light exposure, the protein concentration of arrestin and GCAPs increases by about 30-50%. The up-regulation of these proteins in bright light conditions is expected to reactivate the photocurrent and thus to mediate a late phase of light adaptation. Functional *in vivo* electroretinographic tests show in fact that a partial recovery of the dark current occurs 1-2 hours after prolonged illumination with a steady light that initially causes a substantial suppression of the photoresponse. These observations demonstrate that a prolonged illumination results in the up-regulation of genes coding for proteins involved in the phototransduction signaling cascade, possibly underlying a novel component of light adaptation occurring 1-2 hours after the onset of a steady bright light.

2705-Pos Board B675

His75 in Proteorhodopsin, a Novel Component in Light-Driven Proton Translocation by Primary Pumps

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Proteorhodopsins (PRs), photoactive retinylidene membrane proteins ubiquitous in marine eubacteria, exhibit light-driven proton transport activity similar to that of the well-studied bacteriorhodopsin from halophilic archaea. However, unlike bacteriorhodopsin, PRs have a single highly conserved histidine located near the protein's photoactive site. Time-resolved FTIR difference spectroscopy combined with visible absorption spectroscopy, isotope labeling, and electrical measurements of light-induced charge movements reveal participation of His75 in the proton translocation mechanism of PR. Substitution of His75 with Ala or Glu perturbed the structure of the photoactive site and resulted in significantly shifted visible absorption spectra. In contrast, His75 substitution with a positively charged Arg did not shift the visible absorption spectrum of PR. The mutation to Arg also blocks the light-induced proton transfer from the Schiff base to its counterion Asp97 during the photocycle and the acid-induced protonation of Asp97 in the protein's dark state. Isotope labeling of histidine revealed that His75 undergoes deprotonation during the photocycle in the proton-pumping (high pH) form of PR, a reaction further supported by results from H75E. Finally, all His75 mutations greatly affect charge movements within the PR and shift its pH dependence to acidic values. A model of the proteorhodopsin proton transport process is proposed whereby (i) in the dark state His75 is positively charged (protonated) over a wide pH range and interacts directly with the Schiff base counterion Asp97; and (ii) photoisomerization-induced transfer of the Schiff base proton to the Asp97 counterion disrupts its interaction with His75 and triggers a histidine deprotonation.

2706-Pos Board B676

Slow quinone diffusion limits the photosynthetic rate in Phaeospirillum molischianum

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We have investigated the organization of the photosynthetic apparatus in Phaeospirillum molischianum using AFM, fractionation, functional kinetic measurements and modeling. The various proteins of the apparatus do not co-localize and specific membrane domains appear to be involved in light-collection and quinone reduction, while other regions are specialized in quinol oxidation or ATP synthesis. The overall turnover time of cyclic electron transfer is about 25 msec in vivo, and can be slowed to over 100 msec under oxidizing conditions. We show that the photosynthetic rate in this organism appears to be limited by a very slow quinone diffusion between the reaction center and cytochrome bc1 complex, a process that takes about 250 msec. This particularly slow diffusion appears to be compensated in part by the size of the quinone pool. In this context the details of the organization of the photosynthetic apparatus would seem critical to conserving a competitive bioenergetic system. It is possible that quinone excluding antennae domains are important for maintaining photosynthetic competence by channeling quinones between domains.
Our measurements highlight that the functional organization of the photosynthetic apparatus varies greatly between organisms, and that we observe in Phaeospirillum molischianum is very different from that observed in Rhodobacter sphaeroides.

2707-Pos Board B677

Characteristics of the Dark-Stable Multiline EPR Signal of Ca^{2+}-Depleted Photosystem II

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Photosystem II (PSII), which produces molecular oxygen using energy from light absorption, requires Ca^{2+} and Cl^- ions as inorganic cofactors. PSII shows two electron paramagnetic resonance signals that have been associated with the depletion or disruption of Ca^{2+} at the catalytic Mn_4Ca cluster: a dark-stable multiline signal from an S_2 state that decays very slowly, and a broad metalloradical signal from an S_2Y_Z state that is unable to proceed to higher oxidation states. The conditions for their formation were explored to help clarify how they are correlated. The dark-stable multiline signal was found to form in PSII prepared at pH 5.5 using itaconic acid buffer, a relative of citrate. The signal was very similar to the previously reported signal that is observed after EDTA treatment of PSII lacking the PsbP and PsbQ subunits. Both of these treatments, which employ Ca^{2+} chelators, also resulted in formation of the S_2Y_Z signal when PSII was illuminated in the presence of an electron acceptor. Treatment of intact PSII with fluoride, which is a competitor of Cl^- activation, resulted in formation of the S_2Y_Z signal, but not the dark-stable multiline signal. Fluoride may also interfere with Ca^{2+} function as a result of the high stability of the CaF_2 complex. These findings are examined in relation to the requirements of PSII for Ca^{2+} and Cl^-. (Supported by UNCG Office of Research).

2708-Pos Board B678

Photosystem II Supercomplexes Of Higher Plants: Isolation And Determination Of The Structural And Functional Organization

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Photosystem II is a supercomplex composed of 27-28 different subunits and it represents the most important machinery of the plants photosynthetic apparatus, having the ability to split water into oxygen, protons and electrons. In the last few years the structures of most of the photosynthetic complexes have been resolved, allowing to organize in a "visual framework" the large body of information obtained by genetics, biochemical and spectroscopic methods about the function and organization of the complexes. Only the structure of PSII-LHCII from higher plants is still lacking due to the impossibility to obtain a homogeneous and stable preparation of the supercomplex, which has also prevented functional and spectroscopic studies.
In this work homogeneous and stable Photosystem II supercomplexes with different antenna size were isolated. A full gallery of complexes, from the core to the largest C2S2M2, was characterized by electron microscopy and biochemical and spectroscopic methods, allowing to relate for the first time the supramolecular organization to the protein and pigment content and the energy transfer processes. A new complex containing a monomeric core, a trimeric LHCII (S) and a monomeric CP26 was isolated, showing that the antenna proteins can bind to the monomeric core in contrast to the current belief. The comparison of the supercomplexes obtained from WT plants and knock out mutants of several Lhcb proteins allowed determining the hierarchy of the assembly and to suggest a role for the individual subunits. The data also provides information about the organization of the oxygen evolving complex. For the first time it was possible to study the energy transfer process in the supercomplexes with the use of picosecond fluorescence spectroscopy.
The functional implication of these results on photoinhibition, state transition and energy transfer are discussed.

2709-Pos Board B679

Type I reaction center from the green sulfur bacterium *Chlorobium tepidum*: is Chl *a* a primary electron acceptor?

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The green sulfur bacterium *Chlorobium tepidum* has one of the simplest type I reaction center (RC) complexes. While its structure is still unknown, biochemical and protein sequence analyses suggest that it is similar to photosystem I (PS I), with two BChl *a* forming a special pair P840, four Chl *a* serving as pairs of accessory and primary electron acceptor (A_0) pigments and 14 BChl *a* constituting as an immediate RC antenna. This is a dramatic simplification compared to PS I RC, where 90 Chl *a* antenna pigments serve as antenna and 6 additional Chl *a* molecules function as electron transfer cofactors. The resulting spectral congestion has prevented direct visualization of ultrafast electron transfer processes within PS I RC and even the sequence of primary electron transfer processes in PS I is still under debate. The suggested presence of two types of pigments in RC from *Chlorobium tepidum* removes spectral congestion and opens a way to directly visualize electron transfer steps in type I RC using ultrafast spectroscopy, since the Chl *a* and BChl *a* pigments absorb at ~670 nm and ~800 nm, respectively. To confirm the proposed functional role of Chl *a* as

electron transfer cofactor we performed extensive ultrafast optical pump-probe experiments on different preparations of RC complexes from *Chlorobium tepidum*, revealing energy/electron transfer rates between different groups of pigments. Surprisingly, we found that ~3 out of 4 Chl *a* pigments do not transfer excitation energy to the BChl *a* antenna or to P840, which indicates that these pigments must be >20Å away from any other BChl *a* pigment and thus argues against the suggested presence of 4 Chl *a* in the reaction center core complex.

2710-Pos Board B680

Biochemical and structural characterization of Photosystems from Galdieria sulphuraria

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Red alga (Rhodophyta) is one of the most ancient eukaryotic algae and its photosynthetic apparatus is in a transitional state between cyanobacteria and higher plants. Under rhodophyta, cyanidiales are group of asexual, unicellular red algae which thrive in acidic pH (0.5 - 3.0) and high temperature (50 to 55^0C). Cyanidiales are classified into three genera, Cyanidium, Cyaniodioschyzon and Galdieria. Within cyanidiales, Galdieria has been a considerable debate among researchers about its systematic position and it's an outlier in terms of habitat, reproduction and sequence similarity. There is also considerable difference in photosystems of cyanidiales. In case of photosystem I (PSI), cyanidium has a monomeric PSI with an intrinsic light harvesting complex attached to it. Also, in photosystem II (PSII), different cyanidiales have different lumenal PSII subunits: Cyanidium has PsbV not PsbP, whereas PsbV is replaced by PsbP in cyaniodioschyzon. But there is only minimal knowledge of PSI and PSII in Galdieria. In our study, we addressed these questions by use of high resolution mass spectrometry to identify the different subunits of PSI and PSII in *Galdieria sulphuraria*. For structural and functional aspects of both photosystems, we had studied the isolated complexes by electron microscopy and time resolved fluorescence spectroscopy. Initial results from these studies showed that PSI is a monomer and there are several pools of red-shifted chlorophyll with potentially complex kinetic relationships. Our work is supported from grants of National Science Foundation (MCB-0417142).

2711-Pos Board B681

Direct Photoelectrochemical Energy Transfer from Chlorosomes at Biohybrid Interfaces

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The electrogenic capacity of light antenna structures derived from *Chloroflexus aurantiacus* under light stimulation were explored in this study. Chlorosomes, which are unique light antenna structures composed of bacteriochlorophyll-c oligomers encased in a lipid monolayer, initiate the photoelectrochemical energy harvesting process in green photosynthetic bacteria at high quantum efficiencies (>92%). Previous work by this group suggest chlorosomes could be exploited for their fluorescence properties to enhance conventional silicon photovoltaics. Recent work suggests that chlorosomes can be functionally immobilized on conductive substrates. However, to date, chlorosomes have not been demonstrated to directly transduce light energy in an electrochemical system. In this study, chlorosomes are characterized in customized electrochemical cells using various electrochemical techniques, such as electrochemical impedance spectroscopy, chronoamperometry, cyclic voltammetry. The results obtained from chronoamperometric experimental studies demonstrate that isolated chlorosomes decoupled from their reaction centers are able to generate a measurable photocurrent when irradiated with light. In addition, the results indicate that only chlorosomes in proximity to the electrode participate in bioelectronic energy transfer. Electrochemical charge storage densities, also known charge injection capacities in neuroscience, show that when light stimulated, chlorosomes under a variety of conditions, i.e in bacterial fragments coupled to the photosynthetic apparatus, uncoupled colloidal solutions, and adsorbed systems, increase the charge stored near the electrode. The clear demonstration of the electrogenic capacity of chlorosomes at a heterogenous biohybrid interfaces may facilitate innovation in green technologies to novel biomedical therapeutics.

2712-Pos Board B682

Living Optical Elements in the Vertebrate Retina

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While cells are mostly transparent they are phase objects that differ in shape and refractive index. Any image that is projected through layers of cells will normally be distorted by refraction, reflection, and scattering. Strangely, the retina of the vertebrate eye is inverted with respect to its optical function and light must pass through several tissue layers before reaching the light-sensitive photoreceptor cells, with each photon having a chance of being scattered. Here we report how nature has optimized this apparently unfavourable situation. We investigated the optical properties of retinal tissue and individual Müller cells, which are radial glial cells spanning the entire thickness of the retina. Using confocal microscopy, quantitative refractometry, and a modified fiber-based dual-beam laser trap, we found that these cells act as optical fibers and guide light, which would otherwise be scattered, from the retinal surface to the photoreceptor cells. Their parallel arrangement in the retina is reminiscent of fiber-optic plates used for low-distortion image transfer. Behind the Müller cells, there seems to be a specific adaptation of the rod photoreceptor nuclei for improved light transmission through the outer nuclear layer of nocturnal animals. These nuclei have an inverted chromatin structure that turns them into microlenses channeling the light through the ONL. These findings ascribe a new function to glial cells, demonstrate the first nuclear adaptation for an optical function, and shed new light on the inverted retina as an optical system.

2713-Pos Board B683

Recording of Electrooculography in photo phobia patients

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Abstract

Photophobia is the condition which in accompanied by lack of color perception in human beings. Color perception is one of the characteristics of visual system in human beings. Retina in visual system is responsible for this characteristic. Electrooculogram(EOG) which is an electrophysiological technique has a contribution from cone cells in retina. Therefore EOG was examined in photophobia patients to search the possible disability of color perception. Fifty photophobia were selected & Electrooculography test was examined for all patients. Arden index (AI) was recorded in the population. SPSS a computerized program was used to analyze the data. The result of present study shows fall in Arden index. It is already reported that EOG has contribution from cone cells in addition to Retinal Pigment Epithelium (RPE) in Retina. Therefore the color vision is slightly distorted in patients suffering from photophobia.

KEYWORDS: Photophobia, Electrooculogram, Color Vision

2714-Pos Board B684

The Influence Of Rhodopsin Chromophore Binding On Protein Biosynthesis Examined In Vivo

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Over 100 mutations in the rhodopsin gene are associated with retinitis pigmentosa (RP) and other retinal disorders. A subset of mutations found in the N-terminus of rhodopsin cause sector RP in which the lower retina is preferentially affected, suggesting that in these cases retinal degeneration (RD) is influenced by light exposure. One such example, P23H, is the most prevalent RP-causing rhodopsin mutation in North America. Recently we have developed X. laevis (frog) models of RP based on human and bovine P23H rhodopsin which demonstrate light sensitivity. In these models, dark rearing either partially or completely rescues RD. We have shown that the rescuing effect of dark rearing is associated with chromophore binding, since blocking binding also prevents rescue. Light exposure is associated with decreased expression of P23H rhodopsin and decreased transport of P23H rhodopsin to the rod outer segment, suggesting a defect in export of the mutant protein from the ER. In order to define the role of chromophore binding in the rescue of P23H-induced RD, we have performed an extensive characterization of light sensitivity in these models. We raised transgenic F1 tadpoles in varying intensities, durations and wavelengths of light and determined the influence of these factors on RD. Our results suggest that the rescuing effects of dark rearing are not mediated by increased chromophore availablility, but rather by increased stability of rhodopsin in the secretory pathway. Our results have significant implications for the design of molecular chaperone therapies for RP.

2715-Pos Board B685

Photoreceptor ABC Transporter ABCA4: Its Role in the Visual Cycle and Retinal Degenerative Diseases

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