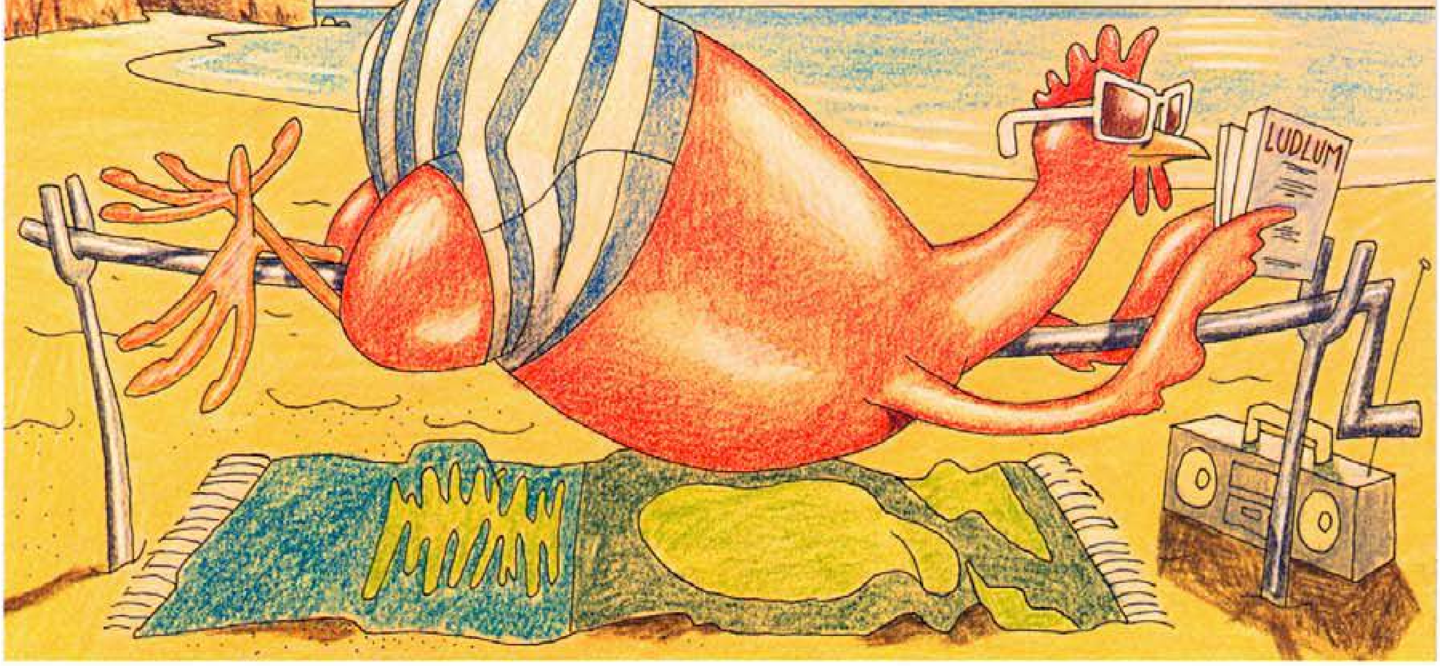
Sun on skin: investigating the costs

Like so many chickens on a rotisserie, millions of Australians line the country's beaches every summer in their quest — often via severe sunburn — for a tan.



But we are slowly beginning to realise that many pay a price for that million-dollar glow, caused by the ultraviolet (UV) radiation from the sun. Our country has the highest incidence of skin cancer in the world, with malignant melanoma — an often fatal cancer of the pigmented cells (melanocytes) in the skin — being twice as prevalent as it was a decade ago.

As well, dermatologists are treating more and more patients with skin tumours related to the use of sun lamps and solaria. Researchers are also identifying a few cases related to exposure to UV light in the work-place from sources such as welding/cutting arcs.

The UV response

The human skin's response to UV light is complex; it includes production of vitamin D, fluid accumulation, blistering, and thickening, as well as tanning and cancers. Ultraviolet light can also produce eye problems — cataracts and conjunctivitis — in some people. These responses, which vary widely from person to person, may be further complicated by factors such as photosensitisation from drugs.

Different parts of the UV band produce different biological effects (see the box). Experiments with animals, using isolated UV wavebands or monochromatic UV light, have shown that the most carcinogenic wavelengths seem to be the same ones that cause sunburn — the range 280–315 nanometres, known as the UVB band.

But little is known about how UV light induces cancer in humans, and researchers are still trying to define the complete 'action spectrum' involved in carcinogenic reactions. A major stumbling block in sorting out the problem has been the difficulty of producing UV light in the laboratory that meets tight specifications for wavelength range and intensity. Experiments have been conducted using imprecise, often unmeasured, doses of UV.

Research groups in Sydney and Newcastle have sought the assistance of CSIRO in overcoming this problem. Now, with the help of Mr Frank Wilkinson of the Division of Applied Physics in Sydney, they can accurately calibrate and monitor a range of UV sources.

Mr Wilkinson works in the Division's spectro-radiometric testing laboratory, which among other things is responsible for maintaining basic light standards — for researchers and others — in the wavelength range 200–2500 nm. The laboratory's staff have established standards for the spectral distribution of lamps, welding arcs, and other sources, for the spectral response of various light-measuring instruments, and for transmittance and reflectance characteristics of materials. They also provide general advice on radiation protection, type testing of selected consumer products such as sun lamps and fluorescent lamps, measurement training, and collaborative support to therapists and researchers.

Immunosuppression

One group of researchers, in the Sydney University Department of Veterinary Pathology, has investigated the effects of immunosuppressive drugs on UV-induced tumour development.

Headed by Professor C.H. Gallagher, the group is using a solar simulator in studies of the effect of ultraviolet exposure on the skin of hairless mice. Devised with the assistance of Mr Wilkinson, the simulator delivers UV light close to the composition of Australia's summer sunlight. More compact simulators are being developed that will allow more control over the UV light used for such tests.

Doctors have known for some years that kidney transplant recipients treated with immunosuppressive drugs have a higher-than-average risk of developing cancer. In fact, the cancer incidence among transplant patients increases progressively with time to 57% 10 years after the operation. Skin tumours account for 80% of all post-transplant tumours in Australia, despite routine prescription of sunscreen protection.

Little is known about how UV light induces cancer.

Two immunosuppressive drugs were tested — azathioprine and cyclophosphamide. Azathioprine has long been a major part of the standard immunosuppressive treatment given to kidney transplant patients. When cyclophosphamide has been used instead of it, transplant patients have suffered less skin cancer.

In the team's experiments, mice treated with the 'transplant' drugs alone did not show any abnormal rate of cancer growth. But when they were exposed to UV light, azathioprine — but not cyclophosphamide — enhanced the degree of tumour development.

At least the noses are protected.

Application of two widely used sunscreen chemicals — 2-EHMC (2-ethyl hexyl-p-methoxy cinnamate) and o-PABA (octyl-N-dimethyl-p-aminobenzoate) — protected mice from the tumour-inducing effects of UV light.

But when the scientists exposed the protected mice to croton oil, a substance that promotes cancer development without causing cancer itself, tumours appeared in some animals — with a higher percentage occurring among the 2-EHMC group. These mice evidently had developed latent tumours during their exposure to UV light.

The researchers concluded that these latent tumours might express the degree to which UV light broke through the sunscreen barrier.

Among mice treated with azathioprine and protected by sunscreens, croton oil treatment resulted in twice as much tumour initiation as in similar non-immunosuppresed mice. Cyclophosphamide caused only a very small increase in the number of tumours initiated. This evidence supports the notion that azathioprine, much more than cyclophosphamide, increases susceptibility of the skin to UV carcinogenesis.

Tumour types and psoralens

Currently, Professor Gallagher's team is studying the influence of psoralens on skin cancer. These substances have been used for more than 400 years to treat skin diseases, and are widely used today in phototherapy with ultraviolet light in the UVA band (315–400 nm) from mercury discharge lamps. Phototherapy is applied to treat dermatitis, eczema, pruritis (itch-

The ABC of UV

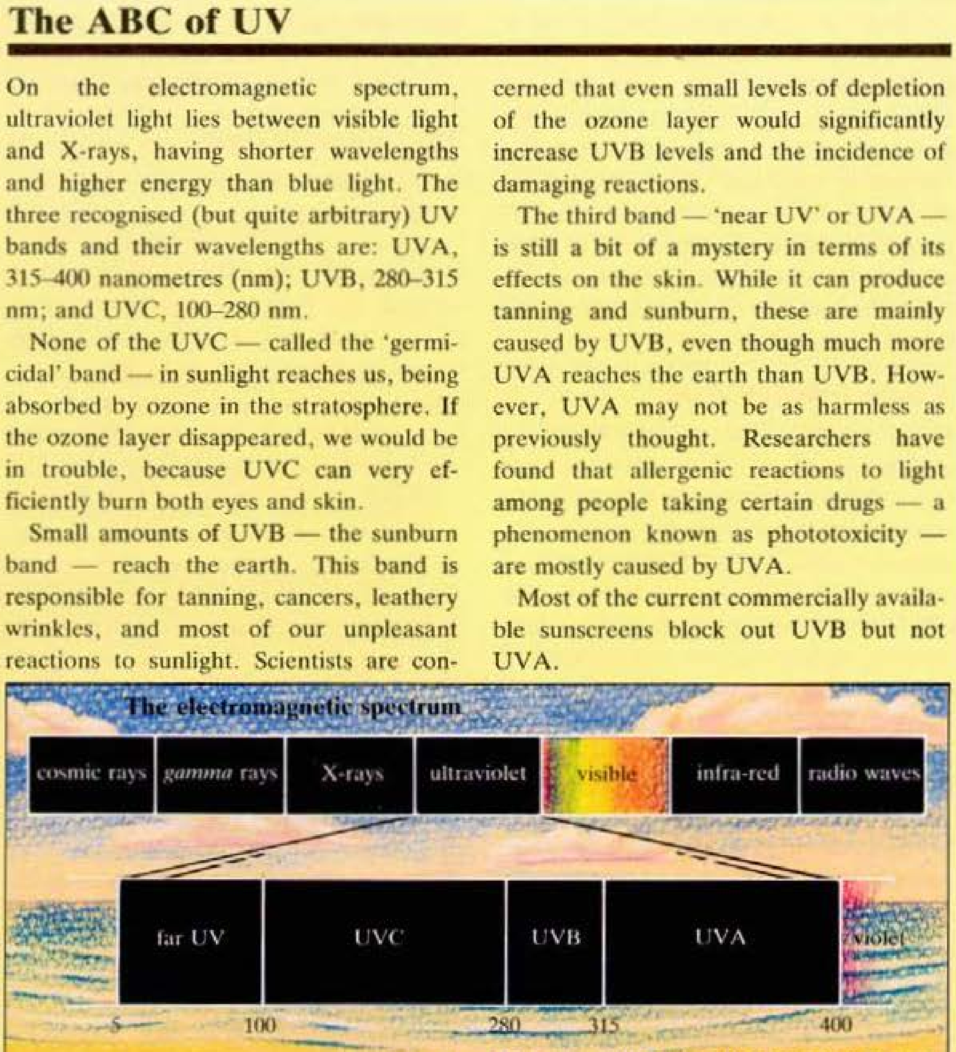
On the electromagnetic spectrum, ultraviolet light lies between visible light and X-rays, having shorter wavelengths and higher energy than blue light. The three recognised (but quite arbitrary) UV bands and their wavelengths are: UVA, 315–400 nanometres (nm); UVB, 280–315 nm; and UVC, 100–280 nm.

None of the UVC — called the 'germicidal' band — in sunlight reaches us, being absorbed by ozone in the stratosphere. If the ozone layer disappeared, we would be in trouble, because UVC can very efficiently burn both eyes and skin.

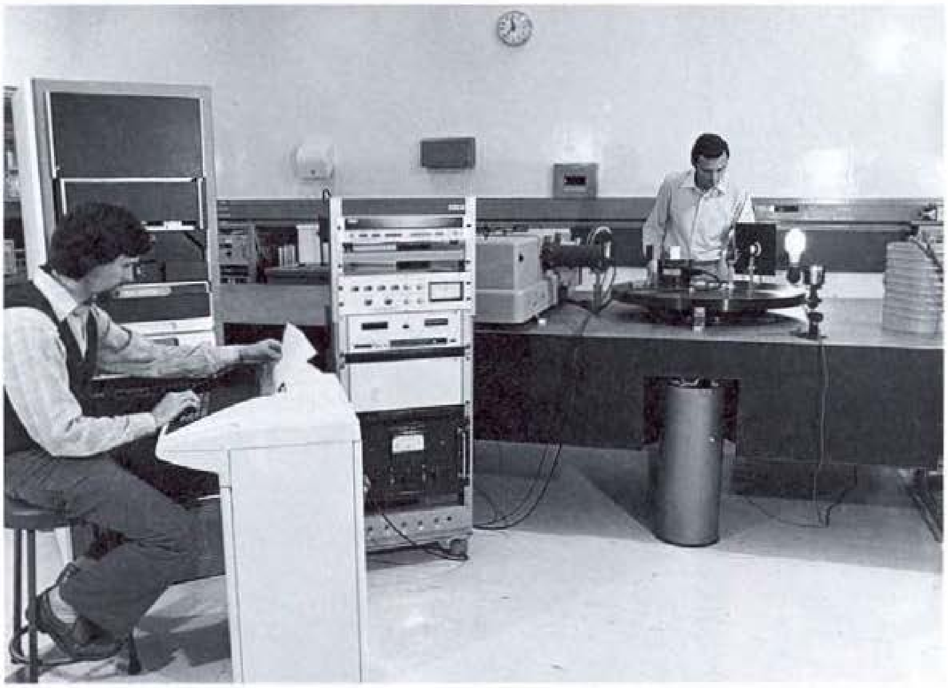
Small amounts of UVB — the sunburn band — reach the earth. This band is responsible for tanning, cancers, leathery wrinkles, and most of our unpleasant reactions to sunlight. Scientists are concerned that even small levels of depletion of the ozone layer would significantly increase UVB levels and the incidence of damaging reactions.

The third band — 'near UV' or UVA — is still a bit of a mystery in terms of its effects on the skin. While it can produce tanning and sunburn, these are mainly caused by UVB, even though much more UVA reaches the earth than UVB. However, UVA may not be as harmless as previously thought. Researchers have found that allergenic reactions to light among people taking certain drugs — a phenomenon known as phototoxicity — are mostly caused by UVA.

Most of the current commercially available sunscreens block out UVB but not UVA.



The ultraviolet band lies between X-rays and visible light.



In the CSIRO spectro-radiometric laboratory. The researchers are preparing to test the UV output of a mercury-vapour street lamp.

ing), acne, herpes simplex, fungal infections, and psoriasis, a skin disorder in which cell turnover is erratic. Apart from their therapeutic use, psoralens are a common photosensitising agent. They occur naturally in parsley, parsnips, celery, figs, and oil of bergamot, an aromatic citrus oil that is often used in perfumes and in some sunscreens overseas to promote tanning.

They hope to determine which parts of the UV spectrum may be responsible for harmful effects on the immune system.

The scientists' preliminary results with mice suggest that the reaction between psoralens and UV is complex. Some psoralens appear to protect against tumour growth when used in conjunction with low doses of UV, but enhance tumour production with doses of UV high enough to produce sunburn.

Phototherapy lamp

At CSIRO's spectro-radiometric laboratory, Mr Wilkinson has developed a new lamp for use in phototherapy. This lamp emits light in a number of wavelength bands: UVC, which is the 'germicidal' band (see the box); UVA, which increases vascularisation of new tissue; and infra-red, which increases blood flow to damaged areas and penetrates the skin more deeply than shorter-wavelength light.

Unlike present equipment, it emits almost no UVB, enabling higher levels of light in the other bands to be delivered while minimising tissue damage. An automatic system is being developed for monitoring exposure that operates by measuring the reflected light from a subject. It is expected to be used to treat pressure sores and wounds in both humans and animals such as racehorses, and clinical trials are proceeding.

A 'solar factor' in blood?

Mr Wilkinson is also assisting Dr Peter Hersey, of Royal Newcastle Hospital's Oncology and Immunology Unit, in examining the effects of UV radiation on man's immune system. Dr Hersey's main concern is what causes melanomas, the most serious type of skin cancer. Unlike other skin cancers, melanomas do not necessarily occur on parts of the body exposed to sunlight. Some medical researchers believe that sunlight triggers the release of a 'solar factor' that circulates with the blood and acts at a more remote site.

What the 'solar factor' is, if it exists, remains to be discovered. Scientists currently favour the idea that UV light stimulates skin cells to produce urocanic acid, which damages cells known as antigen-presenting (or Langerhans) cells in the skin. Langerhans cells are responsible for inducing the skin's immune response. Damage to these cells would activate other specialised cells in the immune system known as suppressor cells. Their activity blocks normal immune reactions, particularly tumour rejection.

As part of their research, Dr Hersey and Mr Wilkinson hope to determine which parts of the UV spectrum may be responsible for harmful effects on the immune system. They also want to find out what surface area of skin needs to be exposed, and at what dose level, before changes begin to occur in the immune system. For this research, new optical and filtering systems are being developed in the spectro-radiometry laboratory.

To see whether tanned and dark skin and sunscreens can prevent such changes, Dr Hersey and his colleagues are conducting studies with volunteers visiting a solarium. Preliminary results suggest that sunscreen agents may not protect against UV-induced changes in the immune system. In particular, natural 'killer cell' activity in normal volunteer subjects was suppressed by UV radiation from solarium lamps irrespective of whether the volunteers applied a sunscreen agent or not. These results suggest that further study of the effectiveness of sunscreen agents in protection against effects on the immune system is needed.

Mary Lou Considine

More about the topic

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