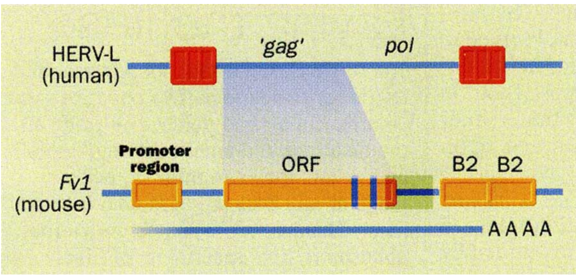

FIG. 2 Structure of the *Fv1* gene. The shaded portions denote regions of difference between the *n* and *b* alleles. The 5′ end of the messenger RNA is uncertain; the 3′ end lies in sequence derived from the B2 repeat. ORF, open reading frame. The relationship to the human endogenous provirus-like element HERV-L, indicated above, implies that *Fv1* might represent a *gag*-related sequence.

The structure and species distribution of *Fv1* are different from those of a usual gene (Fig. 2). It lacks introns as well as obvious promoter and polyadenylation signals. To date, the promoter has not been identified, but the 3′ end has been mapped into a repetitive element (B2) of the coding region. The impression of *Fv1* as a 'neogene', pieced together recently from different parts, is further supported by its distribution. Closely related sequences are found only in laboratory mice and other species of the genus *Mus*. Some species, including cats and rats, show no related sequences at all, and large numbers of distantly related sequences can be seen in other species (including humans). This distribution resembles more closely that of an endogenous provirus than that of a usual gene.

Consistent with this, a search of databases for related sequence turned up a sequence from the *gag* region of a human endogenous provirus-like element (HERV-L), whose *pol* gene resembles that of an unrelated retrovirus, human foamy virus[10]. Although this relationship is tantalizing, it should be kept in mind that the sequence lacks detectable relationship to any retroviral *gag* gene as well as hallmarks of the usual *gag* genes. Its identification as a *gag* sequence relies solely on the position of the related HERV-L sequence.

How *Fv1* works should now be accessible to direct experimentation. Even if it is a *gag* gene, it is unlikely to exert its effect in a simple way. Competition for some cellular factor seems inconsistent with its genetics. The presence in the mouse genome of hundreds of sequences closely related to MLV *gag* genes that exert no obvious suppressive effect argues against simple *gag–gag* interaction. Important clues will probably come from comparative analysis of the different alleles, which differ principally by a truncation and substitution of sequence at the carboxy terminus.

A final point of interest regards the evolution of *Fv1* resistance. *Fv1* may represent a rare example of a sequence that originally belonged to a transposable element, but has been separated from it (perhaps by integration of an intact element followed by deletion of sequence on either side) and brought under the influence of transcriptional control elements from other sources. This process seems to have occurred subsequent to the divergence of *Mus* from other rodents but before the divergence of modern species. Does resistance to MLV infection represent a normal function of this '*gag*' sequence? If so, then the ancestral retroelement might represent some sort of antivirus virus, benefiting its host by causing resistance to other viruses. Alternatively, is the resistance a chance effect of mutation of a sequence that happened to be already present when the species was first exposed to MLV? In favour of this possibility is the presence of an apparently non-functional *Fv1* sequence in *Mus dunni*, a species of mouse that shows no sign of prior exposure to MLV infection. Close analysis of the structure and function of the other mouse elements, as well as the human elements, will be highly rewarding. □

John M. Coffin is in the Department of Molecular Biology and Microbiology, Tufts University School of Medicine, 136 Harrison Avenue, Boston, Massachusetts 02111, USA.

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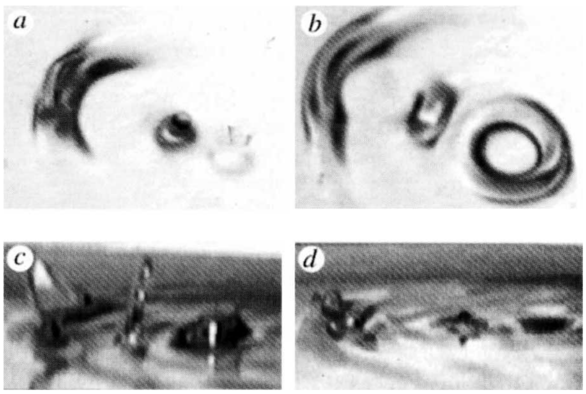
NONLINEAR SYSTEMS

Physics in a jumping sandbox

Jay Fineberg

FROM the stripes of a zebra to rolling sand dunes to the huge cellular structures formed in a thunderstorm, pattern forming systems abound in nature. Although the physical mechanisms that lead to a given type of pattern or structure may be quite diverse, in many cases the formation and subsequent evolution of these states has a universal mathematical description. So the discovery of a new type of structure in a specific system may well be relevant to a large variety of, at first glance, quite different nonlinear systems. On page 793 of this issue[1], Umbanhowar, Melo and Swinney describe the behaviour of a thin, 'sand-like' layer of minute brass balls that are excited into motion by the vertical vibration of their container. At a critical excitation value, strange, well-defined structures form, even though the excitation of the system is spatially uniform.

Previous work by this group revealed that, depending on the strength of the excitation, striped, square or hexagonal structures appear with a characteristic scale many times larger than the grain size. This large-scale organization is interesting because the actual grains interact with each other simply by inelastic collisions. Now Umbanhowar *et al.* have discovered a surprising and qualitatively different type of structure, which they call an "oscillon". Oscillons are highly localized particle-like excitations of the granular layer which oscillate at half the driving frequency. Once formed, single oscillons are stable. They come in two 'flavours', which like charged particles either repel or attract each other to form dipoles, chains, triangular associations and even lattices.



A typical localized 'solitary' state, propagating from right to left in a highly dissipative fluid[3]. Two phases relative to the driving frequency are shown. *a* and *b* are views from above, and *c* and *d* are side views of the same states. Compare with Fig. 1 on page 794.

Against the grain

Granular media behave in some ways like a solid, in some ways like a liquid or gas, and in some ways like none of those things. Some of their stranger properties are mentioned below. (For a more complete description see ref. 8 and references therein.) Unlike a fluid, sand can heap. Once the slope of a sand pile is increased beyond a critical angle, however, the medium will begin to flow. This flow only occurs within a thin layer near the top of the pile while the remainder of the sand is stationary. To the chagrin of many manufacturers, the same thing happens when trying to force a granular medium down a chute.

Another oddity is that, instead of travelling in a straight line, sound launched into the *side* of a sand layer will curve around and eventually come out of the *top* of the layer. Also, because a granular medium can support weight by the formation of minute 'arches', internal stresses in sand are distributed so that only a small fraction of the grains support the whole pile, and entire regions feel no stress at all. J. F.

A peak-type oscillon appears on the cover of this issue.

This is an example of a driven dissipative nonlinear system having many degrees of freedom, that is, many possible states to choose from. How does such a system typically behave as the level of driving (here, the amount of energy pumped in) is increased? A large class of such systems, as the driving is increased to some threshold value, undergo abrupt transitions called bifurcations, from an initially featureless state to one characterized by a well-defined mode or pattern of collective motion that retains a certain degree of symmetry. As the driving is increased further, this pattern may itself become unstable, undergoing more bifurcations which further reduce the system's symmetry. Dissipation in these systems is not confined to a single region but, like the pattern, is uniformly distributed throughout the medium. Many chemical systems and types of hydrodynamic flow have these characteristics[2].

But globally distributed patterns are not the only way for nonlinear systems to organize themselves. Highly localized states called solitons were first documented by J. S. Russell in 1834, who observed "a rounded, smooth and well-defined heap of water, which continued its course along the channel apparently without change of form or diminution of speed. I followed it on horseback... and after a chase of one or two miles, lost it in the windings of the channel". These intriguing states have since been observed in many diverse nonlinear systems having little or no dissipation. Many types of soliton have the remarkable property that neither their shape nor speed are altered upon collision with other solitons.

Do soliton-like structures exist in natural systems where dissipation plays a major role? As any soldier surrounded by sand-bags can confirm, granular media are highly dissipative. The results of Umbanhowar *et al.* are evidence that localized structures can indeed exist in such systems. How universal are these objects? Soliton-like structures, ubiquitous in non-dissipative systems, have only recently been observed in highly dissipative 2D or 3D systems in experiment[3–6] and theoretical model equations[7]. A fascinating property of both oscillons and the structures observed in references 3 and 7 is that dissipation seems to be *necessary* for their existence. We may, therefore, be looking at a new type of nonlinear object which tends to localize dissipation in driven nonlinear systems.

A surprising aspect of the new experiments is the striking similarity of the observed global patterns in a vibrated granular medium to those observed by replacing the sand with a viscous fluid. The similarity continues with the discovery of oscillons, which are reminiscent of the propagating, localized states recently observed in highly dissipative fluid systems (see figure). Although it is tempting to think of a granular medium as a liquid whose grains behave as fluid 'molecules', granular media (see box above) actually behave in a qualitatively different way from liquids, solids and gases[8]. In fact, despite much active research, no underlying theoretical description for these materials yet exists. The similar behaviour of these two very different types of medium under the same type of excitation may lead to some understanding of the fundamental nature of granular media, as well as of the observed states themselves. □

Jay Fineberg is at the Racah Institute of Physics, The Hebrew University of Jerusalem, Givat Ram 91904, Jerusalem, Israel.

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DAEDALUS

Laying the lies

THE Anglo-Saxon system of adversarial law is very imperfect. Two opposite sides — prosecution and defence — trade all the distorted and emotional arguments and insults they can think of, while a judge or jury tries to guess who is lying most. The procedure shares the drama, philosophy, and uncertainty of tribal warfare or big-league spectator sport. Nobody seriously looking for the truth (as in a scientific investigation or an air crash enquiry) would dream of using it.

The crucial problem, says Daedalus, is the ease with which human beings can tell lies. Indeed, this is almost a defining human skill. Many animals can lie in a simplistic way — pet cats, for example, will heroically pretend not to have been fed. But only human beings are self-conscious enough to elevate lying into a way of life, a vital skill in the complex competitive social game. One theory even claims that the human unconscious mind has evolved specifically to hold the secret truth, so that the conscious mind can lie boldly without stumbling over contradictions. Hence the role of the subconscious in psychology.

Now modern brain-scanning techniques can locate the active site of the brain at any moment. Daedalus reckons that telling the truth should activate just one site, where the relevant information is stored. Telling a lie should activate two sites, one holding the lie and the other holding the concealed truth. Positron-emission tomography is perhaps the best locator, but its radioactivity is worrying. So Daedalus plans to use magnetic resonance. DREADCO physicists are now injecting ^{13}C glucose into the blood of volunteers ranging from born-again Quakers to car salesmen, firing at them questions ranging from innocent to highly incriminating, and using ^{13}C NMR tomography to locate the releases of $^{13}CO_2$ evoked in their brains. The results should reveal the brain-signature of lying. With luck, it will be simple, consistent, and easily distinguished from the effects of emotional stress.

Daedalus will then devise an NMR witness box, or even helmet, to detect and display this signature. It will transform our legal system. Guilty criminals will no longer plead innocent, and lying plaintiffs will no longer risk litigation. False claims of liability, negligence, harrassment and abuse will swiftly fade away. NMR helmets for the lawyers themselves would be even more salutary. Many uses for the system beckon outside the court-room, too; but Daedalus is wary. Such a social nuclear deterrent is best kept in reserve as a threat. If widely deployed, it could make social life quite impossible. David Jones