or not this leap is justified, the identification of St Jude 1 helps to move the debate about viruses of the mind from the abstract to the concrete and may lead to the identification of other examples.

We have no intention of launching experimental chain letters into the general population for the purpose of testing hypotheses of quantitative epidemiology, for measuring mutation rates, or for assessing the limits of human gullibility.

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Pulsed dynamics of fountains

SIR — The fascination with ornamentation fountains probably goes back to the *quattrocento* of Francesco di Giorgio and later Leonardo da Vinci[1,2]. The unsteady character of a fountain's flow can reinforce its attraction, and several designs have exploited the intermittency of the flow — for example the so-called Hero fountains[3] such as the *Fontana a tempo* of di Giorgio[2], or spontaneously fluttering water sheets[4,5]. Here I show that a vertical water jet undergoes self-sustained pulsations in height, associated with the gravity-induced backflow of the jet on itself.

Consider the first fluid element to emerge from a vertical fountain. The maximum height that it can reach (assuming no frictional losses with the surrounding air) is given by $h = u_0^2/2g$, where u_0 denotes the velocity with which the fluid emerges and g is the acceleration due to gravity. Having reached the maximum height, the fluid element will start to fall, accelerating downwards under the influence of gravity. This gives rise to a backflow in the jet, which initially takes the form of a stationary 'cap' — a fluid packet perched on top of the jet and fed with liquid from below. It then falls under its own weight, flattening out the ascending column of the fluid while deforming under the inertial pressure of the jet. The cap eventually breaks up into a dispersed corolla, the jet re-emerges and a new cycle begins. The overall effect is a pulsating motion of the jet (Fig. 1), which is apparent not only to the eye but also to the ear (the break-up of the corolla is accompanied by a characteristic dripping sound). It can be easily shown that the pressure at the orifice of the jet is related to its instantaneous height. The (mean subtracted) temporal variation of this pressure displays a dominant period (Fig. 2*a*). For fountains with moderate aspect ratios (height/diameter, $h/d \leqslant 50$), this oscillatory behaviour develops before the onset of the Rayleigh capillary break-up instability, which would otherwise cause the liquid column to fragment.

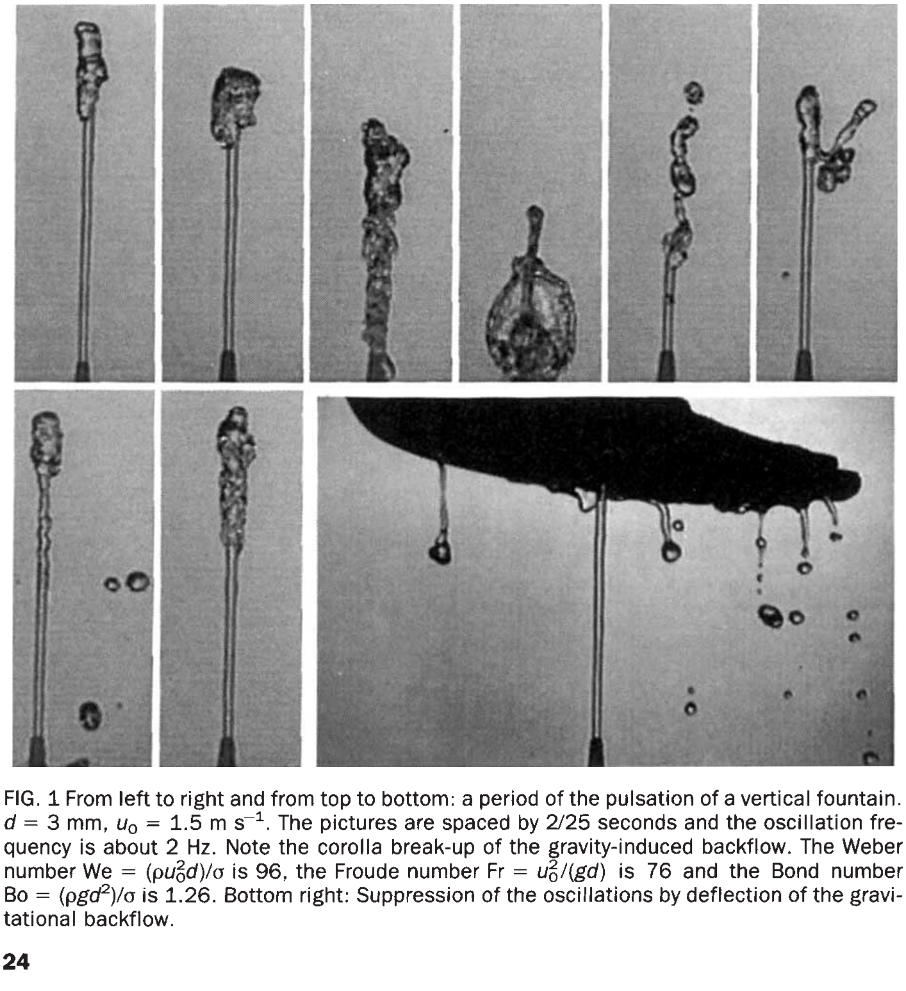

FIG. 1 From left to right and from top to bottom: a period of the pulsation of a vertical fountain. d = 3 mm, u_0 = 1.5 m s^{-1}. The pictures are spaced by 2/25 seconds and the oscillation frequency is about 2 Hz. Note the corolla break-up of the gravity-induced backflow. The Weber number We = $(\rho u_0^2 d)/\sigma$ is 96, the Froude number Fr = $u_0^2/(gd)$ is 76 and the Bond number Bo = $(\rho g d^2)/\sigma$ is 1.26. Bottom right: Suppression of the oscillations by deflection of the gravitational backflow.

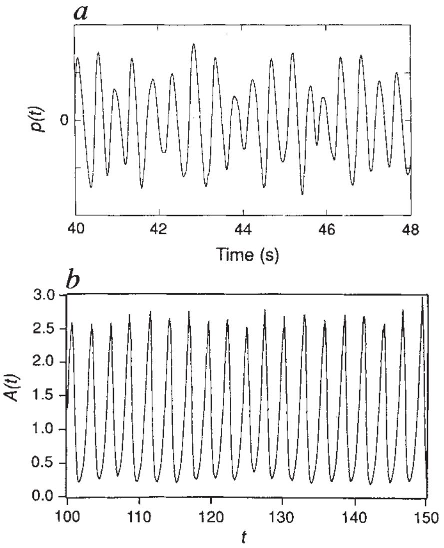

FIG. 2 *a*, Fluctuation of the pressure at the nozzle of the fountain shown in Fig. 1. *b*, Solution for the amplitude $A(t)$ of the nonlinear delayed model equation with r = 2, τ = 0.6, μ = 1. The delay has been allowed to fluctuate at each time step: $\tau(t) = \tau + \delta\tau(t)$. The fluctuating part of the delay $\delta\tau(t)$ is distributed according to a uniform probability density function whose width is such that $|\delta\tau|/\tau = 1/2$.

The role of gravity-induced backflow in this oscillatory behaviour is readily demonstrated. If a flat, horizontal object is used to obstruct the top of the liquid column, the fluid spreads outwards towards the edges of the obstruction, before falling as droplets away from the main jet (Fig. 1). The backflow is thus removed and the oscillations disappear. Similarly, if the fountain is oriented slightly away from the vertical, backflow is no longer possible and the jet describes a parabola with a fixed maximum elevation.

It has been argued[6,7] that for unsteady recirculating flows the existence of oscillations derives from the interplay between linear growth and delayed nonlinear saturation[6,7]. This mechanism can be represented as an evolution equation for the amplitude $A(t)$ of the disturbances in the flow, equivalent to the fluctuating height of the fountain:

$$\frac{d}{dt}A(t)=rA(t)-\mu|A(t-\tau)|^2A(t)$$

where τ is the transit time through the recirculation loop. This time-lag represents the interaction time of a fluid packet initially topping the fountain during its deformation until its break-up in dispersed droplets. It is of the order of the time for the packet to fall by a distance of the order of its own size, fixed by the diameter d of the jet: $\tau \sim d/(gd)^{1/2} = (d/g)^{1/2}$, independent of u_0.

When only one retarded time is involved and when the amplitude $A(t)$ and the delayed feedback $|A(t-\tau)|^2$ are sufficiently out of phase (that is, when $r\tau > \pi/4$), the solutions for $A(t)$ are periodic, nonlinear oscillations (Fig. 2*b*), whose period[7] is an increasing function of τ. The possible variation of $\tau(t)$ at each instant of time around a mean delay τ may reflect the variability of the size of the packets and of their interaction time in the actual situation. In that case, neither the oscillatory behaviour nor the period is appreciably altered[7].

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Climate and food supply

SIR — Rosenzweig and Parry[1,2] have performed a commendable pioneer study of the security of the global food supply in a changing climate. But it is important to note the assumptions and caveats in this study, and the possible effects which it did not consider. These limitations mean that we cannot share the optimistic interpretations put on the findings by Reilly in News and Views[3]. Climate change cannot yet be dismissed as having only minor effects on future global food security.

(1) Rosenzweig and Parry's data suggest that climate change will significantly increase the present unequal distribution of food supplies, thereby exacerbating the problem.

(2) As Rosenzweig and Parry point out, the relatively benign overall result "depends strongly on the full realization in the field of beneficial direct physiological CO_2 effects on crop growth and water use as currently measured in experimental settings". Without these assumed beneficial effects, they find that world cereal production for an equivalent doubling of CO_2 is reduced by 11–20%. The assumed direct effects of CO_2 increase on global wheat yield is about 20 per cent in all three climate change scenarios (Table 9 of ref. 2). Recent studies [4,5], including our own[6], suggest that competitive effects in plant canopies, as well as other factors, may well result in realized beneficial effects on yield considerably less than in the laboratory.

(3) The ability to make large beneficial adaptations, which Reilly claims could be even greater than assumed by Rosenzweig and Parry, may in fact be exaggerated, and very costly. Rosenzweig and Parry take no account of water-supply limitations for irrigation. Reilly points to the 'green revolution' and the high yields achieved by US agriculture, but these have both relied largely on massive inputs of energy through irrigation, artificial fertilizers and pesticides. One of Rosenzweig and Parry's most striking findings is that even massive adaptations make relatively little difference to the global picture (much smaller than the assumed benefits of increased CO_2).

(4) The climate change factors considered by Rosenzweig and Parry necessarily exclude many potentially important, perhaps even dominating, effects. Many phenomena are not yet reliably represented in global climate models, for example the behaviour of the El Niño Southern Oscillation (ENSO), or changes to tropical cyclone intensity, frequency or location[7]; widespread increases in rainfall intensity, with the corresponding reduction in the average interval between flood events[8]; changes in climatic variability[9], together with changes in the frequency of occurrence and distribution of pests and diseases; as well as other considerations.

(5) As demonstrated in Fig. 4 of ref. 2, global crop yields are a non linear function of increasing temperature, with substantial gains from a 2°C warming turning to a loss for a 4°C warning. Without substantial greenhouse-gas emission reductions, warming will continue long after the year 2060 (ref. 10), so that a critical threshold (when production will decline in temperate as well as in tropical countries) may well be reached at a later date.

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Fruitfly origins

SIR — Begun and Aquadro[1] show that four-cutter DNA polymorphism is very different between *Drosophila melanogaster* populations from Zimbabwe and North America. They compare this result with electrophoretic data by Singh *et al.*[2,3]. Begun and Aquadro find that there is much more similarity between populations from Benin (West Africa) and North America at the electrophoretic level than there is between populations from Zimbabwe (East Africa) and North America at the DNA level. Does this result show differences between populations in Africa or between techniques? Singh and Hale[4] suggest that the point is technical. We disagree.

Our group, together with Michael Ashburner, put forward the hypothesis of *D. melanogaster* African origin[5]. This hypothesis does not imply that all African populations were similar, and we suggested that temperate populations recently originated from West Africa. We have studied four-cutter DNA variation in Ivory Coast (West African) flies[6], and found much less difference with North America than Begun and Aquadro did in Zimbabwe (East African) flies. We also have compared inversion polymorphism[7] between five populations from West Africa (including Ivory Coast and Benin) and five populations from East Africa (including Zimbabwe), and found that the two groups are both each very homogeneous, and very different from each other (see Fig. 4 in ref. 7).

Thus *D. melanogaster* populations are substantially differentiated in Africa. Unfortunately, we have only a rough idea of the degree of genetic differentiation among fruitfly populations. Present estimates are obtained from genes that are subject to selective hitch-hiking, or from allozyme and mitochondrial variation.

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