Natural – synthetic – artificial!

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Key words: synthetic chromosomes, synthetic cells, artificial cells, artificial life

Submitted: 07/07/10

Accepted: 07/07/10

Previously published online:
<http://www.landesbioscience.com/journals/artificialdna/article/12934>

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Commentary on: Gibson DG, Glass JL, Lartigue C, Noskov VN, Chuang RY, Algire MA, Benders GA, Montague MG, Ma L, Moodie MM, Merryman C, Vashee S, Krishnakumar R, Assad-Garcia N, Andrews-Pfannkoch C, Denisova EA, Young L, Qi ZQ, Segall-Shapiro TH, Calvey CH, Parmar PP, Hutchison CA 3rd, Smith HO, Venter JC. Creation of a bacterial cell controlled by a chemically synthesized genome. *Science* 2010; 329:52-6; PMID: 20488990; DOI: 10.1126/science.1190719

The terms “natural,” “synthetic” and “artificial” are discussed in relation to synthetic and artificial chromosomes and genomes, synthetic and artificial cells and artificial life.

Terms can be difficult to define rigorously across disciplines, but as disciplines merge a common scientific language is crucial. This is most recently illustrated by the work on synthetic bacterial chromosomes by Venter et al.,¹ and the following scientific and not least media discussions of these results in terms of synthetic and artificial cells and life (see also the Mini-Review in this issue²).

As in all scientific communication precise language is essential for giving and receiving messages correctly. Thus artificial would generally mean something not found in Nature and synthetic would mean something that is man-made. To make a chemistry analogy: chemically synthesized B12 vitamin would not be considered artificial as it is chemically, analytically and functionally indistinguishable from naturally isolated B12 vitamin, but it is not natural either (obtained from Nature), it is synthetic. Likewise, the bacterial chromosome made by Venter et al. is synthetic but not artificial^{1,2}. On the other hand the genome, the sequence information, would be neither synthetic nor artificial. However, by fundamentally recoding the genome it could become synthetic and eventually artificial.

Thus one may pose the question: “Artificial Cells” or “Artificial Cells”: Is there a difference? Yes; of course there is a difference, and it is fundamental! In essence any man-made, genetically modified organisms (GMOs) are “artificial”

as they were not present in or evolved by Nature. Many, may (eventually) have evolved others may not, but all in principle could, as they all rely on the principles of life on earth as created by evolution and natural selection. Artificial Cells (or artificial Life) on the contrary would be fundamentally different, as they would be a new life form, a chemical principle of life unlike our contemporary life. It could be based on alternative chemical components or other chemical principles, and the accomplishment of generating Artificial Cells, i.e. “Artificial Life,” (de novo) would constitute the scientific discovery of centuries. It would touch upon one of the most fundamental questions of mankind (apart from the philosophical, “why are we here”) what is life? What features of a mixture of “dead” chemicals make these come alive, replicate and evolve?

The recent achievement (in a series) of Venter et al.¹ belongs to the “Artificial Cell” category and is a tremendous technical feat, but it does not bear on the “essence of life,” as it is exploiting Nature’s own principles and machinery in the form of a bacterium, which can be given new instructions, a new genome. Clearly, a wide range of technological implications and possibilities emerge from this achievement, but it does not teach us much new on the essence of *life* itself. Nonetheless, this technology may eventually teach us about the boundaries of contemporary life as it allows us through fully synthetic chromosomes to create synthetic (artificial) genomes with de novo information design. This in turn could aid defining which cellular components and chemical circuits are critical to achieve a living

system, and may subsequently give the opportunity to create alternative solutions in terms of e.g. structural and catalytic components as well as metabolic circuits, not used by Nature, but still based on Nature's fundamental principles for information storage and transfer ("the central dogma").

Other researchers are approaching the much more fundamental question of "Artificial *Life*" (de novo) by attempting to devise chemical systems with living, life-like qualities (see for example the work of Szostak, and colleagues.^{3,4} Such experiments may eventually reveal the principles, "the essence" of life.

Thus the borders of "artificial" in biology may not be sharp, but they are there, and they must constantly be challenged and discussed.

References

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