# The Latest Theory and Practice in Using Light for Health and the Impact on Hospitals of the Future

*a report by*

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Mary Rushton-Beales is Regional Co-ordinator for the International Association of Lighting Designers (IALD) in the UK. She is principal of the Lighting Design House, based in London, which she founded in 1990, following experience managing the Lighting Design Division of building services consultants FHP, senior designer at Equation Lighting Design and early design experience with Philips Lighting. Since 1997, a significant proportion of her work has been in the Middle East (principally Dubai and Lebanon) as well as the UK, working on interior and exterior new build and refurbishment projects – mainly shopping centres and hotels – from concept to completion. Ms Rushton-Beales teaches degree-level design students the principles of lighting design and has a personal interest in lighting for physiological benefit on which she has written several articles. Since working on London Underground's 'Platform for Art' series of exhibitions (from 2000 onwards) the practice has had deeper involvement with the arts, in particular contemporary sculpture that integrates light. Ms Rushton-Beales is a Professional Member of the IALD.

In the rush to create commercially viable, beautiful spaces and buildings, just how important light is to our bodies has been forgotten and, therefore, we should think far more deeply about the design techniques and lighting equipment that we use. In the grey, dull days of winter the impact of light on our physiological and psychological wellbeing cannot be denied. However, light – both natural and artificial – plays a major role in our health throughout the year and there are a huge variety of different directions for research and treatments. The keynote speaker at the 5th Lighting Research Office (LRO) Symposium *Light and Human Health*, Dr Mark Rea, of the Lighting Research Center (Troy, New York), said that: *"The last 25 years of research is now challenging our traditional definition of what constitutes 'good lighting'. Vision-based lighting design neglects what recent research has found."*[1]

Sometimes it seems that, for every cautious scientist or engineer carefully documenting a new study, there are many more 'alternative practitioners' or manufacturers ready to misinterpret their results and confuse the public. The trouble is that so much is not known about our bodies' reactions to light at a cellular level, it is important to keep an open mind because even the most far-fetched concept might just be right. If there is still so much to discover at the molecular level, then it logically follows that there is just as much left to consider within the context of environmental lighting design.

The directions of current therapeutic lighting practice falls into four broad categories:

- Biorhythmic correction using bright mostly all white light in the eye, mostly at light levels above 2,500–10,000 lux, used for:
  - alleviating seasonal depression;
  - increasing the length and quality of sleep;
  - consolidating sleep/activity patterns in Alzheimer's disease patients;
  - improving the performance of night-shift workers; and
  - regulating melatonin, which has been shown to affect breast cancer growth.
- Psychological treatment using coloured and often kinetic light in the eye. Far lower light levels are needed to evoke reactions, between 4–10 lux.
- Application of white, polarised light or coloured light to the body in order to create a reaction at cellular level.
- The fourth direction involves modulating monochromatic light to become a carrier in wavelength and frequency of exact electro-magnetic information.

The effects on our body clocks and mental attitude caused by lack of daylight as the seasons change is well documented. The use of bright-light therapy[2–5] to combat both seasonal affected disorder (SAD) and 'normal' depression, if there can be such a thing, continues to grow although it seems to be more commonly self-administered in the UK and physician-administered in the US. High levels of light,

1. *The Lighting Research Office is a research division of the Electric Power Institute in California, whose primary aim is to disseminate lighting research, http://www.lightingresearchoffice.org*
2. *J A Veitch, "Choosing the Right Light: The Benefits of Full-spectrum Lighting Continue to be Researched and Debated", for the National Research Council Canada, 2000.*
3. *P T Stone and S Ferg, "The Effects of Environmental Illumination on Melatonin, Bodily Rhythms and Mood States: A Review",* International Journal of Lighting Research and Technology*, The Chartered Institution of Building Services Engineers (CIBSE), 31 (1999) 3.*
4. *G C Brainard, A J Lewy, M Menaker, R H Fredrickson, L S Miller, R G Welber, V Cassone and D Hudson, "Effect of Wavelength on the Suppression of Nocturnal Plasma Melatonin in Normal Volunteers",* Annals of the New York Academy of Sciences*, 453 (1985), pp. 376–378.*
5. *N E Rosenthal, D A Sack, S P James, B Parry, W B Mendelson, L Tamarkin and T A Wehr, "Seasonal Affective Disorder and Photo-therapy", ibid., pp. 260–269.*

sometimes in combination with controlled dark and administered melatonin, have also been used with some success to enhance sleep patterns, particularly for elderly patients and sufferers of Alzheimer's disease.

Interestingly, the original pioneers of bright-light therapy discovered in 1985[4,5] and 1991[6] and confirmed in 2002[7] that extremely low light levels (0.4–3.3 lux) of monochromatic light of 446–484nm (a blue with some green) was just as effective as night-time melatonin suppression (the excess of which hormone is prevalent in SAD sufferers) as bright polychromatic white light. The logical conclusion is that the eye only 'uses' the wavelengths of light that it 'needs' in the chemical reaction so any white light – provided it contains wavelengths around 446–484nm – should 'work'. This led to the assumption that light at the bluer end of the spectrum that matches daylight is likely to be more effective for daytime background illumination than light at the yellow end.

With regard to the old argument that 6,000K is 'better for you' than 3,000K, it is the author's experience that, provided the colours of an environment are chosen to be in sympathy to the 6,000K and visibility glare is minimised, there is a marked personal preference from users of any working environment for artificial light that approximates daylight (i.e. 6,000K and above).

Bright light in the morning – resulting in the sufferer having to wake up earlier – has been documented as more successful (i.e. faster) than evening bright light for

*Figure 1: Lumie body clock simulates the sunrise over 30 minutes so the user wakes up gradually*


alleviating SAD depression.[8,9] The impact of having to wake up earlier can be softened by using a 'dawn simulation style' alarm clock and a study found that, for mild sufferers, just the low levels of light (1–30 lux) and the method of awakening created by the glowing alarm clock was more effective than sitting in front of a light box.[8,9] Even chronic sufferers found an improvement.

Bright light can also be used to alleviate insomnia[8,9] and, for those sufferers who consistently wake up too early, it seems that bright light in the evening can help to readjust the body clock so that people sleep longer. Research conducted by Eastman, et al. regarding the adjustment of shift workers to a complete reversal of their normal working day by the use of timed exposure to around 1,200 lux and very dark glasses by

*Figures 2a and 2b: This call centre in Norwich uses iGuzzini's Sivra Lighting System*

*The illuminance levels vary between 300 and 1,300 lux throughout the day with the colour temperature varying between a warm 2,800K and a cool 5,300K.*


6. *D Oren, G C Brainard, S Johnston, J R Joseph-Vanderpool, E Sorek and N E Rosenthal, "Phototherapy of Seasonal Affective Disorder with Green Versus Red Light"*, American Journal of Psychiatry, *148 (1991) 4, pp. 509–511.*
7. *Gena Glickman, Robert Levin and George C Brainard, "Ocular Input for Human Melatonin Regulation – Relevance to Breast Cancer", Neuroendrocrinology letter, 2002.*
8. Biol. Psychiatry, *50 (1 Aug 2001) 3, pp. 205–216.*
9. *N E Rosenthal, et al.*, British Journal of Psychiatry, *148 (1991) 4, pp. 509–511.*

*Figures 3a and 3b: These fittings from Whitecroft and Zumtobel distribute light in indirect and direct planes, making the rooms feel brighter whilst maintaining suitable environments for computer-based work*

*Figure 4: Testing of Zumtobel Staffs' Daylight Emulation System showing the difference between soft dawn and bright white*

day remains the benchmark.[10,11] This means that, although 2,500–10,000 lux received by the eye is the light level required for effectively combating SAD, depression and insomnia, the best light level for waking up and proceeding with daily activities is 1,200 lux or more – three times the light level to which most offices are lit. This finding is presumably why total ceiling/lighting environment solutions, such as the iGuzzini® Sivra system (see *Figures 2a* and *2b*) and the Zumtobel Staff Daylight Emulation System (see *Figures 3a, 3b* and *4*) in collaboration with Barisol are capable of delivering what seems to us as lighting designers as excessively high light levels. These systems use sophisticated controls to deliver a variety of lighting effects throughout a working day or night, so that the occupants are in a variable atmosphere that changes in the same way as daylight.

Zumtobel Staff has taken part in research that has concluded that it is not just the brightness and colour temperature that has a physiological and psychological effect but also that the lighting technique, i.e. indirect, indirect/direct or direct light at different times of day, in different weather conditions, can have a positive impact on productivity. Whitecroft Lighting has also taken part in a research project using indirect/direct lighting in schools, which yielded very high user-satisfaction levels.

If a worker sits in a window at his/her office, he/she will be regularly exposed to thousands of lux. It would seem that the 1,000-lux illuminated ceilings of the 1970s – condemned by the energy crisis and somewhat impractical in today's computer-based work environment – were actually quite good for us.

Any discussion of lighting environments for shift workers would not be complete without mentioning further the research into melatonin regulation and its relevance to breast cancer.[7]

This has the most far-reaching implication for a 24/7 operation, such as a hospital, for both staff and patients. As there is a much higher risk of breast cancer in industrialised regions as opposed to developing countries, many theories have proposed

10. *O Tzischinsky and P Lavie, "The Effects of Evening Bright Light on Next-day Sleep Propensity",* Journal of Biological Rhythms, *12 (1997) 3, pp. 259–265, Sleep Laboratory, Bruce Rappaport Faculty of Medicine, Technion-Israel Institute of Technology, Haifa, Israel.*
11. *C I Eastman, K T Steward, M P Mahoney, L Liu and L F Fogg, "Dark Goggles and Bright Light Improve Circadian Rhythm Adaptation to Night-shift Work",* Sleep, *17 (Sep 1994) 6, pp. 535–543, Biological Rhythms Research Laboratory, Rush-Presbyterian-St Luke's Medical Center, Chicago, Illinois.*

that there may be modern environmental causes such as electromagnetic fields[12] or simple night-time light exposure,[13] particularly if the night-time production of melatonin is interrupted because melatonin has been shown to be part of the body's natural defence against cancer.[7,14]

Taking this research into account, it is reasonable to conclude that melatonin production will not be impaired if a room is in either complete darkness or lit with wavelengths of light outside of the 464–484nm band. So, the sleeping environments of nurses and doctors working the night shift, as well as patients on the wards, could have a direct relationship to their physical wellbeing. It seems we need to suppress melatonin in the daylight hours to signal to our bodies that we are biologically awake – and encourage its regular production in our sleep phase.

It is this reaction on a molecular level to light, whether it is white, coloured, coherent, incoherent or polarised, that has formed the impetus for much of the application of light to the body and subsequent physiological and psychological reactions. Thirty years ago, Dr Fritz Albert Popp and his team proved that the 100,000 chemical reactions per second that control the molecules in the cells of water fleas are co-ordinated and regulated by very low level light at the ultraviolet end of the spectrum.[14] To achieve this, a light-measuring device was built that was so sensitive that a candle burning 20km away could be detected. Initially, using water fleas and drawing on past research by Faraday – apparently the biophotonic aspects of Faraday's work is not commonly known – and also Professor Fraulich's work on coherence in a living system, it was proved that ultra-weak emissions of light at 380nm are the conductors for the messages that control the cells' reactions in these organisms. More recent research has concluded that 'messages' are 'sent' in wavelengths ranging from 200nm to 800nm.

This led to a 'new' branch of physics – biophotonics. Biophotonics is now studied at 40 universities worldwide, where different aspects of this extensive subject are being researched. Most people are familiar with the concept of photodynamic therapy used in conjunction with drugs to destroy or detect cancerous cells, which still uses monochromatic lasers. Now, however, following extensive research

*Figure 5: Clearvision*

*Figure 6: Aura*

by Tina Kaaru, those ubiquitous light-emitting diodes (LEDs) are also known.

Research in Hungary by Marta Fenyo and K Samilova into alternatives to lasers for this purpose led to the discovery of the effectiveness of polarised light and the creation of the Bioptron®, a device used for skin disorders and wound healing.[15] Incidentally, the type of polarisation in this unit is completely different to the type of polarisation used in ambient-lighting products such as those from Clearvision and the Aura Corporation (see *Figures 5* and *6*), both of

12. *Thomas Saunders,* The Boiled Frog Syndrome: Your Health and the Built Environment, *Chichester: Wiley-Academy, 2002.*
13. *A Panzer and M Viljoen, "The Validity of Melatonin as an Oncostatic Agent",* J. Pineal. Res., *1997.*
14. *Dr Fritz Albert Popp, IAC Conference lecture, October 2002. Full details of Dr Popp's research is available at http://www.lifescience.de*
15. *K A Samoilova, K D Obolenskaya, A V Vologdina, S A Snopov and E V Shevchenko, "Single Skin Exposure to Visible Polarized Light Induces Rapid Modification of Entire Circulating Blood: Improvement of Rheologic and Immune Parameters", Institute of Cytology, Russian Academy of Sciences: St Petersburg, Russia.*

*Figure 7: 3S Life Enhancement Systems and the Monocrome Dome in Kew.*

*Photo source: Electric Artists Co.*

*Figure 8*

which are often used in hospital environments.

The various research undertaken on the effects of different wavelengths of light (i.e. different colours) have proved that, for every wavelength and frequency of light, there is a reaction. Different wavelengths penetrate the body in different ways and promote different reactions but it is documented that 60% of what happens is understood – the remaining 40% is still left to be discovered.

A practical application of the effect of coloured light on the skin is the use of blue and red light in both fluorescent or LED equipment to heal recurring acne – the result of research by the Society of Dermatologists in 2000, which found that light was more effective than drugs.[16]

Fairly low levels of coloured light are being used to promote a psychological reaction to alleviate both serious illnesses and simply to promote a feeling of wellbeing. The light must be monochromatic to make a biological reaction – so, from a lighting design perspective, it is best to design coloured light in an interior by colour mixing rather than by single filters, otherwise the users of the space may suffer unexpected emotional reactions.

Architect and psychologist Karl Ryberg invented the Monochrome dome, a 'Ganzfeld' space where the participant is bathed in completely even monochromatic coloured light of all seven colours of the spectrum (see *Figure* 7). Even though the light levels are very low by 'biorhythmic' standards (4–10 lux) anyone who has tried this treatment would find it difficult to deny that there is an effect on both mood and physical wellbeing. The maximum length of time that anyone can be placed in this space is 15 minutes per month.

At the forefront of healing on a molecular level is Helionics Therapy using quantum physics to deliver remedies in their highest energy form – electromagnetic radiation. Helionics has developed a system that combines many aspects of homeopathy with 21st century physics and recognises the importance of a spiritual dimension. It combines a range of well-established complementary approaches and delivers the remedies in the highest possible energy form. The electromagnetic frequencies or spectral signatures are administered in the form of light, colour, sound and a low-level electromagnetic field. Often the light is aimed at the 'chakra' points on the back (see *Figure 8*). The treatments can be used to treat current problems or – more importantly – as preventive therapy.

The prevalence of light therapy varies enormously throughout the world. In the US, for example, LED-based units using infrared as well as coloured light are used for healing race-horse injuries and, according to apochryphal evidence, for pain relief in humans.

In Switzerland, the health system is based on the populace all owning their own health insurance and it seems that the cost of upgrading to complementary practices is minimal. As a result, there are far more alternative treatments and practitioners available in Switzerland than anywhere else in the world. Switzerland is also home of the Bioptron polarised healing light.

This reaction at a cellular level is important in the design of environmental lighting design. It seems that the main lesson is that if there is still so much to learn at a molecular level, we are almost certainly missing

16. *P Papageorgiou, A Katsambas and A Chu,* British Journal of Dermatology*, 142 (2000), pp. 973–978.*

something on a macro level and we seem to forget or ignore many past lessons.

In the author's research into this subject, it often seems that research and practice are 'in different rooms, with no connecting corridor'. If truly healing environments are to be created, both rooms must be opened up and learnt from. It is also impossible to separate lighting design from the design of the environment as light is, after all, invisible until it hits a surface, irrespective of its colour and form.

Design must be holistic and integrated with the environment. *Figures 9a* and *9b* illustrate the Vos Pad – an apartment lit entirely with LEDs that changes colour automatically. Designer of the Vos Pad Marcel Jean Vos's approach to hospital lighting is: *"Why shouldn't wards or rest areas with a variable coloured light be incorporated? We need to lift people's spirits as well as cure their problems."* This principle would tie in well with the need to regularise circadian rhythms in order to promote healing.

An example of an holistic approach to a hospital's design, incorporating use of colour, additional daylight and radical integration of art, is the work of architectural practice Gray, Baynes and Shew, at Oxford Radcliffe Hospital. *Figure 10* shows the simulator suite in the radiotherapy department at the hospital. The quality of space and the use of colour has been manipulated to give the department a distinctive image and to ease the stress to patients of extensive radiotherapy procedures. Project partner Nigel Spawton, working in conjunction with architect Matthew Bullock, substantially improved and enhanced the public spaces by opening up the reception area ceiling to allow more natural light through the celestory windows. The size of the waiting room was increased and the incorporation of improved lighting and bold colours on the walls and pillars, coupled with the striking decorative floor, helps to lift the mood.

The contrast between the areas designed by Gray, Baynes and Shew and the original drab, monotonous areas is marked. On entering the refurbished areas one feels completely differently about the space. There are two major research projects that prove people get better faster in better environments – it is about time we saw some changes on the wards.

Design principles that were commonplace, such as designing buildings to maximise daylight, not just to save energy but to make patients healthier and feel happier, are often forgotten.

The final word goes to the Chairman of the LRO Symposium, Dr Edward Rinalducci, Department of Psychology, University of Central Florida. *"Clearly*

***Figures 9a and 9b: Vos Pad***

*Photo source: http://www.locations-uk.com*

***Figure 10: Simulator suite in the Radiotherapy Department at the Oxford Radcliffe Hospital***

*Photo source: Charlotte Woods, Architectural Photographer, Oxford Radcliffe Hospital*

*Figure 11: East Main Entrance Landscape*

*Photo source: Charlotte Woods, Architectural Photographer, Oxford Radcliffe Hospital*

*light has therapeutic properties that can be positive or negative, but which have been neglected in the design of electric-lighted environments."*

It is not just designers who can be neglectful. On questioning several practitioners about the lighting and the colours in their offices and treatment rooms, interestingly not everyone had really considered the rooms holistically and combined appropriate colours with physiologically beneficial lighting. Several did not even know the light levels in which they worked, but a clear favourite was high-frequency, daylight colour temperature, superior colour rendering (or full spectrum) fluorescent lighting – using a polarising filter. ■

## Acknowledgements

*The author would like to thank Keith Halson of Gray Baynes and Shew, artist Chris Tipping, Marcel Jean Vos of Vos Solutions and especially Naomi Miller, International Association of Lighting Designers (IALD), Naomi Miller Lighting Design.*

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