DEPLETION OF THE OZONE LAYER: A MEDICAL EMERGENCY?

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This work is presented with the intention of both informing and provoking action. It has been researched as thoroughly as limited time, resources, and availability of information allow.

Ozone occurs naturally and is distributed throughout the stratosphere from about 10 - 50 km above the Earth's surface. Its concentration is low and it would compress to a layer of a mere 15 mm at ground level. It is being continually created and destroyed in complex chemical reactions which are not really relevant to the following discussion.

There are natural cyclical variations in ozone levels but overall a fairly "steady state" is maintained and the biosphere has evolved under this protective "layer".

In 1974 scientists first suspected that the ozone layer might be at risk from the chlorofluorocarbon (CFC) and halon (bromine-containing equivalents) gases which are being produced by industry. This has since proven to be true and there has been a decrease of more than 2 % in total ozone since 1979.

However, more seriously, there has also appeared an unexpected "hole" in the ozone layer over Antarctica during spring. This was first noted by British scientists in 1985, having previously been missed because NASA satellite data was programmed to automatically exclude major deviations from the expected norm!

The hole is in part caused by the specific climatic conditions of Antarctica and while there is also now an Arctic hole this is much smaller. The Antarctic hole is increasing in extent and duration with time and may lead to a more general depletion of ozone throughout the Southern Hemisphere It is also possible that the loss of ozone is augmented by the conditions created by stratospheric aerosol particles which arise from the massive burn-off of the Amazon forests for grazing land.

Ozone filters out solar ultraviolet radiation, particularly in the B and C bands (wavelengths les less than 320 nm). Most UV-C is absorbed in the upper atmosphere and as the ozone layer depletes the most disturbing effect is likely to be the increase in ambient UV-B. This is precisely the wavelength range where biological damage becomes highly significant.

Ambient UV-B levels also depend upon a host of other variables: solar zenith angle, latitude, altitude, season, cloud cover, atmospheric air currents, atmospheric pollution, dust, stratospheric conditions, time of day, reflective surfaces, shadows, and others.

The effects on living cells and tissues vary with ambient levels, protective properties or behaviour of organisms or plants, and specific properties of the tissues themselves: pigment, action spectrum, repair processes, etc.

There is an estimated average 2 % rise in ambient UV-B for a 1 % depletion in ozone. In fact this is now known to be modified in some areas to an unknown degree by the presence of ground level ozone, i.e. smog - we are irradiated or suffocated!

During the spring of 1987 the ozone in the Antarctic hole dropped to below

50 % of the 1979 figures for the first time. At some altitudes the loss was 95 %. In fact there is now an ozone depletion of about 15 % in all regions at latitudes greater than 45ºS (just South of Tasmania and cutting across Southern New Zealand, Chile and Argentina) during spring. There may already be significant lesser depletion for a longer period of time. The annual average decreases in ozone from 30 - 60ºN (cutting right across Europe. USSR, USA, Southern Canada and Northern Africa), are from 1.7 - 3.0 %, with 2.3 - 6.2 % in spring. These figures are greater than those predicted by developed computer models.

Very clearly we human beings are not as clever as we like to believe we are and are producing dangerously un predictable changes to our ecosphere.

If the 1986 (655,000 tons) production rates for CFC's are maintained there will be a 6.5 % global average depletion of ozone by the year 2000. They are being released at a rate 5 times faster than natural processes can dispose of them and they stay in the atmosphere for many decades. Even if there were no more production we would still have a reservoir which would cause the ozone layer to continue to deplete for decades.

Depletion of the ozone layer is not occurring in isolation, but concurrently with the greenhouse effect, loss of forests, land-degradation, water and soil contamination, atmospheric pollution, and all the other environmental damage we human beings are causing. Many of the interactions are synergistic and we have no way of predicting the precise consequences of what we are doing other than to know that generally we are heading for disaster.

BIOLOGICAL CONSEQUENCES OF DEPLETION OF THE OZONE LAYER

This data is limited by the lack of relevant research which has been undertaken in field conditions. It indicates the directions of changes rather than the magnitudes, which are impossible to predict for all the reasons discussed above and more.

CELL DAMAGE

Cells exposed to UV-B can be adversely affected in many ways. Up to a threshold level of exposure, which varies with tissue and wavelength, they are able to repair themselves. Some repair processes are even photoactivated by concurrent exposure to UV-A in sunlight.

Basically, radiation is absorbed by certain molecules and converts them to a high energy state. From there they participate in a variety of chemical responses - heat release, fluorescence, and production of photoproducts either by rearrangements of bonds within the molecules or interaction with other molecules. These photochemical reactions can occur in many key cellular substances: proteins, lipids, steroids, melanin, urocanic acid and nucleic acids, affecting membranes, cytoplasm, organelles, enzymes and genetic material. In plants there is destruction of the enzymes and chlorosplasts needed for photosynthesis. Many reactive oxygen species are produced which initiate numerous destructive biochemical reactions. UV-B spans the photoabsorption spectrum of DNA and produces pyrimidine dimers that distort the normal helical structure.

EFFECTS ON SKIN

In 1986, already more than half of all skin diseases seen by dermatologists in fair-skinned people from areas of high sun exposure (e.g rural Australia) were sun-induced.

The usual effects of exposure to excessive amounts of UV-B radiation are, of course, sunburn, degrees of tanning, and more chronic changes — altered pigment and surface architecture, atrophy, telangiectasia, elastosis and keratosis.

However, there is also some suppresion of local immune responses and

repair processes. This could result in an increased incidence of skin infections, eg. herpes simplex and leishmaniasis.

More serious is the relationship between UV-B exposure and skin cancer. Australia already has the highest incidence of skin cancer in the world. 3 years ago it was estimated that 2 out of 3 Australians will need treatment for skin cancer during their lifetimes. Non-melanotic skin cancers are about three times as frequent in Australia as all other cancers combined.

The non-melanotic skin cancers are in the main directly related to exposure to ultra-violet radiation. A 2% increase in ambient UV-B is likely to lead to a 4 - 10% rise in squamous cell carcinomas and a 2 - 5% increase in basal cell carcinomas. SCC's are often mis-diagnosed as BCC's and their incidence is generally under-estimated. They represent some 25% of all non-melanotic skin cancers.

For malignant melanomas the positions is a little more complex. Of the 4 types it is the lentigo maligna melanoma which is most directly related to UV-B exposure. However, for malignant melanomas generally there is epidemiological evidence which is highly supportive of a connection between UV-B exposure and the occurrence of the condition. It seems that acute, severe exposure may be more harmfull than chronic, low-grade exposure. It is possible that the UV-B affects growth, rather than induction, of cancer. It may aggravate a genetic sensitivity to sun-induced cancer, eg. as in xeroderma pigmentosum.

The action spectrum for skin carcinogens is similar to that for DNA damage, the more so as temperature and humidity increase, as in tropical climates. UV-A, while being able to photoactivate repair processes, can also potentiate the carcinogenic effect of UV-B. Certain chemicals which occur frequently in our environment are also able to potentiate this effect.

The U.S. Environment Protection Agency has estimated that a 2.5 % reduction in the ozone layer (already superseded many times in many places) would lead to an additional 1,000,000 skin cancers and 20,000 deaths over the lifetime of the existing U.S. population.

There is also a wide range of other known conditions related at least in part to increased UV-B irradiation of the skin:

- immunologic: S. L. E., pemphigus, etc.
- metabolic: porphyria cutanea tarda, etc.
- infectious: lymphogranuloma venereum, herpes simplex etc.
- genetic: xeroderma pigmentosum, albinism, etc.
- nutritional: pellagra, kwashiorkor, etc.
- chemical: drug and other phototoxic interactions of various manifestations.
- allergenic: the UV triggered reaction may persist for years after the allergen is removed.
- sensitizing: many chemicals, dyes, drugs, antibacterial agents, plant products, etc., can augment/alter the tissue response to UV radiation.

EFFECTS ON HUMAN EYES

Normally wavelengths of 400 – 1400nm pass through the aye tissues and impinge on the retina. Of this, the 400 – 780nm range only is visible, the remainder being in the infra-red region. Wavelengths of 300 – 400nm, i.e. UV-A and longer wavelength UV-B, penetrate the cornea and are largely absorbed by the lens.

Only 25% of ambient solar radiation in an upright person looking forward actually reaches the face, and maybe only 10% the eye, as it is protected somewhat by facial contours. As well as the usual factors which affect the level of ambient radiation there are also in particular the effects of clothing, hats, spectacles, and the activity of the person under consideration.

Excessive UV-B may produce an acute kerato-conjunctivitis, as in snow-blindness. This may be severe enough to produce cell necrosis. A chronic actinic keratopathy occurs in areas of the world with high insolation. UV-B may also trigger herpes simplex keratitis or recurrent corneal erosions.

Perhaps of greater significance, though, is the epidemiological evidence which relates UV-B irradiation of the lens with the ocurrence of age-related cataracts even at normal levels of exposure. The effect of UV on the lens depends generally on radiant exposure and duration, pupil size, absorption characterisitics of the overlying tissues, lens transparency and yellowing, nutritional factors and the state of hydration of the lens. The thresholds for damage are wavelength specific.

Most hard evidence for lens damage with UV-B is in experimental animals, but it does parallel the changes normally seen with ageing. There are also clinical reports of photosensitized cataracts in human beings. Hence, with the depletion of ozone it is likely that the incidence of these cataracts will increase and they will occur at progressively earlier ages. Cataracts are already a massive world health problem.

While the retina is certainly vulnerable to UV-B damage, except in aphakics it will mostly be protected by the lens and other eye tissues. However, the developing eye of the infant is known to be vulnerable (retinopathy of prematurity) and it may well have lower thresholds for damage, even in the slightly older infant.

HUMAN IMMUNE SYSTEM

This is an area which seems to be relatively unknown, no doubt because of the difficulties in conducting adequate studies.

The general direction is toward suppression of immune function, probably relating to the total cumulative effect of the UV irradiation. The function and viability of individual circulating and non-circulating cells of the immune system is altered, there is a general suppression of lymphocyte function, and there may be production of suppressor T cells which respond to tumour antigens.

Obviously a whole host of potential consequences which are adverse to human health appear at this point.

Medical considerations would normally stop here, but this creates an illusionary sense of the separation of human beings from the animate and inanimate environment. In fact we are intimately bound into relationship with our ecosphere and until we recognize this we will be at a loss to understand much of what happens to us.

Until the last 150 years or so the world's population was relatively small and its technology relatively primitive, we had not sufficient power to do too much harm and a relative homeostasis had been preserved for millenia. But now we have technologies way beyond our capacity to exercise common sense and responsibility and we will soon pay a heavy price if we do not develop new attitudes of respect and co-operation for each other and our environment.

PROTECCION

(1) There must be immediate measures taken to reduce production of CFC's and halons by 95% within the next 2-5 years. This requires URGENT, INTERNATIONAL efforts. The Australian government is at present considering its response to the 1987 Montreal Protocol. This Protocol was drawn up without taking into account the unexpected Antarctic depletion and is considered to be inadequate in its provisions by those who are well-informed.

(2) Inmediate steps must be taken to recycle those gases already in use in refrigerators, air-conditioning units and fire-extinguishers.

(3) There must be public education as to protective measures to be taken, apart from the avoidance of CFC propellants in spray cans. The dermatologists have already made some headway in their campaign against skin cancers.

- protective clothing: natural fibres have a closer weave than synthetic
- hats
- less exposure, particularly in areas of high insolation particularly if fair-skinned, unused to exposure, and of younger age group.
- one cannot rely on sunglasses and goggles which are currently on the market: these need adequate testing over all wavelengths, and urgent standard specification
- sunscreens: these do not prevent immune suppression and if used too often have been known to lead to Vitamin D deficiency states, especially in the elderly
- good nutrition: skin, eyes and immune system all have certain dietary requirements for optimal functioning, eg. vitamins A, C, E, B_2, B_6, B_6, zinc, selenium, etc.

FINAL COMMENT

We are looking, then, at a planetary situation the likes of which we have never seen before. It is a challenger of enormous dimensions. As a Profession, surely, we have a great responsibility to inform, firstly ourselves, but also governments (world-wide) and the population generally. We are morally, ethically, and spiritually bound to "see" and to act before it is too late. With the exponential increase in the world's population (currently 225,000 per day) and the consequent drain upon limited natural resorces, together with increased industrialization and production of environmentally damaging and wasteful products, we are in a situation which is NON-SUSTAINABLE in the SHORT TERM. We have a choice which is ultimately a personal choice and we have to make it NOW. Surely we must try.