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EFFICIENCY *VERSUS* ROBUSTNESS

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Molecular biology is hallmarked by the study of the fast growing–fast evolving bacteria, such as *Escherichia coli*. Large population sizes, variable mutation rates and horizontal gene transfer endow fast growing bacteria with an awesome adaptive potential based on powerful selection from huge pools of genetic diversity. In small populations (infective inoccula), the mutagenic SOS induction and second order selection of genetic mutators, provide for rapid generation of adaptive diversity. Clearly, the evolutionary success of bacteria is based on their genetic adaptivity in face of selective forces: repeated preferential survival of a small "winning" fraction of the population (favorable mutants) taking over in sequential "selective sweeps". This results in selection for efficiency and "investment" in population fitness. I shall present what appears as an alternative evolutionary strategy of survival: the selection of robustness, instead of efficiency, occurring under harsh environmental conditions (desiccation and scarcity of food) that preclude growth of standard organisms. Such conditions provide a tough "luxury" of life free of agile competitors. This appears as an "investment" in the fitness of the individual, apparently built-up by acquisition of genes across kingdoms of life, followed by a genetic stability (Makarova et al., *Microbiol. Mol. Biol. 65:* 44-79, 2001; Gladyshev, Meselson & Arkhipova, *Science 320:* 1210-1213, 2008). Champions of robustness are bacterium *Deinococcus radiodurans* and aquatic animals Bdelloid rotifers and tardigrada. I shall review the emerging molecular strategies their robustness, the most spectacular being the DNA repair of the genome shattered into hundreds of DNA fragments by ionizing radiation, desiccation or chemicals (Zahradka et al. *Nature 443:* 569-573, 2006). However, the underlying basis of robustness appears at the level of protection and maintenance of protein functions facing damages from free radical attacks. Of particular importance is the maintenance of high quality of "maintenance proteins" responsible for avoidance and repair of damages and errors in nucleic acids and proteins.

Maintenance of the functional fitness of proteins is the likely basis of cellular resilience and longevity, therefore the study of these robust organisms, as well as sturdy long-lived plants, could mark the emergence of a new biology of robustness with a potential major impact on public health and medicine.