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WILLIAM E. CARROLL & RAFAEL VICUÑA

God, Nature and the Origins of Life

Recent experimental research on the origin of life on Earth exhibits considerable progress.[1] Studies in the laboratory are being undertaken following both top down and bottom up approaches. The first consists of gathering information about the onset of life based on biochemical features of extant organisms, whereas the latter's ultimate expectation is to assemble a living organism starting from its chemical components. In the end, what scientists are aiming at is a plausible hypothesis about how life might have emerged by natural causes.

For many, there seems to be a strict disjunction: either we seek to explain the origin of life in terms of purely natural processes or we appeal to some kind of direct divine intervention that bridges the gap between the non-living and the living. However, as scientists seek to discover natural causes, they need to keep in mind the wider philosophical and theological contexts in which these causes operate. Similarly, those who wish to appeal to divine agency in describing the advent of living beings should be able to recognise that such causal agency attributed to God does not exclude explanations in purely natural terms.

One well-known approach to deny the view that it is either God or nature that causes living things to come to be is to speak of God's creative act as the 'primary cause' and causes in nature as 'secondary causes'. This approach has a long history, stretching back at least to the Middle Ages, and has many variations, often associated with different senses of what it means to be a cause. At times, secondary causes were viewed only as instruments of the primary cause, such that fundamental causal agency resides in God, the primary cause, alone. William Paley, for example, looked upon causes in nature as contrivances or mechanisms, like the wheels and cogs of a watch: hence, his famous argument for the need for an intelligent agent to make them function. Another view would see God's creating the natural order with its own laws and then leaving or allowing nature to develop on its own. Although attractive to many, it is easy to see how in such a scenario God's role might disappear the more we think that nature itself is self-sufficient, able that is, in principle, to provide for all those changes that occur in the world.

We are attracted, however, to an understanding of God and nature that affirms a robust notion both of divine creative causality and a real autonomy and self-sufficiency in natural causes. Here we take our cue

1 Budin, I., Szostak, J.W. *Annu. Rev. Biophys.* (2010) 39, 245; McCollom, T.M. *Annual Rev. Earth Planet Sci* (2013)41, 207.

from the philosophy of nature and metaphysics of Thomas Aquinas (1224-74). Even though our knowledge of the world is far greater than that of Thomas, we think that the principles he advanced for understanding that world in terms of a rich array of created causes remain true. Unaware of the insights from evolutionary biology and contemporary molecular biology (and biochemistry), Thomas would have thought that the first living things were created directly by God, without the agency of natural causes. He did admit, however, following Aristotle, of the possibility of the generation of some living things from putrefying matter.

According to Thomas, God is always present, constantly causing all of nature, but in such a way that what he causes has an integrity and autonomy of its own. The various causal powers that exist in nature really are causal powers in themselves, yet they depend for their existence and efficacy upon God's creative act. Thomas remarks that 'the same effect is not attributed to a natural cause and to divine power in such a way that it is partly done by God, and partly by the natural agent; rather, it is wholly done by both, according to a different way'.[2] God as Creator is not a cause competing, as it were, with the whole array of causes that science studies. Whatever comes about in the world has God as cause, but this does not eliminate causes in nature producing their proper effects. So, if we were to discover that life itself in its very beginnings can emerge from natural causes, it does not mean that God is not the origin of living things. It means that causal potentialities in nature are robust enough that a living thing can be the result of processes that begin with non-living matter.

Within this broad recognition of God as the ultimate origin of all things, we can offer a sketch of current reflections in the natural sciences concerning the way or ways in which life might have emerged by natural causes (what for Thomas are 'secondary causes'.) For those following Thomas, all philosophical (and, by extension, theological) reflection on the relationship between God's causality and the order of nature requires careful attention to the best that the natural sciences tell us about the world.

Undoubtedly, the factor that most hinders our understanding of the natural processes leading to the initial appearance of organisms is life's extraordinary complexity. We could theoretically conceive of a minimal cell as being composed of a lipid vesicle containing a self-copying genomic ribozyme (catalytic RNA) that also copies a second ribozyme involved in the synthesis of the vesicle's membrane.[3] Life as we know it, however, is considerably more complex: the simplest bacterium known to date possesses more than 400 genes.

In spite of this overriding limitation, some conclusions have been

2 Aquinas, T. *Summa Contra Gentiles* III, c. 70, 8.

3 Szostak, J.W., Bartel, D., Luigi Luisi, P. *Nature* (2001) 409, 387.

reached. Carbon and sulphur isotopic information,[4] as well as the unequivocal identification and dating of bacterial microfossils in ancient rocks,[5] show that life appeared relatively early on Earth, before the ending of the late heavy bombardment period (about 3.8 billion years ago). This would have required an even earlier condensation of water vapour to form the oceans, a condition that was met, as revealed by analyses of 4.4 billion year old zircons.[6]

Chemistry under alleged prebiotic conditions has also been an area of active research.[7] Most of the biomolecules that are typical of living organisms have been synthesised in the laboratory. It is difficult, however, to conceive of a system whose parts are synthesised independently prior to their assembly in the first living cells. Hence, of particular interest, are recent experiments showing that the precursors of ribonucleotides, amino acids and lipids can all be simultaneously obtained from a couple of simple compounds that are thought to have been present in the primitive Earth.[8] On the other hand, since compartmentalisation is a manifest requirement of cells, it is noteworthy that studies on the assembly, growth and division of lipid vesicles have also yielded remarkable results.[9]

The possibility of an origin consisting of a population of self-replicative RNA-like polymers that could also catalyse reactions in a primitive metabolism has been endorsed by many.[10] This so-called RNA world is not without explanatory problems, such as the synthesis of the precursors, their linear covalent bonding, the intrinsic instability of RNA and the extremely low probability of meaningful sequences. To a certain extent, some of these hurdles have been overcome in the laboratory, such as the polymerisation of activated and non-activated nucleotides and the self-assembly of autocatalytic networks. Moreover, non-enzymatic polymerisation of RNA has been attained inside model protocell vesicles.[11]

The abiotic synthesis of the molecules of life, however essential, is not the main difficulty in studies on the origin of life. Indeed, it is likely that meteorites contributed to enrich the pool of available organic molecules. The real issue is the process of self-organisation of these molecules into a system capable of reproducing and maintaining itself (autopoietic). We

4 Rosing, M.T. *Science* (2009) 283, 674; Shen, Y., Buick, R., Canfield, D.E. *Nature* (2001) 410, 77.

5 Wacey, D., Kilburn, M.R., Saunders, M., Cliff, J., Brasier, M.D. *Nature Geosci.* (2011) 4, 698.

6 Mojzsis, S.J., Harrison, T.M., Pidgeon, R.T. *Nature* (2001) 409, 178.

7 McCollom, T.M. *op. cit.*, (1).

8 Patel, B.H., Percivalle, C., Ritson, D.J, Duffy, C.D., Sutherland, J.D. *Nature Chem.* (2015) 7, 301.

9 Budin, Szostak *op. cit.*, (1).

10 Bernhardt, H.S. *Biology Direct* (2012) 7, 23.

11 Adamala, K., Szostak, J.W. *Science* (2013) 342, 1098.

know that it could not have been a spontaneous episode, unless a stable source of energy allowed the overcoming of the thermodynamic barrier required to reach a far from equilibrium state that characterises living beings.

There are different speculations about the scenarios in which life might have emerged. Owing to the prestige of scientists such as Alexander Oparin, John B.S. Haldane, Stanley Miller, and Antonio Lazcano, the concept of a primordial soup has been dominant for decades among researchers in the field.[12] In recent years, however, the hypothesis of submarine hydrothermal vents has gained considerable attention. In the so-called Lost City type vents, the water percolates through low-silica (ultramaphic) rock. Due to a geological process known as serpentinisation, emerging waters are warm (up to 90°C), alkaline (pH between 9.0 and 11.0) and contain molecular hydrogen and methane. The mixing of the hydrothermal fluid with the cold ocean leads to the building up of porous mounds enriched in calcium carbonate that contain metal complexes that are strikingly similar to present day enzyme cofactors. Hypothetical chemical reactions for carbon dioxide fixation fit fairly well with the biochemistry of extant autotrophic microorganisms inhabiting these vents. In turn, the compartments in the mound offer an enticing condition for the self-organisation of the first cells.[13]

In spite of all these advances, some key matters remain highly speculative and may remain uncertain for a long time, if not for ever. Among them, the origins of homochirality (presence of a single optical isomer) and of the genetic code are perhaps the most conspicuous. Other possible topics of no less relevance are whether there were simpler forms of cellular life, whether life started once or several times, in one or several places, and so forth.

To speak of the 'self-organisation' of the first forms of life and their appearance through natural causes might seem to eliminate the need to appeal to causes beyond natural ones. Although Thomas Aquinas would welcome research along the lines we have briefly described, he would also remind us that whatever 'self-organisation' occurs in the world, it occurs in a causal context wider than that which the natural sciences themselves study. Defence of the competence of the natural sciences ought not to be equated with a denial of divine agency in the world. On the contrary, according to Thomas, the fact that created things are real causes in nature is a powerful argument for divine omnipotence. As he says, to deny the power of created things to be the causes of other things is to detract from the perfection of created things and, thus, to detract from the perfection

12 Lazcano, A., Miller, S.L. *Cell* (1996) 85, 793.

13 Martin, W., Russell, M.J. *Phil. Trans. R. Soc. Lond. B Biol. Sci.* (2003) 59, 358; Sojo, V., Herschy, B., Whicher, A., Camprubí, E., Lane, N. *Astrobiology* (2016) 16, 181.

of divine power. There is, thus, no contradiction in seeking to explain the origin of life by purely natural causes and also recognising that life itself is the result of divine agency.

William E. Carroll is the Thomas Aquinas Fellow in Theology and Science at Blackfriars Hall, Oxford and a member of the Faculty of Theology of the University of Oxford.

Rafael Vicuña is Professor of Biochemistry in the Faculty of Biological Sciences of the Pontifical Catholic University of Chile.