been because the member states in the Council of Ministers so frequently water down the scientific advice they are given. The Treaty of Union requires that the common fisheries policy be reviewed in 2002, and this offers a golden opportunity for a radically improved policy. The European Commission will be producing a discussion document later this year. *Fish, Markets, and Fishermen* should help to stimulate fresh thinking on how to conserve fish better, for fishermen and consumers alike.

The open ocean presents an even more difficult problem, which is not seriously addressed in the book. Deep-sea fish live in cold water with sparse food supplies, and so grow and breed slowly. Although there are substantial standing stocks, they are particularly susceptible to overexploitation. As the boats and gear for catching them have required larger investments, there is strong motivation to overfish. And there is no sign that the Law of the Sea Convention will act soon enough. ■

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More on fishing

Fishing Grounds: Defining a New Era for American Fisheries Management

by the H. John Heinz III Center for Science, Economics and the Environment

Island Press, $27, £25 (pbk)

Science in culture

Inverted logic

Antoni Gaudí's structural skeletons for Catalan churches.

Martin Kemp

It is something of a cliché to say that great thinkers can take an idea and turn it on its head in the search for new perspectives. But few can have done so as literally as the astonishing Catalan architect Antoni Gaudí, who designed a series of remarkable secular and ecclesiastical buildings in Barcelona in the early years of the twentieth century.

In common with adventurous architects across Europe, Gaudí was striving to create a form of design that was genuinely new — called art nouveau in France and modernism in Catalonia — yet deeply rooted in the past. Typically, designer-artists looked to styles that were local and indigenous, in Gaudí's case the medieval architecture of Catalonia and Spain's striking Moorish heritage. The intention was not so much the kind of eclectic imitation common in the nineteenth century as the extraction of underlying principles of form and structure.

To achieve this deeper penetration, a number of European designers were returning to what they considered to be first principles in the geometrical engineering of organic structures. Gaudí was convinced that the clustered piers and soaring vaults of a Gothic cathedral were closer to nature's living forms than the rectilinear geometry of classical columns and cornices.

In this pan-European quest for nature's geometry, Gaudí was inspired to research the complex geometry of surfaces, such as circular and hyperbolic paraboloids, so that he could construct intersecting combinations of convex and concave shapes that were rigorously geometrical and yet seemed true to nature.

When he translated this geometry into structural practice, his most original act was to re-characterize the arch according to the tenets of 'natural engineering'. He took as his model the catenary curve, formed when a chain hangs in a loop from two points. He deduced that the forces of tension in the catenary curve must be resolved along the line of the curve itself. If inverted as a 'catenary arch', the reverse forces of compression should run through the masonry of the arch, without causing the severe outward thrusts that generally necessitated the massive piers or flanking buttresses in large Gothic buildings.

Extrapolating this upside-down design method to cope with complex ecclesiastical buildings, Gaudí plotted their spatial structure through an intricate cobweb of wires and looped strings hanging from points on the scaled ground-plan of the projected building. Small, weighted sacks suspended from the lowest points of the string loops simulated, in reverse, the weight of the intricately curved vaults that were to be suspended between the skeleton of ribs.

Gaudí's towering Expiatory Temple of the Sagrada Familia was begun in 1883 and was still piously under construction 74 years after his death. The remarkable hanging models he made for the temple and for his Chapel of the Colònia Güell (1905–15) no longer survive. But a reconstruction of the model for the chapel can now be seen in the museum attached to the unfinished temple (see figure). On such frameworks, duly inverted, Gaudí worked his plastic variations on organic morphologies. His aspiration was that the building should appear to the worshipper as a force of nature itself, a spiritual distillation of God's perfect engineering and design, rather than a mere container made by human agency.

In Barcelona today, Gaudí's legacy and the desirability of finishing his Sagrada Familia are disputed by politico-religious factions in a way that ironically mirrors the architect's own journey from artistic radical to religious conservative. From an international perspective, we can see how he was one of the most original and profound advocates of reforming architectural design in the light of the timeless example of nature. ■

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Martin Kemp will be giving a talk, "not science AND art", at the Victoria & Albert Museum, London, on 3 November (7 pm).

MARINA WALLACE

Left, vaults of the Sagrada Familia. Far left, Gaudí's hanging model (reconstructed) for the Chapel of the Colònia Güell (Gaudí Museum at the Sagrada Familia, Barcelona).