Living On Earth, **Online Notes**

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Chapter 3. The Forest

51 *The young Charles Darwin*: The account is in his *Journal of Researches*, known also as *The Voyage of the Beagle.* This wording is from the 1845 second edition. The 1839 first edition (*Journal and Remarks*) is very similar in the quoted "bold sea-coast" passage, but does not have the geological speculations. For all these texts, see http://darwin-online.org.uk.

From the 1845 edition:

> The first impression, on seeing the correspondence of the horizontal strata on each side of these valleys and great amphitheatrical depressions, is that they have been hollowed out, like other valleys, by the action of water; but when one reflects on the enormous amount of stone, which on this view must have been removed through mere gorges or chasms, one is led to ask whether these spaces may not have subsided. But considering the form of the irregularly branching valleys, and of the narrow promontories projecting into them from the platforms, we are compelled to abandon this notion. To attribute these hollows to the present alluvial action would be preposterous; nor does the drainage from the summit-level always fall, as I remarked near the Weatherboard, into the head of these valleys, but into one side of their bay-like recesses. Some of the inhabitants remarked to me that they never viewed one of those bay-like recesses, with the headlands receding on both hands, without being struck with their resemblance to a bold sea-coast. (p. 960)

52 *central to the work of Charles Lyell*: The crucial work was his *Principles of Geology: Being an Attempt to Explain the Former Changes of the Earth's Surface, by Reference to Causes Now in Operation*, 3 volumes (1830–33, John Murray). Darwin dedicated the second edition of his *Beagle* book to Lyell.

52 *the geologist Charles Wilkinson hypothesized*: See J. L. Pickett and J. D. Alder, *Layers of Time: The Blue Mountains and Their Geology* (1997, Geological Survey of New South Wales), and J. Milne Curran, *The Geology of Sydney and the Blue Mountains: A Popular Introduction to the Study of Geology* (1899, Angus and Robertson). Darwin: "To attribute

these hollows to the present alluvial action would be preposterous," *Voyage of the Beagle*, second edition, chapter 19.

53 *Ted Hughes, in his poem "Sugar Loaf"*: Published as "Sugar-loaf " in *The Atlantic*, 1962, and as "Sugar Loaf" in *Wodwo*, 1967.

53 *The Bark-Palaces We Call Plants*: "Mayer of Bonn, basing his theory upon molecular motions, considers the smallest granules of the cell-contents as individuals possessing animal life (biospheres) which build up plants for their dwellings. 'Like hamadryads these sensitive monads inhabit the secret halls of the bark-palaces we call plants, and here silently hold their dances and celebrate their orgies.'" Alexander Braun, *The Vegetable Individual, in Its Relation to Species* (American Journal of Science and Arts, May 1855, translated by C. F. Stone, p. 309).

53 *A forest of this kind*: See Graeme Lloyd et al., "Dinosaurs and the Cretaceous Terrestrial Revolution," *Proceedings of the Royal Society B* 275 (2008): 2483–2490. doi: 10.1098/rspb.2008.0715; Jose Barba-Montoya et al., "Constraining Uncertainty in the Timescale of Angiosperm Evolution and the Veracity of a Cretaceous Terrestrial Revolution," *New Phytologist* 218 (2018): 819-834, https://doi.org/10.1111/nph.15011

54 *Land plants arose from colonies*: See Karl Niklas, *The Evolutionary Biology of Plants* (1997, University of Chicago Press), and Tais Dahl and Susanne Arens, "The Impacts of Land Plant Evolution on Earth's Climate and Oxygenation State—An Interdisciplinary Review," *Chemical Geology* 547 (2020): 119665, doi.org/10.1016/j.chemgeo.2020.119665

54 *A new group, flowering plants*: The evolutionary line that led to flowering plants probably branched off from others well before this, though the date is controversial. For one discussion, see Daniele Silvestro et al., "Fossil Data Support a Pre-Cretaceous Origin of Flowering Plants," *Nature Ecology and Evolution* 5 (2021): 449–457, doi.org/10.1038/s41559-020-01387-8

55 *Insects are sprinkled through the fossil record*: Dates using molecular genetics push the origin of insects back to around 479 million years ago, but the fossil record starts much later. See Bernhard Misof et al., "Phylogenomics Resolves the Timing and Pattern of Insect Evolution," *Science* 346 (2014): 763-76, doi: 10.1126/science.1257570

55 *something like 85 percent of species*: See Geerat Vermeij and Richard Grosberg, "The Great Divergence: When Did Diversity on Land Exceed That in the Sea?," *Integrative and Comparative Biology* 50 (2010): 675–682, doi.org/10.1093/icb/icq078. Eighty-five percent is their lower estimate; it could be as high as 95 percent. This number does not include microbes.

56 *Rivers, however, are not just inevitable consequences*: Apparently the fossil record shows quite a dramatic effect on river shape of the evolution of plants— see Neil Davies and Martin Gibling, "Paleozoic Vegetation and the Siluro-Devonian Rise of Fluvial Lateral Accretion Sets," *Geology* 38 (2010): 51–54, doi.org/10.1130/G30443.1, and the more recent Alessandro Ielpi et al., "The Impact of Vegetation on Meandering Rivers," *Nature Reviews Earth and Environment* 3 (2022): 165–178, doi.org/10.1038/s43017-021-00249-6. Thanks to Mark Westoby for comments on this. Soil, too, was largely a product of plants themselves, along with fungi.

57 *This list is not supposed to cover everything*: What about drinking at a water hole? I include that as feeding. I leave out "elimination" behaviors, such as def- ecation, and also some self-directed behaviors such as grooming and cleaning oneself. Wound tending is important in other contexts; it is evidence for felt pain. I am trying to keep the list as simple as I can, in order to focus on some categories that matter most to the themes of this book. As will be evident, I don't think "four Fs" summaries suffice.

59 *All of these forms of action are probably very old*: For building by unicellular organisms, see Mike Hansell's *Built by Animals* (2009, Oxford) on *Difflugia coronata*. The case I am not sure about, in unicellular organisms, is action with the goal of information gathering. There are cases where protists hunt in a way that is informationally efficient, sampling the environment (see Scott Coyle et al., "Coupled Active Systems Encode an Emergent Hunting Behavior in the Unicellular Predator *Lacrymaria olor*," *Current Biology* 29 (2019): 3838-3850.e3, doi.org/10.1016/j.cub.2019.09.034. This is not the same as acting with the sole or main purpose of information gathering. But perhaps there is a case of this kind.

59 *Now a cell can crawl, swim quickly*: Although a cytoskeleton with this sort of power is usually seen as a eukaryotic innovation, it, too, has precursors. The Archaea are a bacteria-like group of organisms, and a rare variety called the Asgard archaea have an internal skeleton that is similar to the ones within cells like ours. These archaea are seen with long,

tentacle-like projections coming out from their bodies. See Thiago Rodrigues-Oliveira et al., "Actin Cytoskeleton and Complex Cell Architecture in an Asgard Archaeon," *Nature* 613 (2023): 332–339.

Bacteria do have a form of cytoskeleton. In addition, engulfing is not wholly absent in bacteria: see Takashi Shiratori et al., "Phagocytosis-Like Cell Engulfment by a Planctomycete Bacterium," *Nature Communications* 10 (2019): 5529, doi.org/10.1038/s41467-019-13499-2

59 *The term "niche construction"*: See John Odling-Smee, Kevin Lala, and Marcus Feldman, *Niche Construction: The Neglected Process in Evolution* (2003, Princeton).

60 *A few small worms may have hunted*: I discuss this in more detail in *Metazoa*, chapter 3. See James Gehling and Mary Droser, "Ediacaran Scavenging as a Prelude to Predation," *Emerging Topics in Life Sciences* 2 (2018): 213-222, doi: 10.1042/ETLS20170166.

60 *the British biologist Nicholas Butterfield*: See his "Animals and the Invention of the Phanerozoic Earth System," *Trends in Ecology and Evolution* 26 (2011): 81-87, doi.org/10.1016/j.tree.2010.11.012.

61 *The phrase "ecosystem engineer"*: See Clive Jones, John Lawton, and Moshe Shachak, "Organisms as Ecosystem Engineers," *Oikos* 69 (1994): 373–386, doi:10.2307/3545850

61 *Earthworms, present-day descendants*: See Renée-Claire Le Bayon et al., "Earth-worms as Ecosystem Engineers: A Review," in *Earthworms: Types, Roles and Research* (edited by Clayton Horton, 2017, Nova).

63 *Action is different on land and in the sea*: See Geerat Vermeij, "How the Land Became the Locus of Major Evolutionary Innovations," *Current Biology* 27 (2017): 3178-3182.e1, doi.org/10.1016/j.cub.2017.08.076. I discussed these ideas in Metazoa, chapter 9.

63 *The novelist Arthur C. Clarke, of* 2001: A Space Odyssey, *said this*: This is in his 1956 book *The Coast of Coral* and various biographies (e.g., https://www.imdb .com/). The screenplay of *2001: A Space Odyssey* was written by director Stanley Kubrick and Clarke, based on some Clarke stories, especially "The Sentinel" (1951).

64 *Early animals in the sea, and their*: There's more on this in *Metazoa*, chapter 3. When I say there are no radially symmetrical animals on land, I exclude anemones who live in the intertidal zone.

64 *Termites don't usually live inside the towers*: See Turner's *The Extended Organ- ism* and Lisa Margonelli's *Underbug: An Obsessive Tale of Termites and Technology* (2018, Macmillan).

64 *There are tube-building worms, and shrimp-like animals*: For the amphipods, see Nikolai Neretin, Anna Zhadan, and Alexander Tzetlin, "Aspects of Mast Building and the Fine Structure of 'Amphipod Silk' Glands in *Dyopedos bispinis* (Amphipoda, Dulichiidae)," *Contributions to Zoology* 86 (2017): 145-168. For the pistol shrimp, see Hansell's *Built by Animals* and references he gives.

This passage is from Hansell's *Built by Animals*:

> the tip of this massive snapping claw in Alpheus saxidomus is worn and scratched by, it is suspected, abrasion against the rock. It seems that the species blasts a cavity in the rock by repeatedly holding its claw to the rock surface and pulling the trigger.

His reference is to "Observations on rock boring by A ipheus saxidomus (Crustacea: Alpheidae) R. Fischer 1and W. Meyer, *Marine Biology* 89 (1985): 213-219.

> Summarizing our observations on the structural damage to the first right pereiopod of Alpheus saxidomus, it seems to be very probable that this species forms its housing cavities by chiseling out rock particles in the manner supposed by Kleemann (1984) for Upogebia operculata. The hammer-dactylus is structurally suited for the mechanical treatment of hard material. The very thick and calcified cuticle of the "hammer" is mostly formed by the sclerotinized, hard exocuticle, which is extremely abundant in pore canals.

The pufferfish are the white-spotted pufferfish (*Torquigener albomaculosus*); see Hisoshi Kawase et al., "Spawning Behavior and Paternal Egg Care in a Circular Structure Constructed by Pufferfish, *Torquigener albomaculosus* (Pisces: Tetraodontidae)," *Bulletin of Marine Science* 91 (2015): 33-43, doi.org/10.5343/bms.2014.1055

65 *At "Octopolis" and "Octlantis"*: These sites are described in detail in my books *Other Minds* and *Metazoa*. Storms and floods have affected the bay where the sites are located in recent years. When I last visited Octopolis, in early 2023, it was very quiet, with only a

couple of octopuses present. Octlantis was livelier on that trip, with five octopuses, though well below the maximum we've seen there, which is around fifteen. See this blog post: https://metazoan.net/109-octopolis-and-octlantis/

There are some worms, tiny shrimp, and other shrimp-like animals who build tubes or masts: For the amphipods, see Nikolai Neretin, Anna Zhadan, and Alexander Tzetlin, "Aspects of mast building and the fine structure of "amphipod silk" glands in Dyopedos bispinis (Amphipoda, Dulichiidae)," *Contributions to Zoology*, 2017.

One kind of amphipod engages in "farming" of diatoms. From L. R. McCloskey, "A New Species of Dulichia (Amphipoda, Podoceridae) Commensal with a Sea Urchin," Pacific Science 24 (1970: 90-98.

> *Dulichia rhabdoplastis* exhibits a remarkable relationship with the urchin *Stroll-gylocentrotns...* Within the depth range of approximately 3 to 25 meters these large urchins carry up to 30 strands of light- brown material trailing off from the tips of the spines. The initial impression is that these strands are injured or decaying spines, or perhaps a streamer of debris or algae which has become caught on the spine; for this reason their origin has been ignored by many divers. Close inspection reveals the strands to be smooth and compacted detritus rods, fastened to the urchin spines and occupied by one or more amphipods. Underwater field observations have revealed that *Dulichia rhabdoplastis* fastens a bit of detritus to the end of a spine and proceeds to lengthen and form the strand upon which it will subsequently dwell and re-produce.
>
> The detritus strands or rods are constructed primarily from the animal's feces and rejected food particles. The amphipod will flex to grasp one of its fecal pellets - in a manner reminiscent of a lagomorph - and, after manipulating it with maxillae and maxillipeds and adding an oral secretion, will cement it to the tip of the strand. Strands may attain a length of 4 cm, but the average is about 2 cm.
>
> During the summer months when young are most abundant, the surface of the rods generally contains a rich growth of a large pennate diatom. The diatoms pivot about on the end which is attached to the detritus strand, and a large patch appears to move in synchronal waves. Some strands possess a very rich growth, and the behavior of the amphipods at this time suggests that they aid the culture of the diatoms by removing all other settling organisms and silt. This is accomplished by the mechanical disturbance of their feeding and movement up and down the strand. The gut of both the adults and young are often completely packed with the diatom.

> It seems unlikely that the diatoms obtain much, if any, of their nutriment from inorganic nutrients released by the detritus strands. The amphipod does "farm" the diatom, however, in the sense of weeding and cropping. There are no records of similar behavior in any marine crustacean, and this behavior may be without parallel in the marine environment.

66 *A tunicate or sea squirt called* Oikopleura: See Hansell, *Built by Animals.*

68 *Why do I think there were tunnels?*: See Takeshi Takegaki and Akinobu Nakazono, "The Role of Mounds in Promoting Water-Exchange in the Egg-Tending Burrows of Monogamous Goby, *Valenciennea longipinnis* (Lay et Bennett)," *Journal of Experimental Marine Biology and Ecology* 253 (2000): 149-163, doi.org/10.1016/S0022-0981(00)00251-3

69 *The feature that is basic to tool use*: In my earlier discussion of categories of action, I said that often the goals of an action form chains—you might move in order to interact with another person, and might do all that in order to make some change to the environment, and so on. I said that my categorization looks to the first goal, when there are chains like this. Why isn't the first goal, in some cases, the use of a tool? Then tool use could become a sixth element added to the earlier list. You might set things up like this, but I think the other way is also okay. I am treating tool use as how you might pursue another goal, rather than ever being a goal of its own.

70 *I learned of a wonderful case from David Scheel*: He sent this in an email. He also cites Sarah Marriott et al., "Somatosensation, echolocation, and underwater sniffing: adaptations allow mammals without traditional olfactory capabilities to forage for food underwater," *Zoological Science* 30 (2013) 69-75, doi.org/10.2108/zsj.30.69

70 *Chimps, bonobos, and crows are the most adept*: For the compound tool and "metatool" use of New Caledonian Crows, see Auguste von Bayern et al., "Compound Tool Construction by New Caledonian Crows," *Scientific Reports* 8 (2018):15676, doi:10.1038/s41598-018-33458-z, and Alex Taylor et al., "Spontaneous Metatool Use by New Caledonian Crows," *Current Biology* 17 (2007): 1504-1507, doi.org/10.1016/j.cub.2007.07.057

70 *The list of seagoing tool users is short*: For a review, see Janet Mann and Eric Patterson, "Tool Use by Aquatic Animals," *Philosophical Transactions of the Royal Society B* 368 (2013): 20120424, doi.org/10.1098/rstb.2012.0424

Octopuses are on the list. Our study of projectile use by octopuses, first mentioned in *Other Minds*, is now published: Godfrey-Smith et al., "In the Line of Fire: Debris Throwing by Wild Octopuses," *PLOS ONE* 17 (2022): e0276482, doi:10.1371/journal.pone.0276482. Another notable case is their carrying and assembling of half coconut shells for protection: see Julian Finn, Tom Tregenza, and Mark Norman, "Defensive Tool Use in a Coconut-Carrying Octopus," *Current Biology* 19 (2009): R1069-R1070, doi.org/10.1016/j.cub.2009.10.052

72 *the neuroscientist and engineer Malcolm MacIver*: See Malcolm MacIver and Barbara Finlay, "The Neuroecology of the Water-to-Land Transition and the Evolution of the Vertebrate Brain," *Philosophical Transactions of the Royal Society B* 377 (2022): 20200523, doi: 10.1098/rstb.2020.0523, and other papers.

73 *Still, I think MacIver might be onto something*: With respect to differences be- tween land-based and seagoing brains, another factor to consider is warm- bloodedness. Warm-bloodedness, which is seen in all the plan-using animals that MacIver discusses, makes for a higher-powered brain. You might say that animals have more need for a higher-powered brain on land, and this may well be true, but warm-bloodedness is also easier to achieve on land than it is in the sea. I looked at this in *Metazoa*, chapter 9.

76 *Side by side, jostling a little and shoulder to shoulder, there were ten finch species by the end:* The ones in the color photo are four Gouldian Finches, three Chestnut-breasted Mannikins, a Yellow-rumped Mannikin (looking out across the scene), and I need to confirm the other two, but the fifth from the left might be a Double-Barred Mannikin.

77 *This picture has impressed a number of thinkers*: The framework was influenced by cybernetics, the mid-twentieth-century theory of control systems and feedback that fed into computer science and robotics. The theory was developed by William Powers. For a recent exposition and defense, see Timothy Carey, "Consciousness as Control and Controlled Perception—A Perspective," *Annals of Behavioral Science* 4, No.2:3, (2018). doi:10.21767/2471-7975.100034

78 *the "predictive processing" framework*: See Karl Friston, "The Free-Energy Principle: A Unified Brain Theory?," *Nature Reviews Neuroscience* 11 (2010): 127–138; Andy Clark, *Surfing Uncertainty* (2015, Oxford); and Anil Seth, *Being You* (2021, Faber).

Clark's description of this side of the predictive processing approach. He calls this "Radical Predictive Processing (RPP)"

> The place to start is with Karl Friston's notion of 'active inference'. The core idea is that there are two ways for brains to match their predictions to the world. Either find the prediction that best accounts for the current sensory signal (perception) or alter the sensory signal to fit the predictions (action). If I predict I am seeing my cat, and error ensues, I might recruit a different prediction (e.g. 'I am seeing the computer screen'). Or I might move my head and eyes so as to bring the cat (who as it happens is right here beside me on the desk) into view. Importantly, that flow of action can *itself* be brought about, some of this work suggests, by a select sub-set of predictions. Action is thus (see also Lotze, 1852; James, 1890) a kind of self-fulfilling prophecy (an idea that has resonances in contemporary sports-science). The resulting picture is one in which perception and action are manifestations of a single adaptive regime geared to the reduction of organism-salient prediction error.

https://philosophyofbrains.com/2015/12/15/conservative-versus-radical-predictive-processing.aspx

78 *The main problem has been expressed*: This is discussed in lots of places; see Andy Clark's *Surfing Uncertainty.*

79 *You might meet all sorts of doom, including, perhaps:* The "perhaps" has a double meaning in this case. Sexual cannibalism has been reported in this species in one early paper, but later studies have not seen it. Some clasping behaviors by the male that had been interpreted very much as anti-cannibalism measures are apparently less clear in their function. If cannibalism does exist in nature, it is one kind of empirical risk the spiders face. But there's some uncertainty, I take it, about whether it exists. I will update this note if I learn more. See S.-C. Frank et al. "Mating behavior of the Sydney funnel-web spider (Atracidae: Atrax robustus) and implications for the evolution of courtship in mygalomorph spiders," *Journal of Zoology* 320 (2023): 169-178

> We observed no sexual cannibalism in *A. robustus* (*contra* Levitt, 1961), but in this species, only legs I (without clasping spurs), could be used to resist a female attack

because they can be crossed in front of the female's fangs. Meanwhile, the grasp of the female's femur II by the male's tibial and metatarsal apophyses in legs II seems unable to stop a downwards movement of the female's fangs if the female's body pivots around the base of her legs II.

Female Sydney funnel-web spiders remain quiescent during mating, but some copulations ended with the male being chased away by the female. We did not observe sexual cannibalism, but this has been observed in captivity (Levitt, 1961), although it is not clear whether it happened during mating.

The Levitt paper is: Levitt, V. (1961). The funnel-web spider in captivity. *Proceedings of the Royal Zoological Society of New South Wales*, 1958–1959, 80–84.

Anil Seth, in *Being You*, rejects the "dark room" argument like this:

> It's worth noting that minimising free energy – sensory prediction error – does *not* mean that a living system can get away with retreating into a dark and silent room and staying there, staring at the wall. You might think this would be an ideal strategy, since sensory inputs from the external environment will become highly predictable. But it is far from ideal. Over time, sensory inputs signalling other things, like levels of blood sugar and so on, will start to deviate from their expected values: you're going to get hungry if you stay in the dark room too long. Sensory entropy will start to grow, and non-existence will loom. Complex systems like living organisms need to allow some things to change in order for other things to stay the same. We have to move to get out of bed and make breakfast, and our blood pressure has to rise while doing so, so that we don't faint. This matches the anticipatory form of predictive control – allostasis – that I mentioned in the previous chapter. Minimising sensory prediction error in the long run means getting out of the dark room, or at least switching on the lights.

The main reply I would make is that in the spider case, it could stay alive for a long time in its dark room, as it ambushes other animals that wander too close. That is how it feeds. But it has no chance of reproducing that way.

I'd also question the passage where it says: "levels of blood sugar and so on, will start to deviate from their expected values." They may start to deviate from their *preferred* values, but the preferred values need not be the expected ones.

80 *I am reminded of one of my precursors:* I refer to Uexküll's book as "A Stroll Through the Worlds of Animals and Men." This is the title given in a translation by Claire Schiller in 1957. There is a newer translation by Joseph O'Neil (2010, University of Minnesota

Press). It translates Uexküll's title as: “A Foray into the Worlds of Animals and Humans." The German is "Streifzüge durch die Umwelten von Tieren und Menschen." O'Neill says that "stroll" is "too casual" a term to be a good translation of "Streifzüge" in this context, and "Menschen" reflects "a bygone use of language." A standard translation of "Streifzüge" according to the Cambridge Dictionary is "ramble." I am not sure that "foray" is more suited to Uexkull's tone than "stroll" (or "ramble"), and the lightness is part the work's appeal.

The Schiller translation is not complete, apparently, and the differences between the two translations are also significant. Here are the three versions of the quote I gave in the text.

Schiller:

> We no longer regard animals as mere machines, but as subjects whose essential activity consists of perceiving and acting. We thus unlock the gates that lead to other realms, for all that a subject perceives becomes his perceptual world and all that he does, his effector world. Perceptual and effector worlds together form a closed unit, the *Umwelt*.

O'Neill:

> But then he will address himself to animals not merely as objects but also as subjects, whose essential activities consist in perception and production of effects. ... But then, one has discovered the gateway to the environments, for everything a subject perceives belongs to its *perception world* [*Merkwelt*], and everything it produces, to its *effect world* [*Wirkwelt*]. These two worlds, of perception and production of effects, form one closed unit, the *environment*.

Uexküll's German:

> Dann wird er aber die Tiere nicht mehr als bloße Objekte, sondern als Subjekte anspre chen, deren wesentliche Tätigkeit im Merken und Wirken besteht. ... Damit ist aber bereits das Tor erschlossen, das zu den Umwelten führt, denn alles, was ein Subjekt merkt, wird zu seiner *Merkwelt*, und alles, was es wirkt, zu seiner *Wirkwelt*. Merkwelt und Wirkwelt bilden gemeinsam eine geschlossene Einheit, die *Umwelt*.

I'll put the surrounding passages in all three versions at the end of this chapter's notes. I am giving a lot of detail here because I'd always assumed the Schiller translation was standard, and I found out about the O'Neill one while this book was in press.

The "soap bubble" passage is similar across the two translations.

80 *Uexküll was a German-Estonian biologist*: A new book looks more closely at his political side: Gottfried Schnödl and Florian Sprenger, *Uexküll's Surroundings: Umwelt Theory and Right-Wing Thought* (translated by Michael Taylor and Wayne Yung, 2021).

82 *His work had a wide influence*: Heidegger praises him in *The Fundamental Concepts of Metaphysics: World, Finitude, Solitude* (lectures from 1929–30). There's also a mention of the *Umwelt* in *Being and Time*. He is discussed in Merleau-Ponty's second lecture course on nature at the Collège de France.

86 *The insect situation is sometimes referred to as the "insect apocalypse"*: For butterflies, see Martin Warren et al., "The Decline of Butterflies in Europe: Problems, Significance, and Possible Solutions," *PNAS,* 2021; for the windshield effect, see Anders Møller, "Parallel Declines in Abundance of Insects and Insectivorous Birds in Denmark Over 22 Years," *Ecology and Evolution*, 2019, and Damian Carrington, "Car 'Splatometer' Tests Reveal Huge Decline in Number of Insects," *The Guardian*, February 12, 2020. For the forests, see https://ourworldindata.org/deforestation.

The longer passage from Uexküll in the two translations:

From Schiller:

> But let us who are not committed to the machine theory consider the nature of machines. All our useful devices, our machines, only implement our acts. There are tools that help our senses, spectacles, telescopes, microphones, which we may call *perceptual tools.* There are also tools used to effect our purposes, the machines of our factories and of transportation, lathes and motor cars. These we may call *effector tools.*
>
> Now we might assume that an animal is nothing but a collection of perceptual and effector tools, connected by an integrating apparatus which, though still a mechanism,

is yet fit to carryon the life functions. This is indeed the position of all mechanistic theorists, whether their analogies are in terms of rigid mechanics or more plastic dynamics. They brand animals as mere objects. The proponents of such theories forget that, from the first, they have overlooked the most important thing, the *subject* which uses the tools, perceives and functions with their aid.

The mechanists have pieced together the sensory and motor organs of animals, like so many parts of a machine, ignoring their real functions of perceiving and acting, and have even gone on to mechanize man himself. According to the behaviorists, man's own sensations and will are mere appearance, to be considered, if at all, only as disturbing static. But we who still hold that our sense organs serve our perceptions, and our motor organs our actions, see in animals as well not only the mechanical structure, but also the operator, who is built into their organs, as we are into our bodies. We no longer regard animals as mere machines, but as subjects whose essential activity consists of perceiving and acting. We thus unlock the gates that lead to other realms, for all that a subject perceives becomes his perceptual world and all that he does, his effector world. Perceptual and effector worlds together form a closed unit, the *Umwelt*.

O'Neill's version:

Whoever is not yet an adherent of the machine theory of living beings might, however, consider the following. All our utensils and machines are no more than aids for human beings. Of course there are aids to producing effects [*Wirken*], which one calls tools [*Werkzeuge*], a class to which all large machines belong, such as those in our factories that process natural products and furthermore all trains, automobiles, and aircraft. But there are also aids to perception [*Merken*], which one might call perception tools [*Merkzeuge*]: telescopes, eyeglasses, microphones, radio devices, and so on.

From this one can readily assume that an animal is nothing more than a selection of suitable effect-tools and perception-tools, which are bound up into a whole by a control device which, though it remains a machine, is nonetheless suitable for exercising the vital functions of an animal. This is in fact the view of all machine theorists, whether they are thinking of rigid mechanics or flexible dynamics. Animals are made thereby into pure objects. In so doing, one forgets that one has from the outset suppressed the principal factor, namely the *subject* who uses these aids, who affects and perceives with them.

By means of the impossible construction of a combined effect-perception tool, it is not only in the case of animals that one has stitched together the sensory and motor organs like machine parts (without taking into account their perceptive and effective functions). One has

also gone so far as to mechanize human beings. According to the behaviorists, our sensibility and our will are mere appearance. In the best case, they are to be valued only as background noise.

Whoever still holds the view that our sensory organs serve perception and our motor organs serve the production of effects will also not see in animals simply a mechanical assemblage; they will also discover the *machine operator* who is built into the organs just as we are into our body. But then he will address himself to animals not merely as objects but also as subjects, whose essential activities consist in perception and production of effects.

But then, one has discovered the gateway to the environments, for everything a subject perceives belongs to its *perception world* [*Merkwelt*], and everything it produces, to its *effect world* [*Wirkwelt*]. These two worlds, of perception and production of effects, form one closed unit, the *environment*.

The German version (p. 26):

Wer aber noch nicht auf die Maschinentheorie der Lebewesen ein geschworen ist, möge folgendes bedenken. Alle unsere Gebrauchs gegenstände und Maschinen sind nichts anderes als Hilfsmittel des Menschen. Und zwar gibt es Hilfsmittel des Wirkens — die soge nannten Werkzeuge, zu denen alle großen Maschinen gehören, die in unseren Fabriken der Bearbeitung der Naturerzeugnisse dienen, ferner alle Eisenbahnen, Autos und Flugzeuge. Es gibt aber auch Hilfsmittel des Merkens, die man *Merkzeuge* nennen kann, wie Teleskope, Brillen, Mikrophone, Radioapparate usf.

Es liegt nun nahe anzunehmen, ein Tier sei nichts anderes als eine Auswahl geeigneter Merkzeuge und Werkzeuge, die durch einen Steuerapparat zu einem Ganzen verbunden sind, das zwar immer noch Maschine bliebe, aber trotzdem geeignet wäre, die Lebensfunk tion eines Tieres auszuüben. Dies ist in der Tat die Ansicht aller Maschinentheoretiker, mögen sie beim Vergleich mehr an starre Me chanismen oder plastische Dynamismen denken. Die Tiere werden da durch zu reinen Objekten gestempelt. Dabei vergißt man, daß man von Anfang an die Hauptsache unterschlagen hat, nämlich das *Subjekt*, das sich der Hilfsmittel bedient, mit ihnen merkt und mit ihnen wirkt.

Mittels der unmöglichen Konstruktion eines kombinierten Merk- Werkzeuges hat man nicht bloß bei den Tieren die Sinnesorgane und Bewegungsorgane wie Maschinenteile zusammengeflickt (ohne Rück sicht auf ihr Merken und Wirken zu nehmen), sondern ist auch da zu übergegangen, die Menschen zu maschinisieren.

Nach Ansicht der Behavioristen sind unser Empfinden und unser Wille nur Schein, im besten Falle sind sie als störende Nebengeräusche zu werten.

Wer aber noch der Ansicht ist, daß unsere Sinnesorgane unserem Merken und unsere Bewegungsorgane unserem Wirken dienen, wird auch in den Tieren nicht bloß ein maschinelles Gefüge sehen, son dern auch den *Maschinisten* entdecken, der in die Organe ebenso eingebaut ist wie wir selbst in unseren Körper. Dann wird er aber die Tiere nicht mehr als bloße Objekte, sondern als Subjekte anspre chen, deren wesentliche Tätigkeit im Merken und Wirken besteht.

Damit ist aber bereits das Tor erschlossen, das zu den Umwelten führt, denn alles, was ein Subjekt merkt, wird zu seiner *Merkwelt*, und alles, was es wirkt, zu seiner *Wirkwelt*. Merkwelt und Wirkwelt bilden gemeinsam eine geschlossene Einheit, die *Umwelt*.