DOWNLOAD PDF BIOPHYSICS OF PHOTORECEPTION

Chapter 1 : UAB - Vision Science Research Center - News and Events

A main problem in biophysics is the interaction of light information with functional living structures to shape the organism's behaviour. This book presents advanced techniques in this highly.

Received Aug 11; Accepted Oct Copyright Roth et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are properly credited. This article has been cited by other articles in PMC. Abstract Arrhythmic mammals are active both during day and night if they are allowed. The arrhythmic horses are in possession of one of the largest terrestrial animal eyes and the purpose of this study is to reveal whether their eye is sensitive enough to see colours at night. During the day horses are known to have dichromatic colour vision. To disclose whether they can discriminate colours in dim light a behavioural dual choice experiment was performed. We started the training and testing at daylight intensities and the horses continued to choose correctly at a high frequency down to light intensities corresponding to moonlight. One Shetland pony mare, was able to discriminate colours at 0. For comparison, the colour vision limit for several human subjects tested in the very same experiment was also 0. Hence, the threshold of colour vision for the horse that performed best was similar to that of the humans. The behavioural results are in line with calculations of the sensitivity of cone vision where the horse eye and human eye again are similar. The advantage of the large eye of the horse lies not in colour vision at night, but probably instead in achromatic tasks where presumably signal summation enhances sensitivity. Introduction Between a sunny summer day and a moonless night there is a million-times intensity difference [1]. To function over this huge range of intensities puts an eye at very high demands. Therefore, most vertebrates have duplex retinae with multiple types of cones that can contribute to colour vision in daylight intensities and very light-sensitive rods for vision in dim light [2]. At night when light is dim it is vital for the eye to capture as many photons as possible to allow for a strong visual signal. Common optical adaptations in animals active at night are consequently large eyes with large pupils and short focal lengths thus, a low f-number to concentrate the sparse photons onto fewer photoreceptors. In addition, the visual signals from neighbouring photoreceptors can be summed in space and in time to generate a higher signal-to-noise ratio at night at the expense of spatial and temporal resolution [1] , [3]. Colour vision is compromising sensitivity since the colour signal requires a comparison between signals from photoreceptor types with different spectral sensitivities. For vertebrates this usually means a comparison between at least two different types of cones [4] , [5] , even though rods influence colour perception at low light intensities. As the signals from the cones are compared to generate a colour signal, the photoreceptor noise adds up and becomes relatively larger generating a low signal-to-noise ratio. Spectral poolingâ€”summation of signals from all photoreceptors independently of their maximum spectral sensitivityâ€”could be one way of strengthening the signal. However, this means sacrificing colour vision. In dim light a monochromat should, due to lower noise levels, be able to discriminate more shades than a dichromat [6]. For the same reason, dichromats, comparing signals between only two cone types, fare better than trichromats [6]. Trichromatic colour vision, such in humans, demands two comparisons of signals from three cone types thus generating a low signal-to-noise ratio. Therefore, dichromatic vision theoretically generates a stronger signal-to-noise ratio and allows discrimination of colours at dimmer light conditions compared to trichromatic vision Fig.

Chapter 2 : Medicine - English Division | WydziaÅ, Nauki o Å»ywnoÅ›ci

This is the first volume of new book series on biophysics and biocybernetics, initiated by the Istituto Italiano per gli Studi Filosofici.A main problem in biophysics is the interaction of light information with functional living structures, in order to shape the organism's behaviour.

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Chapter 3 : intensity and the process of photoreception | Download eBook PDF/EPUB

Aus: Biophysics of Photoreception (C. Taddei-Ferretti ed.) 20 ANALYSIS OF VISION AND GAZE CONTROL IN INSECTS Roland Hengstenberg Max-Planck-Institut fÃ¼r biologische Kybernetik, D TÃ¼bingen.

Molecular phylogenetic tree of the animal opsin family by the neighbor-joining method. Canonical visual opsins and novel non-visual opsins are indicated, respectively, with yellow and red arrows. Blue circled acronyms indicate retinal photopigments of vertebrates; LW, MW, SW1, SW2, respectively, long-, medium-, type 1 short- , type 2 short-wavelength opsin of cones, and Rh, rhodopsin of rods. Modified from Terakita, Recent findings on the molecular evolution of novel non-visual opsins suggest a strict relationship of the NVP process with canonical vision, which could have occurred in lower organisms of the animal phylogenetic tree. In this regard, the identification of novel opsins suggests that the history of visual pigments is strictly connected with the evolution of photoreceptors and eyes Nilsson, In particular, there is strong evidence that opsins evolved according to the main evolutionary lineages of animal visual cells, the ciliary and the rhabdomeric or microvillar photoreceptors see Section 5b. However, although those aspects are not strictly related to the main topics of this paper, some accounts related to NVP will be given. In the primitive eyeless metazoan, Hydra, we first identified an opsin-like protein by polyclonal antibodies against squid rhodopsin probably localized in epidermal sensory nervous cells Musio et al. Immunofluorescence localization of a rhodopsin-like protein in Hydra vulgaris. The distribution pattern of the fluorescent cells is restricted to the ectodermal surface of the animal. Dotted inset is magnified on top right figure. Modified from Musio et al. Molecular approaches, using partial sequences of opsin genes available in the GeneBank, provided us with preliminary evidence of a possible coexistence of putative visual and non-visual opsins in a primitive animal Santillo et al. Hopefully, interesting results will be forthcoming on the regulation of opsin gene expression exerted by diurnal and circadian rhythms in Hydra Santillo et al. More recently, Suga et al. Their expression patterns suggest two possible functions: Furthermore, recent papers accounting for the molecular evolution of opsin visual pigments have reported the identification of multiple classes of opsins in Cnidaria Plachetzki et al. In the brain of four species of lepidopterans, three kinds of spectrally distinct opsins have been reported outside of the retina; UV and blue opsins, which are restricted to adult stemmata where melatonin is expressed together with opsins , and long-wavelength LW opsins, which are specific for dorsal and ventral photosensitive neurons of the optic lobes. Arendt and coworkers have found that in the ragworm, Platinereis, the coexistence of rhabdomeric photoreceptors in the eyes for phototaxis , and ciliary photosensitive cells in the brain for entrainment of biological clocks. The latter referred to as NVP cells use an opsin closely related to vertebrate rod and cone opsins. A recent study in the honey bee, Apis mellifera, has revealed that a ciliary opsin, called pteropsin, is expressed in the brain of this species, indicating the presence of a vertebrate-like light-detecting system in insects Velarde et al. The hypothesis that rhabdomeric invertebrate photoreceptors and photosensitive ganglion cells could have common molecular machinery has been put forward by Koyanagi et al. They used the cephalocordate, Ampioxus, the invertebrate closest to a vertebrate that has rhabdomeric photoreceptors for non-visual function. These authors found that the amphioxus homolog of melanopsin was contained in rhabdomeric photoreceptors. It shows the biochemical and photochemical properties of the visual rhodopsins, similar to those of classic rhabdomeric photoreceptors common to higher invertebrates. Ultimate electrophysiological findings in melanopsin-expressing photoreceptors of Amphioxus support the above hypothesis about a link between ancestral rhabdomeric photosensitive cells of prebilaterians, and the circadian photoreceptors of higher vertebrates Gomez del Pilar et al. More recently, a striking molecular feature of melanopsin has been reported to be phylogenetically close to the visual pigments of invertebrates. In particular, Terakita et al. They reported similar molecular properties between melanopsin and Gq-coupled visual pigments, although these photopigments serve different visual functions. Light-Sensitive Channels and Phototransduction Cascade. Invertebrates show a great variety of eyes and retinal structural patterns constituted by microvillar photoreceptors, with very few ciliary exceptions Eakin RM, Rhabdomeric photoreceptors are carachterized by wide finger-like invaginations of the cellular

membrane, called microvilli, which are variously arranged and contain visual pigments inside Figure 4. Scheme of a rhabdomeric left and a ciliary right photoreeptor. Celina Bedini, University of Pisa. In spite of the functional development of optical solutions, vertebrates share a substantially conserved structural scheme. The image-forming photosensitive elements are constituted by retinal ciliary photoreceptors, rods and cones Cohen, Ciliary photoreceptors show a more regular structure, being entirely of ciliary type. They are carachterized by flattened disks or sacks containing photopigments, which originated from the invagination of the cellular membrane Figure 4. The two main evolutionary lineages of visual cells, ciliary and microvillar rhabdomeric , have different functional properties of visual excitation, although in both the transduction mechanism is characterized by a G-protein-coupled cascade mediated by a second messenger acting on the gating of light-dependent ion channels Figure 5. Schematic drawing of the different phototransduction cascades occurring in classical and non-visual photoreceptors in both vertebrates and invertebrates. Modified from Santillo et al. Due to ancillary and, above all, to new advanced electrophysiological techniques, the study of functional properties of photoresponse in invertebrate photoreceptors is orienting towards the "single cell approach" Musio, , This kind of approach is fruitful when a given cell has already been identified as a photoreceptor, or is used to discover new examples of photosensitivity Nasi et al. The best studied NVP models by means of this approach are those cells identified as neuronal photoreceptors, or those cells belonging to the central nervous system with the soma located outside the brain in peripheral sensory regions Musio, , Important electrophysiological data on the mechanisms of the intracellular signaling cascade in the melanopsin-containing retinal ganglion cells ipGRCs of vertebrates have been reported. These papers show that melanopsin phototransduction resembles the responses of invertebrate photoreceptors, and not the responses seen in vertebrate classical photoreceptors rods and cones Isoldi et al. Unfortunately, electrophysiological investigations on the phototransduction chain in NVP cells of invertebrates are still limited. However, relevant examples can be gathered from mollusks and Limulus. This finding resembles, except for the response polarity, the light-induced hyperpolarizing potential in vertebrate photoreceptors that is also induced by a conductance decrease. Instead, differences are evident if the A-P-1 ionic behavior is compared to the same photoresponse in ocular and extraocular photoreceptors of other invertebrates. Similarly, an increase of conductance occurs also in extraocular photosensitive neurons in the abdominal ganglion of Aplysia Andresen and Brown, , even though in these neurons the receptor potential is hyperpolarizing, analogous to that in invertebrate ciliary ocular photoreceptors Gomez and Nasi, The photoresponse of Onchidium A-P-1 resembles that of vertebrate photoreceptors, as regards the role of internal messenger. Injection of cyclic guanosine monophosphate cGMP in the dark produces an outward current, associated with an increase of conductance, which is suppressed by illumination suggesting a hydrolysis of cGMP by light. Thus, light activates a phosphodiesterase that reduces cGMP, as in vertebrate photoreceptors Koutalos et al. Furthermore, the photocurrent is amplified by the pressure-injection of inositol 1,4,5-triphosphate IP3 , indicating also a role of this messenger in the visual cascade. In this way, the light-sensitive channels of the extraocular photoreceptors seem to be regulated by cGMP in the dark, and by IP3 in the light. These findings have been confirmed by Gotow et al. In the inside-out configuration, a channel that appeared to be the same as the light-sensitive channel was activated opened by the application of cGMP. The photosensitive neurons in the left parietal ganglion of the snail, Helix, provide another well-studied model of ionic mechanisms underlying light detection Kartelija et al. In these cells, the light produces a slow inward current associated with a decrement of slope conductance. This light-induced current is due to the suppression of K2 conductance, and the addition of an internal concentration of cGMP mimics the effect of light. In fact, the trend of light-sensitive and cGMP-induced currents follows a similar course, and shows a common reversal potential. This differs from the Onchidium photosensitive neurons, because in the former case, cGMP acts to produce an outward current that is suppressed by light. In the octopus, Eledone, it has been demonstrated that extraocular photoreceptors, termed "epistellar bodies", located inside the mantle sac, depolarize upon an increase in illumination due to an increase in cell membrane conductance Cobb and Williamson, This study indicates that octopus extraocular photoreceptor cells are comparable in their light-induced depolarization and the underlying ionic phototransduction mechanism with those already

reported for other invertebrate rhabdomeric photoreceptor cells Nasi et al. Apart from its evolutionary value in the development of the photoreceptive function, the Limulus ventral nerve photoreceptor VNP is certainly the well-established invertebrate model among those currently used to investigate light-induced biophysical processes. Since the pioneering works of Millecchia and Mauro a, b , a huge number of studies carried out by several authors have revealed the exceptional suitability of the Limulus VNP to quantitative electrophysiology and biochemical approaches. For the convenience of the reader, a very brief summary of the main biophysical characteristics of the Limulus VNP is given below, with the recommendation that the reader check these excellent reviews for detailed results and references Nagy, ; Stieve and Nagy, The function of Limulus VNP appears very effective, due to the synergic action of light- and voltage-activated conductances. Voltage-clamp recordings showed three different light-activated conductances which act together to shape three different components to the receptor macroscopic current , and four voltage-activated conductances. These components recover with different rates, and have different reversal potentials and behavioral kinetics as well, indicating different excitation mechanisms. In this respect, current data propose three transduction pathways leading to different terminal transmitters: The starting points of these chains, after the triggering by photon absorption, could be different G proteins activated by the same metarhodopsin molecule, even though the presence of other types of metarhodopsin cannot be excluded. Calcium ions also play a crucial role in the Limulus VNP phototransductive process. Recent additions to the VNP phototransduction cascade have been provided by Garger et al. In conclusion, there are still few available examples to depict a common phototransductive cascade by invertebrate NVP cells. A large amount of data is needed to: In fact, previous studies have shown that melanopsin belongs to the orthology group of rhabdomeric opsins, coupling possibly to an invertebrate-like phototransduction cascade. This is indicated by an IP3-based visual cascade triggered by melanopsin in cultured Xenopus melanophore systems Isoldi et al. The involvement of an invertebrate-like rhabdomeric phototransduction cascade in melanopsin-containing photoreceptors has been recently identified in non-visual retinal ganglion cells of chicken Contin et al. Finally, identified elements of the phototransduction cascade of visual and non-visual photoreceptors of invertebrates species cited in the present paper are reported for comparison in Figure 6. Detail of the key-players involved in the phototransduction of visual and non-visual photoreceptors in some invertebrates. On the bottom, comparison with image-forming and extraretinal photoreceptors of vertebrates is given. Each single row should be read from left to right according to the temporal order of the functional events. The up arrows and down arrows, respectively, mean increase and decrease of the intracellular concentration of the chemical substance. For details and abbreviations see Section 5b. Concluding Remarks and Future Directions There is no doubt that the findings obtained in the last decade on molecular, cellular and functional properties of non-visual photoreception are bringing this research field to a new height. However, several issues remain to be unraveled, and more animal models are needed to understand them. Above all, the study of the molecular evolution of the novel opsins shows a need for discovering the evolution of photoreceptors, and definitely of visual function. Also, the comparative physiology of the non-visual photoreceptor may shed light on the course of the phototransduction cascade along the phylogenetic tree. Interesting scenarios have been recently proposed Arendt et al. From the evolutionary point of view, it has been suggested that NVP, through undifferentiated single photosensitive cells, constitutes the first step towards the complex organization of photoreceptive elements clustered into cup-like ocelli, and later into eyes. On the other hand, it should be considered: All together these facts exclude the possibility of considering NVP as a primitive evolutionary step in lower Metazoa, and an evolutionary relic in higher phyla. On the contrary, they suggest a polyphyletic route i. The identification of novel opsins in a wide number of species, above all for invertebrates, their molecular evolution and phylogenetic analysis will help to provide clear answers. Of high priority should be the effort to untangle the evolutionary relationship between invertebrate non-visual cells and photosensitive ganglion cells, since it concerns the putative common molecular and photochemical strategies of phototransduction. From a functional point of view, recent studies in vertebrates including mammals, stress the crucial role of NVP, which seems to parallel and integrate the image-forming process.

Chapter 4 : Non-Visual Photoreception in Invertebrates

The Biophysics of Visual Photoreception The absorption of a single photon by a pigment molecule called rhodopsin in a photoreceptor cell in the retina initiates a process of amplification that ends in a neural response.

Extracellular receptors[edit] Extracellular receptors are integral transmembrane proteins and make up most receptors. They span the plasma membrane of the cell, with one part of the receptor on the outside of the cell and the other on the inside. Signal transduction occurs as a result of a ligand binding to the outside region of the receptor the ligand does not pass through the membrane. Ligand-receptor binding induces a change in the conformation of the inside part of the receptor, a process sometimes called "receptor activation". Often such enzymes are covalently linked to the receptor. Some of them create second messengers such as cyclic AMP and IP3 , the latter controlling the release of intracellular calcium stores into the cytoplasm. Other activated proteins interact with adaptor proteins that facilitate signaling protein interactions and coordination of signaling complexes necessary to respond to a particular stimulus. Enzymes and adaptor proteins are both responsive to various second messenger molecules. Many adaptor proteins and enzymes activated as part of signal transduction possess specialized protein domains that bind to specific secondary messenger molecules. For example, calcium ions bind to the EF hand domains of calmodulin , allowing it to bind and activate calmodulin-dependent kinase. PIP3 and other phosphoinositides do the same thing to the Pleckstrin homology domains of proteins such as the kinase protein AKT. G proteinâ€"coupled receptors[edit] Main article: G proteinâ€"coupled receptor G proteinâ€"coupled receptors GPCRs are a family of integral transmembrane proteins that possess seven transmembrane domains and are linked to a heterotrimeric G protein. With nearly members, this is the largest family of membrane proteins and receptors in mammals. Counting all animal species, they add up to over The dissociation exposes sites on the subunits that can interact with other molecules. A study was conducted where a point mutation was inserted into the gene encoding the chemokine receptor CXCR2; mutated cells underwent a malignant transformation due to the expression of CXCR2 in an active conformation despite the absence of chemokine-binding. This meant that chemokine receptors can contribute to cancer development. The interaction between the cytoplasmic domains stimulates the auto phosphorylation of tyrosine residues within the intracellular kinase domains of the RTKs, causing conformational changes. The process of signal transduction involves around known protein kinases and pseudokinases , encoded by the human kinome [33] [34] As is the case with GPCRs, proteins that bind GTP play a major role in signal transduction from the activated RTK into the cell. In this case, the G proteins are members of the Ras , Rho , and Raf families, referred to collectively as small G proteins. They act as molecular switches usually tethered to membranes by isoprenyl groups linked to their carboxyl ends. Upon activation, they assign proteins to specific membrane subdomains where they participate in signaling. The mutation of certain RTK genes, as with that of GPCRs, can result in the expression of receptors that exist in a constitutively activated state; such mutated genes may act as oncogenes. Integrin An overview of integrin-mediated signal transduction, adapted from Hehlgens et al. Integrins lack kinase activity; hence, integrin-mediated signal transduction is achieved through a variety of intracellular protein kinases and adaptor molecules, the main coordinator being integrin-linked kinase. Important differences exist between integrin-signaling in circulating blood cells and non-circulating cells such as epithelial cells ; integrins of circulating cells are normally inactive. For example, cell membrane integrins on circulating leukocytes are maintained in an inactive state to avoid epithelial cell attachment; they are activated only in response to stimuli such as those received at the site of an inflammatory response. In a similar manner, integrins at the cell membrane of circulating platelets are normally kept inactive to avoid thrombosis. Epithelial cells which are non-circulating normally have active integrins at their cell membrane, helping maintain their stable adhesion to underlying stromal cells that provide signals to maintain normal functioning. In the experimental model plant Arabidopsis thaliana , one of the integrin-linked kinase genes, ILK1, has been shown to be a critical element in the plant immune response to signal molecules from bacterial pathogens and plant sensitivity to salt and osmotic stress. Toll-like receptor When activated, toll-like receptors TLRs take adapter molecules within

the cytoplasm of cells in order to propagate a signal. Thousands of genes are activated by TLR signaling, implying that this method constitutes an important gateway for gene modulation. Ligand-gated ion channels[edit] Main article: Ligand-gated ion channel A ligand-gated ion channel, upon binding with a ligand, changes conformation to open a channel in the cell membrane through which ions relaying signals can pass. An example of this mechanism is found in the receiving cell of a neural synapse. The influx of ions that occurs in response to the opening of these channels induces action potentials , such as those that travel along nerves, by depolarizing the membrane of post-synaptic cells, resulting in the opening of voltage-gated ion channels. This results in amplification of the synapse response between synaptic cells by remodelling the dendritic spines involved in the synapse. Intracellular receptor Intracellular receptors, such as nuclear receptors and cytoplasmic receptors , are soluble proteins localized within their respective areas. The typical ligands for nuclear receptors are non-polar hormones like the steroid hormones testosterone and progesterone and derivatives of vitamins A and D. To initiate signal transduction, the ligand must pass through the plasma membrane by passive diffusion. On binding with the receptor, the ligands pass through the nuclear membrane into the nucleus , altering gene expression. Activated nuclear receptors attach to the DNA at receptor-specific hormone-responsive element HRE sequences, located in the promoter region of the genes activated by the hormone-receptor complex. Due to their enabling gene transcription, they are alternatively called inductors of gene expression. All hormones that act by regulation of gene expression have two consequences in their mechanism of action; their effects are produced after a characteristically long period of time and their effects persist for another long period of time, even after their concentration has been reduced to zero, due to a relatively slow turnover of most enzymes and proteins that would either deactivate or terminate ligand binding onto the receptor. Nucleic receptors have DNA-binding domains containing zinc fingers and a ligand-binding domain; the zinc fingers stabilize DNA binding by holding its phosphate backbone. DNA sequences that match the receptor are usually hexameric repeats of any kind; the sequences are similar but their orientation and distance differentiate them. The ligand-binding domain is additionally responsible for dimerization of nucleic receptors prior to binding and providing structures for transactivation used for communication with the translational apparatus. Steroid receptors are a subclass of nuclear receptors located primarily within the cytosol. In the absence of steroids, they associate in an aporeceptor complex containing chaperone or heatshock proteins HSPs. The HSPs are necessary to activate the receptor by assisting the protein to fold in a way such that the signal sequence enabling its passage into the nucleus is accessible. Steroid receptors, on the other hand, may be repressive on gene expression when their transactivation domain is hidden. Receptor activity can be enhanced by phosphorylation of serine residues at their N-terminal as a result of another signal transduction pathway, a process called crosstalk. Retinoic acid receptors are another subset of nuclear receptors. They can be activated by an endocrine-synthesized ligand that entered the cell by diffusion, a ligand synthesised from a precursor like retinol brought to the cell through the bloodstream or a completely intracellularly synthesised ligand like prostaglandin. These receptors are located in the nucleus and are not accompanied by HSPs. They repress their gene by binding to their specific DNA sequence when no ligand binds to them, and vice versa. Certain intracellular receptors of the immune system are cytoplasmic receptors; recently identified NOD-like receptors NLRs reside in the cytoplasm of some eukaryotic cells and interact with ligands using a leucine-rich repeat LRR motif similar to TLRs. Second messengers are the substances that enter the cytoplasm and act within the cell to trigger a response. In essence, second messengers serve as chemical relays from the plasma membrane to the cytoplasm, thus carrying out intracellular signal transduction. Calcium[edit] The release of calcium ions from the endoplasmic reticulum into the cytosol results in its binding to signaling proteins that are then activated; it is then sequestered in the smooth endoplasmic reticulum [47] and the mitochondria. The nature of calcium in the cytosol means that it is active for only a very short time, meaning its free state concentration is very low and is mostly bound to organelle molecules like calreticulin when inactive. Calcium is used in many processes including muscle contraction, neurotransmitter release from nerve endings, and cell migration. The three main pathways that lead to its activation are GPCR pathways, RTK pathways, and gated ion channels; it regulates proteins either directly or by binding to an enzyme. Lipid messengers[edit] Lipophilic second messenger molecules are derived from

lipids residing in cellular membranes; enzymes stimulated by activated receptors activate the lipids by modifying them. Examples include diacylglycerol and ceramide , the former required for the activation of protein kinase C. Nitric oxide[edit] Nitric oxide NO acts as a second messenger because it is a free radical that can diffuse through the plasma membrane and affect nearby cells. It is synthesised from arginine and oxygen by the NO synthase and works through activation of soluble guanylyl cyclase , which when activated produces another second messenger, cGMP. NO can also act through covalent modification of proteins or their metal co-factors; some have a redox mechanism and are reversible. It is toxic in high concentrations and causes damage during stroke , but is the cause of many other functions like relaxation of blood vessels, apoptosis , and penile erections. Redox signaling[edit] In addition to nitric oxide, other electronically activated species are also signal-transducing agents in a process called redox signaling. Examples include superoxide , hydrogen peroxide , carbon monoxide , and hydrogen sulfide. Redox signaling also includes active modulation of electronic flows in semiconductive biological macromolecules. Gene activation leads to further cellular effects, since the products of responding genes include instigators of activation; transcription factors produced as a result of a signal transduction cascade can activate even more genes. Hence, an initial stimulus can trigger the expression of a large number of genes, leading to physiological events like the increased uptake of glucose from the blood stream [50] and the migration of neutrophils to sites of infection. The set of genes and their activation order to certain stimuli is referred to as a genetic program. Such requirements for extracellular stimulation are necessary for controlling cell behavior in unicellular and multicellular organisms; signal transduction pathways are perceived to be so central to biological processes that a large number of diseases are attributed to their disregulation. Three basic signals determine cellular growth: Stimulatory growth factors Transcription dependent response For example, steroids act directly as transcription factor gives slow response, as transcription factor must bind DNA, which needs to be transcribed. Major pathways[edit] Following are some major signaling pathways, demonstrating how ligands binding to their receptors can affect second messengers and eventually result in altered cellular responses. A pathway that couples intracellular responses to the binding of growth factors to cell surface receptors. This pathway is very complex and includes many protein components. DAG remains bound to the membrane, and IP3 is released as a soluble structure into the cytosol. IP3 then diffuses through the cytosol to bind to IP3 receptors , particular calcium channels in the endoplasmic reticulum ER. These channels are specific to calcium and allow the passage of only calcium to move through. This causes the cytosolic concentration of Calcium to increase, causing a cascade of intracellular changes and activity. End-effects include taste, manic depression, tumor promotion, etc. The earliest notion of signal transduction can be traced back to , when Claude Bernard proposed that ductless glands such as the spleen , the thyroid and adrenal glands , were responsible for the release of "internal secretions" with physiological effects. The discovery of nerve growth factor by Rita Levi-Montalcini in , and epidermal growth factor by Stanley Cohen in , led to more detailed insights into the molecular basis of cell signaling, in particular growth factors. Thus, he deduced that the G-protein is a transducer that accepts glucagon molecules and affects the cell. Thus, the characterization of RTKs and GPCRs led to the formulation of the concept of "signal transduction", a word first used in

Chapter 5 : The Absolute Threshold of Colour Vision in the Horse

"Biophysics of photoreception for non-image vision" Michael Do, Ph.D., Assistant Professor Department of Neurology, Center for Brain Science F.M. Kirby Neurobiology Center Boston Children's Hospital Harvard Medical School.

Molecular mechanisms in visual transduction is presently one of the most intensely studied areas in the field of signal transduction research in biological cells. Because the sense of vision plays a primary role in animal biology, and thus has been subject to long evolutionary development, the molecular and cellular mechanisms underlying vision have a high degree of sensitivity and versatility. The aims of visual transduction research are first to determine which molecules participate, and then to understand how they act in concert to produce the exquisite electrical responses of the photoreceptor cells. Since the s [1] we have known that rod vision begins with the capture of a quantum of energy, a photon, by a visual pigment molecule, rhodopsin. As the function of photon absorption is to convert the visual pigment molecule into a G-protein activating state, the structural details of the visual pigments must be explained from the perspective of their role in activating their specific G-proteins. Thus, Chapters of this Handbook extensively cover the physico-chemical molecular characteristics of the vertebrate rhodopsins. Following photoconversion and G-protein activation, the phototransduction cascade leads to modifications of the population of closed and open ion channels in the photoreceptor plasma membrane, and thereby to the electrical response. The nature of the channels of vertebrate photoreceptors is examined in Chapter 4, and Chapter 5 integrates the present body of knowledge of the activation steps in the cascade into a quantitative framework. Once the phototransduction cascade is activated, it must be subsequently silenced. The various molecular mechanisms participating in inactivation are treated in Chapters and especially Chapter 5. Molecular biology is now an indispensable tool in signal transduction studies. Numerous vertebrate Chapter 6 and invertebrate Chapter 7 visual pigments have been characterized and cloned. The genetics and evolutionary aspects of this great subfamily of G-protein activating receptors are intriguing as they present a natural probe for the intimate relationship between structure and function of the visual pigments. Understanding the spectral characteristics from the molecular composition can be expected to Author by: General Biophysics, Volume II studies biological phenomena at the supramolecular and cellular levels of structure. The book considers biological phenomena on the basis of general physical principles. The text presents topics on bioenergetic processes; structure and properties of mitochondria; photo-biological processes; nonlinear dynamic processes; and physical interpretation of the most general problems of biology. Graduate and postgraduate students in the field of physical and life sciences will find this book very useful. National Academies Press Format Available: One of a continuing series on Frontiers of Visual Science, this short volume contains papers presented at a recent symposium. These papers describe techniques for assessing the structure and function of photoreception, both in isolation and in aggregation as the "receptor mosaic" of the retina. Also described are dynamic and spatial sampling properties of photoreceptors, with an emphasis on techniques of measurement and associated models of retinal function. This volume should be of interest to basic vision scientists, clinical ophthalmologists, workers in human factors, and computer scientists curious about the visual apparatus of biological systems. Federation of European Biochemical Societies. The scientific programme of the 16th FEBS meeting held in Moscow, was very wide and covered practically all major aspects of the study of living matter on a molecular level. The scientific level of all symposia organized within the framework of the meeting was extremely high and reflected the latest achievements in each particular branch of science. This three-part publication of the Proccedings of the 16th FEBS Congress includes the lectures that are of particular interest. The volumes are available separately or at a specially discounted set price. This book reviews the synergism between various fields of research that are confronted with networks, such as genetic and metabolic networks, social networks, the Internet and ecological systems. In many cases, the interacting networks manifest so-called emergent properties that are not possessed by any of the individual components. Knowledge gained from the study of complex non-biological systems can be applied to the intricate braided relationships that govern cellular functions.

Chapter 6 : [Some aspects of the biophysics of photoreception].

From the beginning of the century, the red heterotrichous ciliate Blepharisma has been an interesting subject of studies in the field of photobiology because of its endogenous pigment blepharismin. In fact, if Blepharisma is exposed to relatively strong light, in the presence of oxygen, blepharismin.

Chapter 7 : Signal transduction - Wikipedia

General Biophysics, Volume II studies biological phenomena at the supramolecular and cellular levels of structure. The book considers biological phenomena on the basis of general physical principles.

Chapter 8 : Instructions for Authors | The Biophysical Society of Japan

Photo-induced motile responses in microorganisms differ greatly by their appearance and mechanisms (see Nultsch and HÃ¤der, for comprehensive review). The traditional classification of photomovements has long been based on the behavioral principles (Diehn et al.,). Accordingly, the.

Chapter 9 : the molecular mechanism of photoreception | Download eBook PDF/EPUB

ommatidia in the study of photoreception biophysics, as well as their usefulness in studies of ionic channel ac-tivity. MATERIALS AND METHODS Experimental preparations.