

**Mechanism mediating
biological effects of
radiofrequency fields**

**Henry Lai
Department of Bioengineering
University of Washington
Seattle, WA
USA**

**Radiofrequency fields increase
free radical activities in cells.**

Evidence suggesting radiofrequency field increase free radicals in cells:

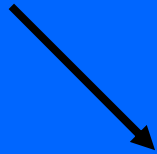
- Measurements of free radicals and enzymes involved in free radical biochemistry**
- Effect blocked by antioxidants e.g., vitamin C & E**

Radiofrequency fields enhance free radical activity and induces oxidative stress/damages in cells.

Lai and Singh [97a, b, 04]; Moustafa [01]; Irmak [02]; Stopczyk [02]; Ayata [04]; Ilkan [04]; Oktem [05]; Ozguner [04, 05, 06]; Yariktas [05]; Koylu [06]; Oral [06]; Yurekli [06]; Balci [07]; Friedman [07]; Guney [08]; Hoyta [08]; Wu [08]; DeIuliis [09]; DelVecchio [09]; Hassig [09]; Kesari [09]; Mailankot [09]; Xu [09]

There are also scientific data indicating that extremely-low frequency (ELF) magnetic and electric fields increase free radical activities in cells.

Free radicals

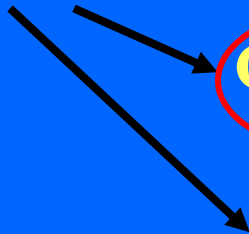


Molecular damages in cells, e.g., DNA damage, protein damage

Cell death



Cancer



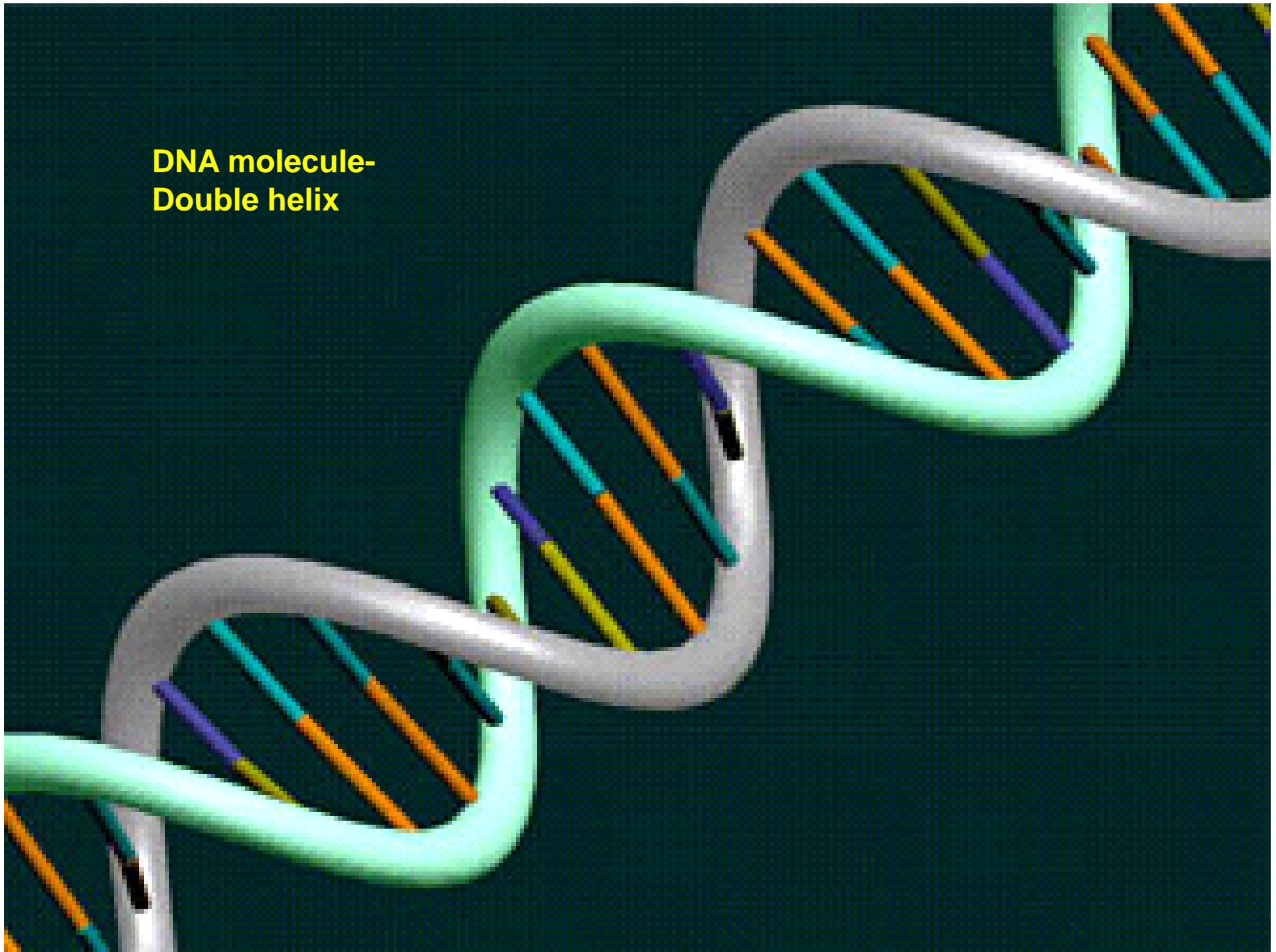
Functional changes



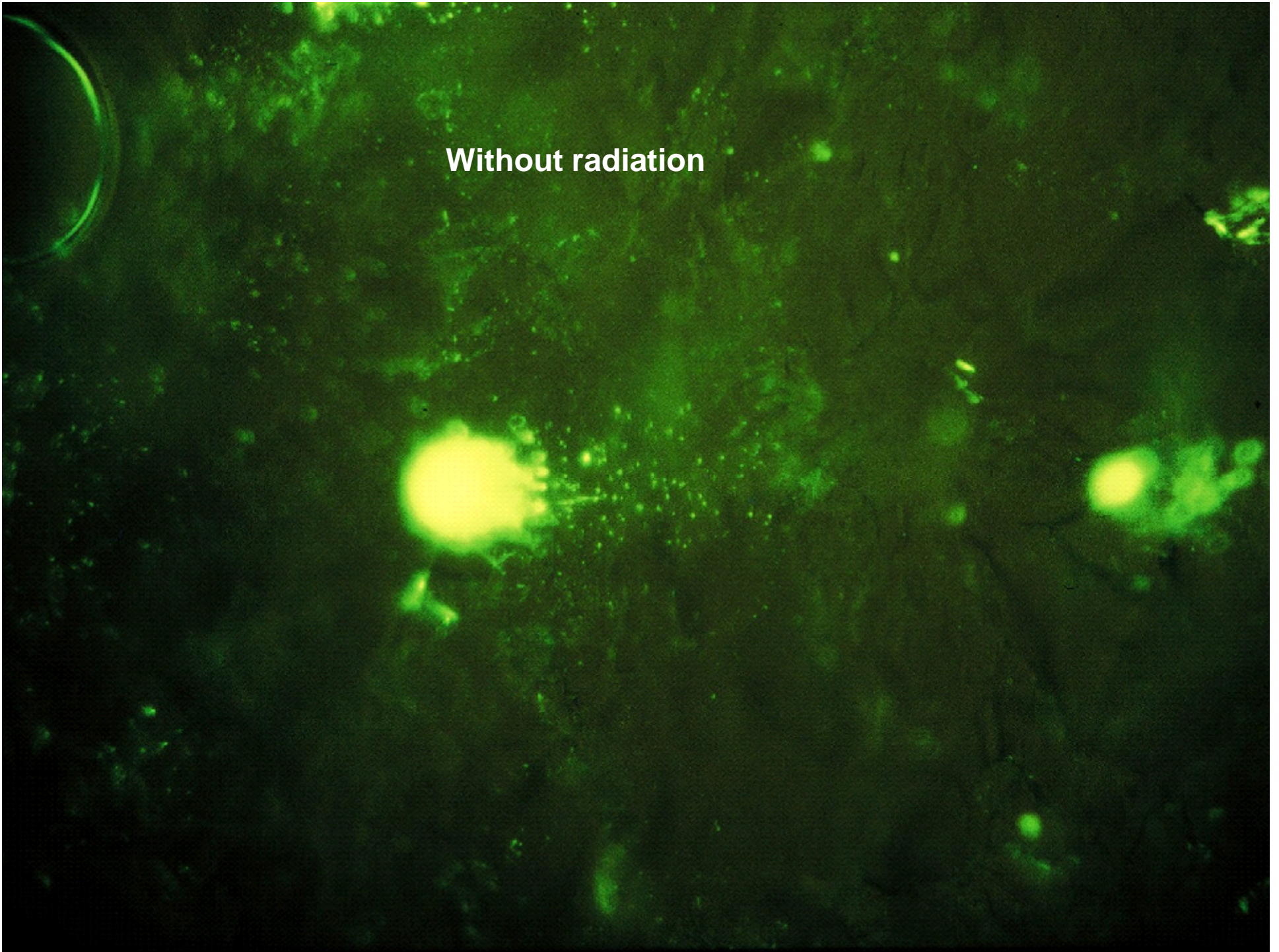
Radiofrequency fields affect DNA and genes

Phillips [98]; Sykes [01]; D'Ambrosio [02]; Tice [02]; Gadhia [03]; Mashevich [03]; Ono [04]; Sarimov [04]; Aitken [05]; Belyaev et al. [05, 06]; Diem [05]; Gandhi and Anita [05]; Gandhi and Singh [05]; Markova [05]; Zotti-Martelli [05]; Ferreira [06]; Lixia [06]; Nikolova [05]; Paulraj and Behari [06]; Sun [06]; Zhang [06]; DeIuliis [09]; Kesari [09]; Xu [09]

**DNA molecule-
Double helix**

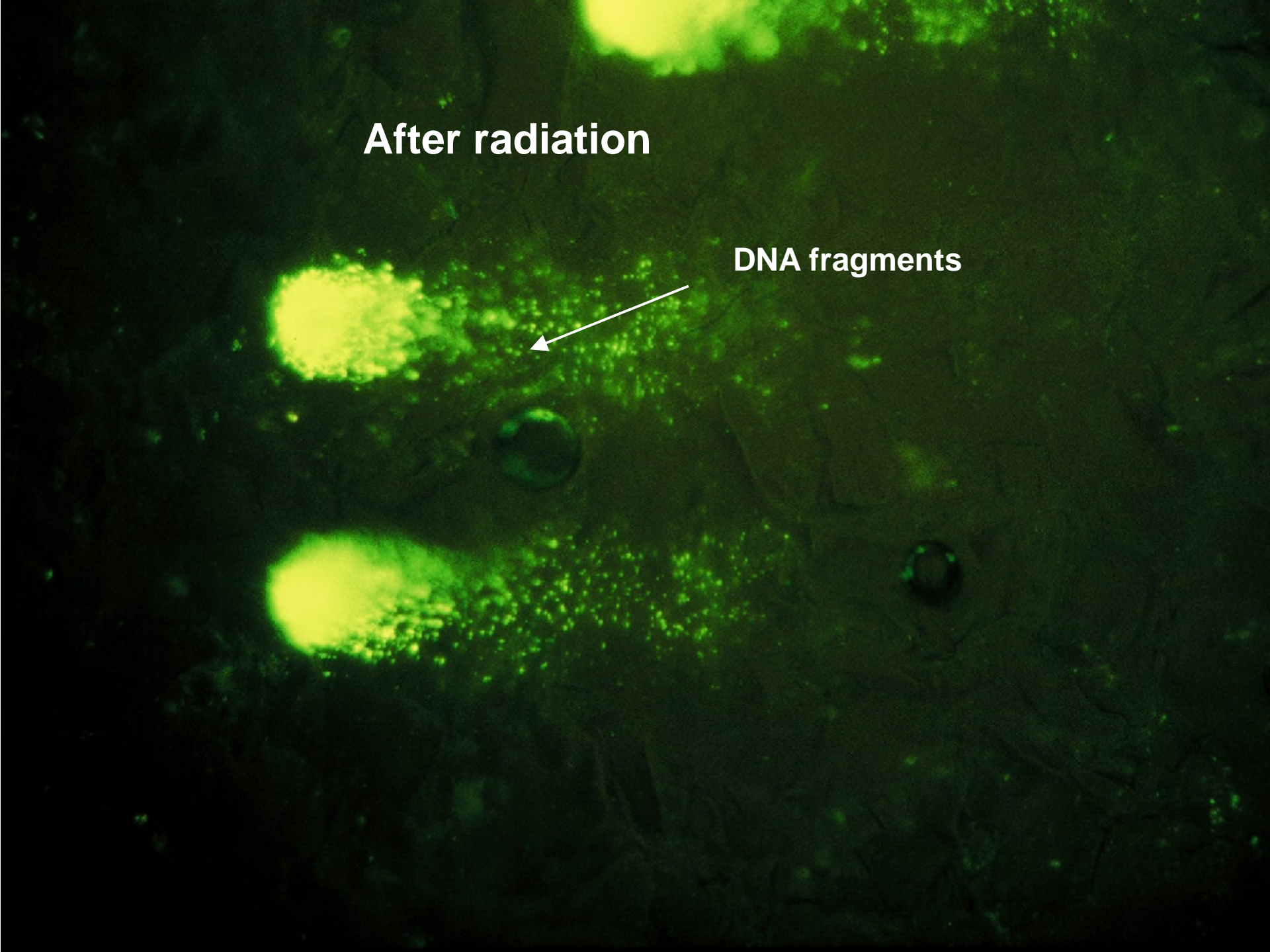
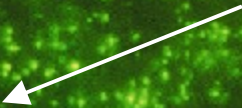


Without radiation

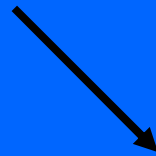


After radiation

DNA fragments



Free radicals

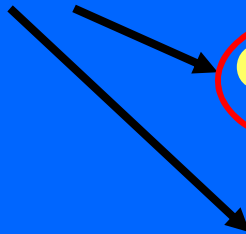


Molecular damages in cells, e.g., DNA damage, protein damage

Cell death



Cancer



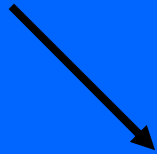
Functional changes



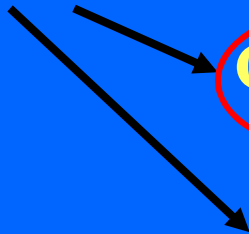
Brain Electrophysiology/Functions

Von Klitzing [95]; Mann and Roschke [96]; Eulitz [98];
Freude [98]; Borbely [99]; Freude [00]; Huber [00] Hietanen
[00]; Krause [00]; Lebedeva [00]; Jech [01]; Lebedeva [01];
Huber [02]; Croft [02]; D'Costa [03]; Huber [03];
Kramarenko [03]; Marino [03]; Hamblin [04]; Hinrich and
Heinze [04]; Krause [04]; Papageorgiou [04]; Vorobyov [04];
Curcio [05]; Huber [05]; Loughran [05]; Aalta [06]; Ferreri
[06]; Krause [06] Papageorgiou [06]; Krause [07]; Vecchio
[07]; Hung [07]; Nittby [08]; Narayanan [09]

Free radicals



Molecular damages in cells, e.g., DNA damage, protein damage



Brain morphology and cell death

**Persson [97]; Salford [03]; Markkanen [04]; Marinelli [04];
Zmyslony [04]; Nikolova [05]; Panagopoulos [06]; Zheo [06];
Del Vecchio [09]; Nittby [09]**

Cells with high iron content are more susceptible to radiofrequency fields.

Brain cells have high content of iron.

Free radicals

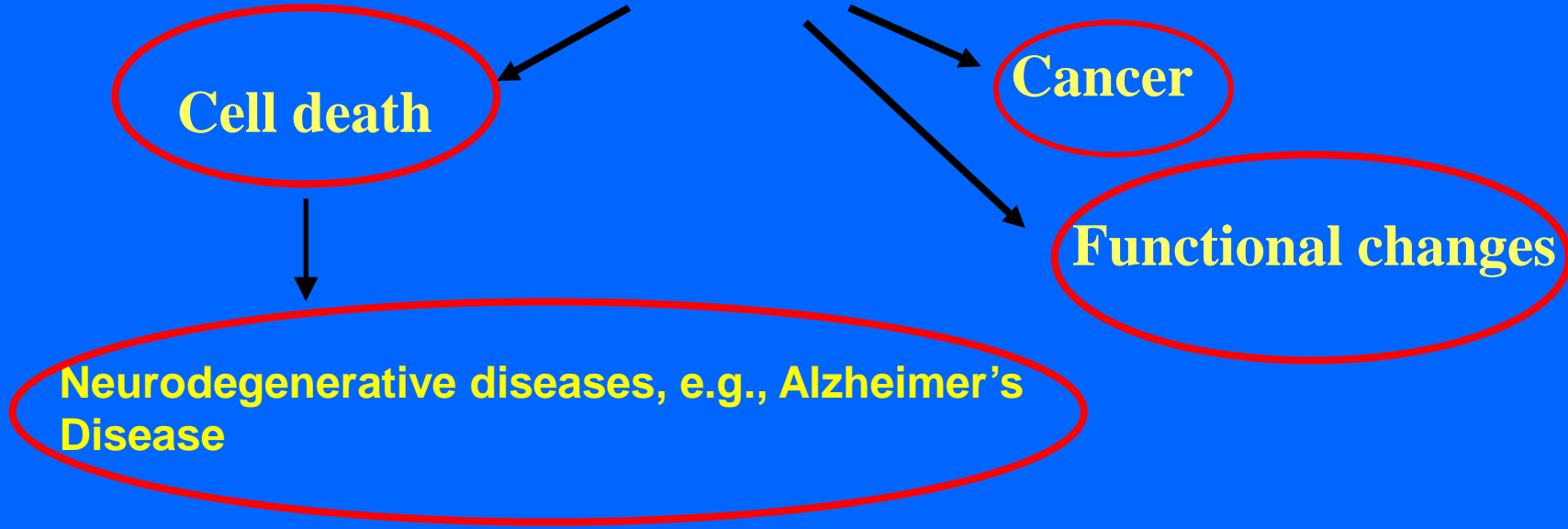
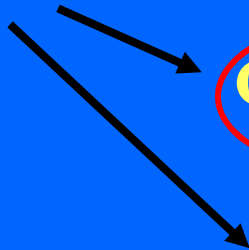
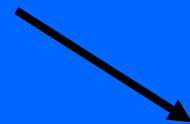
Molecular damages in cells, e.g., in DNA, protein, lipids

Cell death

Cancer

Functional changes

Neurodegenerative diseases, e.g., Alzheimer's Disease



Some health effects caused by increase in free radicals:

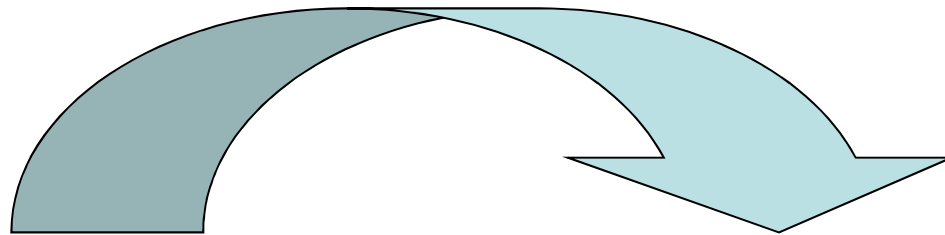
- (1) Cancer**
- (2) Cardiovascular diseases**
- (3) Eye disorders- cataracts and maculopathy**
- (4) Neurological disorders- Alzheimer's, Parkinson's, motor neuron disorders**
- (5) Ageing**
- (6) Diabetes**
- (7) Rheumatoid arthritis**

EMF-induced increase in free radicals
in cells involves iron
– the Fenton Reaction

Electromagnetic fields



iron



H₂O₂

OH



mitochondria



Cellular damage

THE FENTON REACTION

EMF-induced increase in free radicals in cells involves iron

- increase iron enhances effects**
- decrease iron decreases effects**

**Brain cells have large amount of iron,
particularly in their DNA.**

**Cancer cells also contain a lot of iron –
treatment of cancer using low-energy EMF.**