Boundedness, Relationality and Evolution in Biological Systems

Lindy Orthia
PhD Student, Centre for the Public Awareness of Science, Bldg 38A
The Australian National University, ACT 0200 Australia
Email: lindy.orthia@anu.edu.au

Paper given to the 20th Annual Conference of the Society for Literature, Science and Art: 'Evolution: Biological, Cultural, and Cosmic', New York, November 9-12, 2006

In his 1997 book, *Degrees of Freedom,* Alan Rayner made a startlingly obvious observation about life. Living systems are not composed of a series of discretely bounded units. Rather, the boundaries that seem to separate one organism from another, one cell from another, are dynamic. A cell membrane is much more than a container - it expands, contracts and warps as its circumstances change. It is actively porous, allowing inside and outside environments to mingle and flow together. An organism's boundary is also dynamic, since organisms of all kinds are embedded in a complex web of interdependence, and so sit always on the border between collective and autonomous modes of being.

Other biological entities have similarly dynamic boundaries. The boundaries of larger entities such as populations, communities and ecosystems are always shifting, always porous, and never precisely definable. Species boundaries have posed problems for taxonomists for centuries, and still biologists don't have a universally applicable, watertight method of delimiting species. Smaller entities like genes are also difficult to draw solid lines around. A given sequence of DNA might be copied in one direction to make one protein, and in the reverse direction to make a different one. Different chunks may be excised after copying, and parts of one sequence can be combined with parts of another to make still more protein variants. So putting a neat label on a DNA sequence to call it 'the gene for condition X' is rarely a straightforward process. Pinpointing the exact start and finish of a gene is also difficult. The gene's boundary and meaning can only be found within its spatiotemporal context - within the particular sequence of interactions that it has with enzymes and other biochemicals, within the physiological prompts that led to those interactions, and within the plethora of environmental cues that helped create the physiological prompts.

The conclusion to draw from all this is that solid, precise boundaries around any biological entity can only ever be ephemeral. Definitional boundaries only stand up within limited contexts, and if ontological boundaries solidify for too long, then the entity which they contain will lose its ability to change, evolve and interact. In other words, it will die. Heisenberg's uncertainty principle applies here by extension: if you can mark an absolute boundary around something then it cannot be changing, and if you note that it is changing then it cannot have an absolute boundary.

This is important, because despite the seeming obviousness of these observations, western biology for the most part remains a discipline whose primary task is to detect and define the boundaries of the kinds of thing that exist in the biological world; in other words, to classify life. Taxonomists catalogue species, geneticists catalogue genes, physiologists catalogue hormones and their effects. Evolutionary theorists argue about which kinds of entity - genes, organisms, species, and/or communities - natural selection can act upon: which can be called the units of selection. Evolutionary theorists also make catalogues of traits and argue about the functions of those traits. Western biology remains a very classificatory discipline in which things, rather than phenomena or relationships, are the primary epistemological subjects.

This of course goes hand in hand with an individualist western culture that sees people as autonomous, bounded entities. But not all the world's human cultures are individualist. Dividualist cultures, to use Marilyn Strathern's term, locate human identity in relationship. People are not seen to be fundamentally bounded, they are fundamentally relational. The apparent boundary that westerners see, marked by a person's outer layer - their skin - is not necessarily a boundary at all. Under this way

of seeing, the person who I call Lindy Orthia does not in fact begin and end here, but is rather continuous with all of you, since we are in relationship. There is no 'I', there are only different degrees of 'we' - the we in this room, the we at this conference, the we in this city, the we on this planet.

Similarly, Rayner's work on dynamic boundaries in biology suggests that living systems are strongly dividual too, that living things are fundamentally relational. If boundaries are dynamic, then they are remade within relationships and remade and remade and remade with each passing moment.

Let us go a step further and contend that biological entities don't actually exist independently as entities, but only acquire definition within the context of the phenomena that they are part of. As Karen Barad writes, drawing on quantum physics: the primary epistemological units of existence are phenomena rather than objects, and objects only acquire their 'objectivity' within phenomena.

Jesper Hoffmeyer points to a similar conclusion when he shows that biological membranes, far from being mere passive walls separating cells or organisms, are the most active sites in the whole of life, facilitating a huge number of critical biological interactions. The membrane is the active interface - the meeting place - of two fields of existence. Such an interface is defined within action. The relationship is actually the place in which life happens.

So relationality consists of:

- systems that are open to change in a way so fundamental that each interaction shifts their components' ontological boundaries, and thus their definitions,
- systems for which relationships are ontologically and epistemologically prior to things,
- not systems composed of discrete autonomous individuals,
- not systems in which things precede relationships.

But why is this fundamental relationality of life important for evolutionary theory?

Dynamic boundaries are necessary if evolution is to take place at all. They allow evolution: they allow reproduction, they allow replication, they allow important kinds of complex change such as mutation. They set up the necessary conditions for these processes to take place. So dynamic boundaries - and the property of relationality that goes with them - are ontologically prior to evolution, and to reproduction, replication, and change. A life form that stops evolving or reproducing can still be alive; a life form that stops relating is dead. A strand of DNA that ceases to interact with other biochemicals is utterly inert. A cell membrane that is no longer porous, that no longer allows communication between insides and outsides, kills the very quality that makes its cell alive.

Yet evolutionary theory grants ontological priority to reproduction, not to relationality. Interpreted in the light of evolution, relational phenomena such as communication across membranes, or affection between animals, or symbiotic associations between plants and fungi, are seen as functional adaptations that have evolved because ultimately they serve the reproductive fitness of the organisms involved, and so have been selected for over time.

But some things in life make more sense when interpreted outside of evolution. Eric Schneider and Dorion Sagan have said as much in their book *Into the Cool*, in which they search for other explanatory tools with which to understand biological phenomena, tools which reveal the underlying canvas onto which evolution paints its pretty pictures.

I think the concept of relationality is one such explanatory tool. It is particularly so when combined with Schneider and Sagan's hypothesis that the fundamental driving force of life is energy acting in accordance with the second law of thermodynamics. This driving burst of energy has no purpose, no plan, no order, no direction other than what the universe will allow. Its only limitation is that it is constrained to decline towards a zero energy state and so it expends itself, and this results in action happening within its system. In a system such as life where much if not all of the activity takes place on the dynamic boundaries that seem to mark the juncture of two fields of existence, this driving

energy surely compels interaction, indeed creates interaction. Relationship is the compulsive, inevitable result of this most fundamental property of life.

If this is the case, then there is a whole swag of biological phenomena whose ultimate explanation might simply be the relational nature of life, and natural selection might not even come into it. Perhaps it is the case that living systems possess a fundamental openness to making connection, interacting, relating, and sharing boundary spaces. Perhaps this openness is what allowed the evolution of multicellularity many times across the tree of life. Perhaps it explains the enormous variety of symbiotic associations found in life. Perhaps it is why it is so easy for us to get pathogenic diseases. Perhaps it is why animal altruism continually emerges in the face of apparent selective pressure, simply as a manifestation of underlying relationality. Perhaps it is why homosexuality is so common in the animal kingdom, regardless of the adaptationist questions over homosexuality's function - in a relational system, it doesn't need a function in order to occur. The same goes for other non-procreative sexual activity among animals, including cross-species animal sex, which may or may not produce hybrid offspring. In slightly different ways it may also account for hybridisation among other types of organism, both multicellular and unicellular.

Even sexual reproduction itself, which theoretically carries an evolutionary cost compared to the more efficient asexual reproduction, might be better understood in the light of relationality. It is possible that it is a merely statistical inevitability, since really what it amounts to is the leaking of genetic material across the spatial boundaries of an organism. That is a difficult thing to stop. Bacteria exchange genetic material among themselves all the time as well as engaging in asexual binary fission. Even very distantly related organisms can and do hybridise across vast taxonomic boundaries, particularly when they have been symbiotically associated, so that for example some plants have fungal genes. For organisms whose gametes are capable of forming a zygote, it is likely that even if selection increased the incidence of asexual reproduction in a population, sexual reproduction would probably still, at some point, spontaneously occur.

These ideas are preliminary and right now they're just ideas. But I think relationality is a concept that deserves further investigation, as it seems to offer a new way to understand the fascinating phenomenon that is life on this planet.

References

Barad K (2003) Posthumanist performativity: toward an understanding of how matter comes to matter *Signs* **28**: 801-831

Hoffmeyer J (2000) The biology of signification *Perspectives in Biology and Medicine* **43**: 252-268

Rayner ADM (1997) *Degrees of Freedom: Living in Dynamic Boundaries*, Imperial College Press: London, UK

Schneider ED & Sagan D (2005) *Into the Cool: Energy Flow, Thermodynamics, and Life*, University of Chicago Press: Chicago, USA

Strathern M (1988) *The Gender of the Gift*, University of California Press: Berkeley, USA

Acknowledgements

For support, encouragement and always interesting intellectual discussion:
(alphabetically) Chris Bryant, Helen Keane, Rachel Morgain, Ida Nursoo, Sue Stocklmayer

For generous funding:
The Australian National University, particularly the Centre for the Public Awareness of Science

Original abstract for this paper:

BOUNDEDNESS, RELATIONALITY AND EVOLUTION IN BIOLOGICAL SYSTEMS

The study of biology in its current form is largely premised on a classificatory way of seeing that breaks the biological world into bounded entities ranked in one or more hierarchies: taxonomic, ecological, genealogical, structural, etc. It is increasingly apparent that this way of seeing the world does not fully reflect its reality: eg, mycologist Alan Rayner considers it more useful (and more accurate) to characterise biological systems as having dynamic boundaries, and as constantly shifting between determinate and indeterminate ways of being. In this paper I will draw on literature questioning the thingification of the biological world, and discuss how these challenges might affect some of the basic premises of contemporary evolutionary theory. In particular, I want to address the idea that relationality is a more primary characteristic of living systems than is reproduction. This implies the necessity of disrupting the centrality of adaptationist approaches to explaining biological phenomena. Relationality may be an important organising idea for understanding diverse biological phenomena from the 'selection anomalies' of altruism and homosexuality to autoimmune diseases to the maintenance of sexual reproduction.

About my current research:

I am currently undertaking research towards a PhD in the field of Science Communication.

My PhD thesis examines the implications of a classificatory worldview for understanding biological phenomena. I argue that western biology has developed in a classificatory framework, based on Aristotelian philosophy, that incorporates three assumptions about ontology: (1) that the world is made up of discrete, bounded entities (it is 'thingified'), (2) that there exists a natural order of these things, and (3) that there is a singular universal truth in the world which can be seen and described by objective means. My thesis will discuss theoretical and empirical research in biology and other fields of scholarship that questions one or more of these assumptions, and describes alternative views of the world: views that see dynamic boundaries, disorder and an absence of universal truth and objectivity, for example. I will then discuss the implications of these other ways of seeing for understanding biological phenomena, particularly phenomena that are the subjects of questions in contemporary evolutionary theory. I will argue against some of the teleological assumptions biologists generally make about the way natural selection works, and the primacy of 'reproductive drive' as the supposed determinant of the behaviour of living systems. I propose that relationality, as a more universal characteristic of living systems than reproduction, needs more attention in evolutionary theory, and that the dominant adaptationist approaches to evolutionary theory, as well as the more marginal structuralist approaches, neglect to take relationality into account. I will also discuss some of the implications of the classificatory worldview for the communication of biological ideas. Specifically, I want to look at the ethical implications of communicating science in a classificatory way: what partial truths are scientists communicating to the public when they talk about bounded things, natural order and objectivity? I also want to examine the ways that complex systems and ideas can be communicated simply. As a part of the overall project I hope also to examine the impact of the language used in evolutionary theory, which couches life in terms of success and failure, on the communication and miscommunication of biological knowledge.