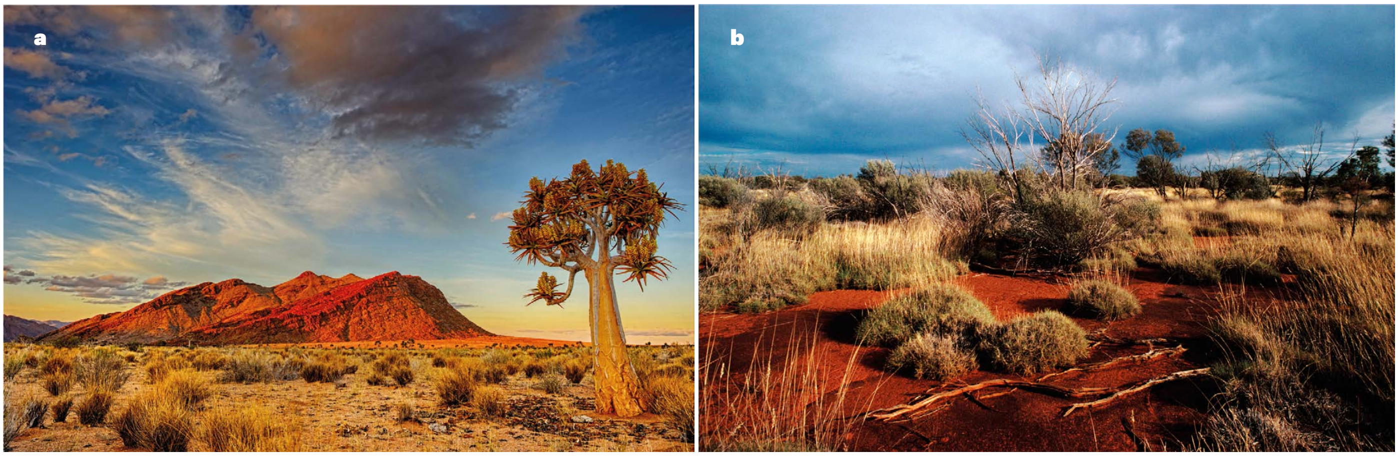

Figure 1 | Biodiversity and climate. Coelho *et al.*[2] examined biodiversity in areas of similar climate around the globe. By comparing places such as the Kalahari Desert in Africa (**a**) and the Great Victoria Desert in Australia (**b**), the study sheds light on the factors that govern global differences in biodiversity.

Ecology

The geography of climate governs biodiversity

Antonin Machac

To explain the interplay of climate, area and isolation that underlies the marked global differences in biodiversity, a switch in focus from geographic space to climatic space offers a way forwards. **See p.537**

Few questions in biology are as enduring and enigmatic as the uneven distribution of species diversity on Earth. From at least the time when Charles Darwin and Alfred Russel Wallace made voyages to the Amazon and the Galapagos, scientists have marvelled at the "vast host of living forms" in the tropics[1]. In today's world of changing climate, research on global biodiversity patterns is not only an academic pursuit but also a crucial quest toward safeguarding species. On page 537, Coelho *et al.*[2] advance this quest by expanding the research into a new realm – the climatic space.

The authors reframe the classic question "Why are tropical regions megadiverse?" into "Why are tropical climates megadiverse?". Motivated by this shift in perspective, Coelho *et al.* navigate uncharted territory by moving between the geographic space, defined by latitude and longitude, and the climatic space, defined by the fundamental parameters of temperature and precipitation. The Amazon and other tropical regions, known for their warmth and humidity, stand in stark contrast to colder, temperate regions, such as New Zealand – as well as to arid deserts, including the Kalahari Desert in Africa (Fig. 1), and the polar extremes experienced in places such as Greenland.

Coelho and colleagues use a grid to define geographic cells, equal-sized areas covering the surface of Earth. Multiple geographic cells might correspond to a particular climatic cell, characterized by a specific combination of temperature and precipitation. The geographic area associated with a specific climate can then be calculated, as can the physical isolation of the geographic cells linked to that climate. This seamless transition between geographic and climatic space goes beyond theoretical exercise, and Coelho and colleagues put it to the test, using data for amphibians, reptiles, birds and mammals.

The authors find that tropical climates cover comparatively large areas that tend to be fragmented across continents. By comparison, temperate and polar climates occupy smaller, more interconnected areas.

Using their conceptually original way of capturing climate, area and isolation, Coelho and colleagues explain more than 90% of the variation in species diversity observed in the climatic space. The authors report that the geography of climate (area and isolation) nearly doubles the effects of climate itself on species diversity. Much of this explanatory power cannot be attributed solely to climate or its geography. Instead, it stems from their joint effects, which cannot be statistically separated. This underscores the idea that the effects of climate, area and isolation are intimately intertwined and therefore need to be studied together.

The findings challenge the conventional wisdom that tropical zones are geographically coherent, given their proximity to each other in both hemispheres. Although these tropical regions themselves are adjacent, tropical climates tend to be fragmented. In line with most biodiversity research, mountain regions emerge as exceptionally diverse, given the geography of their climate; this applies particularly to the Andes of South America. Arid regions, by contrast, harbour lower-than-expected diversity. Because of their extreme conditions, deserts, such as the Sahara, tend to be species poor – even though, compared with mountain regions, they cover expansive and coherent areas.

Research in the climatic space is not without its challenges. The geographic space is unambiguously defined by latitude and longitude. However, the climatic space can, in principle, be defined by a wide variety of climatic variables combined in numerous ways. There is also the issue of scale and how to measure isolation, a challenge that applies to the geographic and the climatic space alike.

Understanding the dynamics of species diversity and the mechanisms through which correlations arise between climate, area and isolation also emerge as remaining challenges for future work. It is possible that, at regional scales, climate and energy availability constrain the number of species that a given area can sustain. At global scales, however, diversity patterns might be governed by the dynamics of species origination, extinction and dispersal. Consequently, tropical climates, which have existed continually for a longer time and cover larger areas than other climates, might serve as the engine of diversity[3], whereas temperate climates – which have less energy and fewer resources for species coexistence – might be constrained in their diversity[4].

Some research, however, has indicated that the opposite might also apply[5]. The comparatively newly opened temperate climates might have the capacity to accumulate new species at high latitudes, whereas the tropics might have had enough time to approach the energetic constraints on species diversity[6]. Although global differences in diversity dynamics are expected, their exact nature remains a point of contention[4,7].

Coelho and colleagues introduce a method that explicitly quantifies area and isolation across various climate types. Rigorously defining tropical and temperate areas might produce more meaningful cross-climatic comparisons, inform the scale-dependence debate and begin to identify the mechanisms that generate the correlations between diversity, climate, area and isolation.

Studying diversity in both geographic and climatic spaces opens up a treasure trove of new patterns to test theories. A true test of a theory is its universality, and the authors demonstrate how climatic space might serve as a common currency, transcending geographic boundaries, continents, latitudes and elevations. Coelho and colleagues present a fresh canvas on which to explore diversity patterns, and thereby invite researchers to delve deeper, explore further and pursue a more profound understanding of Earth's biodiversity. This quest has become increasingly important in today's world.

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Quantum physics

Searching for phase transitions in the dark

Edoardo Baldini

An electrically insulating quantum material turns metallic when placed between two semi-reflecting mirrors – even if there is no illumination between them. This discovery paves the way for engineering other phase transitions. **See p.487**

Take a conventional laser apart and you will find an arrangement of mirrors called an optical cavity, which is a structure that traps light at certain frequencies to form standing waves. A different class of optical cavity can be engineered to manipulate simple quantum systems[1,2] – to tweak the chemical reactivity of a molecular complex, for example[3]. Remarkably, this control can be achieved without any external illumination, even though it involves tuning interactions between light and matter. On page 487, Jarc *et al.*[4] have shown a glimmer of success in extending this principle to more complex quantum solids[5,6], by reporting a cavity that can offer reversible control over an archetypal phase transition.

The authors studied tantalum disulfide, a material with peculiar star-shaped charge patterns that are induced by the cooperation between its ions and electrons. The ordering of these clusters is thought to have a pivotal role in certain phase transitions, particularly one in which the material transforms from metallic to electrically insulating as the temperature changes. This transition, and the material's sensitivity to external stimuli, make tantalum disulfide an ideal platform for exploring the concept of cavity engineering in the realm of quantum matter.

In Jarc and colleagues' experiments, a thin sample of tantalum disulfide was carefully positioned between two semi-reflecting metallic mirrors (Fig. 1). The mirrors were mechanically adjustable, so their separation and alignment could be controlled precisely, creating a tunable cavity that was able to sustain standing waves that span sub-micrometre to centimetre wavelengths. Jarc and colleagues began by using a faint stream of photons to measure the conductivity of the tantalum disulfide sample as they altered the configuration of the mirrors. The photon stream was generated at a frequency that could probe the insulator-to-metal transition, while minimizing disturbance to the electromagnetic environment in the cavity. It served solely to detect any possible cavity-induced phenomena.

This approach yielded a remarkable discovery: a cavity tuned to resonate in the gigahertz frequency range brought about a pronounced – and rather surprising – modification to the thermodynamics of the insulator-to-metal transition. Specifically, the authors were able to switch back and forth between the metallic and insulating phases simply by tuning the cavity length and its mirror alignment. The transition could be induced without the authors having to manually change the temperature. The physical parameters of the cavity itself had become tuning knobs for the material's electronic properties.

Jarc *et al.* investigated whether their observations were a result of black-body radiation arising from the proximity of the mirrors, but they ruled out this possibility because it could not fully explain the change in transition temperature. Instead, the measurements led them to conclude that quantum electrodynamic phenomena were responsible for the effect.

There are two known pathways through which a cavity can affect a phase transition. The first involves the sample exchanging heat with the cavity and with the environment around the cavity. In this case, the quantum electrodynamics of the cavity do not alter the intrinsic material properties of the sample, but rather they reconfigure how heat is transferred from the surrounding environment to the sample. This process causes a change in the emission spectrum of the sample and thus in its temperature, enabling the phase transition to be manipulated. It bears a resemblance to a phenomenon known as the Purcell effect, in which a quantum system's tendency to spontaneously emit radiation varies inside a cavity[7].

The second possibility is that the cavity