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Opinion

From Ashes to Life - The Indestructible *D. radiodurans*

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Abstract

Deinococcus radiodurans (*D. radiodurans*) was accidentally discovered in 1956 when cans of ground meat were exposed to massive doses of ionizing gamma radiation, intended to kill dangerous bacteria. The bacterium can survive doses of radiation, even up to 1,000 times that which is deadly to humans. Among biologists and biophysicists, D. radiodurans is often humorously called "Conan the Bacterium." This extreme radioresistance of the bacterium has been attributed to its ability to protect the proteome from ROS, which originates from water radiolysis, and also to carry out the effective repair of a large amount of DNA damage.

More Information

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Introduction

D. radiodurans were discovered almost serendipitously in 1956 when cans of ground meat were treated with massive doses of ionizing gamma radiation to rid them of dangerous bacteria. This bacterium was found to be capable of surviving radiation doses one thousand times higher than that which is lethal for a human being. Among biologists and biophysicists, this extremophile is often known jokingly as "Conan the Bacterium" [1,2].

Effects of ionizing radiation

It is known that ionizing radiation causes the most deleterious influence on genetic material because it induces Double-Strand Breaks (DSB) in DNA. In most cases, this kind of damage cannot be effectively repaired. Inborn diseases or cancer can develop as a result. In other words, DSB disrupts DNA strands, shattering into myriads of small pieces of different sizes [3,4]. The former process is mainly due to the deleterious activity of Reactive Oxygen Species (ROS) produced by water radiolysis, leading to DSBs. Besides DNA mutilation, ROS inflicts severe damage on the cell's proteome, which plays a vital role in DSB repair; therefore, this mechanism is unfeasible.

Protective mechanisms of *D. radiodurans*

The formation of ROS stimulates protective reactions that donate electrons to the free radicals, thus making them non-reactive. As shown by some of the pioneering studies [5,6], the amazing radioresistance of *D. radiodurans* is attributed to a scavenger that exists in the cytosol (moieties of less than 3 kDa). These small molecules protect *D. radiodurans*' proteome from oxidizing radicals by quenching the ROS produced by radiation.

The secret of radioresistance

The secret behind D. radiodurans' incredible radioresistance lies in its ability to protect its proteome. Thanks to this ability, *D. radiodurans* can repair up to 500 breaks, while the much-studied *E. coli* can fix two or three breaks at once in its DNA. This peculiarity is generalized by the following concept:

Iron-clad concept of cell survival

A cell dies when its proteome ceases to function, as the most critical biological information comes not from its DNA but from its protein structure. A small theoretical-experimental summary concerning the radioresistance and radiosensitivity of *D. radiodurans* can be found in reference [7]. *Deinococcus radiodurans* is also on the list of "the world's toughest bacterium" in the Guinness Book of World Records [8].

Conclusion

Deinococcus radiodurans is an exceptional bacterium for its capability to withstand extremely high doses of ionizing radiation; such resistance is provided by the adequate protection of the bacterium proteome from oxidative damage due to ROS. It gives *D. radiodurans* the potential to repair great extents of damage to DNA relatively quickly

and fast, a process that would be lethal to other organisms. This information, with knowledge of the mechanisms of this bacterium, shows its distinctiveness as a radioprotective microorganism, much in the way the approaches to improve radioprotection strategies in other biological systems are unique.

References

1. Anderson A, Nordon Hc, Cain RF, Parrish G, Duggan D, Anderson A. Studies on a radio-resistant micrococcus. I. Isolation, morphology, cultural characteristics, and resistance to gamma radiation. Food Technol. 1956;10(1):575-577. Available from: https://www.semanticscholar.org/paper/Studies-on-a-radio-resistant-micrococcus.-I.-and-to-Anderson-Nordon/10108eeb961a2a3b7f1a9e2fd139b714da6a58e7
2. Huyghe P. Conan the bacterium. The Sciences. 1998; 38(4):16. Available from: https://openurl.ebsco.com/EPDB%3Agcd%3A13%3A6063805/detailv2?sid=ebsco%3Aplink%3Ascholar&id=ebsco%3Agcd%3A813317&crl=c
3. Krisko A, Radman M. Protein damage and death by radiation in *Escherichia coli* and Deinococcus radiodurans. Proc Natl Acad Sci U S A. 2010; 107(32):14373-7. Available from: https://pubmed.ncbi.nlm.nih.gov/20660760/
4. Krisko A, Radman M. Biology of extreme radiation resistance: the way of Deinococcus radiodurans. Cold Spring Harb Perspect Biol. 2013;5(7):a012765. Available from: https://pubmed.ncbi.nlm.nih.gov/23818498/
5. Daly MJ. A new perspective on radiation resistance based on Deinococcus radiodurans. Nat Rev Microbiol. 2009;7(3):237-245. Available from: https://pubmed.ncbi.nlm.nih.gov/19172147/
6. Daly MJ, Gaidamakova EK, Matrosova VY, Kiang JG, Fukumoto R, Lee DY, et al. Small-molecule antioxidant proteome-shields in Deinococcus radiodurans. PLoS One. 2010 Sep 3;5(9):e12570. Available from: https://pubmed.ncbi.nlm.nih.gov/20838443/
7. Arruda-Neto JD, Righi H, Gomez JG, da Silva LF, Drigo E, da Costa Lemos AC. Radioresistance and radiosensitivity: a biophysical approach on bacterial cells robustness. Theory Biosci. 2022;142:13-28. Available from: https://link.springer.com/article/10.1007/s12064-022-00382-w
8. Guinness World Records. "Most radiation-resistant lifeform". 2015. Available from: https://www.guinnessworldrecords.com/world-records/most-radiation-resistant-lifeform