Proposal of a New Model Including Proliferation and Irradiation for Cancer Therapy

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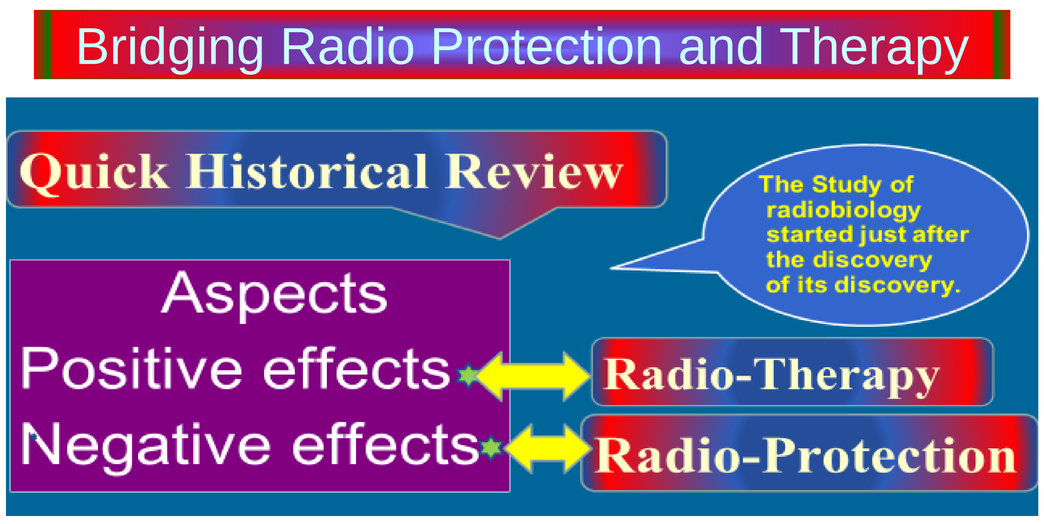
1. Introduction

In order to extend to cancer system, we have taken account of cell proliferation effects, since cancer cells have strong proliferation power. We here extend WAM model[1)] to apply to the cell system which has a power of proliferation. This can be directly applied to clinic plans in radiotherapy and the basic formula for radioprotection.

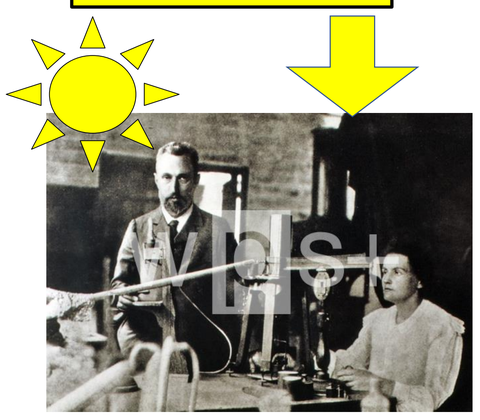
Target
Mutated cells

LNT（Linear non-threshold）

JE Muller's *Drosophila* experiments showed that the mutation frequency increases linearly with the exposed total dose. After that W. Russell pursued the so called "mega mouse project" and found the dose-rate effect.

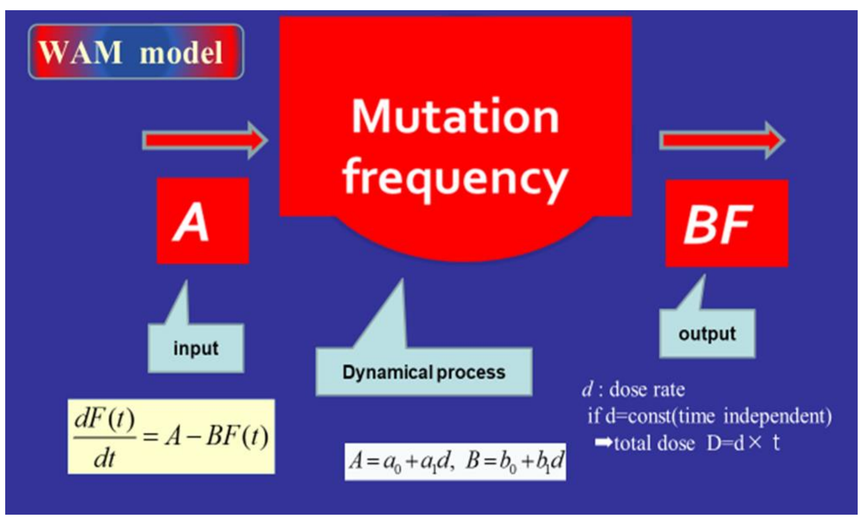


Target
Cancer cells



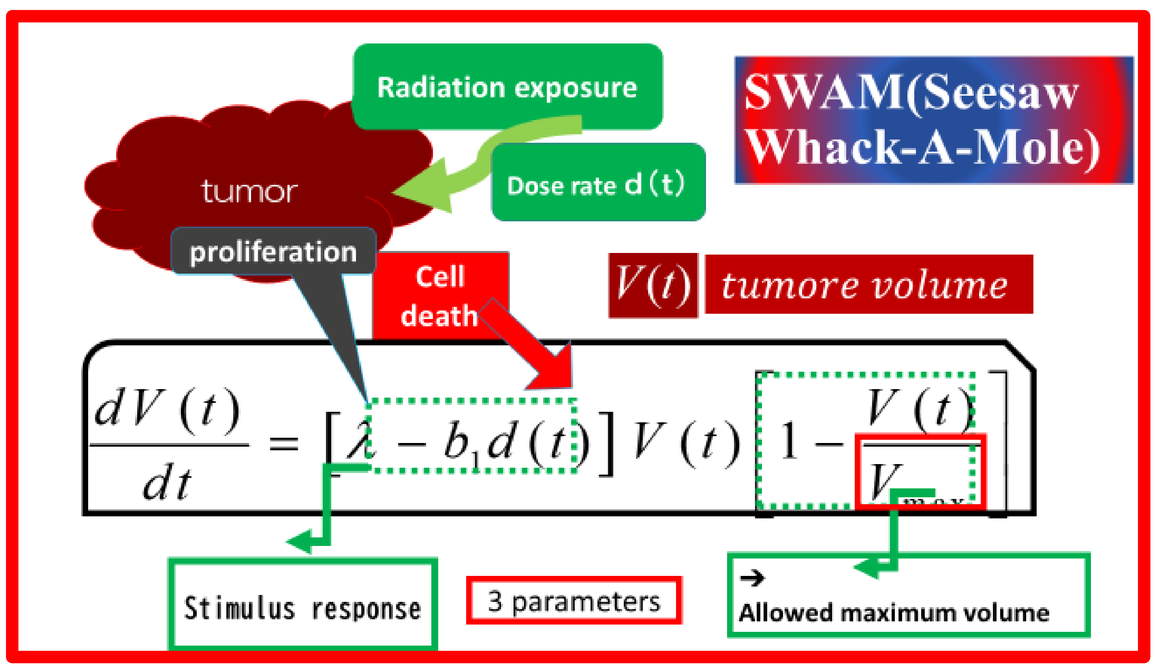
In 1929, Marie Curie's first wrote a paper "Experimental and theoretical studies of the effects of X ray on bacteria. note that the first focusing object is cold Sterilization. and she proposed the idea of target theory.

2. Formulation

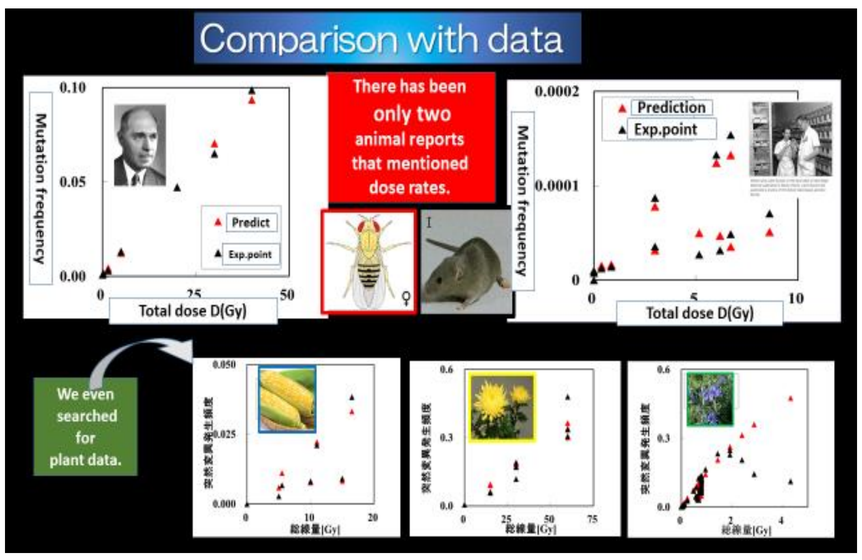


Equation for mutated cells

It is easy to include proliferation effect into WAM formula. Just simply put the proliferation rate λ into WAM formula. Also note that the proliferation usually expressed as growth factor taking account of the maximum volume, which is the allowed maximum volume of corresponding tissue. Thus, we have two more parameters , λ、 Vmax in addition to b1.

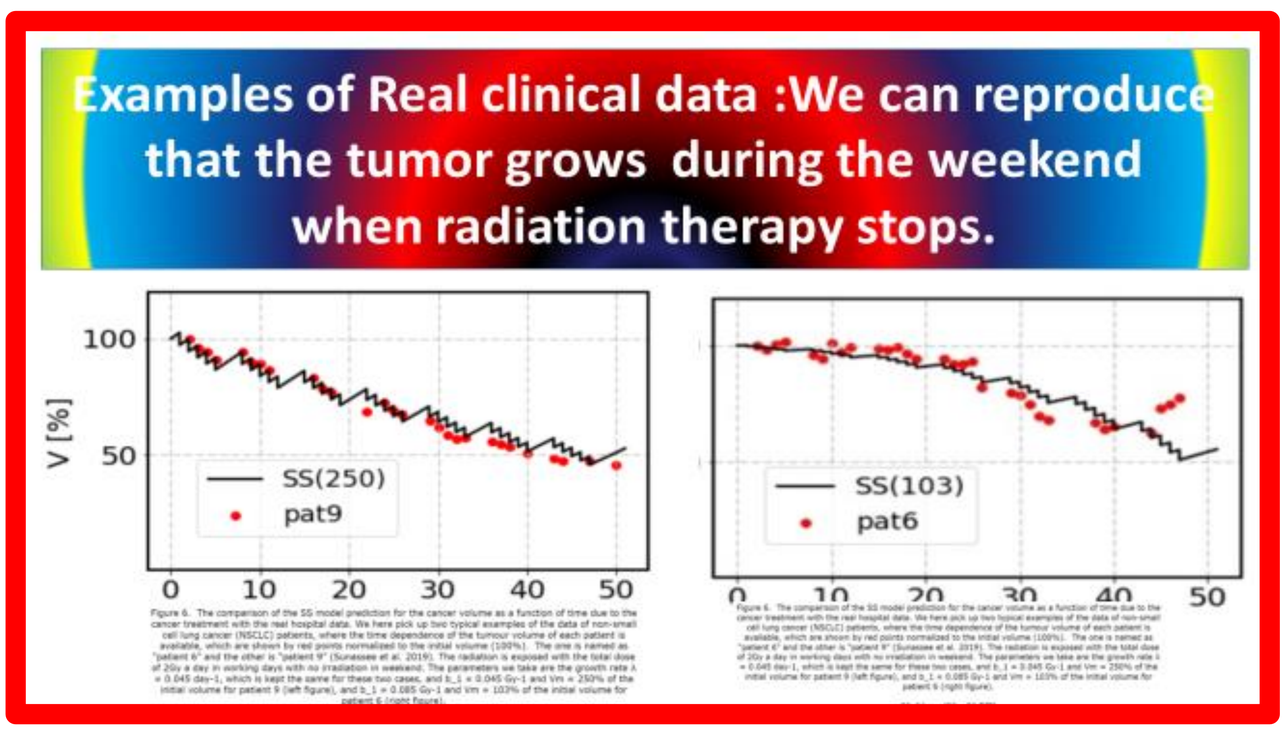


3. Results



Whack-A-Mole (WAM) Model[1)]

Our first outcome is WAM (Whack a Mole) model to estimate mutation frequency observed from the heritable effects by introducing time-dependent formula. This is a realization of the biological organism; competition between damage and recovery which is always operating in a living system. Our theory reproduce the experimental result, *Drosophila* and mouse. We even searched for plant, cone, chrysanthemum and *Tradescantia*.



SeaSaw Whack-A-Mole (SWAM) Model[2)]

The comparison of the SWAM prediction for the cancer volume as a function of time due to the cancer treatment with the real hospital data. We here pick up two typical examples of the data of non-small cell lung cancer (NSCLC) patients, where the time dependence of the tumor volume of each patient is available, which are shown by points normalized to the initial volume (100%) (Sunassee et al. 2019). The radiation is exposed with the total dose of 2 Gy a day in working days with no irradiation in weekend. The parameters we take are the growth rate λ = 0.045 day−1, which is kept the same for these two cases, and b1 = 0.045 Gy−1 and Vm = 250% of the initial volume for patient 9 (left figure), and b1 = 0.085 Gy−1 and Vm = 103% of the initial volume for patient 6 (right figure).

4. Conclusion

We can treat radioprotection and radiotherapy at the same time without any trouble!

Considering dynamic balance, we can we constrict a consistent model that overcomes the most serious drawbacks of LQM.

References
1) Bando M. et al., *Int. J. Radiat. Biol.*, 95(10), 1390-1403 (2019)
2) Bando M. et al., *Int. J. Radiat. Biol.*, 97(2), 228-239 (2021)