How Toxic Is Your Sunscreen?

Toxic Sunscreen Ingredients Exposed

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During the past 50 years, we have increased the number of synthetic sunscreen chemicals that we use. We have done this with virtually no consideration as to how vulnerable we are to these chemicals, how little we know about their subtle and cumulative toxic effects or the effects of interactions of these chemicals. We assume that because they are so easily purchased from the supermarket shelf, they must be safe to use. Wrong! Many of these chemicals are known to be toxic; very few are carefully studied before they are put on the shelf and made available to the general public. In fact, some of these chemicals have been used for decades without any deliberation about their potential toxic effects.

There is no doubt that the products in everyday sunscreens are toxic. The only real question is: what effects do they have on you and your family? Exposure to these chemicals affects you on a cellular level. It may be insignificant or it may actually be contributing to the problem you are trying to avoid.

A quick read of the following pages will undoubtedly open your eyes to a serious problem. The majority of sunscreens on the market are full of toxic ingredients that may be worse than the exposure to the sun or may be contributing to long term health problems.

Background

Since the 1970s, global use of sunscreens and ingredients used in these products has increased dramatically in response to growing awareness about UV exposure and its negative effects on the skin [1,2]. However, there is also increasing acknowledgement of the toxic effects of many sunscreen ingredients, with some already being removed from production in various countries. In addition to use in sunscreen lotions, many of the same chemicals are increasingly being added to a range of cosmetics and skin care products including moisturizers, foundations and lipstick [3,1,4,5]. Thus, virtually every member of the public is exposed to these chemicals, as so many products containing them sit in our cupboards.

In order to block out UV radiation, the active ingredients must react to sunlight and, by its very nature, this reaction will cause energy to be released, which is where the problem begins. Little is known about this energy and how it is being released back into the body or what it can do to the cells of the body [6]. UVA absorbers have a high level of photochemical instability—that is, when exposed to sunlight, they begin to produce free radicals [7]. These free radicals cause DNA damage, which can result in a range of ill effects from premature skin aging to cancer [8]. Padimate O, para-aminobenzoic acid and 2-ethylhexyl-p-methoxycinnamate, when illuminated by sunlight, generate singlet oxygen, a potent free radical that has the potential to cause DNA damage, including strand breaks, when in contact with human cells [8,9].

Sunscreen Toxicity

The general consensus is that sunscreens are a highly important means by which one can avoid excessive UV irradiation and subsequent sunburn, thereby reducing the risk of developing melanoma or other forms of skin cancer later in life. However, there is growing concern regarding the impact that the ingredients contained in sunscreens have on the body [10]. Laboratory tests on the main ingredients of conventional sunscreens have revealed that they are associated with some surprising negative side effects, including: increased skin permeability; endocrine activity resulting in a disruption of natural hormone levels; the generation of free radicals and subsequent damage to cellular DNA within skin cells; and potential skin cancer [11,12,13]. In some cases the active ingredients in sunscreens may outweigh the benefits. Alarmingly, it is the unseen active ingredients that most consumers would not even think to check that are harmful.

While the toxicity of the main ingredients is of concern, there is just as much concern that the full list of ingredients in these products is not disclosed in

Australia. Further, the potential for their interaction is, at this point, not brought to the attention of the consumer.

Do Sunscreens Increase Skin Cancers?

The question of whether sunscreen prevents skin cancer remains unanswered. Many epidemiological studies show an increased risk of skin cancer to the sunscreen user [14]. A review of studies on skin cancer and sunscreens by *Science News* found that people who used sunscreen were more likely to develop basal cell cancer than people who did not. *Science News* reviewed ten studies of melanoma, five of which concluded that people who used sunscreen were more likely than non-users to develop melanoma. Three of the studies found no association between melanoma and sunscreen use, and two studies found that people who used sunscreen were the most protected. *Science News* revealed that epidemiological data were not conclusive. This may be because people involved in the studies were not wearing effective sunscreen or were staying in the sun for long periods of time because they thought they were protected. There may be other factors that were not considered in the studies. *Science News'* review highlights the difficulty in interpreting epidemiological studies of humans.

More recently, results of a randomized controlled trial of adults who used sunscreen daily found increased risk of basal cell carcinoma [15]. A case-control study from southern Sweden of 571 patients diagnosed with malignant melanoma showed significantly increased risk for having developed the disease after regular sunscreen use [16].

The possibility remains that these products may be contributing to skin cancers. This is supported by the fact that the toxic chemicals used in sunscreens could very well constitute a potential mechanism for the development of skin cancers.

Toxic Ingredients

Many of the chemicals in sunscreens have minimal toxicological effects when first applied to the skin. However, once exposed to sunlight, the chemicals are heated and reactions occur between the sunscreen's active and inactive ingredients and the epidermis [17].

Titanium dioxide

- On absorption of UV light, photo-generated titanium dioxide particles create singlet oxygen, superoxide anions (O2-) and hydroxyl radicals (OH-) that are potent free radicals [18,19]. Irradiated particles of titanium dioxide can

induce oxidative damage to DNA [19] which can lead to the development of mutant cells and skin cancers [7,20,21,22] and lipid peroxidation of essential functions on the cell membrane [23].

Octyl-methoxycinnamate(OMC)

- Octyl-methoxycinnamate (OMC), also known as Ethylhexyl methoxycinnamate, is one of the most frequently used chemical UV filters worldwide and has been reported to cause photosensitization and photoallergic effects.

- Recent studies indicate that OMC may have significant undesirable effects as an endocrine (hormone)-active chemical. OMC has also been found to have estrogenic effects, similar to that of estrogen, which can result in health issues. OMC has the ability to interfere with endocrine systems like the hypothalamo-pituitary-gonadal axis, which is of major concern during perinatal development and differentiation of vertebrate organisms [24]. Octyl-methoxycinnamate has been found to be estrogenic in mice and rats.

- OMC easily penetrates the upper layer of the skin and, when exposed to UV radiation, generates reactive oxygen species or free radicals in skin cells [11].

Estrogenic effects

- Extensive research has shown that a number of UV filters frequently used in the formulation of commercial sunscreens cause increased endocrine (hormone) activity [4]. Endocrine disruptors are chemicals that interfere with endogenous hormone action and/or production. These have been implicated in the development of a number of diseases in both males and females, including cancer of the mammary glands and reproductive organs, as well as the abnormal development of the male reproductive system [13,25].

- The Danish EPA reported that three commonly used sunscreens—4-MBC, octyl-methoxycinnamate and oxybenzone (benzophenone-3)—showed hormonal effects in both animal and *in vitro* (test tube) studies. They reported that 4-MBC had a particularly strong effect. More worrying is that these chemicals have been found in breast milk at concentrations known to have estrogenic effects [2,26].

- Research has demonstrated the when exposed to UV oxybenzone, homosalate, 4-methyl-benzylidene camphor, octyl-methoxycinnamate and octyl-dimethyl-PABA increase breast cancer cell proliferation *in vitro* [16]. In

the laboratory, daily dermal application of oxybenzone and 4-methylbenzylidene camphor (4-MBC) increased uterine weight of rats [16]. The results suggest that daily human exposure to sunscreen formulations may have estrogenic effects [16]. In one study application of three active ingredients commonly found in sunscreens (oxybenzone, 4-MBC and octinoxate) for one week led to a statistically significant drop in testosterone and estradiol levels in men [2].

4-Methylbenzylidene camphor (4-MBC)

- The compound 4-MBC competes with estradiol for estrogen binding sites in the uterus, indicating that it may act as an environmental estrogen [25]. Exposure to 4-MBC in rats during and after gestation was found to have an impact on the development of the hypothalamo-pituitary-gonadal system and trigger changes in the estrogen-regulated gene expression in regions of the brain and reproductive organs [26]. Laboratory tests on rats exposed to 4-MBC revealed that male rats born to mothers orally exposed to this compound experienced decreased testis weight, delayed puberty and decreased adult prostate weight. Similarly exposed females experienced increased adult uterine and ovarian weight. The weight of the thyroid of both sexes was increased as a result of the exposure [27].

- Endocrine disrupters such as these substances are found to cause a number of diseases in males, such as sperm anomalies, cryptoorchidism, hypospadia and testicular cancer; in females there is an increased chance of forming breast cancer [25]. 4-MBC has been revealed to accelerate cell proliferation in estrogen-dependent human breast cancer cells. It has the potential to change physiological and developmental processes mediated by estrogen receptor signaling mechanisms, such as uterus growth and gene expression. These have been implicated as potential activators of sex steroid signaling pathways in the cells of mammals, including humans [28].

- Competing with estradiol for uterine estrogen binding sites, 4-MBC is thought to lead to increased activity of osteoblasts and osteoclasts, disturbing the equilibrium between the two cell types that balance the calcium activity in the cell, in favor of osteoclasts [25]. This results in an increased bone reabsorption and can lead to osteopenia and osteoporosis [25].

- It is possible that adults are better able than children to regulate hormone levels in response to the presence of endocrine disruptors and environmental estrogens [2]. However, there is a strong possibility that sunscreen compounds

may pose a danger to prepubescent children with low levels of endogenous hormones. Youngsters are likely to be exposed to greater concentrations of these compounds as a result of their larger surface area to volume ratio, undeveloped toxin elimination systems, greater application rates and the fact that they are likely to swallow small amounts during application to the face and lips [25,29,30]. Conservatively, the potential dose of a chemical following dermal exposure to a child is about 1.4 times greater than in adults [31].

- ***Cinoxate (2-ethoxy ethyl p-methoxycinnamate) and methyl sinapate (methyl 3,5-dimethoxy 4- hydroxycinnamate)*** are cinnamate derivatives. Cinoxate is commonly used as a UV absorber in cosmetics. Both substances increased the DNA damage in animal cells tested when exposed to light [32]. In particular, the chemicals inhibit DNA repair, leading to chromosomal abberations and the potential for cancer.

Benzophenones

- Benzophenones were first used in sunscreens in the 1950s. Benzophenones are lipophilic and commonly cause photo allergies. Daily use of a sunscreen with benzophenones can cause photocontact dermatitis, rosacea, burning, itching and erythema [33].

- Benzophenones used as UV filters in products can be absorbed through the skin into the human body. This is indicated by trace levels found in urine from users of products that contain benzophenone [34].

- Benzophenone, along with menadione, is a potent free radical generator. It has been found to induce oxidative stress (free radicals) on myoblasts (embryonic cells) by superoxide and hydrogen peroxide production. Once the free radicals are generated, a chain reaction is initiated that will damage anything it comes into contact with, including cell DNA [35]. These substances are so well known for their free radical properties that they are used in industry to initiate chemical reactions in the presence of UV light to break down fats [36].

Oxybenzone (benzophenone 3)

- Oxybenzone has been linked with allergies, xenoestrogenic properties and cell damage [4,26,37,38]. Oxybenzone is rapidly oxidized to produce oxybenzone semiquinone, a potent electrophile that inactivates the important antioxidant systems that protect cells from free radical damage and cancer [39].

- A study by the Center for Disease Control in the US found that 97% of 2,500 people, age 6 and older, had oxybenzone in their urine [40]. The study found that women and girls had higher levels of oxybenzone in their bodies than men and boys, likely a result of differences in use patterns of sunscreens. An earlier study found oxybenzone in the urine of all 30 adults tested [41]. It is excreted many days after the last application, which suggests a tendency to accumulate in fatty tissues in the body [42]. Another recent study found that mothers with high levels of oxybenzone in their bodies were more likely to give birth to underweight baby girls [43]. In the words of the researcher, "It would be prudent not to apply oxybenzone to large surface areas of skin for extended and repeated periods of time, unless no alternative protection is available."

- Recent studies have found exposure to oxybenzone results in allergic reactions of sensitive individuals [44,45,46,47] including dermatitis [48].

PABA

- PABA (para-aminobenzoic acid) was one of the first commercially used UVB sunscreens, and one of the most widely used sunscreen ingredients up until the mid-1980s when it almost completely disappeared because of the high incidence of adverse skin effects [50]. An ester of PABA, **amyl para-dimethylaminobenzoate (Padimate A)** causes phototoxic reactions. Padimate A reacts with UVA to produce symptoms widely resembling sunburn in most subjects—without sunburn cells. The similarity between sunburn and a phototoxic response has lead people to believe mistakenly that the sunscreen *causes* sunburn [51].

- PABA is widely used as an active ingredient in sunscreens and is only allowed up to concentrations of 5% in Europe [52]. PABA is listed as a permitted active ingredient (in concentrations up to 15%) in Australia under the TGA 1989. PABA is prohibited as a sunscreen ingredient in countries such as Canada [53] due primarily to PABA's ability to affect DNA in human cells in a manner that results in amplified susceptibility in some people to skin cancer [54,55]. People who lack the mechanism to repair PABA-initiated defects are then more susceptible to skin cancer. PABA has been found to cause oxidative damage to human skin cells by forming oxygen reactive species under the exposure of UV light. Several intermediate reactive species are formed during the photoreaction of PABA in liquids that can then form potent free radicals [56]. This raises huge concerns because PABA

and the other Para-Amino Benzoic Acid derivatives used in sunscreens are known to penetrate the skin [52,57].

Padimate O

- When exposed to sunlight 2-ethylhexyl-4-dimethylaminobenzoate (Padimate O) forms free radicals that cause strand breaks on DNA [9,58]. The result is a decrease in simple and repairable damage and an increase in complex chemical damage, which is more difficult to repair. An experiment with Padimate O found that it produced singlet oxygen (free radicals) upon illumination and increased indirect DNA damage by a factor of 75 over sunlight exposure alone [8]. Thus any sunscreens using Padimate O as an active ingredient may be causing skin aging and DNA harm more serious than that caused by sun exposure.

Dibenzoylmethanes

- Dibenzoylmethanes have been incorporated into sunscreens since 1980 as UVA absorbers. Cases of photoallergy and contact allergy have been reported, as well as cross reactions from prior exposure to dibenzoylemethanes [59]. Instances of contact and photocontact allergy with dibenzoylmethane derivatives such as ***5-methoxypsolaren (5-MOP)*** and ***isopropyl dibenzoyl methane*** (Eusolex 8020) have been found with sunscreen usage; *further, it is often used in conjunction with* ***Eusolex 6300*** [60,61,62].

- In one study, 15 of 280 skin clinic patients tested with sunscreens had positive reactions, with three of them allergic to more than one agent. The most frequent contact allergens were hydroxy methoxy methylbenzophenone (mexenone) followed by isopropyl dibenzylomethane (Eusolex 8020/8021), octyl dimethyl para-aminobenzoate (Escalol 507) and one reaction each to butyl methoxy dibenzoylmethane (Parsol 1789), amyl dimethyl para aminobenzoate (Escalol 506) and ethoxy ethyl-p-methoxy cinamate (Giv-Tan F) [63]. Another study reported immediate and delayed photocontact dermatitis from isopropyl dibenzoylmethane (Eusolex 8020) in patients with minimal exposure to UVA [64].

Parsol 1789

- Parsol 1789 (Avobenzone) is a UVA-absorbing chemical added to sunscreens. Free radicals are produced on illumination of Parsol 1789,

leading to stand breaks in DNA [69] and lipid peroxidation [49]. It has also been shown to produce photocontact allergy [70].

Psolaren

- In 1994, researchers at the Harvard Medical School found that the ingredient psolaren in sunscreens is an extremely efficient carcinogen. Experiments on rodents exposed to UVA also produced the same result: psolaren was found to be carcinogenic [65]. It is worrying that psolaren is known to be a free radical generator when activated by UV radiation, and yet it is used in sunscreens. People with psoriasis are at greater risk than others, as their squamous cell carcinoma rate was found to be 83 times higher than that of the general population [66].

Octyl salicylate

- Octyl salicylate is known to penetrate the skin, however the rate of penetration is slow. The high lipophilicity (attraction to, and accumulation in, fat) of octyl salicylate means that it is likely to be able to accumulate and form a reservoir within the stratum corneum [67]. Salicylates are known to cause photocontact allergy [60].

PBSA (2-phenylbenzimidazole-5-sulfonic acid)

- An ingredient commonly used in sunscreens, 2-phenylbenzimidazole-5-sulffonic acid (PBSA), strongly absorbs UVB wavelength light. In the process PBSA becomes energized and capable of damaging adjacent skin tissue. When exposed to light, PBSA damages the genetic material's guanine base sites. If this were to occur inside cells it might increase the risk of developing skin cancer [68].

Excipients: The Unlisted Chemical Dangers

- There is cause for concern not only about the active ingredients in sunscreens, but also about the inert ingredients, particularly in Australia as there is no requirement for these to be listed on sunscreen labels. Excipients, which act as the carriers or base materials of a product, make up approximately 80% of sunscreens. They "receive" and carry the other ingredients. Excipients include mineral oil, petrolatum, isopropyl esters, lanolin derivatives, aliphatic alcohols, emulsifiers, fragrances, thickeners and preservatives. Sunscreen toxicity, including contact allergies [61], can be caused by excipients in the formulations [60].

- Sunscreens claiming a sun protection factor (SPF) of four or above in Australia are required to be listed on the Australian Register of Therapeutic Goods for over-the-counter medicines and must adhere to regulation by the Australian Standard AS/NZS 2604:1998. Under this legislation, sunscreen manufacturers only have to list preservatives and "active ingredients," those that are used in blocking the sun. By contrast, cosmetics legislation makes companies list all the ingredients, despite the fact that cosmetics tend to be used only on the face while sunscreens may be applied all over the body, multiple times each day. The Appendix shows some of the excipient chemicals that are often not listed.

- In a study of 603 people age 40 and over, 114 people were found to be allergic to ingredients in sunscreens [71]. Fragrances, used extensively in sunscreens, produced the most common reaction, allergic contact dermatitis. In a study of patients with suspected photosensitivity, 47 reacted to fragrances tested, 11 to preservatives and two to lanolin alcohol [72].

- Several preservative compounds are added to sunscreens to inhibit the growth of bacteria [73]. The chemical 2-phenoxyethanol is commonly added to sunscreen lotions and has been found to be readily and rapidly absorbed through the skin and subsequently excreted in the urine [74]. This compound and other cosmetic preservatives can cause cell death at low concentrations and therefore may have a negative impact on the liver, where this compound is metabolised following absorption [73,74]. Formaldehyde, a strong skin irritant that causes cancer in some animals, is also used by some manufacturers as a preservative. Formaldehyde has been the culprit in many of the instances of contaminated clothing from China. Formaldehyde enhances the penetration of other chemicals into the skin. DMDM Hydantion, diazolindinyl urea (also with a trade name GERMALL) and quaternium are chemicals that release formaldehyde and have been associated with skin senitisation and rash. A list of toxic presevatives is hsown in the Appendix.

- A few companies list all of their ingredients but most do not. Only some list preservatives in the sunscreens they sell. The interaction of these chemicals is a major unknown where 1+1 equals a lot more damage than 2.

- Why doesn't the TGA require all the ingredients to be listed?

Dermal Absorption and Penetration Enhancement

Some sunscreen molecules that penetrate the skin contain photochemical properties and thereby increase DNA damage, causing significant safety concerns [54,75]. Whilst some sunscreens absorb only into the viable epidermis, others penetrate completely through the skin and into the blood [76,77]. Only a few of the chemicals used in cosmetics have been tested for their ability to enter systematic circulation through the skin [78].

In one study, all the chemicals commonly found in sunscreens were tested and all were found to penetrate the skin. These included octyl dimethyl p-aminobenzoic acid, oxybenzone, 4 isopropyl-dibenzoylmethane, 3-(4-methylbenzylidene)-camphor, butyl-4-methoxycinnate, the repellent and plasticizer dibutyl phthalate, the antioxidant 3, 5-di-t-(butylparaben), biphenyl-2-ol and triclosane [78]. In another study the penetration and retention of five commonly used sunscreen agents (avobenzone, octinoxate, octocrylene, oxybenzone and Padimate O) in human skin was evaluated to find detectable amounts of all sunscreen ingredients tested present in the uppermost layer of the skin cells, the stratum corneum and viable epidermis with oxybenzone the most evident [79]. Another experiment found that benzophenone-3, OMC and 4-MBC commercially used in sunscreens worldwide were all detected in plasma one to two hours after a single application [77]. Peak median plasma levels for men were reached at three hours, for women increasing concentrations after four hours [77]. It appears that between 1% and 10% of some sunscreen ingredients are absorbed into the body through the skin; this finding is consistent with earlier lab experiments and animal studies. In a study of oxybenzone, participants continued to excrete it many days after the last application of the chemical, which suggests that it may accumulate in fatty tissues in the body [42].

The absorption of sunscreens depends on many factors including where it is applied. The face is probably the most common place of sunscreen application and it absorbs sunscreens at a rate of two to 13 times that of the skin on the forearm [80].

Penetration enhancement

When used in conjunction with other chemicals, sunscreens can act to speed up the penetration of other substances including increasing the transdermal absorption of toxic chemicals [81]. A large proportion of the active ingredients in sunscreens can act individually as penetration enhancers. However, when combined, the adverse effects can be significantly enhanced [12]. In a number of studies sunscreens have enhanced the penetration through the skin of pesticides such as 2,4

dichlorophenoxyacetic acid (2,4-D), paraquat, parathion and malathion [82,83] and industrial solvents [84].

Chemical sunscreens that increase dermal penetration include octyl methoxycinnimate, oxybenzone, homosalate, octyl salicylate, Padimate O, and sulisobenzone[12,85]. This suggests that these chemicals cause damage when regularly used in sunscreen applications[12]. Otocrylene was the only chemical ingredient in sunscreen tested in the study that did not increase the dermal penetration of pesticides[12].

Increased dermal absorption of pesticides via sunscreen use during pregnancy creates an elevated chance of spontaneous abortion or foetal death [86]. As pesticides alone are readily absorbed through the skin, an increasing absorption rate with sunscreen use is a serious concern [86]. N,N-diethyl-m-toluamide (DEET) is an insect repellent commonly found in sunscreen which also increases dermal penetration of pesticides [12].

This clearly shows that one cannot consider these chemicals as single elements, but must take into account how the chemicals work in conjunction with other agents.

Slip, Slop, Slap and Salad: The Diet Link

The human skin can naturally protect itself from photodamage by antioxidants [87]. Humans have evolved in the sun. This does not mean being in the sun all day but we have an innate ability to protect ourselves from damaging sunrays and, in the meantime, produce the all-important vitamin D. Good nutrition enables the body to repair certain amounts of damage to the DNA from the sun. So while it is important to get out into the sun each day for short periods to get adequate vitamin D, it is equally important to get good nutrition to reduce the risk of skin cancers and skin complaints brought about by the sun's rays. This involves more fruit, vegetables, nuts and beans—foods that are rich in antioxidants, vitamins, minerals and so much more. It would be naive to think that nutrition, which provides the building blocks of our physical and chemical bodies, has no role in the protection of our cells. It would also be naive to think that nutrition alone would protect us, but it does play a role. Recent research has shown that B carotene supplementation for 10 weeks provide an SPF around 4 and significantly reduced sunburn [88].

Of all the naturally occurring chemopreventative agents present in the diet, the polyphenolic catechins found in green tea have been identified as the most effective botanical agents for use in the prevention of photodamage and skin cancer [89]. Tea catechins are non-nutritive compounds, however their consumption

has repeatedly been demonstrated to inhibit or decrease the severity of UV damage in laboratory trials [90,91,92,93].

Safer Barriers

A number of products are now available that afford the same sun protection as synthetic, toxic sunscreen ingredients but with a much reduced risk.

A black tea extract gel developed for potential protection from UV damage was found to prevent erythema and acute sunburn due to direct sunlight (UVA, UVB) as well as to repair DNA damage inside the skin when an enzymatic oxidation of tea polyphenols occur [94]. Unlike the gel, sunscreens protect the skin only from incoming UV radiation and have no damage repairing effects inside the skin after exposure (in addition, the sunscreens have toxicological qualities). The black tea gel can be applied liberally and regularly to the skin without toxic side effects. Natural sunscreen used in combination with chemoprevention (such as green tea phenol extracts that have been shown to reduce DNA damage in human cells) suggests that UV radiation-induced sun damage can be prevented [95,96].

Human skin is capable of absorbing various nutrients directly. Clinical studies have indicated that tea polyphenols are readily absorbed when topical applications are applied to the skin [97,98]. Formulations containing products such as vitamin A, vitamin E, lycopene and green tea are at present readily available on the cosmetic market. Perhaps it would be prudent to encourage high-risk individuals to apply these products to their skin in order to reduce their exposure to free radical damage and subsequent skin cancers and to soothe the pain and inflammation associated with inadvertent sun exposure [89,92].

Zinc oxide is considered considerably safer than titanium dioxide and covers the full UVA and UVB spectrum from 290 to 400nm—the most complete spectrum. Microfine zinc oxide is less white than titanium dioxide as a sunscreen ingredient and it is more protective against long wave UVA [99]. Unlike the synthetic chemical sunscreens and titanium dioxide zinc oxide is photostable [105].

How to select safe ingredients

Read the ingredient list and label and buy only products that list all ingredients. The list will be at least 10 items long and in most cases much longer.

When natural is not natural

The claim of being "natural" can be very misleading. Even more misleading, the term "natural" can be a part of the name of a product and therefore not necessarily a claim! Perhaps a better approach is to ask for products that are free from synthetic chemicals. Claims of being chemical-free usually imply this but are not really precise enough. Everything is made from chemicals, so "chemical free" is not possible.

Organic products are best

The term "*organic products*" refers to products that have an extremely high level of certification and quality assurance. This means a lot of work has already been done to validate their safety. None of the toxic ingredients I have listed in this book as are permitted under organic certification.

To find the safest sunscreens, look for products that resemble food ingredients like some of the safer ones I have listed above. This would include a plant-based oil, green tea and vitamin E. In the future all sunscreens will be made of edible ingredients probably with a little zinc oxide thrown in for good measure.

Environmental Concerns

It has been demonstrated that personal care products, including sunscreens, have an impact similar to that of other contaminants on aquatic organisms [100]. During bathing or swimming, a significant amount of sunscreen is washed off and enters the aquatic environment [101]. The high lipophilicity of the UV filters has been shown to cause bioaccumulation in fish and humans, leading to environmental levels of UV filters that are similar to those of PCBs and DDT. Fish species in a German lake contained evidence of six different UV filters in addition to PCBs and DDT at similar levels. This accumulation in humans and the environment suggest that UV filters should be considered relevant environmental contaminants [102].

Even in relatively low levels, the lipophilic (fat loving) nature of these substances suggests that they may accumulate along food chains where they may have an estrogenic impact on top-order consumers [10,25]. A laboratory study conducted on the impact of UV-absorbing compounds on mammalian and amphibian cells revealed that extremely low concentrations of 4-MBC possessed an estrogenic effect on cells and were able to alter gene expression [28]. Even at the low levels observed, these compounds may be having a significant impact on the ecology of aquatic environments [101].

Recent studies have raised the issue of sunscreens having a serious negative effect on coral reefs. Laboratory experiments conducted in several tropical regions (the Atlantic, Indian and Pacific Oceans and the Red Sea) showed that sunscreens cause the rapid and complete bleaching of hard corals, even at extremely low concentrations. By promoting viral infection, sunscreens potentially play an important role in coral bleaching in areas prone to high levels of recreational use by humans [100].

Labeling and Regulation in Australia

Most regulation of sunscreens around the world is largely confined to ensuring that sunscreens can prevent sunburn and that the manufacturers labeling claims are supportable. There is no requirement for manufacturers to determine long-term safety. In Australia most sunscreens are regulated as medicines under the Therapeutic Goods Act (TGA) 1989. However, products containing sunscreen ingredients classified as cosmetic are not regulated by the TGA 1989 and are not required to be tested for photocarcinogenic effects [16].

In the Australian Code of Good Manufacturing Practice for Therapeutic Goods – Sunscreen Products 1994, there are no clauses regarding the toxicity of the ingredients in sunscreens. The code covers buildings and grounds, equipment, personnel and training, factory sanitation and personal hygiene, documentation, manufacturing procedures, contract manufacture, quality management and the use of computers. There are no guidelines for the compounds used in the manufacturing of sunscreen; therefore we can assume that *any* chemicals could be placed in sunscreens unless they are completely banned chemicals such as DDT. The code has no requirement for testing toxicity or the synergy of chemicals within sunscreens. It is also assumed that little or none of a topically applied substance is absorbed into the cells and into the blood.

The Politics of Sunscreens and Skin Cancers

It is widely acknowledged throughout the sunscreen industry and by various cancer authorities that the ingredients in sunscreens may be causing the same problems that they are meant to solve. Despite this, the industry maintians a strong outer appearance of compliance and denies any problems.

Individuals and organisations are quick to dismiss the real results of toxicological studies of sunscreen ingredients and believe that the widespread usage of sunscreens without any immediately apparent negative or acute impact is testimony to the fact that these products are harmless. However, laboratory results

suggest that long-term exposure to these compounds may result in chronic effects on human health and reproduction [4,13,25,29].

It is a paradox and interesting to note that some of these same organizations try to convince people not to smoke due to the presence of potentially toxic chemicals and promote products that are considered as toxic, just not as well researched.

Conclusion

Sunscreens should not be abused in an attempt to increase time in the sun. The misuse of sunscreen has led to a false sense of protection to prolong relaxation in the sun. The development of sunscreens that protect against both UVA and UVB were major steps forward in preventing skin damage 50 years ago. However, it is now time to move to ingredients that do not contribute to the problem.

Poor chemical photostability of many sunscreens is now recognized as a common problem. In addition to losing effectiveness they can become photo-oxidizing agents that damage DNA in skin cells. The research in this report shows that using synthetic chemical sunscreens to help prevent sun damage may be more harmful than not using any protective chemicals.

Most sunscreens are only slightly updated products of the 1950s. It would appear that little progress has been made in the development of more effective UV blockers, in spite of growing concern over UV exposure and the toxicity of sunscreens. Despite the widespread belief that sunscreen usage is essential in the fight against melanoma, the results of laboratory studies on the toxic and estrogenic effects of the major sunscreen ingredients suggest that their use is not without inherent risks. Effort should be directed at the development of safer sunscreens, which are more appealing to consumers and pose a smaller risk to their health.

There are also many assumptions made which enable these chemicals to be poorly regulated. Two of the most critical, but incorrect, assumptions are that little or none of a topically applied substance is absorbed into the systemic circulation and that because they have been around for so long they must be safe.

It is critically important to produce safe, effective sunscreens that can be applied liberally and regularly to the whole body. “User-friendly” sunscreen would require that the sunscreen be made using low-toxicity ingredients such as food grade ingredients that repair UV damage while protecting from UV exposure [94,103]. The evidence suggests that these ingredients, used in combination with

chemoprevention such as green tea phenol extracts, have been shown to reduce UV DNA damage in human cells [95,96]. Choose sunscreens that are free from synthetic chemicals. We should be making sunscreens from the foods we eat. Then we would know that they are safe.

It is a common misconception that sunscreen use alone is sufficient to protect the skin from the effects of UV damage; in fact, this is not the case [16]. More reliable forms of UV protection must be used in conjunction with safer sunscreens in order to minimise the risks associated with chronic exposure to UV radiation, especially amongst individuals with naturally low defences against solar radiation[104,16]. More desirable means of protection include wearing long-sleeved clothing, seeking shade during periods when the UV index is at its highest and conducting outdoor activities during the early morning and late afternoon so as to avoid the sunniest part of the day [16]. In preventing sunburn and skin cancer, the key is to remember that sunscreen should be used in conjunction with protective clothing, a hat, sunglasses and a healthy diet. The use of sunscreens should never be considered as a safe way to spend all day in the sun.

A Final Word

Only through consumer pressure will the bigger companies change to safer, less toxic ingredients in sunscreens. Science has never been enough to change the world—it can only help individuals make better choices.

Now that you have this information, you can make better choices and live a healthier, safer life. There is nothing more important than your health.

By producing this information my aim is not to drive people out into the midday sun without protection. Rather it is to get people to think twice about the products they use. My simple rules are:

1. We all require some sun exposure every day for the production of vitamin D so we should be out in the sun for a brief period, depending on our skin type, in the early or late hours of the day. A little bit of sun is essential for good health. Too much does the opposite.

2. We should cover up in preference to using sunscreens, finding shade and using hats and long-sleeve sunshirts.

3. We should use the safest sunscreens with the least toxic ingredients containing organic plant based ingredients. It is not just good science but also common sense to go for safer ingredients and a safer product when it is available.

4. Eat more fruit, vegetables, nuts and beans to increase your natural sun protection factor and ability to repair damaged skin, not to mention prevent chronic illness of all types.

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Appendix Toxic Ingredients to Avoid

Toxic active ingredients to avoid	
4-MBC (4-Methylbenzylidene camphor)	5-methoxypsolaren (5-MOP)
Avobenzone, Parsol 1789 (butyl methoxy dibenzoylmethane)	Benzophenones
Cinoxate (2-ethoxy ethyl p-methoxycinnamate)	Dibenzoylmethanes
Escalol 506 (amyl dimethyl para aminobenzoate)	Escalol 507 (octyl dimethyl para-aminobenzoate)
Ethoxy ethyl-p-methoxy cinamate (Giv-Tan F)	Eusolex 8020 (isopropyl dibenzoyl methane)
Homosalate	Hydroxy methoxy methylbenzophenone (mexenone)
Menadione	Methyl sinapate (methyl 3,5-dimethoxy 4-hydroxycinnamate)
Octocrylene	Octyl salicylate
Octyl-methoxycinnamate (OMC)	Oxybenzone (benzophenone 3)
PABA (para-aminobenzoic acid)	Padimate A (amyl para-dimethylaminobenzoate)
Padimate O	PBSA (2-phenylbenzimidazole-5-sulfonic acid)
Psolaren	Titanium dioxide

Toxic preservatives to avoid	
Benzyl alcohol	
Butyl paraben	Diazolidinyl urea (GERMALL)
DMDM Hydantion,	Formaldehyde
Hydroxybenzoates	Iodopropynyl butylcarbamate
Methyl hydroxybenzoate	Methyl parabens
Propyl hydroxybenzoate	Phenoxyethanol
Propyl parabens	Quaternium

Other (Excipient) ingredients to avoid (often not listed)	
Acrylates C10-30	Alkyl acrylate crosspolymer
	CetearethCetyl alcohol
DEA-cetyl phosphate	Dihydoxyacetone
Disodium EDTA	Ethanol
Fragrances	Octyldodecanol
Propylene glycol	Sodium acrylates
SD Alcohol 40	Triethanolamine (TEA)
Triethoxycaprylylsilane	

Pesticides to avoid	
N,N-diethyl-m-toluamide (DEET)	