

## Physical Factors of Environment: Summary

### Light

Light is very often perceived as a means of transmitting visual information about a person's surroundings. The natural source of light on Earth is **the sun's radiation**, which illuminates the Earth's surface either by direct radiation or by scattering light in the atmosphere: we then speak of so-called sky light. The sun's radiation is further reflected from the moon, which we identify as moonlight creating lighting conditions at night, especially during the full moon, which contributes to the intensity of illumination in windows and apartments on the order of a tenth of a lux<sup>1</sup>.

When man learned how to make and use **fire** (more than 100,000 years ago), man got his hands on a great weapon and a way to make his life more comfortable. The flame of fire banished the darkness of night, brought warmth, a sense of greater security and, not least, made it possible to prepare food into a more digestible form.

Fire, or the flame of a torch or wax candle, was used as the sole source of light for millennia until the second half of the 19th century. Then, in 1879, the American inventor and entrepreneur *Thomas Alva Edison* (1847 – 1931) lit his incandescent light bulb, which was a huge success. As with the candle flame, Edison's bulb emits light by heating the material (only in the case of the candle, the material is beeswax, whereas in the case of Edison's bulb, the material is tungsten filament).

In contrast to Edison's bulb, today's more advanced light sources (fluorescent lamps, LEDs) emit due to an electrical discharge (fluorescent lamps) or due to the excitation and de-excitation of electrons (diodes). Luminescent sources (fluorescent lamps, diodes) emit a greater proportion of wavelengths belonging to **blue light**<sup>2</sup>, thereby suppressing the endogenous production of **melatonin**, the pituitary hormone, which, on the other hand, is supposed to be boosted, particularly in the evening, in order to induce natural falling asleep and sleep.

The discovery and use of artificial sources of light means that the illuminance of artificial sources is orders of magnitude higher than the naturally occurring illuminance levels found in nature. Unwanted illuminance intensities that penetrate the indoor environment of buildings from the outside at night can be on the order of tens of lux. It has been found that **a third of the population** avoids unwanted illumination of bedrooms from excessive outdoor lighting and illuminated advertisements by shading, and a fifth of those with sleep problems do not consider shading to be sufficient at all.

Another civilization problem of modern societies operating in 24/7 mode (24 hours a day, 7 days a week) is strong artificial lighting reaching hundreds of lux blocking the start of evening production of the hormone melatonin, e.g. **due to night work or consumption of entertainment and services** (light at night). The hormone melatonin appears to be

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<sup>1</sup> Lux: unit of illuminance.

<sup>2</sup> The effect of blue light can be suppressed by using a deep yellow colour filter (compare the colour of candle light with the colour of white fluorescent lamp or LED light).

important for several reasons: one of them is that sufficient serum levels of melatonin induce natural fatigue and the onset of sleep. The consequence of sleep deprived individuals due to impaired melatonin production is impaired attention, reaction times and in extreme cases micro-sleep during the day. **Due to the coexistence of night work and the intense artificial lighting** that almost inevitably accompanies night work, epidemiological studies have described an increased risk of breast cancer in women, prostate cancer in men, colorectal cancer and, to a lesser extent, certain other types of cancer, such as lung cancer, ovarian cancer in women, stomach cancer, kidney cancer and haematopoietic cancer. Several other sources and their meta-analyses have suggested an association of night work and intense lighting at night with obesity, type II diabetes mellitus<sup>3</sup> and metabolic syndrome.

*Control questions:*

1. *Which natural light sources do you know?*
2. *Which artificial light source is the most natural: the classic "Eddison bulb", the fluorescent lamp or the white LED?*
3. *What is the unit of illuminance?*
4. *Which component of light most affects melatonin production and what color filter can be used to eliminate it?*
5. *Is lighting at night physiological?*
6. *What proportion of the population is affected by adverse effects of night light?*
7. *What adverse health consequences can excessive nighttime lighting have?*

## **Climatic factors**

Adequate ventilation to ensure adequate occupant comfort is essential to ensure thermal comfort. Thermal comfort is created not only by the **air temperature** itself, but also by the thermal radiation of objects, the cooling effect of **the air flow**, and above all by **the relative humidity**. The question of the optimum setting of microclimatic parameters is highly debatable.

In a historical context, it is evident that heating requirements have increased over time. In the days before radiant or central heating, which worked without any work, winter indoor temperatures tended to be much lower than today. Indoors today, the cold is almost unknown, as automatic controls keep the interior temperature mostly well above 20°C. However, it turns out that even low indoor temperatures do not lead to increased personal morbidity, even when reduced to 18°C or lower. **Therefore, the current higher heating standard of 20 to 22 °C may be considered unnecessarily high.**

The absolute basis of a good indoor environment is ventilation. Ventilation should be targeted and to achieve the desired comfort. A good and very easy to determine indicator of

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<sup>3</sup> Current knowledge of type 1 diabetes mellitus dependent on insulin supplementation does not suggest the influence of any preventable factor. The causes of such a disease are not known with complete certainty.

ventilation efficiency is the carbon dioxide (CO<sub>2</sub>) concentration. The gas is a normal product of human metabolism and is present in exhaled air at a relatively constant concentration of around 5%. **The recommended concentration of carbon dioxide is less than 1 500 ppm.**

*Control questions:*

1. *Which indicators tell about the microclimate?*
2. *Do you think that the current standard of heating indoors at 20 to 22 oC is quite optimal?*
3. *What is the recommended concentration of carbon dioxide in the indoor environment of buildings*

## **Noise**

Noise means any sound that is harmful, disturbing or annoying. The unit of intensity is the bel; a unit ten times greater is the decibel. The bel, or **decibel**, is actually the decadic logarithm of the energy flow of sound. In practice, we tend to encounter situations where people with hearing problems amplify, for example, radio and television receivers and thus become the source of disturbing noise for their surroundings. This is because we register ratios instead of absolute signal intensities. This means that we perceive by how many percentages or orders of magnitude the signal has become stronger or weaker. Thus, **we do not perceive absolute increments but relative increments (Weber-Fechner law).**

So if the difference in noise intensities between a relatively quiet street and a noisy street is about 30 decibels, this is actually a 30-fold difference in intensity, and that is already a health difference. The effects may be manifested not only in hearing impairment, but also by affecting the length and quality of sleep, and epidemiological studies have also shown an increase in the risk of cardiovascular and some metabolic diseases in exposed people.

*Control questions:*

1. *What is noise?*
2. *What does the Weber-Fechner law express?*
3. *What do you think is the difference in noise between a quiet street and a moderately busy street?*

## **Radiation**

The burden from **natural sources** comes from the aforementioned cosmic radiation, as well as from radioactive isotopes dispersed in the environment, including the radioactive carbon isotope <sup>14</sup>C (carbon-14). Carbon-14 is a completely natural part of living matter and is metabolised during an individual's lifetime, so that the amount of carbon-14 in the body is maintained at a relatively constant level throughout life. A special case of natural radiation is the radiation of **the van-Allen belts** in the uppermost layers of the Earth's atmosphere, which interact with cosmic rays and emit electromagnetic waves of wavelengths corresponding to ionizing radiation by virtue of the interaction of radiation and matter.

**Unnatural (artificial) exposures** originate primarily from medical uses of ionising radiation (radio diagnostics and radiotherapy are together the most important sources of exposure), exposures

from artificially produced radionuclides produced on purpose or as waste from the operation of nuclear facilities, from nuclear accidents, and from the effects of the military use of nuclear energy in nuclear weapons. Radiation exposure originating from nuclear accidents or nuclear weapons attacks is identifiable through the presence of **caesium** and **strontium** radionuclides that are not otherwise present in nature. The use of ionising radiation in radio diagnostics is inherently linked

to the so-called **Compton effect**. The Compton effect describes a situation when, in addition to the passage of a targeted beam of ionizing radiation from the X-ray tube towards the target tissue, there is also a completely random movement of photons of electromagnetic radiation in the environment, even perpendicular to the direction of the primary beam. The consequences of unwanted exposure to ionising radiation photons originating from the Compton effect can be reduced by narrowing the primary beam as much as possible.

High single doses of radiation are manifested as so-called radiation sickness. It is caused by apoptosis of cells that have absorbed the lethal dose of radiation. Lower than lethal doses of radiation damage the genetic makeup of the cell and can lead to **a higher likelihood of cancer**, especially acute lymphocytic leukaemia, acute myeloid leukaemia and chronic myeloid leukaemia.

Of the non-ionizing spectra of radiation, the short-wave component of ionizing radiation, i.e. **the UV-C component**, has the most significant effects, which on the other hand also has practical use for its germicidal properties. Because of its harmfulness to human health, appropriate rules must be applied.

#### *Control questions*

- 1. Is medical radiation one of the natural sources of ionizing radiation?*
- 2. Is radiation sickness one of the stochastic effects of radiation and why?*
- 3. Radionuclides of which elements detect nuclear accidents or the use of nuclear weapons?*
- 4. What is the Compton effect?*
- 5. Which component of ultraviolet radiation is most harmful to human health?*
- 6. Which component of ultraviolet radiation is used in disinfection?*