Doing it like Mother Nature

THE RIGHT SURFACE TEMPERATURE HELPS KEEP THE INSIDES WARM OR COOL, SAYS S ANANTHANARAYAN

Nature provides ways for animals to adjust their skin temperature so that they cool fast when it is warm or lose less heat when it is cold. Finding a way to do this for houses and buildings could save much cost in airconditioning in the summer and heating in the winter. University of Toronto Professor Ben Hatton and his colleagues at Harvard University and the Broad Institute, Cambridge, Massachusetts, report in the journal *Solar Energy Materials and Solar Cells* that they have created a surface to lay on glass windows, which has channels to carry water, like the narrow blood vessels that are found in the skin of animals. The mechanism is not the same as in animals, but the arrangement helps cool the window during hot weather, at any rate.

Ventilation and lighting of buildings calls for large windows and windows have glass panes. While light streams in through the glass and keeps the interiors well lit, glass blocks infra red radiation and soon heats up. The glass windowpanes of a building, on a warm day, can get as hot as the asphalt outside. The result is that the panes radiate heat into the building, like large heating coils, to the discomfort of occupants, or burning up the owner, if there is airconditioning, when he/she receives the energy bill. The authors of the paper say that of the total building energy costs, for cooling and heating, some 40 per cent is estimated to arise because of windows.

Keeping cool: Natural systems, as in warm-blooded animals, need to, in the case of buildings, control internal temperature despite outdoor extremes. Thus, the body needs to stay cool even when it is hot, or after exercise, and has to stay warm even when during a hard winter. Or else rising temperature would block vital processes, like the working of the brain, or there would be great energy loss in keeping warm when it is cold outside. Natural systems have evolved to control temperature in the most efficient way by controlling the surface temperature.

Thus, in warm weather when the body needs to lose heat or receive less heat from the surroundings, the surface temperature, which is the skin temperature, is kept high, nearly the same as the temperature inside. But in cold weather, when the body needs to lose the least heat possible, the skin temperature is kept low, well below the internal body temperature. The way the body manages this is by adjusting the diameter of the blood vessels that are right at the exterior, or the *peripheral capillaries*. When temperature falls, the nervous system causes constriction of the capillaries and less warm blood flows at the surface. The surface of the skin is, thus, cooler and there is less heat loss. On the other hand, if the body needs to lose heat, like after exercise or when it has a fever, or when the weather is warm, the surface temperature needs to be higher. The nervous system then widens or *dilates* the peripheral capillaries and more warm blood flows at the surface and the temperature rises.

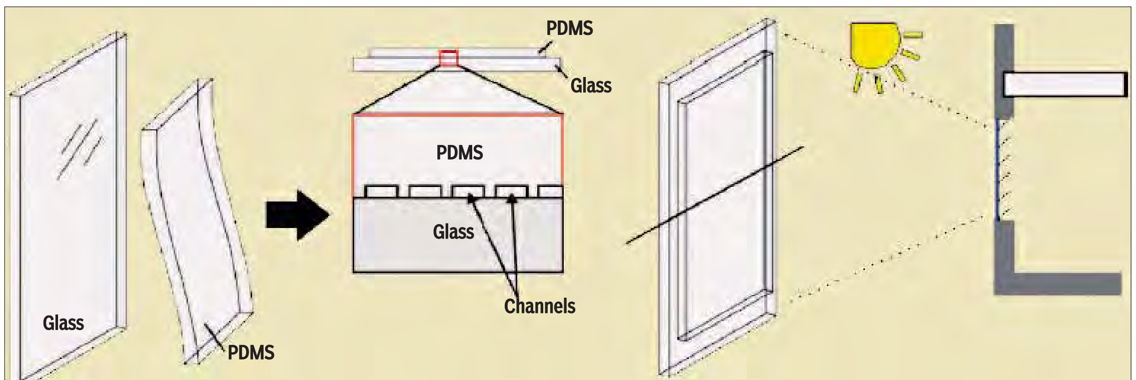
People who live in cold climates adapt, or generally have constricted outer capillaries, to conserve heat. When such people visit warmer places, it takes the body some time to adjust and for a few weeks, or longer, these people would find the heat difficult to bear. The converse is true when people from the plains take a holiday in the hills – they suffer from the cold and do not adapt till it is time to come home again!

Ben Hatton

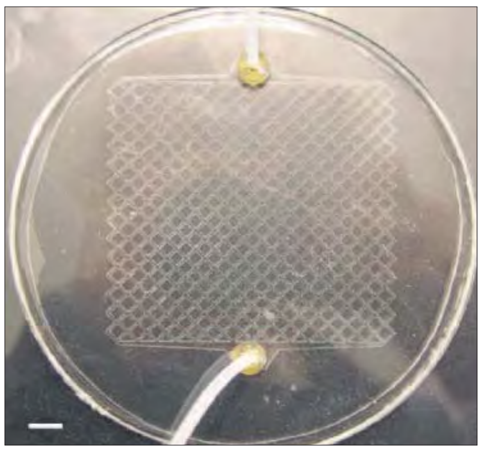
Window to saving power: Ben Hatton and colleagues took a cue from nature and did the same things with glass windows. They created a plastic sheet made of *polydmethylsiloxane* (*PDMS*), a flexible and transparent material, and embedded narrow channels into the sheet. Water could be allowed to flow through these channels so that the glass pane on which the plastic sheet was applied could be cooled. Room temperature water either began to warm and flow upwards, due to convection, or it could be pumped through the film. But the result, in either case, was that the glass pane cooled to almost the temperature within the building and no longer added to the heat load the interior had to handle.

The warm water flowing out of the film could be passed through a cooling tower or used for any warm water application or even with an energy recovery arrangement. During the winter, when windows cause loss of heat to the exterior, flowing water would stem the loss of heat by carrying it away for recovery and reuse. Ben Hatton and colleagues even suggest using coloured or stained water to control the level of light admitted, or for aesthetics.

Solar cells: While on the subject of temperature control and energy saving, the solar cell is now an important source of non-polluting energy that depends on sunlight. The glass surface of the solar cell, like windowpanes, also warms in sunlight and the rise in temperature seriously affects the performance of solar cells. The loss of performance can be as high as five per cent for every degree Celsius. Ben Hatton and colleagues suggest using their PDMS film on solar cells to keep them cool and productive. As against saving energy used for airconditioning, in the case of windows of buildings, this would be an application where the efficiency of energy generation is enhanced.



Windowpane with sheet of PDMS that is provoded with channels to carry water



A piece of PDMS with an array of micro-channels

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Alcohol & the capillaries

Alcohol has the effect of dilating the peripheral capillaries. A stiff drink when one comes in from the cold would make the skin grow warm and this would warm up the woollen garment the person would be wearing, and he/she would be comfortable. But that same drink taken when not securely wrapped up would lead to faster loss of heat and may prove harmful.

The story is told of soldiers or campers at high altitudes who have a drink before they get into their sleeping bags. The drink makes it uncomfortably hot and, being a little drunk, the persons unzip the sleeping bags. If they are not careful to pull the zip back up, they may not wake up in the morning!

CENTRIFUGING COMPONENTS

TAPAN KUMAR MAITRA EXPLAINS AN INDISPENABLE TECHNIQUE OF CELL BIOLOGY

Centrifugation is an indispensable procedure for the isolation and purification of organelles and macromolecules.

This method is based on the fact that when a particle is subjected to centrifugal force, its rate of movement through a specific solution depends on the particle's size and density, as well as the solution's density and viscosity. The larger or more dense a particle, the higher its sedimentation rate, or rate of movement through the solution.

Because most organelles and macromolecules differ significantly from one another in size and/or density, centrifuging a mixture of cellular components will separate, or resolve, the faster-moving components from the slower-moving ones. This procedure is called sub-cellular fractionation, and enables researchers to isolate and purify specific organelles and macromolecules for further manipulation and study *in vitro*.

Albert Claude, George Palade and Christian de Duve shared a Nobel Prize in 1974 for their pioneering work in centrifugation and sub-cellular fractionation. Claude played a key role in developing differential centrifugation as a method of isolating organelles. Palade was quick to use this technique in studies of the endoplasmic reticulum and the Golgi complex, establishing the roles of these organelles in the biosynthesis, processing and secretion of proteins.

De Duve, in turn, discovered two entirely new organelles — lysosomes and peroxisomes. His discovery of lysosomes depended on differential centrifugation, whereas his discovery of peroxisomes depended on equilibrium density centrifugation.

In addition to differential centrifugation and equilibrium density centrifugation, density gradient centrifugation is also commonly employed for resolving organelles. The latter two techniques are also useful for resolving the components of mixtures of macromolecules, such as nucleic acids or proteins.

In essence, a centrifuge consists of a rotor — often housed in a refrigerated chamber — spun by an electric motor. The rotor holds tubes that contain solutions or suspensions of particles for fractionation. There are two basic types of rotors: a fixed-angle rotor holds the tubes at a specific angle, whereas a swinging-bucket rotor has hinges that allow the tubes to swing out horizontally as the rotor spins. Centrifugation at very high speeds — above 20,000 revolutions per minute — requires an ultracentrifuge equipped with a vacuum system to reduce friction (between the rotor and air) and armour plating around the chamber to contain the rotor in the event of an accident. Some ultracentrifuges reach speeds over 100,000 rpm, subjecting samples to forces exceeding 500,000 times the force of gravity (g).

Tissues must first undergo homogenisation, or disruption, before the cellular components can be separated by centrifugation. To preserve the integrity of organelles, homogenisation is usually done in a cold isotonic solution such as 0.25 M sucrose. Disruption can be achieved by forcing cells through a narrow orifice by subjecting tissue to ultrasonic vibration, by osmotic shock, or by grinding the material manually with a mortar and pestle. The resulting homogenate is a suspension of organelles, smaller cellular components and molecules. If tissue is homogenised gently enough, most organelles and other structures remain intact and retain their original biochemical properties.

Differential centrifugation separates organelles on the basis of size and/or density differences. Particles that are large or dense (purple spheres) sediment rapidly, those that are intermediate in size or density (blue spheres) sediment less rapidly and the smallest or least dense particles (black spheres) sediment very slowly.

Sedimentation coefficients are expressed in Svedberg units (S), in honour of Theodor Svedberg, the Swedish chemist who developed the ultracentrifuge between 1920-1940. The sedimentation coefficients of some organelles, macromolecules, and viruses are shown.

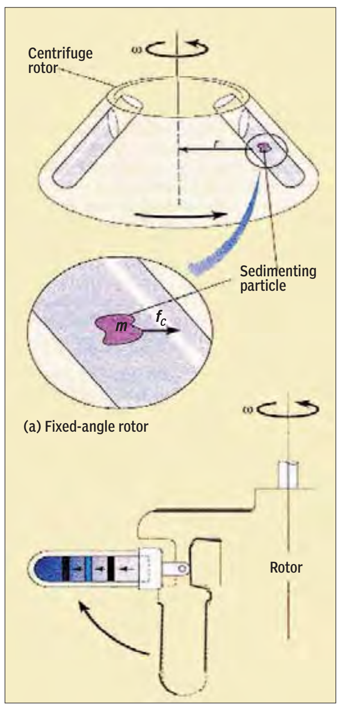
To illustrate an example of differential centrifugation, the tissue of interest is first homogenised (1); subcellular fractions are then isolated by subjecting the homogenate and subsequent supernatant fractions to successively higher centrifugal forces and longer centrifugation times (2-5); the supernatant is the clarified suspension of homogenate that remains after particles of a given size and density are removed as a pellet following each step of the centrifugation process. In each case, the supernatant from one step is decanted, or poured off, into a new centrifuge tube and then returned to the centrifuge and subjected to greater centrifugal force to obtain the next pellet. In successive steps, the pellets are enriched in nuclei, unbroken cells and debris (2); mitochondria, lysosomes, and peroxisomes (3); ER and other membrane fragments (4); and free ribosomes and large macromolecules (5).

The material in each pellet can be resuspended and used for electron microscopy or biochemical studies.

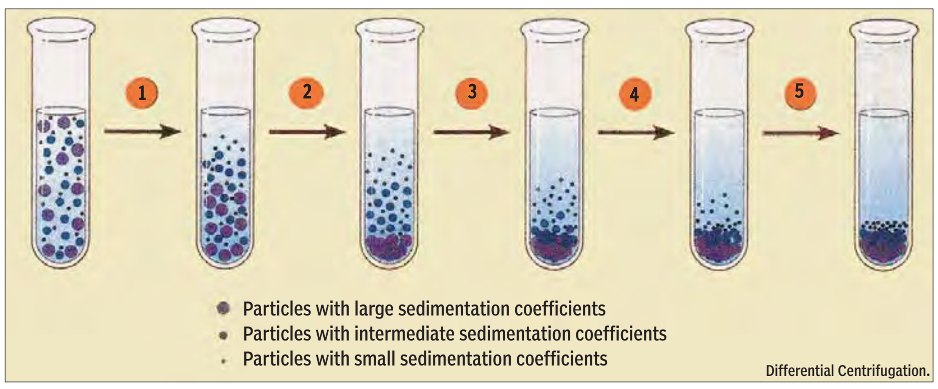
The final supernatant consists mainly of soluble cellular components and is called the cytosol.

Equilibrium density (or buoyant density) centrifugation is a powerful method for resolving organelles and macromolecules based on density differences. This procedure includes a gradient of solute that increases in concentration and density, but in the solute is concentrated so that the density gradient spans the range of densities of the organelles or macromolecules about to be separated. For organelles, a gradient of sucrose is often used, and the density range is 1.10-1.30 g/cm^3 (0.75 - 2.3 M sucrose).

This method can also be used to separate different forms of DNA and RNA based on their differing densities. Because these macromolecules have higher densities than organelles, a heavy metal salt, such as cesium chloride (CsCl), is commonly used for the density gradient. For a classic experiment in which CsCl density gradients were used to resolve double-stranded DNA molecules containing nitrogen isotopes ^{14}N versus ^{15}N, as well as to detect hybrid DNA molecules containing both isotopes.



Centrifuge Rotors. A centrifuge rotor either (a) holds the tubes at a fixed angle or (b) has hinged buckets to allow the tubes to swing out parallel to the centrifugal force during centrifugation.



Differential Centrifugation.

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PLUS POINTS

Crickets, anyone?

The great furry leaves of the giant South American rhubarb glow in the glorious sunshine under a perfect sky and the air is alive with that magical sound of chirping crickets. Welcome, of course, to suburban Oxford. "I just chucked them down there," says Daniel Emlyn-Jones, a 40-year-old plant scientist, pointing to a bush near the fence of his narrow garden in a fairly typical Oxford street.Two weeks ago he ordered 500 crickets from an online reptile centre, hoping to bring some sweet music to his extraordinary tropical garden, and also to fill the gap that has been left in his life by his now deceased pet tarantula. It has worked. Close your eyes and listen and you can see a fireball sun drop beneath the African savannah. Or if not that, at least the shimmering surface of some terrible Greek hotel swimming pool in those enchanted hours immediately after darkness, and hopefully before anyone's thrown up.

His letter to *The Independent*, published on 26 July, has drawn quite a response from readers. Unfortunately, most of Daniel's little beasts promptly legged it into next door's more traditional English garden, where the patio is unencumbered by giant South American rhubarb, and they lie there and bake, occasionally having to scarper from the "inquisitive" cats.

Luckily, the neighbours don't mind a bit. "It's lovely sitting out and listening to them," says Mike from next door. "It lets you imagine you're in a foreign country. At night, when you're going to sleep, it's very relaxing."

Only the males make the chirping noise, technically known as stridulation. It is their mating call, but it's not made through rubbing their legs together, as many believe. Rather, each wing has a long set of teeth at the bottom, like a comb, which it rubs against the flat surface of the other wing; the wings are held up and open, enabling the creatures to broadcast the sound to whomever they hope is listening.

At night, says Daniel, the calling is much louder and more prolonged. "That's when they mate, I think. During the day I think the noises are more territorial." He's right. There are, in fact, four distinct chirps. A loud calling song to attract females and scare off other males (think Justin Timberlake); a quiet courting song deployed when a lady cricket is near (Barry White); an aggressive song triggered by the presence of another male (think Mel Gibson in *Braveheart*); and a final, very short, post-copulatory ditty.

He paid £40 for his 1,000 crickets, and if they carry on transforming this so-far most wondrous of summers into something even more blissful, then that's cheap at the price.

TOM PECK/THE INDEPENDENT

Autism link

A mother-to-be exposed to high levels of air pollution is at a higher risk of giving birth to a child with autism, say researchers at the Harvard School of Public Health in the USA. Autism is a neuro-development disorder that manifests by the age of three. An autistic child typically has difficulties in communication, has trouble learning, adjusting to changes and does the same thing over and over, like repeating a word.

"So far there is no cure for autism and the disorder has to be managed so that the child can lead an independent life," says Praveen Suman, pediatrician at Sir Ganga Ram Hospital in Delhi. Though scientists are yet to determine what causes autism, there is increasing evidence that environmental factors affecting the womb could be behind the developmental disorder.

The HSPH researchers crunched data from Nurses' Health Study II, a long-term study at Brigham and Women's Hospital in the USA that began in 1989. Of the 116,430 nurses involved in the study, the authors studied 325 who had a child with autism and 22,000 with children without the disorder.

Their results show that those who live in locations with the highest levels of diesel particulates or mercury in the air are twice as likely to have a child with autism as those who live in less polluted areas.

SOUNDARAM RAMANATHAN/CSE-DOWN TO EARTH FEATURE SERVICE