Photobiology for Dermatologists

by

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I remember arriving recently at an international airport, and as we drove in a rather noisy aircraft landed. It apparently was the "Concorde", and I had to catch it. But I am jumping ahead.

Dr. L. K. Bhutani, your executive secretary to the Congress, asked me to write something on photobiology that might interest dermatologists in general. Obviously, the bit of photobiology which is of vital interest to all of us is in this equation :

$$CO_2 + H_2O \xrightarrow{hv} (CH_2O)_n + O_2$$

This is, of course, photosynthesis and without it there would be no plants and we would eventually run out of oxygen. This process we take for granted but the ecologically concerned remind us that we may not always be able so to do. Certainly, some of the claims of the protagonists of our impending self destruction appear to be a little bit wild if not hysterical. But are they ?

Let us look for a moment at our Earth's atmosphere. It has in fact, some of the properties of our skin. Both structures are protective layers, particularly against destructive radiation and for maintaining heat balance. Both the skin and the atmosphere also have layers within them in which interesting chemical and photochemical reactions occur.

The atmosphere, like the skin, is really very much of a dynamic nature. "That inverted bowl we call the sky" does not "roll impotently on" as Fitzgerald would have Omar Khayyam have us believe. From about 100 km upwards, the temperature rises and may reach 300°C, or much more. This is the so-called thermosphere. One of the sets of reactions that occur here are :

$$O_2 + \xrightarrow{hv} O + O$$

$$O_2 + O \xrightarrow{M} O_3 + \text{heat}$$

$$O + O_3 \longrightarrow 2O_2 + \text{heat}$$

(Here hv is a photon, M is some other molecular species)

Thus, for every mole of ozone formed and every mole disassociated 490 kilojoules of heat is released into the atmosphere. This energy is that which makes for much of our weather and is the layer of principal interest to the meteorologist.

ABSORPTION

In the skin, photobiologists are much concerned with absorption and action spectra. The same obtains in the atmosphere where again absorption and action spectra are of great importance. The best known, and perhaps the most important absorption spectrum in the atmosphere is that between about 200 and 300 nm. This is where ozone absorbs strongly the harsh noxious short UVR emitted by the sun. Ozone absorption also occurs in the longer UVR spectrum, but to a much lesser extent up to about 350 nm, and even to a very slight extent in the visible spectrum.

The ozone layer is, as indicated above, formed by the photochemical reaction between sunlight and oxygen. But in reality, this reaction is very complex. There is a complicated relationship between the concentration of ozone and of NO_2. If there is too much NO_2, O_3 production is eventually reduced. This occurs as follows :

$$NO_2 \xrightarrow{hv} NO + O$$

$$NO + O_3 \longrightarrow NO_2 + O_2$$

Thus, it would seem that if NO_2 is injected into the atmosphere, ozone would be destroyed. This seems to be a possibility from engine exhausts of the supersonic aircraft. There is controversy about the importance of this destructive reaction of NO_2 and whether it will make any difference to the ozone of the atmosphere remains to be seen.

Oxygen absorption in the UV spectrum is also very important. Its absorption spectrum is principally up to about 200 nm. Thus, it absorbs the much shorter wavelengths that are emitted from the sun. Absorption from molecular nitrogen is probably relatively unimportant as far as biological conditions are concerned on the Earth's surface. However, water vapour has a few strong bands of absorption in the short UVR and some much stronger ones in the infra red spectrum. Gases like hydrogen, nitrogen oxide and carbon dioxide seem to play much smaller roles in absorption in the atmosphere. Other gases, such as ammonia, methane and carbon monoxide seem to play a more important role on the atmosphere of some of the planets rather than on the Earth. Sulphur dioxide gas arises as a pollutant in the Earth's atmosphere, which would play a useful absorptive role as it has an absorption spectrum lying between 240 and 320 nm ; just the thing for preventing sunburn and skin cancer! But sulphur dioxide seems to encourage certain types of aerosols and smogs and anyhow is strongly "scrubbed" out of the atmosphere by rain.

FLUORESCENCE

Photobiologists are interested in this phenomenon due to excited states, etc. Dermatologists are well acquainted with it, for instance with porphyrin fluorescence in diagnosis of porphyria. Fluorescence also occurs in the Earth's atmosphere ; this is the so-called air glow. The aurora is not an example of air glow and is due to the impact of high energy particles and is seen mostly at the poles. True air glow is due to the action of sunlight on normal constituents of the atmosphere. It occurs during the day and night, when its detection requires special instruments, but one example of air glow is very familiar, this is twilight, visible to the naked eye. If you use a spectroscope on twilight, the spectral lines are mainly those of oxygen and nitrogen excitation, for instance there is a green line at 557 nm due to flourecence of the decay of the oxygen excited "singlet". More surprisingly is the presence of sodium emission lines in twilight, discovered back in 1938. How does sodium get in the atmosphere ? Apparently it is mostly from the burning up of meteorites. More puzzling was the recent discovery of lithium emission lines, until it turned out that this was a pollutant from thermo-nuclear explosions.

REFLECTANCE SPECTROSCOPY

The planet Mars has a detectable air glow due to emission from oxygen and CO_2. But more interesting is the presence of ozone in the Martian atmosphere, discovered by reflectance spectrometry by observation over the polar caps of the planet.

To come abruptly back to the Earth from Mars, the dermatologist, although he may not know it, is well acquainted with reflectance spectrometry of a kind. This is in respect of his looking at the colour of the skin. The assessment or perception of colour is, of course, a psycho-physical function performed by the eye and the visual and higher centres of the brain, whereas a reflectance spectrum is merely an instrumental result. But colour vision can be regarded, nevertheless, as a sort of reflectance spectroscopy.

Skin colour, has, of course, an enormous diagnostic interest not only in dermatology but in medicine in general. The main factors in appreciating colour visually are :

(a) hue,
(b) saturation,
(c) brightness (lightness or luminosity)

A surface appears to be white if all the visible spectrum is reflected more or less equally in strength. It appears grey if it is reflected weakly, black if none is reflected. A surface is coloured, that is to say has a hue, if only one or other parts of the visible spectrum is reflected and other parts are absorbed. The term saturation refers to the degree to which a wavelength is predominant in the reflected light.

Brightness refers to the amount of light returned. For instance, a brown skin turns out to be a skin in which the predominant hue is red but the brightness is relatively low (Wassermann, 1971).

The eye is very much the dermatologists main tool. This is a truism. His eye can detect very small differences between two colours but on top of that, can differentiate things like patterns. What makes him a good dermatologist is not only assessing the colour, but recording the information and recalling it when necessary. A good dermatologist's eye, of course, does this far better than any colour photograph. There is no instrument which approaches him in this efficiency, though perhaps in the future the holograph may do so.

CONCLUSION

Back in the International airport I hurried through the formalities of searches, of irradiative and magnetometric procedure and boarded a rather ordinary sort of aircraft, except that it seemed to have no wings. The flight was in no way different from any other, i.e., rather boring. Of mild interest was a big meter in the cabin indicating machs. This meter went up to 2.1 or so, during the flight indicating a speed of more than twice that of sound. I also happened to note that the innermost of the triple glazed cabin windows was warm, perhaps about 40°C. Apparently, the outer surface of the craft would be very much hotter, especially at the nose. In 2 hours 20 minutes, we had crossed the Atlantic.

I find flying either tedious or terrifying, so anything to cut down its duration I will be favorably disposed towards, as long as it is safe. I hope supersonic flight does not damage the ozone layer. Personally I do not find the claims of those who believe that the ozone layer will be damaged very convincing, but then neither are the claims of those who say it will not be damaged any more convincing. No-one seems to know for sure.

$$NO + O_3 \longrightarrow NO_2 + O_2$$

Will this equation matter ?