http://www.sciencedaily.com/releases/2012/11/121113134224.htm

Radiation Science Daily
Breast Cancer Risk

ScienceDaily (Nov. 13, 2012)

Even the very lowest levels of radiation are harmful to life, scientists have concluded in the *Cambridge Philosophical Society's journal Biological Reviews*. Reporting the results of a wide-ranging analysis of 46 peer-reviewed studies published over the past 40 years, researchers from the University of South Carolina and the University of Paris-Sud found that variation in low-level, natural background radiation was found to have small, but highly statistically significant, negative effects on DNA as well asseveral measures of health.

Keywords:

adaptation ; cancer;disease ; DNA repair ; hormesis ; mutation ; radioactivity ; radio-resistance ; radio-tolerance

Natural levels of radioactivity on the Earth vary by more than a thousand-fold; this spatial heterogeneity may suffice to create heterogeneous effects on physiology, mutation and selection. We review the literature on the relationship between variation in natural levels of radioactivity and evolution. First, we consider the effects of natural levels of radiation on mutations, DNA repair and genetics. A total of 46 studies with 373 effect size estimates revealed a small, but highly significant mean effect that was independent of adjustment for publication bias. Second, we found different mean effect sizes when studies were based on broad categories like physiology, immunology and disease frequency; mean weighted effect sizes were larger for studies of plants than animals, and larger in studies conducted in areas with higher levels of radiation. Third, these negative effects of radiation on mutations, immunology and life history are inconsistent with a general role of hormetic positive effects of radiation on living organisms. Fourth, we reviewed studies of radiation resistance among taxa. These studies suggest that current levels of natural radioactivity may affect mutational input and thereby the genetic constitution and composition of natural populations. Susceptibility to radiation varied among taxa, and several studies provided evidence of differences in susceptibility among populations or strains. Crucially, however, these studies are few and scattered, suggesting that a concerted effort to address this lack of research should be made.

The review is a meta-analysis of studies of locations around the globe that have very high natural background radiation as a result of the minerals in the ground there, including Ramsar, Iran, Mombasa, Kenya, Lodeve, France, and Yangjiang, China. These, and a few other geographic locations with natural background radiation that greatly exceeds normal amounts, have long drawn scientists intent on understanding the effects of radiation on life.

Individual studies by themselves, however, have often only shown small effects on small populations from which conclusive statistical conclusions were difficult to draw.

"When you're looking at such small effect sizes, the size of the population you need to study is huge," said co-author Timothy Mousseau, a biologist in the College of Arts and Sciences at the University of South Carolina. *"Pooling across multiple studies, in multiple areas, and in a rigorous statistical manner provides a tool to really get at these questions about low-level radiation."*

Mousseau and co-author Anders Møller of the University of Paris-Sud combed the scientific literature, examining more than 5,000 papers involving natural background radiation that were narrowed to 46 for quantitative comparison. The selected studies all examined both a control group and a morehighly irradiated population and quantified the size of the radiation levels for each. Each paper also reported test statistics that allowed direct comparison between the studies.

The organisms studied included plants and

animals, but had a large preponderance of human subjects. Each study examined one or more possible effects of radiation, such as DNA damage measured in the lab, prevalence of a disease such as Down'sSyndrome, or the sex ratio produced in offspring. For each effect, a statistical algorithm was used to generate a single value, the effect size, which could be compared across all the studies.

The scientists reported significant negative effects in a range of categories, including immunology, physiology, mutation and disease occurrence. The frequency of negative effects was beyond that of random chance.

"There's been a sentiment in the community that because we don't see obvious effects in some of these places, or that what we see tends to be small and localized, that maybe there aren't any negative effects from low levels of radiation," said Mousseau. *"But when you do the meta-analysis, you do see significant negative effects."*

"It also provides evidence that there is no threshold below which there are no effects of radiation," he added. *"A theory that has been batted around a lot over the last couple of decades is the idea that is there a threshold of exposure below which there are no negative consequences. These data provide fairly strong evidence that there is no threshold -- radiation effects are measurable as far down as you can go, given the statistical power you have at hand."*

Mousseau hopes their results, which are consistent with the *"linear-no-threshold"* model for radiation effects, will better inform the debate about exposure risks. *"With the levels of contamination that we have seen as a result of nuclear power plants, especially in the past, and even as a result of Chernobyl and Fukushima and related accidents, there's an attempt in the industry to downplay the doses that the populations are getting, because maybe it's only one or two times beyond what is thought to be the natural background level,"* he said. *"But they're assuming the natural background levels are fine."*

"And the truth is, if we see effects at these low levels, then we have to be thinking differently about how we develop regulations for exposures, and especially intentional exposures to populations, like the emissions from nuclear power plants, medical procedures, and even some x-ray machines at airports."