

If we have sex, does that mean we have to die?

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So leben wir, und nehmen immer Abschied

R.M. Rilke

Though you care about the fate of the Earth and the future of humanity, you may not feel that the perpetuation of the species in any way compensates for the annihilation of your own individual consciousness. And as for caring about your progeny, the fact that they will survive you makes it all the more difficult to bear the prospect of your life's end, on the assumption that you will never know their future and that they, for all your faults, may well miss you. In short, like Woody Allen you aspire to immortality not by your works, or your progeny, or the daisies you will push up from below, but "by not dying".

If those are your sentiments, your attitudes are likely to have been formed by a culture steeped in theistic assumptions. For if you were a Daoist, in the tradition of Lao Zi and Zhuang Zi, or even an atheist mystic in the mould of Leonard Angel (1994), you might feel happy with the thought that Life will go on after your individual life has ceased. You might feel that the merging of your individual self in the totality of the universe renders trivial your preoccupation with individual existence. You would have no use for the elaborate intellectual edifices that attempt to make sense of individual survival.

The construction of stories about ways in which we might transcend our own death represents an impressive intellectual achievement. For to imagine that I can survive my death, I must first have become aware that I will die. At some time in the past of our species, that discovery made us different from all other animals that, in the words of Rilke, “walk ever in eternity, like a flowing brook”.¹ Recent reports of what appeared to be mourning rituals among elephants or cetaceans may well be correct (Masson 1995; Hooper 2011), but they don’t prove that our mammalian cousins have acquired the awareness of their own future death. They may only know the loss of another. Having discovered death, religions add the further achievement of simple denial. This yields two great benefits for religion. First, it affords an ambivalent comfort for the fear of death. Rilke’s eternity is repossessed. Second, it provides an impressive tool of control, in the implied promises and threats of post mortem rewards and punishments.

Chief among the aspects of human behaviour targeted by these threats and promises is sex. Sexuality affords innumerable occasions for *mortal* sin: Aquinas, for example, lists no fewer than six distinct species of the sin of lust. (Aquinas, II-2-Q154) Of these, the "unnatural" sin of masturbation is ranked the worst, as it is by Kant (Kant 1997, p.155-161)), on the grounds that it represents a deviation from the essential procreative function of sex. For those thinkers, it seems, sex is acceptable only when it represents a defiance of death.

It is not only in religion but everywhere in legend and myth that sex and death seem to be indissolubly linked. Perhaps Tristan and Isolde have to die merely because if they live down to a domestic old-age it would make a less exciting story; but we may surmise that some deep association in our own minds dictates that aesthetic demand.

¹ R. M. Rilke, Duino Elegy VIII: “das freie Tier /hat seinen Untergang stets hinter sich / und vor sich Gott, und wenn es geht, so gehts /in Ewigkeit, so wie die Brunnen gehen.” Of course you might wonder: How can he be so sure?

For a number of organisms, sex, for the male, involves possible or certain death. (Zuk 2011). The peculiar heart-shaped mating position of certain species of dragonfly, for example, has led evolutionary biologists to speculate that the male needed to keep as great a distance between his body and his mate's as was compatible with insemination to avoid sudden death. Given "the 'predatory proclivity' of some female dragonflies to banquet off their partners[, m]ales may have adopted the tandem position to protect themselves from becoming their lovers' prey." (Ackerman 2006). Appealing though this somewhat ghoulish topic might seem, what I have to say will shed but limited light on it. What will concern me here is the possibility that the logic of natural selection affords a specific link between sex and death. If such a link exists, it might in some unconscious way underlie the insistence with which theistic religion has consistently striven to control sexuality. It turns out, surprisingly, that while biology is unequivocally on the side of Daoism concerning the issue of the survival of individual consciousness, it can provide solid reason to associate sex with the necessity of individual death. Sex and death are bound up in a common destiny very different from that which, for believers, is symbolized by the serpent in the Garden of Eden, but no less indissoluble and more interesting.

The common roots of science and religion

Amid the noisy squabbles that surround the relationship between science and religion, it is easy to forget that both have a common source in a very specific capacity of the human mind: a disposition to invent relatively simpler but unobservable entities and processes to explain the complicated world of experience. If we gave up all talk of what cannot be seen, heard, or touched, we would be rid of spirits, spells, divinities, and acts of faith. By the same token, however, we would have to abjure electrons, genes, quarks, and all other entities of which science treats but of which we directly perceive only effects.

For the religious mind, the unobservable entities posited are *agents*, who wish us well or ill. Mostly ill, in fact: the most plausible explanations our ancestors devised of the random disasters of life involved divinities whose ferocity could be mitigated only at the cost of bloodthirsty sacrifices. But by what psychoanalysts call a "reaction formation", divine cruelty has, in some religious sects, been transmuted into perfect benevolence. This would seem to confirm a central claim made by Pascal Boyer about the nature of religious faith, namely that religious ideas are most likely to take root in the minds of human beings when the familiarity of humanlike agency is spiced up by implausibility. Unlikely stories are more memorable.²

The inversion of divine motivation from evil caprice to perfect benevolence retains the key feature of teleology that separates religion from science: the positing of unseen agents. Modern science begins when it gives up the hypothesis that hidden causes are agents. Some systems of thought, notably Aristotle's, appear to be transitional in retaining the idea of teleology as part of the natural world without requiring to be backed by spiritual or immaterial agents. But physics and chemistry take their modern form as fundamental sciences by excluding teleology altogether. That is more difficult to do in biology. This is a point which I shall shortly return.

A second requirement for dislodging science from religion was to forge links between imagination and the empirical data that science aims to explain. These links required to be bound by *reason*, *reasoning*, and the *reasonable*. These notions don't quite coincide, and they are difficult to codify; for that reason they are not all that difficult to counterfeit. Indeed, some would claim that the perennial philosophical industry through the ages affords a good illustration of such counterfeiting. Despite its vaunted allegiance to reason and reasoning, philosophy has all

² According to Pascal Boyer, one of the optimal conditions for an idea to be retained and disseminated is that it should contradict an evident truism, while also exploiting familiar and well-established categories. The immortality of the soul, for example is made all the more attractive by contradicting the obvious facts of biology. (Boyer, 2001).

too often presented the unreasonable spectacle of an intellectual fifth wheel turning idly down the centuries.

However that may be, disciplined reasoning has allowed science to uncover large number of hidden mechanisms in nature. Reasoning is seldom compelling: alternative interpretations are always . In 1774, Antoine de Lavoisier reasoned on the basis of his observations that if phlogiston existed, it was peculiar in having negative mass. But that hypothesis was sufficiently bizarre to make it more reasonable to infer instead that phlogiston doesn't exist, and that combustion must be conceptualized as taking on oxygen rather than discarding phlogiston. Similarly, theologians confronting the apparent conflict between faith in a benevolent and omnipotent God and the existence of natural catastrophes can discard the divinity. But they more commonly fall back on a quiver-full of alternative hypotheses: that God has sent suffering to try us; or better, that the designs of the Almighty are beyond us. (Which conveniently absolves us from the need to reconcile contradictions.) In science as in theology, one can always get around an unfavourable result. The difference is that in science a contradiction is a problem whereas in religion it is a solution, renamed Sacred Mystery.

Among such religious Mysteries are the Mystery of the Three-in-One God, and the "Problem of Evil". These illustrate one more feature common to both religion and science: for both, solutions generate their own problems. You first have to come up with the idea of the Trinity before you can worry about making sense of a God that is both one and three. And without the postulate of theism, there is no problem of evil. Nature of itself embodies no values. It is unconcerned with the happiness or the suffering of the creatures that for the last billion years have preyed on one another. One may well find this fact distressing, but only on the assumption that the universe is ruled by a specific sort of God does it constitute an intellectual *problem*.

For science, sexuality, death, and the relation between them are comparable to the Trinity or Evil for theology: they are problems manufactured in-house. Like suffering, sex and death cause a good deal of trouble in everyday life. They become intellectually problematic only on the basis of certain assumptions made by biology itself.

What are these self-made problems? Once one gave up pre-formation, which saw in the spermatozoon a miniature but fully formed adult, it has been accepted that sexual reproduction mixes up genes at every generation. Every gamete, or sex cell ready for merging, results from meiosis, the process that divides the genetic heritage of each parent into two. The male and female gametes resulting from meiosis merge to form a zygote, a single cell in which the two halves of the male and female legacy are united, and which divide, first by simple cleavage and later by mitosis, to form all the cells of an absolutely novel individual body. In this way, sexual reproduction requires that a successful model, constituted by any organisms that has proved itself to be viable, will be abandoned, never to be copied again. At every generation, regardless of the qualities exhibited by the previous unique prototype, the mould is broken. This seems like a terrible waste. At least, it seems extraordinarily risky: two perfectly successful models, instead of being reproduced, are forced to make way for an untested model.

Sexual reproduction also exacts what the evolutionary biologist Maynard Smith described as a twofold cost (Maynard Smith 1978). Various species of geckos and lizards in the deserts of the American South West, among other species, seem to have taken advantage of this fact. (Cole 1984). They have won out over their sexually reproducing cousins by resorting entirely to parthenogenesis. By this expedient they need only half the resources their cousins require, since the latter must feed two parents instead of one for the same number of offspring.

So why do we not do the same? What are the compensating advantages of sex?

Such are the problems that evolutionary biology sets for itself about sex. What of death? Once one ceases to deny its existence, one can still ask: What is death for? Here again, it is not a matter of deploring the practical inconveniences involved. Rather, reflecting on the ironically reference-free phrase, "survival of the fittest", the question is why in fact, absolutely no sexually reproducing organisms ever do survive. Wouldn't it have been more economical for natural selection to have indeed selected the fittest for *perpetual* survival?

Two kinds of possibility

The question rests on two presuppositions that may be debatable, but which I take to be both correct and important. One is that it is appropriate to speak of biology in terms of economics; the second is that we can make sense of natural, biological teleology in the absence of design. The justification of the first assumption is that economics works better for biology than for economics. The reason is simple: economic "laws" work only if we make auxiliary psychological assumptions concerning motivation. These often prove false. In biology, by contrast, the relevant gains, losses and probabilities can be directly computed in terms of the number of genes surviving later generations, and the objective probability conferred on their survival by their capacities in ambient conditions. In order to understand how natural selection drives evolution, there is no need to speculate on the motives, emotions, conventional constraints on greed, or anything else that might inhibit rational maximizing strategies.

The second issue is more tricky. The question, *Why?* often confounds causality and teleology. For all metazoan organisms—multicellular organisms with functionally differentiated cells—decline and death are part of natural life. For Aristotle, any complete explanation worthy of the name must include a teleological component; every creature, as well as every organ, has its own characteristics end, its proper job to do. Among all the different things that are possible,

there is a special class, labelled *potentialities*, which alone are *supposed to* become actualized. It is possible for the acorn to rot; it is also possible for it to grow into an oak tree. Only the latter constitutes its potentiality, what is *supposed to* happen.

But how can we tell which, among all possible events, is the one that is supposed to take place? Aristotle thought the answer could be derived from simple observation. On the assumption that species are more or less immutable, what is statistically normal is also *normative*. In this way, what happens "always or for the most part" is a sufficient guide to what nature "intends".³

Modern science has abjured the teleological perspective inherent in Aristotle's worldview. Yet perhaps Aristotle's demand for teleological explanation expresses a basic intellectual craving. Perhaps, then, we still yearn for a narrative that linked sex and death by telling us what they are both *for*. After Darwin, however, no such divining of the inherent intentions of nature makes sense. Nature is mindless. Worse, Aristotle's recipe leads to a particularly paradoxical conclusion in the light of Darwin: if all our ancestors had functioned properly, that is, if all had conformed to what happens "always, or for the most part", we would still be, like the vast majority of living things, unicellular organisms. Every ancestor whose difference brought us a little closer to being human was necessarily, in Aristotelian terms, a monster. None could be reckoned to be what was "supposed to happen". And of our current deviancies and perversions, none can say which will be hailed in retrospect as progress.

It is therefore quite true that in a certain sense Darwinism has banished teleology. Evolution is a random walk through the space of possible forms. Nevertheless, in what may well be that rare case, a genuine philosophical advance, analytic philosophy of biology has constructed, over

³ Aristotle, *Met.* 6 vi.

the past fifty years, a purely naturalistic version of the teleological notion of "objective function". In this reconstruction, some actual or possible effects are distinguished, as in Aristotle's view, as those that are "supposed to happen", on the basis of past facts. But beyond that similarity there is an abyss between Aristotle's conception and the modern one. There are three crucial differences. First, those effects that we can label as functions are not part of an essence or nature that is manifested always or for the most part. As Ruth Millikan has pointed out, we don't hesitate to assume that the function of a spermatozoon is to fertilize an ovum, though only one in a billion or more ever does so.⁴ According to the *aetiological* conception of teleology—so called because it is based entirely on causation—a function is simply an effect that has contributed to the differentially successful reproduction of similar ancestral organisms. This notion of function is entirely objective: it does not depend on our interests or on our perspective. That is not to say that it is easy to detect in all cases, since it appeals to differential advantages in ancestral populations which cannot be verified directly. But it is a matter of fact even when it is unverifiable that the capacity of an organ to produce certain specific effects did or did not give the organisms that contained it an adaptive advantage.

Take the heart, for example. We can observe two effects of its activity. One is the circulation of the blood; the other is the production of rhythmic sounds audible through a stethoscope and useful, as it happens, for various diagnostic purposes. Which of these constitutes the function of the heart? According to the aetiological criterion, the use we make of heart sounds is probably irrelevant. The reason is that the former effect, and not the latter, presumably afforded an adaptive advantage to ancestors of organisms currently equipped with a heart. That does not

⁴ Ruth Millikan (1993). It is possible, though not well established, that this must be qualified, if we believe the hypothesis put forward in Baker and Bellis (1995), to the effect that most spermatozoa actually have the function of killing other spermatozoa from a rival male.

necessarily exclude the possibility that heart sounds also had certain advantages for organisms equipped with hearts. But whatever the actual facts of the matter may be, what it means to say that the heart's primary function is to circulate the blood, is that blood circulation was more important than rhythmic sounds to the successful dissemination of genes for having a heart. The aetiological conception of function has given rise to a number of criticisms and refinements. In the main, however, it has remained unshaken, and it is not necessary here to rehearse the debates and intellectual meanderings to which it has given rise.⁵ The simplified account I have given suffices to show how this conception explicates a viable notion of teleology for biology.

A second difference between Aristotle's story and the one I have just sketched is this. For Aristotle, the fulfillment of the teleological goal—the actualization of a natural potentiality—automatically embodies a positive value. The same is not true for the objective functions I have characterized. Sometimes, perhaps often, the exercise of a natural function is a Good Thing. But many natural dispositions that are plausibly regarded as functions are obviously to be deplored. Predispositions to xenophobia, for example, or to rape, may well in the past have contributed to the evolutionary success of our ancestors. But that is no reason to approve of them now. The taste for fatty salty and sweet foods so effectively exploited by fast food chains is certainly an adaptive trait that once functioned to steer us to foods that were both necessary to our thriving and hard to find. Again this is not a tendency which currently serves us well. Its function is objective, but not thereby to be valued positively.

A third important difference is the following. For Aristotle, teleology applied not only to organs but also to whole organisms. By contrast, the logic implicit in the idea of an objective function requires that the beneficiary of that function be external to the entity that executes it. So

⁵ For an excellent collection of papers on objections and proposed refinements of the aetiological conception, see (Allen, Bekoff, and Lauder 1998).

the idea that an individual organism as such has a function is problematic. It makes sense only insofar as we consider the role of an individual in relation to a larger entities such as a group, a society, a corporation—in short, any larger unit in which the individual functions like an organ in an organism. Etymologically, an organ is a tool. I might be serving as a tool for the purposes of some entity of which I am not even aware. But in myself, as an individual considered as such, it makes no sense to say that I have a natural function.

Perhaps, however, individual organisms should not be regarded simply “as such”. Perhaps there is a way of regarding metazoan individuals that allows them to play the role of “organs” in the context of a larger unity. This way of thinking is familiar to students of bees and other social insects. (Hölldobler and Wilson 2008): in relation to the hive, each individual can be regarded as an organ with a function. If human society is viewed in that light, one might think of birth and death as functions fulfilled by individuals in the service of the collective entity.

From the point of view of a modern individualistic ideology, that perspective may seem alarmingly reminiscent of certain collectivist ideologies that have been all too happy to sacrifice individual humans to a supposed social whole. But we don’t need to think of the entity we serve as a larger, societal entity. One can instead think of it as consisting of smaller units. Genes might be just the thing: they are the only entities that actually survive, transcending not only the puny life of individuals but even the species. It is not the fittest individuals that survive, but the fittest genes. As such, they influence the course of individual lives, in both morphology and behaviour. It is therefore open to us to regard the propagation of genes as constituting the goal in relation to which the individual human being is a tool fulfilling a function.

Richard Dawkins has spoken metaphorically of the individual organism as a vehicle used for their own purposes by the genes that inhabit it temporarily, and programmed to facilitate their

perpetuation. By "genes", I mean, with Dawkins, not only specific sequences of DNA mapped by the cartographers of the Genome and entrusted with the programming of protein manufacture. The term must be understood as referring to any informational complexes that are transmitted from one generation to the next (Dawkins, 1982). It is generally agreed nowadays that these may include more than the codes embodied in DNA sequences (Oyama 2000). Under the general designation of "epigenetics", some biologists have reported evidence for mechanisms of transmission may work directly through the cell structure independently of DNA (Jablonka 2002). But regardless of what the mechanisms of heredity consist in, the informational entities that get transmitted are privileged in relation to the perishable individual organism that is constructed on the basis of the various heritable mechanisms as well as of the interaction between them and a complex environment.

So far, nothing has been said to imply the necessity of either of death or of sexuality. If the "goal" of my genes is to survive, would not the best means to this be to make the vehicle that carries them last forever? What then is the role played by death and sex in this vision of things?

There is no law of biology that decrees that all organisms must die.

Let me begin by disposing of two pseudo solutions. One finds too much teleology in death, while the other ascribes too little.

Some, including the French Jesuit evolutionist Teilhard de Chardin (1965), have seen death as facilitating the great epic of evolution construed as a march towards a clear destination, culminating in a creature made in the image of God. In this conception of evolution, of which many versions have recently taken to huddling under the largeish tent of "intelligent design" (Pennock 2001), natural selection is responsible for the easy bits in the uneven progress toward complexity and perfection. The divine intelligence which Darwin did without reappears either to

steer the whole enterprise in the right general direction, or as the “God of the gaps”, to produce the occasional miraculous saltation to some new plateau of “irreducible complexity” (Behe 1998). On this view, death is required in order to make room for new prototypes. Even a sophisticated evolutionist can sometimes be caught saying something that sounds rather like that. Jacques Ruffié, for example, in a book entitled *Sex and Death*, no less, writes that “sexual reproduction ceaselessly creates new types.... But these are able to disseminate new combinations and forms only if the old ones make room for them.” (Ruffié, 1986). There is nothing wrong with this formula, so long as it is interpreted as a mere observation of fact. If the earth’s every niche were fully occupied by a fixed number of immortal individuals, any experimental novelties would be crowded out. But if Ruffié’s observation is intended as more than a platitude, it seems to commit two rather common fallacies. The first consists in presupposing that evolution as a whole has a general direction towards a predetermined goal. The second is to assume that complex forms are inherently superior. This is both subjective and self-serving.⁶ The only objective criterion of success is persistence through the aeons. In light of that criterion, cockroaches and bacteria have been by far the most successful forms of life.

The most attractive alternative in the face of these disappointing attempts to wring a purpose to life out of the facts of evolution is simply to fall back on the null hypothesis. That term refers to situations in which a phenomenon of interest is merely the product of chance rather than the effect of some specific cause. On the null hypothesis, there is literally nothing to explain.

Newton's first law provides a handy illustration. Ever since the Ancients, philosophers had

⁶ Some biologists have argued, however, that a broad trend towards greater complexity follows from the simple fact that in a random walk there is an absolute level of minimal complexity compatible with life, but no absolute maximum. Certain specific “discoveries” in evolution, such as eyes or wings, have evolved several times independently, which suggests that certain outcomes might be highly probable in the long run, even if these are attained by different paths. Simon Conway Morris has argued that the existence of numerous cases of convergent evolution shows that intelligent human-like beings were bound to arise sooner or later. (Conway Morris 2003).

worried about the question: What keeps the arrow in-flight? Newton's first law simply rejects the question, and replaces it with its inverse: What is it that *impedes* the arrow from continuing in uniform flight? The first law states that any body in a state of uniform motion in relation to an inertial system will continue in that state unless acted upon by a force. The null hypothesis about death, then, is that death has no function whatever in the objective sense of the term I have sketched. Rather, it is merely the consequence of an absence of special causes or conditions that would bring about the long-term persistence of individuals.

A number of considerations lend plausibility to the null hypothesis.

It is known that—with some specific exceptions which will concern us in a moment—cells set to divide freely in vitro will continue to do so for only about fifty times. Thereafter, the copying process peters out, as if copies had degraded to the point where they are incapable of further reproduction. If we remember that any process of copying, however careful, involves a certain probability of introducing copying errors, this suggests what might be called the xerox-copy model. Faithful reproduction to any given number of copying generations can be secured by a suitable increase in the redundancy of the information to be copied. (Thus when telegraphing a number, it is advisable to send it in letters as well as in figures). But the introduction of redundancy is not cost-free. In the case of sexually reproducing organisms, natural selection is likely to prefer those organisms that have enough redundancy in their cell-reproducing mechanisms to endure long enough to produce a new generation. But once the organism has actually reached sexual maturity and produced offspring, the genes it has passed on are more efficiently conserved and reproduced by those offspring than by the continuation of the parents' own reproductive activity. The reason is that the latter option would demand a higher level of redundancy in the parents' own somatic cells. The biological surmise which this

suggests, crudely put, is that the sex cells provide the intact archival copy that is referred to when new runs of copies are to be made, and death is a side-effect of the limited redundancy of genetic information encoded in each somatic cell. At every generation, copies must be made from the original—the sex cells—because the copies already made of somatic cells in this generation are no longer capable of producing more. Death is in no way an adaptation; rather it is merely the absence of any "adaptation" that would entail perpetual life. The xerox-copy model can be regarded as the null hypothesis regarding the existence of death.

Biological reproduction reaches astonishing degrees of accuracy. It has been estimated that in each transmission of a human genome, for example, one can expect about 200 errors. (Ridley 2000). The human genome comprises some 30,000 genes, made up of about 3.08×10^9 base pairs. 200 errors therefore represent two out of 6.16×10^7 , or an error rate of 0.0000000325%.⁷ This is already a spectacularly low error rate, but it applies to sex cells, not to somatic cells. We shall see in a moment what the significance of the distinction might be. For the moment, suffices to say that if we remember that somatic cells need to reproduce themselves by mitosis on a very frequent basis, even a very low error rate will result eventually in deleterious changes in cells' properties. Sooner or later, these errors will prove lethal. Introducing further protection against error, in the form of redundancy or in any other way nature might devise, is necessarily going to be costly. And the inexorably economic point of view of natural selection will impose an equilibrium between the cost of exactitude and the benefits that might result from it.

What benefits might these be? In a sexually reproducing species, it is obvious that the utility of the mature individual to the dissemination of its genes lasts only as long as it is capable of procreating. Only genes are literally reproduced. The individual that constitutes the vehicle, once

⁷ Estimates in these matters differ by an order of magnitude. The figures cited here were retrieved from <http://www.wolframalpha.com> on 15 Oct 2011.

it has effected its mission of transmitting its genes, is expendable. It is therefore to be expected, without appealing to any hypothesis about what might be the inherent benefits of death, that the level of redundancy in effect in any given species will protect somatic cells from degeneracy just long enough to ensure the transmission of the sex cells containing the faithfully copied genes. Somatic cells last only so long and there are regularly replaced by fresh cells, arising either from division of themselves or from “stem cells” capable of adopting any functional role. It is now known that the limitation to 50 divisions depends on the gradual shortening of telomeres, the sort of expendable plug at the end of a chromosome that provide a necessary buffer for complete copying of what lies in between. (Greider 2009). That number of divisions takes about 120 years. This suggests that natural selection has equipped the human body with just enough endurance to last about two or three times the maximal duration of the reproductive cycle. Like any good engineer, it would then have given itself enough of a margin to guarantee the performance of the essential reproductive task, in such a way as to satisfy both the demands of quality control and those of a kind of planned obsolescence designed to avoid wasting resources on the maintenance of the tools of gene transmission beyond their useful life. Scientists may well soon discover a way to protect the telomeres from erosion, so that limit may not be ineluctable; but as things stand in nature, we can expect a normal human organism to break down after its cells are no longer able to reproduce normally. Such an explanation, which amounts to the rejection of a demand for explanation, is both plausible and economical.

Despite that, there are reasons to believe that one might, after all, establish a tighter link between the existence of sexual reproduction and the regular death of all individuals. Two factors are particularly worthy of attention on this score.

The first is the phenomenon of *apoptosis* or programmed cell suicide. When a cell receives an appropriate signal, or rather, which comes to the same thing, when it ceases to receive a signal that serves to avert apoptosis, the process of self-destruction automatically begins. Jean Claude Ameisen has described this process as essential to the construction of bodily structures, particularly very complex ones such as the brain and the immune system. Although it might seem paradoxical, suicide at the level of the cell guarantees the integrity of the body up until the moment that the body as a whole is sacrificed in death. (Ameisen 2002). The very existence of apoptosis casts doubt on the null hypothesis, insofar as the latter would seem to entail that cells would cease to reproduce themselves with sufficient accuracy only because the protection afforded by redundant informational resources had finally become exhausted: at first sight, that seems incompatible with the existence of a specific mechanism for cellular auto-destruction.

Actually this would not preclude the null hypothesis. Death of the organism might still be ultimately due to the degeneration of the information required to keep its cells alive. For if apoptosis is essential to the construction and maintenance of the body, it may itself be one of the processes that ceases to function properly after a certain amount of wear and tear.

An additional piece of corroborating evidence is therefore desirable. And it can be found in the existence of three exceptions to the general rule that says that cells can only divide successfully a fixed number of times.

The first exception concerns bacteria for which, unless their simple reproduction by division counts as death, there is no natural death. Cancer cells constitute the second exception. They behave as if they had become deaf to the regulatory signals that rule the community of cells by controlling mitosis or mandating apoptosis. Cancer cells seem to have unilaterally abrogated the contract that binds every specialized cell to the organism of which it is a part, and to which it, as

it were, owes allegiance, insofar as it cannot survive alone. By killing off the organism, cancer cells ultimately destroy themselves, so their rebellion is self-defeating. Unless, of course, their potentially immortal life is sustained by being used in research, like those of the black cancer patient, Henrietta Lacks, whose story was told by Rebecca Skloot (2010).

The third exception is the lineage of sexual cells from which gametes emerge. In each organism, these cells are kept isolated from others, and passed from one perishable body to another by means of sexual reproduction.

What is demonstrated by the existence of these three sorts of lineages of potentially immortal cells is that natural death is not an absolute rule of nature. It is only among creatures like us, that is, metazoan creatures that reproduce sexually, that the death of individual organisms is an inevitable part of life. Somatic cells are copies which beget more copies of themselves, just as sexual cells do, but the former, once they are specialized for the specific tasks required of the organs they constitute, become more vulnerable to changes that will impair their functioning to the point of uselessness. They will not, however, transmit the defects they have acquired in the course of doing their job. Instead, they will disappear when they have exhausted their capacity to serve their function. That sexual lineage, by contrast, will devote its entire efforts to ensuring the accuracy of the copies they make-up themselves, and in so doing they will escape the wear and tear to which somatic cells are subject, and thus escape death itself.⁸

The sex and death complex

Evolution did not take place in order to trace a path to the emergence of us humans, or for any other purpose. It is as a blind exploration of the space of possibilities. Sexual reproduction, in particular, followed on two random “discoveries” that together set new constraints on the life

⁸ In this section, apart from the other works cited, I have made extensive use of (Clark 1996).

of cells at the same time as they greatly expanded the space of possibilities. The two discoveries in question are *conjugation*, and *collaboration* between agglomerated cells.

Cell conjugation allows genetic material to flow between two individual unicellular organisms such as bacteria. Conjugation is unrelated to reproduction: after conjugation, there are still just two cells (though one of them might have benefited, and the other might have been harmed, by the transfer of genetic material involved). One might say that conjugation was the first recreational sex, invented by bacteria a few hundred million years before sexually reproducing species thought they had discovered it. That invention already brings some of the advantages that biologists have surmised compensate for the drawbacks of sexual reproduction: some cases of conjugation are thought to result in the repair of one cell's genetic material. It affords a cell the opportunity of raiding another in the hope of replacing a defective piece of genetic material. (Margulis and Sagan 2002). Like sexual reproduction, this mechanism is highly risky, for the change in genetic holdings in one or both of the cells in question can result in damage rather than repair. What is certain is that it is likely to produce something new, and thus to promote diversification.

In the small section of the biosphere inhabited by us metazoans, gene exchange has hit on new functions within the framework of cooperating agglomerated cells capable of reproducing sexually. That is what has brought about the imbrication of death and sex. That interdependence stems from a number of constraints inherent in the nature of metazoans, and notably to "Weismann's barrier" and what Francis Crick baptized the "Central Dogma" of molecular biology. Let us briefly see how these factors work to link sex and death.

First, a metazoan organisms is made up of about a ten to a hundred trillion cells, differentiated in both morphology and function into a few hundred types that make up the

different organs integrated into an individual body. Some hundred billions of those cells are neurons, organized into a brain whose activity produces consciousness, together with such a powerful illusion of unity that many philosophers from Plato to Descartes have insisted that we possess an indivisible and therefore indestructible individual soul responsible for our rationality. Rationality and individuality are properties that are not easy to reconcile, for the latter suggests that we are all different, while the former seems committed to our being all the same. This follows from the presumption that reason is capable of converging on truth and more generally on the uniquely correct solution to any question that admits of one—at least if we can bring ourselves to formulate the questions fairly and confront the answers clearly. Reason, as Heracleitus is said to have remarked, is common to all, yet each one of us thinks it belongs peculiarly to ourselves (Barnes 1983,102).

Elliott Sober and David Wilson have made an ironic comment on our sense of uniqueness, suggesting that natural selection has equipped us with a special feeling of “ipseity”, the sense that I am different from anybody else, precisely in order to compensate for the fact that there is nothing distinctive about me. This view makes good sense within the economic perspective I have been advocating. It is important that each organism look out for its own interests in the medium term. But if there is nothing objective that distinguishes my own future or my own interests from those of anyone else, nature must instill in us an illusion of difference in order to save us the trouble of calculating what does and what does not pertain to the interests of the long-term continuant that is my body. Sober and Wilson note the irony: “people use the concept of “I” to formulate the thought that they are unique. Yet part of the reason that people have this concept is that they are not unique.” (Sober and Wilson 1998, p. 350).

Second, both reason and consciousness are frail capacities. They depend entirely on delicate configurations of our trillion neurons. Even those sorts of experiences that have been taken as proof of our separable spiritual essence, such as "out of body experiences", in which subjects think they are observing their body from an external point of view, have now been provoked to order by the stimulation of the right group of neurons. (Blanke et al. 2002). If unicellular organisms are conscious, they can hope to retain an unlimited memory of their lives before previous fissions. But sexual reproduction guarantees that individual consciousness will not survive individual death, since the neurons that embody our mental states, including our memories, once dispersed, could never be reassembled to constitute the same brain state again. So if it is individual survival you want, you are out of luck. Better fall back on the Daoist view.

The third piece of supporting evidence relates to Weismann's barrier. By ensuring that information coded in the DNA goes only one way, from the sex cells to the protein that are made of somatic cells, and never from protein back to DNA, the "central dogma" sees to the sequestration sex cells, and makes it impossible for any Lamarckian process to endow the next generation's genome to be influenced by lifetime changes brought to an organism's somatic cells. (Crick 1970). From the point of view of the aetiological conception of function sketched above, which alone is compatible with the standpoint of Darwinian evolution, this alliance between somatic death and the preservation of faithfully copied sexual cells can be regarded as the function of Weismann's barrier.

Some qualification is in order: the barrier is not absolute, at least not in the first few divisions of a zygote. As we have seen, the zygote results from the fusion of gametes which themselves issue by meiosis from sex cells segregated from the parental body. The zygote divides repeatedly and ultimately generates cell differentiation and proliferation, giving rise

ultimately to the adult organism. But this means that the zygote is the ancestor of both somatic and sex cells. The former will constitute the building blocks of the parts and organs of the living body; the latter will hold on to the genetic material that will ultimately constitute the essential message contained in future gametes. But until this division of labour is set up, that is, for the first dozen or so divisions, the zygote gives rise by simple cleavage to cells that are as yet undifferentiated, and hence 'pluripotent', to every kind of cell. (Buss 1987). A change brought to the DNA of these early cells could be inherited by insect cells and find itself in the following generation. But this window quickly closes. Soon the destiny of somatic cells will have been sealed, and that destiny, our destiny, in fact, will be that of a cul-de-sac of evolution.

Sexuality therefore condemns us to die, but it also ensures that we will never meet another individual just like ourselves unless we have a "real" or monozygotic twin. The generality of this fact may explain both the attraction and the occasional horror that is inspired in some by the idea of cloning. To copy an individual human being, many people feel, is to do something that is against nature in a particularly creepy way, prompting politicians to ban the practice preemptively even before it has become practicable. Who knows what unicellular politicians might have said, one or two billion years ago, when the first bacterium "decided" to "experiment" with sexual reproduction?

I mentioned above two of the notorious drawbacks of sexual reproduction: the twofold cost entailed by the requirement to keep males around, and the risks inherent in meiosis. Many hypotheses have been suggested to explain the countervailing advantages of sex. One of them, it will be recalled, is that sex contributes to the diversity of genomes, which may become an advantage under changing condition, in that it increases the chances that descendants of any particular organism will include some that are pre-adapted to different conditions. But there is

something glib about this formula. It leaves unspecified the precise identity of the beneficiaries in question. If this is an advantage, who exactly is it an advantage for? Remember that whoever survives, it will not be *me*. I will not be the one to benefit from the genetic diversity to which my sexual union with another individual might contribute. At this point, one generally switches from talk of the individual to speaking of the species. But what motive do I have, as an individual endowed with an individual consciousness, to identify with the interests of a *species*, even if it is my species? Why should I care? I can empathize with another consciousness; but I cannot literally merge with it. So it is not literally in my interests that the species, or my descendants, should survive. Conversely why should I exclude from my concern other real or imagined consciousnesses with which my own might find itself in harmony? Why should I not find a kind of mystical comfort in what links me to other inhabitants of the biosphere, even if they are unlike me and are not members of my own species?

Just such an attitude is to be found, expressed with poetic panache, by the great biologist David Hamilton, who evoked in his testament the idea of a survival devoid of any individual consciousness. Instead, he relished the thought of being consumed by and scattered into a thousand brilliantly coloured *Coprophanaeus* beetle:

They will enter, will bury, will live on my flesh; and in the shape of their children and mine, I will escape death. No worm for me or sordid fly, I will buzz in the dusk like a huge bumblebee. I will be many, buzz even as a swarm of motorbikes, be borne, body by flying body, out into the Brazilian wilderness beneath the stars, lofted under those beautiful and unfused elytra which we will all hold over our backs. So finally I too will shine like a violet ground beetle under a stone.” (Hamilton 2007).

As a matter of psychological fact, most of us feel more closely concerned by the fate of our own descendants than by that of the Coprophanaeus beetle of Brazil; but that is just the effect of a subtle manipulation of our minds by our genes. In order to maximize their chances of being perpetuated, my genes have programmed me to forget that my children are not identical to me. Strictly speaking, the feeling that my descendants' fate concerns me is an illusion. My genes are not me; their goals (metaphorical though they are) are not my goals. I can choose to endorse those goals, or struggle to resist them. The very existence of that choice implies that if I feel concerned, then I am concerned. In matters of emotion, bootstrapping can work to establish that the objects of my concerns are real merely in virtue of my feeling that they are. But the fact that the fate of my descendants seems so evidently relevant to my concerns is merely the psychological manifestation of that destiny that links the four aspects of metazoan life and death to gather in the way I have sketched in this essay.

Conclusion

To begin with, purely chance encounters resulted first in the gene exchanges of conjugation, and later in the process that gradually established functional differentiation in agglomerated cells. In order to protect themselves against an accumulation of copying errors in the lineage that included the cells that would give rise to gametes, the sex cells segregated themselves from the somatic cells, which became doomed to die as soon as they had accomplished their mission, thus entailing the necessary death of the individual. The fact that we are individuals and the fact that we must die are aspects of the very same reality.

Is this story just another myth? If it is, how shall we assess it in relation to those that were wont to comfort our ancestors? Some of us, like Hamilton, may find a certain charm in the

thought of the unity of life; others may find it repellent. In such aesthetic matters we can hardly reject as illegitimate the claims of subjectivity.

If this story still seems implausible, we should remember that according to Pascal Boyer, as we saw above, implausibility is a characteristic that is liable to improve a myth's chances of survival. But this particular myth enjoys an additional advantage: that of being veridical. At the very least it has as much claim to being veridical as can accrue to a perspective grounded in scientific fact, accepted with the usual admission of fallibility. The truth has its own poetic allure. Compared to the hopes for survival encouraged by theistic religions, the vision of our destiny afforded by the mutual implication of sex and death seems to me more interestingly surprising, and perhaps ultimately more consoling.

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