Appendix 1

I. Skin structure and functions

Skin is very important as it covers and protects everything inside your body. Skin holds everything together. It also protects our body, helps keep it at just the right temperature and, through nerve endings close to the surface of the skin, allows us to have the sense of touch.

However skin can become infected with bacteria, viruses and fungi, and can be irritated by chemicals or other substances that it is in contact with. Skin is also exposed to sunlight, and can suffer as a result.

Skin is composed of two parts (see Figure 1) – dermis and epidermis. The upper most layer of **epidermis** is called *stratum corneum*. Stratum corneum is made up of keratinuous dead cells. This is the part of skin and body that is peeled off daily. New skin cells are formed in the lower, e.g. basal layer, which is always forming new cells through cell division. The new cells gradually move towards the surface, which takes 1-2 months. As they move up they gradually die, become flattened and develop keratin and the outermost layer of flat dead cells is being continually worn away by friction. The keratin and oil from the sebaceous glands help to make the skin waterproof. Keratin is the substance that hair, nails and horns are made of. The thickness of stratum corneum can easily be measured in cell layers — it is the thickest under the heels, some people have more than 100 cell layers. The thinnest stratum corneum covers the genital organs, for example the penis has only 6 cell layers.

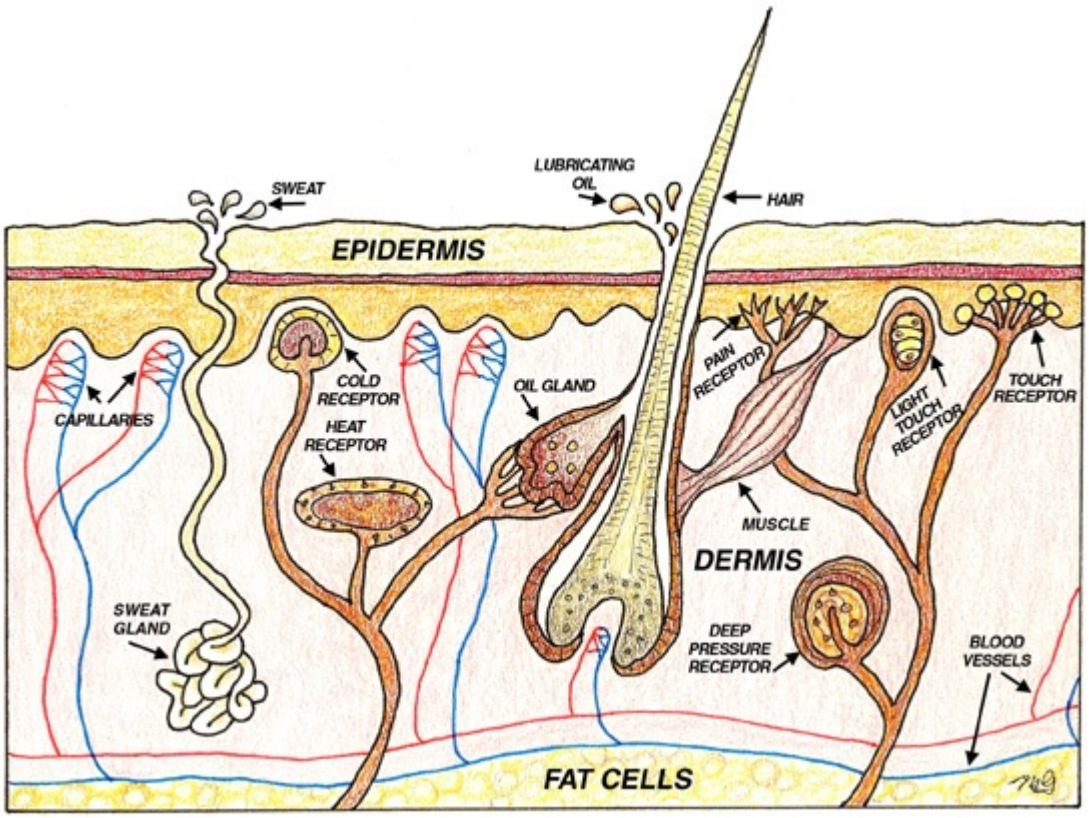


Figure 1: The cross-section of skin (Source: http://www.infovisual.info/03/036_en.html)

The **dermis** is the inner layer. The following tissues and structures can all be found in the dermis:

Connective tissue – packs and binds the other structures in the skin.

Elastic fibres – makes the skin resilient.
Capillaries – tiny blood vessels.
Muscle fibres – to move the position of the hairs.
Sensory cells – to sense touch, pressure, heat, cold and pain.
Nerve fibres – to activate muscles and glands and relay messages from the sensory cells to the brain.
Pigment cells which produce melanin, a very dark pigment.
Sweat glands which open onto the surface as pores
Hair follicles – pits in the epidermis in which hairs grow.
Sebaceous glands – produce oil to keep hair follicle free from dust and bacteria, and to help waterproof the skin.

There is a layer of fat underneath and in the lower regions of the dermis. The thickness of this layer varies depending on the place in the body and from person to person. A store of fat is useful to the body as insulation and it can be used for energy when the intake of nutrients is insufficient.

Skin has many functions:

- Controls of body temperature
- Keeps away infection
- Makes a waterproof barrier
- Protects delicate tissues underneath
- Mends itself when damaged

Temperature control

Body temperature is normally 37ºC no matter what the temperature of the surroundings is. It is controlled by a feedback system, that is, information about the temperature of the body, for example from the temperature-sensitive receptors in the skin, is fed back to the hypothalamus, the temperature-regulating centre of the brain. The brain then sends messages to parts of the body, including the skin, to keep heat in or to lose excess heat.

Other feedback systems are used in controlling the amount of glucose and water in the blood.

Keeping temperature, glucose and water at the right levels is known as homeostasis and is important for the chemical processes of the body to work properly.

A waterproof coat

Keratin in the epidermis and oil produced by the sebaceous glands help to make our skin waterproof. This means that we do not go soggy in the bath or dry up in the sun.

Keeping away infection

Millions of microorganisms live harmlessly on the skin and in the air around us. The skin forms a very effective barrier to stop them entering the body unless damaged; infections can occur when skin is damaged.

Skin colour

Melanin is a pigment that gives skin a colour from pink to brown to black. People have different skin colours because their skin contains different amounts of melanin. Melanin protects skin from ultra-violet (UV) radiation. When skin is exposed to the sun, more melanin is produced and the skin darkens. The skin of an albino person contains no melanin. Therefore they have no natural protection from UV rays. Their skin must be covered up in sunlight.

Resources

http://courses.washington.edu/bioen327/Labs/Lit_SkinStruct_Bensouillah_Ch01.pdf
http://www.abpischools.org.uk/page/modules/skin/.cfm?coSiteNavigation_allTopic=1

II. The main ingredients of cosmetic creams

Because the manufacturers have to present the ingredients of the cosmetic product according to the requirements of INCI (International Nomenclature for Cosmetic Ingredients), the substances' names below are given according to INCI (in latin). This will also be helpful when looking for information from the internet. The list of ingredients on the package of the product must be presented in the order of decreasing content percentage.

Oils, fats and waxes

Oils and fats are composed of basically non-polar molecules (prevailingly C-C and C-H bonds) and they are thus hydrophobic. Fats and oils are used to strengthen the lipid[1] layer on the skin. The lipid layer on the skin functions mainly as a barrier to protect the skin from the outside influences. It reduces the fluid loss from epidermis by forming a thin film on the skin. It also fills the microscopic unevennesses and by that it makes the skin smoother and softer and reduces smaller wrinkles. Oils and fats with a low melting point are easily appliable onto the skin, whereas substances like wax that have a higher melting point can be quite solid; this however is useful in the case of lipsticks.

(a) Natural oils and fats

Herbal and animal oils and fats are triglycerides (esters[2]) that are formed of three fatty acid (usually composed of 16 or 18 carbon atoms) and one glycerine (alcohol) molecule. They are basically non-polar and hydrophobic substances. Natural oils and fats are never pure substances, rather they are a complex mixture of triglycerides and various additives.

[1] **Lipids** are biolmolecules with an ester-like structure. They are composed of at least two components: an alcohol and a fatty acid. Fats, oils, waxes, steroids and other water-insoluble compounds are lipids.

[2] **Esters** are formed as a result of a reaction between a carboxylicacid and an alcohol. The general formula is R-COO-R'

$$R\text{-}COOH + R'OH \rightleftharpoons RCOOR' + H_2O$$

When the fatty acid residues in the fat molecule consist of double-bonded carbon atoms, then they are called unsaturated fatty acids; when there is a single bond between carbon atoms then they are called saturated fatty acids. Fats composed of unsaturated fatty acid residues are more liquid-like than these composed of saturated fatty acid residues and are thus more convenient to be used in a cream; at the same time it makes the fats more open to being oxidised by oxygen from the air. The latter process is called rancidification. As a result of rancidification, the smell, taste and/or the appearance of fats changes. In figure 2, one can see that the molecule in composed of two saturated and one unsaturated fatty acid residues.

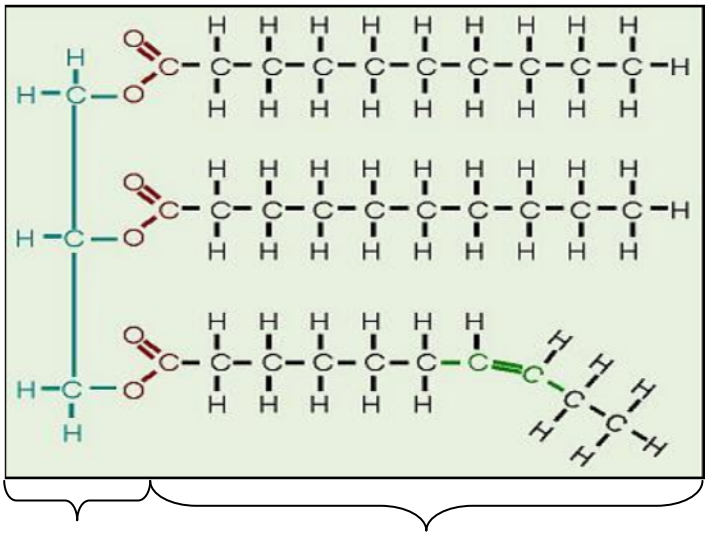


Figure 2. The structure of fats

Most often used natural fats and oils in cosmetic products:

- **Cocoa butter** – a liniment with a balmy chocolate smell, heals, moistens and softens (rough, dry) skin and is thus recommended to be used for smoothing scars, spots and other skin defects, to treat sunburn. It has an anti-wrinkle effect and makes the skin more elastic. Cocoa butter is a natural cream thickner that stabilizes an emulsion. Creams usually contain 3-6%, balsams 6-60% of cocoa butter.
- **Greipfruit seed oil** – it is known as a natural preservative and in some recipes it is added to the soap mixture in a cold process of up to 5% of the liquid oil volume. Since it contains antioxidants, it is an antibacterial oil and thus it is good to use it on problematic and sensitive skin. Because it contains a lot of C-vitamine, it is good to be used for making creams (inc. anti-acne), lotions and serums.
- **Coconut oil** – one of the basic ingredients of soap and cream. It nicely adds strength to soaps and foams, softens and smoothens skin. It is used in making creams, emulsions, soaps and shampoos, also in ointments, baby care products, protection creams and bath oils.
- **Shea butter** – offers a maximal care for the skin; it is moisturizing, smoothening, anti-ageing and anti-inflammatory; it has a calming effect, treats microwounds; to some extent protects against UV-radiation. It is added to emulsions, creams, pre- and after-suntanning creams, moisturizing creams, body liniments, to ointments in the range of 3 to 100%.

- **Sweet almond oil** – one of the most popular oils for making cosmetics. It is squeezed from the fruit cores of the almond tree. It is suitable for dry and sensitive skin, has a wonderful skin moisturizing and smoothening effect, vitalizes and absorbs well into the skin, treats well chapped skin. It is added to creams, emulsions, ointments, bath oils and baby care products.
- **Rasberry seed oil** – cold-pressed rasberry seed oil contains a lot of E- and A-vitamins that make the oil a wonderful skin care product. It protects the skin from free radicals and offers protection from the sun radiation. Because of this, the oil is used in creams meant for putting around one`s eyes, in lip balms and also in face creams.
- **Castor oil –** it has a diverse skin softening and smoothening effect. It is used in creams, emulisons, hair care products, bath oils, sunscreens, lip balms and lip balsams.
- **Avocado oil –** this oil contains A, B_1, B_2, D ja E vitamins. It has a healing effect on skin diseases such as psoriasis and eczema. It is a natural sunscreen, contains natural antioxidants. It is used in creams, emulsions, body liniments inc. lip liniments (lip balm), products usually contain 4-20% of avocado oil.
- **Olive oil** – moisturizes the skin, increases its elasticity, reduces the signs of aging and rejuvenates skin. It can be used on its own or in a mixture with other luxury oils to make a perfect face serum.
- **Grape seed oil –** it absorbs well, slightly astringent; it is a non-greasy softener with a tonic effect. Because of this the oil works best for problematic and impure skin. It can be added in the amount of 1-100% to creams tonics, massage oils and bath oils.
- **Rose hip seed oil –** it is a wonderful softener and moisturizer, helps treat surgical wounds, burns, eczema, reduces wrinkles, ideal for stressed skin. In an undiluted form used as a massage oil. In creams, emulsions, bath oils, tanning and baby care products used in the range of 1-100%

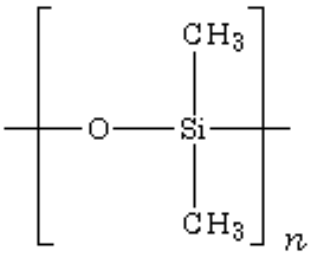
(b) Synthetic oils and fats

Synthetic fats and oils are much more tolerant to oxygen from the air since they do not contain multiple bonds like herbal fats/oils. However they do not break into essential fatty acids like natural fats. Hydrocarbons (paraffin, vaseline and other petroleum products) and silicones form an impermeable film on the skin and reduce the skin`s natural resilience when used for a long time.

- **Vaseline and mineral oils** (*paraffinum liquidum, petrolatum, petroleum jelly)* – petroleum products; mixture of hydrocarbons, mainly that of alkanes, where the number of carbon atoms in the molecule is usually > 25. Vaseline and mineral oils soften the skin and dissolve other hydrophobic substances. They are often used in hand creams, but mainly still in cheaper products.

$$H(-CH_2-)_nH$$

- **Silicones** are polymers consisting of silicon. Dimethicone is one example of a silicone. It forms an extremely efficient water-repellent film on the surface of skin or hair. Silicones are used a lot in hair care products.



Polydimethylsiloxane (PDMS) or dimethicone.

(c) Waxes

Waxes are complex mixtures of alcohols, fatty acids and esters[2]. They are harder, less greasy and highly resistant to humidity, oxidation and microbiotic degradation. Waxes are very useful ingredients in cosmetic products due to protective, softening and thickening properties as well as for the fact that they form a film. They increase the persistence and viscosity of cosmetic products and make them more even.

- **Bee wax** – non-congealing thickener, emulsifier, forms a film, slightly anti-bacterial, softens the skin. Melted by heating to a temperature of 61-68 ^{o}C. Usual content of 2-40%. Used in creams, emulsions, pomades, liniments, lipsticks, mascaras, eye shadows, ointments, protective creams.
- **Carnauba wax**
- **Candelilla wax etc.**

Emulsifiers and humectants

Cosmetic creams (lotions) are emulsions. Emulsions are dispersion systems where liquid substance(s) are dispersed or mixed with another liquid substance while the liquids actually do not mix microscopically. In cosmetic emulsions these are oils-fats as one part and water as the other part. Everyone knows that this kind of spray is not very persistent. Since oil drops are lighter than water, they accumulate quite quickly to the surface after shaking and form two separate phases: an oil phase and an aqueous phase. Emulsifiers are used to make the emulsion more persistent.

Emulsifiers

Emulsifiers are used in creams and other emulsions in order to mix two phases that do not mix: the oil phase and the aqueous phase. This makes the system more persistent.
The typical emulsifier molecule is rather bulky and mostly basically non-polar making it hydrophobic and dissolvable in fat (directed towards the oil phase). The polar and hydrophilic end is directed towards the aquous phase.

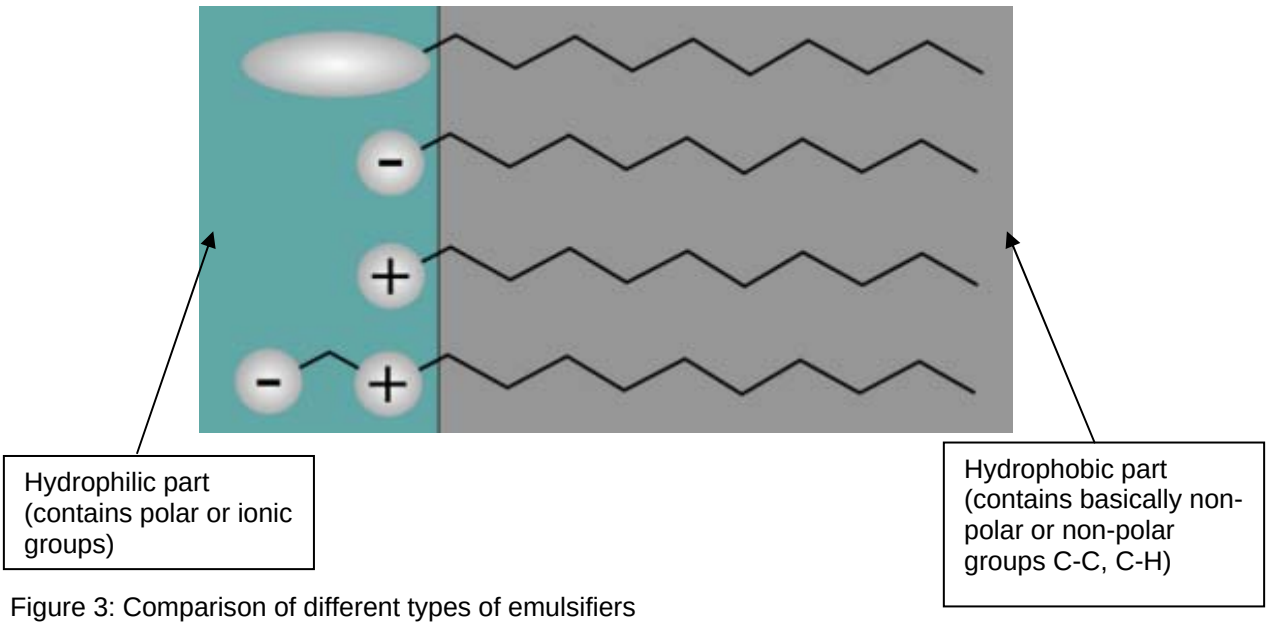


Figure 3: Comparison of different types of emulsifiers

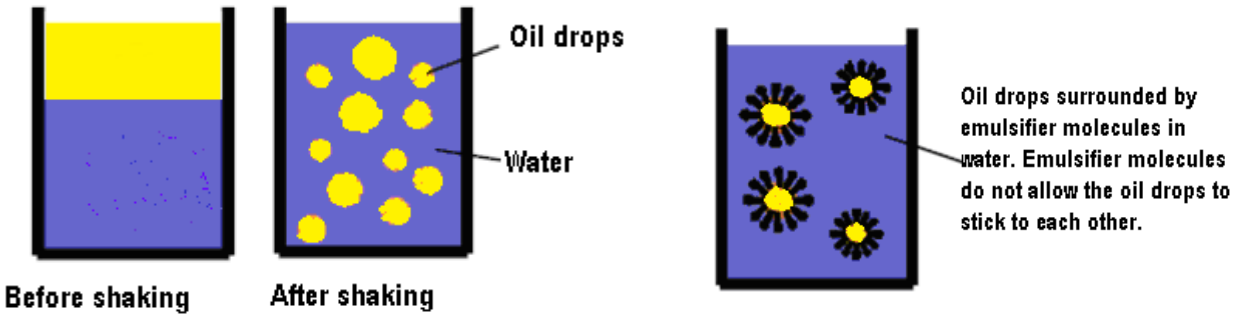


Figure 4. Emulsion without emulsifier (left) and emulsion with emulsifier (right)
(Source: http://www.makingcosmetics.com/articles/02-making-emulsions-for-cosmetics.pdf)

There are 2 types of emulsifiers (Figure 5): oil in water (o/w) and water in oil (w/o). Night creams and sunscreens are often w/o- type of emulsions that are quite greasy. Body lotions and day creams are o/w-type of emulsions that are lighter and moisturise better.

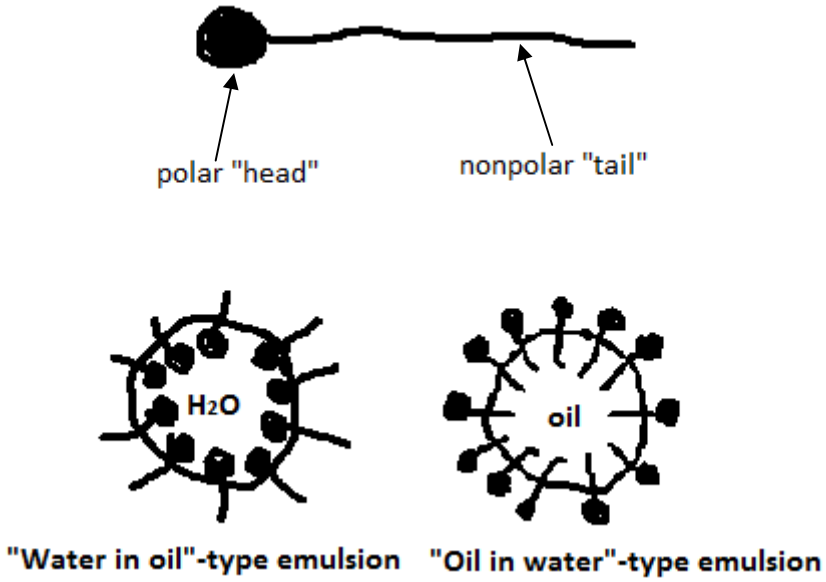
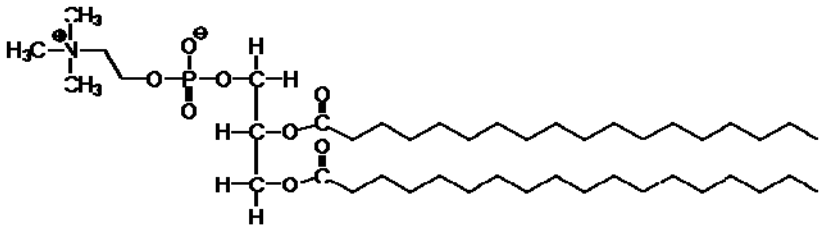


Figure 5. A comparison between water in oil and oil in water type of emulsions

(a) Water/in oil type of emulsifiers

- **Lecitine** – it is added to the oil phase before mixing. Used in creams, ointments, body gels, shampoos, sunscreens, body liniments and decorative cosmetics.



- **Egg yolk**
- **Sorbitan monostearate**
- **Triglyceryl monooleate**

(b) **Oil/ in water type of emulsifiers**

- **Stearic acid –** emulsifies and thickens, gives the skin a slightly waxy feel, shiny and a cooling effect. Content is usually 2-10%. Extensively used in soaps, creams, emulsions, in protection and shaving creams and other care products.

- **Polyethylene glycols (PEG) and polypropyleneglycols (PPG)**

They can act both as emulsifiers as well as fat-like substances. The number behind the abbreviation represents the number of elementary links in the molecule. For example, PEG-40.

- **Polysorbate**
- **Cetearyl alcohol –** contains molecules consisting of 8-22 carbon atoms. Makes up 1-5 % of the total mass of a cream. It is added to both w/o as well as to o/w type of emulsions

Octane-1-ol

Humectants
Humectants are important ingredients of cosmetics allowing to avoid and maintain the moisture loss of the skin. Strateum corneum can protect the skin efficiently only when it contains enough water. Skin becomes dry and develops cracks when the water level decreases. Microbes can enter via the cracks and the dryness of skin causes itching. The moisture content of skin can decrease when a person is smoking or due to dry air and of course when the skin ages. The natural humectants between two skin cells are amino acids and sugars. The main characteristic of a humectant is the ability to strongly bond water (via hydrogen bonds). Humectants are not only added to skin care products but also to hair care products to add volume to the hair. This group includes a number of proteins, acids, polysaccharides and some smaller molecules: polyhydroxyl alcohols such as glycerin, hexane-1,2,3,4,5,6-hexaol (sorbitol), propylene clycol, but also urea and amino acids such as aloe vera juice.

Preservatives and antioxidants

Preservatives
Cosmetics are a good surface for bacteria, viruses and fungi since the products contain water, oils, peptides and sugars. Because of this, the various cosmetic products require preservatives or their life-span is very short.

- **Grapefruit seed oil** – (look at previous pages). This can be added to warm or cold mixtures before adding the odour. Usual content of 0.5-1% (for more complex mixtures it is 2-3%). It is not enough for long term preservation and is thus combined with different parabens.
- **Potassium sorbate, sodium sorbate**
- **Sodium bensoate**
- **Parabens –** disputable, but bound to be found in cosmetic products from stores. Is absorbed easily and fast into skin and gets into the blood circulation within tens of minutes after use. Studies done have shown that they mimic the body`s own hormones and can thus interfere with the endocrine systems. Most known parabens are methylparaben and ethylparaben.

Antioxidants

Antioxidants are active components of cosmetic products. Generally they help stop oxidation reactions and bind free radicals (eg. peroxides). Both of these processes ruin the functions and integrity of natural substances. Antioxidants are useful in two ways: they prevent the degradation of natural ingredients (proteins, carbohydrates, fats) in a cosmetic product; and at the same time they protect the skin cells and slow down aging-related processes. Antioxidants have become useful substances that help make the skin more shiny and decrease the signs of aging.

- **Vitamin E** (tocopherol) and its derivatives – besides having an antioxidant effect they also moisturize, are anti-aging, repair the skin relief, soften and are anti-inflammatory. They also stimulate the growth of skin cells and the activeness of enzymes. They are added in the range of 0.5-2.5% to have an effect on the skin and in the range of 0.1-0.5% to stabilize the fat- and oil-containing product. Used in various skin and hair care products. Added to the oil phase.
- **Vitamin C** (L-ascorbic acid) and its derivatives – besides having an antioxidant effect it is also anti-aging: it repairs skin elasticity and stimulates the formation of collagen, avoids over-pigmentation, is anti-inflammatory. Added to the aquous phase, usual content of 0.2- 4%. Used in emulsions, creams, after-tanning products etc.
- **Vitamin A** – promotes skin regeneration. Promotes epithelium and keratin formation, anti-wrinkle properties. It is useful to freeze it in order to preserve it. Should be put into a warm-water bath to melt and add to the product as the final ingredient. Average amount of 10 drops per 100g of cream. Used in all sorts of skin care products, especially in nutritive and sunburn creams.
- **Green tea extract -** Green tea contains a simple form of flavonoid known as catechins (flavan-3-ols) plus gallic acid, both known as good antioxidants. It also contains carotenoids, tocopherols, ascorbic acid (vitamin C) and minerals such as chromium, manganese, selenium, zinc and certain phytochemical compounds strenghtening even more the antioxidant potential of green tea**.**

Other components

Skin peeling agents

Skin peeling agents work in two ways: via mechanically and chemically removing dead skin cells. Various herbal flours, but also sugar and salt crystals are mechanical peelers. Weak acids such as lactic acid, citric acid and malic acid are chemical peelers and they dissolve the space between two cells—this causes the release of the cells on top. As a result of peeling, the skin becomes more shiny and the effect of other cosmetic products increases as they can get deeper into the skin. The top layer of the skin recovers very quickly.

Alpha hydroxy acids (AHA's) most commonly used in cosmetic applications are typically derived from food products including glycolic acid (from sugar cane), lactic acid (from sour milk), malic acid (from apples), citric acid (from citrus fruits) and tartaric acid (from grape wine). For any topical compound to be effective, including AHA, it must penetrate into the skin where it can act on living cells. Bioavailability (influenced primarily by small molecular size) is an important factor in a compound's ability to penetrate the top layer of the skin. Glycolic acid, having the smallest molecular size, is the AHA with greatest bioavailability and penetrates the skin most easily; this largely accounts for the popularity of this product in cosmetic applications.They have a peeling effect, keratolytic effect, added in the range of 5-15% to the aqueous phase.

Odours

Nowadays most loitions contain odours. The purpose of those added odours is to make the product more attractive, while at the same time they might also be used to conceal the smell of the original components, which might not be so pleasant. Odours can be natural as well as synthetic. The best known natural odours are essential oils, which constitute complex mixtures of compounds. The best known synthetic odours are geraniol, citronellol, citral and others, which simulate natural odours.

- **Citric acid** – acidity regulator, gelatine formation, neutralizes certain minerals in order to increase the efficacy of antioxidants and preservatives, has buffer capacity (helps maintain a pH between 2.5 to 6.5), higher concentration has exfoliating properties (like with AHA acids), moisturizes, exfoliates, softens, has an anti-wrinkle effect. The safe use of citric acid should not exceed 10% and not be at a lower pH value than 3.5. Citric acid is added creams, shampoos, shower gels, bath pearls (along with sodium carbonate).
- **Salicylic acid** – proven anti-acne effect due to its anti-septic properties, very effective keratolytic effect (exfoliating effect extends to the pores of the skin). Used in exfoliators, anti-dandruff products, anti-psoriasis products and in products meant for problematic skin: for acne – 0.5-3%; for dandruff – 1-3%, for warts – 5-25%. Products containing salicylic acid may smell on the skin. When salicylic acid is attempted to be used together with other exfoliators such as benzoyl peroxide, recorcinol or soaps and other cometics products that dry your skin one must be aware of an excessive exfoliating effect.
- **Aloe Vera** juice (extract, gel) – moisturizes, rejuvenates, heels, penetrates easily through the skin while stimulating the blood circulation and the immune system, increases the elasticity of the skin and stimulates collagen synthesis, found in various products.
- **Allantoin** – heels (sun) burns, abrasions, works well for chapped skin, leaves a soft and dry feeling (for example in the case of an incubated diaper), usually added to an aqueous base in the amount of 0.2 - 2%. Added to a great variety of products.

Resources

- http://www.makeyourcosmetics.com

a comprohensive page where a lot of different information can be found: recipes, components, the content of the components, effect etc.

- http://www.naturalnews.com/022113.html

the effect of parabens

- http://lifestyle.blogtells.com/2009/03/17/home-made-skin-creams-and-ointments recipes/

home-made creams

- http://www.vitaminstuff.com

a lot of information about vitamins

- http://www.essentialwholesale.com

here one can buy substances, but it also gives information about the ingredients and their effect

- http://www.makingcosmetics.com

articles about cosmetics and a whole book about the ingredients of cosmetic products, the effect and how much and where to add something

- http://www.joik.ee/?section=et/2033&class=shop_order_center&action=show_items&id=203

ideas to experiment with different mixtures

- http://allnaturalbeauty.us/emulsions.htm

a lot of information about emulsifiers