Ageing and total quality management:
extending the reliability metaphor for longevity

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ABSTRACT

Question: How can the limitations and potential of biological repair processes be reconciled with evolutionary theory to understand patterns of ageing?

Approach: Current mathematical models of ageing under conditions of biological repair are drawn from a limited range of engineering analogies that implicitly assume repair is perfect and/or harmless, with the only constraint being its cost to a common energy budget. Other analogies suggest new models which may be (and in some cases are being) fruitfully developed. A useful guiding principle is the engineer’s ‘total quality management’, which imposes a balance between high-level and low-level design.

Key point: Reparability itself may impose trade-offs against, for instance, reliability and efficiency, and may not always be advantageous, even when cost-free.

Conclusions: Because the repair of damage is often incomplete or imperfect, the accumulation of repair increases the disorder within the system over time, decreasing the effectiveness of the local controls over repair. Asymmetry and sequestration appear to be ways of channelling the disorder to parts of the systems that are reparable.

Keywords: ageing, damage segregation, evolutionary models of senescence, optimization, reliability models.

INTRODUCTION

The accumulation and the repair of damage are essential to theories of senescence. Typically neglected are the consequences of reparability as a designed property. We analyse some of these consequences, with an eye towards informing more complete models.

Current theories of ageing hold markedly divergent views of the role of repair. Most mechanism-based theories assume that wear and tear is an inevitable consequence of existence, for living objects no less than non-living ones, and senescence represents little more than the accumulation of that damage. In this view, mechanisms of repair,
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