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# Occupational diseases caused by physical factors

Noise

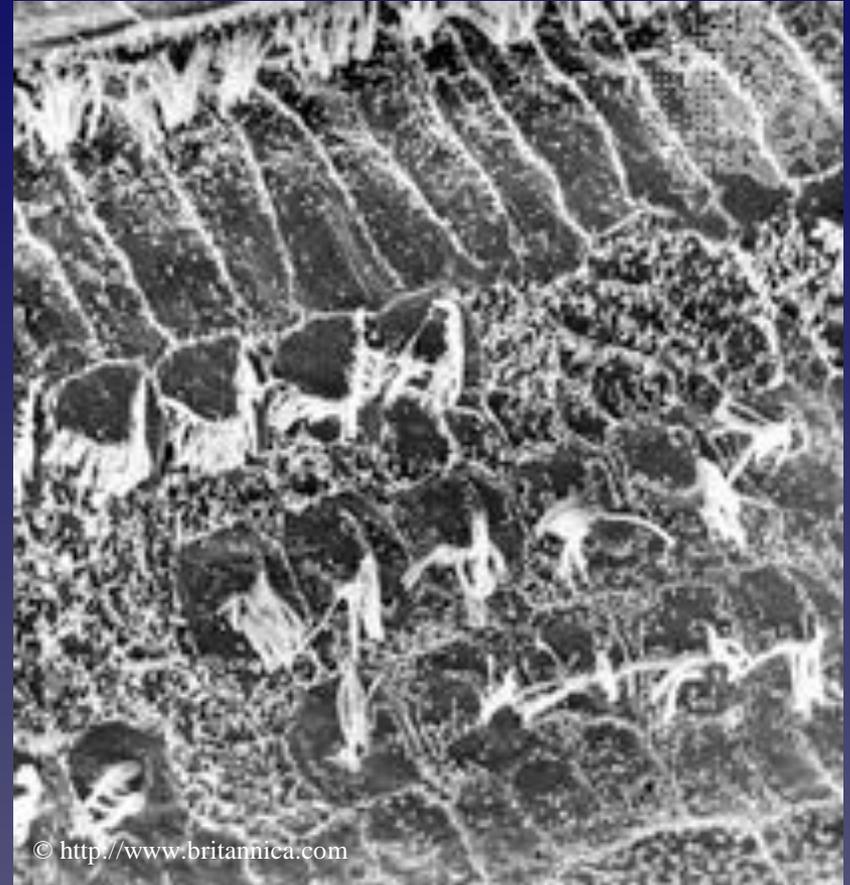
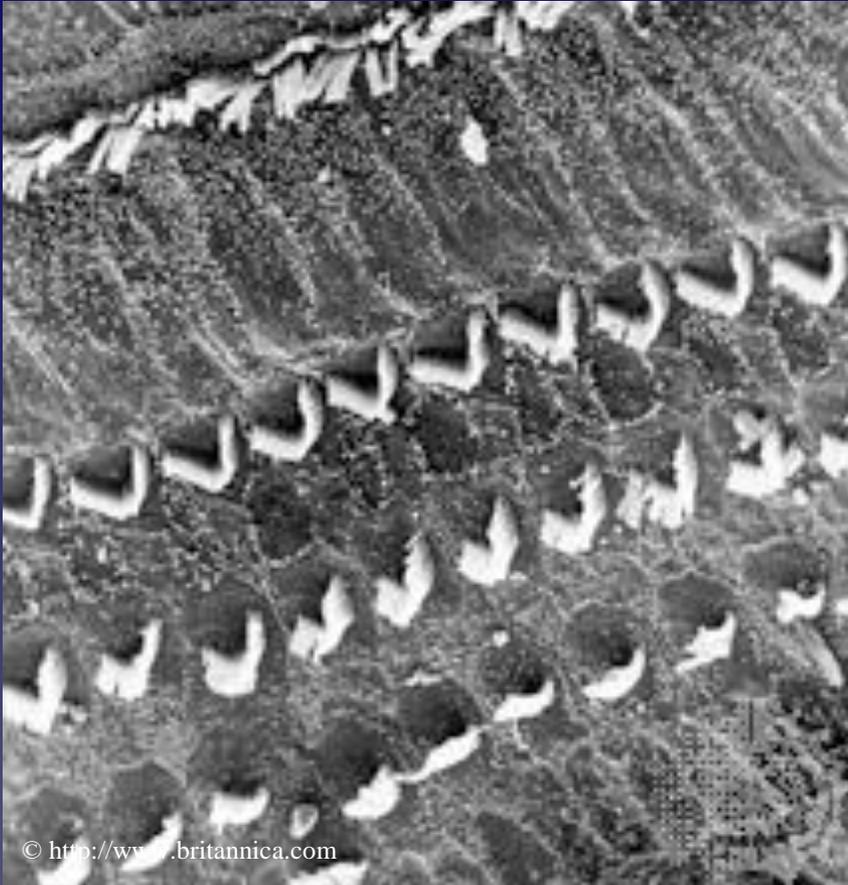
Radiofrequency radiation

Ionizing radiation

# Sound and Noise

- **Characteristics of sound:**
  - Frequency (Hz) – Human cochlea 20 – 20 000 Hz
  - Intensity (sound pressure) (dB) – Human tolerance 0 -120 dB
- **Noise is unpleasant sound, which can damage hearing**
- Sensory hearing loss can be caused by continuous exposure to noise in excess **85 dB**
- **Type of noise**
  - **Non impulse** – stabilized (permanent)
  - **Impulse** – 1 impulse – duration less than 1 sec.
  - **High frequency noise** – 8 – 20 kHz
- **Professional hearing damage**
  - **Acute acoustic trauma** – (gunshot) damage of memb. tympani, structures of vestibule and inner ear
  - **Chronic acoustic trauma** – deterioration of cochlea with loss hair cells from the organ of Corti (occupational hearing loss) + tinnitus

# Occupational hearing loss



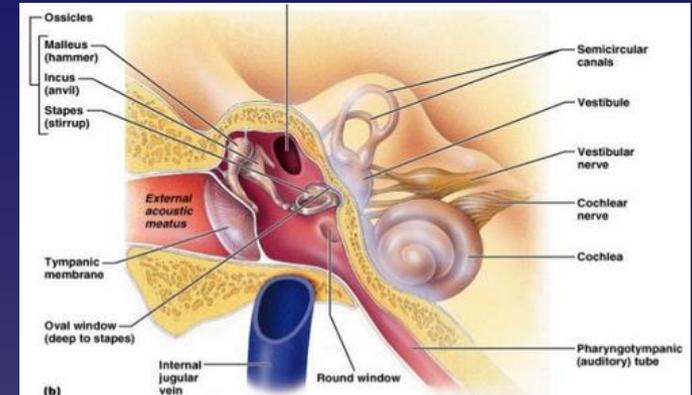
Normal hair cells

Injured hair cells

# Occupational hearing loss

## Conductive hearing loss

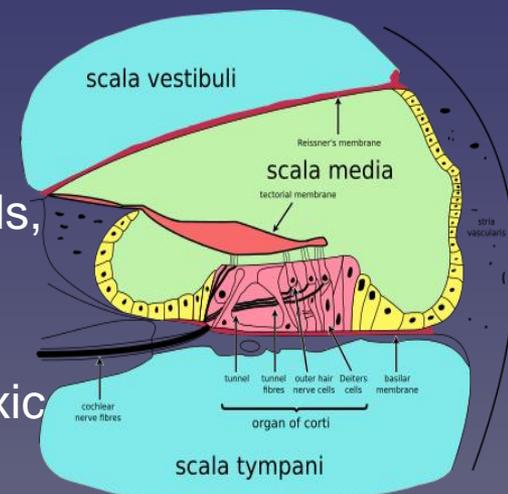
- It is results from dysfunction of external or middle ear
  - Non professional
    - Age – degenerative changes
    - Injury – perforation of eardrum
    - Inflammation middle ear
  - Professional
    - Head injury – blunt, penetrating
    - Explosion, thermal injury ...



© <https://www.toppr.com/ask/content/concept/structure-of-human-ear-201151/>

## Sensoryneural hearing loss

- It is results from dysfunction of the Corti organ
  - Non professional causes of damage
    - Age, infectious disease, damage of blood vessels, Meniere ´ s disease
  - Professional
    - Long-term exposure to noise, exposure to ototoxic substances ...

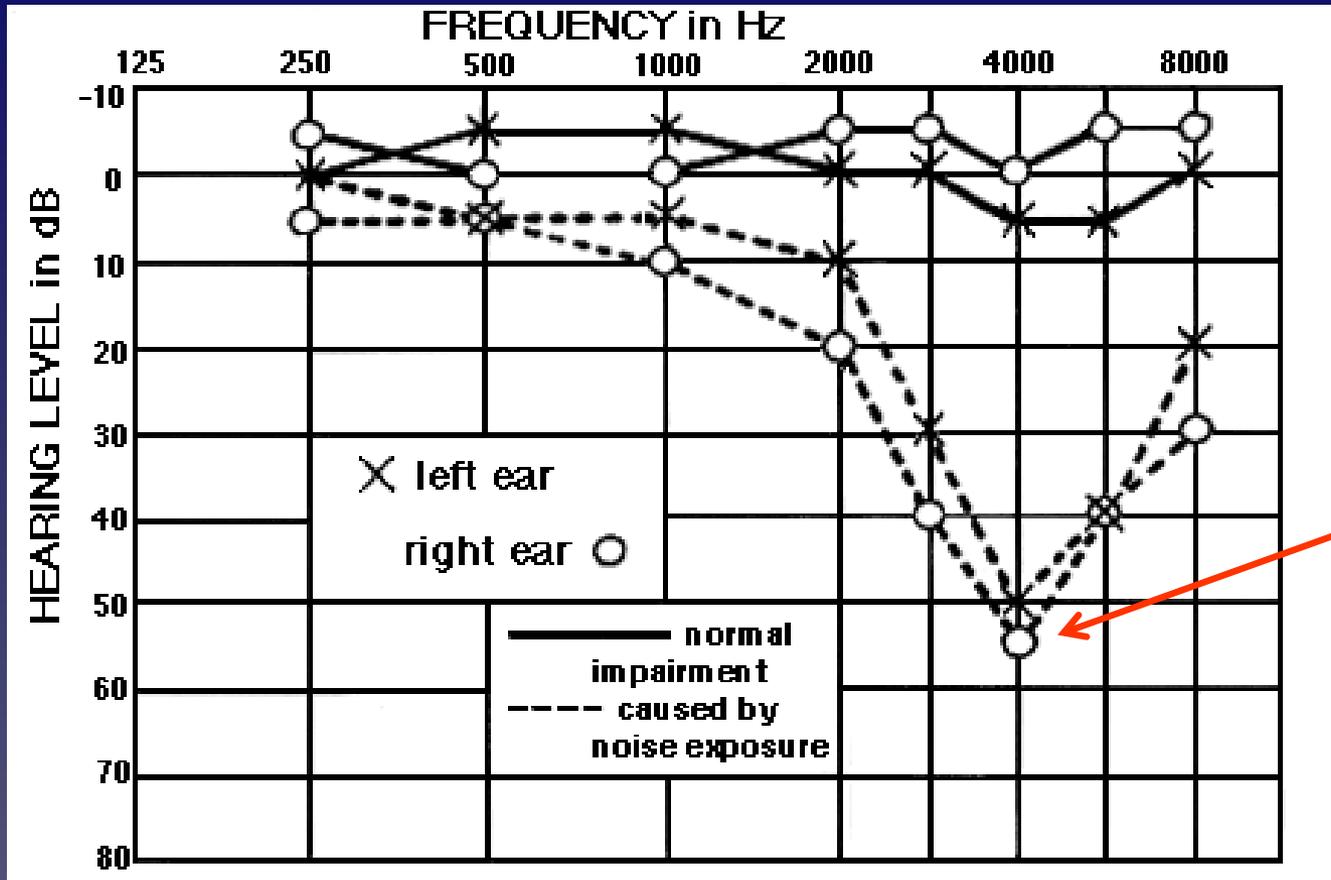


# Occupational hearing loss

## Diagnostic

- Test of spoken words
- Pure tone audiometry
- Evoked response audiometry (Brain stem audiometry)
- Tympanometry
  - Measure impedance of eardrum and ossicular chain
    - Decreasing of response – auditory tube dysfunction
    - Increasing of response
      - Disturbance of tympanic membrane
      - Disruption of ossicular chain

# Occupational hearing loss - audiometry



Physiologic hearing boundary

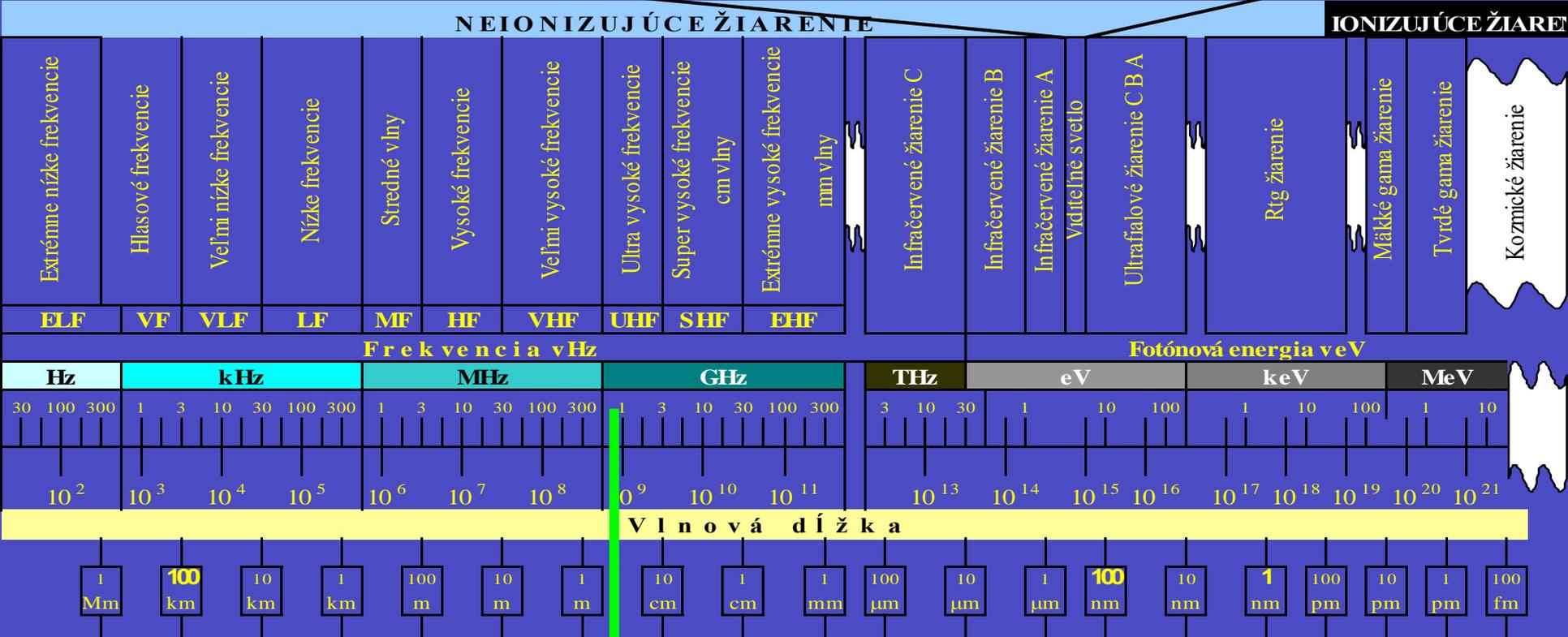
Bilateral decreasing of the hearing boundary on the high frequency 4000 Hz

# Occupational hearing loss

## Treatment - symptomatologic

- Medicaments – aim - increase blood flow to the inner ear and improve the regeneration of the hair cells
  - Hearing amplifiers
  - Tinnitus – **Betahistine**, tinnitus maskers
  - Antihistamines - **Cinnarizine** is an calcium channel blocker - antagonistic action against vasoactive molecules, e.g. histamine, nicotine and reduces the influx of calcium into the cell.
  - Corticoids
  - Hyperbaric oxygenotherapy
  - Vitamins – A, B, C
  - Cochlear implant
  - Psychotherapy
- **Very important and most effective is hearing protection at work**

# Ionizing and nonionizing radiation



**Elektrické**  
- Vedenia  
- Spotrebiče

**Transmitters**



**Radary**  
Mobilné telefóny  
Magnetrony, Klystróny  
Mikrovlné rúry



**Sklárske pece**  
Žiarovky  
Žeravé kovy  
Lasery



**S i n k o**  
Hg výbojky  
Lasery



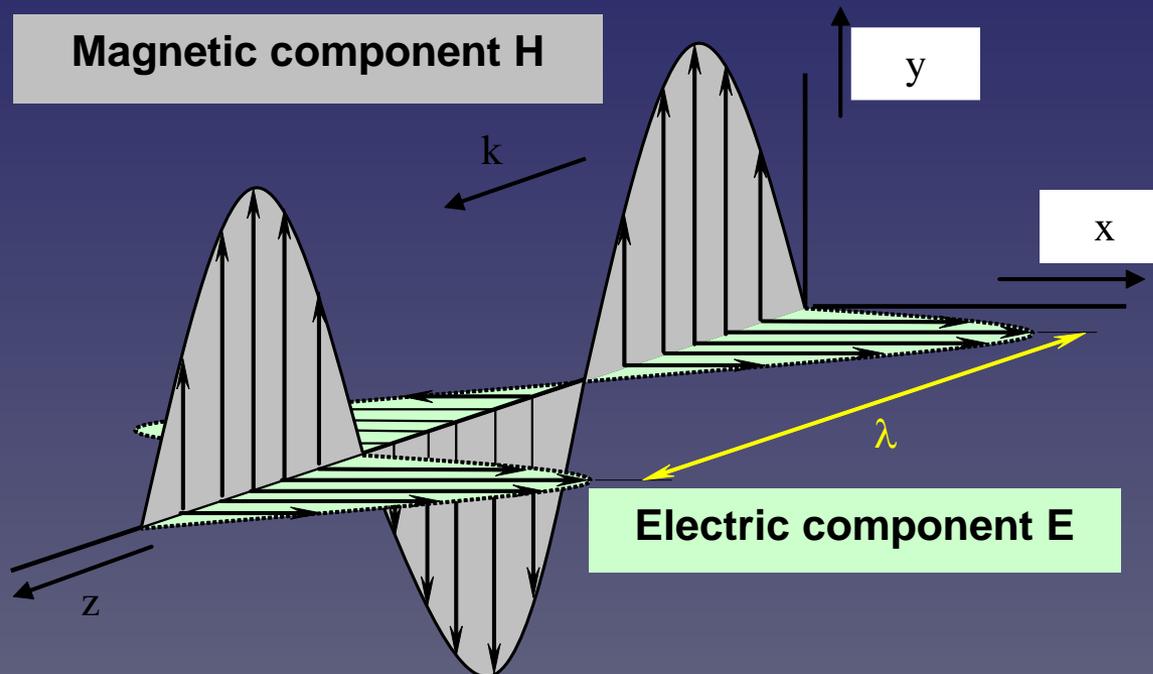
**Rtg lampy**



# Electromagnetic fields (EMFs)

## Non-ionizing radiation (radiofrequency radiation)

- Has insufficient energy to cause molecular ionization
- Can cause vibration and rotation of molecules
- Energy of the field increase temperature inside tissues
- Composed form separate electric and magnetic field, each perpendicular to other



# Sources of Electromagnetic fields (EMFs)

- **Electrostatic fields**
  - production of very good nonconductive isolating materials
- **Electric fields** – very low frequency band
  - Distribution electric lines, home electric distribution points, city electric distribution points, all types of electric appliances
- **Magnetic fields**
  - Industrial electrolysis 20mT, production and installation of magnets, transformers, home electric appliances – about 1 mT
  - Medical applications – MRI (1,5 or 3 T)
- **Electromagnetic fields** – high and very high frequency band
  - Shortwave transmitters – police, firefighters, rescuers
  - Mobile phones, base stations for mobile nets
  - Microwave ovens, Radio locators, Satellite communication systems

# EMFs

- Absorption EMFs depend on:
  - Frequency
  - Power density - increasing power has more serious effects
  - Distance from the source
- Effects on health
  - Thermal – denaturation of proteins, cataract
  - Non thermal – are not scientifically confirmed
    - Possible increasing brain tumours, otoacoustic neurinomes,
    - Leukaemia,
    - Increasing permeability of hematoencephalic barrier
- IARC – Radiofrequency EMFs – 2B: Possibly carcinogenic to humans

## Non thermal effects in band low frequency

- **Phosphens** -- 20 Hz – the visual perceptions – blinking of white light  
Described at magnetic induction 10 – 12 mT or 7 – 70 mA.m<sup>-2</sup>.
  - Phosphens are caused by stimulation of retine, they can by caused by other stimulus – blow to head, pressure, chemical substances
- **Increase of free radicals** – 50 Hz steelworkers (20 V.m<sup>-1</sup>, 2 A.m<sup>-1</sup>, exp. 3 – 10 and more years)
- **Electrochemical potential changes of neurons**
  - Electricians – higher risk senile dementia and demyelination diseases of CNS
- **Vegetative changes** – magnetic fields
  - Capillary vasodilatation, nonspecific change of T wave,
- **Nonspecific stress reaction** of organism at 20 kV.m<sup>-1</sup>

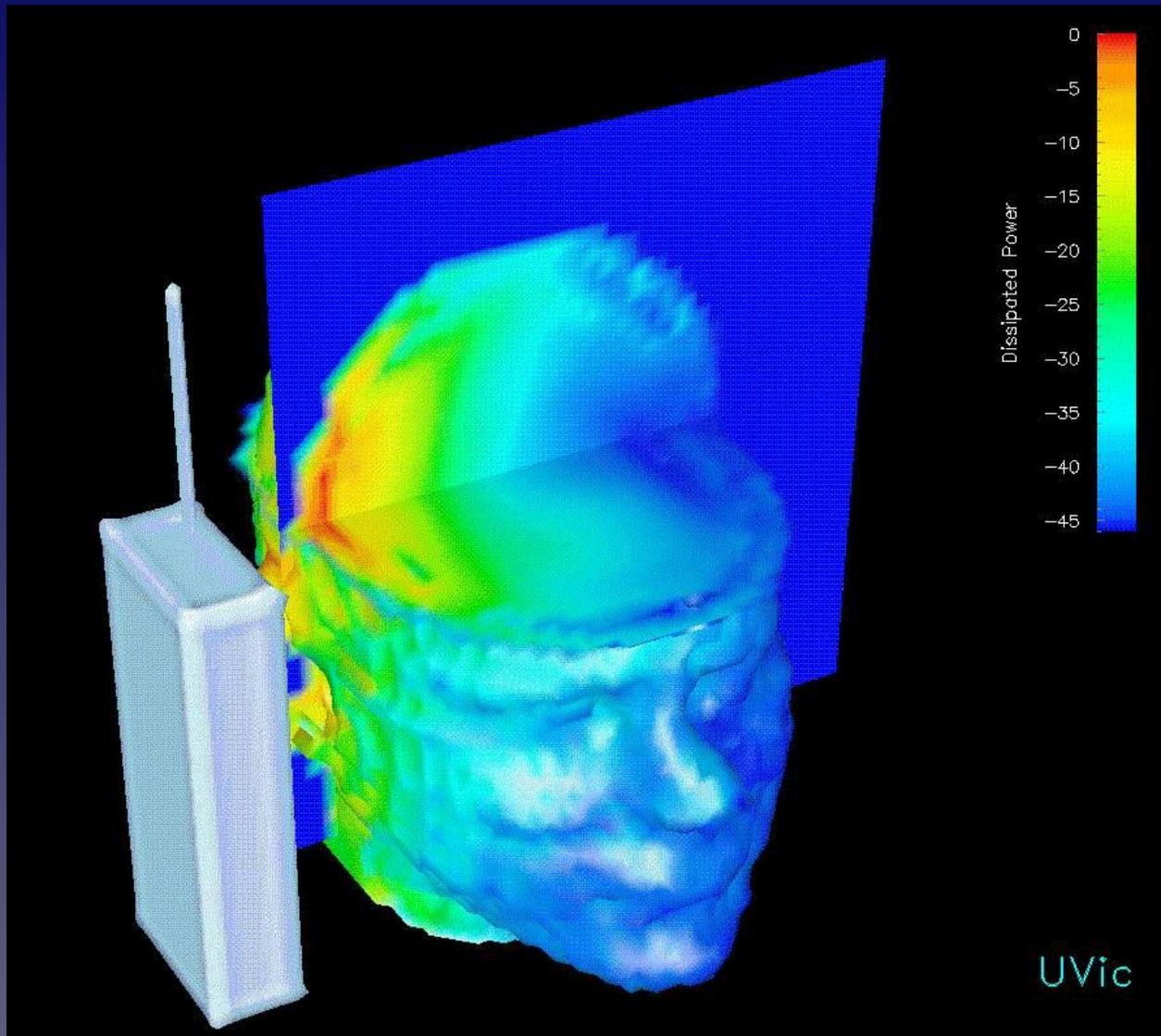
## Most often subjective complains of high voltage power distribution workers in band low frequency

- Exhaustion after work
- Pains of upper extremities
- Concentration disorders
- Sleeping disorders
- Repeated conjunctivitis
- Headaches

# Acute thermal effects of EMFs in hf and vhf bands

- Exposure can be
  - Whole-body
  - Local – head, hand, eyes, chest, abdomen
- Occurrence of symptoms – at power density  $50 - 60 \text{ W.kg}^{-1}$  , after few min exposure
- Clinical symptoms and damages
  - Feeling of heat up to burns
  - Headache, neuralgia of irradiated extremities
  - Vegetative disorders – excessive sweating
  - Edemas of irradiated parts
  - Pains inside abdomen cavity – increase of temperature inside organs with liquid content
  - Cataract – power density more than  $10 \text{ mW.cm}^{-2}$
  - Reversible mans sterility – decreasing number and motility of sperms

# Thermal effect of EMF on CNS a ANS



After exposure 10  
and more min.

Intracranial  
increasing of  
temperature  
about 0,11 °C

## Subjective symptoms users of mobiles phones

Symptoms in Norway population (Ofstedal and all. 2000)	Total No. of probands n = 2828	
	No.	%
Vertigo	228	8,0
Diskomfort	138	4,8
Concentration disorders	127	4,5
Memory disorders	79	2,8
Fatigue	218	7,7
Headache	308	10,9
Sense of warm behind ear	620	21,9
Sense of warm on ear	663	23,4
Sense of skin burning	301	10,6
Ring in ear	145	5,1
Other	78	2,8

## Non-thermal effects of EMFs in band vhf

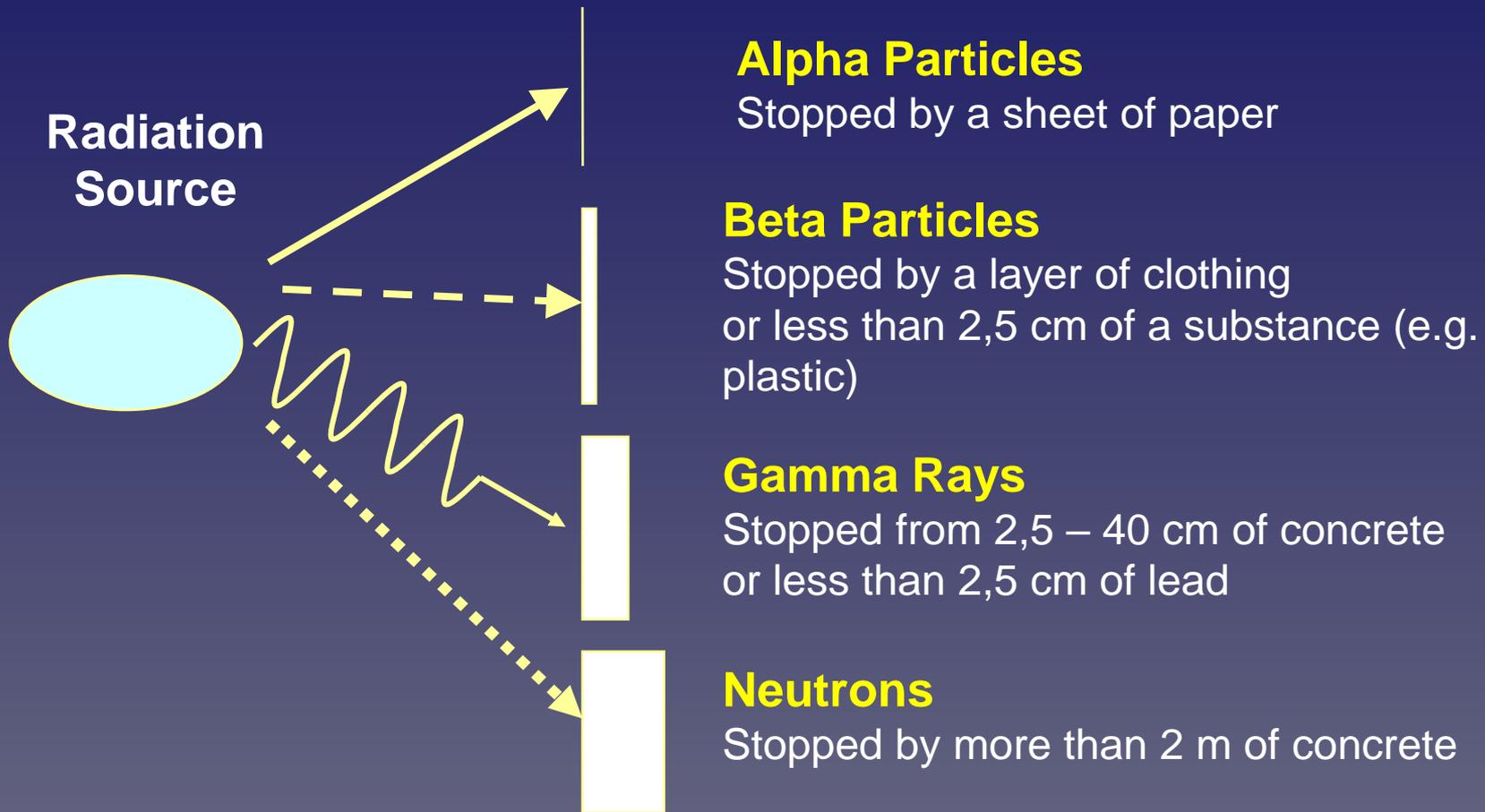
- Changes of permeability hematoencephalic barrier – depend on significant increasing temperature inside tissue at 1800 MHz
- EEG – large scale of changes tendency to increasing of normal activity (900 MHz, 2W, 2x 7,5 min – changes of  $\alpha$  waves)
- Different part of brain has different sensitivity to EMF in band hf and vhf
- Possible stress reactions
- Negative effect on complicated psychical activity – car drivers (900 MHz, 187,5 mW, exp. 5 min.)

# SAR

- **Specific Absorption Rate (SAR)**
  - Amount of power absorbed per mass of tissue
  - Unit - W/kg
- CENELEC (European Committee for Electrotechnical Standardization)
  - max.  $2 \text{ W.kg}^{-1}$
- FCC (USA Federal Communications Commission)
  - max  $1.6 \text{ W.kg}^{-1}$

# Ionizing radiation

Electromagnetic radiation can break atoms or molecules, separate electrons from their orbits



# Radiation units

## The gray (Gy) - absorbed dose

- One joule of radiation energy on one kg of the matter (J/kg)
- It is used as a unit of the quantity radiation absorbed per unit of mass
- The average radiation dose from
  - Abdominal CT scan is .... 8 mGy (0,008 Gy)
  - Pelvic CT scan is ..... 6 mGy

## The sievert (Sv) – dose equivalent

- It is used on the measure of the health effect of low levels of ionizing radiation on the human body.
- Equivalent dose for occupational exposure per 1year is **20mSv**
- Equivalent dose for public exposure per 1year is **1 mSv**

# Ionizing radiation – sources of exposure

- Professions with exposure to Ionizing radiation
  - Radiologists and other technicians
  - Uranium miners and workers,
  - Nuclear power plant operators,
  - Military personal
- **Accidents**
  - Nuclear reactor
  - Medical radiation therapy
  - Industrial irradiators, during transport
- **Terrorist Event**
  - Radiological dispersal device (dirty bomb)
  - Attack on or sabotage of a nuclear facility

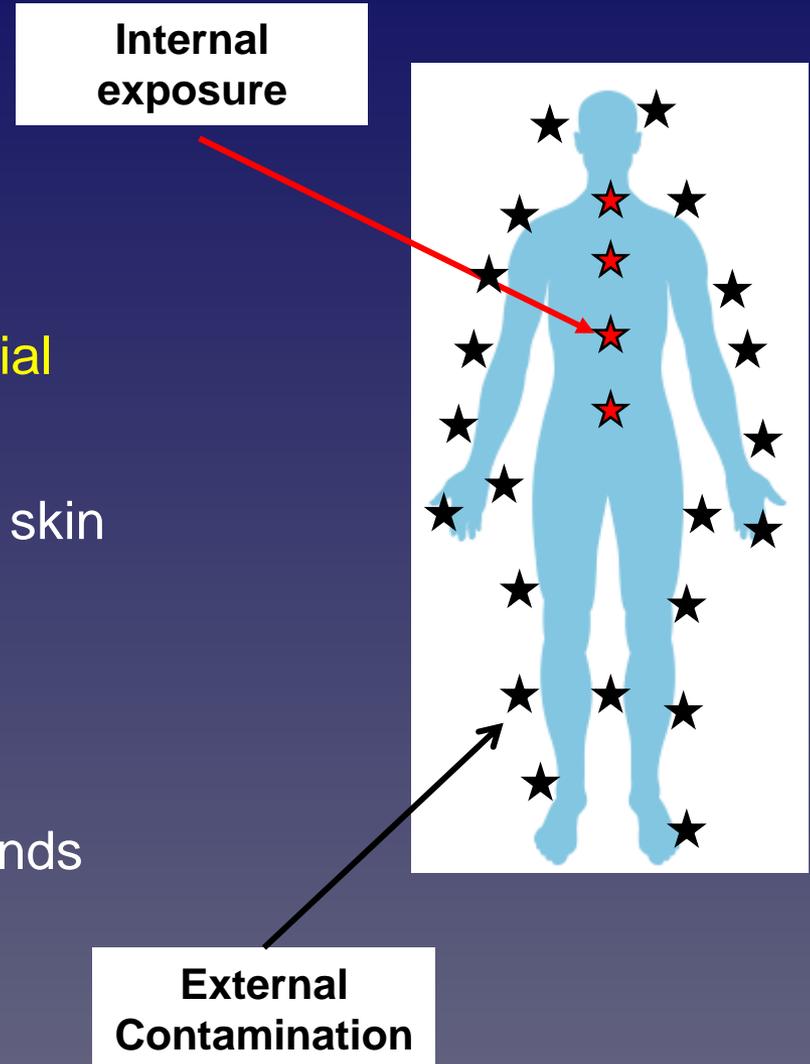
# Types of exposure and contamination

- External exposure to radiation

- x-rays, gama rays, neutrons
  - Whole-body
  - Partial-body

- Contamination – contaminated material

- Alpha, Beta - particles
  - External contamination of the skin
  - Internal contamination
    - ❖ Inhalation – lungs
    - ❖ Consumption – GIT
    - ❖ Absorbtion - through wounds
    - ❖ Radiopharmaceuticals

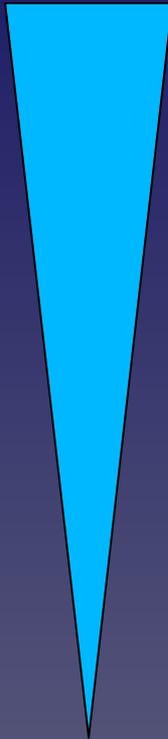


# Ionizing radiation

- Clinical finding depend on: Dose, body distribution, duration of exposure
- Most radiosensitive tissues
  - Reproductive,
  - Hematopoetic
  - Gastrointestinal
- Damage of health
  - Acute radiation syndrome
  - Delayed effects
    - Cancer of bone, thyroid gl., lung, liver, leukemia
    - Reproductive and teratogenic abnormalities

# Sensitivity of cells to Ionizing Radiation

**Highly Sensitive**



**Least Sensitive**

Mature lymphocytes  
Erythroblasts  
Certain spermatogonia  
Myeloblasts  
Intestinal crypt cells  
Basal cells  
Endothelial cells  
Gastric gland cells  
Osteoblasts  
Spermatozoa  
Erythrocytes  
Fibrocytes  
Chondrocytes  
Muscle Cells  
Nerve Cells

# Phases of Acute radiation syndrome

**Exposure**



**Time (days to years)**



	<b>Prodromal phase</b>	<b>Latent phase</b>	<b>Manifest illness</b>	<b>Recovery</b>
<b>Symptoms</b>	Anorexia, nausea, vomiting, headache, diarrhea, dehydration, fatigue, arrytmia, fever, hypotension ...	Period of relative better health state	Fatigue, weaknes, ataxia, fever, arrythmia, diarhea, weight loss, hair loss, ileus, disorientation, convulsions, coma, shock ...	After irradiation up to 6 Gy the prognosis is relatively good with the right treatment

# Prodromal phase and exposure dose

Symptom	Mild (1-2 Gy)	Moderate (2-4 Gy)	Severe (4-6 Gy)	Very severe (6-8 Gy)	Lethal (> 8 Gy)
Vomiting	2 hours or later after exposure (Rate of incidence) Up to 50%	1 to 2 hours 70 to 90%	Within 1 hour 100%	Within 30 minutes 100%	Within 10 minutes 100%
Diarrhea	None	None	Moderate	Severe	Severe
Headache	Very mild	Mild	Moderate	Severe	Severe
Consciousness	Unaffected	Unaffected	Unaffected	Affected	Loss of consciousness
Body temperature	Normal	Slight fever	Fever	High fever	High fever

Gy: Grays

Source: Prepared based on IAEA Safety Reports Series No.2 "Diagnosis and Treatment of Radiation Injuries" (1998)

# Acute Radiation Syndrome

## Absorbed dose: to 0,25 Gy

- No symptoms or minimal viral symptoms for up to 48 hours
- Spontaneous recovery usually occurs
- Sterility is a risk

## Absorbed dose: 0,25 – 2 Gy – Mild hematopoietic syndrome

- **Prodromal phase** –after more than 2 hours - vomiting
- **Latent phase** – 21 – 35 days
- **Manifest phase** - start from 5 - 8 week after exposure
  - Bone marrow suppression occurs with loss of WBC (lymphocytes earliest) and platelets
  - Infection and bleeding problems occur
  - Haemorrhagic anemia

# Acute Radiation Syndrome

Absorbed dose: 2 - 6 Gy Severe hematopoietic syndrome

- **Prodromal phase** – after 1 - 2 hours - nausea, vomiting, headache, increase body temperature
- **Latent phase** – 8 – 28 days
- **Manifest phase** – 8 – 18 days after prodromes
  - Anorexia, Fever, Malaise, Weakness, Bleeding, Infection, hair lost, Nausea, vomiting, strong diarrhea, alteration, coma
  - Life saving bone marrow transplantation needed
- ❖ **Lethality** – 20 - 70% of irradiated persons - beginning at 4-8 weeks

# Acute Radiation Syndrome

Absorbed dose: 6 – 8 Gy

## Hematopoietic + Gastrointestinal syndrome

- **Prodromal phase** – 30 min after exposure
- **Latent phase** – less than 7 days
- **Manifest phase** – less than 7 days after prodromes
  - Small bowel - main organ affected, GI lining cells die
  - Anorexia, Fever, Malaise, Weakness, Bleeding, infection, hair is lost by day 11, Nausea, Vomiting, Diarrhea: common by day 6-9; more severe with increased dose from exposure, Disorientation, Hypotension, Electrolyte losses
  - Life saving fluid and electrolyte replacement
- ❖ **Lethality** – 50% of irradiated persons can occur 7 – 14 day after irradiation

# Acute Radiation Syndrome

Absorbed dose: more than 8 Gy

Hematopoietic + gastrointestinal + neurovascular syndromes

- **Prodromal phase** – 10 min. after exposure
- **Latent phase** – rapid progress to manifest phase
- **Manifest phase** – Immediate
  - Anorexia, Fever, Malaise, Weakness, Bleeding, Infection, Hair loss, Nausea, Vomiting, Diarrhea - common by day 4-5; severe, profuse, bloody, Seizures, impaired level of consciousness, Hypotension
- **Lethality** - within 1-2 weeks without aggressive supportive care

# ARS - Treatment

## 1. Initial Assessment and Decontamination

- **Decontamination** is the first step if there is any risk of ongoing radiation exposure. This involves removing clothing, cleaning the skin, and possibly administering agents that bind to radioactive isotopes to reduce further radiation absorption.
- **Monitoring radiation dose:** Determining the level of exposure using dosimeters and blood tests (such as lymphocyte count) is essential for assessing the severity of ARS and guiding treatment decisions.

## 2. Symptomatic Management and Supportive Care

- **Fluid and electrolyte management:** Patients with ARS often are vomiting and diarrhea, leading to dehydration and electrolyte imbalances. Immediate rehydration and electrolyte replacement is crucial.
- **Pain management:** Severe burns or injuries may occur, analgesics and possibly more intensive care like burn treatment.
- **Blood pressure and cardiovascular support:** Severe radiation exposure can lead to shock or cardiovascular collapse

# ARS - Treatment

## 3. Infection Control

- **Immune system damage:** The bone marrow, which produces white blood cells, is highly sensitive to radiation. Severe damage to the immune system is reason of high risk for infections.
- **Antibiotics, antivirals, and antifungals** - especially if white blood cell counts are critically low.
- **Reverse isolation:** Patients may need to be placed in a sterile environment to minimize exposure to infectious agents while their immune system is compromised.

## 4. Bone Marrow and Blood Support

- **Hematopoietic growth factors:** granulocyte colony-stimulating factor (**G-CSF**) and granulocyte-macrophage colony-stimulating factor (**GM-CSF**)
- **Blood transfusions**
- **Stem cell or bone marrow transplant**

# ARS - Treatment

## 5. Treatment of Gastrointestinal and Neurovascular Syndromes

- **Gastrointestinal (GI) symptoms:** In moderate to severe ARS cases, the intestinal lining can be damaged, causing nausea, vomiting, diarrhea, and bleeding. Anti-nausea medications and agents to protect the gut lining are given to reduce symptoms and promote healing.
- **Neurovascular support:** anticonvulsants, monitoring for brain swelling and intensive care management.

## 6. Psychological Support

- **Trauma and stress management** - psychological support and medications  
anxiolytics, antidepressants

## 7. Long-term Monitoring and Recovery

- **Late effects of radiation exposure** long-term complications - cataracts, infertility, increase risk of cancers (especially leukemia or thyroid cancer).
- **Rehabilitation** - physical therapy, nutritional support and rehabilitation