

DALTONIANA

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The bulletin of the International Colour Vision Society

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Daltoniana on the web

Welcome to the 14th edition of the web based **Daltoniana**. This edition will be transmitted by email and mailed to members from locations in North America, Europe and Australasia.

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Officers and Committee

President	Joel Pokorny ,
General Secretary	Ken Knoblauch
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Message from the General Secretary - Ken Knoblauch

The results are in for the election of six new Directors. The ballot was sent out along with the last Daltoniana and was available as well on the ICVS web site. Votes were accepted through the end of January. The official tally is:

Candidate	Total votes	Elected
Barbur	22	*
Buck	28	*
Foster	21	
Nacimiento	12	
Neitz	27	*
Nerger	10	
Shevell	28	*
Smithson	13	
Vienot	28	*
Zrenner	22	*

42 votes. 0 votes invalidated

Congratulations to the new directors and thank you to all who participated.

We also include an advance copy of the table of contents for the next proceedings which will be published in Visual Neuroscience. All papers went through the normal peer review process. Thank you to the editors for a great job.

We continue with the second column by Joe Carroll reviewing web sites of potential interest to ICVS members and a short compilation of abstracts of recently published articles on color vision.

Obituary - Robert William Rodieck, Neuroscientist (1937- 2003)

The death of Bob Rodieck occurred on September 30, 2003 in Seattle. At the time of his death Bob was Bishop Professor Emeritus of Ophthalmology at the University of Washington.

Bob Rodieck was born on April 17th 1937 in the United States of America. Bob's father was with the US Army, and his childhood was correspondingly peripatetic and culturally broadening. Though born on its east coast, he grew up in many parts of the USA. In 1946 - 1947 Bob and his younger sister lived with their parents in Japan. During that period Bob has gained a life-long sympathy for Japanese art and intellectual life. Later on as a teenager, Bob became a good player of the very cerebral Japanese board game 'Go' and remained practicing player through most of his life. From high school Bob went to the Massachusetts Institute of Technology, where he majored in electrical engineering. After graduating (BS, 1958) Bob worked briefly in the Bell Telephone Laboratories in New Jersey. Bob's first sort of contacts with neuroscience were games of Go played during lunch breaks with another Bell's employee, famous psychophysicist and also recently departed, Bella Julesz. Bob was seriously drawn to neuroscience, in Nelson Kiang's group at the Eaton Peabody Laboratory of the Massachusetts Eye and Ear Infirmary. His career and intellectual life were to be spent in neuroscience, and particularly in the neuroscience of vision. His work was distinguished by a powerful analytical intelligence, a deep respect for experimental observation, an abiding commitment to teaching and a willingness to fight for the quality of academic and scientific life.

By 1961, Bob had completed a Master of Science at MIT and, with the Cold War at its height, decided to move to Australia. He joined P.O. Bishop's laboratory in the Department of Physiology at University Sydney, enrolling for a PhD, which he gained in 1964. He remained in that Department, gaining the distinguished rank of Reader, before returning to the United States in 1978 to take up the E. K. Bishop Chair of Experimental Ophthalmology at the University of Washington, which he held until his retirement in 1998. He is survived by his first wife, Patricia (now Anna Johnson), and their sons Arlo and Jorma, and by his wife Babs, and their son Kim.

Bob's doctoral work combined the analytical tradition of his MIT training with Peter Bishop's strong empiricism, and in 1965 he published several important papers. Two of were experimental (*J. Neurophysiol.*, 28 : 819 – 832; *J. Neurophysiol.*, 28 : 833 – 849), systematic analyses of ganglion cell receptive fields. A third (*Vision Research*, 5 (11): 583 – 601) was a mathematical model of the receptive field, which explained the response over time of an individual cell to both stationary and moving objects and which, Bob demonstrated, also showed the instantaneous response of a distributed population of cells to the same stimuli. It was powerful extension from detailed observation to a general theory of coding. The papers became classics and, 4 decades later, are still cited.

Bob's papers from the late 1960's and early 1970's included the first evidence of unrecognised variety in receptive field organization in cat retina (*Science* 157 (784):90 – 92), an important step in the evolution of the concept of parallel-processing in the visual system. He also undertook a fundamental re-appraisal of components of electroretinogram (*Vision Research*, 12 (5): 773 – 780). Most of Bob's energies in this period, however, went into his classic volume *The Vertebrate Retina: Principles of Structure and Function* (1973). This was a powerful synthesis and analysis of current knowledge of the vertebrate retina. He relied on others for many aspects of the volume, on two artistically gifted research assistants Rhonda Lysenko and Diane Ace, for example, for many illustrations and on a linguist, Deborah Macguire, for an appended translation of Ramon y Cajal's '*La Rétine des Vertébrés*' (1883). The breadth and depth of *The Vertebrate Retina* arose, however, from Bob's drive to understand and to teach, and it was a superb contribution.

In the mid1970's, still in Sydney, Bob teamed with W.A.H. Rushton, from Cambridge. From these two powerful minds, and personalities, two elegant papers flowed, on rod-cone interaction in single receptive fields. By exchanging two spectrally distinct light spots of controlled intensity covering receptive field centre they were able to change the photon catch rate for cones without changing the photon catch for the rods (the rod isolept) and conversely, to change the photon catch for rods, without changing the catch for cones (the cone isolept). They were then able to demonstrate rod and cone dark adaptation separately in the same cell after the same bleach, and to show for the first time the ability of rod and cone signals to

cancel each other (*J. Physiol.* 254(3) 759–773 and *J. Physiol.* 254(3) 775–785). During the same period, Bob continued his work on parallel processing with a major analysis of the thalamic relay of visual information in the primate ((1976) *J. Physiol.*, 258 (2):433 – 452). The evidence of parallel visual processing had emerged from studies of the cat retina; this paper showed that the same organization was to be found in primate visual system, an important step for the understanding of human vision.

In Seattle Bob made major contributions to the understanding of ganglion cell morphology and function in primates (*Science*, 213 (4512):1139-1142) including humans ((1985) *J. Comp. Neurol.*, 233 (1):115 – 132), extending the analysis to include the central targets of ganglion cell projections. He also undertook, several years before his retirement, a new book. His *The First Steps in Seeing* (1998) is superbly written and illustrated (with the advent of computer graphics Bob became the sole illustrator) and, characteristically, it is marked by a strong and lucid emphasis on explanation-from-first-principles. Arguably the book is less analytical, less broad-ranging than *The Vertebrate Retina*, but its accessibility is an enormous strength. It was true of Bob that, as Chaucer wrote of his scholar of Oxenford, ‘gladly would he learn, and gladly teach’.

His death, whose approach Bob kept private, took from us a friend, colleague and teacher of long standing. Our field and our lives as scientists were richer for his intellectual drive, his discoveries, his openness to new ideas, his enthusiasm and his capacity for friendship and loyalty. And we are poorer for his passing

Bogdan Dreher, University of Sydney

Jonathan Stone, Australian National University

November 2003

The original version of this obituary appeared in the Proceedings of the Australian Neuroscience Society Volume 15. Reprinted with the kind permission of the editor, Paul Martin.

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Web Sites of Interest - Joseph Carroll

Listed below are a few web sites that may be of interest to ICVS members. If you have any interesting, fun and/or scientifically useful web sites (old or new ones) that you would like to share with the Society, please forward the URL (and a brief description, if you like) to Joseph Carroll (jcarroll@cvs.rochester.edu).

Lab web site for Dale Purves' Lab

<http://www.purveslab.net/>

This website has some rather slick features that aren't seen in many vision science sites. It was professionally designed (see below) and does a good job at illustrating some basic concepts in perception. I found navigating the site easy and fun, and there was ample documentation available in PDF to accompany the site.

The main feature of interest is the "See for Yourself" section, which contains 16 interactive demonstrations, including Chromatic Adaptation, Brightness Contrast, Color Contrast and Color Constancy. Also worthwhile is the "Test Your Perception" tool, which allows you to investigate your misperceptions directly in the demo. Obviously, due to variations in monitors and viewing conditions, none of these demos and tools can be used for collecting real data, but they are quite effective at illustrating principles.

Purveslab.net was developed by Pyramis Studios, Inc. for the laboratory of Dale Purves in the Department of Neurobiology at the Duke University Medical Center to share research ideas and findings regarding visual perception in an interactive, highly graphical and easily accessible forum. You will need Macromedia Flash player to view the site correctly.

For those of you who are interested, Pyramis Studios, Inc. provides a full range of biomedical media services including textbook illustration, web development, and 3D modeling/animation (www.pyramis-studios.com).

Webvision

<http://webvision.med.utah.edu/>

An oldie, but a goodie. Most of us have seen this site at one time or another, but the authors (Helga Kolb, Eduardo Fernandez and Ralph Nelson) do an excellent job of updating the site regularly and as a result, this remains one of the essential sites for information on the retina, including photoreception, color vision and anatomy. The various chapters (there are currently 12 main chapters) are authored by recognized experts in that particular field. This site provides a number of useful images that can be used as teaching tools, and the "Facts and Figures concerning the Human Retina" section is a nice reference. Two recent additions on the electroretinogram and clinical electrophysiology may be of particular interest to some ICVS members.

From the website: “The goal of this resource is to summarize the recent advances in knowledge and understanding of the mammalian retina. We have tried to describe a conceptual theory, based on our and others' anatomical and physiological investigations and on the actual pathways used by neurons to code visual signals in the retina.

Webvision is arranged like a book with text and many illustrations. Please click on the title of the chapter or section within the chapter that you wish to access. Some chapters are in several parts and the succeeding parts or sections can be accessed by clicking on the topics listed at the beginning or end of the chapter as well as from the index.

Since on the World Wide Web, the most universally accepted image formats are GIF and JPEG, all our images are in these formats. Both GIF and JPEG store images in a compressed format, which means that images can be stored in relatively small files. However most of our images are still too large, so we use thumbnail sketches which link each image to the larger version (to see the actual images, and not simply the reduced-size icon of the actual image, you should click inside the thumbnail image). Note that sizes of the linked images are also given.

Webvision also contains movies and animations in Quicktime format (QuickTime is the technology that makes multimedia a reality on Macintosh, Windows and other platforms). Since most World Wide Web browsers are not capable of displaying these movies we recommend that you upload to Netscape Communicator 4.0 (or later versions) or a version of Microsoft Explorer that include Quicktime plug-ins in order to take advantage of WebVision.”

Causes of Color

<http://webexhibits.org/causesofcolor/index.html>

This is one of the most complete websites I have seen that deal with light and color. It addresses numerous questions, including “Why are things colored?”, “How do different light bulbs work?”, “What do animals see?”, “How do we see color?” and “Where do auroras come from?”. Of course, it doesn't introduce any new scientific concepts, and many of you probably have seen answers to these questions before, but this is a nice collection of information. One of the nicest features is the interactive images, which you can save and use in your PowerPoint presentations (with proper citation, of course!). I especially liked the images of all of the old color atlases (Oswald, Munsell, Hering, Runge, Lambert...). There is a good deal of historical information on color, which is nice. A note of caution, the website is a bit large and one can end up spending significant time browsing. Also note that all pages of the site cannot be accessed via the menu bar on the left, there are many, many additional links within each category and they are located on the actual web pages, but not listed on the left.

Verriest Medal. Call for nominations

We are inviting nominations for the award of the Verriest Medal for 2005. The Verriest Medal is

bestowed by the International Colour Vision Society (ICVS) to honor long-term contributions to the knowledge of colour vision. The Medal was established in 1991 in memory of Dr. Guy Verriest, and is presented at the ICVS biannual Symposia. Previous recipients have been Harry Sperling (1991), Marrion Marre (1993), Vivianne Smith and Joel Pokorny (1995), Jack Moreland (1997), John Krauskopf (1999), Donald MacLeod (2001) and Andre Roth (2003) Candidates need not have been active in the affairs of the ICVS but they must be either current or former ICVS (or IRGCVD) members. Candidates previously proposed for the award will be twice renominated in the next award cycle. Submitted materials should include a letter of nomination and the candidates's curriculum vitae. Please take the time to consider and to nominate a worthy candidate for this honour. Address to whom nominations should be submitted before October 1, 2004:

Dr. Andre Roth
chemin de Grand-Donzel 25
1234 Vessy
Switzerland
e-mail: andre_roth@bluewin.ch

Next Symposium

The 18th Symposium of the International Color Vision Society will be held in Lyon, France July 2005.

Membership 2002/3

Next call for Membership Dues in December

At the last symposium it was decided that dues would *not* be collected for the year 2004, to bring the start of the membership period in line with the year of the conference. The next call for dues will therefore be for the years 2005/6 and will start at the end of this year. Thanks to those who obligingly sent renewal forms for 2004. They were not processed.

Anne Kurtenbach

Visual Neuroscience

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Number 3

Guest Editor's Forword

Genetics and Evolution Articles

Samir S. Deeb The molecular genetics of color-vision deficiencies

Michael A. Crognale, Michael Fry, Jennifer Highsmith, Gunilla Haegerstrom-Portnoy, Maureen Neitz, Jay Neitz, and Michael A. Webster Characterization of a novel form of X-linked incomplete achromatopsia

Mauren Neitz, Joseph Carroll, Agnes Renner, Holger Knau, John S. Wermer, and Jay Nietz Variety of genotypes in males diagnosed as dichromatic on a conventional clinical anomaloscope

M. P. Rowe and G. H. Jacobs Cone pigment polymorphism in New World Monkeys: Are all pigments created equal?

Jessica Strachan, Ling-Yu E. Chang, Matthew J. Wakefield, Jennifer Marshall Graves, and Samir S. Deeb The cone visual pigments of the Australian marsupials, the stripe-faced and fat-tailed dunnarts: Sequence and inferred spectral properties

Cone Mosaics and Signals Articles

I. J. Murray, N. R. A. Parry, J. Kremers, M. Stepien, and A. Schild L- and M- cone distribution and flicker

Nra Parry, S. Plainis, I. J. Murray, and D. J. McKeefry Effect of foveal tritanopia on reaction times to chromatic stimuli

Arthur G. Shapiro, Anthony D'Antona, Jared B. Smith, Lindsay A. Belano, and Justin P. Charles Induced contrast asynchronies may be useful for luminance photometry

A. Kurtenbach, J. Heine, and H. Jaegle The multifocal electroretinogram in trichromatic and dichromat observers under cone isolating conditions

Rod-Cone Interaction Articles

Laura P. Thomas and Steven L. Buck Generality of rod hue biases with smaller, brighter, and photopically specified stimuli

Joel Pokorny, Hannah Smithson, and Jules Quinlan Photostimulator allowing independent control of rods and the three cone types

Chromatic Mechanisms Articles

Delwin T. Lindsey and Angela M. Brown Masking of grating detection in the isoluminant plane of DKL color space

D. J. McKeefry, P. V. McGraw, C. Vakrou, and D. Whitaker Chromatic adaptation, perceived location and colour turning properties

Romain Bouet and Kenneth Knoblauch Perceptual classification of chromatic modulation

Gianluca Monaci, Gloria Menegaz, Sabine Susstrunk, and Kenneth Knoblauch Chromatic contrast detection in spatial chromatic noise

Allen L. Nagy, Kelly E. Neriani, and Travis L. Yo Color Mechanisms used in selecting stimuli for attention and making discriminations

Central Processing Articles

Peter B. Delahunt, Michael A. Webster, Lei Ma, and John S. Werner Long-term renormalization of chromatic mechanisms following cataract surgery

Barry B. Lee and Hao Sun The chromatic input to cells of the magnocellular pathway: mean chromaticity and the relative phase of modulated lights

Hao Sun and Barry B. Lee A single mechanism for both luminance and chromatic grating vernier tasks: Evidence from temporal summation

Marco Puts, Joel Pokorny, and Vivianne C. Smith Inferred retinal mechanisms mediating illusory distortions

Patrick Monnier and Steven K. Shevell The influence of motion on chromatic detection

Color Constancy Articles

D. H. Foster, S. M. C. Nascimento, and K. Amano Information limits on neural identification of colored surfaces in natural scenes

Sergio M. C. Nascimento, Vasco M. N. de Almeida, Paulo T. Fiadeiro, and David H. Foster Minimum-variance cone-excitation ratios and the limits of relational color constancy

Vasco M. N. de Almeida, Paulo T. Fiadeiro, and Sergio M. C. Nascimento Colour constancy by asymmetric colour matching with real objects in three-dimensional scenes

R. C. Baraas, D. H. Foster, K. Amano, and S. M. C. Nascimento Improved colour constancy with natural reflectance spectra for protanopic observers

Color Appearance Articles

Sang Wook Hong and Steven K. Shevell Brightness induction: Unequal spatial integration with increments and decrements

Yoko Mizokami, Carrie Paras, and Michael A. Webster Chromatic- and contrast-selectivity in color contrast adaptation

Baingio Pinna, Lothar Spillmann, and John S. Wener Flashing anomalous color contrast

Steven K. Shevell and Dingcai Cao Chromatic assimilation unaffected by perceived depth of inducing light

Vivianne C. Smith and Joel Pokorny Interaction of chromaticity and luminance in edge identification depends on chromaticity

Sherry X. Xian and Steven K. Shevell Changes in color appearance caused by perceptual grouping

Development of Human Color Vision Articles

Maria Pereverzeva and Davida Y Teller Infant color vision: Influence of surround chromaticity on spontaneous looking preferences

Davida Y. Teller, Andrea Civan, and Kevin Bronson-Castain Infants' spontaneous color preferences are not due to adult-like brightness variations

Color Deficiencies Articles

David L. Bimler and Galina V. Paramei Luminance-dependent hue shift in protanopes

A. M. Brown, D. T. Lindsey, M. P. Rowe, and G. H. Jacobs Color and language: Worldwide distribution of Daltonism and distinct words for "blue"

Takaski Hayashi, Kenichi Kozaki, Kenji Kitahara, Akiko Kubo, Yoshiteru Nishio, Satoshi Omoto, Yosuke Nakamura, Akira Watanabe, Kazushige Toda, and Yasuo Ueoka Clinical heterogeneity between two Japanese siblings with congenital achromatopsia

Dora F. Ventura, Marcelo T. V. Costa, Multifocal and full field electroretinogram
Marcelo F. Da Costa, Andrian Berezovsky, Solange changes associated with color vision loss in
R. Salomao, Ana Luiza Simoes, Marcos Lago, Luiz mercury vapor exposure
H. M. Canto Pereira, Marcilia A. M. Faria,
John M. De Souza, and Luiz Carlos L. SiLveira

Color Testing and Standards Articles

- J. E. Bailey, M. Neitz, D. Tait, and J. Neitz Evaluation of an updated HRR color vision test
- S. J. Dain Colorimetric analysis of four HRR
pseudoisochromatic tests
- David Bimler and John Kirkland Multidimensional scaling of D15 caps: Color-
vision defects among tobacco smokers?
- Jeffery K. Hovis, Shankaran Ramaswamy, Repeatability indices for the Farnsworth D-15
and Matthew Anderson test
- Shankaran Ramaswamy and Jeffery K. Hovis Ability of the D-15 panel tests and HRR
pseudoisochromatic plates to predict
performance in naming VDT colors
- Bruce Drum FDA regulation labeling and promotional claims
in therapeutic color-vision devices: A tutorial
- Miyahara, E, Pokorny, J, Smith, VC, Szewczyk, Computerized color vision test based upon
E, McCartin, J, Caldwell, K, Klerer, A postreceptoral channel sensitivities
- J. D. Moreland The Moreland match revisited
- P. B. M. Thomas and J. D. Mollon Modelling the Rayleigh match
- Jeff Rabin Quantification of color vision with cone contrast
sensitivity

Abstracts of color vision papers.

Influence of cone pigment coexpression on spectral sensitivity and color vision in the mouse. Jacobs GH, Williams GA, Fenwick JA .Vision Res. 2004 Jun;44(14):1615-22

The mouse retina contains both middle-wavelength-sensitive (M) and ultraviolet-sensitive (UV) photopigments that are coexpressed in cones. To examine some potential visual consequences of cone pigment coexpression, spectral sensitivity functions were measured in mice (*Mus musculus*) using both the flicker electroretinogram (ERG) and behavioral discrimination tests. Discrimination tests were also employed to search for the presence of color vision in the mouse. Spectral sensitivity functions for the

mouse obtained from ERG measurements and from psychophysical tests each reveal contributions from two classes of cone having peak sensitivities [Formula: see text] of approximately 360 and 509-512 nm. The relative contributions of the two pigment types to spectral sensitivity differ significantly in the two types of measurements with a relationship reversed from that often seen in mammals. Mice were capable of discriminating between some pairs of spectral stimuli under test conditions where luminance-related cues were irrelevant. Since mice can make dichromatic color discriminations, their visual systems must be able to exploit differences in the spectral absorption properties among the cones. Complete selective segregation of opsins into individual photoreceptors is apparently not a prerequisite for color vision.

Chromatic and luminance losses with multiple sclerosis and optic neuritis measured using dynamic random luminance contrast noise. Flanagan P, Zele AJ. *Ophthalmic Physiol Opt.* 2004 May;24(3):225-33.

Abstract We measured thresholds for detecting changes in colour and in luminance contrast in observers with multiple sclerosis (MS) and/or optic neuritis (ON) to determine whether reduced sensitivity occurs principally in red-green or blue-yellow second-stage chromatic channels or in an achromatic channel. Colour thresholds for the observers with MS/ON were higher in the red-green direction than in the blue-yellow direction, indicating greater levels of red-green loss than blue-yellow loss. Achromatic thresholds were raised less than either red-green or blue-yellow thresholds, showing less luminance-contrast loss than chromatic loss. With the MS/ON observers, blue-yellow and red-green thresholds were positively correlated but increasing impairment was associated with more rapid changes in red-green thresholds than blue-yellow thresholds. These findings indicate that demyelinating disease selectively reduces sensitivity to colour vision over luminance vision and red-green colours over blue-yellow colours.

Blue cone monochromatism: a phenotype and genotype assessment with evidence of progressive loss of cone function in older individuals. Michaelides M, Johnson S, Simunovic MP, Bradshaw K, Holder G, Mollon JD, Moore AT, Hunt DM. *Eye.* 2004 Apr 16 [Epub ahead of print]

AIM: To perform a detailed clinical and psychophysical assessment of the members of three British families affected with blue cone monochromatism (BCM), and to determine the molecular basis of disease in these families. **METHODS:** Affected and unaffected members of three families with BCM were examined clinically and underwent electrophysiological and detailed psychophysical testing. Blood samples were taken for DNA extraction. The strategy for molecular analysis was to amplify the coding regions of the long wavelength-sensitive (L) and middle wavelength-sensitive (M) cone opsin genes and the upstream locus control region by polymerase chain reaction, and to examine these fragments for mutations by direct sequencing. **RESULTS:** We have confirmed the reported finding of protan-like D-15 arrangements of patients with BCM. In addition, we have demonstrated that the Mollon-Reffin (MR) Minimal test is a useful colour-discrimination test to aid in the diagnosis of BCM. Affected males were shown to fail the protan and deutan axes, but retained good discrimination on the tritan axis of the MR test, a compelling evidence for residual colour vision in BCM. This residual tritan discrimination was also readily detected with HRR plates. In two families, psychophysical testing demonstrated evidence for progression of disease. In two pedigrees, BCM could be linked to unequal crossovers within the opsin gene array that resulted in a single 5'-L/M-3' hybrid gene, with an inactivating Cys203Arg mutation. The

causative mutations were not identified in the third family. **CONCLUSIONS:** The MR test is a useful method of detecting BCM across a wide range of age groups; residual tritan colour discrimination is clearly demonstrated and allows BCM to be distinguished from rod monochromatism. BCM is usually classified as a stationary cone dysfunction syndrome; however, two of our families show evidence of progression. This is the first report of progression associated with a genotype consisting of a single 5'-L/M-3' hybrid gene carrying an inactivating mutation. We have confirmed that the Cys203Arg inactivating mutation is a common sequence change in blue cone monochromats. Eye advance online publication, 16 April 2004; doi:10.1038/sj.eye.6701391

Long-lasting sensitization to a given colour after visual search. Tseng CH, Gobell JL, Sperling G. Nature. 2004 Apr 8;428(6983):657-60.

Visual attention enables an observer to select specific visual information for processing. In an ambiguous motion task in which a coloured grating can be perceived as moving in either of two opposite directions depending on the relative salience of two colours in the display, attending to one of the colours influences the direction in which the grating appears to move. Here, we use this secondary effect of attention in a motion task to measure the effect of attending to a specific colour in a search task. Observers performed a search task in which they searched for a target letter in a 4 x 4 coloured matrix. Each of the 16 squares within a matrix was assigned one of four colours, and observers knew that the target letter would appear on only one of these colours throughout the experiment. Observers performed the ambiguous motion task before and after the search task. Attending to a particular colour for a brief period in the search task profoundly influenced the perceived direction of motion. This effect lasted for up to one month and in some cases had to be reversed by practising searches for the complementary colour, indicating a much longer-persisting effect of attention than has been observed previously.

Chromatic and spatial properties of parvocellular cells in the lateral geniculate nucleus of the marmoset (*Callithrix jacchus*). Blessing EM, Solomon SG, Hashemi-Nezhad M, Morris BJ, Martin PR. J Physiol. 2004 May 15;557(Pt 1):229-45. Epub 2004 Mar 26.

The parvocellular (PC) division of the afferent visual pathway is considered to carry neuronal signals which underlie the red-green dimension of colour vision as well as high-resolution spatial vision. In order to understand the origin of these signals, and the way in which they are combined, the responses of PC cells in dichromatic ('red-green colour-blind') and trichromatic marmosets were compared. Visual stimuli included coloured and achromatic gratings, and spatially uniform red and green lights presented at varying temporal phases and frequencies. The sensitivity of PC cells to red-green chromatic modulation was found to depend primarily on the spectral separation between the medium- and long-wavelength-sensitive cone pigments (20 or 7 nm) in the two trichromatic marmoset phenotypes studied. The temporal frequency dependence of chromatic sensitivity was consistent with centre-surround interactions. Some evidence for chromatic selectivity was seen in peripheral PC cells. The receptive field dimensions of parvocellular cells were similar in dichromatic and trichromatic animals, but the achromatic contrast sensitivity of cells was slightly higher (by about 30%) in dichromats than in trichromats. These data support the hypothesis that the primary role of the PC is to transmit high-acuity spatial signals, with red-green opponent signals appearing as an additional response dimension in trichromatic animals.

Ancestral loss of short wave-sensitive cone visual pigment in lorisiform prosimians, contrasting with its strict conservation in other prosimians. Kawamura S, Kubotera N. J Mol Evol. 2004 Mar;58(3):314-21.

Mammals are basically dichromatic in color vision, possessing middle to long wave-sensitive (M/LWS) and the short wave-sensitive (SWS) cone opsins in the retina, whereas some nocturnal mammals lack functional SWS opsins. Prosimians, primitive primates consisting of three extant groups (Lorisiformes, Lemuriformes, and Tarsiiformes), include many nocturnal species. Among nocturnal prosimians, a species of lorisiforms, the greater galago (*Otolemur crassicaudatus*), is known to lack a functional SWS opsin gene, while lemuriforms and tarsiiforms appear to retain SWS opsins in the retina. It has not been established, however, whether the loss of SWS opsin is a universal phenomenon among lorisiforms and whether the functional SWS opsin genes of lemuriforms and tarsiiforms are under strict or relaxed selective constraint. To gain better insight into an association between nocturnality and loss of SWS function, we isolated and sequenced the SWS opsin genes from two species of lorisiforms, the slow loris (*Nycticebus coucang*; nocturnal) and the lesser galago (*Galago senegalensis*; nocturnal), and one species each of lemuriforms and tarsiiforms, the brown lemur (*Eulemur fulvus*; cathemeral) and the western tarsier (*Tarsius bancanus*; nocturnal), respectively. Our sequence analysis revealed that (1) the SWS opsin gene was disrupted in the common ancestor of galagids and lorises and (2) the rate of nonsynonymous nucleotide substitution has been kept significantly lower than that of synonymous substitution in tarsier and lemur, demonstrating the presence of strict selective constraint on the SWS opsin genes in tarsiiforms and lemuriforms.

Significance of color, calories, and climate to the visual ecology of catarrhines. Dominy NJ, Lucas PW. Am J Primatol. 2004 Mar;62(3):189-207.

Here we describe correlations among visual ecology and the physiochemical properties of fruits and leaves consumed by four species of catarrhine primate: *Cercopithecus ascanius*, *Colobus guereza*, *Pan troglodytes*, and *Ptilocolobus badius*. Collectively, their diet was diverse, with each species relying on fruits and leaves to different extents. The mean chromaticity of both foods, as perceived by the green-red and yellow-blue signals that catarrhines decode, was distinct from background foliage. However, selection on the basis of color was evident only for leaves. Primates consumed leaves with higher green-red values than the leaves they avoided—sensory mechanism that correlated with key nutritional variables, such as increased protein and reduced toughness. Moreover, the monkeys ingested leaves near dusk, when reddish targets may be more salient. Similar patterns were never observed with respect to edible fruits, the chromaticities of which did not differ from unconsumed fruits or correlate with nutritional properties. We also found that primate biomass is higher in seasonal sites. We conclude that these findings are consistent with the notion that routine trichromatic vision evolved in a context where seasonal folivory was pivotal to survival.

L and M cone contributions to the midget and parasol ganglion cell receptive fields of macaque monkey retina. Diller L, Packer OS, Verweij J, McMahan MJ, Williams DR, Dacey DM. J Neurosci. 2004 Feb 4;24(5):1079-88.

Analysis of cone inputs to primate parvocellular ganglion cells suggests that red-green spectral opponency results when connections segregate input from long wavelength (L) or middle wavelength (M) sensitive cones to receptive field centers and surrounds. However, selective circuitry is not an obvious retinal feature. Rather, cone receptive field surrounds and H1 horizontal cells get mixed L and M cone input, likely indiscriminately sampled from the randomly arranged cones of the photoreceptor mosaic. Red-green spectral opponency is consistent with random connections in central retina where the mixed cone ganglion cell surround is opposed by a single cone input to the receptive field center, but not in peripheral retina where centers get multiple cone inputs. The selective and random connection hypotheses might be reconciled if cone type selective circuitry existed in inner retina. If so, the segregation of L and M cone inputs to receptive field centers and surrounds would increase from horizontal to ganglion cell, and opponency would remain strong in peripheral retina. We measured the relative strengths of L and M cone inputs to H1 horizontal cells and parasol and midget ganglion cells by recording intracellular physiological responses from morphologically identified neurons in an in vitro preparation of the macaque monkey retina. The relative strength of L and M cone inputs to H1 and ganglion cells at the same locations matched closely. Peripheral midget cells were nonopponent. These results suggest that peripheral H1 and ganglion cells inherit their L and M cone inputs from the photoreceptor mosaic unmodified by selective circuitry.

Cone inputs in macaque primary visual cortex. Johnson EN, Hawken MJ, Shapley R. J Neurophysiol. 2004 Jun;91(6):2501-14. Epub 2004 Jan 28.

To understand the role of primary visual cortex (V1) in color vision, we measured directly the input from the 3 cone types in macaque V1 neurons. Cells were classified as luminance-preferring, color-luminance, or color-preferring from the ratio of the peak amplitudes of spatial frequency responses to red/green equiluminant and to black/white (luminance) grating patterns, respectively. In this study we used L-, M-, and S-cone-isolating gratings to measure spatial frequency response functions for each cone type separately. From peak responses to cone-isolating stimuli we estimated relative cone weights and whether cone inputs were the same or opposite sign. For most V1 cells the relative S-cone weight was <0.1 . All color-preferring cells were cone opponent and their L/M cone weight ratio was clustered around a value of -1, which is roughly equal and opposite L and M cone signals. Almost all cells (88%) classified as luminance cells were cone nonopponent, with a broad distribution of cone weights. Most cells (73%) classified as color-luminance cells were cone opponent. This result supports our conclusion that V1 color-luminance cells are double-opponent. Such neurons are more sensitive to color boundaries than to areas of color and thereby could play an important role in color perception. The color-luminance population had a broad distribution of L/M cone weight ratios, implying a broad distribution of preferred colors for the double-opponent cells.

The impact of suppressive surrounds on chromatic properties of cortical neurons. Solomon SG, Peirce JW, Lennie P. J Neurosci. 2004 Jan 7;24(1):148-60.

Stimulation of the suppressive surround of a cortical neuron affects the responsivity and tuning of the classical receptive field (CRF) on several stimulus dimensions. In V1 and V2 of macaques prepared for acute electrophysiological experiments, we explored the chromatic sensitivity of the surround and its

influence on the chromatic tuning of the CRF. We studied receptive fields of single neurons with patches of drifting grating of optimal spatial frequency and orientation and variable size, modulated along achromatic or isoluminant color directions. The responses of most neurons declined as the patch was enlarged beyond the optimal size (surround suppression). In V1 the suppression evoked by isoluminant gratings was less than one-half that evoked by achromatic gratings. Consequently, many cells were most sensitive to achromatic modulation when patches just covered the CRF but were most sensitive to isoluminant modulation when patches were enlarged to cover the suppressive surround. Non-oriented neurons that were strongly chromatically opponent generally lacked suppressive surrounds. In V2 most neurons showed equal surround suppression from isoluminant gratings and achromatic gratings. This makes the relative sensitivity of V2 neurons to achromatic and isoluminant gratings mainly independent of the size of the grating. We also measured the chromatic properties of the CRF in the presence of differently colored surrounds. In neither V1 nor V2 did the surround alter the chromatic tuning of the CRF. Cortical mechanisms sensitive to chromatic contrast seem to provide little input to the suppressive surrounds of V1 neurons but substantial input to those of V2 neurons.

How well does color perimetry isolate responses from individual cone mechanisms? Simunovic MP, Cullerne A, Colley A, Wilson TD. J Glaucoma. 2004 Feb;13(1):22-7.

URPOSE: Over the past two decades there has been renewed interest in the use of color perimetry as a means of detecting early functional defects resulting from glaucomatous optic neuropathy and other forms of ophthalmic and neurologic pathology. The most popular form of color perimetry employs a colored background that selectively desensitizes two of the cone mechanisms, while the wavelength of the test target is selected to favor detection by the remaining, relatively unadapted, cone mechanism. While there are data to support the assertion that blue on yellow perimetry adequately isolates the short wavelength sensitive (SWS) cone mechanism, the only estimates of isolation of the other two cone mechanisms are for the region of the visual field corresponding to the fovea. The purpose of this experiment was thus to determine the amount of cone mechanism isolation that is afforded by automated perimetry when using yellow, blue, and magenta adapting backgrounds. **METHODS:** To estimate cone mechanism isolation, we determined spectral sensitivity for a range of narrow-band stimuli using a standard 30-2 program on a modified Humphrey perimeter. Targets were presented against three different backgrounds of different luminance; yellow at 2.1 log cd.m⁻², magenta at 1.3 log cd.m⁻², and blue at 1 log cd.m⁻². Sensitivity values for each background at each stimulus position were plotted as a function of wavelength, normalized, and then fitted with cone sensitivity templates to determine the relative sensitivity of the three cone mechanisms. **RESULTS:** The maximum relative isolation of an individual cone mechanism was achieved with a yellow background, where there was an average relative isolation of 0.94 for the SWS cone mechanism; the blue background provided a relative isolation of 0.89 for the long wavelength sensitive (LWS) cone mechanism. The magenta background proved poor at isolating the medium wavelength sensitive (MWS) cone mechanism, where a relative isolation of only 0.51 was obtained. **CONCLUSION:** Although color perimetry is capable of isolating individual cone mechanisms, the magnitude of isolation in normal observers may be small under certain circumstances. Therefore, when the technique is used to examine pathologic states, it may be necessary to employ at least two target wavelengths to determine the cone mechanism that is performing target detection. Furthermore, we

suggest that MWS cone mechanism isolation may be improved through the combination of the so-called silent substitution technique with that of selective adaptation.

Color classification by chimpanzees (*Pan troglodytes*) in a matching-to-sample task. Matsuno T, Kawai N, Matsuzawa T. *Behav Brain Res.* 2004 Jan 5;148(1-2):157-65.

We investigated chimpanzees' color classification using a matching-to-sample procedure. One of the two subjects had learned symbolic color names through long-term training, while the other had received less training and had a limited understanding of color names. The results showed similar distributions of classified colors in a color space, irrespective of the subjects' differential color-naming experience. However, the chimpanzee with little color-naming experience showed less stable classifications. These results suggest common features of color classification in chimpanzees, as well as the influence of color experience and/or the learning of color names on the stability of classification of colors.

Search for color 'center(s)' in macaque visual cortex. Tootell RB, Nelissen K, Vanduffel W, Orban GA. *Cereb Cortex.* 2004 Apr;14(4):353-63.

It is often stated that color is selectively processed in cortical area V4, in both macaques and humans. However most recent data suggests that color is instead processed in region(s) antero-ventral to V4. Here we tested these two hypotheses in macaque visual cortex, where 'V4' was originally defined, and first described as color selective. Activity produced by equiluminant color-varying (versus luminance-varying) gratings was measured using double-label deoxyglucose in awake fixating macaques, in multiple areas of flattened visual cortex. Much of cortex was activated near-equally by both color- and luminance-varying stimuli. In remaining cortical regions, discrete color-biased columns were found in many cortical visual areas, whereas luminance-biased activity was found in only a few specific regions (V1 layer 4B and area MT). Consistent with a recent hypothesis, V4 was not uniquely specialized for color processing, but areas located antero-ventral to V4 (in/near TEO and anterior TE) showed more color-biased activity.

The chronoarchitecture of the human brain-natural viewing conditions reveal a time-based anatomy of the brain. Bartels A, Zeki S. *Neuroimage.* 2004 May;22(1):419-33.

A dominant tendency in cerebral studies has been the attempt to locate architecturally distinct parts of the cortex and assign special functions to each, through histological, clinical or hypothesis-based imaging experiments. Here we show that the cerebral cortex can also be subdivided into different components temporally, without any a priori hypotheses, based on the principle of functional independence. This states that distinct functional subdivisions have activity time courses (ATCs) that are, if not independent, at least characteristic to each when the brain is exposed to natural conditions. To approach a time-based anatomy experimentally, we recorded whole-brain activity using functional magnetic resonance imaging (fMRI) and analyzed the data with independent component analysis (ICA). Our results show that a multitude of cortical areas can be identified based purely on their characteristic ATCs during natural conditions. We demonstrate that a more 'rich' stimulation (free viewing of a movie) leads to more areas being activated in a specific way than conventional stimuli, allowing for a more detailed dissection of the cortex into its subdivisions. We show that stimulus-driven functionally specialized areas can be identified by intersubject correlation even if their function is unknown. Chronoarchitectonic mapping thus opens the prospect of

identifying previously unknown cortical subdivisions based on natural viewing conditions by exploiting the characteristic temporal 'fingerprint' that is unique to each.