They should also be carefully monitored for sustained immune responses until it can be shown that vaccinations provide long-term protection.

Post-Ebola syndrome, which consists of a mixture of musculoskeletal and non-musculoskeletal symptoms[12], is only one of the personal and societal challenges faced by survivors of Ebola. It will be important not to add to survivors' burdens by letting them know that they are potentially a source of new outbreaks. As pointed out by Keita and colleagues, these individuals must continue to be prioritized for long-term medical care.

Ongoing community-based efforts to prevent stigmatization of survivors must be supported to detect and reduce the risk of Ebola re-emergence. Such efforts must be paired with rebuilding trust in those who might be wary of seeking health care, as happens after any disease outbreak. Perhaps most important will be future research to determine whether vaccinating survivors can prevent the re-emergence of the disease and onward transmission.

Finally, a commendation should be added for all of the authors who contributed to this work. The study results from an international collaboration between groups of scientists in Africa, Europe and North America. Although unusual, such cooperation is exactly what is needed to respond to the threats of emerging viruses.

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Engineering

Seed-inspired vehicles take flight

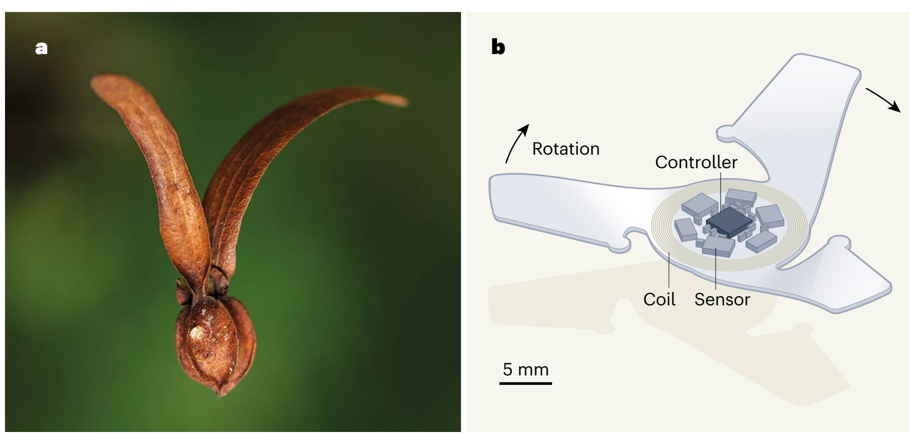
E. Farrell Helbling

Many plant seeds have shapes that aid their efficient dispersal by wind. Inspired by these seeds, a range of fliers have been constructed that could have applications from environmental monitoring to wireless communication. **See p.503**

On page 503, Kim *et al.*[1] report 3D fliers that are inspired by the passive, helicopter-style wind-dispersal mechanism of certain seeds. The adopted production processes enable the rapid parallel fabrication of many fliers and permit the integration of simple electronic circuits using standard silicon-on-insulator techniques. Tuning the design parameters — such as the diameter, porosity and wing type — generates beneficial interactions between the devices and the surrounding air. Such interactions lower the terminal velocity of the fliers, increase air resistance and improve stability by inducing rotational motion. When combined with complex integrated circuits, these devices could form dynamic sensor networks for environmental monitoring, wireless communication nodes or various other technologies based on the network of Internet-connected devices called the Internet of Things.

So far, research into collectives of aerial vehicles has been focused on active systems, including quadcopters[2,3] and insect- or bird-inspired robotic platforms[4]. Active systems have the benefit of being able to move independently through their environment. However, their practical applications are limited because of the size and safety concerns of larger platforms (such as quadcopters, which have a wingspan of about 50 centimetres) and lack of onboard electronics and power supplies that enable autonomous locomotion in real-world settings in the case of smaller platforms (with a wingspan of roughly 3.5 cm)[5]. Furthermore, because these research platforms[5–7] are highly specialized and assembled by hand, they cannot be used for studies of collective systems.

Plants use passive mechanisms — such as the dispersal of seeds by wind — to help to propagate their genetic information (Fig. 1a). Wind-dispersed seeds have specific geometries that boost their dynamic stability and transport distance by lowering their terminal velocity and increasing air resistance during free fall. Such geometries fall broadly into four categories: parachuters, gliders, helicopters and flutterers (also known as spinners). Wind dispersal can transport seeds over hundreds of kilometres. These passive dispersal



SHUTTERSTOCK

Figure 1 | An aerial vehicle inspired by wind-dispersed seeds. a, Many plant seeds (including the *Dipterocarpus alatus* seeds shown) have shapes that aid their dispersal by the wind. **b**, Kim *et al.*[1] produced a series of aerial vehicles that are inspired by such seeds. One of these vehicles contains a simple circuit to detect airborne particles and can be used as a battery-free wireless device for atmospheric measurements. The circuit consists of a controller, sensors and a coil for wireless power transmission, and the vehicle rotates as indicated. (Vehicle image adapted from Fig. 4e of ref. 1.)

mechanisms can serve as a mechanical analogue for dynamic sensor networks in which high spatial range and low power consumption are crucial features.

Kim and colleagues outline a framework to produce fliers on the microscale (smaller than 1 mm), millimetre-scale and macroscale (larger than 1 mm), inspired by seeds that use helicopter-style dispersal mechanisms. In this framework, the 3D shape of the devices is created using planar-fabrication processes — manufacturing methods similar to those used by the semiconductor industry. A layer of a shape-memory polymer (a material that can return to its original shape when a particular stimulus is applied) is bonded to a prestrained elastomer (a rubber-like material) at specific sites. When the strain is released, associated buckling at these sites causes the materials to fold, and the shape-memory effect fixes the fliers into the 3D shape.

These devices can vary in overall shape (by controlling the location of bonding sites), aspect ratio (the ratio of height to width; by adjusting the magnitude of the prestrain) and the number and shape of the aerodynamic surfaces. Importantly, because this framework uses planar-fabrication and lithographic (surface-patterning) techniques, hundreds of fliers, designed with different parameters, can be made in a single assembly process. This is crucial for practical realizations of devices that will form part of the Internet of Things.

Using analytical, computational and experimental techniques, Kim *et al.* defined and quantified the underlying aerodynamic mechanisms of these fliers. The authors explored the effect of scale, porosity, number of wings and aspect ratio on the terminal velocity and stability of the devices during free fall. They found that the scale has the largest effect on the terminal velocity owing to a transition from smooth (laminar) airflow to turbulence. Porous features, which have similar effects to parachute-like seeds, reduce the terminal velocity but have a larger impact on microscale fliers than on macroscale ones. By contrast, the curvature and angle of the aerodynamic surfaces have a greater effect on macroscale vehicles than on microscale ones.

Although this work focuses mainly on understanding the aerodynamic mechanisms of these fliers, Kim *et al.* also show that the production process supports the integration of semiconductor fabrication. The authors constructed vehicles containing simple semiconductor devices (a transistor and a diode) and found that these devices perform as well as ones fabricated using conventional techniques. Future studies could investigate whether complex integrated circuits can be directly incorporated into the fliers to create microscale sensing devices that are lightweight and mobile. For now, the authors used a macroscale flier (with a diameter of 5 cm) that contained a simple circuit to detect airborne particles, realizing a battery-free wireless device for atmospheric measurements (Fig. 1b).

This research provides a foundational understanding of these engineered systems and poses some questions to be addressed in future studies. Further analysis needs to be conducted into how wind affects the aerodynamics of the fliers — Kim *et al.* considered several environmental factors, but wind still needs to be investigated in detail. Furthermore, the authors' results focus on helicopter- and spinner-style dispersal methods, which leaves the design of parachuter- and glider-type fliers to future studies and raises questions about possible trade-offs between spatial range, payload and so on.

Kim and colleagues' work also paves the way for the integration of complex integrated circuits to increase the fliers' capabilities. Since the 1990s, researchers have been developing millimetre-scale wireless sensing systems[8–10]. Supplying a platform for these devices could provide improved spatial ranges for future technologies in the Internet of Things. As a roboticist focusing on the development of autonomous insect-scale systems, I am excited about the questions posed by the authors' microscale robotics technology.

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Ecology

Policy, drought and fire sear Amazon biodiversity

Thomas W. Gillespie

Analysis of the ranges of nearly 15,000 plant and vertebrate species in the Amazon basin reveals that, from 2001 to 2019, a majority were affected by fire. Drought and forest policy were the best predictors of fire outcomes. **See p.516**

The Amazon basin contains the largest continuous area of tropical rainforests in the world, and has a crucial role in regulating Earth's climate[1]. Rates of tropical-rainforest deforestation and the impacts of fire and drought there are well established[2,3]. Less is known, however, about how these factors might interact to affect biodiversity, and about the role that forest policy and its enforcement have had over time. On page 516, Feng *et al.*[4] address these issues.

To track effects on biodiversity, the authors undertook unprecedented analyses of the geographical ranges of 11,514 plant and 3,079 vertebrate species in the Amazon basin. Feng and colleagues also analysed satellite data of forest-cover changes, tracked forest degradation due to fire and identified the potential consequences for biodiversity of drought and forest policy from 2001 to 2019. Their results clearly show the extent of fire-affected forests in the Amazon basin, and indicate how drought conditions and policy changes (for example, enforcement of laws, interventions in supply chains for soya bean and beef, and the expansion of protected areas[5]), particularly in Brazil, affected the temporal trend of fires. These factors have had an impact on the ranges of more than 13,000 of the plant and vertebrate species studied over the period.

Even more strikingly, the cumulative effects of fires have substantially affected the ranges of 77–85% of species identified as threatened by the International Union for Conservation of Nature (IUCN). The authors further discover a close association between forest policy in Brazil (pre-regulation between 2002 and