RAD JOURNAL

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APPLICATION OF AQUEOUS EXTRACT OF *LEDUM PALUSTRE* IN “GREEN” SYNTHESIS OF SELENIUM NANOPARTICLES FOR ASSESSMENT OF RADIATION SENSITIVITY OF YEAST CELLS

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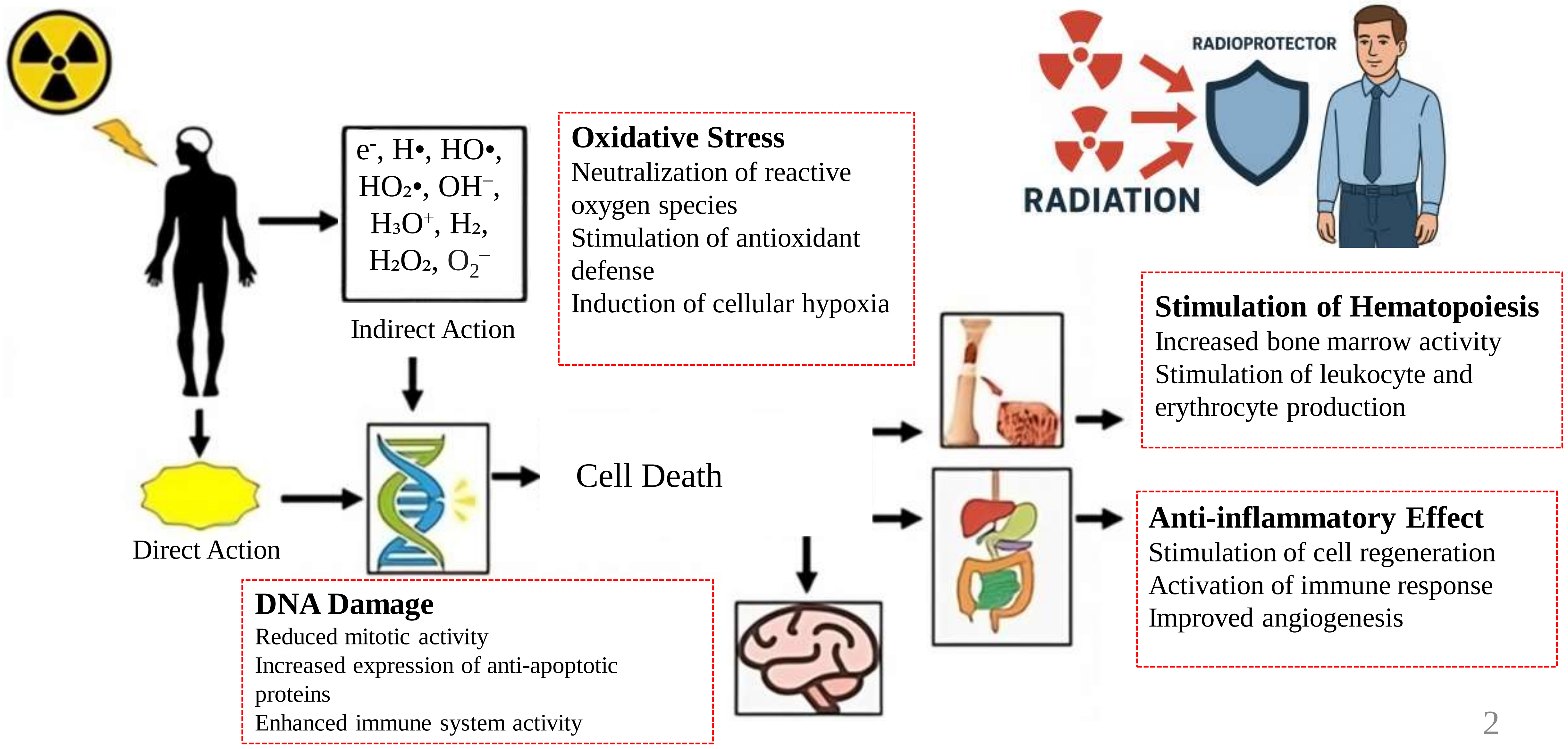
Radioprotectors: Mechanism of Protection Against Ionizing Radiation



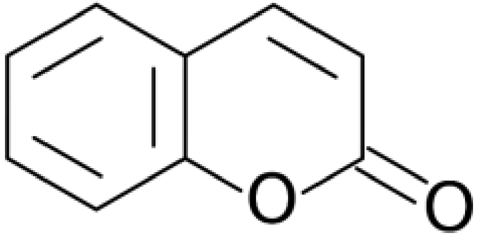
Comparison of Synthetic and Natural Radioprotectors

Criterion	Synthetic Radioprotectors	Natural Radioprotectors
Mechanism of Action	Neutralization of free radicals, DNA repair, hypoxia induction	Neutralization of reactive oxygen species, reduction of oxidative stress
Effectiveness	High	Moderate
Toxicity	High at doses exceeding the therapeutic threshold	Low toxicity, possible pro-oxidant effect at high doses
Side Effects	Nausea, hypotension, allergic reactions, toxicity at high doses	Safe
Examples	Amifostine, cysteamine, thiol compounds	Vitamins C and E, beta-carotene, flavonoids, resveratrol, selenium, zinc

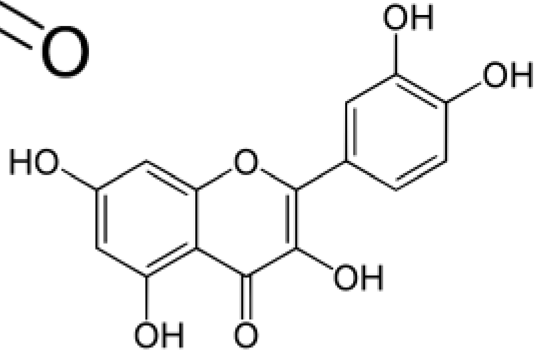
Natural radioprotectors have lower toxicity but are less effective compared to synthetic ones. A promising approach is their modification using nanotechnology

Biologically Active Compounds of *Ledum palustre*

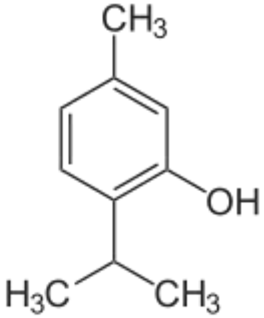
Coumarin



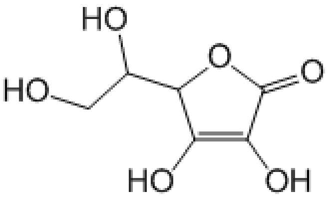
Quercetin



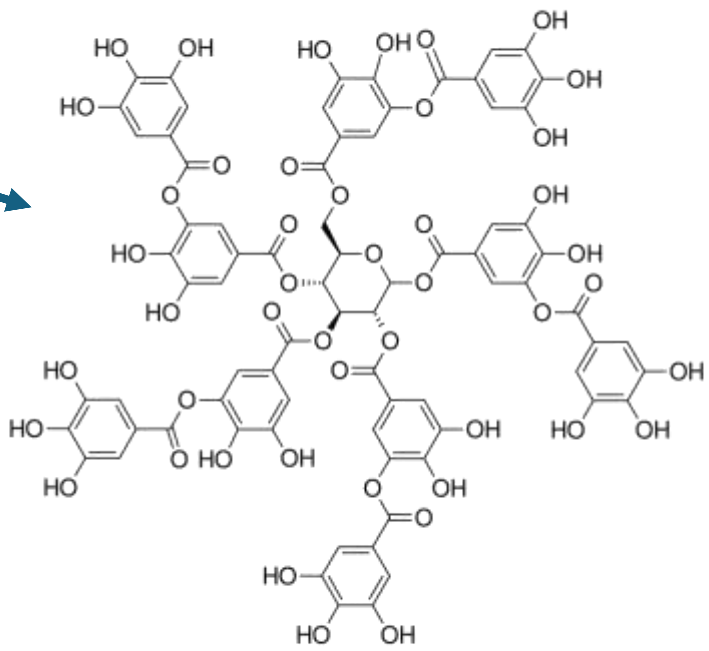
Thymol



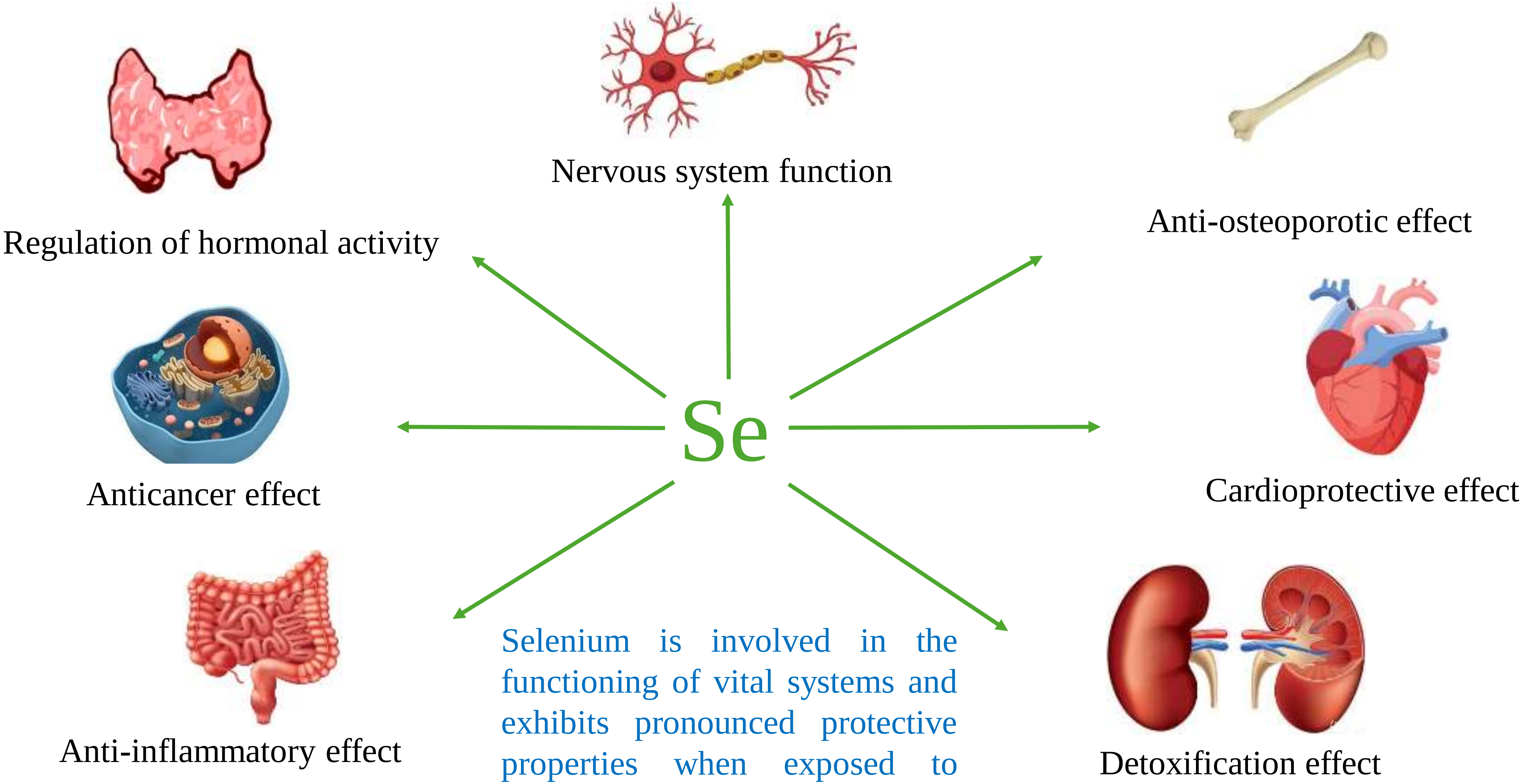
Vitamin C



Tannins

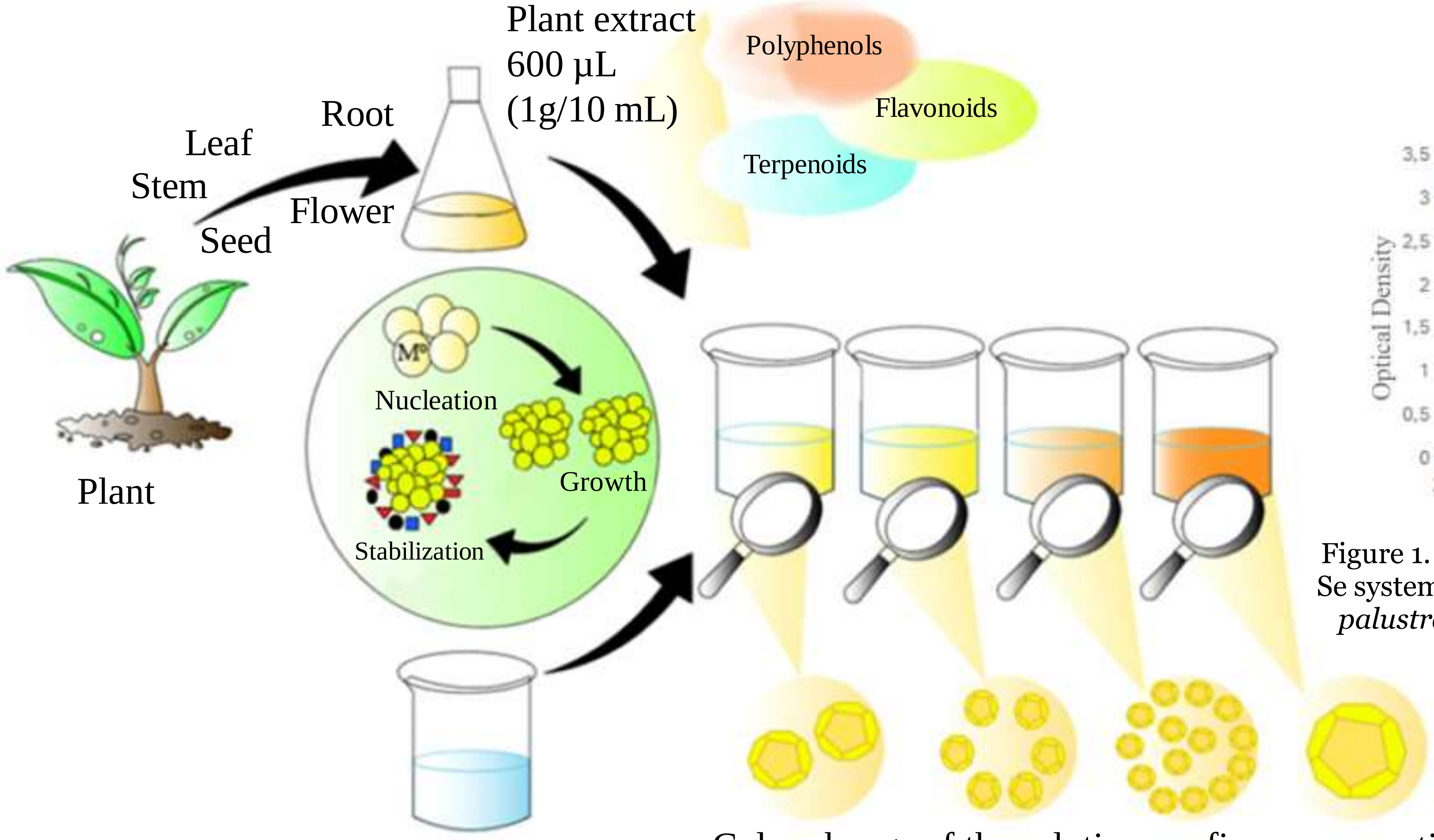


Biological Role of Selenium



Selenium is involved in the functioning of vital systems and exhibits pronounced protective properties when exposed to radiation.

Green Synthesis of Nanoparticles



7.4 mL of aqueous Na_2SeO_3 solution, 100 mM

Color change of the solution confirms nanoparticle formation

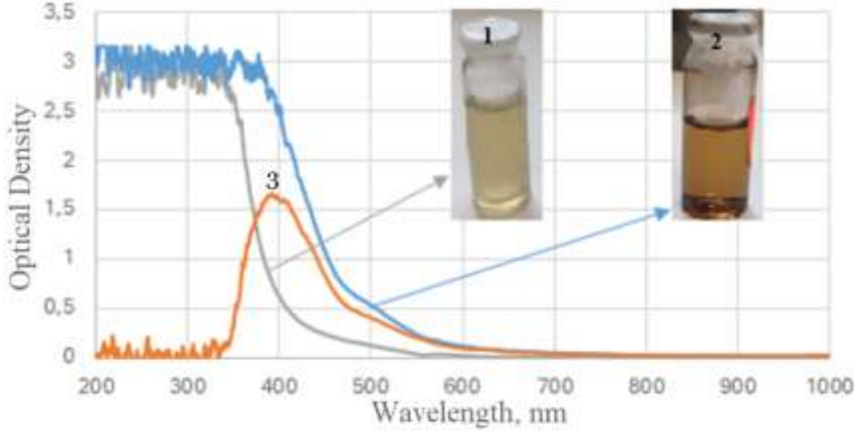


Figure 1. UV-Vis absorption spectra of the *L. palustre*/NP-Se system: 1 – aqueous extract of *L. palustre* (1:100), 2 – *L. palustre*/NP-Se system, 3 – spectral difference between curves 2 and 1.

Research methods

X-ray Irradiation System

Absorbed dose rate:

3 Gy/s (50 mA, 40 kV), as measured by Fricke dosimetry

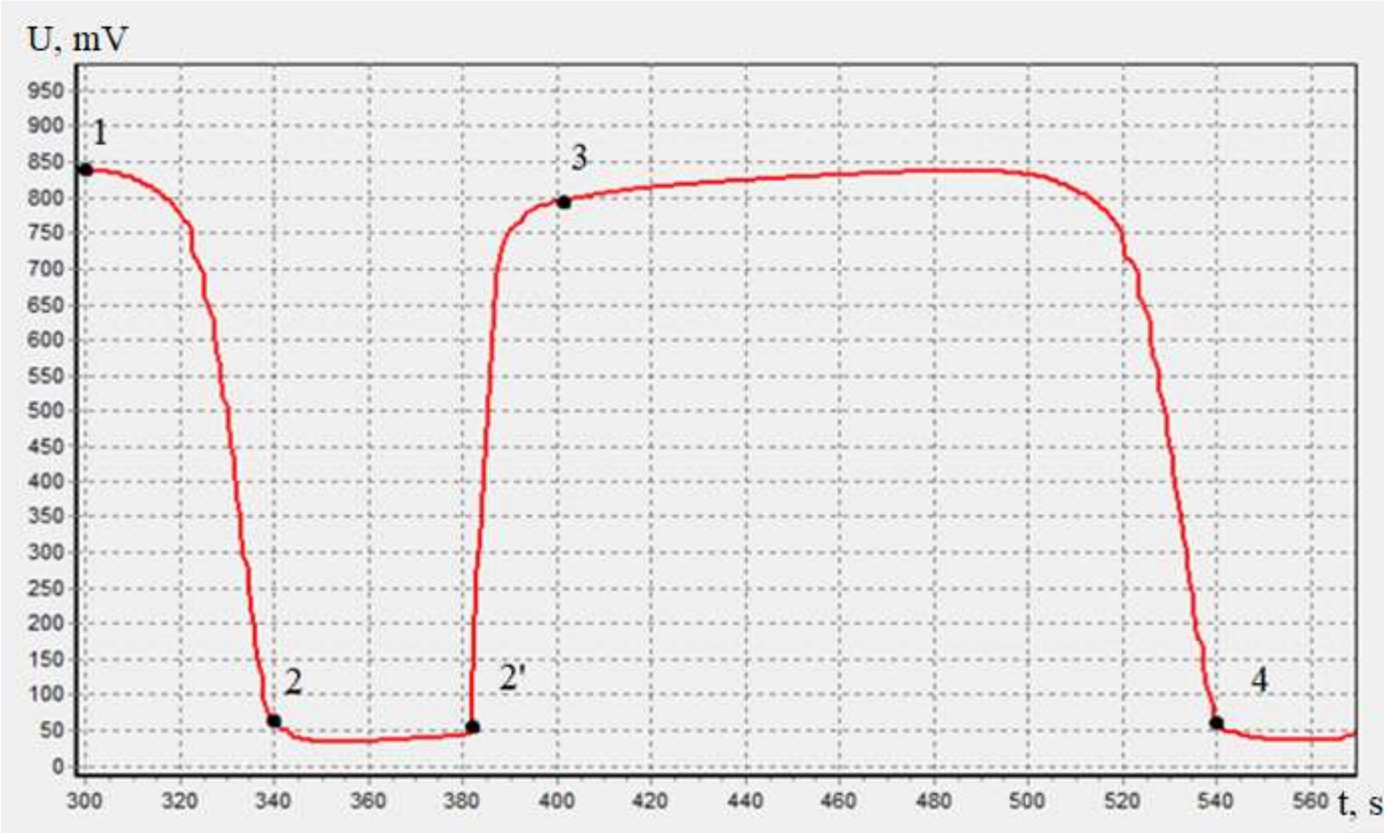
Spectrophotometer SF2000

Iodometry used to analyze NP-Se/plant extract systems

Coulometer "Expert-006"

Evaluation of antioxidant properties before and after irradiation in the presence of ROS (Sample mass: 100 mg, measurement range: 30 mV, initial current: 10 mA, main current: 50 mA)

Assessment of Sample Aliquot Influence on Antioxidant Activity



Polarization Curve of Coulometric Titration:
1–2 pre-electrolysis (system stabilization)
2–2′: waiting for sample addition
2′: sample injection; 2′–3: mixing; 3–4: electrolysis.

Method Description:
Electrogeneration of bromine is performed at a constant current of 5 mA from an aqueous 0.2 M KBr solution in 0.1 M sulfuric acid, with endpoint detection during titration.
At the anode, Br^- is oxidized to Br_2, causing a visible yellow coloration of the solution:

$$2Br^{-} - 2\bar{e} \longrightarrow Br_2$$

Characterization and Antioxidant Activity of *L. palustre*/NP-Se

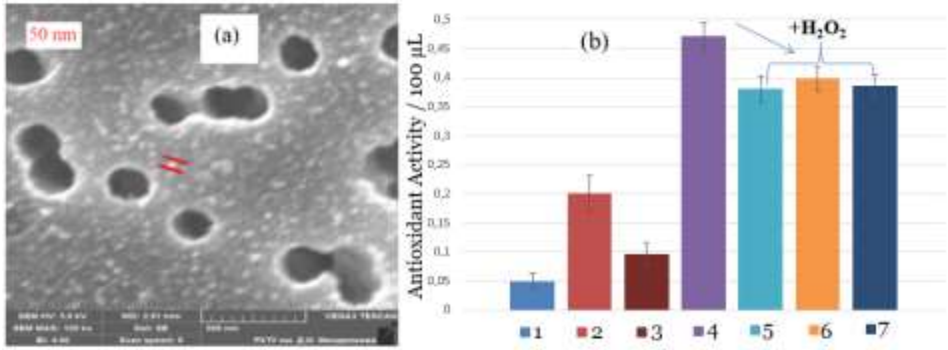


Figure 2. (a) SEM image of *L. palustre*/NP-Se nanoparticles at 100,000× magnification; (b) evaluation of the effect of the sample aliquot on antioxidant activity using the bromine reaction for the following samples: 1 – ethanol solution of ionol (0.5 mM), 2 – aqueous extract of *L. palustre* (1:100), 3 – Na_2SeO_3 (2.5 mM), 4- *L. palustre*/NP-Se, 5 – *L. palustre*/NP-Se + 100 µL H_2O_2, 6 – *L. palustre*/NP-Se + 200 µL H_2O_2, 7 – *L. palustre*/NP-Se + 300 µL H_2O_2; detection at 100 mg.

L. palustre/Np-Se demonstrate high antioxidant activity, which remains stable in the presence of hydrogen peroxide, indicating their potential as effective ROS scavengers under oxidative stress conditions.

Table 1. Hydrogen peroxide concentration in the *L. palustre*/NP-Se system as a function of absorbed dose for different samples: 1 – H_2O (Sample №1, control), 2 – 0.5 mL *L. palustre*/NP-Se (Sample №2), 3 – 1 mL *L. palustre*/NP-Se (Sample №3), 4 – 1.5 mL *L. palustre*/NP-Se (Sample №4).

Dose (Gy)	№1 (µM)	№2 (µM)	№ 3 (µM)	№ 4 (µM)
0	0	0	0	0
90	12±0.6	0	0	0
180	21±1.1	23±1.2	0	0
270	35±1.8	36±1.8	37±1.9	6±0.3

L.palustre/NP-Se reduces hydrogen peroxide accumulation even at high radiation doses, indicating effective ROS scavenging.

Based on the protocol described in: A. A. Fenin, I. G. Antropova, S. V. Gornostaeva, “Laboratory Workshop on Radiation Chemistry,” D. Mendeleev University of Chemical Technology of Russia, Moscow.

Radioprotective Effect of *L. palustre*/NP-Se in Yeast Cells

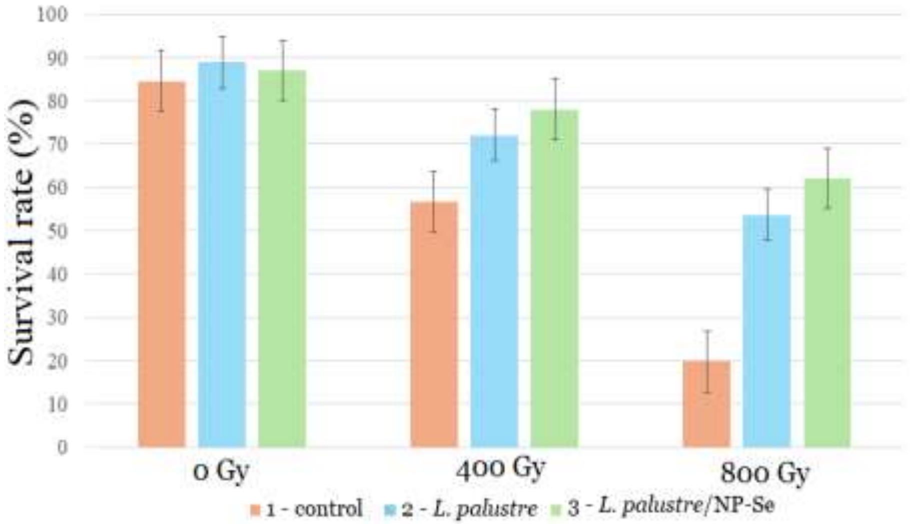


Figure 3. Survival rate of *S. cerevisiae* yeast cells after 3 hours irradiation for different sample groups: 1 – control, 2 – *L. palustre*, 3 – *L. palustre*/NP-Se.

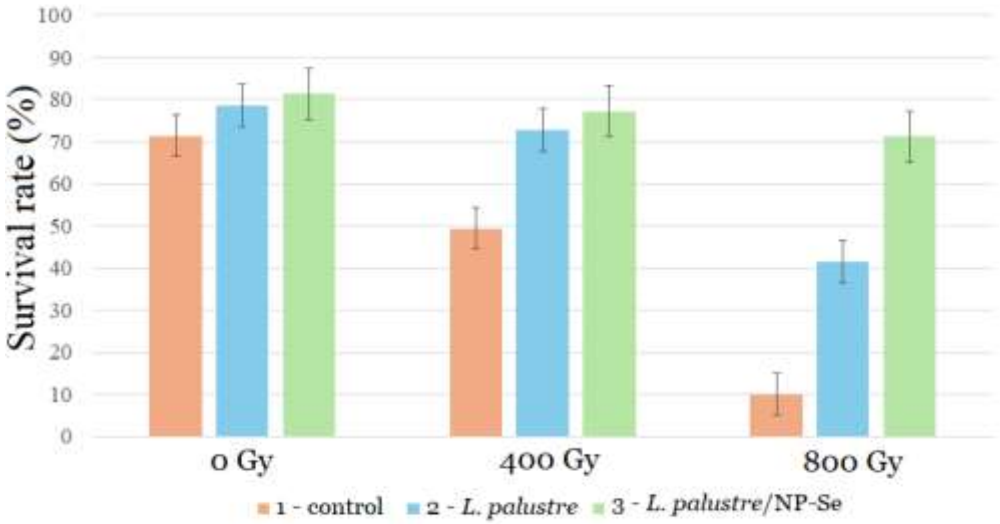


Figure 4. Survival rate of *S. cerevisiae* yeast cells after 24 hours irradiation for different sample groups: 1 – control, 2 – *L. palustre*, 3 – *L. palustre*/NP-Se.

L. palustre/NP-Se significantly increased cell survival after high-dose radiation (400–800 Gy), demonstrating a time-dependent radioprotective effect.

The number of viable cells was assessed by microscopy using methylene blue staining.

Conclusions and Perspectives

- The *L. palustre*/NP-Se complex exhibits strong antioxidant and radioprotective properties
- It reduces H_2O_2 levels and increases cell survival after irradiation
- Biocompatible and synthesized using a green chemistry approach
- Promising for applications in radiobiology and radiomedicine
- Further studies on animal models and mechanism elucidation are required