mating systems, parental care systems and parent–offspring conflict are all covered: the list seems all too human. Barlow has a behavioural view of the world, and draws on his impressive knowledge of the behaviour and natural history of many groups of fishes to make more general, important points about evolution and the ecological circumstances that shape the development of parental care and mating systems.

But Barlow has aimed this book at a wider, not strictly hard-core scientific, audience. There is a huge community of what he calls "cichlidiots" who keep and breed the typically beautifully coloured and 'brainy' cichlid fishes. They will enjoy the lucid writing and the plethora of general biology facts and aquarium behavioural observations. The book is also entertaining and fun to read because of (or in spite of, depending on your taste) headings in chapters such as "Beauty is only fin deep", or statements such as "gonads are in command".

Cichlid Fishes has a different focus from the grand ol' book of cichlid research, Geoffrey Fryer and T. D. Iles' 1972 text, *The Cichlid Fishes of the Great Lakes of Africa: Their Biology and Evolution* (Oliver & Boyd). The latter book focuses more on ecological and evolutionary questions, and, owing to very active research by many laboratories around the world, is quite outdated in places. An updated synthesis focusing specifically on the ecology and evolutionary biology of cichlids is still wanting. ■

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Science in culture

Architect reaches for the clouds

How fractals may figure in our appreciation of a proposed new building.

Richard Taylor

We're all familiar with the Manhattan skyline of New York, with its many skyscrapers reaching into the clouds. Imagine the effect if one of these skyscrapers were shaped like the clouds surrounding it. This is the plan of the Guggenheim Museum, which recently unveiled a design by the architect Frank Gehry for an $800 million building to house its modern art collection. The Guggenheim Museum is no stranger to controversial architecture. Its current collection is housed in the landmark white spiral structure designed by Frank Lloyd Wright. But with its swirling layers of curved surfaces spanning three piers, the proposed 45-storey, 'cloud-like' structure is expected to radically reshape New York's waterfront.

Traditional architecture is based on euclidean shapes, such as circles, squares and triangles. But clouds belong to fractal geometry, consisting of patterns that recur at increasingly fine magnifications. How, then, will people react to architecture designed to mimic one of nature's fractal patterns? The answer may lie, not in architectural concepts, but in recent perception studies of fractal patterns.

The study of human aesthetic judgement of fractal patterns constitutes a relatively new research field of perception psychology. Only recently have researchers started to quantify people's visual preferences for (or against) fractal content. The visual appearance of a fractal object is influenced by a parameter called the fractal dimension, *D*. This quantifies the fractal scaling relationship between structure observed at different magnifications. Its value lies between 1 and 2 and moves closer to 2 as the complexity and richness of the repeating structure increase.

In 1995, Cliff Pickover at the IBM Thomas J. Watson Research Center in New York used a computer to generate fractal patterns with different values of *D* (ref. 1). He found that people expressed a preference for fractal patterns with a value of 1.8. A subsequent survey by Deborah Aks and Julien Sprott at the University of Wisconsin also used a computer, but with a different mathematical method for generating the fractals[2]. This survey reported much lower preferred values of 1.3. The discrepancy between the two surveys seemed to suggest that there is no universally preferred *D* value, but that the aesthetic qualities of fractals instead depend specifically on how the fractals are generated.

To determine whether there are any 'universal' aesthetic qualities of fractals, I collaborated with psychologists Branka Spehar at the University of New South Wales, Colin Clifford at Macquarie University in Sydney and Ben Newell at University College London. We performed perception studies incorporating the three fundamental categories of fractals — 'natural' fractals (scenery such as trees, mountains and clouds), 'mathematical' fractals (computer simulations) and 'human' fractals (cropped sections of Jackson Pollock's dripped paintings, which I have shown to be fractal[3]). Participants in the perception study consistently expressed a preference for fractals with *D* values in the range 1.3 to 1.5, irrespective of the pattern's origin. Significantly, many of the fractal patterns surrounding us in nature have *D* values in this range. Clouds have a value of 1.3.

Although Gehry's proposal for the Guggenheim Museum is designed to mimic the general form of clouds, it is clear that the completed building will not be strictly fractal. To build a structure described by a *D* value of 1.3 would require many layers of repeating patterns. Although this is no great challenge for nature, such complexity is beyond current building techniques. In fact, both Gehry and New York's mayor, Rudolph Giuliani, readily admit that no shovel will be turned for at least five years and that the plans will have to evolve during that time. It will be fascinating to see if people's fundamental appreciation of fractal clouds will inspire New Yorkers to embrace this revolutionary building design. ■

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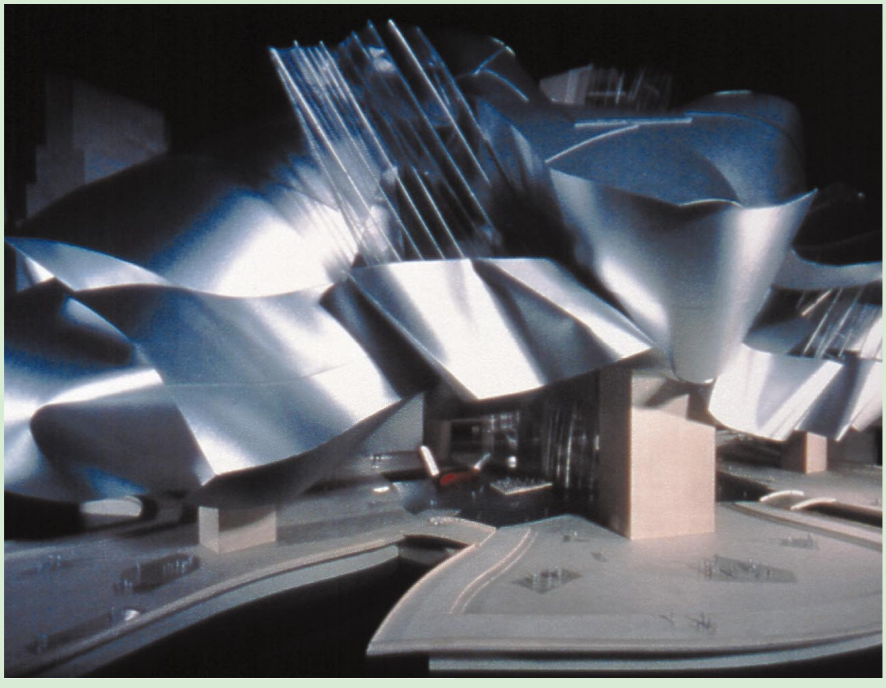

DAVID HEALD

Fractal future: a model of the proposed new Guggenheim Museum in New York.