causes underlying an observed decline: changes can be traced back to reveal which taxonomic groups or ecosystems are losing populations of species the fastest, and whether the overall deterioration is due to many declining populations, a few localized extinctions, or a combination of the two.

The problem of data availability has been sidestepped rather than solved: Scholes and Biggs' calculation is based on expert opinion about how various species fare under different land use in each ecosystem. Clearly, real data would be preferable. But this method might also help to encourage the collection of data, because sampling systems established against this framework would be both achievable and useful, and might therefore be more likely to be implemented.

In addition, because land-use change is incorporated into the index, the results suggest where best to direct efforts to mitigate loss of biodiversity. For example, Scholes and Biggs' BIIs for different taxa (Fig. 1 on page 47) show the relative sensitivity of birds, mammals and amphibians to a change in land use from moderate to degraded — that is, use at a rate exceeding replenishment and causing widespread disturbance. Thus, this method has already moved beyond the stage of designing measures to suggesting actions to achieve the target. ■

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Sonoluminescence

Cavitation hots up

Detlef Lohse

Gas inside collapsing bubbles can become very hot and, as a result, emit light. It turns out that temperatures of more than 15,000 kelvin can be reached — as hot as the surface of a bright star.

In 1917, Britain's Royal Navy had problems with bubble cavitation. This is a process in which tiny bubbles grow in size and then collapse as a result of pressure variations in the turbulent water around ships' propellers. The process is so violent that it was causing considerable damage to the propellers[1], so the navy asked the renowned physicist Lord Rayleigh to analyse the problem[2]. His research led to what is now called the Rayleigh equation, which describes the dynamics of the collapsing bubble walls[1,2]. However, the solution to the equation produced a singularity. It implied that, during collapse, the gas inside the bubble is compressed so fast that it cannot equilibrate with the surrounding liquid, leading to energy focusing and an infinite temperature increase. In reality, of course, this cannot happen, so the question is: what limits the temperature increase, or, in other words, how hot does the bubble get? On page 52 of this issue[3], Flannigan and Suslick report a study of light emission from single bubbles during cavitation, and provide a direct answer to this question.

The temperature reached by the collapsing bubble depends on how much of the focused energy is lost by sound emission at the collapse and how much is consumed by internal processes such as vibrations, rotations, dissociation and eventually ionization. If there are many collapsing bubbles, they disturb each other, which leads to a less-spherical collapse and therefore less-efficient energy focusing. Nonetheless, temperatures can rise so high that the bubbles start to glow. This phenomenon has already been investigated intensively by using sound waves to drive bubble production in liquids and then detecting the light emitted; the sound waves cause a temporarily reduced pressure in the liquid, which makes the bubbles grow and eventually collapse again (Fig. 1, overleaf). So far, emission spectra with a detailed line structure have only been observed for many transient bubbles together (so-called multi-bubble sonoluminescence). Analysis of the emitted spectral lines[4] indicates that the temperature reached inside these bubbles is around 5,000 kelvin.

In single-bubble sonoluminescence[5,6], an isolated and stable bubble is studied; disturbances from other bubbles are absent. The light emission from such a bubble can be more than 10^7 photons per flash[7]. As the bubble is driven periodically with sound waves at frequencies of typically 20–40 kHz, the emitted light is visible to the naked eye.

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100 YEARS AGO

"Charge carried by the α Rays from Radium." I have recently attacked this problem again, using the methods and apparatus previously described, but, in addition, employing a strong magnetic field to remove the slow-moving electrons present with the α particles. The apparatus was placed between the pole-pieces of an electromagnet, so that the field was parallel to the plane of the plates. In such a case, most of the escaping electrons describe curved paths and return to the plate from which they set out. On application of the magnetic field, a very striking alteration was observed in the magnitude of the current. The positive and negative currents for a given voltage were greatly reduced. The upper plate, into which the α particles were fired, rapidly gained a positive charge… I think these experiments undoubtedly show that the α particles do carry a positive charge, and that the previous failures to detect this charge were due to the masking action of the large number of slow-moving electrons emitted from the plates… Since the film of radium bromide is so thin that all the α particles escape from its surface, it is easy to deduce from the observed charge from a known weight of radium the total number of α particles expelled per second from one gram of radium bromide… a most important constant, for on it depends all calculations to determine the volume of the emanation, and of helium, the heat emission of radium, and also the probable life of radium and the other radio-elements. **E. Rutherford**

From *Nature* 2 March 1905.

50 YEARS AGO

While recognizing the greatness of its opportunities and responsibilities in Europe, the [British] Council remarks: "It would be an exaggeration but not an untruth to say that a much closer understanding of the Englishman and his ways exists at Karachi than at Lyons, partly because Englishmen are a more familiar sight in one city than in the other, and partly because an outward similarity of culture helps to mask a basic difference of mental approach."… The Council exists as a body which helps to interpret overseas the permanent features of the British way of national life and to make available to the rest of the world the British contribution to knowledge, welfare or enjoyment.

From *Nature* 5 March 1955.

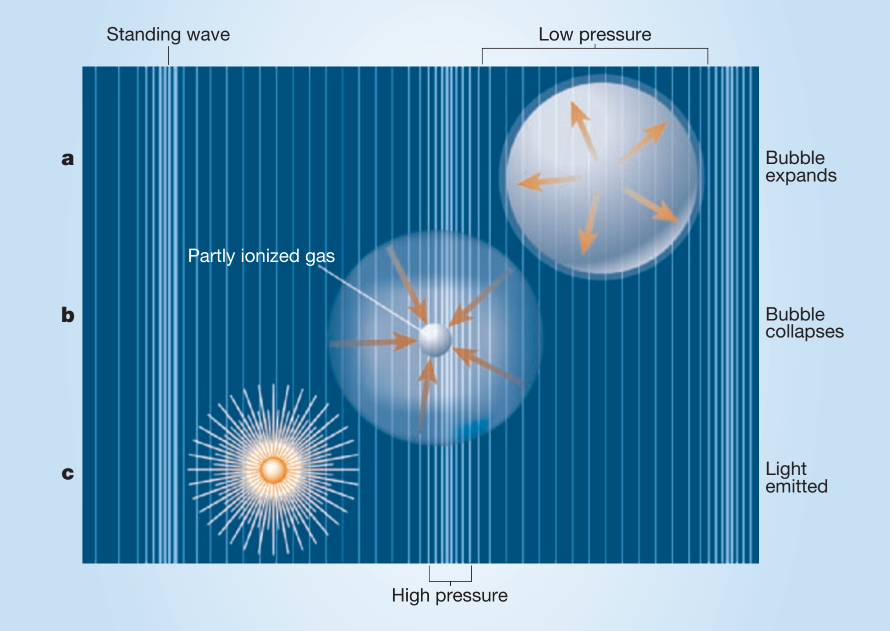

Figure 1 **Bubble sonoluminescence — bubbles are driven by sound waves to emit light.** a, **At low sound-wave pressure, a gas bubble expands until** (b) **an increase in pressure triggers its collapse. Flannigan and Suslick[3] find that, during collapse, temperatures can soar to 15,000 K, as the authors observed from spectra of light emitted from the bubble** (c)**. Analysis of the emission spectra also provides direct evidence for the existence of a plasma inside the collapsing bubbles.**

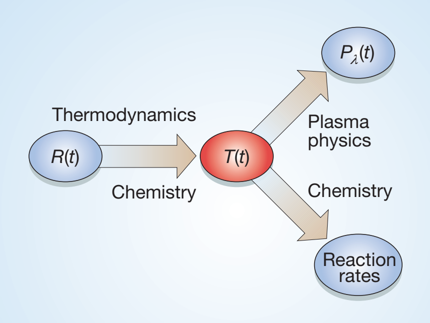

Figure 2 **Indirect evidence for the temperature reached inside a collapsing bubble. Hitherto, the temperature $T(t)$ (as a function of time t) in single collapsing bubbles could only be deduced indirectly, using modelling steps to link observable parameters (blue circles) such as the chemical reaction rates[11], bubble radius $R(t)$, and the spectral radiance $P_\lambda(t)$. Flannigan and Suslick[3] have measured the temperature directly from light-emission spectral lines.**

However, it has previously been difficult to deduce the temperature reached, as the emission spectra from single bubbles were basically featureless.

But Flannigan and Suslick[3] have obtained well-resolved spectral lines for the single-bubble case. They use xenon- and argon-filled bubbles in sulphuric acid, a set-up that has various advantages[6]. First, the high fluid viscosity of sulphuric acid ensures a stable spherical shape for relatively large bubbles. Second, monoatomic gases such as argon and xenon do not consume energy in rotational and vibrational degrees of freedom, and so more of the focused energy ends up as thermal energy. Third, because of the low vapour pressure of sulphuric acid, hardly any (polyatomic) vapour molecules invade the bubble at expansion; that would also eventually lead to additional energy absorption. In this way, Flannigan and Suslick are able to observe a thousand times more photons than observed from xenon and argon bubbles in water. As a result, they obtain good spectral details, from which a temperature of 15,000 kelvin is deduced — as high as is found at the surface of bright stars.

Perhaps an even more remarkable finding is that the emission spectra indicate the existence of plasma (ionized matter) inside the collapsing bubbles. Flannigan and Suslick observe that there are highly excited emissive states, which is inconsistent with thermal processes. Instead, some of the emitted light must originate from high-energy electrons and ions that are decelerated owing to collisions inside the gas bubble.

The presence of a weakly ionized plasma and the origin of the light emission, as well as the high temperatures in single bubbles, have been predicted theoretically[6,8–10], but experimental evidence has been indirect. In previous work, the deduction of the bubble temperature from observable parameters required modelling assumptions (Fig. 2). Flannigan and Suslick's experiments are a milestone in single-bubble sonoluminescence, as they constitute the first direct measurement of the temperature and the state of matter in a single bubble at collapse. ■

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Cell cycle

Cyclin guides the way

Curt Wittenberg

The main enzymes that drive cell division can work on numerous substrates, but how is their specificity ensured? Regulatory subunits show the way, using various tricks to guide enzymes to their targets.

Even before Walther Flemming coined the term 'mitosis' in the 1880s, the choreography of cell division fascinated scientists. Since then it has become clear that the events that define different phases of the cell-division cycle are driven by distinct forms of an enzyme known as cyclin-dependent protein kinase.

Protein kinases facilitate the transfer of phosphate to protein substrates, generally altering their function or fate. As their name suggests, the cyclin-dependent kinases (CDKs) depend for their activity upon the binding of a regulatory subunit called a cyclin to the catalytic subunit. Many organisms use numerous cyclins (and in some cases numerous CDKs) to drive the cell cycle. Different cyclin–CDK complexes phosphorylate different substrates and so have different effects. But how do cyclins influence the capacity of their catalytic partners to recognize substrates? On page 104 of this issue, Loog and Morgan[1] report that they can do so by altering the affinity of CDKs for their targets.

Structural complementarity between substrates and the active sites of enzymes — first proposed more than a hundred years ago by Emil Fischer in his 'lock-and-key' model — is in theory sufficient to account for the ability of the enzymes to discriminate