

**ADAPTIVE RESPONSE**  
in  
**Mammalian Cells**  
Exposed to  
**Ionizing Radiation**  
&  
**Non-Ionizing**  
**Radiofrequency Fields**

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*Samson & Cairns. Nature. 267, 281 - 283, 1977.*  
*Samson & Schwartz. Nature. 287, 861 - 863, 1980.*

**Chronic exposure of  
Escherichia Coli  
Chinese Hamster Ovary Cells**  
**small non-genotoxic dose**

Adaptation Dose, AD

**alkylating mutagen(s)  
were less susceptible  
mutagenic & killing  
subsequent exposure  
higher genotoxic dose**

Challenge Dose, CD

**of the same mutagen**

**ADAPTIVE RESPONSE**

*Olivieri et al. Science. 223, 594 - 597, 1984.*

**Prior Exposure**  
**Human Blood Lymphocytes**  
1 cGy X-rays (AD)  
**RESISTANT**  
**Chromosomal Aberrations**  
**Subsequent Exposure**  
150 cGy X-rays (CD)

*Wiencke et al. Mutagenesis. 1, 375 - 380, 1986.*  
*Shadley & Wolff. Mutagenesis. 2, 95 -96, 1987.*  
*Shadley et al. Rad Res. 111, 511 - 517, 1987.*  
*Wolff et al. I J R B. 53, 39 – 48, 1988.*

# **Adaptive Response** **Ionizing Radiation**

**Dose**  
**Dose–Rate**  
**Quality of Radiation**  
**Cell Cycle**  
**Time Interval**  
( between AD and CD )



# Human Blood Lymphocytes

one genotoxic agent exhibit

**CROSS - RESISTANCE**

another genotoxic agent

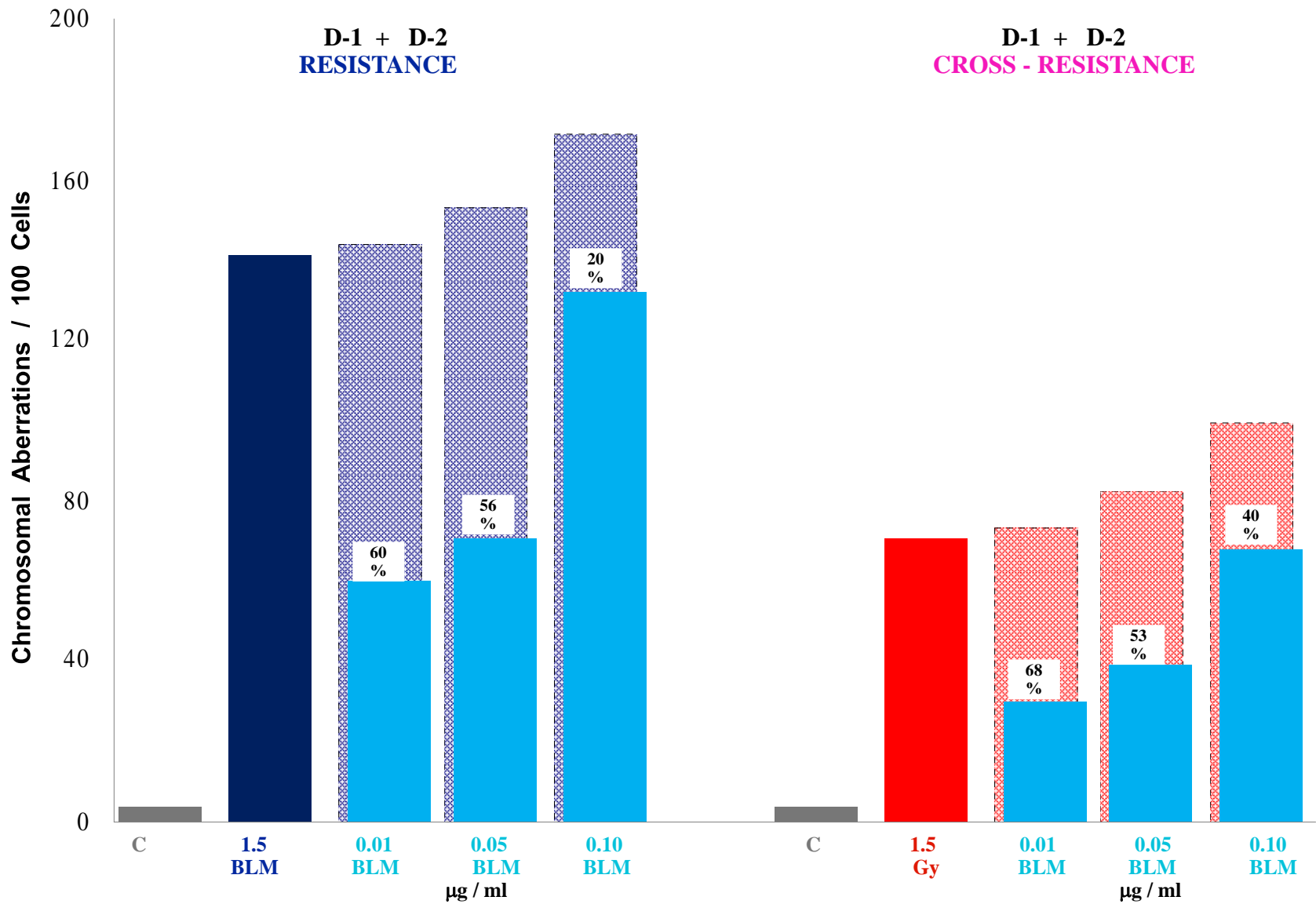
Chemical Mutagen - **Bleomycin**

Physical Mutagen - **X-irradiation**

Both induces similar kinds of DNA lesions  
Single & Double Strand Breaks

# Experimental Protocol





**DNA Repair - AR**

**Indirect Approach**

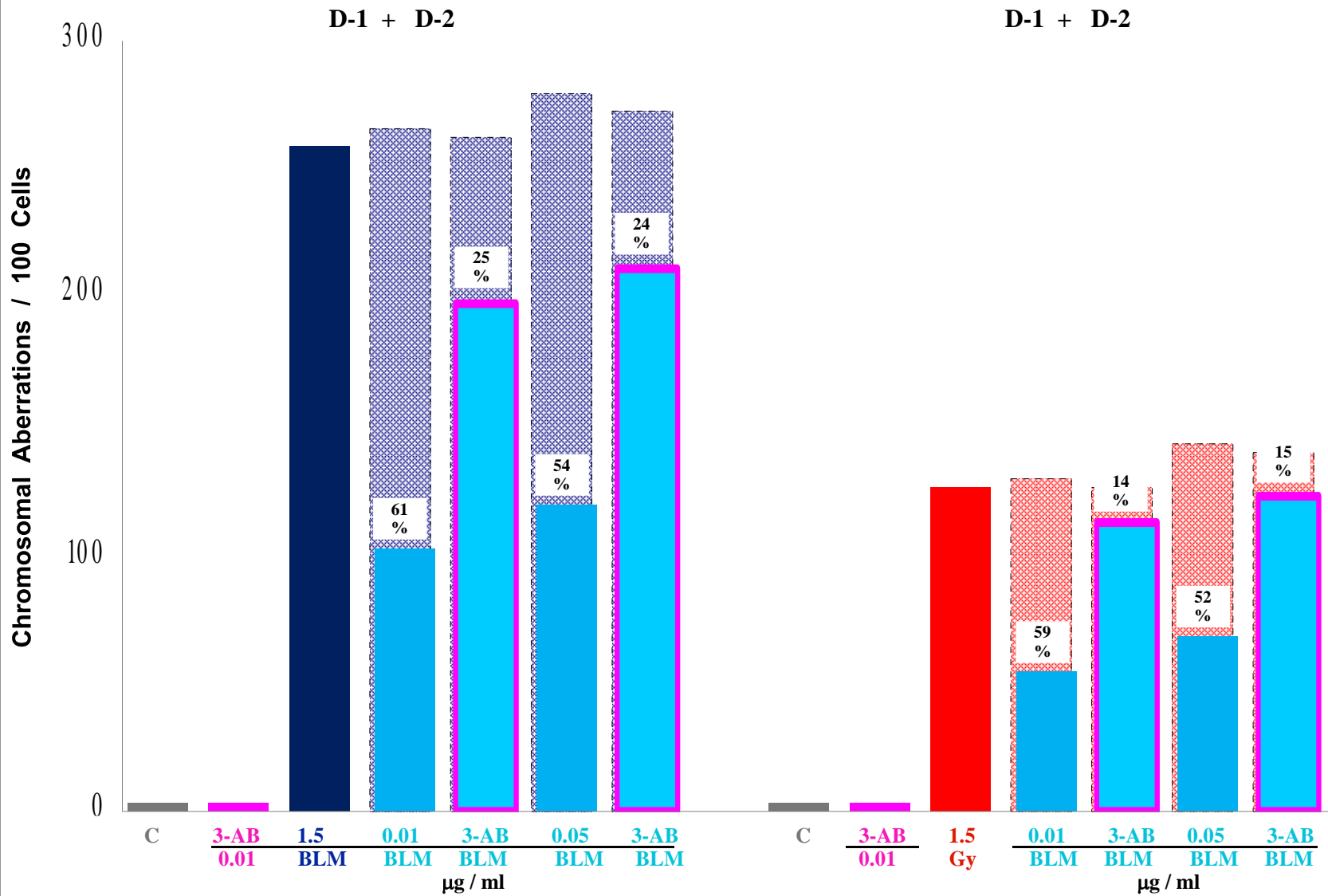
**3-Aminobenzamide**

**Inhibits Poly-(ADP-Ribose)-Polymerase  
enzyme involved in DNA repair**



# Experimental Protocol



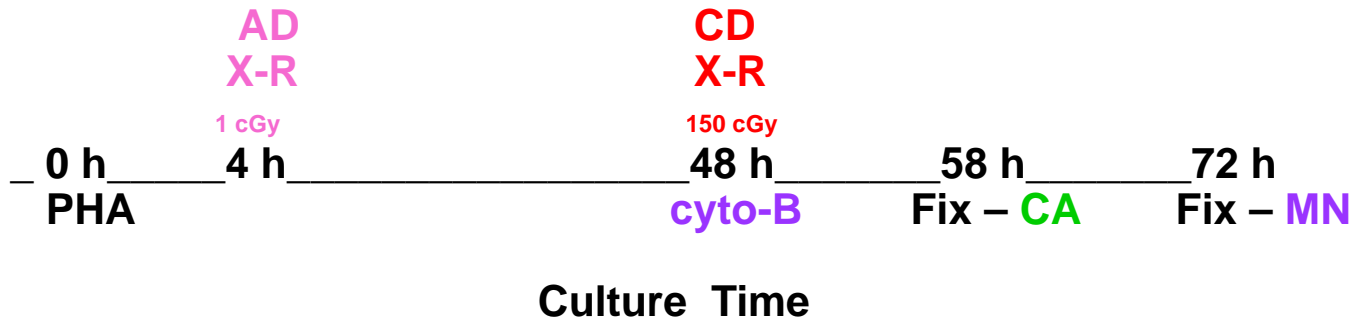


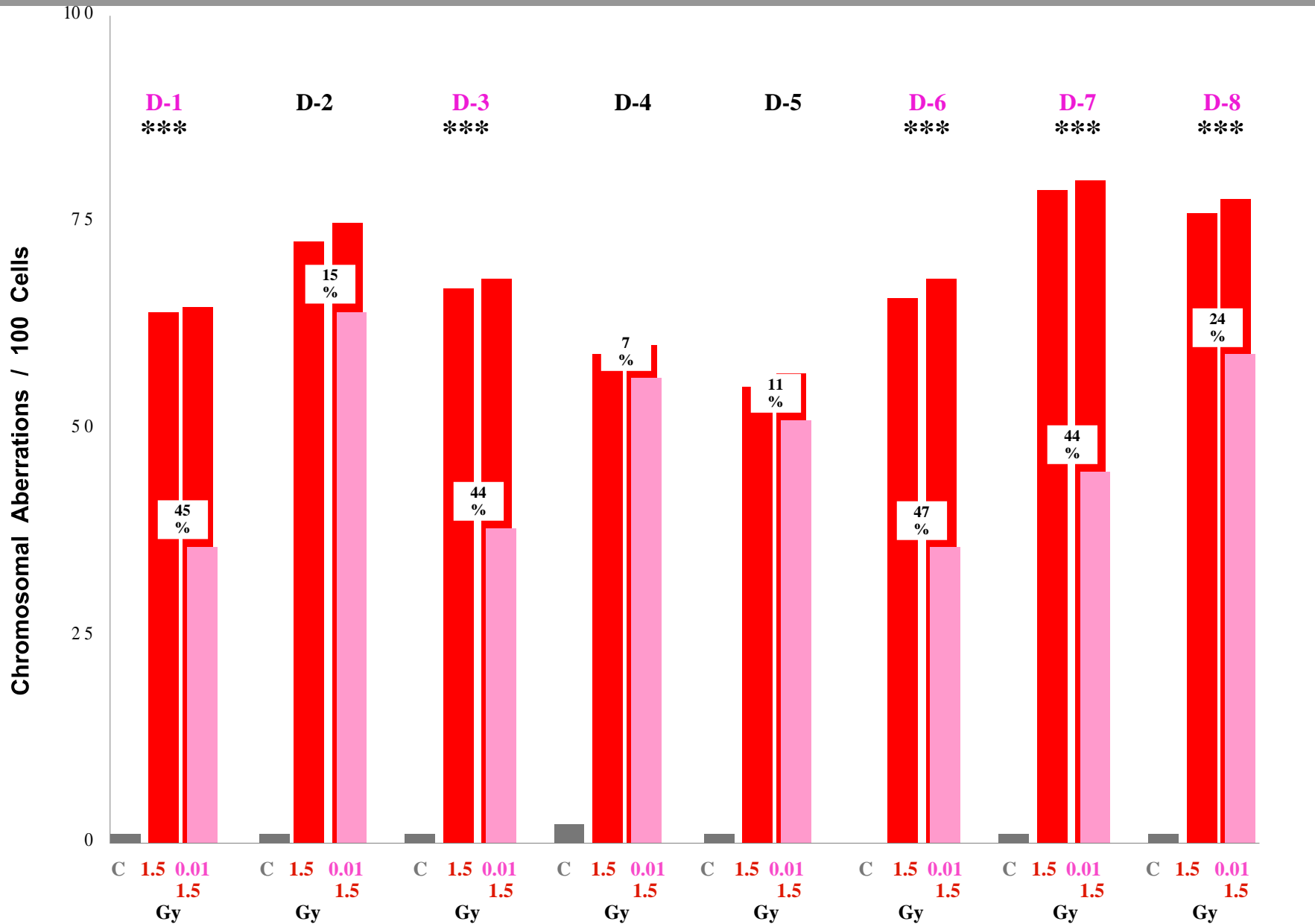
# **Adaptive Response**

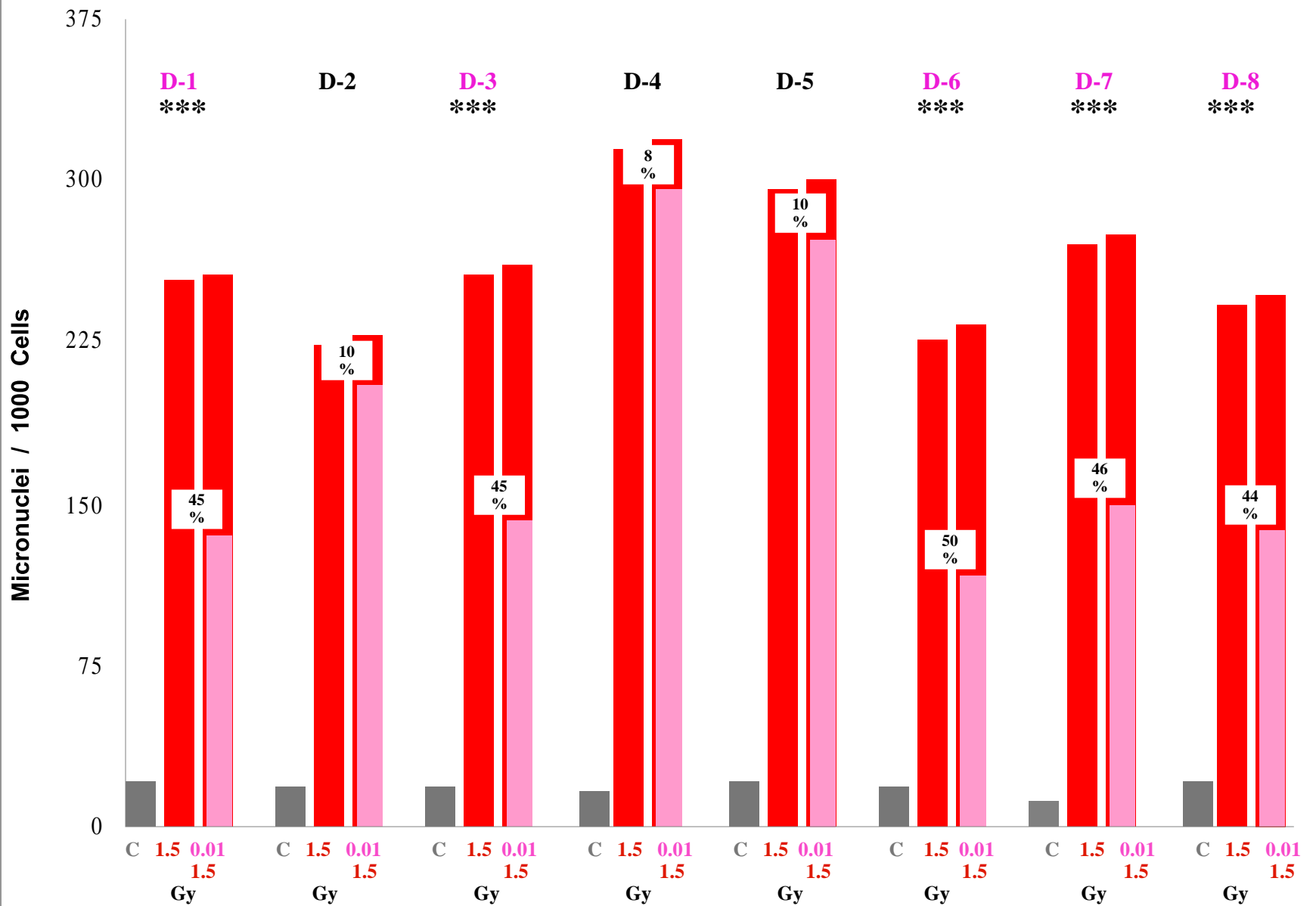
**Responders**  
**Non-Responders**

**Two Genotoxicity End-points**

# Experimental Protocol



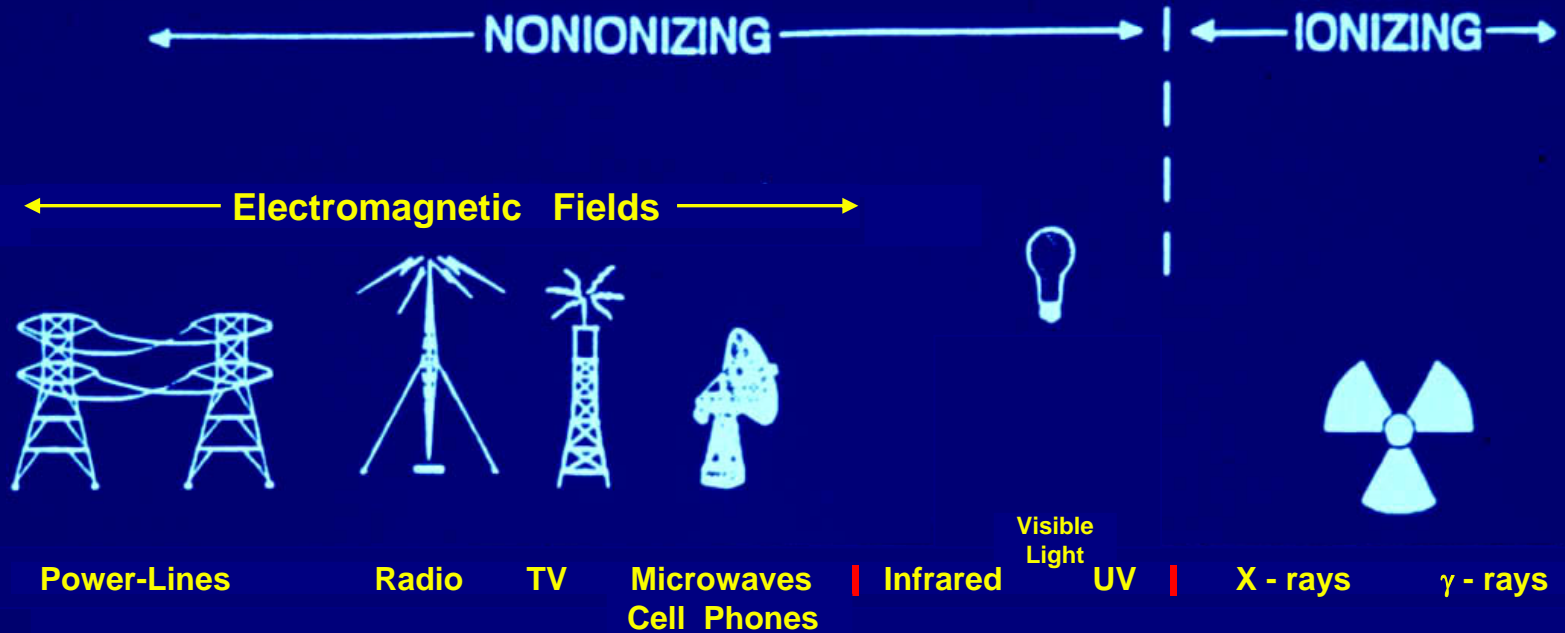




**Non-Ionizing  
Radiofrequency Fields**

**Genotoxicity**

# ELECTROMAGNETIC SPECTRUM



Frequency  
Hertz



Energy  
eV



1 Hertz (Hz) = One Cycle per Second



# Overall Conclusions

## Genotoxicity

# SIMILAR

## RF & Sham Cells

( very few exceptions )

At the Recommended Safety Levels.

*Vijayalaxmi & Prihoda. Rad Res. 169, 561 - 574, 2008.*

Specific Absorption Rate	
( Based on the Threshold for Behavior Disruption at <b>4</b> W / kg whole body averaged SAR )	
General Public	Occupational
<b>0.08</b> W / kg ( 50x safety factor )	<b>0.4</b> W / kg ( 10x safety factor )
<b>2.0</b> W / kg / 10 gm Av. SAR Localized Tissue Exposure for brain in mobile phone users 10 W / kg averaged over 10 gm for professional two-way radios	
<i>IEEE ( 2005 ) &amp; ICNIRP ( 1998, Reaffirmed in 2009 )</i>	

**Non-Genotoxic**

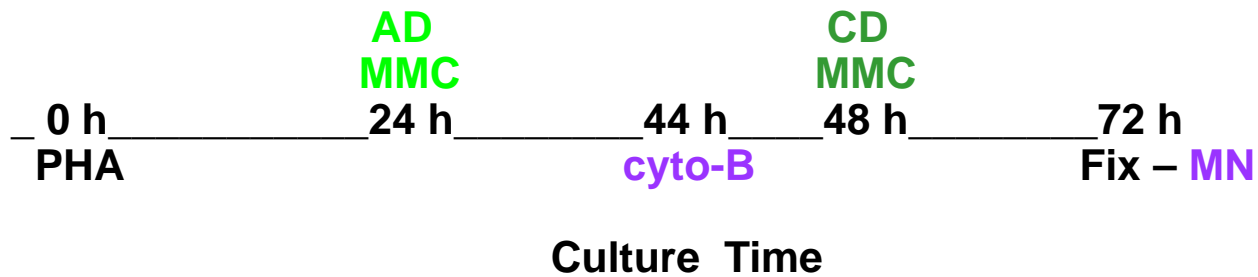
**900 MHz RF**

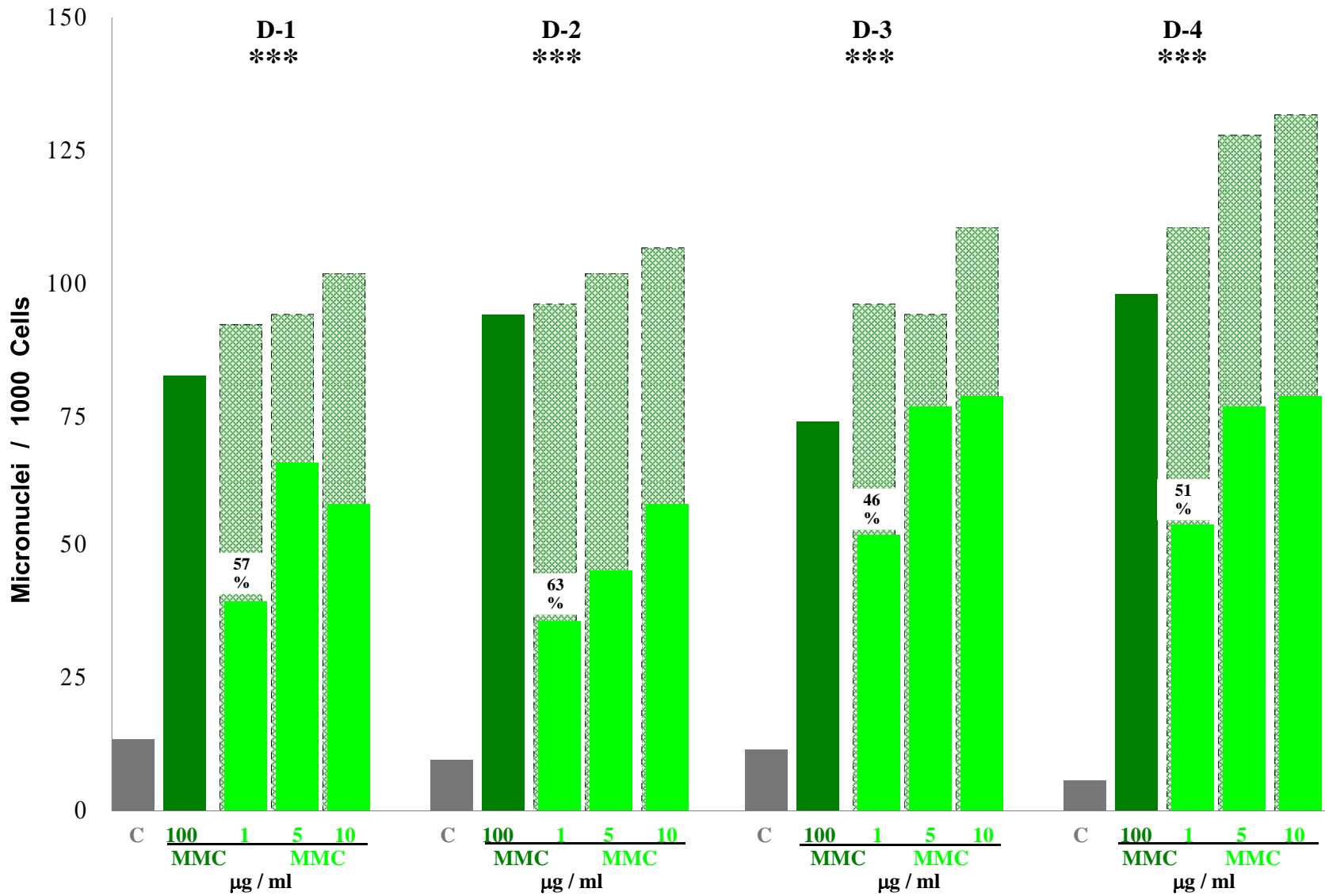
( average SAR of 1.25 W/kg )

**Adaptive Response**

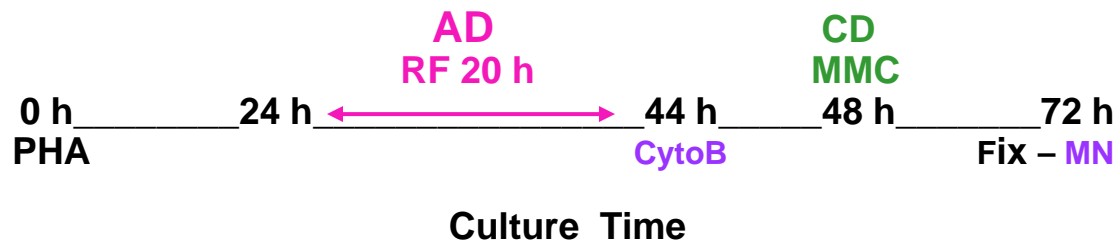
**Human Blood Lymphocytes**

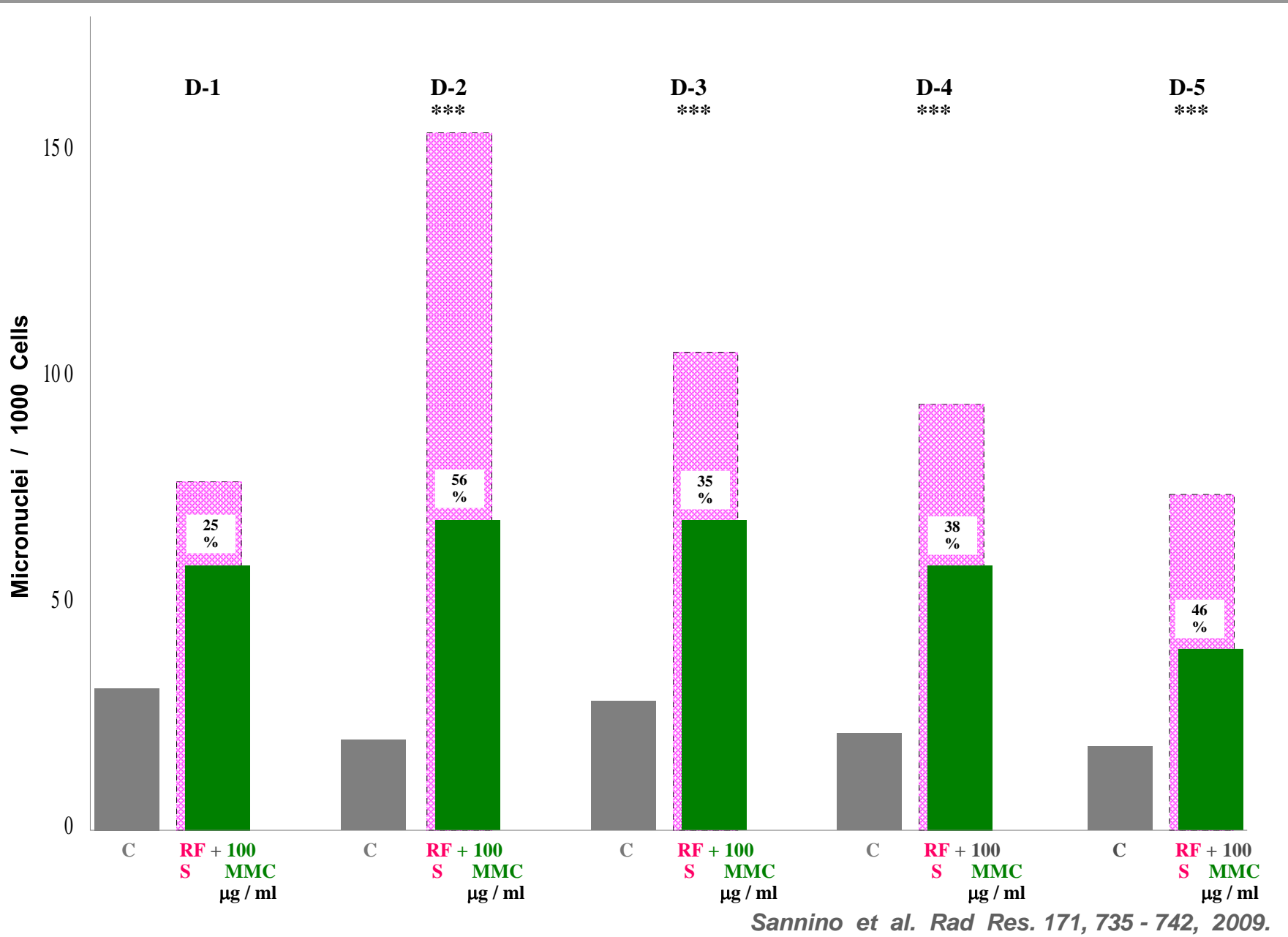
# Experimental Protocol





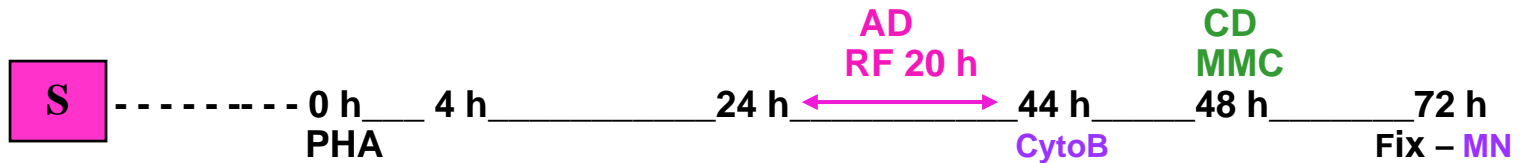
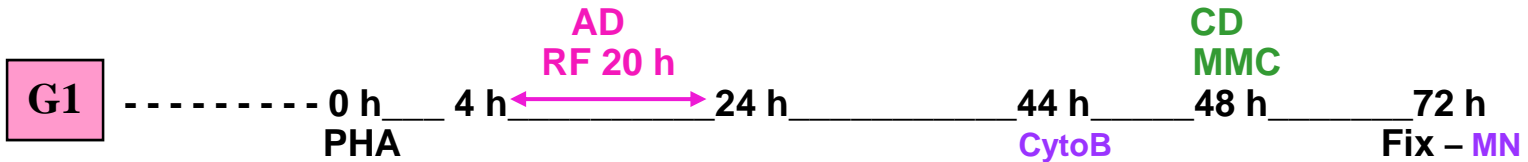
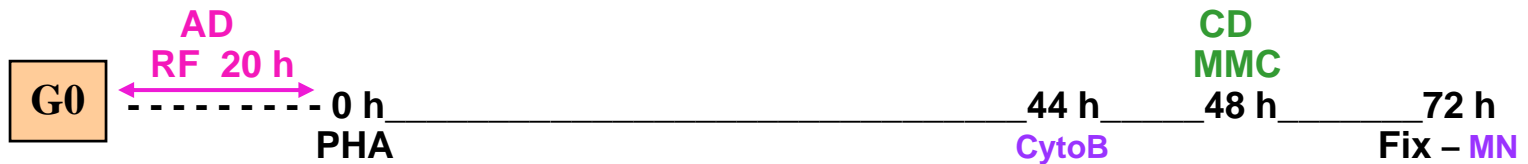
# RF - AR



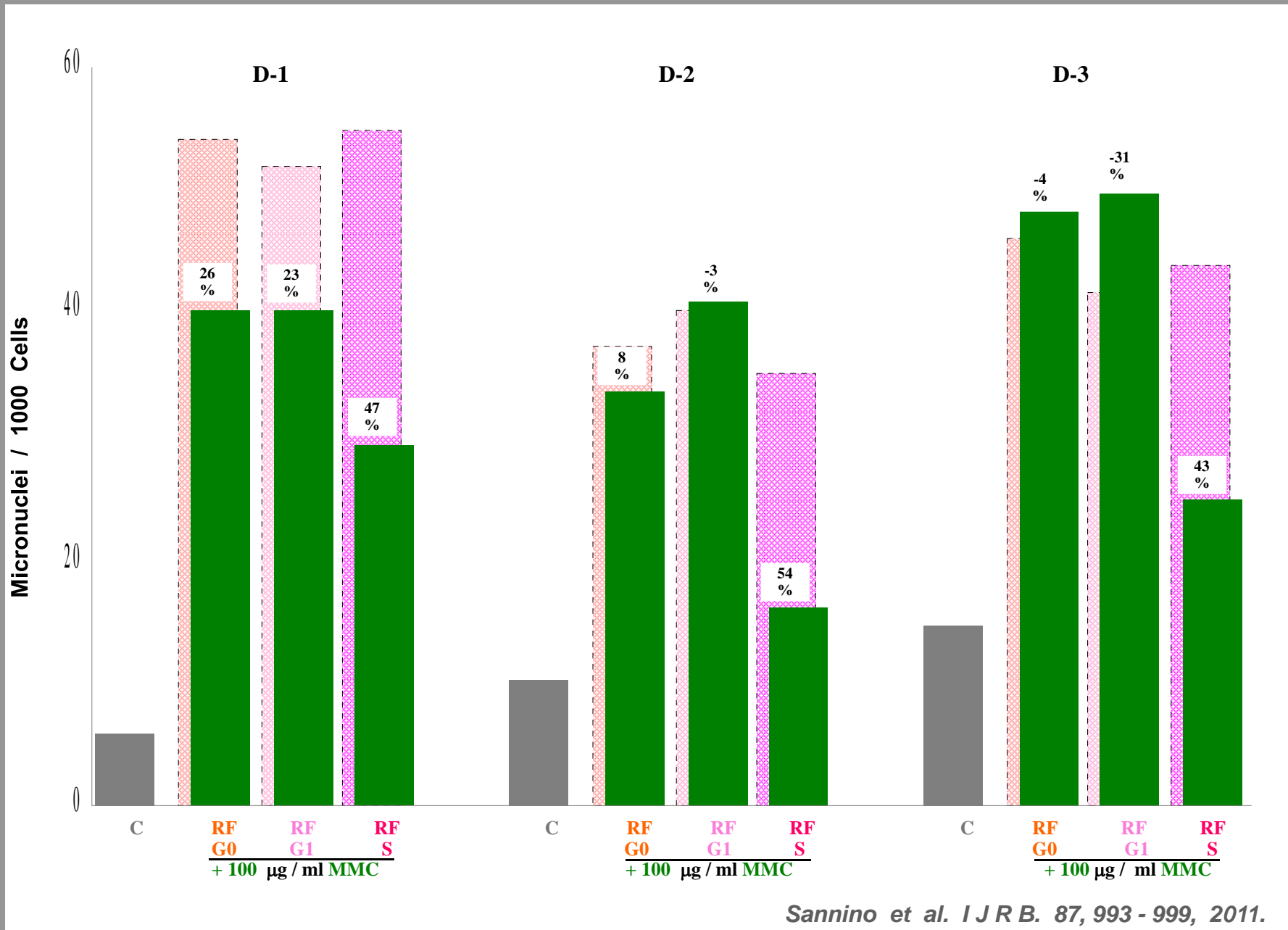


# RF - AR

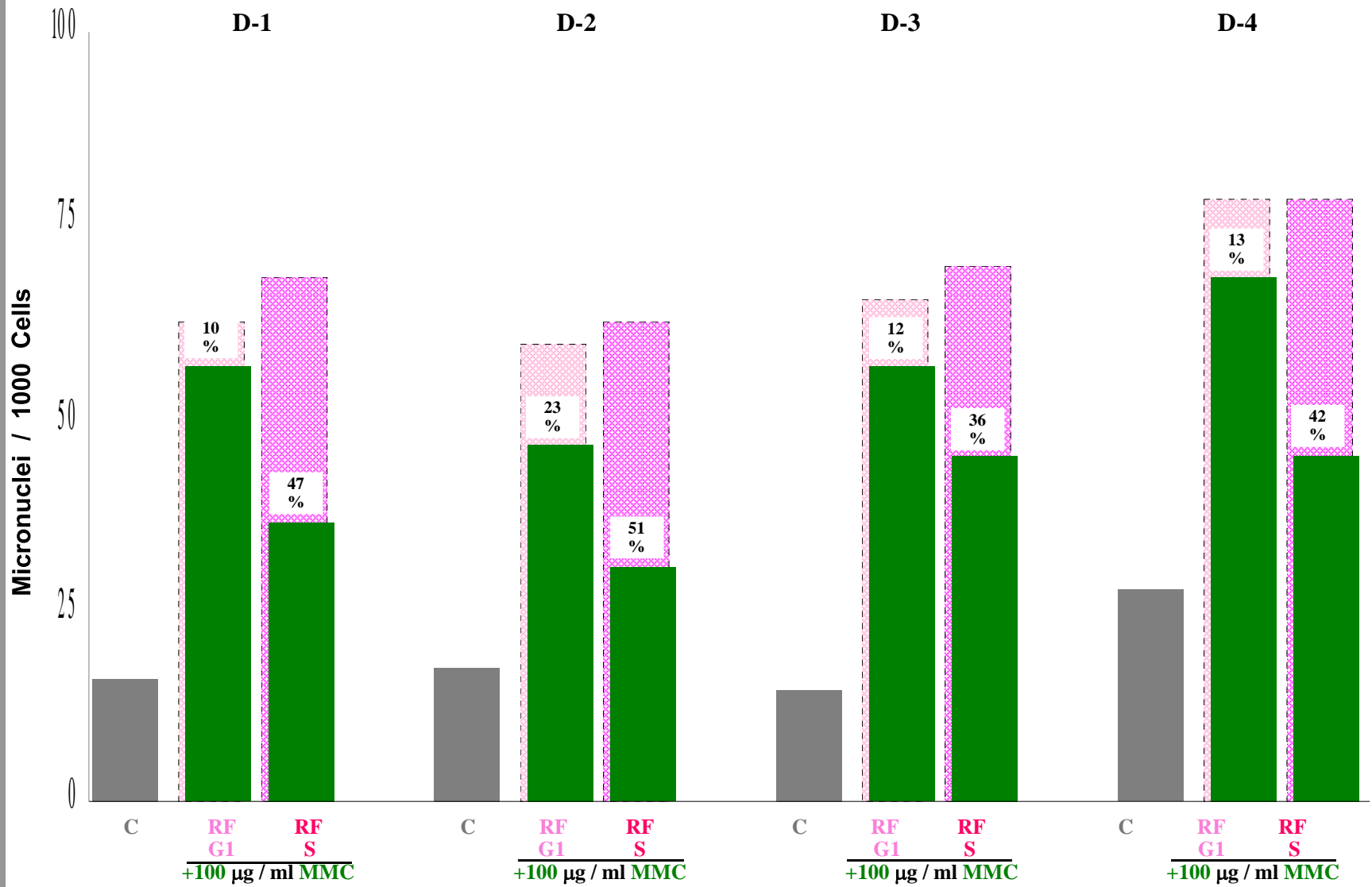
## Cell Cycle Effect



Culture Time



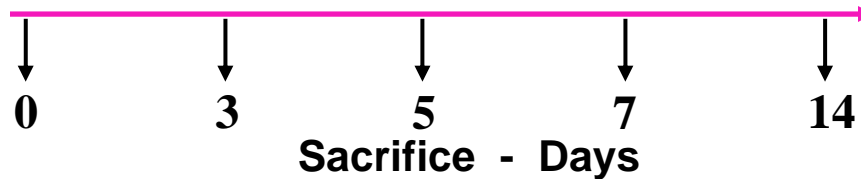




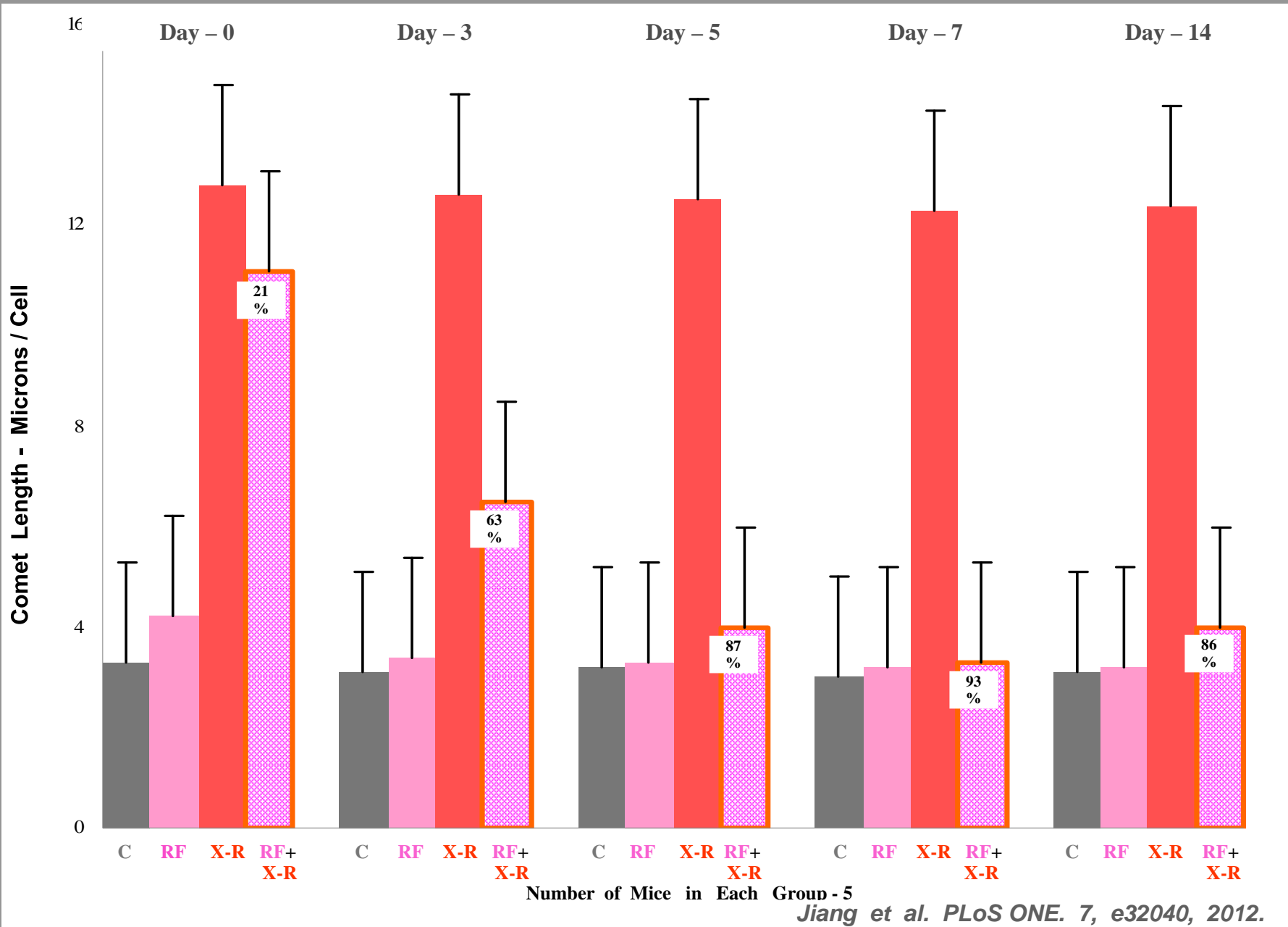
# Mice - AR

## Experimental Protocol

900 MHz RF - 548 mW/kg  
4 hours / day  
Exposure



Peripheral Blood Leukocytes



**Thank You**



## Inhibitors of DNA repair Enzymes

3-Aminobenzamide – Poly (ADP-Ribose) polymerase

Arabinofuranoside Cytosine – DNA Polymerase  $\alpha$

Aphidicolin – DNA Polymerase  $\alpha$  and  $\delta$

3-Dideoxy-Thymidine – DNA Polymerase  $\beta$

Caffeine – Post Replication Repair

Cyclohexamide – Protein Synthesis