Organisms or Machines?

January 13 2016, by Aakriti Jain

Dr. Dan Nicholson is first a scientist, a molecular biologist. However, unlike most researchers in the constantly changing and expanding field of biology, Dan questions the very directions fields like synthetic biology are taking us. With his PhD in Philosophy, Dan's research now is centered around understanding how machine models can explain biology. I had a Q&A with Dan on his publications on the machine conception of organisms to gain some interesting insights on the direction of biological research today:

Aakriti: Before getting into the meat of things, I'm interested in understanding how you got interested in this topic? Could you give me a brief description of your background and what events led you to start thinking and researching on the similarities and differences between organisms and machines? How did you come up with your specific conclusions?

Dan: My background is in molecular biology. However, I quickly became disenchanted with the mindless minutiae of actual biological practice (that is, with the tediousness and monotony of experimental research) and so I reoriented my efforts away from doing biology and towards thinking about biology. In practical terms, this meant switching my career from molecular biology to the history and philosophy of science. Then, when I began to exam-+ine the historical development of philosophical debates regarding the nature of life ('life' understood here

not in the waffly philosophical sense but as a strictly biological phenomenon) I discovered that the organism-machine analogy lied at the very heart of the matter. What a past biological thinker may have supposed about the nature of life or about the relation of biology to physics derived more or less directly from his stance on whether he took organisms to be mechanical in nature, or whether he thought this to be a dangerously misleading characterization. And its importance is not simply a matter for historians of science. Machine analogies are everywhere in biology today! Molecular biologists speak of protein complexes as 'molecular machines'; developmental biologists speak of the unfolding of development as the execution of a 'program' encoded in the genome; and evolutionary biologists refer to natural selection as an engineer and to adaptations as products of design. So it is very much a current issue in contemporary biology, even if this is not always appreciated.

Aakriti: In your papers, one of your main arguments against the machine conception of organisms (MCO) is that an organism is intrinsically purposive whereas machines are extrinsically so. Why do you conclude this? Could one argue that an organism itself doesn't care about itself, it is only deluded into believing that it does, but that it actually serves a larger purpose (such as, procreating and passing down it's genetic material, and furthering its species)? Or have I misconstrued what you mean by intrinsically purposive?

Dan: The intrinsic vs. extrinsic purposiveness distinction is meant to encapsulate most (if not all) the major differences between organisms

and machines by appealing to what prima facie appears to be their most obvious similarity, namely the fact that they operate towards the attainment of particular ends. However, the key point is that they do so in fundamentally different respects. A machine is extrinsically purposive in the sense that it works/functions towards an end that is external to itself; that is, it does not serve its own interests but those of its maker or user. An organism, on the other hand, is intrinsically purposive in the sense that its activities are directed towards the maintenance of its own organization; that is, it acts on its own behalf. The intrinsic purposiveness of organisms is grounded on the fact that they are self-organizing, self-producing, self-maintaining, and self-regenerating systems. Conversely, the extrinsic purposiveness of machines is grounded on the fact that they are organized, assembled, maintained, and repaired by external agents. An organism maintains its integrity and autonomy as a whole by regulating, repairing, and regenerating its parts, whereas a machine relies on outside intervention not just for its construction and assembly, but also for its maintenance and repair. I take this to be a crucial and very general difference, which underlies why talk of design is appropriate when discussing machines but not organisms, why reductionism suffices as an explanatory strategy in the context of machines but not organisms, and why we speak of machines that malfunction in ways that we don't about organisms. I can elaborate on any of these claims if you wish further clarification. Organisms, whether conscious of their own existence or not, function and operate in ways that ensure the maintenance of their own organization, and hence the continuation of their own existence. What an organism does (and that includes all the physiological and biochemical reactions that take place within it) ultimately serves the purpose of maintaining its own existence through time. The organism needn't be aware of this for it to be true. Of course, staying alive is not the only purpose in life. Reproduction, as you point out, is also of central importance, and depending on what branch of biology you specialize in you may be inclined to believe that it is more important. But the fact of the matter is that one can survive without

reproducing, but one cannot reproduce without surviving (at least, survive until one can reproduce!). So I believe that the thermodynamic challenge of staying alive and ordered in a world that is inexorably moving towards ever greater degrees of entropic disorder is the most basic, and most formidable, of all of life's goals. And for this reason it provides a useful means of distinguishing the biological from the mechanical.

Aakriti: You mention that organisms are self-generating and self-maintaining and this differentiates them from machines; but what are your opinions on the dependent nature of organisms? What I mean by this is, organisms need food, sustenance, particular environments, in our case, doctors, and other infrastructure. In this sense, can an organism not be seen as just a more intelligent or more evolutionarily progressed machine? In the same vein, are AI robots organisms (a bit sci-fi here, but maybe something like the robots in the Terminator, if it ever comes down to that).

Dan: I don't see a conflict here. To say that organisms are autonomous systems (that is, that they act on their own behalf) is not to say that they are self-sufficient. As you note, organisms are strongly dependent on their environment. By virtue of existing in a highly organized state far from thermodynamic equilibrium, an organism must continuously exchange matter and energy with its surroundings in order to stay alive. When this flow stops, death ensues. The contrast with machines is particularly telling here. A machine can be operating to perform a particular task, or it can be at rest. Organisms, however, don't have an

'off' switch. When an organism stops working (in the thermodynamic sense), it stops existing. So the important point here is not to assume that just because organisms have autonomous capacities that they don't rely on their environment for their continued existence.

A potential problem for any attempt to demarcate organisms from machines is that one must always allow for the possibility that future technology will eventually develop to such an extent that it will enable us to create machines with the features that we consider most distinctive of organisms. What then? My answer is that if we ever succeed in engineering an artificial system that possessed all the attributes proper to living systems (self-organization, self-production, self-maintenance, self-regeneration, and consequently intrinsic purposiveness) then I would not have a problem to declare it to be alive, despite its artificial origin. If you think about it, the question of origins is not that important. Yes, it is true that until now all organisms have evolved naturally and all machines have been artificially created. But being the product of evolution is not what makes organisms what they are. And being the product of artificial design is not what makes machines what they are. The distinction between intrinsic and extrinsic forms of purposiveness is, I think, far better suited than the distinction between natural and artificial origins to capture the respective features of organisms and machines.

Aakriti: In your writings, you mention that we study organisms "top-down", whereas we study machines "bottom up". Is this because we are only beginning to understand what organisms are made of, etc., and therefore we haven't developed a bottom-up approach yet, since machines are obviously a human creation and therefore we understand them better than we do ourselves?

Dan: What I say (in p. 163 of my 2014 paper) is that embryonic development is a 'top-down' process, whereas machine construction is 'bottom up'. What does this mean and why does it matter? In that passage I am drawing attention to the fact that organisms and machines come into existence in radically different ways. The whole that constitutes the finished machine does not exist as such prior to the assembly of the parts that compose it. One first designs all the machine parts and then these are arranged to constitute the whole. In the case of the organism the situation is reversed. Here, one already starts out with a rudimentary integrated 'whole', i.e. the fertilized egg. As the zygote develops, its regions begin to differentiate into tissues and organs. In a way, the parts that one identifies in an adult organism emerge much later than the whole from which they derive. This ontological difference has important epistemological and methodological implications. The reductionistic approach (i.e. breaking down the system to its parts in order to understand it) works brilliantly with machines because reductionism is simply the reverse of assembly. When we study machines by decomposing them, all we are doing is invert the process by which they come into existence. In the case of organisms, however, breaking them down is to do 'violence' to their nature given that, strictly speaking, organisms are not made of parts to begin with. Parts are parts by virtue of the whole. Thus, these cannot be fully understood in isolation from the whole from which they are extracted (note my emphasis on 'fully' – of course, one can learn a great deal by studying biological parts, as biochemistry and molecular biology clearly testify). The difficulty of building an organism from scratch (through a genuinely 'bottom-up' approach) is that many of its properties and capacities depend on it already existing as an integrated, organized whole. None of the parts that compose it suffice by themselves (or in different combinations) to explain why the whole system functions the way it does. Only when they are all taken as a collective, systemic entity can one truly make sense of why organisms function and behave the way they do. This obviously imposes some rather severe restrictions on the explanatory adequacy of

reductionistic programs in biology. What is certain, at any rate, is that such approaches do not suffice (as they do in the case of machines).

Aakriti: What are your thoughts on genetic engineering? You touch upon this briefly in one of your papers, but I'd like to hear if you have anything more to add to this. For example, is an E. coli that we engineer to produce specific chemicals, such as biofuels, still considered an organism or is it now a machine because it serves an extrinsic purpose? Furthermore, and excuse me if this is an incorrect line of questioning, is this good or not? That is, should we control other organisms to serve our purpose in such a way?

Dan: Genetic engineering does complicate the intrinsic vs. extrinsic purposiveness distinction to a certain extent, as we do modify bacteria to serve our own ends (just as in the past we have domesticated animals and cultivated plans to serve our own ends). In such cases these organisms do appear to have an extrinsic purpose (at least for us, as their users and exploiters). Still, this only represents a contingent interference with the natural workings of these organisms, which left to their own devices, would act intrinsically purposive on their own behalf (rather than on our behalf). In fact, even when these organisms are being used by us, they are still primarily working for themselves. Bacteria that produce specific chemicals for us (to use your example) still also produce all the other chemicals they require to maintain their own metabolic integrity. Indeed, we cannot work against an organism's intrinsic 'interests'. Quite the opposite, our success in exploiting organisms (through domestication, cultivation, and now through GE) crucially relies on ensuring that our

extrinsic purposes do not conflict with the basic organismic drive for survival that all living systems possess. Only once this basic need is met can organisms be found useful to other organisms (like ourselves). We can again contrast this with the case of machines. As its user, you can get a machine to do anything you want it to do without having to worry whether this goes against the machine's interests. The machine has no interests of its own. It is an instrument designed, created, and operated by us in order to serve our own ends. In a way, machines are extensions of ourselves. They have no agency of their own.

As to the question of whether using organisms is good or not, that's a very convoluted issue that lies outside my expertise (here we leave philosophy of biology and enter bioethics). It is obvious, though, that if one thinks of organisms as machines then one needn't feel a moral obligation towards organisms (for the reasons discussed above). As machines don't have interests and organisms are machines, we can do with organisms what we please without feeling morally responsible for our actions. Having said this, I don't wish to say that we shouldn't use organisms. I'm simply saying that realising that organisms are fundamentally different from machines forces us to be more aware about how we treat them.

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