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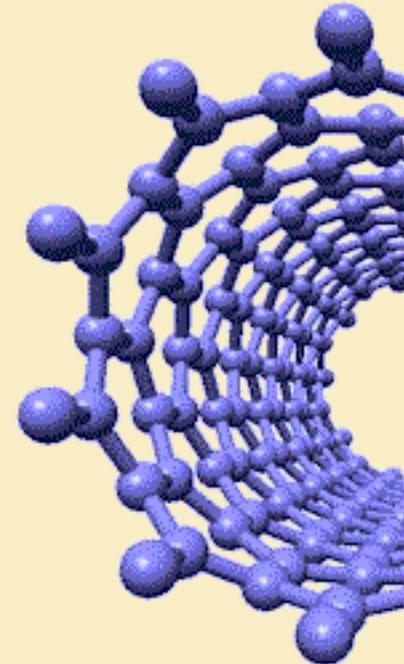
OP Education  
for Competitiveness

INVESTMENTS IN EDUCATION DEVELOPMENT

# Innovation and Development of Study Field Nanomaterials at the Technical University of Liberec

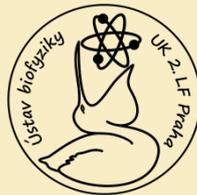
[nano.tul.cz](http://nano.tul.cz)

These materials have been developed within the ESF  
project: Innovation and development of study field  
Nanomaterials at the Technical University of Liberec



TECHNICAL UNIVERSITY OF LIBEREC  
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# THERMOGRAPHY



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## Essential control mechanisms for organism temperature decrease

- vasodilatation
- perceptible sweating
- reduction of heat production

## Essential control mechanisms for organism temperature increase

- vasoconstriction
- increased heat production – muscular shivering - tremor
- metabolism increase
- „goose skin“
  
- fever – higher temperature is set at thermoregulating centre (pyrogenous substances)



# TEMPERATURE MEASUREMENT

## Temperature

**Describes the state of the organism as a biological system  
Of high significance, easily detectable symptom**

- thermometry, thermography
- invasive methods
- non-invasive methods
  - contact
  - non-contact

## Thermometry

- based on thermal expansivity of materials (length for solids, volume for liquids)
- metallic resistance thermometers
- thermocouple thermometry
- thermistor thermometry
- special thermometry



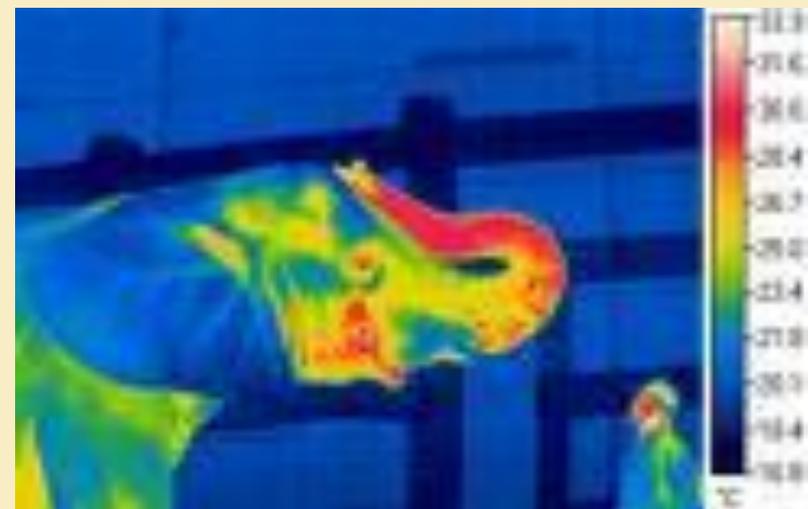
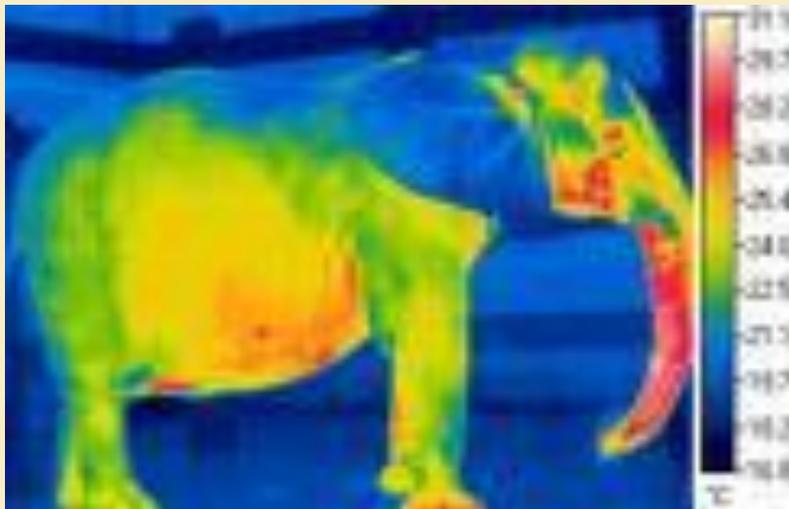
# TEMPERATURE MEASUREMENT

<i>Type of thermometer</i>	<i>principle</i>
clinical thermometer (mercurial) bimetallic thermometers	thermal expansivity of materials
metallic resistance thermometer	dependence of electrical conductivity of materials on temperature
Thermocouple (precise, possibility of miniaturization, also for invasive measurements)	circuit composed of wires from two different metals; different temperatures of interfaces cause electric current
Thermistor (precise, e.g. in a form of needle, thermistor on the top)	dependence of electrical properties of semiconductor on temperature
Optical thermal sensors	e.g. dependence of afterglow of phosphorescent substance on temperature

# THERMOGRAPHY

**Imaging method – for graphical representation of distribution of surface temperature of the examined object**

- **contactless**
- **contact**





# THERMOGRAPHY

## CONTACTLESS

detection of thermal radiation, predominant wavelength

- optical system focusing radiation on scanning elements
- scanning element converts the incident radiation into the electrical signal (based on photoemission)
  
- radiothermometer – determines temperature of a given point (place)
- pyrometer
- thermocamera – thermogram (image in virtual colors, different colors assigned to different temperatures)

# THERMOGRAPHY

## CONTACT

- utilizing liquid crystal substance between a solid and liquid; no isotropic arrangement, optical and electromagnetic properties of solids; cholesteric phase – molecules arranged into layers, majority of one orientation along rod axis
- dependence of liquid-crystal color on temperature to spiral angle; spiral angle depends on temperature

## Versions

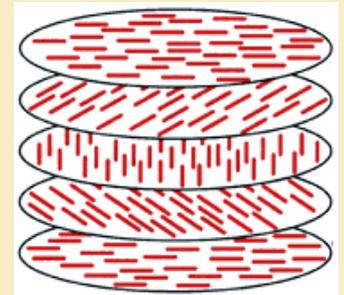
spray or thermographic plate

## Thermographic device

light source

thermographic plate

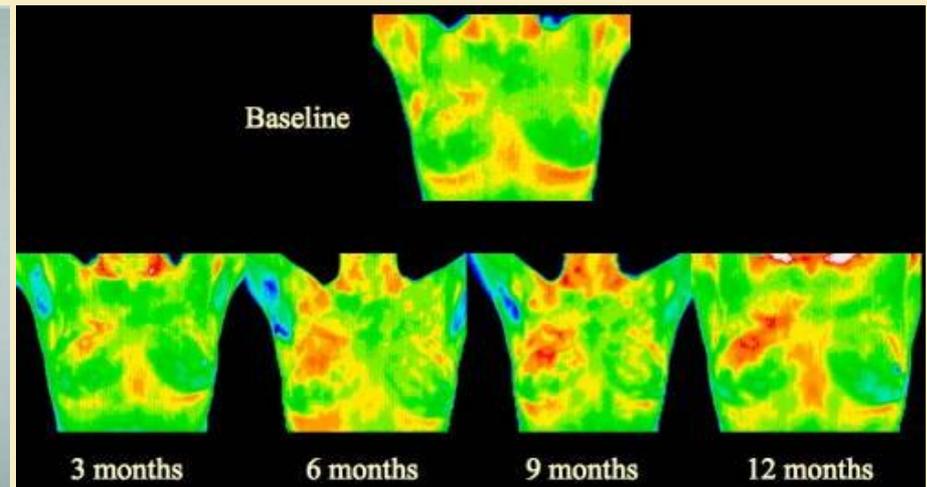
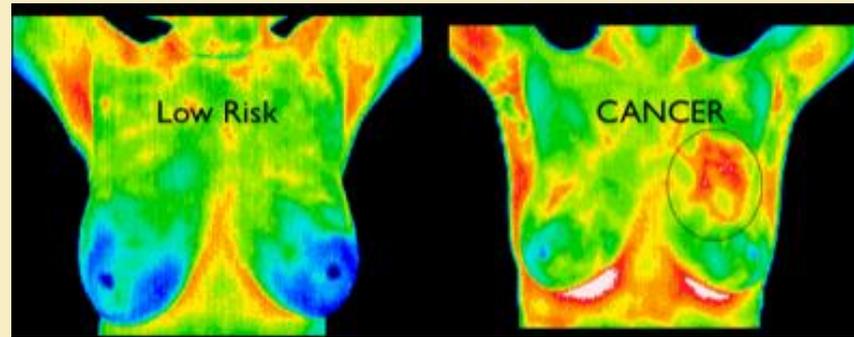
recording device (camera)



# THERMOGRAPHY

## APPLICATION

diagnostics of pathological changes that manifest themselves by temperature deviations of body surface (inflammations, vascular disorders, cancers in the proximity of body surface)





# THERMOTHERAPY

Process, during which the heat is  
bringing into the organism (positive thermotherapy)  
deflected from (negative thermotherapy) the organism





# INFLUENCE OF HIGH TEMPERATURES ON HUMAN ORGANISM

**positive thermotherapy** (physiotherapy, balneology)

local therapy (parafine packs, compresses, limb baths)

whole-body therapy (baths, packs, saunas ...)

**applied temperature** must be adjusted according to health conditions and habit

important is **body surface**

**limit of thermal tolerance** – from ~ 42 °C for whole-body bath up to ~ 130 °C in sauna (depends on humidity, i.e. thermal conductivity of surrounding air)



# HYPERTHERMIA

Utilization of the secondary effect of microwaves, ultrasound or laser in conjunct therapy of tumor disease

- low-temperature (heating of tissues up to 39°C)
- high-temperature (heating of tissues to 41-45°C, 45-60 minutes)

Temperature increase – collapse of blood circulation of the tumor

- low heat sink
- deficit of oxygen and nutrients
- increased acidity

warming-up by microwave (ultrasonic) source with simultaneously measured temperature in irradiated range (in case of surface hyperthermia e.g. by thermistor, non-invasive deep measurement is a subject of research work at present time)

according to the temperature heating-up power is controlled

- relatively cheap method
- well-tolerated by patients with minimum amount of adverse effects
- generally improves surviving of patients

# HYPERTHERMIA

- Ionizing radiation destroys DNA of the cancer cell, heating prevents reparation
- Blood-flow increase leads to higher absorption of active substances
- Encapsulated substances (into liposomes) released by hyperthermia in the tumor – limitation of side-effects

## Methods

- Local hyperthermia
- Regional hyperthermia
- Whole-body hyperthermia





# Mechanism of the effect

## 1. physical level

damage to the tumor tissue by heat; contrary to surrounding health tissue, the tumor tissue is usually not able to take the heat off by blood circulation

## 2. DNA reparation

experimentally confirmed that hyperthermia increases number of unrepaired DNA breaks induced by radiation

## 3. immunologic level

a response to thermal stress stimuli is production of „heat-shock“ proteins - assist regeneration of the tissue impaired by the heat (undesirable in this case) and – in the case of fail – it initiates immunity response (desirable)

Damage to the tumor tissue described in (1) occurs especially in the case of hypoxic tumors. Also in the case of relatively well-perfused tumors, usage of hyperthermia is reasonable with respect to (2) and (3).

# Therapy



## Usual sequence of combined therapy

chemotherapy, (radiotherapy), hyperthermia

## Clinical usage

### surface (superficial)

tumors of head and neck, breast (recurrence on chest wall),  
ganglionic processes in axilla, inguinal region, limb sarcomas

### in-depth (regional) –

pelvis (rectum, cervix)

### interstitial a intercavity

head, neck and pharynx

## In the phase of research

regional hyperthermia

heat-labile polymers as carriers of chemotherapy



# INFLUENCE OF LOW TEMPERATURES ON HUMAN ORGANISM

## **Extremely low temperatures**

also in case of very good thermal insulation by wear, energy loss are caused by expired air

## **Local effect of cold**

tissue freezing (sensitive large-surface tissues – ears, fingers)  
impaired cellular structure of tissue and peripheral blood circulation (perniosis)

## **Effect of cold on whole body**

hypothermia (overcooling) of peripheral layers, later also deeper located organs  
at the beginning, changes in blood circulation, accelerated pulse (tachycardia), later deacceleration, general attenuation, changes in the function of CNS; decrease under 20 °C causes death for a human organism



# Cryotherapy

**Cryotherapy (Cold Therapy) – the local or general use of low temperatures in medical therapy or the removal of heat from a body part.**

from the Greek **cryo** (κρυο) meaning *cold* and the word **therapy** (θεραπεία) meaning *cure*

It has been around since the 1880-1890s

- to decrease cellular metabolism
- increase cellular survival
- decrease inflammation
- decrease pain and spasm
- promote vasoconstriction
- destroy cells by crystallizing the cytosol (extreme temperatures)

# Application in medicine – cryotherapy



**anesthesia** – local application of liquids with high heat of vaporization

**patient cooling** – tumor treatment

**hypothermic temperatures while surgery** (limit  $-3\text{ }^{\circ}\text{C}$ ) – substantially lower consumption of oxygen by brain at temperatures lower than  $30\text{ }^{\circ}\text{C}$  the thermoregulating mechanisms are eliminated (functionless)

**surgery** – tissue fixation by congelation

**cryosurgery** – destroying pathological tissue by deeply frozen probe (liquid nitrogen)

**pain silencing** –  $4\text{--}5\text{ }^{\circ}\text{C}$  (local)

**ice pack therapy** – treatment of cold temperatures to an injured area of the body

immediate vasoconstriction with reflexive vasodilation, decreased local metabolism and enzymatic activity, and decreased oxygen demand; decreases muscle spindle fiber activity and slows nerve conduction velocity; used to alleviate the pain of minor injuries

**short-term conservation** –  $\sim 4^{\circ}\text{C}$  (blood, serum, cells, organs)

**cryothermia** – freezers  $\sim 250\text{ K}$ , sublimating  $\text{CO}_2$   $195\text{ K}$ , liquid nitrogen  $77\text{ K}$

**long-term conservation of cells** – use of cryoprotectives (glycerol)

**hibernation** – animals



# Cryogenic chamber therapy

**treatment whereby the patient is placed in a cryogenic chamber for a short duration (i.e. no more than three minutes, which is comparable to ice swimming), and if used properly, will not destroy tissue.**

**chamber** is cooled, typically with liquid nitrogen, to a temperature of  $-110\text{ }^{\circ}\text{C}$ .

**patient** protected from acute frostbite with socks, gloves and mouth and ear protection, wears bathing suit. The patient spends a few minutes in the chamber.

During **treatment** the average skin temperature drops to  $12\text{ }^{\circ}\text{C}$ , while the coldest skin temperature can be  $5\text{ }^{\circ}\text{C}$ . The core body temperature remains unchanged during the treatment, it may drop slightly afterwards. Therapy triggers the release of **endorphins** which induce **analgesia** (immediate pain relief).

Patients report that the experience is invigorating and improves a variety of conditions such as psychological stress, insomnia, rheumatism, muscle and joint pain, fibromyalgia, itching, and psoriasis. The immediate effect of skin cooling and analgesia lasts for 5 minutes, but the release of endorphines can have a lasting effect, where the pains and signs of inflammation as found in blood tests remain suppressed for weeks.