SENSE about SCIENCE

MAKING SENSE OF CHEMICAL STORIES

A guide for the lifestyle sector and anybody with questions about chemical stories.

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The Disconnection Between Lifestyle Commentary and Chemical Realities

Scientists are worried about the growing disconnection between the lifestyle view of chemicals and the chemical realities of the world.

They are worried not just because people are likely to misunderstand what chemicals are and do, but because of the consequences for decisions about lifestyle choices, family health and social policies.

In lifestyle commentary, chemicals are presented as something that can be avoided, or eliminated using special socks, soaps or diets, and that cause only harm to health and damage to the environment. The chemical realities of the world, by contrast, are that everything is made of chemicals, that synthetic chemicals are often much safer for human health than so-called 'natural' ones, and that unfounded anxiety about chemicals is encouraging people to buy into ideas and 'remedies' that make little scientific or medical sense.

Anxiety about chemicals is a big part of the discussion about lifestyle and modern living. Lifestyle commentary – health, food, family, and environment – has grown enormously in the past ten years, with increased TV coverage, the expanding internet, and publications by retailers and producers swelling the ranks of the magazine markets. In the daily papers too, lifestyle columns, supplements and advice fight news content for space.

With this rise in lifestyle commentary, misconceptions about what chemicals are and what they do have increased and spread. So much so, that the facts about chemicals seem surprising and counter-intuitive. Do people know that nothing can be 'chemical free'? How many know that 'E-numbers' simply denote approval for food use and include some essential vitamins? Did you know that your body functions in exactly the same way whether you follow a 'detox' regime or just a normal diet? Or that the idea of the 'cocktail effect' in relation to alcohol is an urban myth? When it comes to chemicals, there are so many misconceptions that people are often scared and anxious when they needn't be, and complacent when they shouldn't be.

So why is there such a disconnection between perception and reality? It seems partly to be the result of intensive merchandising of 'alternative' products, lifestyle ideas and campaigns that play on misconceptions about chemicals and about how the body works. It is also notable that lifestyle commentators are excluded from science-related briefings, and have few opportunities to make relevant scientific contacts. So, something needs to be done by the scientists in a way that is genuinely helpful to people writing quick copy for a lifestyle audience.

This briefing document flags up the more serious misconceptions that exist around chemicals and suggests straightforward ways for writers and presenters in the lifestyle media to evaluate them. It is not a "here's the science bit"; rather, it is intended to open a conversation that promotes a stronger connection between lifestyle commentary and chemical realities.

The content is drawn from workshops and consultations with chemical scientists. The document covers:

- Six of the most prominent misconceptions
- How to evaluate claims about chemicals, particularly in relation to risks and cures
- Some specific information that may surprise non-specialists and challenge recent claims made about chemicals in our bodies
- The language used to discuss chemicals
- Who chemical scientists are and how to get in touch with them

We hope that this guide provides useful tools to delve a bit more into chemical-related stories and inspires new questions and commentary.

Tracey Brown,
Director, Sense About Science

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Misconception 1:

you can lead a chemical-free life

The chemical reality is that you cannot lead a chemical-free life, because everything is made of chemicals. Chemicals are substances and chemistry is the science of substances – their structure, properties and the reactions that change them into other substances. Claims that products are "chemical free" are untrue. There are no alternatives to chemicals, just choices about which chemicals to use and how they are made.

"Did you know that the average person has more than a trillion atoms of uranium in their body and that hundreds of these atoms are radioactively disintegrating every day? (It sounds a lot but in weight terms it is truly tiny.) All is coming from a perfectly natural source: the food we eat. The uranium comes from uranium that is naturally occurring in soil."

John Emsley, chemical scientist and author of Nature's Building Blocks

Chemicals affect us less than they did our grandparents. The Royal Sanitary Commission of 1871 noted that the water in Bradford Canal was so dirty a dropped lamp could set it alight. Clearly we have come a long way in terms of our understanding and control of pollution. Chemical scientists have been at the forefront of identifying problems and innovating responses to them. We are often told that we face an unprecedented, new threat from the chemicals in our environment. In fact, unlike today, in former times poisonous chemicals surrounded the population, unrecognised and unregulated. The Romans used various compounds of lead in drinking vessels, water pipes, cosmetics, coins, and as a sweetener and wine preservative. This led to lead-induced gout, sterility and chronic lead poisoning.

In the nineteenth century, arsenic compounds were used in paints: 'Paris Green' was a bright emerald green favoured by painters like Cezanne and Van Gogh, but it was also a potent pesticide used to kill rats in Parisian sewers. 'Scheele's Green' was used in wallpaper, with the drawback that it was degraded by damp conditions to become trimethylarsine, which was believed to cause arsenic poisoning in homes, but it has since been proven otherwise. Chemicals used in hat-making gave off mercury nitrate dust, causing muscle tremors ("hatters'shakes"), distorted vision and slurred speech - the first signs of mercury poisoning. Hence the origin of the phrase "mad as a hatter". All these chemicals, and many more, are now carefully monitored so that exposure to them should be minimal or virtually non-existent.

Everything is made of chemicals... but we usually refer to things by more familiar names. When substances are described as chemicals, it can be alarming:

"If someone came into your house, mixed you a cocktail of unknown chemicals - and offered you a drink - would you take it? Of course not. You wouldn't want untested chemicals in your home, your drink, or your body. You don't want them - but shockingly - they're already there."

Chemicals out of Control section, Greenpeace International website

But..."If someone came into your house and offered you a cocktail of butanol, iso amyl alcohol, hexanol, phenyl ethanol, tannin, benzyl alcohol, caffeine, geraniol, quercetin, 3-galloyl epicatchin, 3-galloyl epigallocatchin and inorganic salts, would you take it? It sounds pretty ghastly. If instead you were offered a cup of tea, you would probably take it. Tea is a complex mixture containing the above chemicals in concentrations that vary depending on where it is grown."

Derek Lohmann, research chemist

Drop “detox”

have a glass of tap water and get an early night!

Every January, we seem to go a bit further with the innovation of products and practices designed to purify, detoxify and restore ourselves.

Scientists say: “save your money: have a glass of tap water, and a good night’s sleep!”

Our bodies have their own “detox” mechanisms. The gut prevents bacteria and many toxins from entering the body, the liver acts as an extraordinary chemical factory. It usually combines them with its own chemicals, making water soluble compounds that can be excreted by the kidneys. The body thus detoxifies itself.

This process does not occur any more effectively as a result of taking “detox” tablets, wearing “detox” socks, having a “detox” body wrap, eating Nettle Root extract, drinking herbal infusions, following a special “detox” diet, or using any of the other products and rituals that are promoted.

“On detox the Romans got it right: mundus vult decipi - the world wants to be deceived - better translated as, ‘there’s a sucker born every minute’. The only thing that loses weight on a detox diet is your wallet.”

John Hoskins, toxicologist

“The body’s own detoxification systems are remarkably sophisticated and versatile. They have to be, as the natural environment that we evolved in is hostile.”

Alan Boobis, toxicologist

“One of the most poisonous chemicals that many people encounter is alcohol. However, even if you drink an almost lethal dose of alcohol (which I don’t recommend) your liver will clear it in 36 hours without any assistance from detox tablets. As a pathologist, I am frustrated by the claims that a detox diet will somehow improve your liver function, the only thing you can do to help your liver after a period of indulgence is to stop drinking alcohol and drink water.”

Sir Colin Berry, pathologist

“Detox diets and products may not do harm, except, perhaps, to your wallet, but neither do they do you much good, except, perhaps, psychologically! Your natural bodily functions are effective at clearing out harmful substances and there is little you can do to enhance these. Patience and a proper diet are more valuable than detox socks and supplements.”

Paul Illing, toxicologist

“Our bodies are very good at eliminating all the nasties that we might ingest over the Festive season. There is a popular notion that we can speed up the elimination process by drinking fancy bottled water or sipping herbal teas, but this is just nonsense. In fact, many of the detox diets and supplements really aren’t that good for you, nor have they been properly tested. These alternative remedies are now regarded as having little value medicinally, and while they might have trace amounts of active ingredients, they do not stand up to close scientific scrutiny as effective treatments.”

John Emsley, chemical scientist and popular science writer

“Detox is a ridiculous health concept promoted by those with little knowledge of nutrition, and offers no health benefit for the short term it is used. The enduring myths associated with this silly concept makes the public ambivalent to their normal diet. The concept of ‘detox’ is a marketing myth rather than a physiological entity.”

Catherine Collins, Registered dietitian

“‘Detox diet’ is a meaningless term that is used all the time. And because it hasn’t been defined, it’s impossible to say if it’s worked or if it hasn’t.”

Ursula Arens, nutrition writer

Misconception 2:

man-made chemicals are dangerous

> "It is worth noting that, although it's popular to complain about 'all those synthetic chemicals', this contrasts with increasing demand for them in and around the home e.g. oral contraceptives, mouthwash and decorating materials, and for gadgets which are manufactured using them, like mobile phones, computers and CDs."
>
> Andrew Cockburn, toxicologist

The chemical reality is that whether a substance is entirely new, copied or extracted from nature, it tells us nothing about its intrinsic safety. Likewise, the terms "industrial", "synthetic", "artificial" and "man-made" by no means mean damaging and "natural" does not necessarily mean better. For example the dye Henna can cause allergic reactions, untreated water can kill, and poor food hygiene can result in toxins that make people very ill, yet these are all natural. Notwithstanding, we continue to learn a great deal from nature for our mutual benefit.

Nature can be harsh in the case of the human body too. Even our own bodies produce chemicals that in excess can poison us, such as histamine, which can lead to severe allergic responses or gastric acid which can lead to ulcers. Paradoxically man-made medicines are then required to treat such conditions. Moreover infections are familiar to everyone and without modern pharmaceuticals to treat opportunistic bacterial, fungal and viral infections such diseases would rapidly increase with devastating effect. Likewise, chemical products such as disinfectants, anti-bacterials and sprays are commonplace in our homes to protect us from naturally occurring bugs. The use of highly active synthetic medicines and chemicals in ways like this has contributed to improved life expectancy.

Man-made chemicals have freed us from the limited range of substances that societies were once dependent upon. Producing chemicals in the lab makes it possible to create products that we can trust by controlling the ingredients exactly, their content, and eliminating some of the impurities and toxicants that can be present in natural sources. We are now able to work out why a substance has an effect, isolate the active ingredient and use it precisely, which helps to reduce our intake and thus minimise the likelihood of side-effects. Foxglove flowers are highly poisonous but modern chemistry enabled us to identify and extract the active principal, digitalis and use it in minute doses to treat heart conditions. An advantage of synthetic products is that other desirable properties can also be incorporated e.g. pills that are easily digested; creams that spread; and medicated shampoos that lather so that less is needed.

Understanding chemistry and the impact of chemicals on human health is critical. This is the role of the toxicologist. Until the Middle Ages, lead compounds were used cosmetically to dye hair black, and in China to create a yellow foundation on the face. In sixteenth century Europe, the white mask on Elizabethan faces was created by applying a mixture of white lead and vinegar. The lead aggravated the skin conditions that the mask was meant to cover, and also caused hair loss. When ingested or absorbed, more serious lead poisoning (anaemia, kidney problems) could occur. Nowadays, lead compounds are banned from modern cosmetics, but are still reported to be found in traditional hair-dyes and traditionally made kohl or surma cosmetics (though not in modern eyeliners).

Natural products are inherently variable which is one of the main problems. A plant that has a particular content in the Spring will typically be different come the autumn as its chemical composition changes seasonally due to different biological growth and sunshine conditions (this is why the same variety of fruit is sometimes sweet and sometimes not e.g. strawberries). The same natural preparation produced by one maker may be very different in strength and purity to that produced by another due to a lack of standardisation. Not surprisingly, people prefer to rely on chemically defined, quality controlled synthetic versions of chemicals when they need reliable efficacy, such as for contraception or disinfection.

it depends on the dose...

A chemical can't simply be classified as "dangerous" or "safe": it always depends on the amount, or dose, received. The effects of a chemical will change with different amounts, so that below a certain dose it may be harmless or beneficial and at a higher dose it may be toxic. We all know that a little aspirin is good for us, whereas 50 tablets could cause acute renal failure, coma, and heart failure from salicylate poisoning.

"Botulinus toxin (botox) is one of the most powerful poisons we know; its use in 'cosmetics' is safe only because of careful localisation. What might kill you if put into your stomach can ease your worry-lines."

Sir Colin Berry, pathologist

Chemicals are ranked for their toxicity, from low to high, but of course a chemical's effects are dependent on what amount of it you come into contact with. Below a certain dose a chemical may be harmless or beneficial but at a higher dose it may be toxic. Doses of chemicals are often as "parts per million" (ppm) or "parts per billion" (ppb). One part per billion is equivalent to one grain of sugar in an Olympic swimming pool. Modern technology enables us to detect minuscule amounts of chemicals in our bodies, so minuscule they are measured on that tiny a scale. So, just because a chemical that in some large amount would be toxic can be detected in a person, that is not necessarily dangerous at all. To understand if it is a problem, we need to know how much of it is present to look at what kind of effect, if any, it may be having.

Drinking water should be clean, never natural!

"Much is being made of the benefits of natural water but all water needs to be processed so that we can drink it."

Kevin Prior, water and waste water chemical scientist

The water from your tap is at least as good as bottled water. In the developed world we take access to a safe supply of drinking water for granted, unlike the developing world where unsafe drinking water contributes to the death of 2200 children a day (Liu et al 2012, Lancet). Considering recent trends people would be forgiven for thinking that drinking water can somehow be improved by putting it in a bottle, giving it a fancy name and paying a premium for it. In fact, tap water is carefully treated to make it safe to drink. It is filtered to remove particles and organic matter, and treated with a small amount of a disinfectant, such as chlorine, to remove potentially harmful microbes. The public water supply is subject to a battery of tests to ensure that it is safe to drink. Occasionally, there may be a slight residual taste from the disinfectant, which is easily removed by boiling or standing a covered jug in the refrigerator for a few hours. Tap end filters also work, but they are expensive and potential sources of microbial contamination if not properly maintained. Bottled mineral water carries a large carbon footprint relative to tap water, and unsubstantiated claims are made about its benefits. The World Health Organisation, (Fact Sheet No. 256) states "WHO is unaware of any convincing evidence to support the beneficial effects of consuming such mineral waters". On the other hand, drinking tap water will benefit both your pocket and the environment...so stick with that!

Misconception 3:

synthetic chemicals are causing many cancers and other diseases

The chemical reality is that many claims about chemicals being 'linked' to diseases simply tell us that a chemical was present when an effect occurred, rather than showing that the chemical causes the effect. Broadly speaking, it can be helpful to think of three kinds of 'links':

1. The chemical was present when the effect occurred

There are many examples of these kinds of 'links', not least because pathologists record things like the presence of prescribed medication during an autopsy. Such 'links' are usually of no consequence.

2. The chemical and the effect appear to be related

There is a correlation between the dose of the chemical and the extent of the effect. This is usually tested scientifically by increasing and decreasing exposure and/or by comparing effects in different groups of people. A correlation is not the same as a causal relationship. For example, heavy drinkers might be more likely to develop lung cancer, but this could be because they are likely to be heavy smokers too, rather than because alcohol causes the cancer. Caution is needed in reporting apparent correlations: it is in the nature of scientific experiments that many disappear when a further test is done or they turn out to be explained in other ways.

3. The chemical causes the effect

This means that there is a plausible mechanism to explain how the chemical might cause the effect. You would generally expect this to be consistent with what is known about how the chemical or the organism works and to be supported by evidence of predictable effects.

HOW CAN YOU EVALUATE CLAIMS ABOUT CHEMICALS AND THEIR RISKS?

In order to evaluate the risks of chemicals scientists would normally try and answer some of the following questions.

1. What is the status of the claim about the particular chemical? For example:

- Is it anecdotal?
- Is it based on objective scientific experiments or observations? (Look for mention of 'Randomised Controlled Trials' or whether it is published in a peer-reviewed science journal, for example.)
- Has the effect been widely observed in relation to the chemical?

2. Who is the individual or organisation making the claim about this chemical; do they have experience in the area of concern? (This is much more important if claims are from sources other than a scientific journal.)

- What else have they published?
- Is the main aim of the information to promote something? (This doesn't mean it's wrong but it can be useful to ask.)

3. Is the exposure to the chemical always followed by the claimed effect?
4. Does the effect occur in the absence of the chemical? If so, there might be another explanation for the effects.
5. Does there appear to be a relationship between the level of exposure to the chemical and the severity of the effects?
6. Is there a plausible mechanism to explain how the chemical could produce this particular result?
7. Does the evidence that is presented fit the known facts or data?

The emotive language of chemicals:

how words are misused

Chemical is a word that has taken on many unfavourable associations. 'Insidious' and 'industrial' chemicals are 'dangerous', 'nasty', 'hazardous' and 'harmful'; they 'contaminate', bombard', 'invade', 'pollute', and we and our children are 'pumped' full of them.

> *"Language is a large part of the problem. Science makes everything sound scary, and so we are scared. Even that neutral word 'chemical' has been tainted by the company it keeps, as if it were somehow the antithesis of 'natural'."*
>
> Richard Gerling, The Sunday Times, 4th July 2004

Cocktail a 'cocktail of chemicals' is often used to suggest that the effect of the combined substances is more potent than the sum of the parts. Chemically speaking, such 'synergistic' effects are rare and scientifically well-understood. However, what is occurring in a 'cocktail' is the cumulative effect of having more than one dose of the same active ingredient, which is why we are warned not to drink hot lemon cold and flu remedies and take paracetamol as both contain paracetamol, or to drink alcohol and take valium as both are depressants.

Contamination is frequently used to imply harmful effects. However, just because a substance is found somewhere it does not normally occur, this does not necessarily mean it is having a detrimental effect.

Endocrine disruptors are often referred to as 'gender-bending' chemicals. They have the potential to affect hormone activity and can disrupt the development of reproductive systems, but not usually in the concentrations at which we typically encounter them in the environment.

Industrial chemicals are usually thought of as dangerous, whereas a chemical is a chemical, whatever its source, and some chemicals are more toxic than others.

Natural is often used to imply 'healthier' and 'safer'. This is misleading because many natural substances are neither healthy nor safe (e.g. nicotine or arsenic). Chemical scientists use 'natural' to describe substances that are derived from nature.

Persistent chemicals are those that take a long time to break down. They are not necessarily man-made or harmful. Dioxins, for example, are created in forest fires and reside naturally in soils and mounds of fallen leaves. At these concentrations they are harmless.

> *"Ironically, we sometimes need to ensure that certain artefacts will not break down. If paper and parchment were not persistent we wouldn't have found the Dead Sea Scrolls or be able to read a first folio of Shakespeare. Similarly, if paint and pigments were not persistent the Mona Lisa would no longer exist."*
>
> *David Taylor, environmental chemist*

Significant is sometimes used as a synonym for important. However, it does not mean this: it is a statistical term that refers to the likelihood that a research finding did not occur by chance.

Synthetic is sometimes used to mean 'unpleasant' or 'dangerous'. Synthetic simply means 'made'. 'Artificial' implies, in addition, that a chemical does not occur naturally, whereas 'synthetic' may refer to naturally occurring chemicals that are copied.

Time-bomb is used to imply that the effects of chemical exposure may not be known for a long time, but will probably be bad. Time-bomb claims are only meaningful if there is evidence to support them. Toxic is typically used in a way that implies that a chemical causes harm. However, we don't know whether a chemical is toxic to particular organisms unless we know the dose.

Toxin is often used to describe any toxic chemical, but strictly speaking, toxins are only produced by living organisms, such as bacteria.

Misconception 4:

our exposure to a cocktail of chemicals is a ticking time-bomb

The chemical reality is that, although the language of "cocktails" and "time bombs" is alarming, neither the presence of chemicals nor the bioaccumulation of them, in themselves, mean that harm is being done. We have always been exposed to many different substances, because nature is a "cocktail of chemicals". Modern technology enables us to detect minuscule amounts of substances, but the presence of such a small amount of a specific substance does not mean that it is having any discernible effect on us or on future generations.

There are now frequent public scares about the presence of a variety of man-made chemicals in our bodies, particularly in relation to press releases from campaign groups testing the excretions and tissue of celebrities and other groups. Out of context, these announcements sound alarming, but there are three vital pieces of information missing in such discussions:

1. The concentration of the chemical: we can detect some chemicals in the body in parts per billion. A part per billion is equivalent to one grain of sugar in an Olympic swimming pool.
2. The fact that our bodies are able to process and excrete harmful substances.
3. The presence of a chemical in our bodies does not mean it is doing harm. Our bodies contain traces of many substances that we are in contact with, natural and synthetic, some beneficial and some harmful at certain levels.

To understand whether the presence of a chemical is a problem, we need to know how much of it is present and to look at what kind of effect, if any, it is having.

"People should realise that if this is to become a sustainable planet by the end of this century, and we are still to enjoy the wonderful materials that we use every day, then we will need chemists to devise new ways of making fertilisers, plastics, fibres, paints, pharmaceuticals etc. from renewable resources such as wood and crops. A lot of research is going to be needed to create a 'green' chemical industry and that research can only be done by chemists of the next generation."

John Emsley, chemical scientist and author of The Consumer's Good Chemicals Guide

The Cocktail Myth

Contrary to popular wisdom, cocktails don't make you any more drunk than the equivalent alcohol in other drinks like beer. The mixing process has no effect. The perception that it does probably arises because cocktails, which are often sweet, encourage people to consume more alcohol in a short time and it's harder to keep track of how much you're consuming.

So what about the interplay of different chemicals with one another? A lot of commentators and merchandisers promote concern about a 'cocktail of chemicals' in our bodies. What this description usually implies is that, while individual substances may be considered safe at current levels of exposure, they may interact with each other and create unforeseen effects. But, chemically speaking, a 'cocktail' – or synergistic – effect is only true of a relatively small number of substances and these are well-known. What actually occurs in a'cocktail'is a cumulative effect of having more than one dose of the same active ingredient. Examples include drinking alcohol and taking valium, both of which are depressants.

The natural world is a 'cocktail of chemicals' so our bodies are used to dealing with a mix of substances. The same processes of storing, neutralising, breaking down and excreting occur when we encounter new substances.

Bioaccumulation

It may surprise many people to discover that bioaccumulation is not, in itself, a bad thing. There are some chemicals that we actively need to accumulate to survive, such as vitamin D over the summer months in order to get through the winter. If we don't get enough exposure to sunlight over the summer months we won't have enough vitamin D to get through the winter. Without vitamin D our bodies are unable to absorb calcium efficiently. Vitamin D deficiency can lead to rickets in children and osteomalacia in adults. Vitamin A is another chemical that must be stored in the body for gradual use.

Misconception 5:

it is beneficial to avoid man-made chemicals

"Minuscule traces of flame retardants may sometimes be detectable in childrens' bodies. This shows that the clothing they are wearing is protecting them from death or injury from fire. To fail to expose them to such chemicals could be regarded as negligent."

Alan Malcolm, biochemist

The chemical reality is that insofar as there is a 'need' for anything, synthesised or man-made chemicals have given societies choices beyond measure about what they are exposed to and the problems they can solve.

Costs and benefits

Claims about potential risk from particular chemicals should be looked at in context: how they are used; what the exposure levels are; and whether there are alternative ways to get the same benefits.

As a society, we rarely acknowledge the dependency of modern life on understanding and innovating chemicals. Sanitation, medication, materials and food technology are clearly entwined with social progress and increased life expectancy. But chemicals are essential to the manufacture of all things, including products we don't directly associate with them, such as computers.

Even where chemicals are potentially harmful, they must be considered in the context of their purpose. For example, when locusts attack African farms, threatening rural survival, farmers use a pesticide even if this means they might inhale some of it themselves. Historically, we have balanced the potential risks of chemicals against the very real problems that they have solved. Initial anxiety about using bleach to disinfect water in the nineteenth century was soon left behind when it offered us the option of eradicating typhoid fever.

The option of discontinuing those chemicals that we now worry about has itself resulted from the vigilance and innovation of chemical science. Polychlorinated Biphenyls (PCBS), which are no longer in use, were introduced because they don't conduct electricity and because they were less flammable than alternative materials. Without them, electricity would never have been introduced into homes. However, problems arose when the transformers leaked or had to be disposed of. The properties that gave rise to their stability also meant that they remained in the environment for a long period of time. They have now been replaced by compounds that are not as good electrically but are less hazardous for the environment – again a balancing of properties.

Chemicals in context... brominated flame retardants (BFRs)

Flame retardants are chemicals added to furniture, clothing and many plastic materials to slow down or prevent combustion. They decrease the chance of ignition, reduce the spread of fire and delay "flash over" (when materials close to the fire burst into flame). Fire is a major cause of death, injury and property damage throughout the world. It has been estimated that, cumulatively from 1988 to 2002, the 1988 UK furniture regulations that made flame retardants compulsory alone saved 1,150 lives and prevented 13,442 injuries. Many chemicals are used as flame retardants, grouped according to the chemical elements that provide their effectiveness, the most important are: bromine, chlorine, phosphorous, aluminium, magnesium and nitrogen. The choice of which to use depends on the product. Unfortunately, many of the chemicals used have been found to have unwanted side-effects such as persistence in the environment or toxicity to humans and animals. For example, the once popular and very effective brominated flame retardants were found in a variety of consumer products but bio-accumulation and allegations of side-effects have resulted in many of them being banned. Now they account for less than a quarter of world production but only a little over 5% in the EU. New chemicals and new technologies are replacing them, some involving innovative nano-materials.

A word of warning on 'alternatives'

Any alternatives to using man-made chemicals are often seen as good because the word 'alternative' is used to mean 'without all the nasties just described'. Alternatives are seen as providing all the benefits and none of the disadvantages. But substitution is treated over-simplistically – sometimes we know less about the negative impacts of proposed alternatives than we do about the chemicals we wish to replace.

We need E-numbers

Since 1986, food additives – colours, preservatives, anti-oxidants, stabilisers, gelling agents, thickeners, etc. – have been identified in food labels, either by name or by E-number. An E-number says that it has been approved for its intended use across the European Union. Approval depends on scientific testing and monitoring and is reviewed in the light of new scientific information.

Additives have been around for centuries. Nitrites and nitrates (E249-252) have been used as curing agents. Baking powder (bicarbonate of soda [sodium hydrogen carbonate], cream of tartar [potassium hydrogen tartrate, monopotassium tartrate, E336] and starch) is a 19th century additive. Pickling is an ancient method of preservation that uses vinegar (acetic acid E260) to prevent microbial spoilage. Many agents that are essential for commercial food preparation and storage have their analogues in the kitchen. Caramel (E150a), a colouring agent, can be made at home by heating sugar. Gelling agents include pectin (methylated ester of galacturonic acid, E440) for jams. Preservatives include benzoic acid (E210), present in high quantities in cranberries.

Some additives are clearly beneficial: in 1941 calcium was added to flour to prevent rickets; and anti-oxidants (necessary to prevent the fats in all prepared foods involving meat or pastry from going rancid) include ascorbic acid (vitamin C, E300) and the tocopherols (vitamin E, E306-309).

By Paul Illing, toxicologist (risk assessment for occupational health, product and environmental pollution).

"What would a product look like without a chemical preservative?"

"Most cosmetics and toiletries contain water, hence make a good substrate for the growth of microbes (e.g. bacteria or fungi). A product that is not properly preserved could show various signs that something is wrong: it might smell strangely, or change colour slightly, or you may even see something growing in it, for example the black dots of mould like the ones in damp old bathrooms.

Also, creams and lotions might separate out, with a layer of oil on the top and water underneath. What may be even more dangerous is what you cannot see. Bacterial cells are too small for the naked eye to detect, but if there are enough of them in the product, they may cause skin infections and other problems, especially if the skin is already damaged (cut, bruised or a sore). Eye infections and, in extreme cases, blindness could be caused by contaminated products. This is why proper preservation of cosmetics and toiletries is a necessity, not a choice. "

Professor Danka Tumburic. in Cosmetic Science, London College of Fashion

One of the most widely used preservatives is sulphur dioxide (E220). As a gas in high concentrations, this is very toxic and causes breathing difficulties. However, when used in food stuffs – either directly or through its compounds, and present in much smaller quantities – it is one of the most important preservatives. Most wine is treated in this way and some dried fruits – even those sold in health shops – need to be preserved with sulphur dioxide or sulphite to be fit for sale.

Misconception 6:

we are subjects in an unregulated, uncontrolled experiment

Related ideas in lifestyle commentary:	The effects of chemicals are unknown. Chemicals have not and cannot be tested in the long term. The use of chemicals is unregulated and out of control. The regulatory system isn't working.

The chemical reality is that there is an extensive regulatory system that strictly controls what chemicals can be used: what experiments can take place, what can be used, for which purpose, how it should be transported, used and disposed of and how its use should be controlled and monitored. This includes specific regulation of chemicals for use as drugs, food additives, veterinary medicines, medical devices, plant protection products, biocides, etc. as well as regulations concerned with the air we breathe and the water we drink.

> "On any plate of food the only things that can be relied on to be safe to eat are those chemicals, natural or synthetic, which are traces of pesticides or hormones or those that have E-numbers. The rest of the food must be taken on trust."
>
> John Hoskins, environmental toxicologist

As most people recognise we will always learn more about a chemical once it has been used for a long time and sometimes in a variety of settings. This is true of all products and ways of doing things, so it is not right to refer to it as an "experiment".

> "I worry that the supply of young people – people who can become true magicians with matter – will dry up through bad publicity and lack of motivation."
>
> Peter Atkins, physical chemist

Some of the commentary about chemicals seems to suggest that chemical scientists are part of a big conspiracy that would see people poisoned in order that more products are sold and profits made. The term 'uncontrolled experiment' implies that the scientists are willing to create a harmful environment. Is that realistic? Quite apart from their role in improving health and environmental conditions, they have to raise families and live in it too!

Chemicals must be handled and used carefully. Contrary to the impression created by some scare stories, chemical scientists have been at the fore of identifying safety thresholds and promoting better chemical handling in workplaces, homes and the wider environment.

Sense About Science is grateful to the many chemical scientists and others who contributed to this briefing document through participation in the working group, provision of material, checking, editing and answering a very long list of questions. Our special thanks go to: Ursula Arens, Peter Atkins, Sir Colin Berry, Alan Boobis, Andrew Cockburn, Catherine Collins, John Emsley, Professor John Henry, John Hoskins, Paul Illing, Steven Lipworth, Derek Lohmann, Alan Malcolm, Sean McWhinnie, Kevin Prior, David Taylor, Danka Tumburic, Richard Van Noorden and Martin Wiseman.

Who are the chemical scientists?

In the science world, people specialising in chemistry – the science of substances – are usually called chemists. However, in wider society we use 'chemist' to mean pharmacist, so throughout this briefing we have used 'chemical scientist'. You might also come across the following terms: Toxicologist – someone who looks at the adverse effects of chemicals on living organisms, Endocrinologist – someone who investigates how hormones work.

- In the UK there are 32,000 employed chemists, 110,000 individuals with a chemistry degree in the population, and 100,000 individuals with a chemistry degree in the working population (Labour Force Survey, merged 2003-04).
- The largest employers of chemical scientists are the pharmaceutical industry, the chemical industry and academic research. Other large employers are statutory bodies such as the Environment Agency, the electronics industry, the health sector, and forensics.
- Many chemists are members or fellows of professional and learned societies. The largest of them in the UK is the Royal Society of Chemistry, which has 47,500 members.

CONTACT A CHEMICAL SCIENTIST

Sense About Science is a charity that promotes evidence in public debates about science and medicine. We help journalists, civic groups, NGOs, institutions and others get in touch with scientists.

When we first published this guide we had journalists and lifestyle writers in mind, but since then it has been used far more widely: by helpline workers, midwives, GPs and many others who deal with the questions people have about chemicals; as well as people with questions getting in touch themselves.

Questions about chemical stories?

Call Sense About Science on

020 7490 9590

or email enquiries@senseaboutscience.org

Through Evidence Base – our constantly expanding database of scientists, scientific organisations and research facilities – we can usually find help on stories that interest the public.

The Sense About Science webpage www.senseaboutscience.org is another place to go when you need more information. In the chemicals section you will find:

- The Voice of Young Science Detox Dossier: a report of their hunt for evidence behind the claims made about detox products and diets.
- Parabens in cosmetics: an office experiment.

For further information, or copies of this briefing, please contact

Emily Jesper on publications@senseaboutscience.org

A list of the main members of the working group is available at the Sense About Science website: www.senseaboutscience.org. This document was prepared by a Sense About Science secretariat with additional research by Richard Van Noorden.

ABOUT US...

Sense about Science is an independent campaigning charity that challenges the misrepresentation of science and evidence in public life. We advocate openness and honesty about research findings, and work to ensure the public interest in sound science and evidence is recognised in public discussion and policy making. We focus on socially and scientifically difficult issues where evidence is neglected, politicised or misleading.

Sense about Science is a small team working with thousands of supporters, from world-leading researchers to community groups.

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