



The Science *of* Beauty

Debunk the myths
and discover what goes
into your beauty routine

DR. MICHELLE WONG

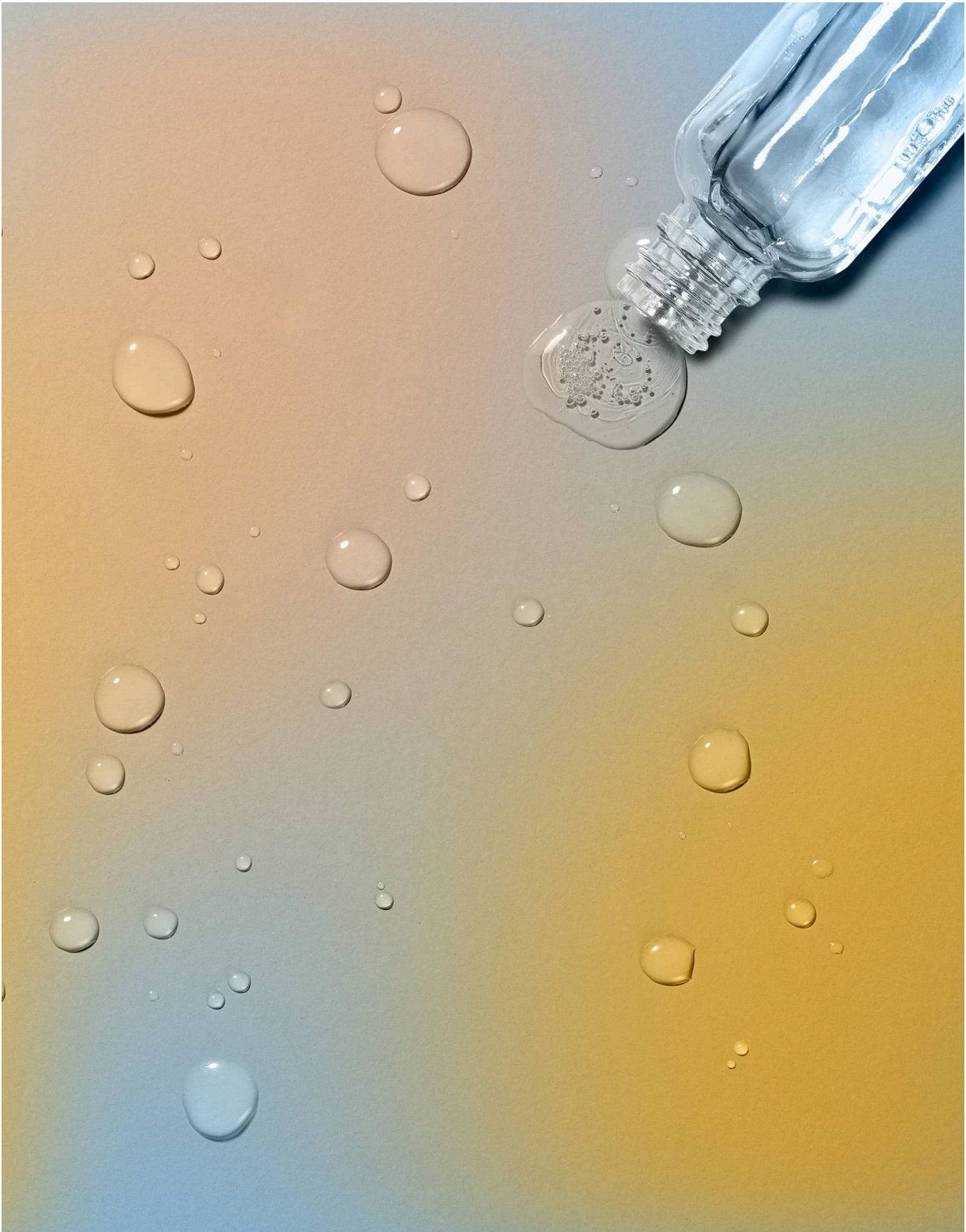
a.k.a. Lab Muffin Beauty Science



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How to use this e-book

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Double-tap images in the book to open images to full screen and to be able to zoom in and see details clearly.

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What is beauty?

Subjective, valuable, and almost impossible to define, the concept of beauty is an inescapable part of how we experience the world—and one another.

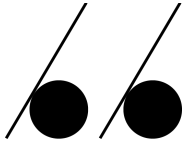
As the saying goes, “Beauty is in the eye of the beholder.” But many aesthetic preferences transcend boundaries: research has shown that certain facial traits, such as youth, symmetry, and happy-looking features, are universally regarded as attractive. One theory for this suggests that beauty may be an evolutionary instinct. A symmetrical face may imply health, while youth would suggest fertility. Another study created “average” faces by blending photos of people from the same country, then showed those images to people from that country. The more faces they blended together, the more attractive the face was deemed to be—in other words, each country (or culture) saw beauty in the faces that looked the most familiar to them.

At the same time, what is considered beautiful can vary from person to person, influenced by cultural norms, media representations, and individual tastes. Fashions can change from one year to the next, while different subcultures and groups have their own beauty and styling preferences. In some cultures, tanned skin is considered desirable; in others, paler skin is prized. Of course, it is difficult to disentangle modern beauty standards from the effects of colonization and globalization, which have spread Eurocentric beauty ideals. Together, these influences have led to the perpetuation of harmful standards in many societies. The pressure to conform can be immense, particularly for people whose looks are further from these often unrealistic ideals, amplifying body dissatisfaction and appearance-based discrimination.

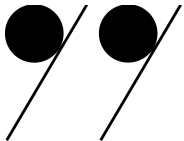
The beauty industry

Beauty isn’t just an abstract idea. It is big business, and beauty products and practices play many roles in our lives. Many have health or hygiene purposes, and even purely aesthetic functions are important: they allow self-expression, give us agency over how we present ourselves to the world, and can boost our well-being and confidence. They can even have a financial function. Though unfair, studies have found that physically attractive people receive higher incomes on average, but makeup can be a way to level the playing field.

Yet the beauty industry has played a large role in perpetuating harmful beauty standards. For decades, airbrushed advertisements have reinforced narrow concepts of beauty, although in recent years there have been genuine attempts at diversity. Product marketing often exploits our insecurities, promising to make us look younger and thinner and erase natural biological features like pores and cellulite. And there’s a lot of money to be made from inventing problems for new products to solve. While this book will discuss the science behind common appearance-related concerns and how to address these, it’s important to remember that these wants are often shaped by artificial expectations and our looks do not dictate our value as people.



Beauty isn't just an abstract idea. It is big business, and beauty products and practices play many roles in our lives.



Myths and misinformation

I started Lab Muffin Beauty Science in 2011 because I was frustrated at the lack of accessible information on how beauty products worked and the sheer volume of unrefuted misinformation online. Despite being a chemistry PhD student at the time, it was still incredibly challenging to unravel the science, so I wanted to make this information easily available to anyone interested. And clearly, many people were—my blog expanded onto Instagram, then a YouTube channel as well.

But despite talking about beauty science for over a decade, there's no end of myths to debunk and concepts to decipher. The beauty industry has traditionally been hesitant to reveal the scientific intricacies behind their products, leaving a vacuum for misinformation to grow. Many companies also profit from selling false hope and encouraging convenient misconceptions.

This book answers many of the questions I've been asked over the years in a detailed but digestible way. It explains the science behind skincare, haircare, makeup, and nails, as well as beauty products themselves. I hope you'll find it fascinating and empowering—it'll equip you with the knowledge to sort out fact from fiction when it comes to marketing claims, and work out which products will actually deliver the results you want.





Beauty basics

Are beauty products safe?

Are natural beauty products better or safer?

Are cosmetic ingredients dangerous?

Are expensive products better?

What is an active ingredient?

What do the different ingredients in beauty products do?

Does packaging matter?

What do marketing buzzwords mean?

Can I trust the research in beauty marketing?

What do beauty product labels tell us?

How should I store my beauty products?

Can beauty products be sustainable?

Are my beauty products cruelty-free?

How does menopause affect my hair and skin?

How does pregnancy affect my hair and skin?

Are beauty products safe?

It's a common misconception that beauty products are largely unregulated and that many mass market products are harmful to our health.

While there have been dangerous beauty products throughout history—heavy metals in 18th-century makeup, radioactive creams in the 1930s—the science surrounding health risks has progressed immensely, along with legal principles of liability.

In most well-regulated marketplaces like the US and the EU, companies are legally responsible for demonstrating the safety of their products, and it is illegal to sell harmful products.

Cosmetic companies have a commercial interest in ensuring safe products. There is no financial benefit in hurting customers they've already convinced to buy their products, and negligence can lead to extensive litigation. Product recalls and safety infringement notices generate negative publicity and lead to large drops in sales. Standard practices have been developed within the industry to ensure that beauty products are safe before launch.

Ingredient selection

The safety of cosmetic ingredients is assessed by scientists using the same principles of toxicology used for evaluating foods and medications. Safety assessments are published by independent expert bodies, including the Scientific Committee on Consumer Safety in the EU, the Cosmetics Ingredient Review in the US, and the Research Institute for Fragrance Materials.

The amount of the ingredient is particularly important, hence the saying, "The dose makes the poison." If more ingredient molecules are present, they are more likely to interact with the body in a harmful (or beneficial) way. If the amount is extremely small, the likelihood of any molecules even reaching the relevant part of the body becomes infinitesimally small. This is why traces of heavy metals in beauty products usually aren't a big concern—modern scientific instruments can detect minute amounts of substances, well below the threshold for harm. Because risk depends on both hazard and exposure, a highly hazardous ingredient can still be used safely. For example, botulinum toxin (botox) is the most toxic substance known, but depending on exposure, it can be very safe (if a tiny amount is injected in a face muscle by a trained professional) or very dangerous (large amounts eaten in contaminated food, causing botulism).

From hazard and exposure data, toxicologists can calculate the concentrations of ingredients that can be safely used in different products. Cosmetic formulators refer to their recommendations when creating products. Concentration limits established by regulatory agencies are sometimes written into law.

$$\text{RISK} = \text{HAZARD} \times \text{EXPOSURE}$$

To work out safety, scientists refer to risk, which depends on both hazard and exposure.



Hazard

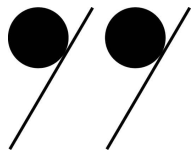
The harms an ingredient might potentially cause. Includes short-term irritation and allergic reactions, as well as longer-term effects like cancer and endocrine disruption. Hazard assessments consider:

- Tests on chemicals, cells, or isolated tissues (in vitro, ex vivo)
- Tests on animals (in vivo)
- Information from computer models (in silico)
- Clinical studies in human volunteers
- Epidemiological studies that look at population-level effects
- Case reports of people being harmed by the ingredient
- Data on similar ingredients that can be extrapolated (read-across)

Exposure

How consumers might be exposed to the ingredient, which can involve:

- How much of the ingredient is used (dose)
- The ingredient's properties (such as how much is absorbed through skin)
- How it's used in products (wash-off or leave-on, frequency of use, how much is applied and where)
- The total exposure if the ingredient is in multiple products someone might use, including food and household products
- Foreseeable misuse

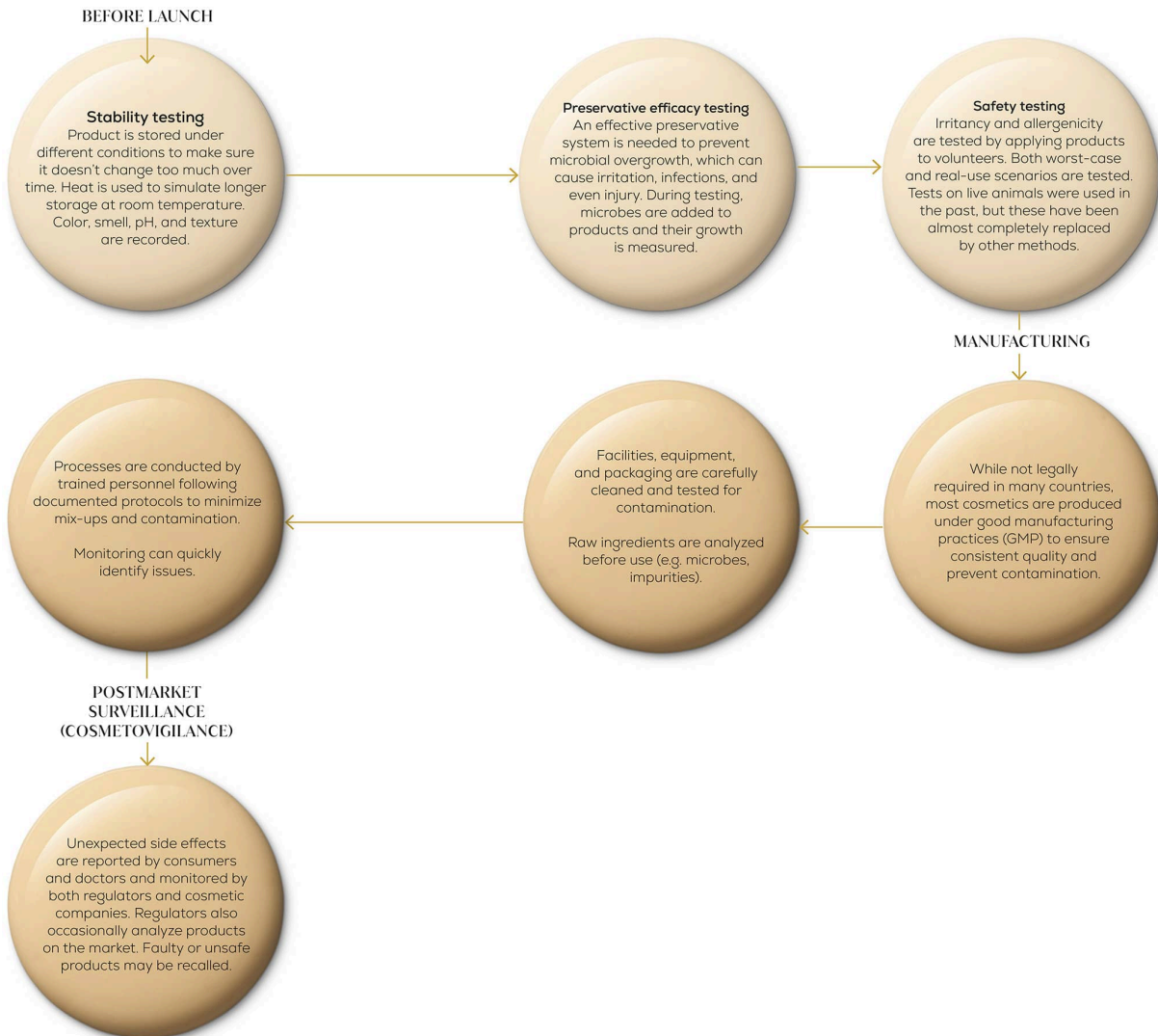


The safety of cosmetic ingredients is assessed by scientists using the same principles of toxicology used for evaluating foods and medications.

Margin of safety

A large margin of safety is built into these recommendations. This means that the amounts used are a tiny fraction (usually $\frac{1}{100}$) of a dose that would still not be harmful based on current scientific evidence.

PRODUCT SAFETY



Stability testing

Product is stored under different conditions to make sure it doesn't change too much over time. Heat is used to simulate longer storage at room temperature. Color, smell, pH, and texture are recorded.

Preservative efficacy testing

An effective preservative system is needed to prevent microbial overgrowth, which can cause irritation, infections, and even injury. During testing, microbes are added to products and their growth is measured.

Safety testing

Irritancy and allergenicity are tested by applying products to volunteers. Both worst-case and real-use scenarios are tested. Tests on live animals were used in the past, but these have been almost completely replaced by other methods.

SAFETY TIPS

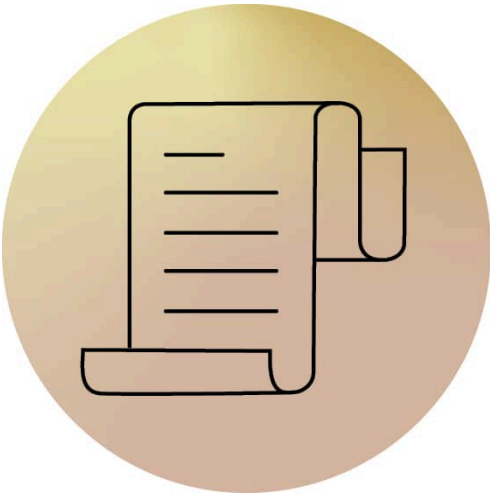
The vast majority of beauty products are very safe, but following a few guidelines will ensure extra protection against harm.



Buy from reputable stores and brands to avoid products that may not follow standard safety practices (for example, counterfeit products).



Do not use recalled products.



Follow directions for use, including storage instructions, expiry dates, and any occupational safety requirements.



If you have a concerning reaction to a product, seek medical attention.

Are natural beauty products better or safer?

Natural products and ingredients are often marketed as being safer. But this claim is misleading for many reasons.

Natural isn't well-defined

No one can agree on exactly what counts as “natural.” Everything technically originated on Earth, so in a sense all ingredients are natural. But to get into a jar of cream safely, ingredients need to undergo extensive processing, so they're all also pretty unnatural by the time they reach us.

Additionally, any substance found in nature can be theoretically made in a laboratory, and the natural and synthetic versions will have identical impacts on your body—their molecules will be exactly the same.

Many ingredients originally sourced from nature are made synthetically for cosmetic use. This can have many advantages:

Reduces strain on natural resources

Often lower cost

More predictable composition and properties (such as any contaminants present)

Some certification bodies have definitions for “natural” or “naturally derived,” but there is major disagreement between standards, and the distinctions drawn are pretty arbitrary. For example, petroleum jelly is usually considered “unnatural,” even though it's a purified extract of natural crude oil—impurities are removed, but the petroleum jelly molecules are unchanged from when they were extracted from the ground.

Natural isn't automatically safer

It's a myth that natural substances are inherently safer. Many dangerous contaminants in beauty products throughout history were natural, including lead, asbestos, and mold.

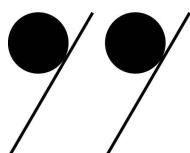
Natural ingredients can be riskier than synthetic alternatives. For example, natural fragrance materials often contain common allergens, but they can be avoided when creating synthetic blends. Synthetic iron oxide pigments are almost always used in makeup because natural iron oxides are often contaminated with toxic heavy metals.

Natural ingredients aren't more effective

Nature has provided us with many valuable substances, including medications. But evolution is geared toward having organisms survive long enough to reproduce. There's no evolutionary pressure for a plant to produce substances that benefit humans, so it's largely luck when a natural ingredient happens to be helpful.

On the other hand, synthetic molecules can be customized to improve their properties. There's also a lot of variation in natural products, which raises quality control issues. A single plant extract can contain thousands of unique chemicals, so its exact composition and subsequent effects depend on many factors like climate, season, and extraction method. In contrast, synthetic ingredients can be produced in a more consistent way, so their properties and effects are far more predictable.

The bottom line: an ingredient's origin doesn't say much about its safety or effectiveness. Every ingredient needs to be evaluated on its own merits, whether natural or synthetic.



Synthetic ingredients can be produced in a more consistent way, so their properties and effects are far more predictable.

NATURAL VS. SYNTHETIC INGREDIENTS

Synthetic ingredients are often inspired by naturally occurring substances, with modifications that improve their properties.

Squalene (natural)

Found in shark liver oil, olive oil, and human sebum.



Double bonds are removed from squalene to make squalane, which improves its stability.



Squalane (synthetic)

Synthesized from sugarcane via microbiological and chemical processes.

Squalane is more stable than squalene while having similar moisturizing properties.

Squalene (natural)

Found in shark liver oil, olive oil, and human sebum.

Squalane (synthetic)

Synthesized from sugarcane via microbiological and chemical processes.

Are cosmetic ingredients dangerous?

“Free from” lists are common in beauty marketing. However, the vast majority of the ingredients mentioned have not been linked to health issues when used in the context of cosmetics.

Often, these fears come from cell or animal studies that used much higher amounts than we’d get from beauty products, frequently millions of times higher. Sometimes, it’s from reports of weak links or outlier findings that cannot be reproduced. Many ingredients have been removed from products due to sensationalist media coverage and unscrupulous marketing instead of any legitimate safety issue. The replacement ingredients are usually less studied and may have greater health risks.

Safety assessors regularly recommend reducing the use of older ingredients, but this is part of a gradual process of minimizing even small risks as new science emerges and alternatives are developed. These changes are almost always because of small effects in animals or changes in biochemical measurements that may or may not be linked to health problems—it’s incredibly rare that anyone has actually been harmed.



Many ingredients have been removed from products due to sensationalist media coverage and unscrupulous marketing.

Parabens

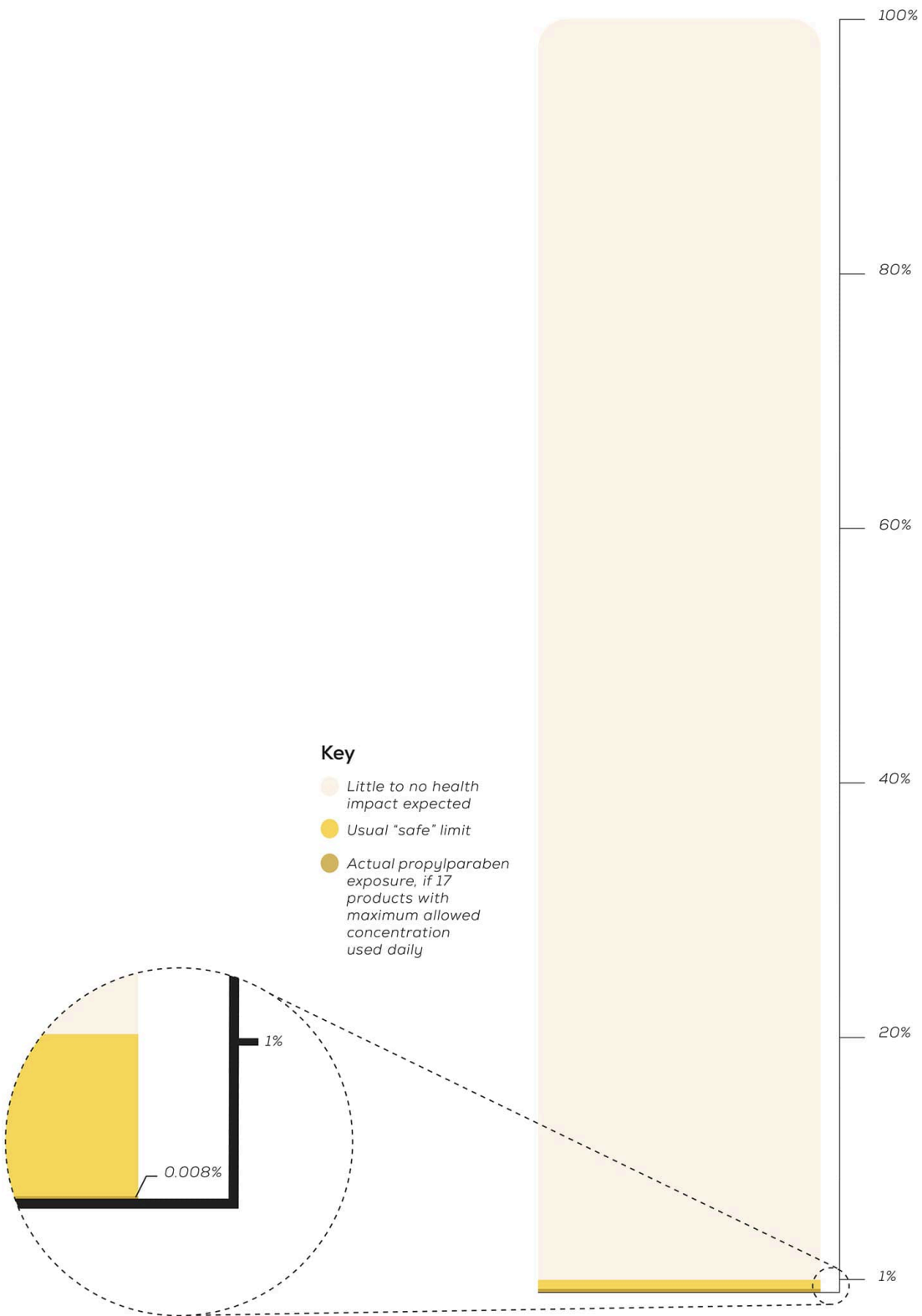
“Free from parabens” is one of the most popular claims. Parabens are a diverse family of preservatives that have been used widely in cosmetics and food for about a century due to their safety, low allergenicity, and effectiveness.

Much of the concern is around their estrogenic activity and potential endocrine disruption, but studies have repeatedly found that parabens are thousands to millions of times weaker than natural estrogen.

In 2004, a study reported that parabens were found in breast cancer tissue. However, the levels found were not compared to noncancerous tissue, and some of the parabens seemed to have been introduced during the experiment. Nevertheless, this sparked a lot of media attention and calls for parabens to be removed.

Many parabens (methyl-, ethyl-, propyl-, and butylparaben) are still permitted in cosmetics in most regions due to the large body of scientific evidence demonstrating their safety. Some larger parabens have been banned in the EU not due to evidence of harm but lack of data and their inherently higher (but still extremely low) estrogenicity. In 2021, EU safety assessors found that

using 17 products daily, all with the maximum allowed amount of propylparaben, would expose you to $\frac{1}{12,500}$ of an amount still considered safe.



Relative risks of propylparaben

Recommended ingredient use levels have large margins of safety. Here, we can see the propylparaben exposure from beauty products relative to levels still considered safe.