to conform to empirical rules established largely on the basis of JONSWAP data. On the other hand, swell components (defined in this context as long waves, well removed from the peak of the wind-sea spectrum) are essentially uncoupled from the wind-sea and must be individually considered as linear free waves. Differences in the definition of the transition from the wind-sea to swell, and in the representation of the non-linear interactions probably explain why agreement between second generation models in the SWAMP study is no better in quality than that between the two generations.

So there are two principal objectives in the new joint initiative to develop third generation models. First, all wave components in the spectrum, whether swell or wind-sea, must be treated in the same way and allowed to evolve freely. Second, the Boltzmann integral quantifying the non-linear interaction needs to be evaluated at every grid point and time step, if not exactly, at least more accurately than in the second generation models. Already, participants from the Max Planck Institute for Meteorology in Hamburg, FRG, have run a prototype global, deep-water third generation model on the Cray computer at the European Centre for Medium Range Weather Forecasts with results which, though very preliminary, are promising. The development of regional versions of the global model is planned, including finite-depth effects where necessary. A programme of verification studies, using wind and wave data collected by the participating institutes, is also planned. The project, presently being coordinated by G. Komen of the Royal Netherlands Meteorological Institute, is a commendable example of international cooperation in pursuit of a common goal, and offers some exciting prospects. □

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100 years ago

AT a recent meeting of the German Asiatic Society of Japan a paper was read by Dr. H. Muraoka of Tokio, on the magic mirror of Japan. It is generally supposed that its magical quality was discovered only recently; but it was, says Dr. Muraoka, known for a long time in Japan. Old ladies have told him that in their youth, fifty years since, they frequently noticed, when at toilet, that the reflection of the sun from the mirror on the wall or ceiling contained the figures or letters on its back. It is said to have been known to the Romans in connection with some of their own mirrors, and any one concealing a mirror possessing this quality was arrested as as sorcerer; but the authority for this statement is not given. The subject is engaging considerable attention, as will be seen from the fact that in recent years a list of fourteen writers on the subject is quoted, from Stanislas Julien, in 1847, to Messrs. Ayrton and Perry quite lately; and, as the subsequent discussion showed, there are omissions even in this list. These writers, especially the latter, have demonstrated beyond doubt that unequal convexities in the mirror beget its magical quality. The polished surfaces are convex, but the convexity is not continuous, and is broken in certain places. After going over what had already been done on the subject, and its results, the author described his own investigations. The riddles of the mirror are far from being all answered by the discovery of unequal convexity. For example, how is the inequality caused—by pressure, heat, or by changes in the molecular tension of the metal plates? The writer tried many experiments to answer the question, and he succeeded by means of chemical agents in drawing lines on the flat back of a mirror, which were reproduced on a reflected image from the front.

From *Nature* **31** 249, 15 January 1885.

Bacterial motion

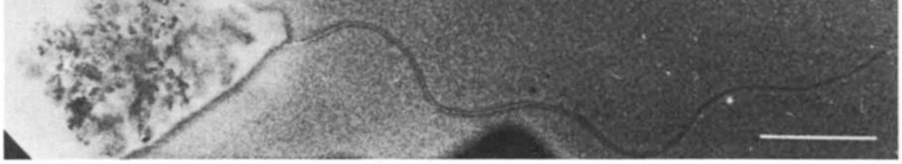
Square is beautiful

from Michael Spencer

NOT many things in the natural world are square. Hexagonal objects are common enough; but on the whole it is the smooth curves of circle, ellipse and spiral that dominate the evolutionary drawing board. In human affairs, this preference for the well-rounded extends from beauty contests to the marketing of food. Some years ago, the British Egg Marketing Board devised an ingenious solution to the problem of packaging millions of fragile, odd-shaped objects: the eggs would be fed into a vast machine to be individually broken and re-sealed in square-sided plastic boxes. No more was heard of the scheme, doubtless due to market research indicating that the customer would not stand for it. The same aesthetic sense must have dictated that potato crisps (US chips), now made by cutting up sheets of processed potato paste, still retain the pleasing contours of a thinly-sliced tuber.

Biology, however, offers an example of almost any shape if you look hard enough. This august journal achieved some kind of scoop a few years ago by publishing the first sighting of square bacteria (*Nature* **283**, 69; 1980). These surprising objects are to be found lurking in the briny pools of southern Sinai. A new report by M. Alam *et al.* (*EMBO J.* **3**, 2899; 1984) concentrates on their motile behaviour. This is of unusual interest because of the discovery that at least one kind of halobacterium (*H. halobium*) swims differently to other bugs: it goes backwards and forwards by simply reversing the sense of rotation of its right-handed helical flagella, rather than going through the more normal cycle involving a change of the helical sense. As I have recently pointed out in these columns (**310**, 367; 1984), this presents a conundrum to those trying to understand how individual flagellar motors could operate; it requires a rather tortuous argument (or an entirely new model) to explain how a bundle of many flagella could reverse its direction of rotation without getting tangled up.

Alam *et al.* find that square bacteria, which have apparently not yet been graced with a taxonomic title (*H. quadratum*? *H. incredible*?), pose the same problem as their better-known cousins. Their flagella are right-handed helices; and as they swim about, for all the world like animated postage stamps, they reverse direction by simply changing from clockwise to anti-clockwise rotation. Although the flagella show a strong tendency to stick together in bundles, reversal does not cause the bundles to fly apart as it does in non-halophiles. One of the possible let-outs suggested by earlier work now seems less plausible because electron micrographs show that large bundles or 'super-flagella' are unlikely to be detached flagella aggregating around a single rotating filament. It seems they really can be formed by filaments arising at different points on the cell surface. Even more oddly, the slower contrary rotation of the cell body is sometimes absent. Rather teasingly, Alam *et al.* remark that this interesting problem will be dealt with in another communication. This one should run and run. □



Electron micrograph of a square bacterium with a single flagellum negatively stained with phosphotungstic acid. The bar indicates 1 μm. From Alam, M. *et al. EMBO J.* **3**, 2899; 1984.

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