

# The Inner Purpose of Waterlilies

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As children my sister and I spent many afternoons in Oxford's botanical gardens. She liked the dry air of the cactus room, I the mountain flowers and herbarium, but best of all, we agreed, was the tropical greenhouse. Its deep, shaded pool was filled with tadpoles, and on the surface were waterlilies so large I longed, so I remember, to climb onto their raftlike pads. In the Amazon, a plaque reads, the leaves of the *Victoria amazonica* – the largest of any plant – can grow to three metres in diameter; Oxford's, perhaps half that, still seemed broad enough to hold my weight. Smooth flesh above, but ridged and richly-patterned as Gothic stonework below, patterns, the plaque continues, that inspired Charles Paxton's design of the Crystal Palace in London in 1851, the same year the Water Lily House was built in Oxford. And indeed Paxton, a renowned horticulturist, had discovered the strength of the lilies' 'natural engineering' upon finding his daughter Annie floating on a leaf of an *amazonica* he had cultivated.



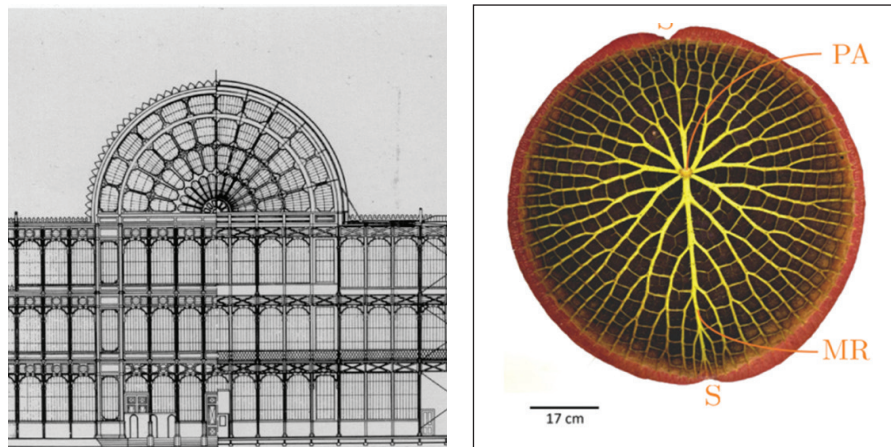
*Annie and the lilies, Illustrated London News, 17th November 1849, from the Senate House Library archives in London*

The Crystal Palace was constructed to house The Great Exhibition of the Works of Industry of All Nations, where a hundred thousand artifacts were displayed, from Sèvres Porcelain to the hydraulic press. Conceived as a secular celebration of science and industry, the expo and its

glasshouse were monuments to human ingenuity, although Paxton's Palace, as some were quick to point out, was based on structures found in nature. Thus clergymen in attendance declared the 'laws of power, motion, and transformation' that governed the exhibits and their production to be 'the same laws by which the Almighty governs His creation'; God was 'the author of all those gifts and qualifications by which men become experts in the productions of Industry.'<sup>1</sup> God the industrialist! The economy, like nature, was all His handiwork, its competition sanctified by trickle-down divinity.

Another attendee of the Exhibition, hard at work on *The Origin of Species*, reversed the analogy. Where the clergy extended divine providence from nature to industry, Darwin saw in nature the same ruthless competition that powered economic 'progress'. The real motor of natural evolution, he was to argue, drawing on the pessimist economist Malthus, was an unremitting struggle for survival.<sup>2</sup> In his notes and letters Darwin never mentions what he made of the Exhibition, but a few weeks earlier he had lost his own daughter Annie to illness, his grief deepening his hatred of providential arguments.<sup>3</sup>

Darwin's theory rendered the waterlilies' gigantism an enigma: natural selection, unlike God or Victorian architects, favours leaner proportions. But a 2022 study in applied engineering confirms the key to understanding the selective advantage is in the *economy* of their 'abaxial mechanics', the resource-efficient strength afforded by the embroidered buttresses that 'decorate the underside of the leaf'.<sup>4</sup> The authors marvel at the precision-engineering of the leaves, their structures so finely tuned and 'economical' that our own architects might mimic them. 'The vascular architecture of the world's largest floating leaves', they conclude, 'could also inspire structurally efficient, freestanding platforms'.



Common structures, common stories: the known and the strange must be analogues. So we see a glasshouse in a lily's leaf, or God in the cogs of industry. In a flash of insight, or perhaps reasoning, interdependent parts or purposive behaviour are understood by analogy with a more familiar structure, whether artifact, society, or organism.

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1. Cantor, G. 2012. 'Science, Providence, and Progress at the Great Exhibition'. *Isis* 103.3, 439-459.
  2. For the origin of *The Origin* in Malthus, see Darwin, C. 1958 *The Autobiography of Charles Darwin*, p. 120. And in a letter of 1860 Darwin says natural selection is 'from analogy' with 'domestic production... and the struggle for existence.'
  3. Keynes, R. 2001. *Annie's Box: Charles Darwin, his daughter, and human evolution*.
  4. Box et al. 2022. 'Gigantic floating leaves occupy a large surface area at an economical material cost'. *Scientific Advances: Applied Engineering*, vol. 8.

### The question concerning teleology

Early on in *Dr Faustus*, Thomas Mann's narrator meets Jonathan Leverkühn, amateur biologist and father of Adrian, the budding composer who will later sell his soul to the devil. Of a leaf-mimicking butterfly Jonathan asks, 'How does nature accomplish it through the animal? For it is impossible to ascribe the trick to the animal's calculated observation', he wonders. 'And though, to be sure, it serves the butterfly's purpose to resemble a leaf, what is that purpose from the viewpoint of the hungry lizard?' Leverkühn's investigations of nature's artistry lead him to the intricate patterns on the shells of mussels he collects. That the gelatinous inhabitants of such beautiful conches should be responsible for their décor seems to him perhaps more miraculous than divine design. The hieroglyphics give him no moment's peace: they display, he insists, 'a strong resemblance to early Oriental scripts, much like the strokes of Old Aramaic.'<sup>5</sup> He borrows from the local library volumes of archaeology and linguistics, but, needless to say, his research comes to nothing. However, Leverkühn tells the young Adrian, although we lack a Rosetta stone that might translate the conch, its script cannot be meaningless. And indeed, he concludes, 'for the message to be inaccessible, and for one to immerse oneself in that contradiction – that also has its pleasure.'



The butterfly and the mussel present the problem of *purpose*: organisms seem as though designed to a plan, their organs of extreme perfection explicable, like the interdependent parts of a machine, by the role they play. And these organs seem not only to depend upon each other, but to depend, furthermore, upon the whole they form – the lily upon its leaves, and the leaves upon the lily. But just as the analogy with machines helps us understand an organism's structures, it points the way to missing analogues, or, seen differently, limits to the analogy. The cause of a machine's existence is, of course, its designer and builder. Its parts can be explained by their function *because* it is built with a purpose, and a plan, in mind. What is the analogue in the living thing?

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5. For a recent mechanistic model of the markings of the *Lioconcha hieroglyphica*, see Boettiger, Alistair & Ermentrout, Bard & Oster, George. (2009). 'The neural origins of shell structure and pattern in aquatic molluscs.' *Proceedings of the National Academy of Sciences of the United States of America*. 106. 6837-42.