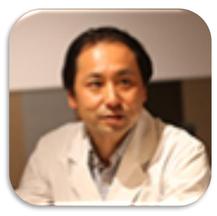
Challenge to use the Concept, Dose Rate instead of Total Dose

Yuichiro Manabe
Nuclear physics

Takahiro Wada
Nuclear physics



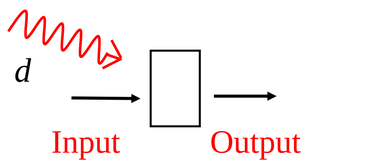
Yuichi Tsunoyama
Molecular biology

Hiroo Nakajim,
Mouse experiment

Issei Nakamura
Molecular dynamics

Masako Bando
Elementary particlle

1. Introduction



$$A = a_0 + a_1 d \qquad B = b_0 + b_1 d$$

4 parameters

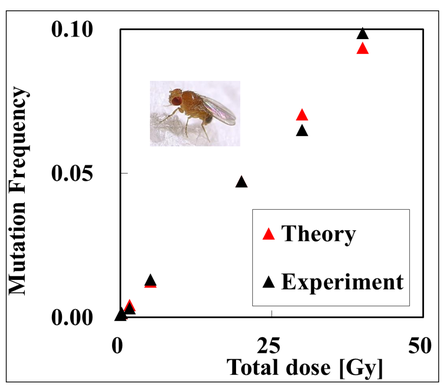
$$a_0, a_1, b_0, b_1$$

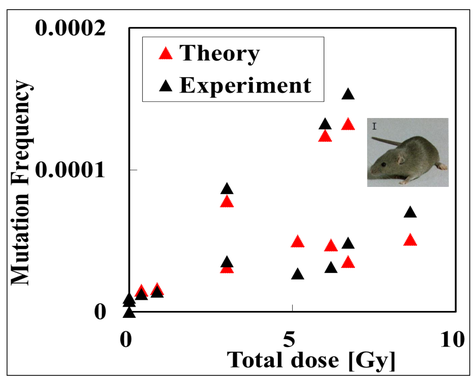
$$F(t) = \frac{A}{B}\left(1 - e^{-Bt}\right) + F(0)e^{-Bt}$$

$$d = 0 \rightarrow F(\infty) = \frac{a_0}{b_0} \quad (1)$$

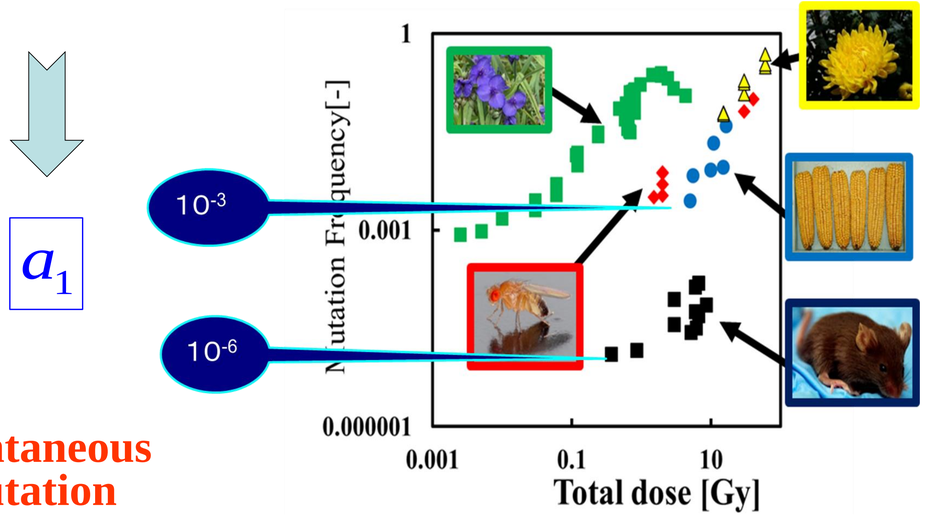
$$a_0 = a_1 d_{eff} \rightarrow A = a_1(d + d_{eff}) \quad (2)$$

Sketch of data of Drosophila & Mouse



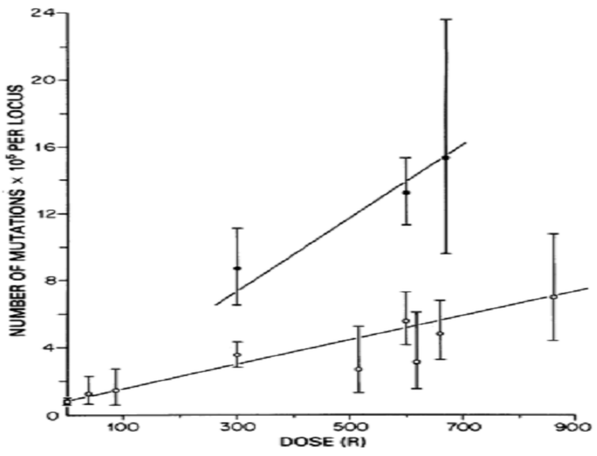


Order of mutation frequency?
Drosophila vs Mouse 1000 times!



Spontaneous mutation

At D=0(d=0)
Spontaneous
mutation



DD to ED

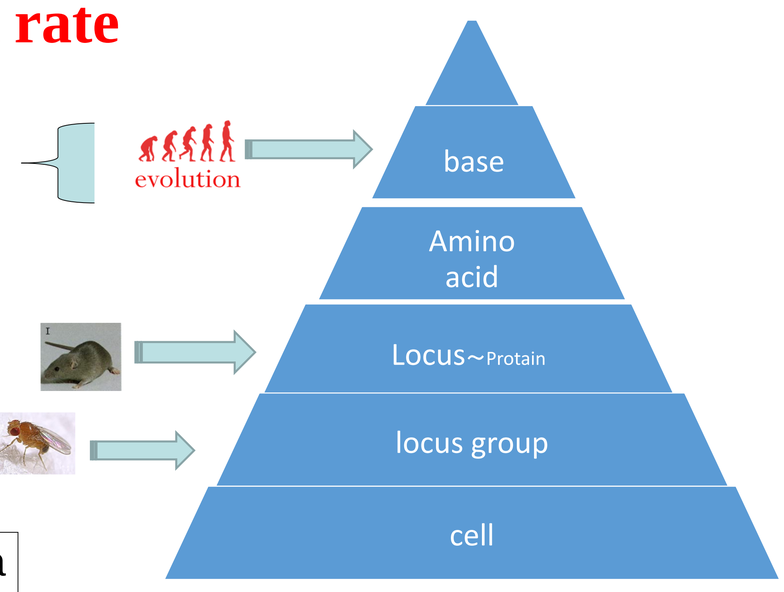
2. Mutation rate

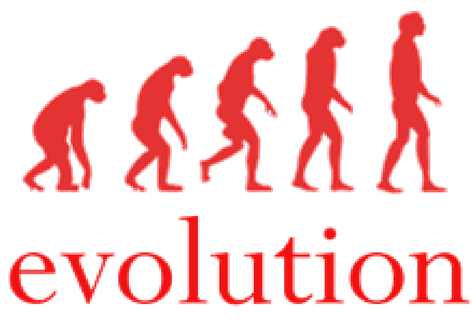
Mutation rate

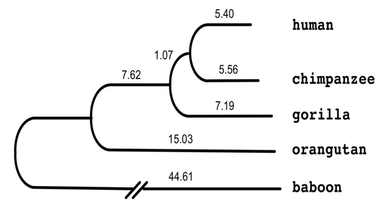
dose rate per base

500-1000 times

Drosophila data
recessive lethal
mutation

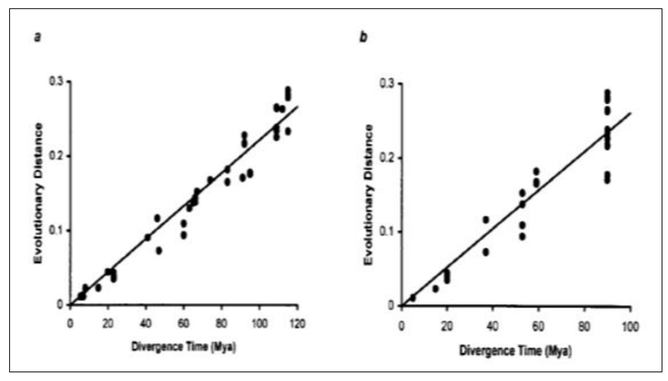






Evolution velocity

Molecular Clock
Zuckerkandr
&Pauling



1pauling : 10^{-9} / y / base

S. Kumar&S, Subraminian;PNAS Vol. 99(2002)803

$$a_0 = 10^{-8} / \mathrm{h} / \mathrm{locus} \sim 10^{-4} / \mathrm{y} / \mathrm{locus}$$

$$\sim 10^{-9} / \mathrm{y} / \mathrm{base}$$

3. Effective Dose Rate

Spontaneous mutation is a fact of life

Even without artificial exposure $d = 0 (D = 0)$

The doubling doses are almost of the same order among different experimental conditions, different species. Muller, Russel, Neel etc

A tool to make across-species comparisons

However the value doubling dose varies with the dose rate even under the same D

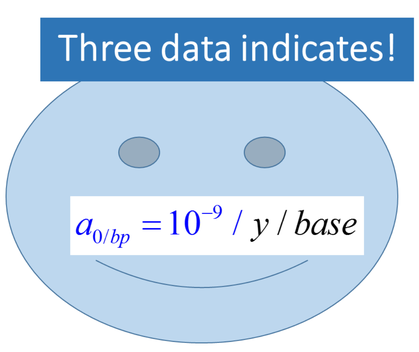
DD to EDR → Effective dose rate

$$a_0 \equiv a_1 d_{eff} \rightarrow A = a_1(d_{eff} + d)$$

Comparison with the values obtained so far **dose rate dependence**

- 1.11×10^{-3} [Gy/hour] =1.11 [mGy/hour] d :[Gy/hour]
  WAM model (our result)
- 2.84 [mGy/hour] ← 0.14 [mGy/min]
  M. Tubiana, L. E. Feinendegen, C. Yang and J. M. Kaminski,
  Radiology 251 (2009) 13. p14 (from Human data)

4. Conclusion



- **Effective dose rate may be replaced as a tool which makes across-species comparison**
- **We can apply this model to the scheduling of cancer therapy and radiation protection of nuclear plant workers.**

Unified Understanding of Biological Effects induced by Radiation Exposure