The conservation of cultural heritage artefacts made of textile by irradiation

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Conference:
The most important procedures in preservation and state enhancement of historical textiles, 24–26 Nov. 2008., Mimara Museum, Zagreb, Croatia
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with the support of the Ministry of Culture of the Republic of Croatia.

The deterioration of cultural heritage objects

- natural aging through the processes of:

Biological deterioriation

- Insects
- Fungi
- Bacteria
- Algae

Mechanical deterioriation

- rubbing, shock, vibration
- wind, waves
- water (swelling)

Chemical deterioriation

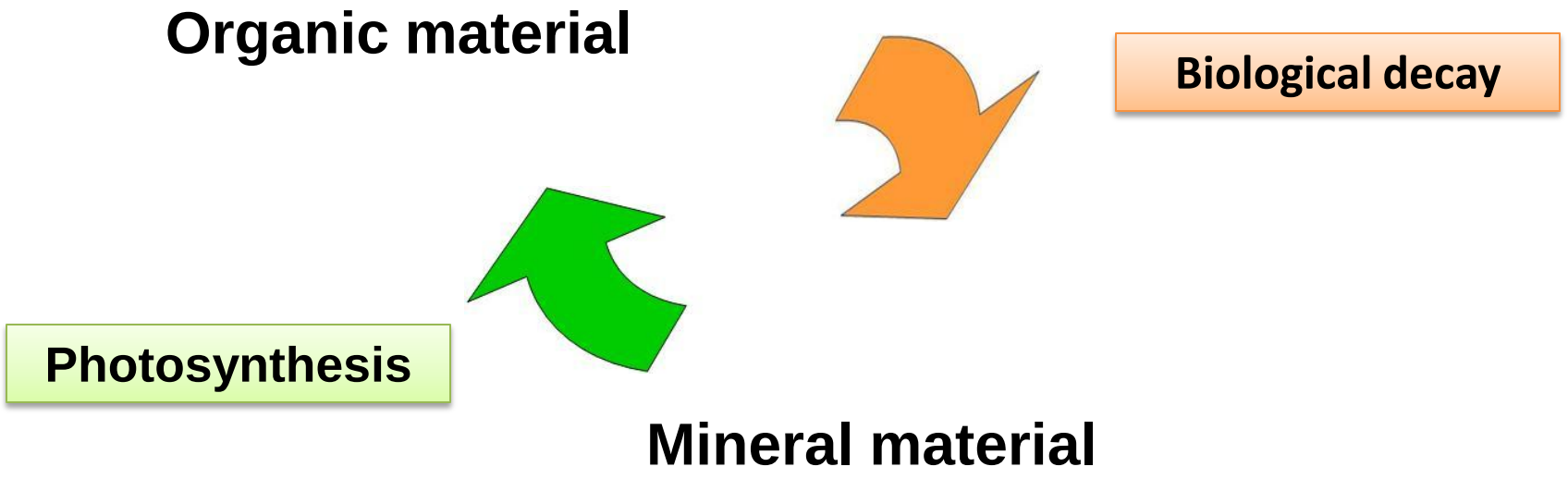
- Thermal aging
- Pollution
- pH
- Water (hydrolysis)
- Photo-aging (UV, visible)

Biodeterioration of cultural heritage objects of organic origin

Materials of organic origin: textile, wood, paper, leather, etc.

- readily attacked by biodeteriorants: insects, fungi, yeasts, molds, bacteria, etc., which thrive and feed on these materials

- Biodeterioration is a natural process in which the metabolic activity connected with the growth of living organisms maintains the equilibrium in the “matter transformation cycles”



Biodeteriorants in textile of the vegetal origin

Cotton, flax, hemp, jute and sisal

- mainly composed of cellulose derived from plant fibres

Biodeteriorants in the degradation of vegetal fabrics:

- fungi, the most active agents; the fungal genera *Chaetomium, Myrothecium, Memnoniella, Stachybotrys, Verticillium, Alternaria, Trichoderma, Penicillium and Aspergillus.*
- Bacteria, of lesser significance,

  mainly the *genera Cytophaga, Cellulomonas, Cellvibrio, Bacillus, Clostridium and Sporocytophaga.*
- Insects, the main families involved in textile biodeterioration are *Blattidae* (cockroaches), *Lepismatidae (*silverfish) *and Mastotermitidae, Hodotermitidae, Rhinotermitidae)* (termites)

Biodeteriorants in textile of the animal origin

Wool:

- keratinolytic bacteria, the most frequent agents, especially of the genus *Bacillus (B. Mesenthericus & B. subtilis), Proteus (P. vulgaris)* and some species of Actinomycetes (*Streptomyces albus & Streptomyces fradiae), Pseudomonas aeruginosa*
- fungi, not very frequently involved, but reported those of the genera *Trichophyton, Fusarium, Chaetomium, Aspergillus*
- insects, cause the most serious damage of animal-derived textiles in museums; families: *Dermestidae, Oecophoridae* (brown house moth) & *Tineidae* (cloth moth), also *Tinea pellionella, T bisselliella & Hofmannophila pseudospretella,*

Silk :

- bacteria, predominantly: *B. Megaterium, Pseudomonas, Serratia, Streptomyces , Ps. Cepacia*
- insects, cause the most serious damage in e.g. wool

Casemaking cloth moth; ***Tinea pellionella***

Adults - do not feed

Larvae - feed on textile fibers, responsible for their destruction

Effects of biodeterioration on textiles

Biodeteriorants afect all stages of textile processing and storage causing:

- discolouration,
- changes in appearance,
- loss of strength and elongation
- partial or total destruction of the material

with underlying chemical changes:

- oxidation state,
- degree of polymerization,
- breakdown of molecular structure.

Control methods of textile biodeterioration

Textile objects are usually kept in confined environments in museums

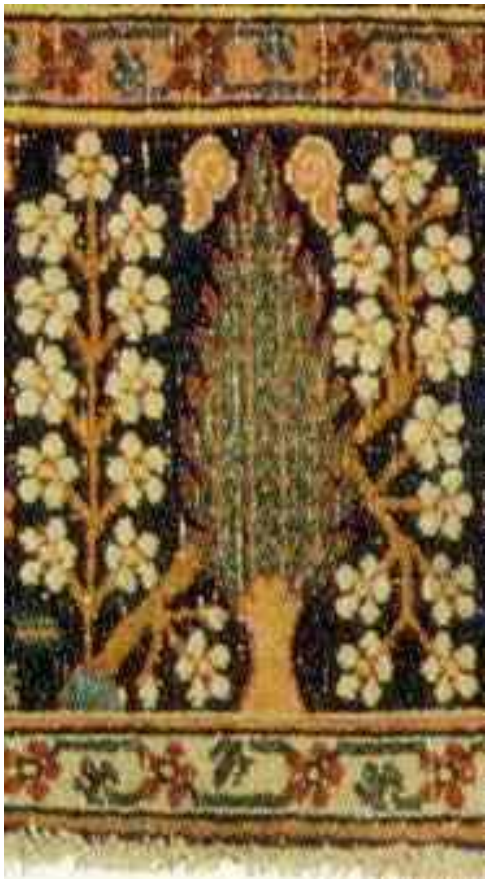
- **preventive treatment**, indirect methods:
  maintenance of proper conservation conditions: humidity, temp.,etc.

- **curative methods**, when biological attack occured
  the choice of the most suitable method with regard to:

- material condition
- type of pest to be treated and its life cycle
- the lowest environmental impact

Textile conservation methods

- most often used: chemical method,
  - fumigation with poisonous gases, (phased out);
  - replacement with inert gases
- emerging methods: physical methods
  - irradiation treatment

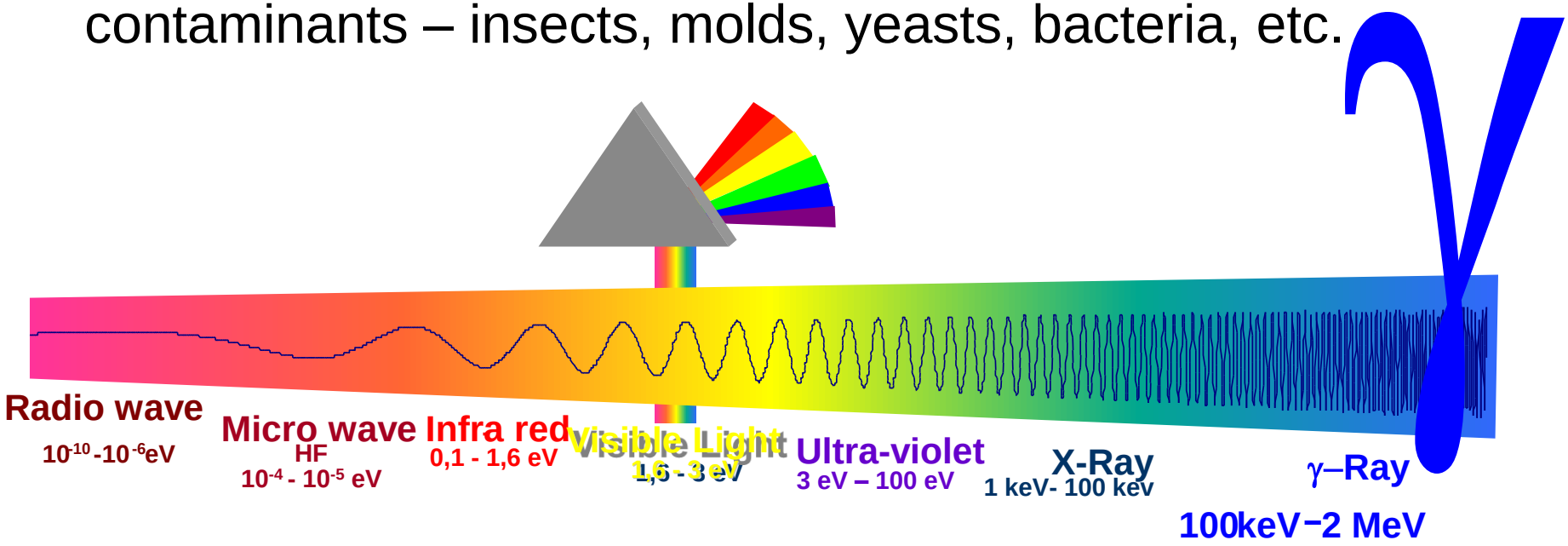


Radiation method for disinfestation

Physical method, based on the ability of

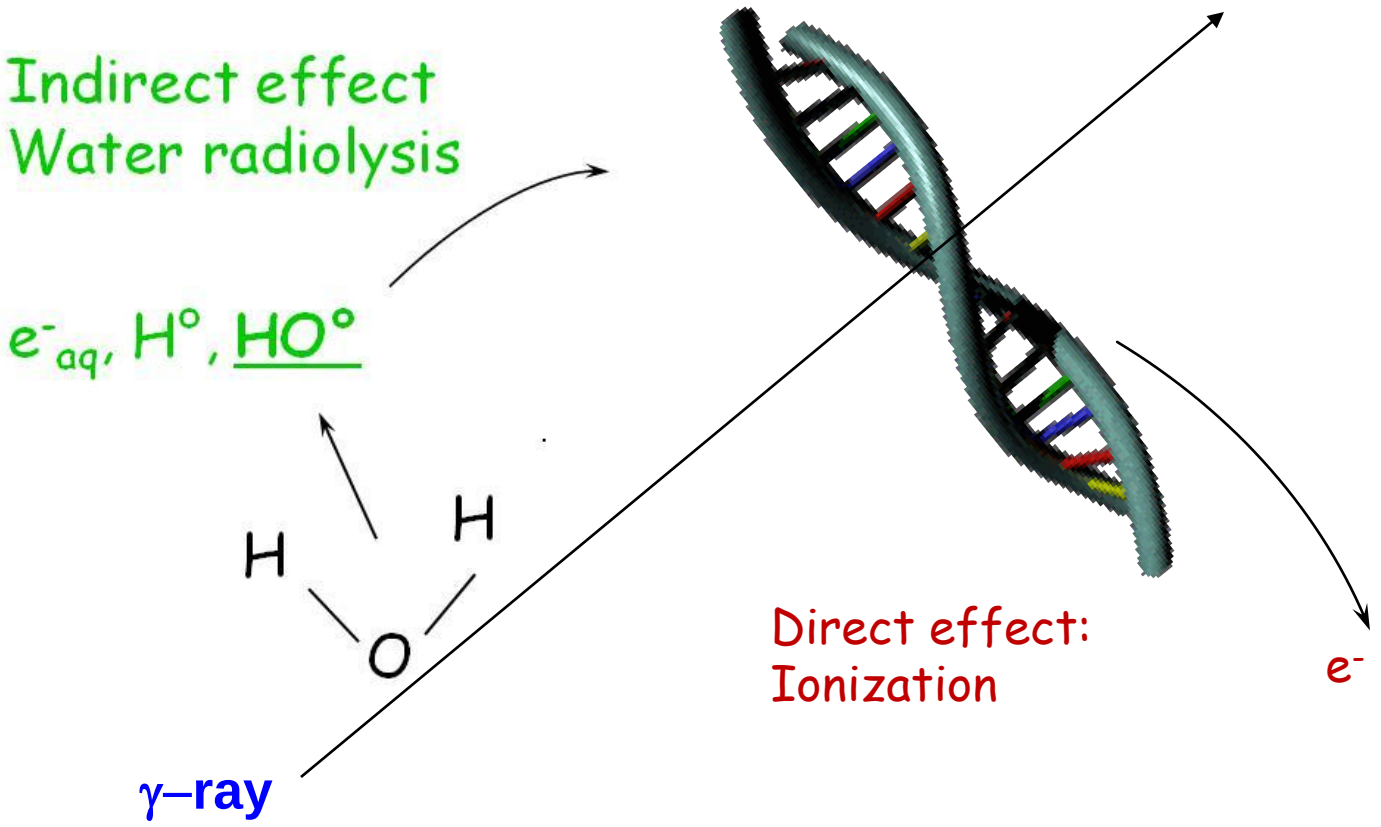
high energy photons, electromagnetic radiation from radioactive ^{60}Co

to induce chemical damage of DNA of all biological contaminants – insects, molds, yeasts, bacteria, etc.



Radiation treatment for disinfestation

Biocidal effect: DNA damage induced by ionizing radiation



Detrimental effect to all biodeteriorants at all stages of the life cycle

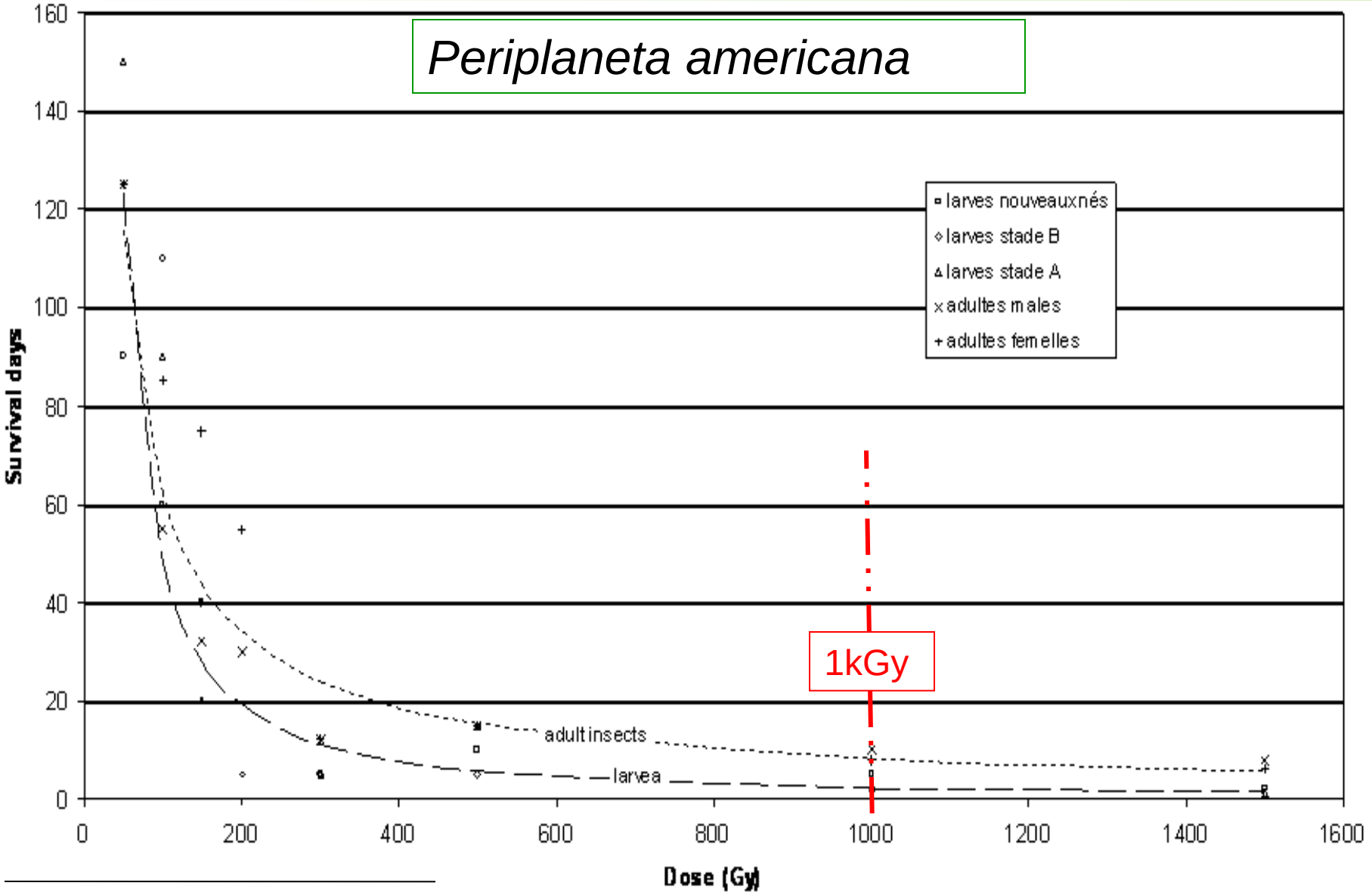
Radiation treatment of cultural heritage objects

Radiation dose - the most important parametar of the treatment

Dose determination:

- initial level of contaminats
- radiosensitivity of contaminatig agents
- desirable factor of reduction
- minimal damage to irradiated material

Efects of radiation dose on insects inactivation



G.Magaudda, M. Adamo, A. Pasquali, G. Rossi, The effect of gamma ray radiation on the biology of the *Periplaneta americana, Restaurator* 21 (2000) 41–54.

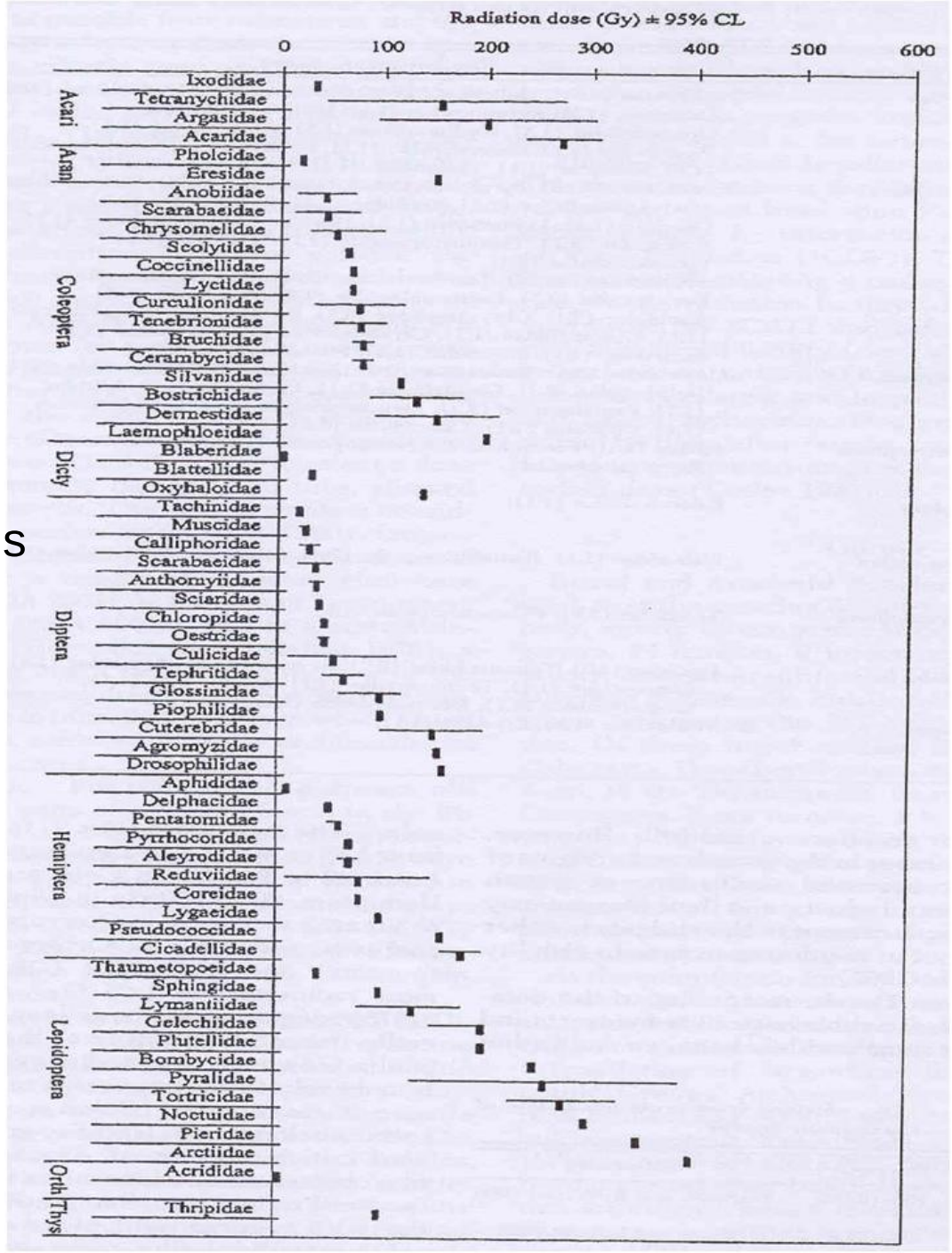
Radiation sensitivity of insects

Investigation in radiobiology results:

radiosensitivity determination of all known contaminating organisms

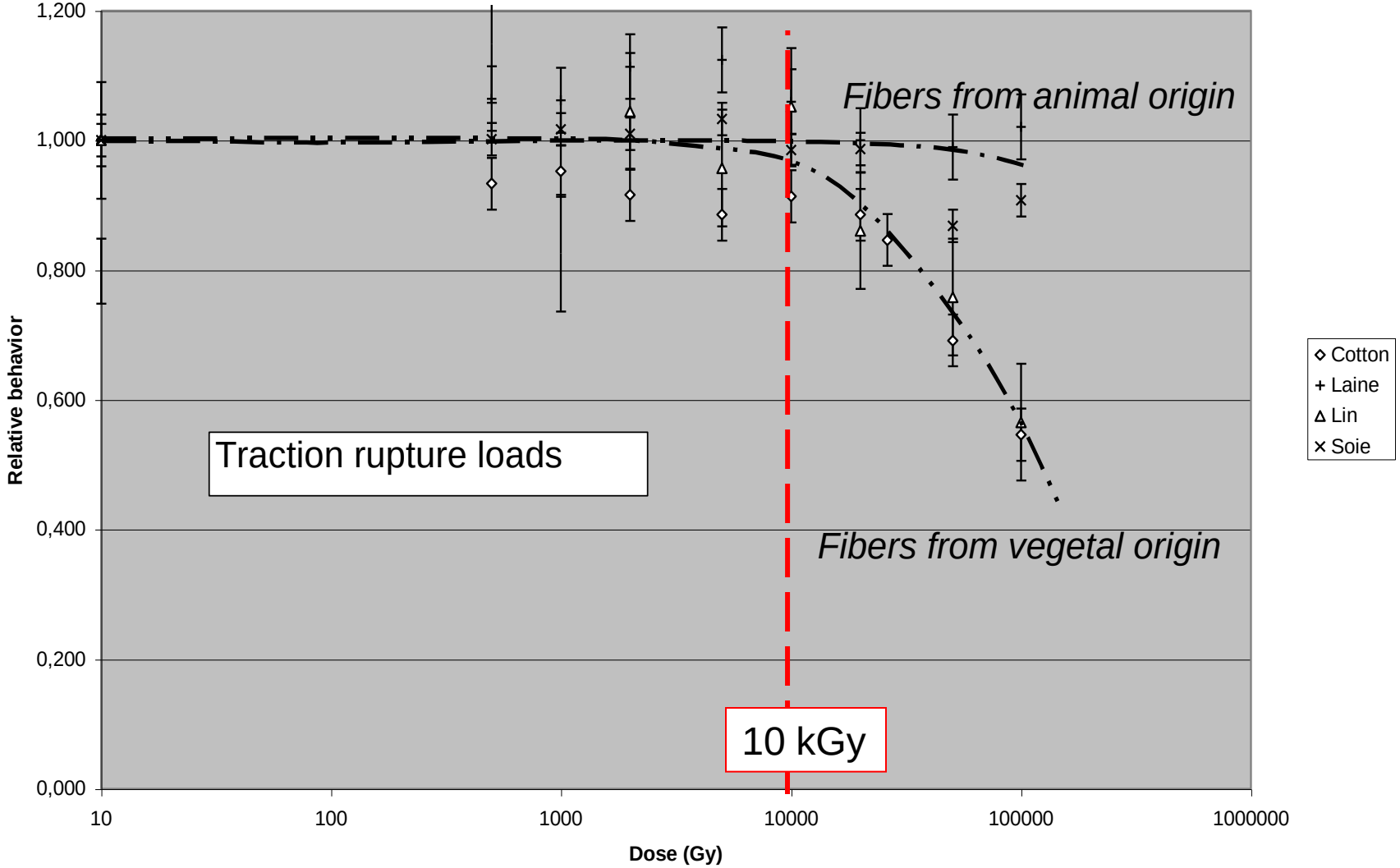
With desirable factor of reduction desinfestation doses are:

insect control	*0.5 - 2 kGy*
fungus control	*4 - 10 kGy*
decontamination	*5 - 20 kGy*



Effects of radiation dose on cellulose

Textile fibers are susceptibe to depolimerization by physical, chemical and biological agents; irradiation is a physical agent.



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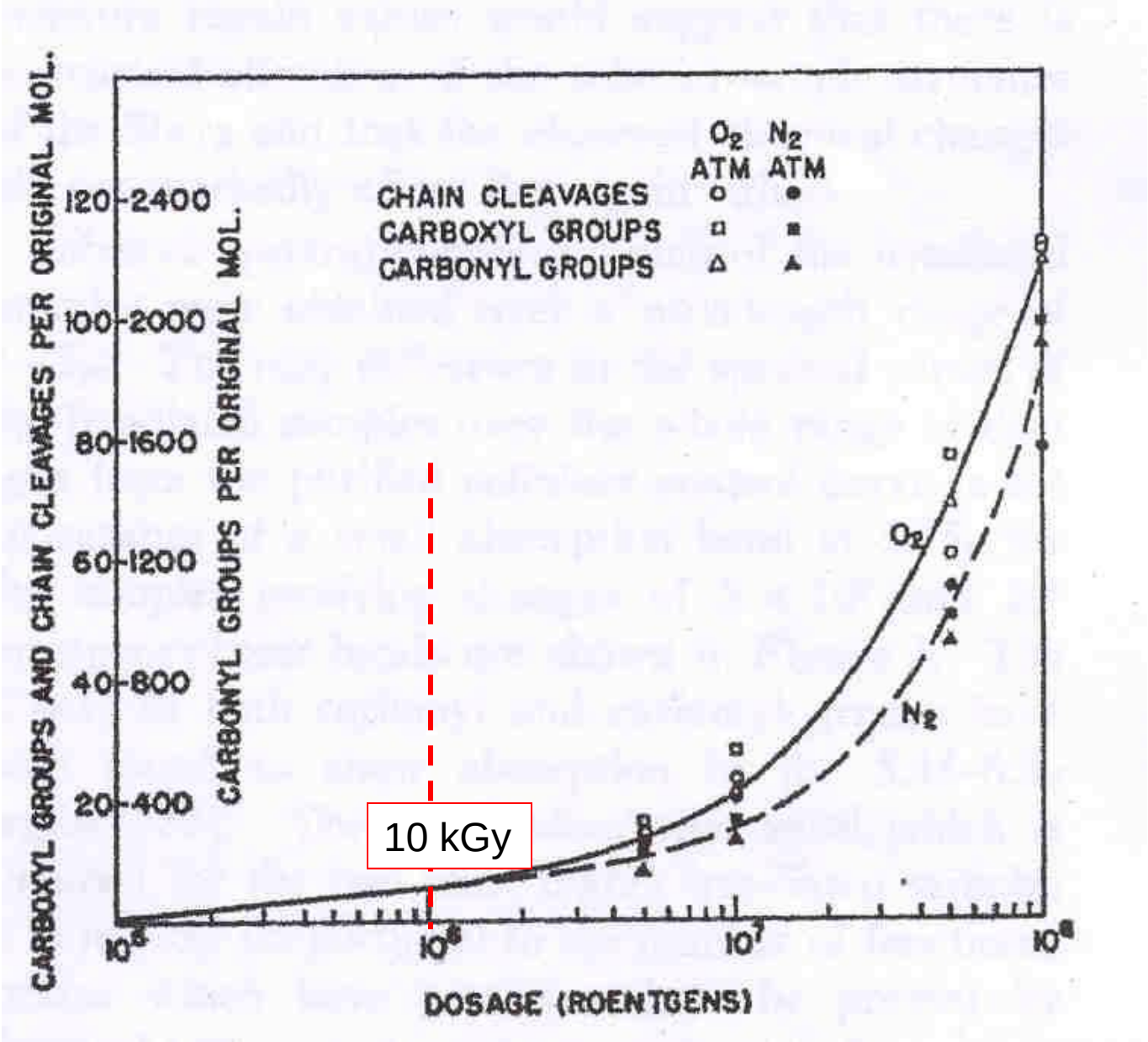
Effects of irradiation dose on chemical decomposition of cellulose



Doses in radiation treatment of textile objects

- the same as in radiation treatment of other cultural heritage objects

insect control	*0.5 - 2 kGy*
fungus control	*4 - 10 kGy*
decontamination	*5 - 20 kGy*

Doses below 2 kGy are efficient and relaeble in killing all insects without causing undesearable changes of textiles.

Higher desinfestation doses need to be justified.

Radiation treatment of cultural heritage objects

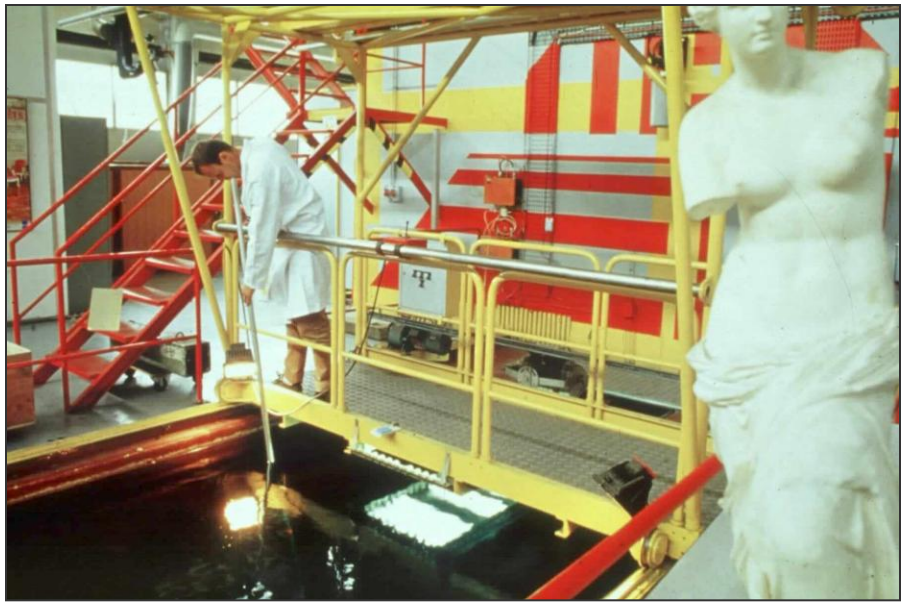
- made possible by the development and acceptance of radiation treatment of pharmaceuticals, cosmetics & medical materials

-in 1978 breakthrough for the method with high profile case of emergency treatment: radiation disinfestation of Ramses II mummy,
- performed by the NucleArt Laboratory, Grenoble, France
- presented at the 5th Triennial Meeting of ICOM, Zagreb

Irradiation facilities dedicated to the conservation of cultural heritage artefacts

Leaders in the field for 30 years:

Pool irradiator of ARC-NucléArt, Grenoble, France



Radiation Facility, Museum of Central Bohemia, Roztoky near Prague, Czech Republic

Radiation Chemistry and Dosimetry Laboratory: Ruđer Bošković Institute (RBI)

- Batch type panoramic ^{60}Co irradiator; designed for 150 kCi

- Start: 1969 with 3 kCi

- Pilot plant activity:
  in 1983: 50 kCi
  in 2000: 100 kCi
- Presently: cca 50 kCi

Irradiation chamber:
rectangular,
4.95 m × 3.90 m, 3.5 m high
capacity 4 - 6 m^3 of material

Gamma irradiation facility, RBI

The only one of its kind in Croatia

applications:

- suitable for a variety of applications
from medium dose range used in radiobiology to the high doses pertaining to radiation processing and radiation chemistry

irradiation services:

- for research and radiation processing

D. Ražem: Twenty years of radiation sterilization in Croatia, *Radiation Physics and Chemistry* 71 (1-2), pp. 595-600 (2004)

Radiation treatment of cultural artefacts in RBI

- upon upgrading of the irradiation facility in 1983
- treatment for preventive and curative purpose

- desinsection (up to 2 kGy): wooden objects, textiles, paper, parchment

- disinfestation (5 to 10 kGy): wooden objects

Radiation desinsection of textile materials, RBI

Our own experience includes treatments of contemporary ethnological textile materials, but none of rare old historic textile artefacts.

It is safe to say that radiation desinsection of textile materials (up to 2 kGy) is a safe and eficient method accepted by the specialists community.

Exceptions: radiation disinfestation of textiles

Higher doses (over 10 kGy) for textile disinfestation were reported in the emergency and massive treatments

1. adjoined pharaoh robe, (textile) was treated with 18 kGy in the process of radiation disinfestation of Ramses II mummy, after affirmative testing.

2. sixty thousands prisoners shoes (leather and textile) were irradiated with 19 kGy for the State Museum, Majdanek, Poland

Conclusion: RBI activity

Important national cooperations:

-Croatian Conservation Institute

International cooperation:

- International Atomic Energy Agency (IAEA) regional projects:

- RER 1006 (2006-2008) *: Nuclear Techniques for the Protection of Cultural Heritage Artefacts in the Mediterranean Region*

- RER 8015 (2009 - 2011): *Nuclear Techniques for the Characterisation and Preservation of Cultural Heritage Artefacts in the Europe Region*

Radiation treatment of cultural artefacts in RBI facility (summary)

treated by irradiation over 15 years:

More than 5000 wooden sculptures, parts of altars, furniture, tools, musical instruments, other wooden, paper, straw, textile, leather items, ect.

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5. United Nations Radio; Louise Potterton, Radiation Treatment for Artefacts http://www.unmultimedia.org/radio/english/detail/10528.html

Thank you for your attention!