

## Editorial

# Man, Machines, Manufacturing, and Maintenance: Merits of a Much-Maligned Metaphor

*Everybody wants to build and nobody wants to do maintenance.*  
—Kurt Vonnegut

**W**ELL, OK, STRICTLY IT IS AN ANALOGY rather than a metaphor, but I couldn't resist.

In overview talks on the "SENS" repair-and-maintenance approach to combating aging that I favor, I generally introduce the basic concept by analogy with the fact that the functional lifespan of a car may be made unusually long by sufficiently comprehensive maintenance. I use this analogy to explain not only why a rejuvenation approach to combating aging is plausible, but also to contrast it with the more preemptive approach preferred by most biogerontologists and the less preemptive approach of geriatrics. I am persistently surprised at the resistance I encounter to the validity of this analogy, so I think it is time to explain why I find it so useful. The validity of this analogy determines the applicability to gerontology of a wealth of evidence from our experience of man-made machines, so it may conspicuously affect ethical judgments<sup>1-3</sup> and public policy.<sup>3-6</sup>

### THE ANALOGY ITSELF

The human body is a machine. Yes, it is a vastly more complicated machine than anything man-made, and yes, that disparity is made worse by the fact that we do not have the plans, but it is still a machine. As such, we should at least consider the possibility that we could extend the healthy lifespan of a human being in the same ways that we already, successfully use to extend the healthy (i.e., fully functional) lifespan of a man-made machine,

such as a car.<sup>7-12</sup> Moreover, we may be able to gain insights into the potential of various general approaches to making a human being last a long time by examining the efficacy of corresponding approaches to making man-made machines last. And finally, the plausibility of features that we might otherwise aim for in postponing human aging, such as negligible senescence<sup>13,14</sup> or compression of morbidity,<sup>15,16</sup> can be assessed in light of whether they are achievable for man-made machines. And the primary method we use to maintain a machine's function is maintenance.<sup>17</sup>

Fine so far? If you think so, you probably do not need to read on, except to discover why some people are not so sure.

### THE IRRELEVANCE OF PART REPLACEMENT

Since ancient Greek times, philosophers have cogitated over the question of whether an object composed of multiple replaceable parts is still the same object after those parts have been replaced one at a time, possibly over so long a period that each part has been replaced multiple times. This is, of course, just the sort of question that gives philosophy a bad name in the wider world, because of the absence of (or, at least, the failure of philosophers to identify) any real-life context, hypothetical or actual, in which different answers to the question would motivate different actions. In practice, our intuition with regard to this question seems to

come down to the size of the parts being replaced at any one time: the smaller they are, the happier we are to view the postreplacement object as being the same as the prereplacement one. The only reason there is a paradox at all is that we feel the need to have a black-and-white sense of continuity of identity—and particularly so in the case of the human body. In that context, of course, size is not everything: replacing the whole liver in one go is a routine (albeit elaborate) procedure that we do not feel compromises identity of the recipient, whereas replacing the whole brain in one go would distinctly defeat the object of maintaining an individual's health. But it is well known that hardly any atoms in your brain (except those buried within inert aggregates such as senile plaques, which most of us would not consider essential to our identity) were in your brain at all, let alone in the same place, a decade ago. SENS proposes to replace parts at the molecular and cellular level (although, in the case of organs other than the brain, whole-organ replacement is certainly an option). Replacing molecules and cells is intermediate between replacing atoms and replacing the whole organ, but I have yet to hear an argument even attempted that doing so would be on the whole-brain side of the identity-threatening threshold.

#### THE MORE-THAN-IRRELEVANCE OF INBUILT REPAIR

A common criticism of the man/machine analogy is that we are not machines because we have really good inbuilt, automatic self-maintenance systems. Sometimes it is accepted that the question depends on the definition of "machine"—but still, this difference is claimed to make us so unlike man-made machines that analogies concerning, for example, extending functional longevity are inadmissible.

One easy way to rebut this objection is to point to the very limited auto-maintenance that is indeed present in existing machines—perhaps most obviously in computers. My Macintosh performs auto-maintenance when it checks for software updates. More profoundly, today's computers incorporate various "garbage collector" systems—programs

that periodically clean up and optimize the utilization of memory and disk space in the wake of the detritus left behind in those locations by other programs. The clearest way to convince yourself that these are bona fide maintenance functions is to disable them and see what you have to do manually to achieve the same effect. Machines' use of external resources, likewise, is a decisive rebuttal of the idea that the second law of thermodynamics applies to machines (because they are closed systems, near enough) but not to living organisms that are very far from closed.

It could be retorted that, OK, primitive auto-maintenance functions do not make a machine not a machine, but what about really comprehensive ones? But the same logic applies—and it shows, of course, that the presence of such functions does not merely fail as an argument why maintenance is not a plausible approach to extending healthy human longevity: rather, it succeeds very well as an argument for the opposite conclusion, because any type of damage that is repaired by systems already present in the body is one less thing to be repaired by biomedical intervention.

#### THE PROBABLE IRRELEVANCE OF MEMORY

Some biogerontologists like to avoid the term "aging" to describe what they work on, and instead to use the term "senescence"—which, put simply, can be defined as the aspects of aging that we might like to preempt by biomedical means if we could. An aspect of aging that rather clearly does not fit into that category is the accumulation of knowledge, wisdom, etc., and some are concerned that this is a difference between man and machines that may undercut the maintenance approach. But this is incorrect too, because by middle age we seem already to be forgetting things about most of our adulthood as fast as we are learning new things, a phenomenon known in psychology as the reminiscence bump. If we are at equilibrium (until physical deterioration sets in) during a currently normal lifetime, there is no reason to expect that equilibrium not to persist indefinitely.

## AN EXAMPLE OF THE ANALOGY'S UTILITY AMONG GERONTOLOGISTS

My friend and colleague, Jay Olshansky, is one of the more skilled rhetoricians in gerontology, and has put his talents to great effect in his outreach efforts. Unfortunately, rhetoric works just as well in support of an incorrect point as a correct one. A conspicuous case was Olshansky's tongue-in-cheek article "If Humans were Built to Last" that appeared in *Scientific American* a few years ago.<sup>18</sup> In that piece, he and his coauthors identified—complete with illustrations—a variety of "design improvements" that humans might need in order to live longer—their conclusion being, of course, that since we do not have these features our arbitrarily distant descendents are doomed to experience aging and death at very much the same age as our forefathers. (Whether the improvements would actually extend lifespan was not explored remotely seriously, because they were chosen so as to be obviously unimplementable by plausible surgical, or even germline genetic, means.) Much to my dismay, this conclusion was swallowed whole by a remarkable number of readers—to the extent that I fear Olshansky genuinely believes it himself.

For anyone who does not see the problem, I will return to my opening topic—the analogy that I use in overview talks about SENS. As I explain in such talks, there are two ways to make a car last unusually long. One is to build it really sturdily in the first place (I show a 50-year-old Land Rover here); the other is to build it with enough character that its owners will fall in love with it and perform unusually thorough maintenance on it (I show a 50-year-old Beetle here). The point is clear. To make a machine outlast—by an arbitrary factor, no less—its designed lifespan, one does not need to perform surgery on it to turn it into the same structure as a car that was built to last in the first place: one can just do maintenance. And the human body is, unequivocally, a machine.

Like any tool, analogies can be misused but when they are valid, they are valuable. I plan to hammer this one—among others<sup>19</sup>—home until it sticks.

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