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Further danger from the sun

Visible light, in addition to ultraviolet radiation, may also cause skin cancer

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This finding is bad news for those who like to sunbathe, even if they slather on sunscreen. The currently available sunscreens protect against the effects of ultraviolet radiation, which is invisible to the human eye, but they cannot prevent the damage caused by visible light. This damage can be severe. A study conducted by São Paulo and Paraná researchers has recently demonstrated that visible light can also cause skin cancer, the most common form of cancer in Brazil. According to Brazil's National Cancer Institute, skin cancer accounts for 25% of cases of malignant tumors.

Maurício Baptista, a biochemist at the University of São Paulo (USP) and the study's coordinator, is not surprised by this finding, which was published in November 2014 on the journal PLoS ONE. Indeed, from a physical standpoint, the light that the human eye can detect has much in common with ultraviolet (UV) rays. Both types of light result from the same form of energy, electromagnetic radiation, which has different names – gamma rays, X-rays, visible light and infrared radiation – based on the frequency. "To skin, the distinction between visible and invisible light is arbitrary," says Baptista, a researcher at USP's Chemistry Institute and at the Research, Innovation and Dissemination Centers (RIDC).

He and his team have shown that visible light can indirectly damage the genetic material (DNA) of cells by interacting with melanin. This dark pigment, which is responsible for skin color, absorbs some of the energy of visible light and transfers it to oxygen molecules, thus generating highly reactive forms of oxygen known as singlet oxygen. In turn, this excited oxygen molecule reacts with organic molecules such as DNA and degrades them. When this type of damage affects a gene that regulates cell proliferation, the cell can begin to multiply uncontrollably, causing cancer.

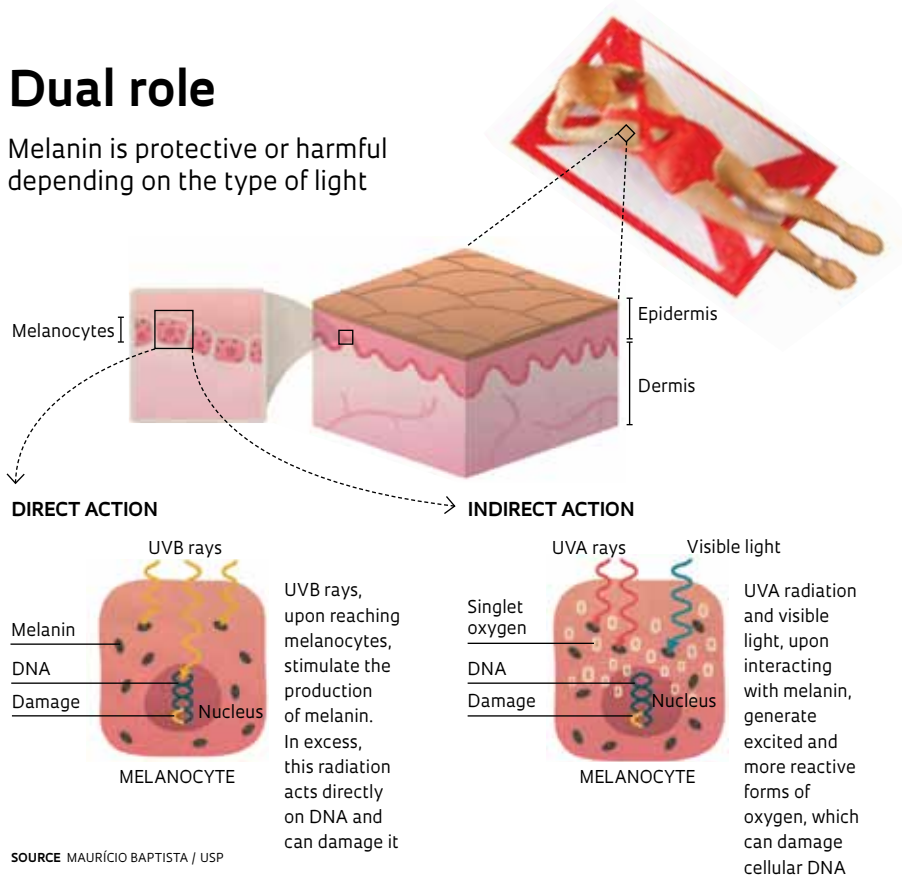
This finding can help us to better understand the origin of some forms of skin cancer. "The group's contribution, which is very rigorous in scientific terms, helps us to understand the mutation profiles we found in human melanomas, where evidence of DNA oxidation events is often observed," says Roger Chammas, a researcher at the University of São Paulo School of Medicine and at the São Paulo State Cancer Institute. "In the past these events were attributed to UVA radiation, but now, as it turns out, it could also be the effect of visible light."

The mechanism producing these more reactive molecules observed by Baptista's group confirms melanin's dual role: it protects the skin from damage caused by certain types of light while at the same time facilitating the damage caused by others. Like the current experiment, previous studies had shown that exposure to ultraviolet type B (UVB) rays caused melanocytes (melanin-producing cells) to increase their synthesis of the pigment. The studies also showed that a greater proportion of these cells survived under this form of radiation. The mortality rate, however, was much higher when more pigmented cells were subjected to ultraviolet type A (UVA) radiation, a result that is similar to the current findings for visible light.

The protection that melanin offers against UVB rays is not sufficient to prevent skin cancer. This form of radiation is associated with sunburn, an acute inflammatory response to excessive exposure to sunlight, and UVB was the first

Dual role

Melanin is protective or harmful depending on the type of light



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INFOGRAPHIC ANA PAULA CAMPOS **ILUSTRATION** PEDRO HAMDAN

radiation proven to be carcinogenic. It penetrates the skin slightly, but the UVB rays that are not absorbed by melanin go directly to DNA – particularly melanocyte DNA – and can damage it and cause a rare and very aggressive form of cancer: melanoma, which is more common in adults with a fair complexion and represents 4% of the malignant skin tumors found in Brazil.

UVA radiation, like visible light, penetrates more deeply and causes DNA damage through the production of excited and more reactive forms of oxygen. Research in the 1980s revealed that UVA rays cause another form of cancer – nonmelanoma, which is more common after age 40 – originating in cells known as basal or squamous cells. After the harmful effects of UVA and UVB rays were proven, the pharmaceutical industry developed compounds that effectively block these two bands of radiation. However, we are now beginning to see that this may not be sufficient. "Sunscreens only protect against ultraviolet rays, so the information about what protects the skin is incomplete," says Baptista. "One important aspect is the regulation of packaging and advertising, so as not to disseminate misleading information."

Sunscreens currently on the market protect against UV radiation, but not the effects of visible light

This is an issue yet to be resolved. Baptista recalls the case of UVA radiation. Although its harmful effect had been established for approximately 30 years, it was not until 2013 that manufacturers were required to indicate on the packaging whether a product protected against one or both types of UV radiation.

Baptista obtained the first evidence that visible light could also be harmful in 2011, when tests showed that singlet oxygen appeared when it interacted with pure melanin or the melanin found in hair. "The discovery of the harmful effects of UVA a few decades ago shattered the dogma that UVB was the only band of the solar spectrum that caused damage to the skin," says Baptista. "Now we need to shatter the dogma that these harmful effects are only due to UV rays."

To fully demonstrate the carcinogenic effect of visible light, however, at least one more step is needed. It must be shown that the DNA damage caused by visible light leads to profound genetic changes (mutations). "Tests will need to be done on animals and then in humans, and, if confirmed, this will be an important discovery," says João Duprat Neto, an oncology surgeon and director of the Skin Cancer Group of the A.C. Camargo Cancer Center. "It is possible that this data will stimulate the development of more effective skin protectors."

While waiting for sunscreens that also filter out visible light, the best way for people to protect against skin cancer is to avoid overexposure to the sun. However, only excessive exposure must be prevented because another factor must be considered: sunlight is essential to the skin's ability to synthesize vitamin D, which is important in prevention of osteoporosis and other bone diseases. According to Marco Antônio Oliveira, a dermatologist, who also works at the A.C. Camargo Skin Cancer Group, those who have a higher risk of developing skin cancer should replace sun exposure with vitamin D supplementation. The body's production of vitamin D decreases after age 40, as the skin ages. "It's important to remember that the use of sunscreen is essential," says Dr. Oliveira. "In the younger generations, which are better informed about the effects of the sun and use more sunscreens, the incidence of cancer has dropped significantly." ■

Projects

1. Photosensitization in the life sciences (Nº. 12/50680-5); **Grant mechanism** Thematic Project; **Principal investigator** Maurício da Silva Baptista (Chemistry Institute/USP); **Investment** R$3,067,571.88 (FAPESP).

2. Redoxoma (Nº. 13/07937-8); **Grant mechanism** Research, Innovation and Dissemination Centers (RIDC); **Principal investigator** Ohara Augusto (Chemistry Institute/USP); **Investment** R$20,674,781.25 (for the entire project) (FAPESP).

Scientific article

CHIARELLI NETO, O. *et al.* Melanin photosensitization and the effect of visible light on epithelial cells. **PLoS ONE**. November 18, 2014.