

Dorion Sagan – Eine Vorstellung

Alle sind wir zwischen Himmel und Erde geboren, unter Sternen und auf den Sümpfen. Aber den amerikanischen Philosophen und *writer of science* Dorion Sagan ereilte dies Schicksal auf eine besondere Weise: durch Vater und Mutter. Der Name seines Vaters Carl Sagan nennt einen amerikanischen Pionier der Kosmosforschung und ihrer Popularisierung. »Cosmos«, das ist Anfang der 1980er eine Sagansche Marke, TV-Sendung und Titel des meist verkauften englischsprachigen Wissenschaftsbuchs aller Zeiten inbegriffen. Dorions jüngerer Bruder Nick spricht als 7-jähriger das »Hello from the children of the planet earth« auf die *Voyager Golden Record*, das die gleichnamigen Sonden bis heute ins All hinausstragen. Dorions Mutter, geborene Lynn Alexander, ist seit Studentinnenzeiten 1957 mit Carl Sagan verheiratet (ab 1967 mit dem Kristallographen Thomas N. Margulis). Ihr Begehren nach dem Wissen wohnt woanders: nicht oben, sondern unten, nicht auf Sternen, sondern im Schlamm von Tümpeln, Meeresufern, Böden, dort, wo die Einzeller wohnen, prokaryotisch als Archea und Bakterien, eukaryotisch als Algen und Protozoa. Sie revolutioniert die Mikrobiologie durch eine neue Theorie: Treibende Kraft der Evolution seien nicht Konkurrenzen, sondern Symbiosen. Vieles in der Evolutionstheorie bislang Unerklärbares wird dadurch erklärbarer. Aber weil die Wissende Teil der Welt ist, die sie weiß, schreibt Lynn Margulis auch ihre Bücher nie allein (niemand tut es), sondern umgeben von drei Ehen, vier Kindern, Verehrern, Studentinnen und Studenten, »gebend und redend«, wie der Einsiedler James Lovelock, Vater der Gaia-Theorie, einmal bewundernd bemerkte. Seit 1986 aber, italienisch sogar seit 1983 (*Nascita ed evoluzione della vita*), schreibt Margulis fast

alle ihre Bücher zusammen mit ihrem Sohn – Dorion Sagan, geboren 1959 in Madison, Wisconsin. Diese erstaunliche Erweiterung der Reihe Theweleitscher »production couples« ist nicht bloß als Familienkonstellation interessant. Denn sie verbindet Wissensformen, weit diesseits und jenseits von *Zwei Kulturen*. Dorion Sagan studiert Geschichte (europäische) und vergleichende Literaturwissenschaft, hat eine Ausbildung als wissenschaftlicher Illustrator, beginnt sich, einer Liebe zuliebe, für kontinentale Philosophie zu interessieren – und ist der begabteste Mikrobiologiestudent seiner Mutter. Er bringt in die Reihe der berühmt gewordenen gemeinsamen Bücher nicht nur schriftstellerisches Talent, sondern ein Wissen ein, das Mikrobiologinnen sonst eher fremd ist. Freud, Lacan, Bataille, Artaud, Emily Dickinson und Donna Haraway, Empedokles und Aristoteles stehen dann neben *Euglena gracilis*, *Spirotrichonympha psammotermidis*, *Pseudodevescovina uniflagellata*, um nur auf der Ebene von Namen zu bleiben. In seinen eigenständigen Veröffentlichungen treibt Dorion Sagan das auf seine Weise weiter, oft in großer historischer Perspektive (*From Empedokles to Symbiogenetics* 2021), als Würdigung des Lebenswerks seiner Mutter (*Lynn Margulis: The Life and the Legacy of a Scientific Rebel* 2012) oder in psychoanalytisch geradezu einschlägigen Essays (etwa: *Metametazoa: Biology and Multiplicity* 1992) und seiner großen Aufsatz-Sammlung von 2013: *Cosmic Apprentice: Dispatches from the edges of science*, mit einem weit gespannten Horizont von Batailles Sonnentheorie über Thermodynamik (alias *Thermosemiosis*) bis zur Gaiatheorie. Immer wieder, schon in den Büchern zusammen mit Margulis, kreuzt Dorion Sagens Denken die bioanalytische Kernfrage: »Evolution« und »History of Sex« – die Frage also nach der Biologie des Geschlechts und ihren Grenzen. Im Folgenden, schriftlich geführten Gespräch antwortet Dorion Sagan auf Fragen, die diesem Feld angehören und ihm von Peter Berz und Marcus Coelen gestellt wurden. Wir haben uns entschieden, das Gespräch in englischer Sprache zu belassen, um Ton und Stil Dorion Sagens zur Geltung zu bringen.

The Berlin Interview

1) Cannibalism and Merger

RISS: One of the most famous arguments of the endosymbiotic theory is the cannibalism of cells. Cells in free living state, prokaryotic and eukaryotic, eat each other. The cannibal does not fully digest the other, rather integrates genetic features, merging it with its own. This is the origin of sex, all processes of »acquiring genomes« in organelles like chloroplasts or mitochondria and finally also the evolution of Eukaryotes (Eukaryosis or Eukaryogenesis) originate here. Acquiring the mechanisms of sexual reproduction – mitosis, meiosis including all features of the »dance of chromosomes« (microtubules, spindle apparatus, poles for moving) – is itself already a kind of sex. A psychoanalytical viewpoint might begin by asking questions about this model of merger and love.

SAGAN: We are confused about sex in biology both because in us it is literally a matter of fusion linked to reproduction and because we have a very particular human example of it that we tend to generalize. We are right to be confused because in reproduction our sex cells literally fuse, after a briefer encounter of our bodies. But this endosymbiosis-like process probably arose from cannibalism followed by incomplete digestion (doubling the number of chromosomes) and is not symbiosis because in this case our remote protist ancestors were of the same kind, rather than neighbors from different species or larger taxa. What endosymbiosis among prokaryotes leading to eukaryotes – eukaryosis or eukaryogenesis as you mention – and the origins of meiotic sex (our kind of reproductive sex) share is a process of coming together and incomplete merger. This is mediated by what the great but maligned American biologist Ivan Wallin called prototaxis¹, a tendency to sense, touch, move toward or away from other organisms. Such a tendency describes the microbial precursors to feeling, thought, desire, drives etc. that would later be a focus of psychoanalysis. But not all of what a biologist best defines as sex has a probable origin from starvation-desiccation followed by canni-

balism and incomplete merger. Most sex in nature is not reproductive, and can be described as the reception of new genes and their integration into an organism's genome. This is defined coherently and non-anthropocentrically as the production of a new organism combining genes from different organisms. Bacteria get new genes all the time by conjugation, plasmid transfer, viruses, naked DNA, and other means. Without the ozone layer (which was produced by green bacteria using hydrogen from water and releasing oxygen as a waste gas, eventually turning Earth's atmosphere blue due to Rayleigh scattering²) early prokaryotes would have been bombarded by ultraviolet radiation, breaking up cells and releasing their genes, some of which got picked up by their neighbors, getting new traits in the process directly, without reproducing. This would have been sex in the genetic sense without cannibalism. Indeed, if there were no stable cells yet but just nucleotides as some suggest, it could have been the UV-prompted origin of sex prior to the origin of life!

2) Cover individuals

RISS: The bodies of lovers do not merge. They touch each other, the skin being not an interface of merging is an autonomous organ like others. 19th century's Wilhelm Bölsche and following him Sándor Ferenczi speak of »cover individuals« (»Deckindividuen«, like a cover, or undercover agent; but also as in »Deckerinnerung«, screen memory), they speak of the loving and coupling bodies as »revenants of the germ cells«. Albert Moll (*Betrachtungen über die Libido Sexualis*, 1898), a source for biological aspects in Freud's early theory of sexuality, forges the term »contractation«, from latin verb contractare: touching, feeling, grabbing. How would you localize the bodies, the multicellular organisms and their passions in the big theater of the cells and cell-mergers?

SAGAN: The term revenant is a good one. It cannot seriously be doubted that the sperm and egg cells viewed on their own look like microbes. What seems to have happened is that, in times of great hunger, protists, members of the protocist kingdom, unicells with nuclei and mitochondria and looking like variations of amoe-

bae, ingested but did not digest each other. This led from haploid cells, that is cells with one set of chromosomes like eggs and sperm, to diploid cells, cells with two sets of chromosomes. Lemuel Roscoe Cleveland at Harvard University chronicled such conspecific microbes³, mastigotes with undulating organelles, devouring but not digesting one another. Their cell membranes and nuclei merged. Phenomenologically at this point one is confronted with a great paradox of sex. Although we feel alone, we exist in a double-chromosome state, that is, in a state of having cells with two sets of chromosomes. Our ancestors were probably confronted with the problem of what Cleveland spoke of the »relief of diploidy«: How do we, how did our ancestors, recover to their ancestral haploid state of our ancestral cells? Well, the short answer is we don't: we, identified with our psyche or brains, don't »ourselves« make it back, but rather libido uses and discards us in the physiological compulsion of making new sex cells which repeat the elaborate process of their reproduction.

3) Cannibalism and the stages of sexual organisation in Psychoanalysis

RISS: Psychoanalysis transforms cannibalism into something else by placing it within the phases of the erogenous development of human sexuality, mostly in the oral phase, which is followed by the anal and genital phases. Cannibalism is oral introjection and identification, and always involves the ambivalent processes of integration and destruction. Cannibalism ends in sadism, in the biological moment when the muscles are sufficiently developed so as to allow for biting and catching (the anal stage of sadism). All this makes the formula: »Sex is a more refined version of feeding« (Bölsche) an overly simplistic view of both the biological reality and the playground of the unconscious. Could psychoanalysis—despite its connection with the 19th and 20th century biological sciences—introduce an other view into the biology of sex?

SAGAN: I think Nabokov was right to malign psychoanalysis for its un-nuanced excesses, and for its leveling of the subtlety of

literature into monolithic views centering on sex. From my reading of Ferenczi, who is very appreciative of Bölsche and deferential toward Freud, I would say that there are lots of problems with psychoanalysis from a modern evolutionary biological point of view. However, I think there is something important in the evolutionary broadness of Ferenczi's approach. While the wide berth he gives to speculative analogic thinking (which he readily admits may be wrong but, quoting Goethe says is better than nothing) becomes almost self-parodic, he goes beyond Freud in his thinking of the biological unconscious, which owes something to Ernst Haeckel, who granted microbes, symbiotic collectives, and even the tissues of the human body psyches. There is an inside to the biology of sex which might be studied by biophenomenology or, as he says, riffing off of psychoanalysis, bioanalysis. His emphasis on a »tendency to regression which governs both psychic and organic life« can be found also in nonliving thermodynamic systems which revert to earlier stages of organization when harmed or deprived of energy. This opens the possibility of a »depth biology« which would focus on life not just as a physical but feeling system. For example, we wrinkle our noses at hydrogen sulfide with its rotten egg odor.⁴ As sulfidometers show, the gas is briefly produced in our cells but has no known metabolic function. However, it is released by volcanoes and vents and was more prevalent on the early Earth, and is part of the metabolism of some archaea, among which were the host cells infected by proteobacteria that symbiogeneticized and became mitochondria. It seems likely that our sensoria preserves not just genetic and metabolic but psychic traces in the multibillion-year path of our evolutionary history.

4) The Phylogeny of Sex

RISS: In your book *Mystery Dance*, in the chapter on »Orgies and androgynes«, the encounter of cells which finally merge is connected to a search for humid milieus and water as a medium of life, in times of hunger and drought. In merging, two cells are to each other this humid milieu. A similar argument lies at the center of Sándor Ferenczi's phylogenetic speculation in *Thalassa* (1924). Having to leave the aquatic milieu generated a sort of trauma for

the multicellular organisms; trauma transmitted up to the human being. This is also the situation of birth when the newborn leaves the womb. Phylogenetically, the womb symbolizes the sea and copulation is a wish to return to the sea.—Which place would you see for such a theory in the realm of modern biology?

SAGAN: In mentioning Bölsche, who in »other respects [is] an unswerving follower and apostle of Haeckel,« Ferenczi argues how he thought the penis was reminiscent of Melusina in the French folk-tale who changes each Saturday night into a snake from the waist down. Ferenczi then adds that Bölsche »does not adhere long to this metaphor, to be sure, and in fact designates the question of the origin of this appendage as a problem of merely minor interest and importance—although in this place we are certainly not in agreement with him.« He talks of the »intrinsically non-pleasurable sex act« made possible by the spell cast by the male as the female hypnotically regresses »to the maternal womb.« (This Svengalism might better be seen to evoke the mixed motives of the asymmetrical clinical relationship in 19th century Europe.⁵) In *Thalassa* he conjectures (from the male point of view of course) that erection is »an incompletely achieved attempt to detach the genital, charged with »unpleasure« of various kinds from the rest of the body,« that the »sex act begins as a tendency in the direction of the complete detaching of the genital and thus as a kind of self-castration, but is then satisfied with the detachment of its secretion [semen],« and then goes on about an »impulse to genital friction« which he conjectures is an »unpleasure accumulated in the whole body« and »stored in the form of an itching, which is removed by a kind of scratching ... an archaic vestigium of the autonomy tendency ... to tear away the itching part of the body with the nails.« But itching and scratching is better understood as an impulse among mammals historically imperiled by insects, sometimes carrying deadly diseases, to rid themselves of their parasites. Far from being dominant, the male angler fish, attaching to its larger mate to fertilize her, is so much smaller that it was thought to be another species.⁶ Hyena females, thought to be males by Aristotle and Hemingway because of their androgenized clitorises, dominate males and give birth through those clitorises, often

dying.⁷ There is vast diversity, even among mammals, in sexuality. The origins of the penis occurs in the context of sperm competition, where males that produced sperm closer to the female egg, more copiously, and ultimately inside female bodies transitioning from external fertilization ultimately generated offspring that were more successful if the female had multiple partners. Ferenczi's emphases, especially his point that the water was the mother before there were mothers, seems right, but the extent to which many of the changes were volitional rather than the result of natural selection of variations is debatable. Ferenczi adds more biological speculations but is still very lopsided towards a humanocentric zoocentrism. For all we know plants feel orgasmic as they soak up the sun and grow. The impulse to think evolution phenomenologically is admirable, and should be updated, but in his specifics Ferenczi strikes me as most often useful as a warning against the excesses of premature speculation from a too-human standpoint!

5) Sex and The Anthropological Difference

RISS: Sex of human beings, very different from animals, does not run smoothly. Famous sentence of Lacan at the Caracas Conference in 1980: *«Avec les grenouilles ça marche!»,* Frogs have no problem. But in the human subject we find perversion, regression, neuroses, and a general discontent about the sexual which, while creating poetry and pornography as well as war and structures of kinship, doesn't ever seem to diminish—all going back to the peculiar human fate of sexuality.—How would you situate humane sexuality in horizon of the five kingdoms? Where else in these kingdoms do you see points, situations of malfunction? Would sexual malfunction introduce new aspects in biological theory?

SAGAN: Malfunction assumes a steady state, but evolution is not Platonic or Aristotelean but more Heraclitean, Lucretian, and Dionysian. It is not bound by static forms or categories. Hermaphroditic slugs mutually fertilizing each other in a tree and then dropping to the ground, presumably from ecstasy, are not perverted but normal in their own context.⁸ Empedocles wrote

of organs wandering the early Earth and merging to become organisms, some leaving more offspring than others, essentially postulating both symbiogenesis and natural selection.⁹ »Normal« means different things in different species, and in the same species over time. *Schizophylum commune* for instance is a fungus with thousands of genders (mating types).¹⁰ Sexually reproducing species themselves were perversions of prokaryotic pansexuality and pro-
tist asexual reproduction!

6) Never Really Becoming Human: Neoteny and Premature Birth

RISS: In *Microcosmos* (1986) you dedicated a paragraph to human beings as being neotenous, that is, retaining embryonic and youthful characteristics into later stages of the life cycle like Axolotls or Olms (*Proteus anguinus*). Another technical term coined in the 1920s is »fetalization«. Philosophers like Arnold Gehlen or psychoanalysts like Michael Balint adhere to this model. The latter for instance states that in genital love, during copulation, humans are also regressing to infant stages. In their sexual life, human beings are »neotenic embryos«, bodily and mentally (Michael Balint: *Primary love* (1952), chapter on »Genital love«). For Lacan the most fundamental point of the human condition is not only that the human baby is born a year too early, compared to primates for instance, but also that a »certain dehiscence at the heart of the organism« due to »fetalization« determines its being. Decisive processes derived from these biological conditions converge in the hypothesis of the »mirror stage«. Freud also came across neoteny when researching the *Ammocoetes*¹¹, and his notion of »Helplessness« (Hilflosigkeit) is certainly linked to the idea of the »eternal embryo«.—Are there comparable situations in other groups of animals or living beings of the five kingdoms? Why does sexuality place such a small role, almost none, in most anthropological discourses about animals becoming humans?

SAGAN: In the Anglo-American world the avoidance of sexuality in the theorization of human origins may be partly a Puritan holdover. The theoretical exponential increase of ancestors (2 par-

ents, 4 grandparents, 8 great grandparents etc.) suggests there was much mating of second cousins, and other forms of incest in our past. And of course humans are animals; your question is about the becoming human of nonhumans. However, this issue has been addressed in speculative and scientific detail, for example by Robert Smith in *Sperm Competition*, and the works of Desmond Morris.¹² Adults are not embryos but we seem to carry the plastic impressionability of a developing embryo into early childhood, allowing us to exponentially increase psychological connections, including Ferenczi-like speculations, not all of which are correct but are part of an evolutionary pathology, we might say, which is specifically human.

7) Neuroses and Homeostasis

RISS: Following Lacan, neurosis means to believe in homeostasis and to try to devote ones existence to this belief. This is the general neurotic point, at least as far as the obsessional dimension is concerned (the hysterical dimension is more devoted to a rearrangement and stitching together the dehiscences of the neotenic body). The dissolution of homeostasis is a threat, it generates anxiety. In the knowledge of biological sciences, homeostasis is a main feature, disturbed equilibria tending to restore itself is an important force driving evolution.

SAGAN: Ferenczi I think, following Freud, correctly emphasizes the potential impact of not just ontogenetic but phylogenetic catastrophes, overlain on them à la Haeckel, in the formation of the human body-mind. His focus on the desire of those in our lineage to return to the water that was the »mother« in externally fertilizing ancestors is contagiously imaginative, but many other catastrophes loom in our past: the origins of life, the adaptation to an oxygen atmosphere by respiring bacteria, their initial often deadly infections of/cannibalism by archaea etc. We and all extant life forms, 99+ % of which are extinct, are survivors of multiple traumas: not just desiccation but starvation, meteoritic impacts, toxic oxygen, killing infection, death by carnivory, by infection, by vulcanism, and so on. A genetically based estimate of the viral

contribution to the evolution of the mammalian placenta, humans included, is about forty percent.¹³ Living systems homeostatically or better, homeorhetically maintain themselves, or they become one with their environment, no longer alive. The death drive can I think be understood both as a manifestation of the ever-present tendency of complex systems to return to an inert state (similar to the »pull« one feels looking down from a great height); it a kind of mental concordance with the more-than-human, more-than-living attractor toward equilibrium described in the 2nd law of thermodynamics. But the more-than-living pull described by this law favors eros over thanatos insofar as sex in us keeps new entropy-producing beings going even after our own bodily demise. The death drive, from another perspective, reflects the physiology of aging, which is not that of inevitable slow disrepair, but is actively selected for because it prevents extinction from hyperpopulation followed by starvation or infections which wipe out whole clades. Bataille's emphasis on the general economy is correct because it divorces itself from categorical thinking emphasizing the solar reality of continuous expenditure, in which life, continuously »burning« at room temperature, is a cosmic expert.¹⁴

8) Neurotic science or Gaiadelics

RISS: Is biological science in itself neurotic? What other kinds of knowledge about living beings would be possible? Do the experiences, for instance, of the McKenna brothers in the 1970ties, of Terence and the scientifically very erudite Dennis, amount to another form of knowledge—in the midst of science and jungle (like in »True hallucinations«). Lynn Margulis took part in this experience for a while and invested it with her microbial and biochemical knowledge. Someone named it »Gaiadelics«.

SAGAN: Well it is true that Terence was a wild psychedelophile and that his brother Dennis has a broad scientific knowledge of botany. »Gaiadelic« is used by my friend Rich Doyle, who also used the term »ecodelic« to refer to psychoactive substances that tend to reorient the human psyche to its embodied cognition with a more than human organism-rich, energy-transducing environ-

ment.¹⁵ Such words are important because they de-pathologize largely plant- and fungally derived substances such as psilocybin, ayahuasca, and mescaline which in evolutionary context tend to derive from the bodies of organisms whose ancestors have co-evolved with ours in mind-altering ways. Once called psychotropics, which suggest debilitating psychoses, and hallucinogens, which suggests irreality, terms such as ecodelic and gaiadelic suggest their deeper ecological status as compounds neither fantastic nor pathological, neither wholly good nor evil, but rather representative of important bio-eco encounters between chemically active aliens on our own planet, beings with bodies and perhaps body-minds far different than our own. Some psychedelic fungi, for example, *Psilocybes sp.*, can grow on cow feces, and thus may be seen as mediators of a kind of ecological bardo between the living and the dead, whose action on our psyches impresses upon us the importance of other species, not just animals but fungi, plants, and microbes. William Blake famously wrote that »If the doors of perception were cleansed every thing would appear to man as it is, infinite. For man has closed himself up, till he sees all things thro' narrow chinks of his cavern.« Ecodelics may work a similar magic on our understanding of the place in the living biosphere we inhabit, which includes all our rational thoughts, science, technology, and dreams but remains far more. —

- 1) The term prototaxis was coined by Ivan Wallin to refer to the desires and actions of organisms in moving towards and away from each other; he used it to describe the beginnings of symbiotic associations. For more, see Sagan, Dorion (open access article): »From Empedocles to Symbiogenetics: Lynn Margulis's revolutionary influence on evolutionary biology«. In: *Biosystems*, 204.2021, 104386: <https://www.sciencedirect.com/science/article/pii/S0303264721000435>.
- 2) »Rayleigh scattering« is a mathematical treatment of the scattering of particles smaller than the wavelength of radiation. Oxygen atoms, absorbing wavelengths at the edge of the ultraviolet region of the spectrum, scatter a mix of colors, mostly blue and green, leading to the pale blue color of the sky. Seen from space, earth itself, the blue marble, is colored, but the sky around the Earth looks black and the sun white.—Note of the editors: Before, nomen est omen, the Barons Rayleigh, number 3 and 4, in 1899 postulated the biosphere-born oxygen itself as the cause for the azure of the sky, it was the physicist and ingenious »science-writer« John Tyndall, who imagined in the 1870s (e. g. *On Light*, 1873) the blue sky as a turbid medium, the sunlight scattering around particles bigger than molecules smaller than dust. He visioned them as the »floating organic germs« seen by de la Rive in the mist of the alpine air near Mont Blanc.
- 3) See Margulis, Lynn, and Sagan, Dorion: *Origins of sex: three billion years of genetic recombination*. Chapter 9: *Cannibalism and other mergers*. New Haven, London 1990: Yale University Press, p. 146–152; id.: *The Symbiotic Planet. A New Look at Evolution*. London: Orion House 1998, p. 99–103 (dt.: *Der symbiotische Planet. Wie die Evolution wirklich verlief* (mit einem Nachwort von Peter Berz). Frankfurt a. M. 2017: Westend, S. 130–137)
- 4) Hydrogen sulfide (H₂S), outgassing from volcanoes, would have been more prevalent in the atmosphere of the early Earth, as would ammonia (NH₃), methane (CH₄), and elemental hydrogen, the main stuff of stars and the main substance from which the solar system gravitationally accreted. As the lightest element, hydrogen tends to escape in space. Presuming life originated on Earth, it would have evolved from *in situ* geochemicals organizing under the influence of energy gradients. See, e.g., Cairns-Smith, A. Graham, Alan J. Hall, and Michael J. Russell. »Mineral theories of the origin of life and an iron sulfide example«. In: *Marine Hydrothermal Systems and the Origin of Life*. Dordrecht 1992: Springer, p. 161–180. For a more general account of cells, organisms and ecosystems as natural forms of metastable energy use, see Schneider, Eric D., and Sagan, Dorion: *Into the cool: Energy flow, thermodynamics, and life*. University of Chicago Press 2005. For a collection on the evolution of sensing cell systems, see Margulis, Lynn, Celeste A. Asikainen, and Wolfgang E. Krumbein, eds. *Chimeras and consciousness: Evolution of the sensory self*. MIT Press 2011

- 5) After Svengali, villainous hypnotist in the novel *Trilby* (1894) by George du Maurier
- 6) Deep-sea anglerfish with luminescent lures from modified fins were collected by scientists and all found to be females, some with smaller fish thought to be parasites. Further investigation revealed that the fish were actually males, born with highly developed olfactory capabilities but not reaching maturity unless they attached to the body of a female; the alimentary canals of some does not full develop, and their bodies fuse with the females, meaning they are fed by her body as they provide their sperm.
- 7) In *Green Hills of Africa* Ernest Hemingway calls a particular hyena, Fisi, »hermaphroditic self-eating devourer of the dead ... with jaws that crack the bones the lion leaves, belly dragging, loping away on the brown plain ...«. Females of the spotted or laughing hyena (*Crocuta crocuta*) have six-inch clitorises and labia that can be mistaken for testicles; the clitoris ruptures during birth (often fatal to the mother) but can heal afterwards. The dominant females hunt in packs, and the feces of this species is often white from the bones they ingest with their powerful jaws. Such examples show the lability of evolution, in which males are hardly always dominant.
- 8) Hermaphrodites of the great grey slug, *Limax maximus*, encounter each other on a branch or bracket fungus, engaging each other's tentacles, then circling in a mouth-to-tail dance that lasts up to two-and-a-half hours. During the growing passion, each slug »bungee jumps« from the tree, stopping itself short on a 38–46 cm line made of its own mucus. Swinging in mid-air, each then unsheaths its penis, up to 10 cm long, and inserts it in the appropriate bisexual organ. After exchanging sperm, they either climb up the mucus cable whence they came, or drop to the ground in the »petite morte« of orgasmic exhaustion.
- 9) Empedocles suggested that Earth's early beings both merged and differentially reproduced; a speculation that was rejected by Aristotle probably because it suggested mythological chimeras that had no place in observational biology, and later by Charles Darwin, who mentioned Aristotle's rejection of Empedocles to show that he knew of but did not accept natural selection, thus helping Darwin make his own claim to the theory in a Victorian culture whose thinking of origins was dominated not by Greek mythology but by Christian special creation. See Sagan, Dorion. »From Empedocles to Symbiogenetics: Lynn Margulis's revolutionary influence on evolutionary biology.« (see footnote 1).—Note of the editors: A detailed inspection of the first footnote in Darwin's *The origin of species*, concerning Aristotle and Empedokles, see also the paper from Oliver Primavesi, discoverer and editor of most of the crucial Empedocles-fragments: Primavesi, Oliver: »Aristoteles oder Empedokles? Charles Darwin und Eduard Zeller über einen antiken Ansatz zur Evolutionstheorie«. In: *Eduard Zeller. Philosophie- und Wissenschaftsgeschichte im 19. Jahrhundert* (Hg. Gerald Hartung), Berlin/New York 2010, S. 25–65. Looking for a way from Empedocles' Cosmic Cycle of 4 elements (which are 4 gods) to microbe-driven elementary cycles analysed by Margulis and others, see: Berz, Peter: »Respondenz zu Oliver Primavesi ›Tetrakty und Göttereid«

- (V. Die Zukunft der Zyklen)«. In: Götter und Schriften rund ums Mittelmeer (hg. v. Friedrich Kittler, Peter Berz, Joulia Strauss, Peter Weibel). München 2017: Fink, S. 372–400
- 10) *Schizophyllum commune*, a basidiomycete fungus, is an extremely successful mushroom found on every continent except Antarctica. It has twenty-eight thousand genders, each of which can mate with any of the others, except its own.
 - 11) Note of the Editors: Freud studied the distributed nerve system of *Lampetra planeri* (the *European brook lamprey*, old name: *Petromyzon planeri*), order *Petromyzontiformes*, an archaic fish without jaws (Agnatha) that does not migrate from its birthplace in freshwater habitats down to marine estuaries like other lampreys do in specific season, but grows and spends its whole life upstream in rivers. Freud remarks: »daß es nicht Wunder nehmen darf, wenn bei einem Thier, *das in vieler Hinsicht einen permanenten Embryo darstellt*, sich zurückgebliebene Zellen vorfinden, die den Weg bezeichnen, den die Spinalganglienzellen eingewandert sind«, »one should not being surprised when in an animal that is in many respects a permanent embryo there are retarded cells which mark the way the cells of the spinal ganglion immigrated.« (Freud, Sigmund: »Über Spinalganglien und Rückenmark des Petromyzon«. In: *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften Wien, Mathematisch-naturwissenschaftliche Classe*, III. Abtheilung, 1878, 35, S. 81–167, 139)
 - 12) Robert Smith's compendious survey of sexual selection in animals: Smith, Robert L. (ed.): *Sperm competition and the evolution of animal mating systems*. Elsevier 2012. — Although it has been rightly criticized, zoologist Desmond Morris does attempt to integrate sexuality into the evolution of humans, for example, in Morris, Desmond: *The naked ape: A zoologist's study of the human animal*. Random House 1967. See also Margulis, Lynn, and Dorion Sagan: *Mystery dance or the evolution of human sexuality*. New York 1991: Summit Books (dt.: Dies., *Geheimnis und Ritual* (übersetzt von Margit Bergner und Monika Noll), Berlin 1991: Byblos, S. 54–58)
 - 13) Viruses play a very important role in the history of the biosphere, and of life's evolution on Earth. For example, it's estimated that some 30 percent of the human genome has a viral origin. This includes the placenta, the defining feature of mammals such as ourselves. A retrovirus is considered to have been necessary for the evolution of the placenta in sheep. Scottish molecular biologist Stephen D. Bell argues that there are striking likenesses between viruses such as HIV and Ebola, and viruses that infect organisms called archaea that grow in geothermal springs. Despite a vast difference in environments and two billion years of evolution between archaea and humans, the viruses hijack the same set of proteins to break out of infected cells. See, e.g., Haig, David: »Retroviruses and the placenta«. In: *Current Biology* 22.15 (2012): R609–R613: <https://www.sciencedirect.com/science/article/pii/S0960982212006410> .
 - 14) The »general economy« is explored in Bataille's *The Accursed Share: An Essay on General Economy* (French: *La Part maudite*, 1949) in which he emphasizes the importance of spending, or expenditure, over

capital accumulation. For example, a society that builds monasteries is very different than one which builds weapons of war. Bataille argued that life's biggest problems and aesthetic possibilities came not from scarcity but excess and what to do with it. Moreover, although Bataille is best known in literary and postmodernist studies, behind his thought is the deep thermodynamic reality of solar excess; one might say that, if for Freud and Lacan the phallus is the master metaphor, for Bataille it is the Sun and solar excess. (I would argue that Bataille's analysis of the ways this solar excess feeds into rhetoric beyond discrete signification is evident in Derrida: »La mythologie blanche: la métaphore dans le texte philosophique«. In: Id., *Marges de la philosophie* [engl. *Margins of Philosophy*], Paris 1972, Les éditions de Minuit, p. 247–324. See especially the paragraph about »L'ellipse du soleil: l'énigme, l'incompréhensible, l'imprenable.«.)¹⁵ Moreover, I speculate that in his thoughts on the Sun Bataille was crucially influenced by his 1929 reading in the French translation of Vladimir I. Vernadsky's *La Biosphère* (Russian 1926, French 1929), which he references in *The Accursed Share* in a chapter about the »Exuberance of the biochemical energy and the growth«. Via Derrida primarily, these thoughts have entered continental philosophy. One might argue that the Sun, the main energy source for life forms on Earth, becomes, via Derrida, a post-Lacanian master signifier that does away with the zoomorphism of the phallus, the master signifier of psychoanalysis. The end state of isolated thermodynamic systems may be stasis (thanatos), but the open complex systems of living beings

actively delocalize concentrated energy (a generalized eros?) to continue their existence as metastable, nonequilibrium thermodynamic systems whose goal is not so much death as entropy production, made possible by cosmic gradients. See e.g. Sagan, Dorion, and Jessica Hope Whiteside. »Gradient reduction theory: Thermodynamics and the purpose of life«. In: *Scientists Debate Gaia: The Next Century* (ed. Stephen H. Schneider et al.). MIT Press 2004: p. 173–186. And chapter 2 of »Bataille's Sun and the Ethical Abyss«. In: Sagan, Dorion: *Cosmic apprentice: Dispatches from the edges of science*. University of Minnesota Press 2013: p. 33–40

15) Note of the Editors: See Doyle, Rich: »Gaiadelic: Lynn Sagan and LSD«. In: *Margulis, Lynn. The Life and Legacy of a Scientific Rebel* (ed. Dorion Sagan), Vermont: Chelsea Green Publishing 2012, p. 143–149; and Margulis, Lynn: »An Open Letter to Mr. Joe K. Adams«. In: *The Psychedelic Review*, 2.1963, p. 354–356 (answer to Joe K. Adams: »PSYCHOSIS: »Experimental« and Real«, ibid.: p. 121–141)

