Boundary Issues in Bionanotechnology: Editorial Introduction

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That a journal for the philosophy of chemistry such as *Hyle* devotes several issues to nanotechnology does not mean that nanotechnology would overtake chemistry, as Eric K Drexler boldly predicted when he claimed that molecular manufacture would relegate current chemical technologies in the prehistory of mankind, along with chipping flint (Drexler 1986, p. 4). Rather nanotechnology is only one potential future for chemistry. In reality, a number of research pathways developed over the last decades of the twentieth century – catalysis, supramolecular chemistry, biomimetic chemistry, soft chemistry, *etc*. – paved the way for nanotechnology and are sometimes relabeled nanochemistry. They are of special interest because they create new interactions with biology.

The interface between bio and nanotechnology is at the core of the set of papers here presented. They came out of a research program supported by the French Agence nationale de la recherche scientifique called 'Nanobioethics' (ANR NT05-4_44955 'Biotechnologies et nanotechnologies: enjeux éthiques et philosophiques'). Whilst a second set of papers dealing with ethical aspects will come in a forthcoming issue, this one is focused on boundary issues.

Boundaries Blurred

All scholars concerned with the cultural dimensions of nanotechnology have pointed out that they blur many boundaries (Baird, Nordmann & Schummer 2004; Schiemann 2005). They first blur the organizational boundary between science and technology. Even though the French and the British reports maintain the dual name – 'nanoscience' and 'nanotechnology' (Académie des sciences & Académie des technologies 2003, Royal Society & Royal Academy of Engineering 2004) – it is unclear where the boundary should be placed. Whether research is aimed at practical or at cognitive aims, in both cases, the basic units of matter – atoms, molecules, and macromolecules – are viewed as

HYLE – International Journal for Philosophy of Chemistry, Vol. 15 (2009), No. 1, 1-4.

functional units: devices, motors, or machines. Nanotechnology also fostered the Converging Technologies program (NBIC, for nanotechnology, biotechnology, information technology, and cognitive science) which seeks to bridge the chasm between man and machine, in designing hybrid creatures such as conscious robots, or 'spiritual machines' with the purport to take over nature's job and to continue the work of biological evolution. More generally nanotechnology challenges the grand metaphysical divide between nature and artifact. Not only are the building blocks of nature redefined as machines or devices, also the nanomachines currently designed in laboratories are often hybrid entities made of raw materials designed by living organisms (DNA, bacteria, *etc*.), thus taking advantage of the exquisite properties of molecular recognition and self-assembly of structures selected by biological evolution. Nature and artifact are thus confounded in two ways. On the one hand, nature has been redefined in terms that belong to the realm of machines and artifacts. On the other hand, technology itself is presented as part of the biological process of evolution. This technological view of nature and the naturalization of technologies seem to be among the major cultural impacts of converging technologies.

Bio is Nano

The process of blurring the boundaries is particularly visible at the interface between nano and biotechnology. With cloning and synthetic biology, bioengineers cross the boundary between the products of life and the products of human technologies. They cross the species-boundaries when they design for instance goats producing spider silk instead of milk. Living matter is instrumentalized for technological purposes, as a number of nanostructured materials use components such as DNA or genetically modified bacteria in order to produce useful artifacts.

Such technological practices are facilitated since the boundary between inanimate and animate fades away at the nanoscale. Genes are just sequences of macromolecules and proteins are chains of amino acids.

It seems also legitimate to promote bionanotechnology as a single entity, when we know that biomaterials are at the nanoscale made from bottom-up. It is tempting to argue that, after reading the book of nature (which was the task of modern science), we are now in a position of rewriting it and that this will be the main task of the new era of converging technologies. Writing IBM with 35 xenon atoms on a surface or rewriting the genome of bacteria are only two icons of the ambitious project of re-engineering nature, atom by atom, gene by gene.

The convergence between biotechnology and nanotechnology is therefore a main pillar of the Converging Technologies program. However, when looking more closely at the actual practices in research laboratories, the convergence seems less obvious and the shift from science to technology more problematic.

Metaphysical Assumptions Underlying Research Practices

The papers here presented pay attention to the practices of research rather than to the rhetoric of research programs. Most of them rely on visits in laboratories and interviews conducted with scientists active in various fields of bionanotechnology.

It would be naïve however to think that for being empirical this investigation was free of assumptions. Rather we took for granted the antipositivist claim that there is no science without metaphysical commitments. As pointed out by a number of philosophers of science such as Emile Meyerson, Alexandre Koyré, and Thomas Kuhn, we considered that metaphysical assumptions are embedded in scientific and technological paradigms. Because they determine the sort of issues that should be addressed by the practitioners and shape a set of values shared by the community, they are crucial for understanding the conditions of emergence and the meaning of emerging paradigms.

We therefore tried to identify the metaphysical views underlying various research practices, ranging from molecular electronics to bio-informatics and synthetic biology via biomimetic chemistry. This approach opens up big questions such as: What is the meaning of technology in the phrase nanotechnology? What happens to nature? Will bionanotechnology prompt the postmodernist 'death of nature' (Merchant 1989)? What is the real impact of the bottom-up approach in the process of convergence? Hopefully the five following papers provide a few clues on such broad issues.

References

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