Hydroxyl Radicals ($^{\cdot}OH$): Very Dangerous to All Biomolecules

$H_2O \rightarrow H_2O^{+\cdot}$ (water radical cation) + e^-

$e^- + nH_2O$---fast --$\rightarrow$ e^-_{aq} (electron becomes solvated)

H_2O-------$\rightarrow$ H_2O^*(excited water)---$\rightarrow$ $^{\cdot}OH$ (hydroxyl radical) + $H^{\cdot}$-atom Very short-lived and highly oxidizing

$H_2O^{+\cdot} + H_2O$---fast---$\rightarrow$ $H_3O + {}^{\cdot}OH$

$^{\cdot}OH + {}^{\cdot}OH$--slower--$\rightarrow$ H_2O_2---fast----Fe(II) ------$\rightarrow$ $OH + OH^-$ (Fenton Chemistry (& Haber-Weiss))

$^{\cdot}OH + H^{\cdot}$ ----fast----$\rightarrow$ H_2O considerable re-conversion to water

Superoxide ($O_2^{\cdot-}$): Substantially less oxidizing and not considered to contribute significantly to oxygen enhancement of radiation damage (Misra & Fridovich, 1976)

$e^-_{aq} + O_2$ -------limited by [O_2]-------$\rightarrow$ $O_2^{\cdot-}$(superoxide: moderately oxidizing and longer lived)

$O_2^{\cdot-} + O_2^{\cdot-}$--$2H^+$---moderate ---$\rightarrow$ H_2O_2 (long-lived) fast----Fe(II) ------$\rightarrow$ $^{\cdot}OH$ diffusable

$O_2^{\cdot-} + O_2^{\cdot-}$**+ SOD** --$2H^+$---faster---$\rightarrow$ H_2O_2 fast----Fe(II) ------$\rightarrow$ $^{\cdot}OH$

Role of Mn^{2+}: Powerful Scavenger of superoxide ($O_2^{\cdot-}$) and does not catalyse $^{\cdot}OH$ formation from H_2O_2

Metabolism-Induced ROS are Dangerous

The most important source of ROS *in vivo* in aerobic bacterial cells is the electron transport chain, that can give rise to high levels of $O_2^{\cdot-}$ which is rapidly converted to H_2O_2 by dismutation.

$O_2^{\cdot-} + O_2^{\cdot-}$--$2H^+$--moderate->//-- + SOD (faster)--$\rightarrow$ H_2O_2 (long-lived and diffusable)

Electron Transport systems leak electrons directly on to O_2, yielding superoxide

Following return-to-growth, electron leaks may be greater

Normal *E. coli* generates 5 mM $O_2^{\cdot-}$ per second in rich medium yielding steady-state 0.1-0.2 mM H_2O_2, & Much higher in minimal medium.

SOD mutants of *E. coli* (*sodA*$^-$*B*$^-$) cannot grow in minimal medium where high levels of metabolic ROS are generated; and recombination deficient (*recA*$^-$) *E. coli sod* mutants are killed in all aerobic growth conditions.

D. radiodurans (*sodA*$^-$[*B*$^-$]) grows on MM and under chronic radiation

D. radiodurans (*sodA*$^-$[*B*$^-$] *recA*$^-$) is viable under aerobic conditions

Irradiation : Releases Fe(II) from proteins, in the absence of Fe(II) causes H_2O_2 accumulation; protein-, lipid-, and DNA-damage