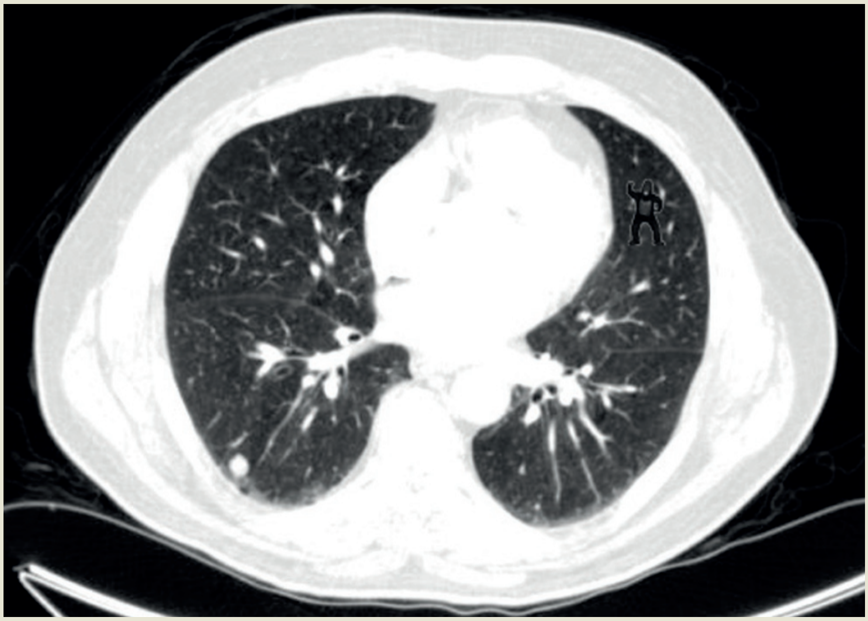
PSYCHOLOGY

Spot the gorilla

If it's not relevant you may miss it. This phenomenon of inattentional blindness is well documented; in a classic study, most observers asked to monitor a video of a ball game missed a gorilla on the court. But would experts also miss a gorilla? Yes, according to a study on the subject (T. Drew *et al. Psychol. Sci.* http://doi.org/m9s; 2013).

The authors asked 24 radiologists to search for lung nodules (small, bright circles) in several chest scans; the final scan (pictured) contained the image of a gorilla, 48 times larger than an average nodule. Surprisingly, and perhaps worryingly, 83% of the experts missed the gorilla. It is somewhat reassuring that the miss rate among non-medical observers performing the same task was even higher. **Sadaf Shadan**



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NANOTECHNOLOGY

Tiny thermometers used in living cells

Nanometre-scale thermometers that operate with millikelvin sensitivity have now been made from diamond crystals. The devices have been used to measure temperature gradients in living cells. SEE LETTER P.54

KONSTANTIN SOKOLOV

Despite many promising studies, taking temperature measurements of environments at nanometre-scale resolution remains a formidable challenge. On page 54 of this issue, Kucsko *et al.*[1] report a precious solution to this problem: a thermometer based on diamond nanocrystals, also known as nanodiamonds. This sensing tool could have many applications, ranging from studies of cell biology to measurements of nanoscale chemical reactions.

Temperature affects diverse physical phenomena. For example, changes in Earth's temperature patterns can lead to the formation of severe storms, droughts and floods. Temperature governs the kinetics, activation and equilibrium states of chemical reactions. And in humans, body temperature is precisely controlled, so that any deviation from the normal range triggers a cascade of biomolecular mechanisms to restore the body's equilibrium. Scientists have therefore developed a range of precise temperature-measuring tools — from satellites to infrared cameras, and a variety of more familiar thermometers — to measure temperature over length scales from multiple kilometres to submillimetres. But how can we measure temperature at length scales of a few micrometres, or a few tens of nanometres?

Kucsko and co-workers' approach is to use the unique properties of electron spins associated with single-nitrogen-atom impurities in diamonds. The presence of a nitrogen atom in a diamond's carbon-atom lattice creates a point defect called a nitrogen vacancy (NV) centre, in which the nitrogen and a vacancy replace two neighbouring carbons. The ground state of an NV centre is split into two energy levels: the spin state of the lower level is 0, whereas that of the higher level is 1. The energy difference between the levels, known as the ground-state energy gap, is highly sensitive to temperature because it varies in response to thermally induced lattice strains. The principle of diamond thermometry is based on accurate measurement of changes in the transition frequency associated with this energy gap — the microwave frequency that corresponds to the energy difference between the lower and higher levels.

In their technique, Kucsko and colleagues used green light to excite electrons in NV centres, which then decayed to the ground state by emitting red fluorescence. The intensity of the fluorescence depends on the spin state of the NV centres. The authors also irradiated their nanodiamonds with microwaves to modulate the electron occupancy of the ground spin states 0 and 1, and determined the occupancy of the states from the observed fluorescence. They then used this information to work out the changes in the ground-state energy gap that are associated with temperature variations.

The researchers first used an isotopically pure (carbon-12 isotope) bulk diamond sample to determine the ultimate sensitivity of their NV-based thermometry. In this system, they detected temperature changes with an accuracy of up to 1.8 millikelvins under ideal experimental conditions. Similar sensitivity has just been reported by other groups[2,3] using analogous experimental techniques and conditions.

However, Kucsko *et al.* went further by demonstrating how nanodiamond thermometers can measure the temperatures in living cells (Fig. 1). They used a clever nanowire-assisted delivery method[4] to position nanodiamonds and gold nanoparticles inside the cells. When excited by laser light, the gold nanoparticles acted as localized heat sources. By using their technique to measure sub-kelvin temperature changes inside a single cell, the authors directly monitored the amount of heat generated by a single gold nanoparticle that was required to kill the cell.

Kucsko and colleagues' nanodiamond temperature sensors have high spatial resolution together with sub-kelvin thermal sensitivity, chemical inertness, biocompatibility and the