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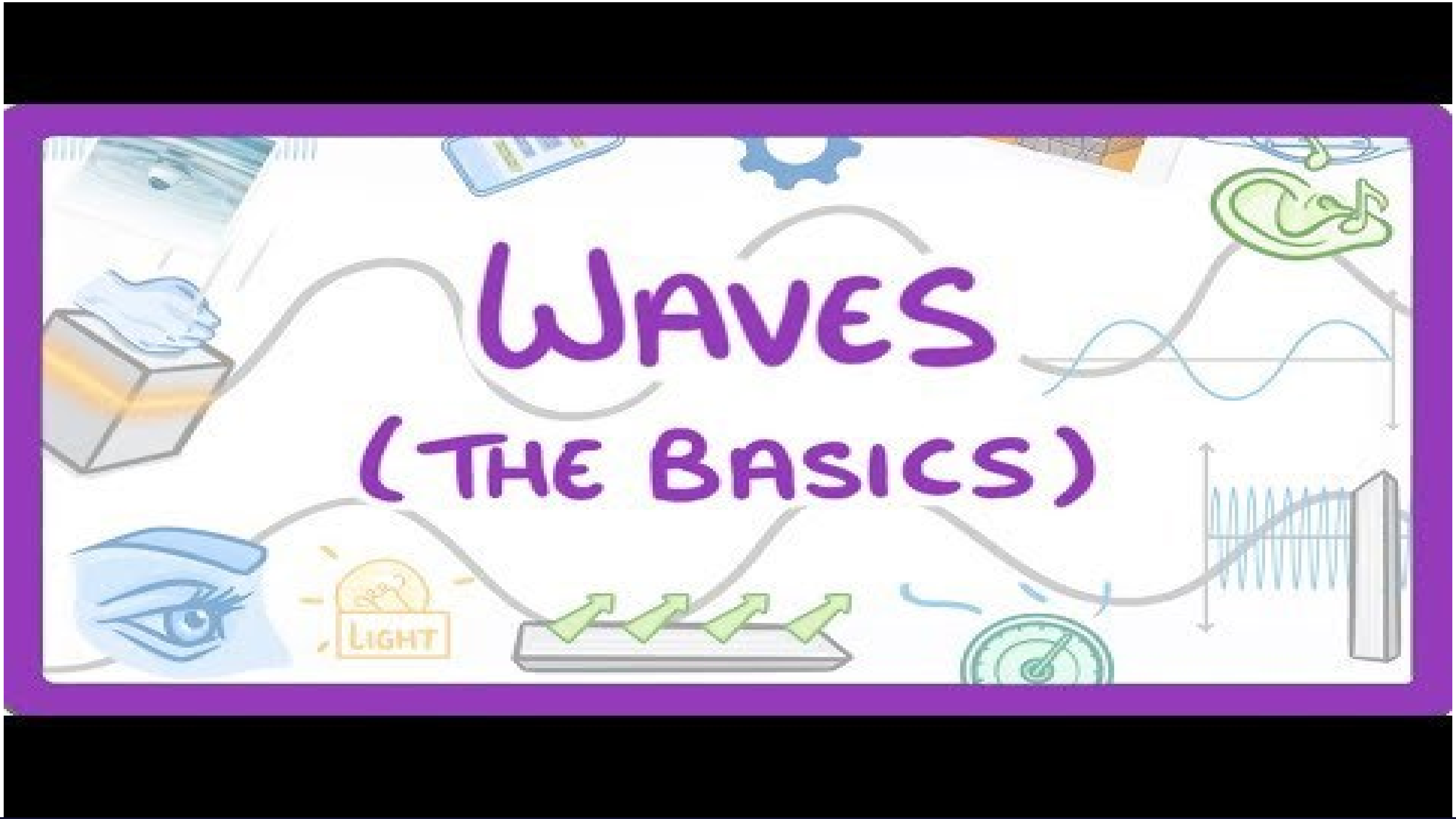
Physical Factors in Environment

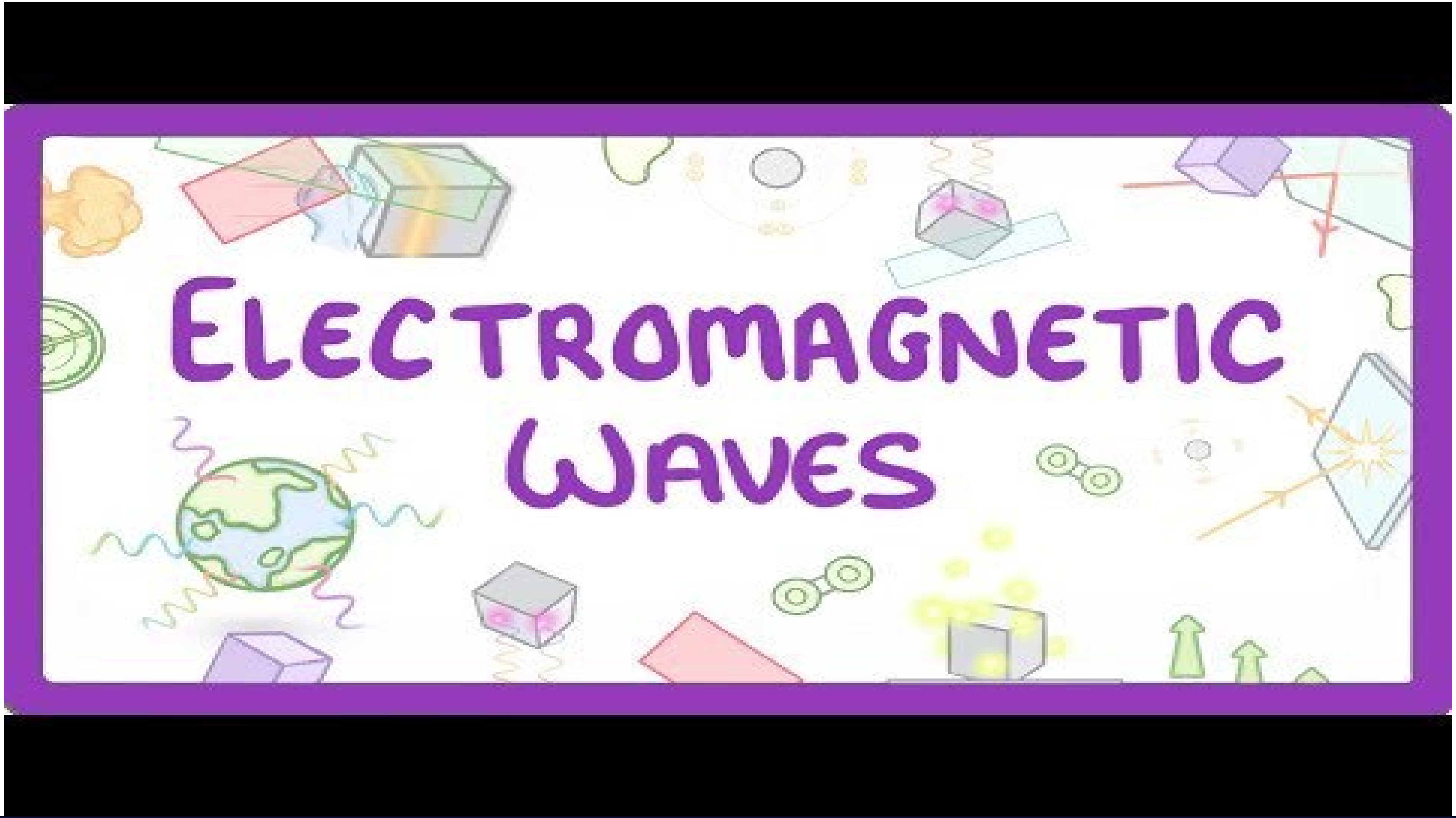
Distribution of physical factors

Waves	Mechanical waves	Noise	
		Vibrations	
	Electro-magnetic waves	Non-ionizing radiation	Radio waves, Microwaves, Radar waves, Infrared radiation, Visible light, Ultraviolet radiation
		Ionizing radiation	alpha, beta, gamma, X-rays
Thermal comfort	Climatic factors	Air temperature, Air humidity, Speed of air flow, Intensity of heat radiation	
	Individual factors	Activity, Thermal resistance of clothes	

Waves



Electromagnetic waves



Non-ionizing radiation

- Non-ionizing radiation is characterized by the inability to induce ionization of the material in which it is absorbed.

- According to the wavelength or type of source, non-ionizing radiation is divided into following categories: radio waves, microwaves, infrared radiation, visible light and ultraviolet radiation.

Non-ionizing radiation - Influence on humans

- The changes induced by this radiation are mostly reversible.
- At high intensities even **thermal phenomena** are possible but **non-thermal phenomena** occur more frequently.
- In general, the **biological effects** are the bigger the greater is the field intensity, and therefore induced tension.
- Different intensities of non-ionizing radiation can produce three different responses of the exposed organism:
  - indifferent response (functional changes do not exceed physiological norms),
  - active adaptation (non-specific but observable effects),
  - extreme effect (cumulative of various types).

Principles of health protection

- The principles of health protection against adverse effects of non-ionizing radiation are:

1) time protection,
2) protection by distance,
3) the protection by screening (e.g. the Faradays cage for screening HF field).

Radio waves

Radio waves

- Radio waves are the longest and contain the least energy of any electromagnetic waves.
- Radio waves are used for transmission of data, television, mobile phones, wireless networking or amateur radio.
- Naturally occurring radio waves are made by lightning or by astronomical objects.
- Artificially generated radio waves are used for fixed and mobile radio communication, broadcasting, navigation systems, communications satellites, computer networks and innumerable other applications.

Microwaves

- Microwaves fall between radio waves and infra-red waves with wavelengths from about 30 cm to 1 mm.
- Microwaves are used for high-bandwidth communications, radar and as a heat source for microwave ovens and industrial applications.
- Low-intensity microwave radiation is used in Wi-Fi, at intensity levels unable to cause thermal heating.
- Radar uses microwave radiation to detect the range, speed, and other characteristics of remote objects and can be used for air traffic control, weather forecasting, navigation of ships or speed limit measurement.
- Radar waves can be also used in astronomy or spectroscopy.

Microwaves and Infrared waves

Infrared waves

- The infrared part of the electromagnetic spectrum covers the range from 1 mm to 750 nm.
- The infrared radiation can be divided into the near-infrared radiation (IR-A), the short-wavelength infrared radiation (IR-B), the mid-infrared and long-wavelength infrared radiation (IR-C) and far-infrared (FIR) radiation.
- We cannot see these infrared waves with our eyes, however, instruments that can sense infrared energy, such as night vision goggles or infrared camera allows us to see these infrared waves from warm objects like humans and animals.
- Some objects (such as a fire) are so hot, that they emit also a visible light.

Visible light

- Visible light is an only part of the electromagnetic spectrum that humans see with wavelengths ranging from violet at 380 nm to red at 700 nm.
- Objects appear to have a colour because EM waves interact with their molecules.
- Some wavelengths in the visible spectrum are reflected and other wavelengths are absorbed.

- Lighting is usually divided into the **daylight**, **artificial lighting** and **mixed lighting**.

Visible light

Daylight

- **The biggest advantage of the natural daylight is its dynamic component, i.e. the variable intensity and variable color.**
- The daylight is the direct sunlight and the sky light (reflected light).
- The daylight coming from the side (usually from windows) is called a lateral/side lighting and is mostly used in living and administrative spaces.
- The daylight coming from above is called the top/upper lighting and is mostly used in factories, halls, studios, etc.
- Sometimes we can also use the combined daylight which means that light is coming to the room both from the side and from above.

Daylight

- For measuring and evaluating the lighting we use the following quantities and units:
  - The luminous intensity (I) is defined as a power emitted from a small light source, in a particular direction. The unit of luminous intensity is the candela (cd).
  - The luminous flux (Ø) is the quantity of the energy of the light emitted per second in all directions. The unit of luminous flux is lumen (lm).
  - The luminosity (E) is the intensity of lighting or illumination. The unit of illumination is lux (lx) which is the amount of illumination provided when 1 lumen is evenly distributed over an area of 1 m2.
  - The brightness (B) is an attribute of visual perception in which a source appears to be radiating or reflecting the light.

Daylight

- Because of this permanent variability of daylight, the intensity of daylight is expressed as a relative unit called **factor of day illumination**, which is defined as a ratio of daylight illumination at the given point of the given level to simultaneous comparative illumination of the outer not screened level at the estimated or known distribution of sky brightness.
- For evaluation of the room illuminance, we also need to take into account:
  - shape of the room (the relation of depth of the room and its height),
  - light coefficient (the ratio of the area of glass in the windows to the floor area)
  - reflections or barriers outside the building (shading by neighboring buildings, vegetation, terrain, etc.).

Artificial Lightning

- The artificial lighting, even the best one, is not a natural component of the living environment and is not quite in conformity with physiological needs of a human sight.
- Despite the technical progress, an artificial lighting mostly misses the dynamism of daylight and its spectral composition is usually less favorable for a man than the natural lighting.
- Simultaneous local and general artificial lighting is called a combined artificial lighting. The intensity of local lighting should be in a suitable proportion to the intensity of the general lighting.

Mixed Lightning

- Mixed lighting is **simultaneous lighting by daylight and a supplementary artificial light source**.
- A mixed/joint lighting cannot fully replace a good natural daylight, however, it can to some extent, join the advantages of daylight (spectral composition, variability) and an artificial lighting (suitable intensity).

Disturbing glare/dazzle

- A disturbing glare/dazzle can be caused directly by a light source or by its reflections on surfaces with a high reflection factor.
  - **absolute glare – dazzle by critical brightness**: occurs when the brightness in the field of sight is so high (critical) that the sight is not able to adapt itself (direct sunshine, electric arch etc.)
  - **transitory glare**: is caused by a sudden change of brightness in the sight field when the difference of brightness is greater than 1:100 and the sight adaptation takes longer than the change of brightness (a light is switched on suddenly, the transition from a dark space to a lighted one etc.)
  - **relative glare – dazzle by contrast**: occurs when there are surfaces of various brightness in a ratio higher than 1:100 in the sight field of the observer simultaneously (e.g. bulb filament and surrounding wall, glare from the oncoming vehicle).

Visible light and ultraviolet waves

Ultraviolet waves

- The light behind the visible violet, the ultraviolet waves (UV radiation), are in wavelengths from 400 nm to 10 nm and can be subdivided to the three regions, UV-A (320 – 400 nm), UV-B (280 – 320 nm) and UV-C (280 - 10 nm).
  - **UV-A**, the long wave ultraviolet, is the closest to the visible light, most UV-A also reaches the Earth’s surface.
  - Shorter wavelengths, called **UV-B**, are the harmful waves that cause the sunburn. Fortunately, about 95% of UV-B is absorbed by ozone in the atmosphere.
  - **UV-C** waves are the shortest and most harmful and are almost completely absorbed by our atmosphere. The atmospheric protection from harmful UV-radiation is good for humans because if all the UV-radiation would have reached the Earth's surface, it would have deadly effects on life on the Earth.

Effects of UV radiation

- clinical findings - headaches, decrease of blood pressure, fever
- histopathological changes - reduction of LC in epidermis
- biochemical changes - release of histamine from histidine
- effects on DNA - dimerization of pyrimidine and thymine: UVB
- immunological changes - selective immunosuppression
- carcinogenic effect, melanoma - by increased UVB exposition
- germicidal effects - disinfection of air by use UVC radiation 254 nm
- curative effects - psoriasis: UVA radiation + psoralens
- production of D provitamin

UV prevention and protection

- The main **protection** against excessive UV radiation of the sun is limiting the time of exposure, especially at noon.
- When it is not possible to limit the sun exposure e.g. for professional reasons (farmers, sailors, lifeguards at swimming pools etc.), it is necessary to apply lotions with effective sun filters to unprotected areas and to use eyes protection (dark glasses).
- Staying outdoors, however, positively influences physical and psychical regeneration and also leads to the above-mentioned production of D vitamin.

Time for a break

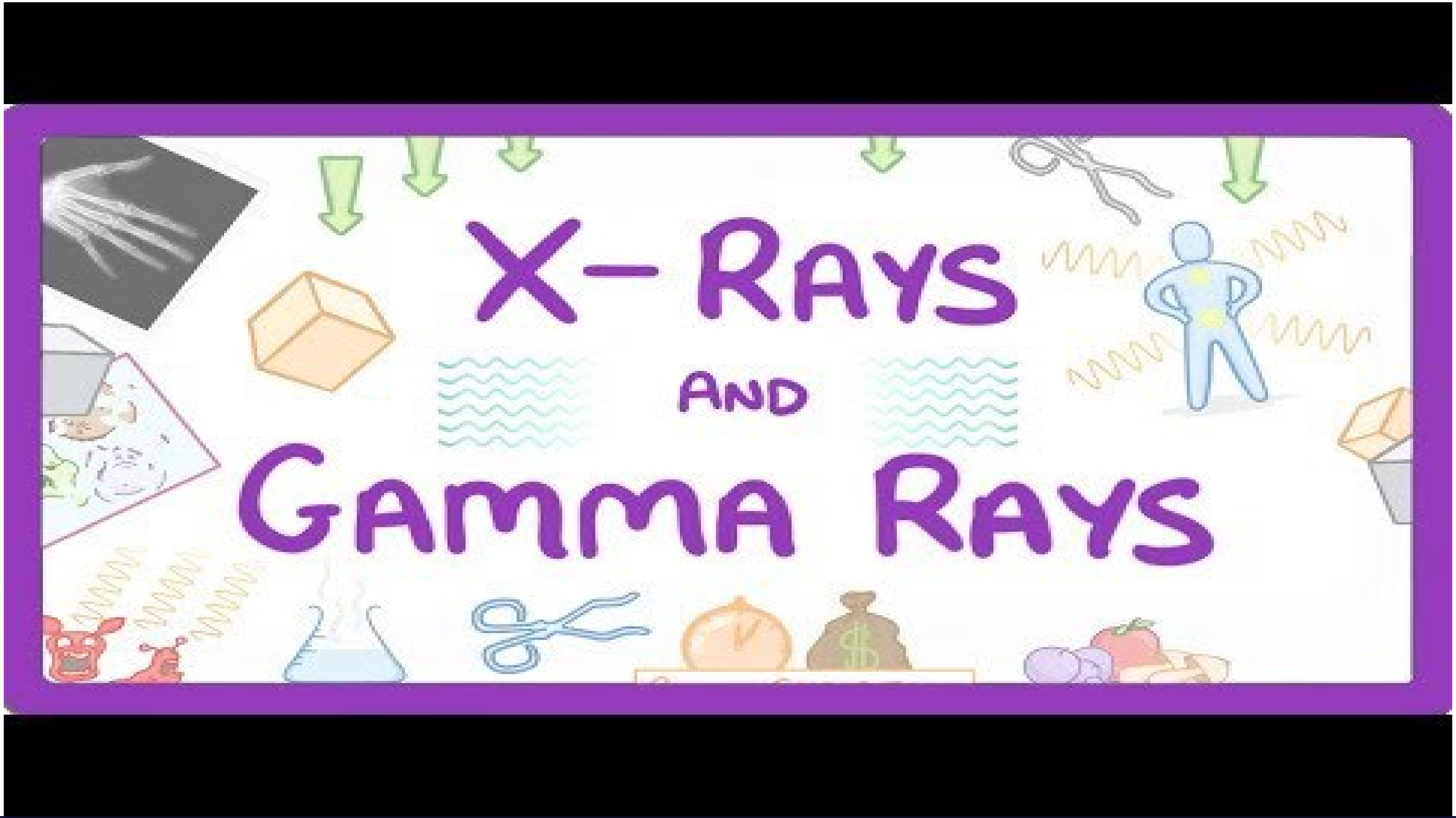
Ionizing radiation

- **The ionizing radiation causes, when passing through a matter, its ionization.**

- We distinguish three types of ionizing radiation: alpha, beta and gamma radiations.

Ionizing radiation

Ionizing radiation



Ionizing radiation

- We distinguish two main types of radionuclides:
  - **sealed source of ionizing radiation**, which is a type of radio-nuclide, whose arrangement eliminates a possibility of elusion of radioactive materials for anticipated conditions.
  - **opened radio-nuclide**, which is a type of radio-nuclide, which don’t answer to the qualification of a sealed source of ionizing radiation, e.g. various radioisotopes (radiopharmaceutical materials).

Influence on humans

- Two types of effects in mammals are recognized:

1) **Deterministic**: acute post-irradiation syndrome or acute skin injury
2) **Stochastic**: malignant tumors and genetic disorders

Measuring and evaluation

- **Absorbed dose** (D) = Energy absorbed per unit mass.
  - Its unit is the joule per kilogram, which is given a special name Gray: (Gy = J/kg)
- **Equivalent dose** (H) = Absorbed dose (D) correct by special factor according to relative biological effectiveness of radiation.
  - The unit is also joule per kilogram, with a special name Sievert: (Sv = J/kg)
- **Activity** = Mean number of radioactive decays per unit time.
  - The unit s^{-1} has a special denotation Becquerel: ($1Bq = s^{-1}$)

Measuring and evaluation

- For individual monitoring of persons in **external irradiation risk**, we use the personal dosimeters or the finger thermo-luminous dosimeter for the work with opened radio-nuclides in hoods.
- The monitoring of persons in **inner contamination risk** we can divided to direct by external measuring by whole-body computer and indirect monitoring by excretion analysis (blood picture, hematocrit, chromosomal aberrations of lymphocytes or immunological indicators).
- The last possibility can occur in the case of so-called **"radio-active" patient**, which received radio-nuclide mostly for the diagnostic purposes.

Principles of radiation protection

- **Principle of justification** – the practice should be justified on the grounds that it produces sufficient benefit to the exposed individual and to society to outweigh the radiation detriment it may cause.
- **Principle of non-exceeding the limits** – for justified practice, other than those involving medical exposures, dose limits are required in order to ensure that no person be subject to an unacceptable risk attributable to radiation.
- **Principle of optimization** – the number of people exposed and the likelihood of incurring exposures all be kept as low as reasonably achievable.
- **Principle of source protection** – physical protection of the source against misuse by other people, and safeguarding the technical safety to enhance the operational safety and to prevent radiation accidents.

Principles of radiation protection

- The effect of the ionizing radiation from sealed source can be minimalized:

1) by technical solution:
   - Protection by shielding: The installation of shielding by building material, shielding layers (e.g. plasters with barium carbonate) or providing the remote control.
2) by organizational arrangement:
   - Protection by distance: With the square of the distance the absorbed energy of radiation is lowering.
   - Time protection: The control areas are delineated with limited staff access. An appropriate working regime is here established and carefully watched there to shorten of exposure time.
3) by using the personal protection (shielding) equipment:
   - lead-containing gloves and aprons for radiologists.

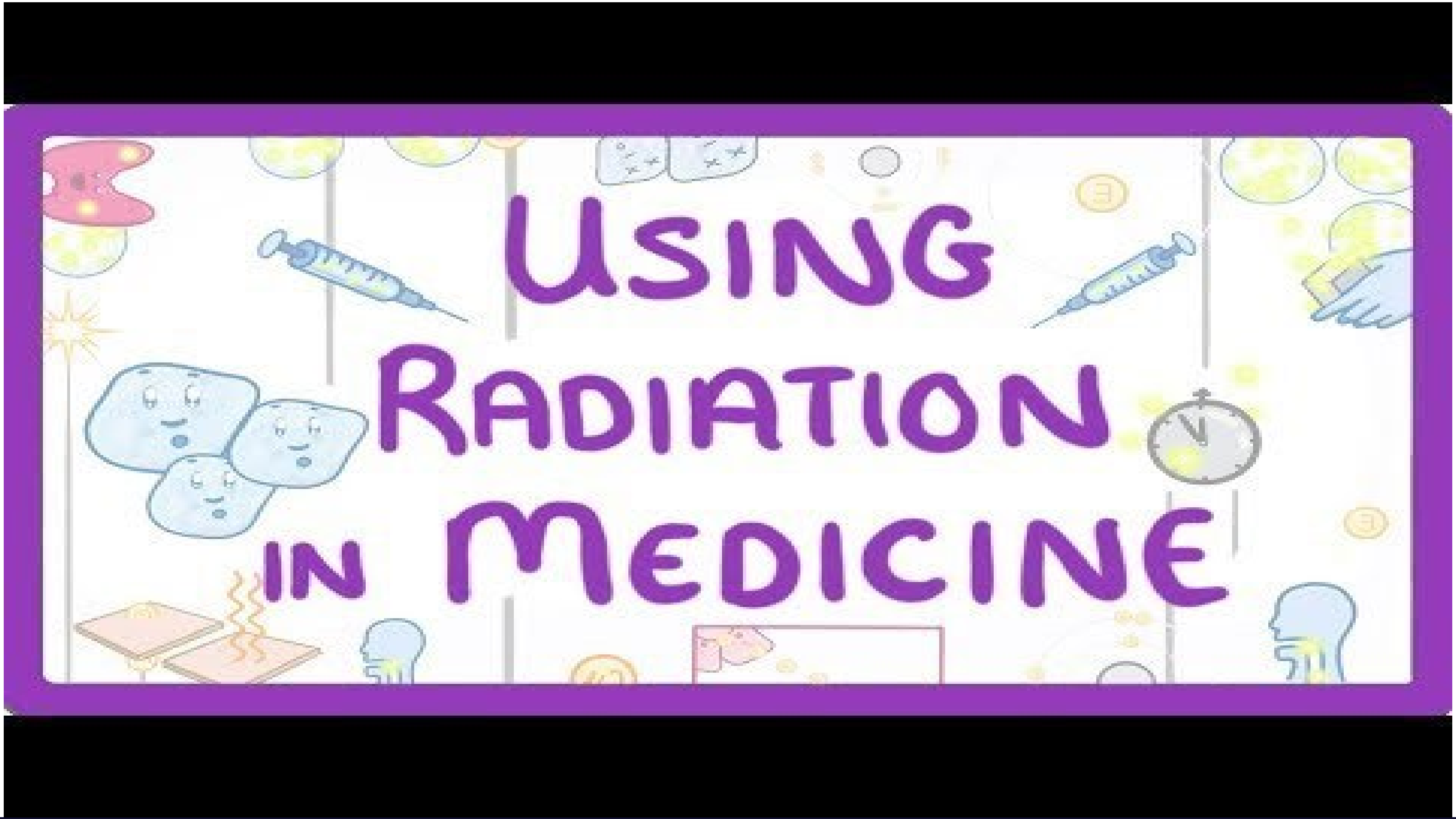
Principles of radiation protection

- The radioactivity contamination risk from opened radio-nuclides can be prevented:

1) by the technical solution:
   - ventilation and isolation systems (e.g. hoods, glove boxes, hot cells);
2) by organizational arrangement:
   - work with a minimum necessary quantity of substance;
   - work with liquid substances, no with powder materials (danger of inhaling or spilling);
3) by using the the appropriate personal protective tools for the work with unsealed radionuclides (overalls, gloves, masks).

Electromagnetic radiation

Using radiation in medicine



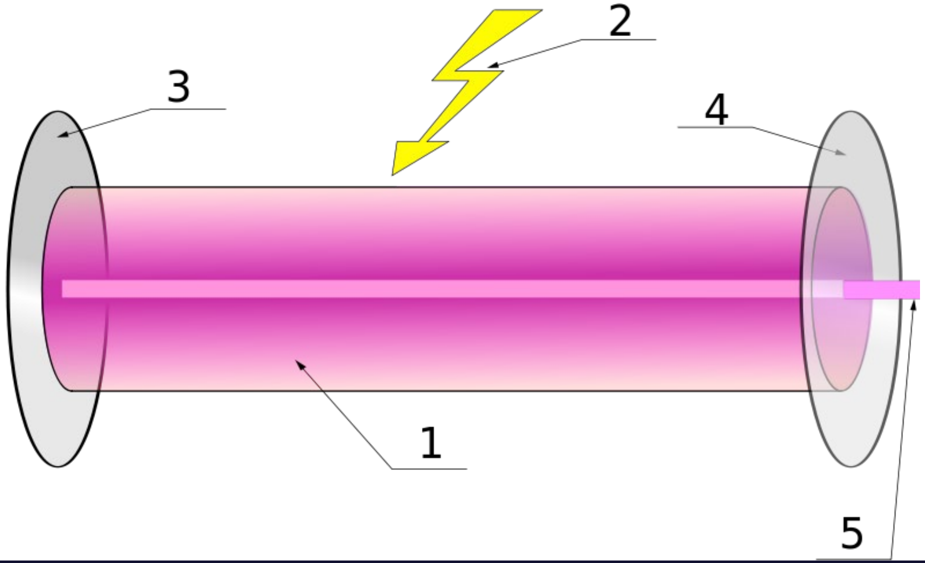
Lasers

- LASER = Light Amplification by Stimulated Emission of Radiation.

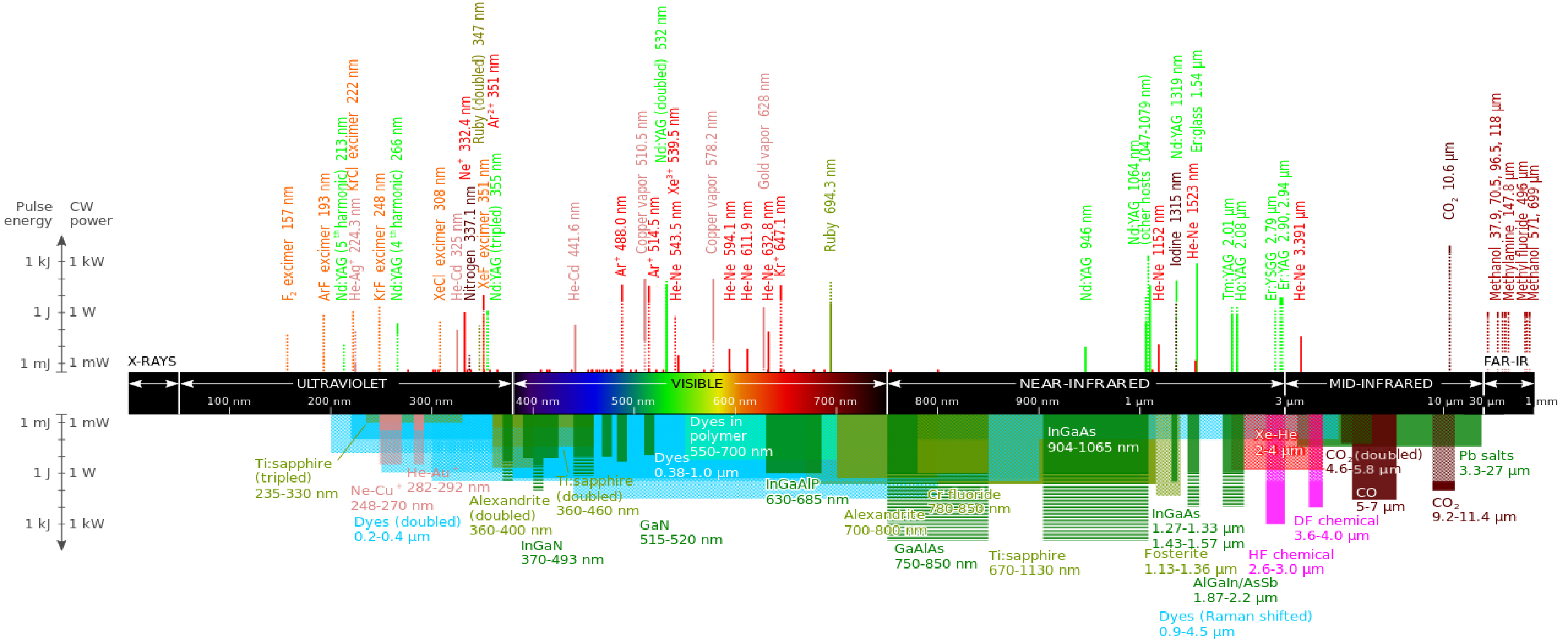
- Laser light is: **monochromatic** (unicolour), **coherent** (orderly) and it has a **small divergence** (diverging beam).
- Parameters: wave length; operating time; an angle by which exposed worker sees source of radiation

Laser construction

1) Gain medium [a material with properties that allow to amplify light by way of stimulated emission]
2) Laser pumping energy [a mechanism to energize the gain medium; e.g. electric current or light at a different wavelength.]
3) High reflector [feedback from an optical cavity - a pair of mirrors on either end of the gain medium.]
4) Output coupler [partially transparent mirror]
5) Laser beam



Laser types



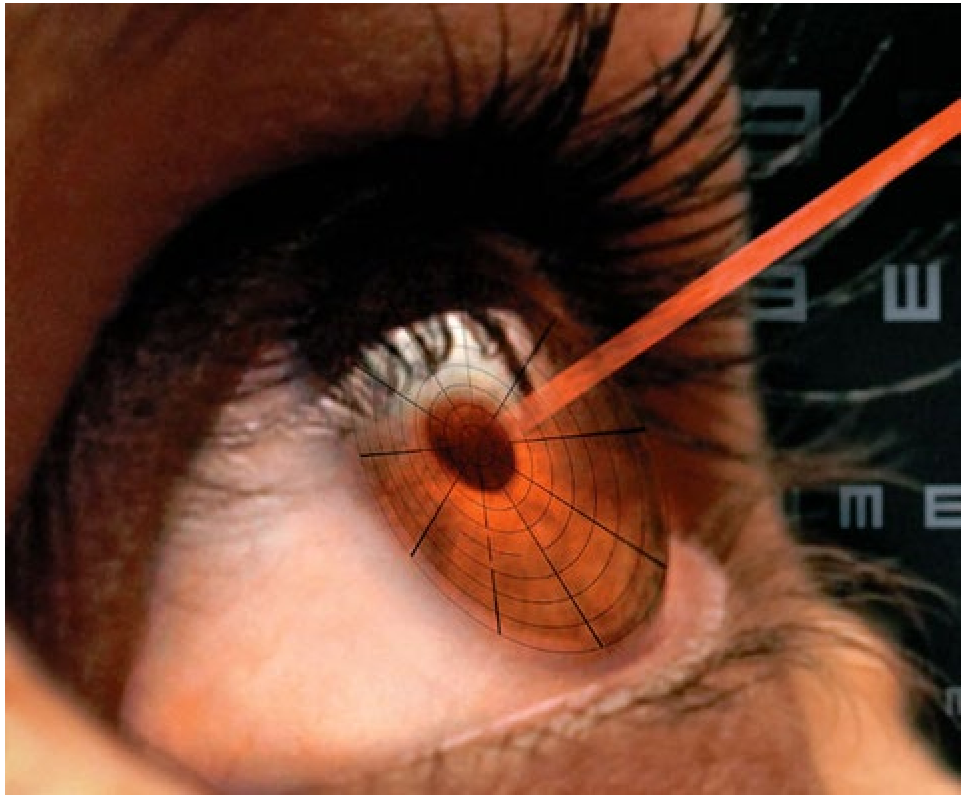
Pulse energy
CW power
X-RAYS
ULTRAVIOLET
VISIBLE
NEAR-INFRARED
MID-INFRARED
FAR-IR
Ti:sapphire (tripled) 235-330 nm
Ne-Cu+ 248-270 nm
He-Au+ 282-292 nm
Dyes (doubled) 0.2-0.4 µm
Alexandrite (doubled) 360-400 nm
Ti:sapphire (doubled) 360-460 nm
InGaN 370-493 nm
GaN 515-520 nm
Dyes 0.38-1.0 µm
Dyes in polymer 550-700 nm
InGaAlP 630-685 nm
Alexandrite 700-800 nm
Cr:fluoride 780-850 nm
GaAlAs 750-850 nm
Ti:sapphire 670-1130 nm
InGaAs 904-1065 nm
InGaAs 1.27-1.33 µm 1.43-1.57 µm
Fosterite 1.13-1.36 µm
AlGaIn/AsSb 1.87-2.2 µm
Dyes (Raman shifted) 0.9-4.5 µm
Xe-He 2-4 µm
HF chemical 2.6-3.0 µm
DF chemical 3.6-4.0 µm
CO2 (doubled) 4.6-5.8 µm
CO 5-7 µm
CO2 9.2-11.4 µm
Pb salts 3.3-27 µm

Laser types

- Ruby and argon laser – ophthalmology (eye retinae surgery), dermatology (pigmentary taches removal)
- Nd:YAG pulse laser – secondary cataract
- Excimery laser (ArF, KrCl, KrF, XeCl, XeF) – myopia, hyperopia
- GaAs laser – laser display cursor, laser printer
- GaAlAs laser – CD players, display units
- AlGaInP laser – DVD players
- InGaN laser – Blue-ray disks

Lasers in Medicine

- Ophthalmology:
  - Retinal surgery
  - Treating diabetic retinopathy
  - Removal of secondary cataract
  - Treatment of glaucoma: treatment by cleaning the tear ducts, reducing the ciliary body or creating a hole in the iris
  - Elimination of myopia or hyperopia - photoablation - the use of excimer laser



Lasers in Medicine

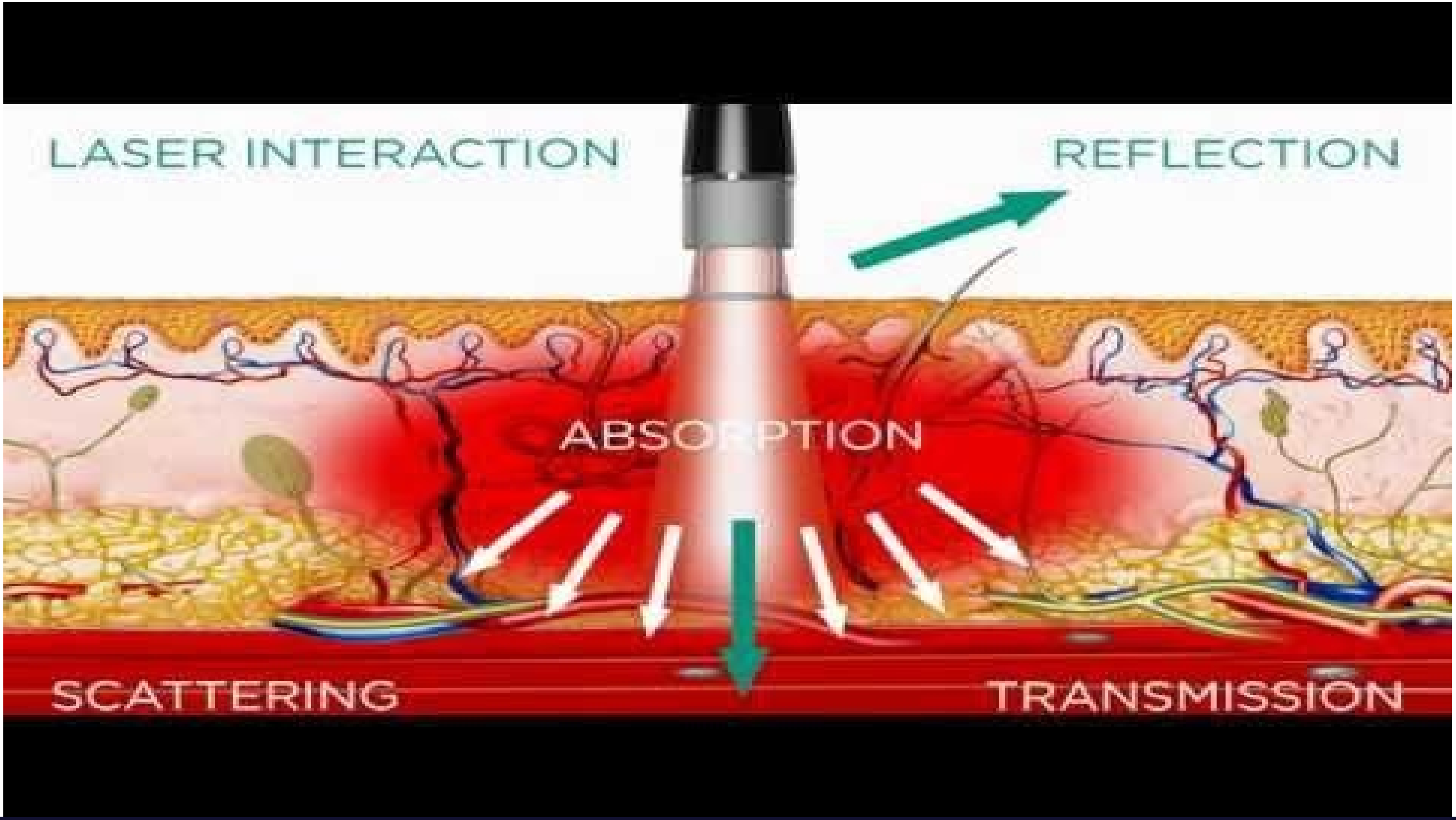
- Dermatology
  - Removal of naevi
  - Removing color tattoos
  - Treatment of red spots or small veins
  - Cosmetic purposes: wrinkle removal, hair removal, hair implantation, laser lipolysis

Lasers in Medicine

- Surgery
  - Nd: YAG or CO2 laser operating in a continuous or pulse mode
  - Advantages of Laser Surgery:
  1) precision without touch,
  2) sharply demarcated cut,
  3) work in a dry surgical field.
  - Disadvantages:
  1) poorer tissue adhesion

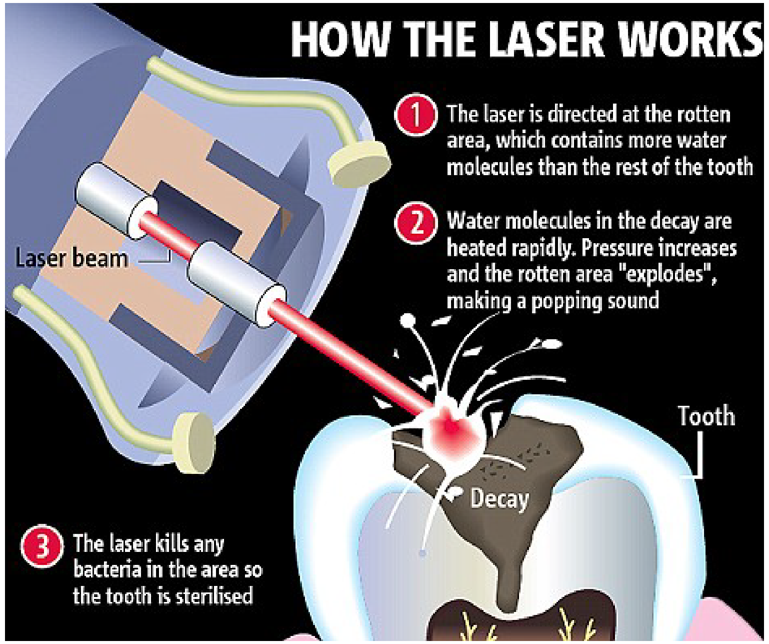
- Cardiology
  1) Heart Surgery: CO2 laser
  2) Angioplasty
  3) Shaping plaque:
     Laser - Argon or Nd: YAG
  4) Removal plaque (ablation):
     Laser - Ho: YAG or excimer laser

Lasers in Medicine



Lasers in Medicine

- Dentistry
  - Biostimulation treatment
  - Laser painless dental drills (Er: YAG laser)



- Photodynamic Therapy (PDT)
  - Non-invasive methods of phototherapy

1) Applying photosensitive substance (the photosensitizer) that accumulates selectively in the fastest proliferating cells (particularly cancer cells)
2) A subsequent irradiation of the tissue with light of such a wavelength that can be absorbed by the photosensitizer.

Laser dental drill

Laser classes

- **Class I** is inherently safe, usually because the light is contained in an enclosure, for example in CD players.
- **Class II** is safe during normal use; usually up to 1 mW power, for example laser pointers.
- **Class IIIa** lasers are usually up to 5 mW and involve a small risk of eye damage within the time of the blink reflex. Staring into such a beam for several seconds is likely to cause damage to a spot on the retina.
- **Class IIIb** can cause immediate eye damage upon exposure.
- **Class IV** lasers can burn skin, and in some cases, even scattered light can cause eye and/or skin damage. Many industrial and scientific lasers are in this class.

Safety risks

- Even low-power lasers (class I, II) with only a few milliwatts of output power can be hazardous to human eyesight when the beam hits the eye directly or after reflection from a shiny surface.
- Powerful lasers (class IV) are cause burn, lacerated or incised wound; eventually cause fire. People working with class IIIb and class IV lasers can protect their eyes with safety goggles which are designed to absorb light of a particular wavelength.
- Series of lasers emit dangerous materials or work with a high electric tension in order tenfold kilovolts.

Prevention and protection

1) Technical solution
    - Laboratory/Room without windows
    - Room without glass or reflective surfaces and objects (mirrors, metal objects etc.)
2) Organizational measures
    - secure entrance
    - instructed personnel
3) Use of personal protective equipment
    - Goggles, gloves

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THANK YOU FOR YOUR ATTENTION

QUESTIONS?

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