Water and Aqueous Solutions

\[ \text{H}_2\text{O} \rightarrow \text{e}_{\text{aq}}^-, \text{H}_3\text{O}^+, \text{OH}, \text{H}, \text{H}_2, \text{H}_2\text{O}_2 \]

\( \text{e}_{\text{aq}}^- \): e transfer, \( \text{H}_2 \) formation
\( \text{H}_2 \): explosive, flammable
\( \text{H}_2\text{O}_2 \): corrosive
\( \text{OH} \): biological
Probe relative strand breaks of DNA as a function of LET (-dE/dx)
Studies to complement the extensive work using x-rays and γ-rays
Data used to set standards for therapy and in space travel
DNA Radiation Damage

Direct Effects

DNA $\rightarrow$ single strand breaks, SSB
double strand breaks, DSB
multiply damaged sites, MDS

Indirect Effects

$\text{H}_2\text{O} \rightarrow \text{OH}$
$\text{OH} + \text{DNA} \rightarrow \text{SSB}$
$\text{OH} + \text{SSB} \rightarrow \text{DSB, MDS}$
Radiolysis with $\gamma$-rays
Gel Electrophoresis
Gel Electrophoresis

+50V  DNA⁻
Gel Imager
Fluorescence of Stained DNA

- pUC18
- DSB
- SSB

DOSE
SIZE
Fluorescence of Stained DNA

DNA amount is proportional to volume.
Survival Plot

Radiation sensitivity / yield is proportional to slope.
Scavenger Concentration Dependence

γ-rays

- Milligan et al.
- Ryan et al.

SSB Yield (μmol/J)

[OH + DNA \rightarrow SSB]

[OH + DMSO \rightarrow Products]
Scavenger Concentration Dependence

\[ \text{OH} + \text{DNA} \rightarrow \text{SSB} \]

\[ \text{OH} + \text{scavenger} \rightarrow \text{Products} \]
Target Ring
Notre Dame Nuclear Structure Laboratory

1. SNICS Ion Source
2. HIS Ion Source
3. FN Van de Graaff Accelerator
4. Gamma Spectroscopy Beamline
5. Spectrograph Beam Line
6. R2D2 Beam Line (1 m scattering chamber)
7. Weak Interaction Beam Line
8. RNB Beam Line
9. Neutron Detection Wall
10. Conference Room
11. Accelerator Control Consoles
12. ECR Ion Source Test Setup
13. KN Van de Graaff Accelerator
14. JN Van de Graaff Accelerator
15. ORTEC Scattering Chamber
16. Windowless Gas Target Beam Line
17. Gamma Table
Radiation effects depend on particle type and energy.
Future Studies of Heavy Ions on DNA

Probe relative strand breaks of DNA as a function of LET (-dE/dx)

Determine partition of damage due to direct and indirect effects

Examine specific damage to DNA and how it affects the cell
The End
Water Decomposition

H₂O → ionization → e⁻ + H₂O⁺

water excitation
thermalization
solvation
(250-300 fs)

(H₂O)⁺ → eaq⁻, H₂ + O⁻, H⁺ + OH⁻, OH⁻ + H₃O⁺

proton transfer hydration (100 fs)

G = 4.2, G = 0.3, G = 0.6, G = 4.2 molecules/100 eV

radical reactions (0.1 ns - 1 μs)

Radiation effects are generally over within a microsecond.
Differences in 10 keV Track Segments at 1 ps

10 MeV $^1$H

5 MeV $^4$He
Development of a 10 keV Section of a 5 MeV \(^{4}\text{He}^{2+}\) Ion Track in Water