Case study

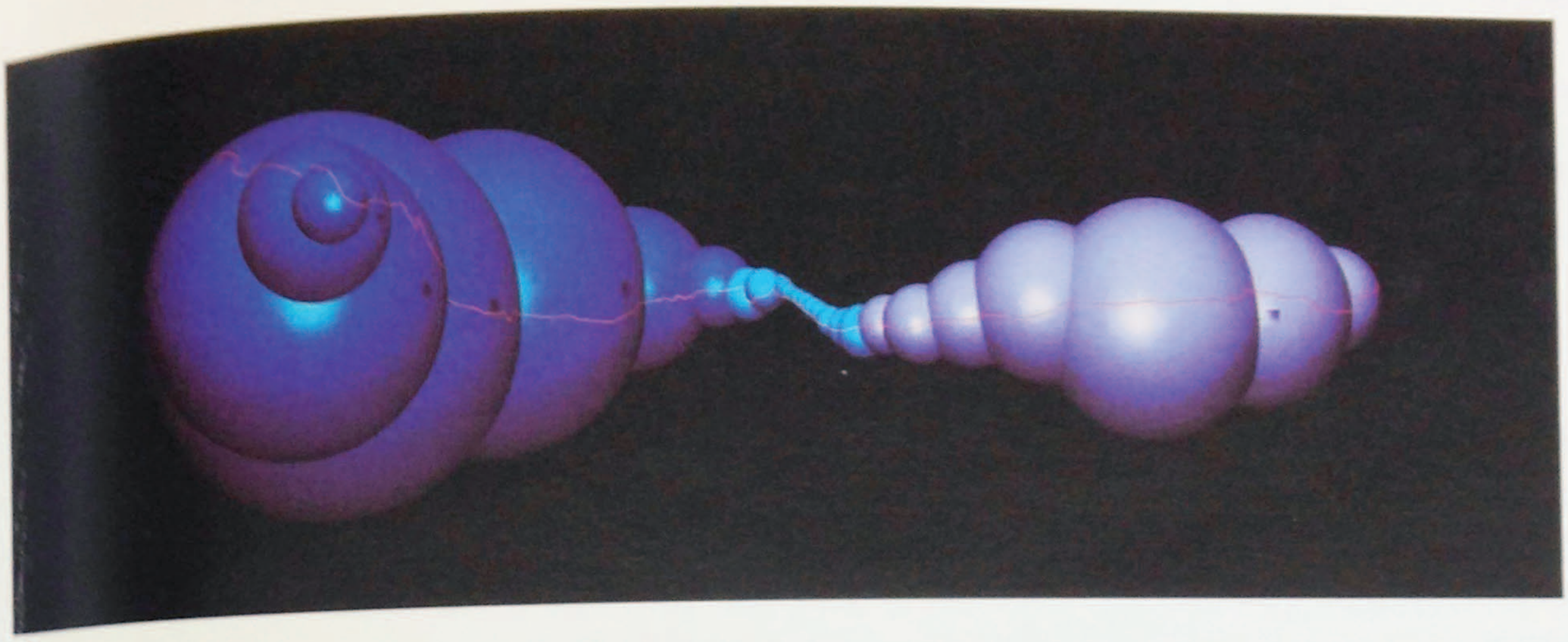
The Eden Project Humid Tropics and Warm Temperate Biomes

The most difficult challenges often hold the potential for the most inventive solutions. This is an adage that all architects learn as students, and the Eden Project, by Grimshaw, is perhaps as potent a demonstration of this as one could find. The brief called for the world's biggest greenhouse and the site was a huge china-clay pit – 90 m deep, hundreds of metres across and, in places, very unstable. To make matters more difficult, the site was still being quarried and there was no certainty about its ultimate shape.

The first design exercise was to establish which would be the best parts of the site for the building to inhabit. In spite of the challenges, the site had some great benefits – it created a sheltered microclimate and a series of south-facing slopes against which the building could be placed in order to maximise passive solar gain. To resolve the challenges of the irregular site, one of the members of the team, David Kirkland, proposed a radical solution inspired by soap bubbles (fig. 24) – a genuine Eureka moment. The idea was to create a string of bubbles, the diameters of which could be varied to provide the right growing heights in the different parts of the building, and to connect these along a 'necklace' line that could be arranged to suit the approximate topography. The team explored lots of different iterations of this bubble string and set them into 3D terrain models of the site. By cutting away everything that was below ground, the team arrived at the first images that resembled the final scheme.

The next challenge was to strive for the lightest possible structure. Studying a whole series of natural examples – from carbon molecules and single-celled animals such as radiolaria through to pollen grains – revealed that the most efficient way of structuring a spherical form is with a geodesic arrangement of pentagons and hexagons. Richard Buckminster Fuller pioneered this technology, and even has a form of carbon molecule (the 'Buckminster Fullerene') named after him. The design started with conservative structural assumptions and then set about refining the system. The most significant move in this process came in trying to maximise the size of the hexagons so that light penetration could be increased. Glass would have been a serious constraint, both in terms of its unit sizes and weight, so the team explored a material which had been used on some much smaller and more conventional buildings but that showed great potential.

Ethylene tetraflouroethylene (ETFE) is a high-strength polymer that can be formed into an ultra-lightweight cladding element by welding the edges of three layers together and then inflating it for stiffness. The great advantage of this was that it was one per cent of the weight of glass (a factor-100 saving) and could be made in much larger 'pillows' than the biggest available sheets of safety glass. A combination of wind-tunnel exploration and thorough material testing allowed the design of the enclosure to be tuned to the specific conditions of the site. A positive cycle of design occurred, in which one breakthrough facilitated another: with such large pillows it meant there was less steel, which in turn admitted more sunlight and reduced the amount of heat that would be needed in the colder times of the year. Less steel also produced substantial savings in substructure. The process of design refinement, resulted in a scheme that used a fraction of the resources of a conventional approach and cost a third of the normal rate for a glasshouse. The weight of the superstructure for the Humid Tropics Biome (fig. 25) is less than the weight of the air inside the building. If the team were to tackle the same challenge again, with more advanced materials technology and learning further lessons from biology, it is likely that further radical increases in resource efficiency could be achieved.



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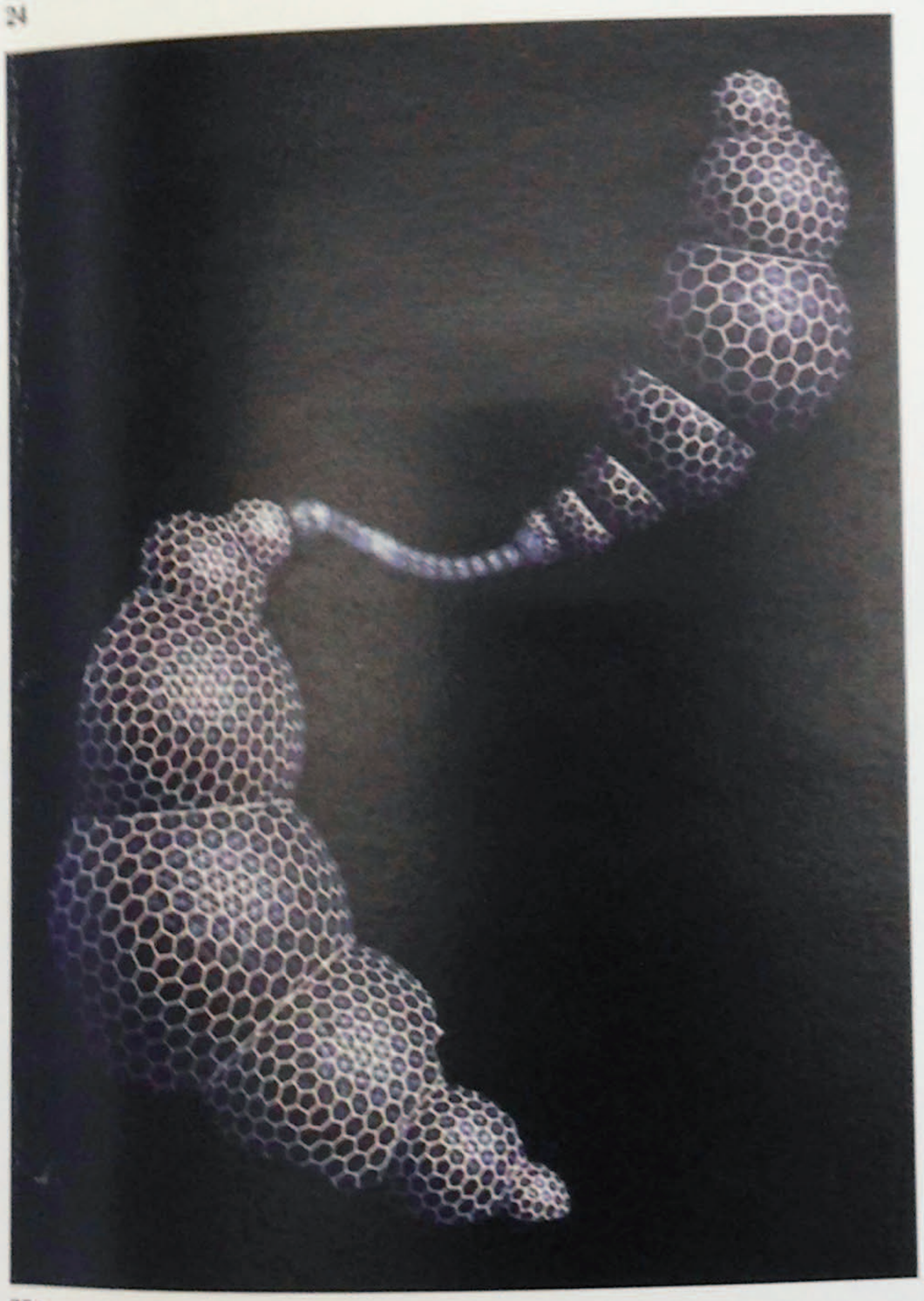

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24. An early computer model developed by the Grimshaw team when conceiving of The Eden Project as a string of bubbles to be set into the irregular site

25. (a) Computer generated image showing the sections of geodesic structure of the bubbles that protruded above the ground; and (b) the interior of the Humid Tropics Biome at The Eden Project

In contrast to many of the historical precedents that were studied, the biomimetic approach resulted in a much more sympathetic relationship with the landscape. Examples such as the Palm House at Kew – a highly symmetrical building on a flattened site – can be read as an expression of the view of nature that prevailed at the time, as something that could be dominated by man. The Eden Project Biomes accommodated the existing form of the site with a minimum of excavation, and suggest a more respectful reconciliation between humans and the natural world.