ON A HYBIRD SCALE MODEL OF DOSE-RESPONSE RELATIONSHIPS UNIVERSALLY APPLIED TO VARIOUS DATA OF IONIZING RADIATION EXPOSURE

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OBJECTIVE

To evaluate the low dose risk, this is to develop a universally applied method for dose-response data with a hybrid scale (HS) model that integrates multiplicative and additive reactions.

METHOD

Generalized Hybrid Scale (GHS) Model

Incidence $\log[I(D)] = \log[F(D)] + \log[S(D)]$

HS Model of $F(D) = I(D) / S(D)$

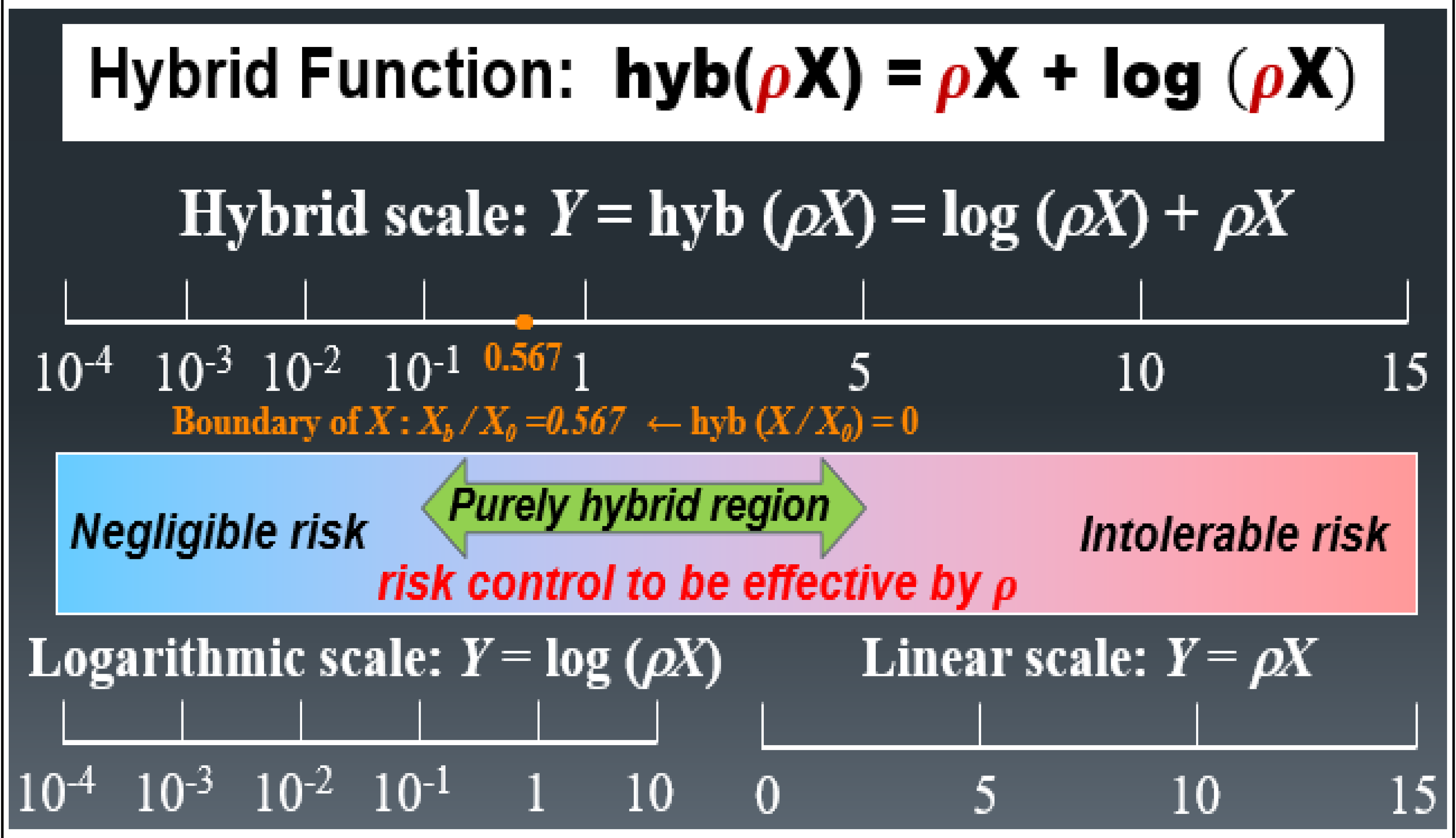
$$\log[F(D)] = \alpha + \beta\, \mathrm{hyb}(\tau D)$$

HS Model of S(D), cell survival

$$\mathrm{hyb}[\rho S(D)] = \delta - \lambda D, \quad \delta = \mathrm{hyb}(\rho)$$

$$\log[S(D)] = \rho[1-S(D)] - \lambda D$$

- α, β : model parameters
- τ : effect modifier per dose
- ρ : feedback factor of sublethal cell repair
- λ : inactivation constant per dose

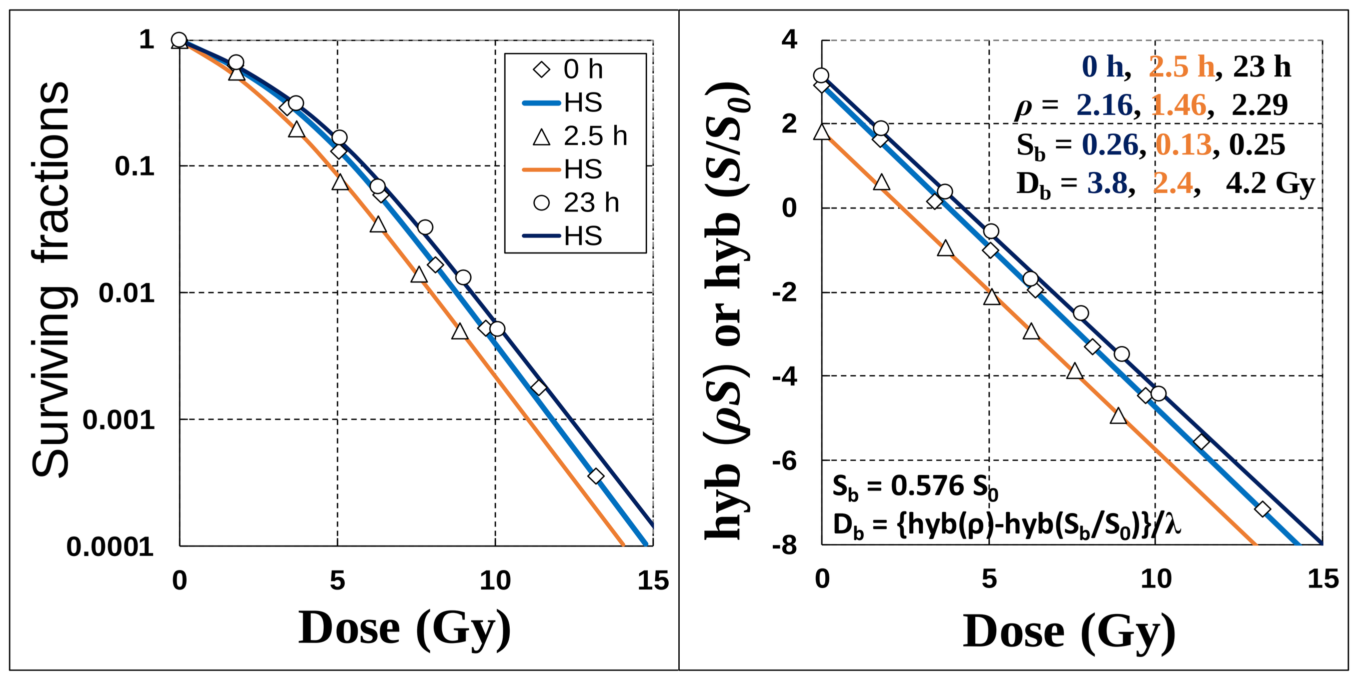


Dose reducing	$\Delta D_i = \varepsilon_i D_{i-1}/(1+\rho D_{i-1}) \rightarrow \rho\Delta D_i + \frac{1}{D_{i-1}}\Delta D_i = \varepsilon_i$ $\Delta\{\rho D_i + \log(\rho D_i)\} = \Delta\,\mathrm{hyb}(\rho D_i) = \varepsilon_i$
Cell repairing	$dS/dD = -\lambda S/(1+\rho S) \rightarrow \left(\rho + \frac{1}{S}\right) dS/dD = -\lambda$ $d\{\rho S + \log(\rho S)\}/dD = d\,\mathrm{hyb}(\rho S)/dD = -\lambda$

The concept of hybrid scale is important to identify the effective range of risk control for radiation protection and bio-defense system.

RESULTS-1 S_HS model applied to data of Elkind and Sutton (1960)

HS model: $\mathrm{hyb}(\rho S) = \mathrm{hyb}(\rho) - \lambda D$

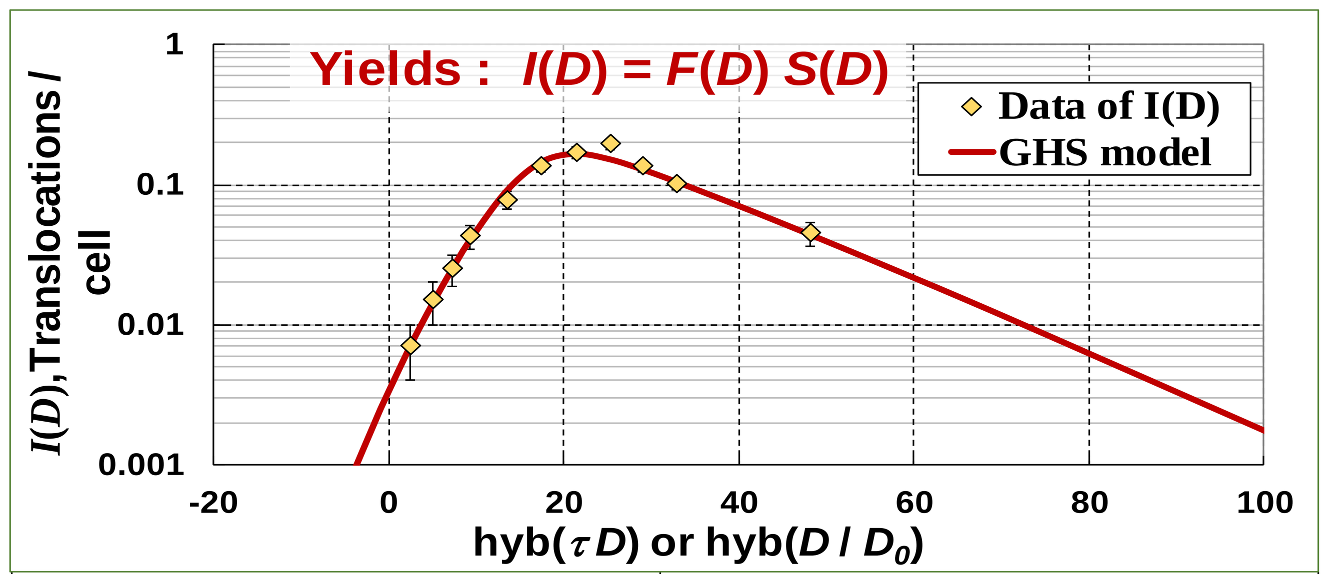


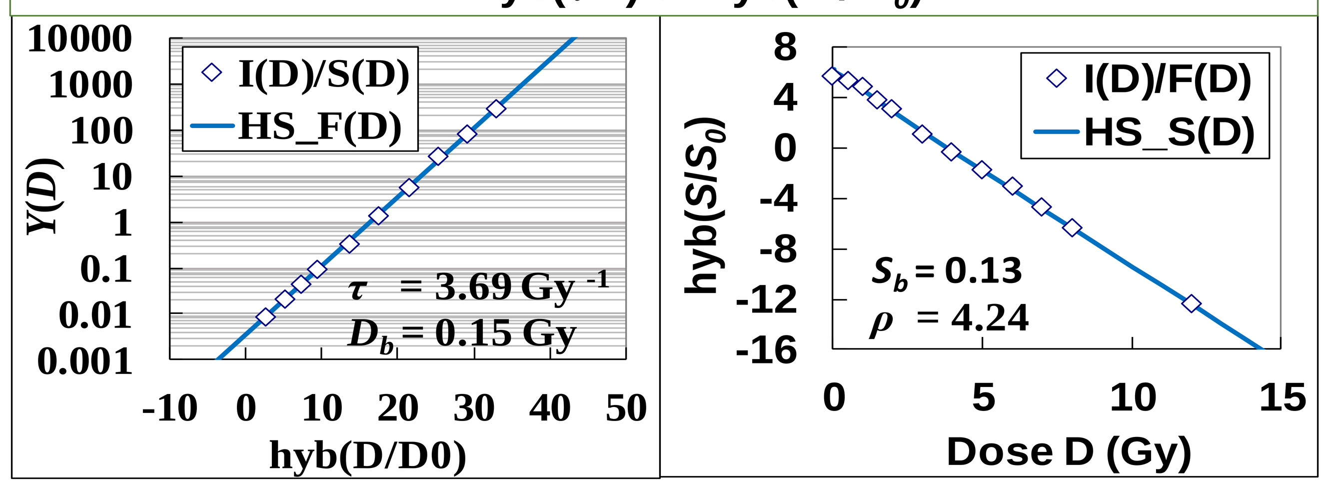
Fraction of surviving mammalian cells by split-dose of x-ray. The fitting is all good and ρ is small for 2.5 h due to less repair.

S(D): Cell survivals	F(D): Yields / viable cell
$\dfrac{dS}{dD} = \dfrac{-\lambda S}{1+\rho S}$	$\dfrac{dF}{dD} = \beta F\left(\tau + \dfrac{1}{D}\right)$
$\mathrm{hyb}(S/S_0)$ vs D	$\log(F)$ vs $\mathrm{hyb}(D/D_0)$

RESULTS-2 F_HS model, GHS model applied to Preston & Brewen (1973)

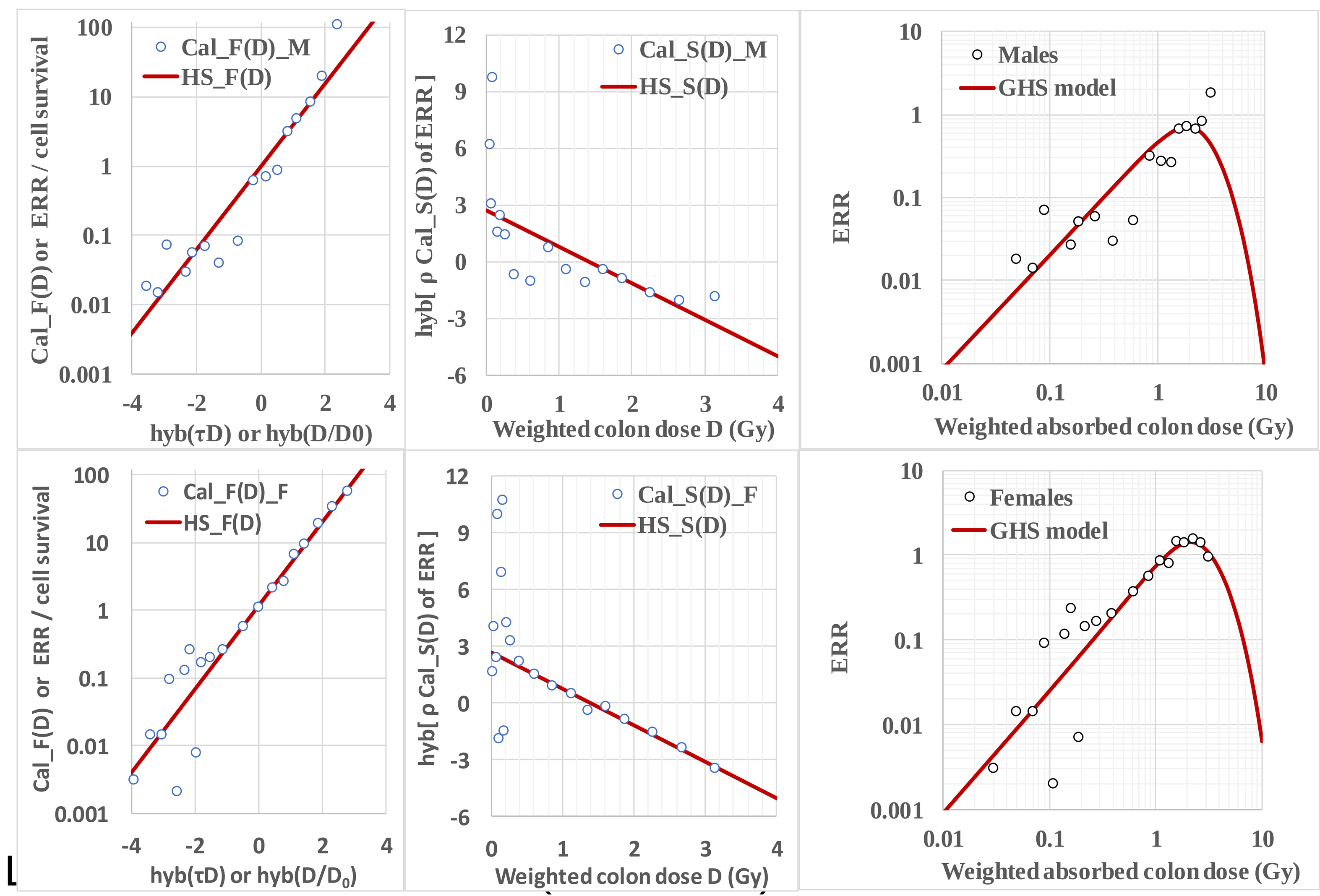
HS model: $\log[F(D)] = \alpha + \beta\,\mathrm{hyb}(\tau D)$





Reciprocal translocations of mice spermatogonia by x-ray. The fitting is good and a bio-system of F(D) is normal for $D < D_b$.

RESULTS-3 GHS model (Grant et al., 2017)



females at attained age of 70 years after exposure at age 30 years. **The fitting is all good over the dose range of S(D), F(D) and I(D) with a similar characteristics between males and females for extrapolating the low dose-response. The GHS model is better than L or LQ model due to using all available data.**

CONCLUSION

1. The HS model of survival S(D) was confirmed on data of Elkind and Sutton (1960).

2. The GHS model was fitted well to data of Preston and Brewen (1973), Mole (1984) and Majo et al. (1986), others.

3. The GHS model was fitted well to LSS solid cancer incidence ERR (Grant et al. 2017), better than L or L-Q model fitted to data in the range over 0.005 to 1 Gy or > 4 Gy.

REMARKS:

- Source: From Figure XVI, ANNEX B, UNSCEAR 1986 REPORT
- Data: Myeloid leukemia incidence of male CBA mice to x-rays (Mole, 1984; Majo et al., 1986)
- Results: The GHS model fitting is good and it predicts a smaller risk coefficient in the low dose range than the model shown in Figure XVI of the UNSCEAR 1986 Report.
- Transformations per surviving cell (Borek, 1984) in Figure VII of the ANNEX B is also fitted by HS model of F(D) well.