50 & 100 YEARS AGO

50 YEARS AGO

It was natural that the genetic transformation of bacteria effected by the introduction of foreign deoxyribonucleic acid should lead to speculation as to whether the phenomenon could also be induced in higher forms. That similar treatment should be capable not only of altering the racial characteristics of the growing vertebrate but that such changes would also be heritable seemed one of the least likely outcomes of such an experiment. Recently published reports by Benoit *et al.* state that they have succeeded in changing the characteristics of ducks of one breed by injections of deoxyribonucleic acid from another, and that the modifications continued to be identifiable in the progeny of the treated birds. Because of the importance that must be attached to such revolutionary claims, and in the absence, as yet, of substantive evidence from repeat experiments, the work of Benoit and his colleagues should be subjected to critical scrutiny.
From *Nature* 22 February 1958.

100 YEARS AGO

In the February issue of *British Birds* the editors discuss certain allegations against the black-headed gull which formed the subject of notice in the previous issue. Without entering into the controversy, we may notice that the allegations have induced two county councils in Scotland to strike gulls of all kinds out of the protected list. In another paragraph the editors refer to the subject of "luminous owls." In their opinion, the luminosity is most probably to be attributed to phosphorescent bacteria derived from decaying wood. It may, however, be due either to a phosphorescent feather-fungus (akin to one known to occur in geese) or to a diseased condition of the oil-gland, whereby the oil is more abundant than usual, and so abnormal in its nature as to become luminous on exposure to the air.
From *Nature* 20 February 1908.

The authors[3] show that such disassortative networks tend to confer a significant degree of stability against disturbance. More generally, ecologists and others have long suggested that modularity — the degree to which the nodes of a system can be decoupled into relatively discrete components — can promote robustness. Thus, a basic principle in the management of forest fires and epidemics is that if there is strong interconnection among all elements, a perturbation will encounter nothing to stop it from spreading. But once the system is appropriately compartmentalized — by firebreaks, or vaccination of 'superspreaders' — disturbance or risk is more easily countered.

As the report[1] notes, this is a complicated question, because modularity will often involve a trade-off between local and systemic risk. Moreover, the wrong compartmentalization in financial markets could preclude stabilizing feedbacks, such as mechanisms for maintaining liquidity of cash flows through the financial system, where fragmentation leading to illiquidity could actually increase systemic risk (as in the bank runs leading to the Great Depression). Redundancy of components and pathways, in which one can substitute for another, is also a key element in the robustness of complex systems, and effective redundancy is not independent of modularity.

In short, the dynamical implications of the topology of financial networks emerge as good candidates for further research. This is a lively field: the interplay between network topology and random or targeted 'attack' has also provided insights for the control of infectious diseases[4] and the defence of networks such as the Internet[5].

Following this theme, the Federal Reserve Bank of New York commissioned a study[6] of the topology of interbank payment flows within the US Fedwire service (Fig. 1); this is a real-time settlement system, operated by the Federal Reserve System, within which some 9,500 participating banks transfer funds. The sample from this network amounted to around 700,000 transfers, with just over 5,000 banks involved on an average day (ecologists studying food webs can only dream of such high-quality data). The authors[6] find the connectivity of this network — the ratio of the number of banks or nodes connected by one or more transfers to the total number of possible connections (essentially $0.5n^2$, where n is the number of banks) — is very low, around 0.003. This connectivity is characterized by a relatively small number of strong flows (many transfers) between nodes, with the vast majority of linkages being weak to zero (few to no flows). On a daily basis, 75% of the payment flows involve fewer than 0.1% of the nodes, and only 0.3% of the observed linkages between nodes (which are already extremely sparse). This kind of inequitability in linkage strengths (with most links being weak) is thought to predominate and help stabilize some ecological networks.

Overall, the topology of this Fedwire network is highly disassortative: large banks were disproportionately connected to small banks, and vice versa; the average bank was connected to 15 others, but this does not give an accurate idea of the reality in which most banks have only a few connections while a small number of 'hubs' have thousands. These strongly nonrandom and disassortative characteristics of the bank-transfer network are, as noted above, shared by some ecological systems. They also resonate with theoretical studies suggesting that sparseness of strong linkages can confer greater stability in systems whose components (nodes, banks, species) have some self-regulation[7,8].

These insights must be viewed against the reality that the payments system may not always be the relevant network for understanding systemic events. As the report notes, political and social networks may emerge to play a larger role in liquidity transactions and/or in the spread of rumours, which can ultimately influence the tides of fear and greed, and thence consensus valuation of markets. In this way the ever-changing finance problem, despite having certain resemblances to that posed in understanding ecosystems, is different from the fixed networks considered in physical sciences. The report puts it succinctly: "the odds on a 100-year storm do not change because people think that such a storm has become more likely". Emphasizing the point is this observation[1]:

"… in contrast to management of the electric power grid, there are only coarse or indirect options for control of the financial system. The tools available to policymakers — such as those used by central banks — are designed to modify individual incentives and individual behaviors in ways that will support the collective good. Such top-down efforts to influence individual behaviors can often be effective, but it is still difficult to control the spread of panic behavior or to manage financial crises in an optimal way. Within the financial system, robustness is something that emerges; it cannot be engineered."

Thus, although the study of payment flows is of immediate interest to central bankers, it may miss an essential aspect of systemic risk, namely the 'contagion dynamics' of public perceptions and asset valuation associated with the interaction of balance-sheets (the mutual financial obligations and exposures that link companies). For example, how contagious are inflated valuations of Internet stocks? Are there hidden, mutually dependent risks associated with such high valuations? It could be useful to examine the dynamic network of balance-sheets, and if possible to quantify the interactive effects of valuations, credit policies, hedging and so on among financial institutions, especially investment banks. Such balance-sheet networks could be helpful in studying the effects of asset-pricing bubbles, credit crises and the poorly understood but potentially worrying effects of the current widespread use of derivatives (futures and options) and dynamic hedging by investment banks to manage risk on the fly. Whatever the case, it seems that the ephemeral networks