Less is more: dimensionality reduction as a general strategy for more precise luminescence thermometry

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Temperature and heat exchange are at the base of biological processes throughout the realm of Nature. Several of these biological processes are associated with temperature changes in the order of few degrees or even below 0.1 degrees Celsius. To reliably monitor these processes, approaches that minimally perturb the studies system and with thermometric precision below 0.1 degrees Celsius are needed.

To this end a team of scientists from Spain and Portugal has cracked the code for an increased precision in the thermal readout using luminescent nanothermometers. These are nanomaterials whose optical properties are sensitive to temperature changes, and they can be inserted in biological (micro)environments to act as temperature nanoprobes down to the single-cell level. With their reduced size (Figure 1) they comply with the prerequisite of minimal perturbation of the probed system. However, when operating in aqueous environments, the precision in the readout of the temperature is generally above 0.1 degrees Celsius.

To calibrate a luminescent nanothermometer, changes in the optical properties of the nanomaterial are quantitatively correlated with variations in the temperature of the surrounding environment. This calibration passes through the selection of a suitable thermometric parameter and the acquisition of a calibration dataset, meaning that the photoluminescence (photon absorption followed by photon emission) of the nanothermometer is recorded as a function of a set of temperatures. Through the use of large-data analysis approaches collectively referred to as dimensionality reduction (Figure 2), the researchers have demonstrated that it is possible to automatize the selection of the thermometric parameter that maximizes the precision of the thermometric approach.

Reference

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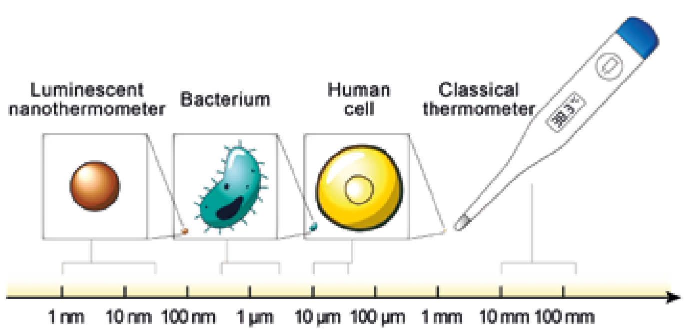

FIGURE 1
Size comparison of thermometers. Luminescent nanothermometers have a size that is much smaller than bacteria and human cells, making the measurement of temperatures in such small organisms possible.

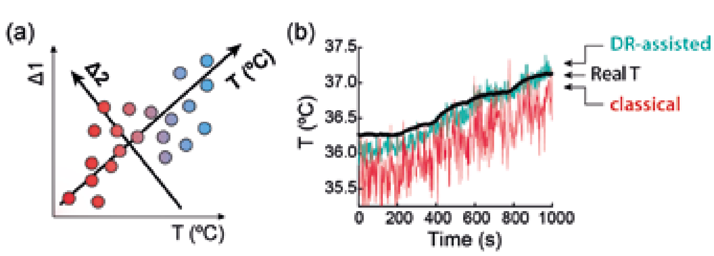

FIGURE 2
Dimensionality reduction in luminescence nanothermometry. (a) The application of a dimensionality reduction approach (in this case a linear transformation such as Principal Component Analysis) results in the definition of a new space of coordinates wherein a temperature change is more easily quantifiable.
(b) An example of the increased precision of luminescence nanothermometry achieved applying dimensionality reduction (DR) approaches (*teal line*) compared to a classical trial-and-error approach (*magenta line*) to define the thermometric parameter. The *black line* is the real temperature of the medium in which the luminescent nanothermometers are embedded.