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Intercellular Communication and Transport Processes during Development

Dr. Prahlad Kumar Meena*

Assistant Professor, Govt. College, Karauli

Abstract – All forms of communication between human beings have long been recognized as a requirement for reciprocal understanding, transfer of knowledge, and productive development of societies. This also applies to living cells who are organized in micro societies that constantly adjust to their environment through a complex network of signaling pathways. The chemical communication which occurs at various levels results in an integrated exchange of information that is essential for coordinated responses.

We wish to present a few features of Cell Communication and Signaling: an open access, peer-reviewed journal devoted to the publication of manuscripts covering all aspects of cell communication, with a particular focus on molecular processes that govern intercellular signaling and events that sustain cellular communication, both in normal and pathological conditions.

The launching of Cell Communication and Signaling provides us the opportunity to present a brief overview of basic processes underlying cell communication and the signaling processes that take place within and between cells to permit an efficient communication.

Keywords: Intercellular, Communication, Transport, Process

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INTRODUCTION

Birth, life and death involve the integration of a complex array of biosignals that living cells sense and process to respond and adapt to modifications of their environment.

The signals that are sent and received by cells during their whole existence are essential for the harmonious development of tissues, organs and bodies. They also govern movement, thought and behavior.

It is now well established that cells do not behave as selfish entities but rather tend to form micro-societies whose proper functioning requires a precise coordination of emission and reception of signals. Dysfunctioning of the networks is associated with pathological situations that can range from abnormal proliferation to death.

Deciphering the molecular basis for the coordinated treatment of biological signals is a challenge of prime importance. It will provide better insight into the processes governing fundamental biological activities such as growth, differentiation, and quiescence. It will also open the road to new therapies in order to fight diseases resulting from improper signaling.

Once thought to be restricted to higher eucaryotes and multi cellular organisms, cell communication has been shown to be essential throughout the living world.

For example, the existence of bacterial cell communication involving chemical signal molecules has been abundantly documented during the last decade. This process, designated quorum sensing, involves the exchange of specific signal molecules known as auto inducers. It occurs both in gram positive and gram negative strains and it is thought to govern bacterial behavior. Recent work has shed light on the transcriptional regulatory cascades that are underlying quorum sensing and which result in the production of colonization factors and other metabolites involved in biofilm formation.

Cell communication is also essential for plant development. Plasmodesmata are regulatable channels which support macromolecular transport between neighbouring cells. Their permeability, structure and function are dependent upon the plant's developmental stage and cell proliferation status. Signaling molecules circulate within the plasmodesmata and their transport can be altered in pathological conditions, such as viral infection.

Recent work has established dynamic changes in the occurrence and ultrastructure of plasmodesmata during the development of the antheridia of Chara species. The relationship that exists between symplasmic isolation of the antheridium, induction of spermatozoid differentiation and elimination of the hormones' transport through plasmodesmata has been well documented. In higher eucaryotes critical aspects of cell communication have been known for a very long time.

INTERCELLULAR COMMUNICATION AND TRANSPORT PROCESSES DURING DEVELOPMENT

Hormones, growth factors, neurotransmitters are among the signaling agents that have been the most extensively studied. In each case, individual cell reactions are transmitted via inter cellular signals to neighbouring cells and integrated to generate a global cellular response at the level of tissues, organ and body.

The ability to communicate between cells is an absolute requisite to ensure appropriate coordination of the cell activity at the level of organisms. The endocrine hormonal signaling processes have provided several examples of complex relationship among regulatory pathways. Many receptors have been identified and shown to play critical roles in the adaptative cell response.

Depending upon the nature of the biosignals distinct pathways are being used to enter the cell.

For example, hydrophobic compounds such as steroid hormones can proceed through the lipid bilayer of the cells and eventually combine with receptors that are known to be transcription factors regulating gene expression. In spite of considerable progress made over the past two decades in the understanding of hormone receptor signaling, major questions remain unsolved regarding coordination of the various networks and their relationships in governing the complex cell response.

Another famous family of signaling components is represented by the G-protein-coupled receptors, often referred to as seven transmembrane (7TM) domains receptors. Upon the binding of agonists to these receptors, second messengers such as cAMP (cyclic Adenosine Mono Phosphate), arachidonic acid, DAG (diacylglycerol) and IP 3 (inositol-3-phosphate) are produced within the cell and act as amplificators of the initial signals generated by the primary binding.

Other types of external receptors include those with enzymatic activities, such as tyrosine kinase, serine-threonine kinase and tyrosine phosphatase. The functions and biological properties of these receptors, in normal and pathological conditions have been largely documented and reviewed. Because they showed critical functions in the control of fundamental biological processes, including cell proliferation and differentiation, homeostasis, development, and other important biological processes, they have provided the key for the understanding of several pathological situations, among which cancers were of prime concern.

One of the signaling pathways often used as a paradigm is that involving the Ras proteins, whose mutation has been associated to the development of human cancer. The mutations in ras that are frequently observed in human tumors abrogate the GTPase activity of RAS proteins. As a consequence, the RAS mutant proteins expressed in cancer cells remain in the active GTP-bound form and both cell growth and apoptosis regulatory pathways are scrambled.

Other key signaling factors that have been described in the past years include STAT (Signal Transducer and Activator of Transcription)and MAPK (Mitogen-Activated Protein Kinase).

Signaling also proceeds through ion channels, made of proteins that allow ions to cross the membrane, inward and outward. These channels are selective for the ions that they transport and they are classically designated after their gating type (the event which governs their opening). For example, «Voltage-gated channels» are open upon potential changes, whereas «ligand-gated channels» are regulated by ligand binding.

A considerable amount of information has been obtained regarding the sodium, potassium and calcium channeling. Both sodium and potassium play a key role in regulating the variations of membrane potential which are associated with nervous conduction. Calcium channeling has been reported to be essential in several biological conditions, including muscular contraction and bone remodeling.

DISCUSSION

Efficient coordination is an absolute requirement to safe functioning. Although currently, little is known about the molecular processes that coordinate the various cellular signaling pathways, the pace at which new data is accumulating makes this field an extremely important area in biology.

An increasing amount of evidence supports the idea that proteins of the ECM (extracellular matrix) are major players in the global control of intercellular communication and integration of environmental signals. Among them, the CCN family of matricellular proteins represent a new group of cell growth regulators. Manuscripts published over the past few years have established

the important role of these multimodular proteins in signaling through their functional interaction with several bioregulators in the extracellular matrix, at the cell membrane, and in the nucleus. Recently, two of the CCN proteins were also reported to modulate channel ion signaling.

Publications addressing these types of problems were often scattered and buried in the large number of manuscripts published in «signal transduction» journals. Our increasing interest in cellular communication, the lack of journals devoted to this important topic, and BioMed Central's efforts to create open access journals catalyzed the start of *Cell Communication and Signaling*, a journal that strongly encourages reports of studies incorporating morphological, biochemical, molecular and physiological approaches, as well as innovative *in vitro* models that facilitate investigation of cell networks and cell behavior.

Cell Communication and Signaling's open access policy changes the way in which articles are published. First, all articles become freely and universally accessible online, and so an author's work can be read by anyone at no cost. Second, the authors hold copyright for their work and grant anyone the right to reproduce and disseminate the article, provided that it is correctly cited and no errors are introduced.

Open access has four broad benefits for science and the general public. First, authors are assured that their work is disseminated to the widest possible audience, given that there are no barriers to access their work. This is accentuated by the authors being free to reproduce and distribute their work, for example by placing it on their institution's website. It has been shown that free online articles are more highly cited because of their easier availability.

Second, the information available to researchers will not be limited by what their libraries can afford, and the widespread availability of articles will enhance literature searching. Third, the results of publicly funded research will be accessible to all taxpayers and not just those with access to a library with a subscription.

Note that this public accessibility may become a legal requirement in the USA if the proposed Public Access to Science Act is made law. Fourth, a country's economy will not influence its scientists' ability to access articles because resource-poor countries (and institutions) will be able to read the same material as wealthier ones (although creating access to the internet is another matter).

CONCLUSION

Numerous studies have permitted to decipher the various steps of signal transduction, i.e. the propagation of chemical signals, from the outside of the cell to the nucleus and establish their critical function in the maintenance of normal cell behavior. Because of their key role in the control of normal life, and because alterations of the signal transduction pathways have been associated to the development of many types of pathologies including cancer, these processes have been the subject of thousands of publications.

Much less is known about the molecular basis for cell-cell communication which is taking place at the level of each organ and in whole bodies. By providing a new journal for rapid publication of peer-reviewed results and concepts regarding the global-type signaling networks, we hope that Cell Signaling and Communication will stimulate scientific exchange of high quality and thereby contribute to the diffusion of knowledge in a field of prime importance, that is expanding at a remarkable pace.

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Corresponding Author

Dr. Prahlad Kumar Meena*

Assistant Professor, Govt. College, Karauli