted from one cell to another, the cells respond in our body.

Keyword – Cell signaling, Signal transduction, Ligand, Receptor, GPCR mechanism.

INTRODUCTION

Intercellular communication or signaling is an important part of understanding cell and system function. There are different types of signals, such as neurotransmitters recognized at synapses, antigens that trigger antibody responses, and target cells that respond to specific hormones [1]. Some cells require cell-to-cell contact to communicate. There are gap junctions that connect the cytoplasm of two cells. In most cases, the molecule carries a signal from one cell and a receptor on the other cell binds to the signaling molecule to enable communication. A number of pathways then arise, leading to cellular responses [2]. The autocrine pathway is a type of signaling that allows cells to communicate with themselves. In this pathway, cells directly affect their function by secreting substances that act on cell receptors. Paracrine pathways allow cells to communicate with nearby cells as well. Paracrine signaling is of particular importance in local immune responses. In endocrine signaling pathways, signals are transmitted from afar. It is caused by the presence of hormones. Hormones are biologically active substances

that are released into the bloodstream. For example, many regulators of leukocyte growth and development are hormones [3].

CELL SIGNALING

Cell signaling is the fundamental process by which specific information is transferred from the cell surface to the sporangia and finally to the nucleus, resulting in changes in gene expression [4]. Cells receive and respond to extracellular signals through receptors. Cell signaling begins as soon as the first messenger (ligand) binds to a receptor (a protein with complementary structure on a transmembrane protein or within the cell). Ligand binding induces a conformational change in the receptor, a well-regulated series of actions carried out by second messengers or signaling intermediates that relay messages from the receptor to quantifiable effector functions. activates the reaction [5]. Cellular signaling involves the transformation of one event into another. In sensory transmission, sensory cells are exposed to external signals that are transduced to generate neural signals called action potentials. Many aspects of multicellular life are regulated or involved by extracellular messengers, including cell proliferation, cell division, cell death, differentiation, cell migration, metabolism, immune response and neurotransmission. Moreover, signaling is essential for processes such as vision and smell that multicellular organisms use to perceive their environment [6].

Signaling is not a linear sequential activation cascade of signaling molecules, but a concatenation of signaling relays within the cell. Cells recognize extracellular signals that are processed and interpreted in well-defined ways by intracellular machinery. In some cases, conformational changes in ligand-bound receptors activate their kinase activity, leading to downstream signaling. In other cases, ligand-bound receptors recruit a series of signaling intermediates, primarily adapters that incorporate kinases, to form signalsome (CSN) complexes. This is through various other secondary messengers such as calcium (Ca2+), cAMP, cyclic guanosine monophosphate (cGMP), diacylglycerol (DAG), inositol triphosphate (IP3), kinases, lipids, functional pass the signal.

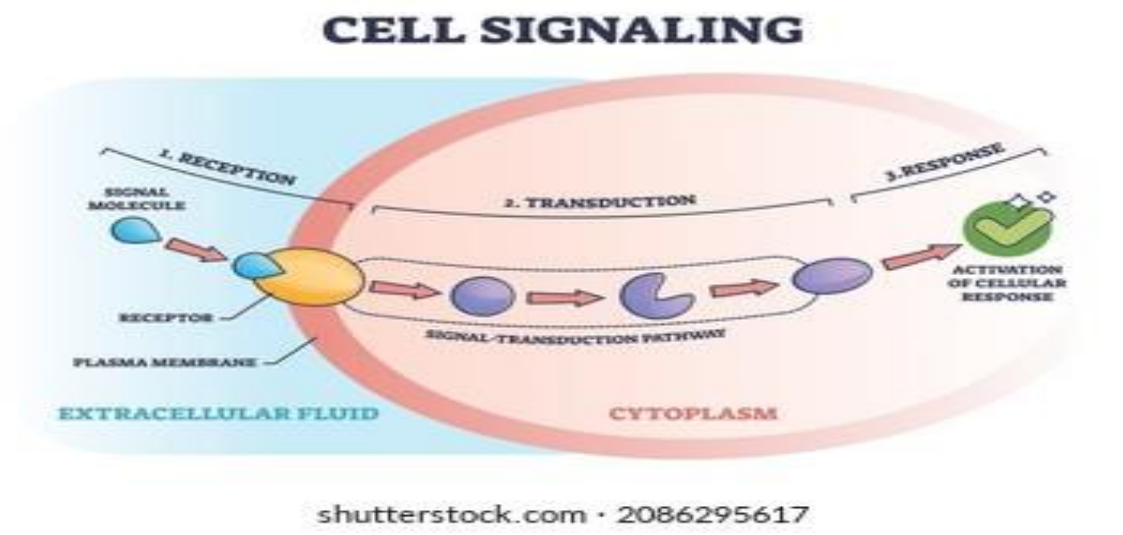

Figure 1. Signal transduction process in cell signaling

COMPONENTS OF CELL SIGNALING

(1) LIGANDS / SIGNALS

Most of the signals are chemical in nature. For example, prokaryotic cells have sensors that detect nutrients and mediate mechanotransduction to higher nutrient gradients. Similarly, eukaryotic cells have sophisticated ways of responding to signals such as growth factors, hormones, cytokines, neurotransmitters and extracellular matrix components. There are different types of signaling: endocrine (long-range), paracrine (short-range/local), paracrine (contact-dependent signaling), and autocrine (acting on the same cell that produces the factor).) can be characterized as and neurotransmitters (signaling to synaptic connections). Ligands vary in chemical nature and are small molecules such as lipids (prostaglandins, steroids, etc.), proteins (peptide hormones, cytokines, chemokines, growth factors, etc.), and complex polymers of sugars (β-glucans, zymosans, etc.). It is included.) and combinations thereof (such as proteoglycans), nucleic acids, etc. Peptide ligands are polar in nature and bind to cell surface receptors, whereas steroids are lipophilic in nature and diffuse passively across cell membranes [7].

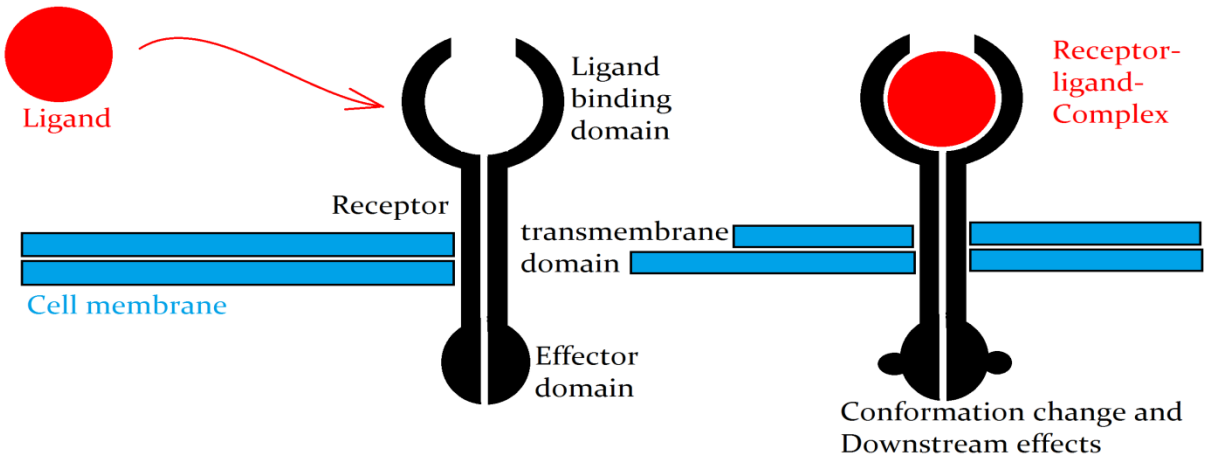

Figure 2 ligand receptor complex

(2) RECEPTORS

Increased signaling cascades occur through a number of changes triggered by ligand binding to their receptors (signal acquisition) [8]. Receptor binding triggers the activation of second messenger-associated primary effectors, leading to the activation of secondary effectors, ultimately triggering specific responses on the cell [9]. In general, receptors fall into two main classes: intracellular and extracellular receptors

INTRACELLULAR RECEPTORS

Intracellular receptors are soluble proteins localized to their respective regions. They are mainly classified into nuclear receptors and cytoplasmic receptors. All nuclear receptors contain three major domains. Generally, small nuclear receptors are lipid molecules. This property allows it to diffuse through both the lipid bilayer and nuclear membrane of cells. Receptors in the nucleus can bind directly to DNA material to facilitate expression. In signaling processes, ligands passively diffuse across the plasma membrane, bind to their receptors, cross the nuclear membrane and enter the nucleus, causing changes in gene expression [10,11].

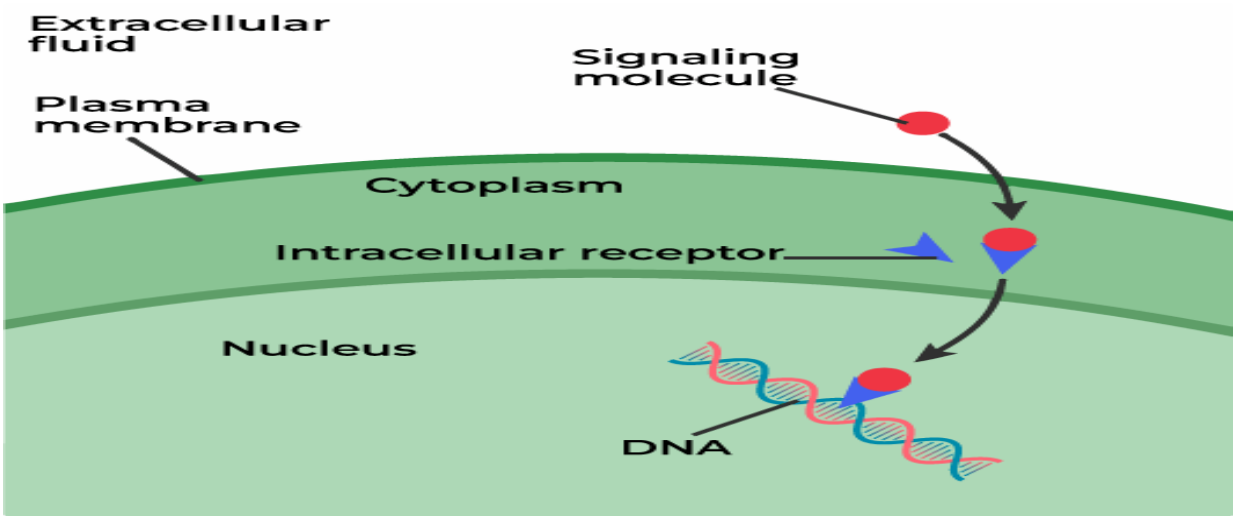

Figure 3 [intracellular receptor]

EXTRACELLULAR RECEPTORS

Extracellular receptors are integral transmembrane proteins that span the plasma membrane of a cell, with part of the receptor on the outside and part on the inside. The process of ligand-receptor binding results in receptor activation by stimulating structural changes in the receptor core [12,13].

ENZYME LINKED RECEPTOR

Six types of enzyme-linked receptors have been identified, including tyrosine kinase receptors. Tyrosine phosphatase, tyrosine kinase-related receptor. serine/threonine kinase; guanylate cyclase and histidine kinase-related receptors. Tyrosine kinase receptors (RTKs) represent the largest population and are prevalent. They are transmembrane proteins with ligand-binding extracellular and intracellular kinase domains [14,15].

LIGAND - GATED ION CHANNEL

When a ligand-gated ion channel receptor binds its ligand, a conformational change opens a cell membrane channel through which ions can signal. In neuronal synaptic cells, ion influx through orifice channels leads to potential effects such as neuronal signaling through depolarization of the postsynaptic plasma membrane, resulting in voltage-gated ion channels such as Ca2+ (second messenger). is amplified [16,17] .

G PROTEIN COUPLED RECEPTOR

G protein-coupled seven-transmembrane proteins (GPCs) constitute one of the largest families of cell surface receptors. They share a general topology consistent with an N-terminal extracellular domain, seven transmembrane helices separated by loop regions of different sizes, and an intracellular C-terminal domain. GPC receptors activate signaling by binding their cytoplasmic domains to a family of heterotrimeric GTP-binding proteins (G proteins). Ligand binding facilitates the exchange of G protein-bound GDP for GTP, and this activated G protein exits the receptor complex to initiate signal transduction. GTP is hydrolyzed to GDP by the intrinsic GTPase activity of the G protein itself, providing a convenient self-limitation mechanism. However, each receptor can activate a number of G proteins before signal transduction is terminated by internalization of the receptor, resulting in substantial amplification before signal transduction is terminated. Different GPC receptors use the same basic mechanism to act on different signaling pathways such as adenyl cyclase, tyrosine kinase cascades and phospholipases. The ligands for these receptors are diverse and mediate numerous cellular responses, including retinal stimulation by light, heart rate regulation, and cell migration. To explain this diversity, I briefly describe two emerging areas of

general interest. Namely, the mechanisms of olfactory and chemosensory receptors and chemokine receptors [18]. The chemical senses of higher organisms consist of taste and smell. In mammals, olfactory neurons are located in the nasal cavity. Scents activate specific receptors on the cilia of these neurons. These molecular receptors are always G protein-coupled seven-transmembrane proteins [19].

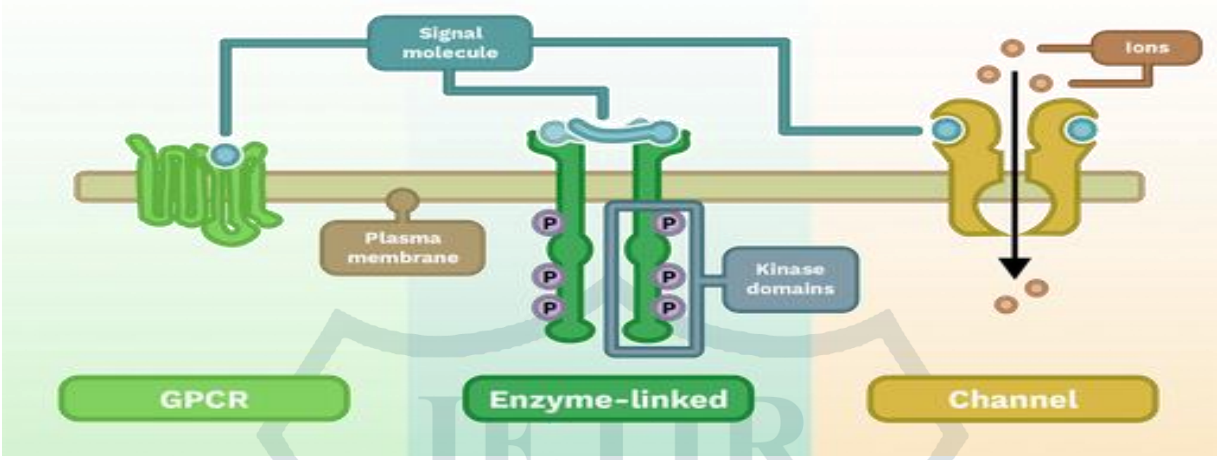

Figure 4 types of receptors – GPCR receptor, enzyme linked receptor, ligand gated ion channel

MECHANISM OF G PROTEIN COUPLED RECEPTOR

GPCRs are classical allosteric proteins. Agonist binding at a site accessed from the extracellular space, termed the orthosteric site, facilitates binding to another cytoplasmic partner (eg, a heterotrimeric G protein). The binding balance between agonist and G protein binding is well known. Agonist binding not only facilitates binding of the receptor to the G protein, but the affinity of the agonist for the receptor is increased 7-fold by the G protein crossing the cell membrane. G protein receptors are ubiquitous in the human body. Some important examples are the olfactory receptors and the rods and cones responsible for vision. In the immune system, G-protein receptors are important as chemokine receptors. G-protein receptors are bound to molecules attached to the inner surface of the cell membrane. The molecule is composed of her three parts, the α, β, and γ subunits, and is inactive when BIP binds. Upon G protein-coupled receptor activation, GDP is phosphorylated to GTP, allowing the α subunit to dissociate from the βγ subunit. The α-subunit has intrinsic GTPase activity that rapidly terminates and activates the receptor [20, 21].

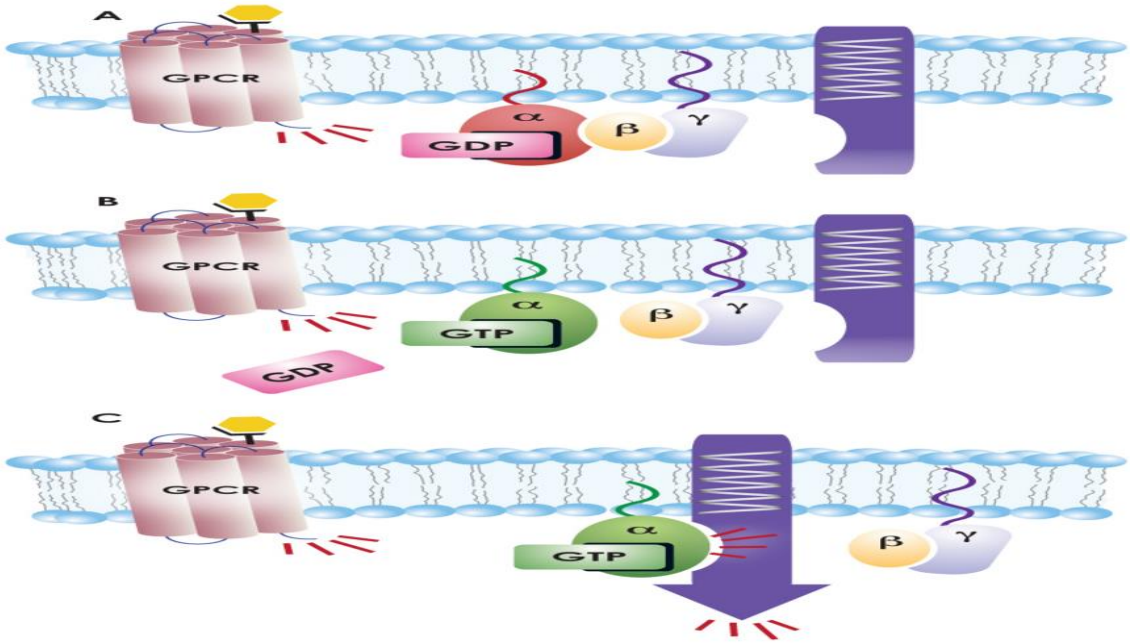

Figure .5 G protein coupled receptor mechanism

CONCLUSION

We have described how major classes of cell surface receptors mediate the transduction of extracellular stimuli into intracellular events that alter cellular behavior. Although we did not describe each receptor or mechanism, we tried to explain how different signals are integrated into coordinated responses through the complex interplay of signaling.

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