sites, and it is likely that alterations in one community will affect the other. In some scenarios, disease-specific coexistence of bacteria and fungi has been noted — for instance, bacteria of the genus *Pseudomonas* are often isolated from the lungs of people with cystic fibrosis, which are often infected with fungi called *Aspergillus*[10]. Understanding these microbial networks will further enhance our understanding of disease progression and inform therapeutic interventions.

Another unresolved question is how MBL and the complement system integrate with the rest of the immune system during PDA progression. For example, how do MBL and the complement cascade interact with the signalling pathways triggered by an immune-cell receptor protein called dectin-1? This protein recognizes the fungal cell wall and activates protective antifungal immune pathways, often in collaboration with other receptors, including those that recognize the complement cascade. In addition, dectin-1 can directly recognize proteins on tumour cells and modulate the activity of tumour-killing immune cells[11]. But dectin-1 can also associate with tumour-recognizing receptors, which can promote PDA progression[12]. Thus, it is clear that we need a much better understanding of the complex interplay between the components of the immune system that target fungi and those that target tumours.

This study highlights a role for fungi in the development of cancer. Excitingly, the work points to the possibility of new therapeutic approaches. Perhaps altering microbial communities by directly targeting specific populations could help ameliorate PDA. Alternatively, therapies targeting immune components such as MBL that control fungal infections could provide a route to combat this lethal cancer. ■

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SEISMOLOGY

Predicting if the worst earthquake has passed

When a big earthquake occurs, it is hard to tell if it will be followed by a larger quake or by only smaller ones. A method has been developed that aims to distinguish between these scenarios while events are still unfolding. **SEE ARTICLE P.193**

EMILY E. BRODSKY

After every major earthquake, seismologists warn the public that the danger has not yet passed: aftershocks will continue to shake the ground. These aftershocks usually get smaller over time, but, occasionally, an aftershock will be larger than the original event. Standard earthquake statistics suggest that the latter situation should occur about 5–10% of the time[1,2], but is there any way of knowing which aftershock sequences will behave in this anomalous way? More simply, after a big earthquake, is it possible to determine whether an even larger one is coming? On page 193, Gulia and Wiemer[3] propose an answer to this question. They suggest that, by continuously measuring the relative numbers of large and small earthquakes, comparatively safe aftershock sequences can be distinguished from those that will get bigger.

The magnitude distribution of earthquakes generally follows a relationship known as the Gutenberg–Richter law[4]. Roughly speaking, in most places on Earth, for every earthquake of magnitude 4 or larger, there will be 10 quakes of magnitude 3 or larger and 100 quakes of magnitude 2 or larger. The exact ratio of big to small earthquakes in a particular time or place is described by a parameter called the b value. If this value is low, there will be comparatively fewer small quakes for every big one. And if it is high, there will be more small quakes for every big one.

In previous work, Gulia and Wiemer, together with co-workers, found that the

50 Years Ago

It was recently announced that the United States will cooperate with India in setting up a satellite system for bringing educational TV into 5,000 Indian villages … Under the agreement with India, the sixth of NASA's series of Applications Technology Satellites will receive TV programmes transmitted from a ground station at Ahmedabad and relay them to small village receivers. The programmes will be under Indian control and are expected to be directed at family planning, education in agriculture and to make a much-needed contribution to Indian unity. Direct broadcasting to village receivers is made possible by an increase in the power which can be provided on Geostationary satellites, and by a highly directional aerial, which in turn means that the receivers on the ground can be modest and inexpensive.
From *Nature* 11 October 1969

100 Years Ago

Mr. V. Stefansson describes his successful method of Arctic exploration in an interesting article entitled "Living Off the Country" in the May issue of the *Geographical Review* … Mr. Stefansson's well-known adoption of [local] habits and diet have enabled him to travel … far into the unknown for long periods without any anxiety. He contends that from experience he has found that a diet of flesh or fish is quite sufficient to sustain a person in good physical and mental condition, and that salt is not necessary for health … So convinced is Mr. Stefansson of the abundance of food in the Arctic lands and seas he knows that he asserts that any man conversant with the ways of wild animals and the hunting and living methods of the [local people] can load on one dog-team all the equipment he needs for a journey of several years.
From *Nature* 9 October 1919

Figure 1 | Damage caused by an earthquake aftershock in Norcia, Italy. On 30 October 2016, the town of Norcia was hit by the aftershock of a large earthquake that had occurred two months previously. Unlike most aftershocks, this one was bigger than the original quake. Gulia and Wiemer[3] suggest that it might be possible to predict whether a large earthquake will be followed by a bigger aftershock or by only smaller ones.

b value normally rises during an aftershock sequence, which means that small earthquakes become more common[5]. In the present work, the authors noticed that, occasionally, the *b* value drops instead of rising, implying that big quakes increase in frequency. They also noticed that these sequences are the only ones that contain an aftershock larger than the original quake.

According to the definition of the *b* value, sequences that have low values are more likely to be associated with big earthquakes than are those that have high values. Therefore, Gulia and Wiemer's finding might seem to be merely a restatement of aftershock statistics. However, the authors suggest that the observed pattern is deterministic rather than statistical, on the basis of the fact that a falling *b* value is seen robustly for only two earthquake sequences in the entire data set: the 2016 Kumamoto earthquakes in Japan and the 2016 Amatrice–Norcia earthquakes in Italy (Fig. 1). Each of these sequences contained an anomalously large and damaging aftershock. For nearly all of the other sequences, the *b* value increased directly after the original quake. The authors note one exception to this, which they attribute to poor data quality in the early 1980s.

Making such a claim based on two aftershock sequences might seem bold. But in earthquake science, we are often driven to closely analyse the few examples that are available because nature provides only uncontrolled experiments at irregular intervals. Nonetheless, we need to proceed with extreme caution in the face of such sparse data.

In particular, measuring the magnitude distribution is not as simple as it at first seems. Many judgement calls are required to determine how big the measurement region should be, how to define the normal *b* value for a region and how to account for the fact that many aftershocks are not recorded in the wake of a large earthquake. These decisions must be made for each region, and the decision-making is the Achilles heel of statistical seismology studies such as this one.

For instance, the authors opt to use data collected at least 3 days after the first large Amatrice–Norcia earthquake to compute the *b* value, but used data collected at least 0.05 days after the first Kumamoto event, because of the higher quality of the Japanese earthquake catalogue. If they had waited 0.2 days after the first Kumamoto quake, their traffic-light coding system would have given a yellow warning rather than a red one — that is, a less-definitive warning.

Expert judgement is intrinsic to the design of scientific analyses and, in this case, a different judgement would have led to a different answer. So how can we determine whether the correct decisions have been made? The gold standard of any scientific theory is its ability to predict data that have not been collected when the theory is proposed. Gulia and Wiemer have documented their decisions through a full release of their computer code. As new earthquakes occur, the key test of the paper will be in the reuse of this code.

Earth is already providing us with opportunities to test the authors' claim. The 2019 Ridgecrest earthquakes in California are notable for having a magnitude-6.4 event followed within days by a magnitude-7.1 event (see go.nature.com/2pjalib). Other examples will surely follow. We can all hope for a more predictable future in which these anomalous events cease to be surprises. ■

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