Beating the heat

s ananthanarayanan explains how animals display ingenious forms of adaptation to survive in harsh environments

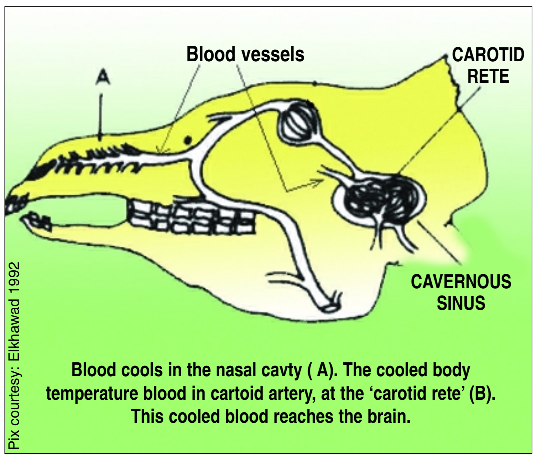
THE Arabian oryx or large black and white antelope is one example of animals adapting to extreme conditions in the arid areas of Africa. This instance of evolution "to the very edge", which even sports a built-in refrigeration system to save its hypothalamus, was officially declared extinct 40 years ago. Fortunately, in the early 1960s, the late Sheikh Zayed bin Sultan Al Nahyan, founder of the United Arab Emirates, arranged for two breeding pairs of Arabian Oryx to be caught and preserved as the nucleus of a captive-breeding programme

The release of captive-born Arabian Oryx individuals into suitable habitats was carefully planned and started in 2007. With close monitoring, the programme has been effective and it is estimated that there are now 1,100 of the animals in the wild and 6,000 in zoos, reserves and private collections.

The places the Oryx inhabits see effectively no rainfall, no vegetation except for patches of grass and shrubs and daytime temperatures higher than 45° Celsius. The Oryx, then, has adapted to need no surface water for survival. The only moisture is from the grass and shrubs, on which the animal grazes during the night. By feeding during the night, it saves on valuable fluid loss and also benefits from greater moisture content of the grass. In the day, it aligns itself to present the least area to the sun and will seek shady spots or lie in cooler mud to shed heat. The oryx's white belly also helps deflect the heat from the hot, desert sand.

Shedding heat

The great challenge, in fact, is to shed heat and maintain body temperature. Nature has two main categories of animals – warm-blooded and cold-blooded. Being warm-blooded means the animal has to maintain its body temperature, which needs energy – burning calories when it is cold and usually cooling by sweating when it is warm. The cold-blooded animal simply takes the temperature of the environment and manages with much less calorie intake. But metabolic processes are slower at low temperatures and cold-blooded animals often spend long periods in hibernation, becoming active only when the environment warms up. Warm-blooded animals are active throughout the year and are equipped to exploit the surroundings for more nutrition.



Pix courtesy: Elkhawad 1992

Blood cools in the nasal cavty (A). The cooled body temperature blood in cartoid artery, at the 'carotid rete' (B). This cooled blood reaches the brain.

The problem arises when warm-blooded animals need to deal with extreme temperatures. When temperatures are high, animals usually cool down by sweating and allowing evaporating fluids to carry away excess heat. But where there is a need to conserve even moisture, then one way of coping is to simply *not cool down* but allow the body temperature to rise! This is a case of behaving like a cold-blooded animal and (in a warm-blooded animal) is called *heterothermy*, as opposed to *homeothermy*, or constant temperature, on the one hand and *poikilothermy*, which is temperature varying with the environment, on the other.

Arabian Oryx

Various studies have shed light on how the Oryx, which manages with the least moisture intake of the all desert animals, deals with high temperatures. One study, in 2003, revealed that its body temperature varies between 36° Celsius in the morning to over 40° Celsius in the evening. The lowest temperature in the summer, in fact, was lower in than in the winter, apparently to permit more heat-trapping in the summer. But the maximum body temperatures are known to rise as high as 45° Celsius, something that would be fatal to most other animals.

Warm-blooded animals, which benefit from higher rates of metabolism, have evolved so that many vital functions depend on temperatures staying within narrow limits. Very high temperatures can thus threaten vital functions, the most sensitive being the central nervous system or parts of the brain. Allowing the body to heat up could, thus, be dangerous when the ambient goes higher than 45° Celsius.

The Arabian Oryx and other desert animals, like camels, often need to spend hours on end at temperatures as high as this. With the body temperature also rising, how do they avoid brain damage? The answer is found to be through a system of cooling the blood that goes to the brain by a slightly energy consuming but effective cooling device – the passage of air through the nose.

In the Oryx and the camel, the blood to the brain passes through a mesh of vessels in the animals' sinus, where it comes into contact with vessels carrying blood that is returning after passing by the nasal cavity. In the nasal cavity, there is very economical evaporative cooling, which cools the blood in the surrounding vessels. This cooled blood comes into the sinus cavity and here it absorbs heat from blood going to the brain. It is also possible that the sinus cavity is anyway cooler because of air from the nostrils expanding into the cavity. The carotid artery also seems to be in the form of a crisscross of blood vessels, to act as an efficient heat exchanger. And the effect is that despite all the warming of the animals' blood, the brain gets temperature-regulated supply and stays cool. Even when running for long, the faster breathing leads to more cooling and protects the brain despite still higher body temperature.

The arrangement is highly efficient, as the cooling in the nasal passage is immediately absorbed by the surrounding blood flow and then transferred to the limited blood supply specifically for the temperature-sensitive parts of the brain. The arrangement, thus, permits a saving of scarce moisture by allowing body temperature to rise and yet avoiding the effect of rising temperature on the brain.

The writer can be contacted at simplescience@gmail.com

Arabian Oryx

Into the unknown

Will philosophy and modern physics converge, asks rhishav n choudhury, or will the laws of physics replace metaphysics in understanding creation?

If there only is one universe, you might have to have a fine tuner. If you don't want God, you'd better have a multiverse.
— Bernard Carr, cosmologist, Queens Mary University of London.

WE'VE been given either a gift or curse by nature — consciousness. Because of this we search, question and attempt to expand on the known and solve unknown. What we know is whatever can be observed within the three dimensions of space and time and empiricism is the foundation of modern scientific method. But we'll never be able to explain all phenomena with certainty because we can't perceive everything, which is why scientists accept protoscientific fields – that category of hypotheses that conforms to a known framework of evidence but the predictions of which cannot be tested because of current technological limitations.

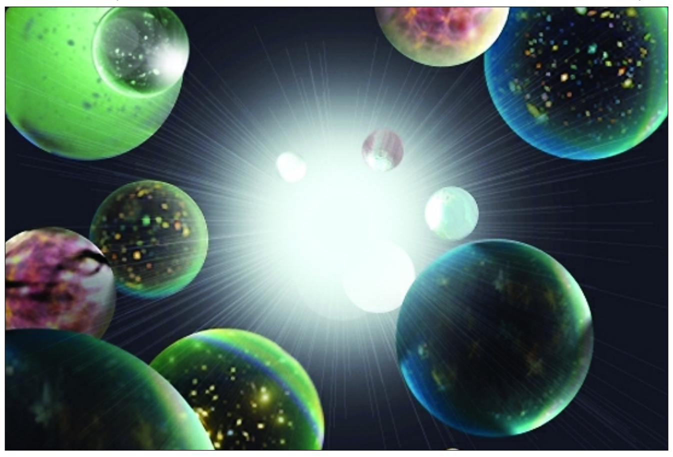
Every theory we use to answer the imponderables of existence is just temporary, till we find an explanation we decide fits the question better. So what do we really know? In his *Brief History of Time*, Stephen Hawkings acknowledged that "any physical theory is only provisional, in the sense that you can never be sure that next time the result will not contradict the theory".

Whether at the quantum or cosmological scale, we either look within to break things down further, or look beyond for something even larger. From molecules to atoms, then to even smaller protons, neutrons, electrons and, now, to quarks on the quantum scale; on the cosmological scale, from planets to solar systems, galaxies to universes. What beyond today's final frontiers? Many theories are in the churning of contemporary scientific thought and two of the most promising are String Theory and Multiverse Theory. The first tates that the ultimate constituents of physical reality are not particles but infinitesimal vibrating strings with different oscillations that give rise to all the particles and forces in the universe. Extremely abstract, this theory requires 11 dimensions to be workable, of which only four are known — length, breath, width and time. If it can ever be proved, this theory will be a mathematically convincing way to knit together the known laws of physics.

The latter theory, at the other extreme, states that a warp in space time occurs wherever huge masses are concentrated. This then expands, forming a cosmic bubble that creates a passage from one cosmic region to another called a wormhole. Eventually, this wormhole closes up, forming a new universe, leaving almost no trace of this link as the bubble expands into a baby universe of its own. If true, it would mean our universe could be just one of infinite universes in an inconceivably vast multiverse.

Try visualising our universe as only one of many, each with its own laws of physics. This would imply that if the laws of physics in our universe were any different, life as we know it may not exist. Suppose, for example, that protons, the positive constituents particles of an atom, were just 0.2 per cent more massive then they actually are. This would make them unstable and cause them to decay into simpler particles and, in turn, atoms wouldn't exist nor would we. Now let's say gravity were just slightly more powerful. This pumped up gravitational force would compress stars more tightly, making them smaller, hotter and denser. Instead of surviving for billions years, stars would burn through their fuel in a few million years, dying out long before life had a chance to evolve. Is life, then, mere coincidence? Could this be the only universe where the laws of physics allowed life to evolve the way we know it? Maybe life or something like it does exist in a different form, but since the existence of other universes can neither be proved nor disproved yet, for now all we can do is speculate. If the Multiverse Theory is valid, then the odds are that at least one of these universes has the right combination of conditions to bring forth stars, planets and living things similar to what we have in our own.

However, as physicist Andrei Linde of Stanford University — one of the early visionaries in the Multiverse Theory — suggests, "If multiverses do exist, in some other universe people there will see different laws of physics. They will not see our universe, they will see only theirs. They will look around and say, 'Here is our universe, and we must construct a theory that uniquely predicts that our universe must be the way we see it, because otherwise it is not complete physics.' Well, this would be a wrong track because they are in that universe by mere chance."



If an infinite number of random universes exist (or will exist), will our present universe repeat itself an infinite number of times?

Using String Theory, the number of possible solutions representing a unique way to describe the universe is as many as 10 ^ 1000. If so, we are very, very lucky to be here, our universe just happened to be born with the right kind of physics for our kind of life. Proving these theories, though, is going to be a task that may take centuries, if not millenia.

Physicists will need a theory of the multiverse that makes new but testable predictions about properties in our own universe. If experiments confirm such a theory's predictions about the universe we can perceive, there would make a strong case for the reality of those we cannot. If String Theory is proved, it could form the basis for proving multiverses.

The results of the Large Hadron Collider, the particle accelerator project on the Swiss-French border, could boost the credibility of both theories and provide more answers. The formation of a host of new particles, and maybe even the possibility of evidence of extra dimensions, would prove String Theory and open the door to the existence of multiverses.

"It's an extremely tantalising possibility that will certainly elucidate our understanding of the universe and the processes of the universe as we see it today. The Large Hadron Collider which will shed light on the physical properties of the early universe would make a fundamental contribution to our understanding of string theory and, therefore, multiverses. The importance of the LHC in providing substantiating evidence for these theories is that it provides a controllable experiment which the other spheres of cosmic interaction (even if they may provide higher energies than those of LHC) cannot provide," says Professor Shibaji Raha, director of the Bose Institute, Kolkata, on the multiverse theory and the contribution of the LHC in further validating the theory.

Upcoming space missions may bring back observations in support of multiverses, with some models of the theory predicting that our universe must have a specific geometry that would bend the path of light rays in specific ways that might be detectable. Finding acceptable evidence to establish these theories is going to be incredibly complex, but to have reached this point and even be able to ask these questions and provide feasible solutions is like those giants who thought beyond the known to provide theories that help us explain the existence of both the seen and unseen.

The conjunctures of ancient Greek and Indian thinkers, whether Aristarchus or Yajnavalkya, led to the Copernican hypothesis of a heliocentric solar system. The physics that led to these questions was difficult, if not impossible to conceive of 2,000 years ago, but here we are now, grappling with questions whose answers lie in an indeterminate future. And even if these answers aren't found for generations, the incredible progress scientific thought has achieved in a few thousand years shows what the human mind is capable of. Will philosophy and modern physics converge, or will the laws of physics replace metaphysics in understanding creation? Your guess is as good as mine.

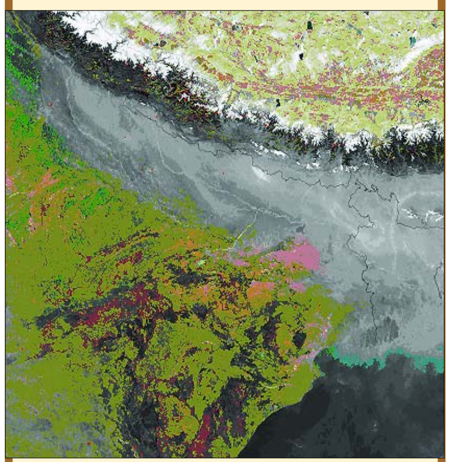
The writer is a freelance contributor

Pollution levels

A satellite study reveals grim picture of the Indian subcontinent, writes saswato r das

A NINE-YEAR study of aerosol pollution over the Indian subcontinent, conducted through instruments on board the National Aeronautics and Space Administration's Terra satellite, has found that pollution levels across the India subcontinent are at least twice as much as what the World Health Organisation deems acceptable, according to Larry Di Girolamo, an atmospheric scientist at the University of Illinois at Urbana-Champaign and an author of the study.

"This study has shown that the level of atmospheric pollution across most of the country is two to five times larger than what the World Health Organisation guidelines call for – and it's home to one-sixth of the world's population," Di Girolamo said. He and fellow researcher Sagnik Dey, now at IIT, Delhi, charted the variations in seasonal pollution from 2000 to 2008 over the Indian subcontinent which, for the most part, lacks on-the-ground monitoring sites, making it difficult for researchers to map aerosol distribution from the ground.



A satellite image of the Indo-Gangetic plain showing high levels of aerosol pollution.

Aerosols are tiny particles suspended in the air that can be harmful to human health. Some aerosols, such as dust or pollen, come from natural sources, while others are generated by human activity, such as soot from coal fires.

The satellite data show very high levels of both natural and manmade aerosol pollutants in the air over the Indian subcontinent all through the year, with the worst being the pre-monsoon season when prevailing winds carry an immense amount of dust from Africa and the Arabian peninsula.

"Just before the rains come the air gets really polluted, and for a long time everyone blamed the dust," Di Girolamo said. "But satellite data has shown that not only is there an influx of dust, there's also a massive buildup of manmade pollutants that's hidden within the dust."

During the monsoon season, rains wash some of the dust and soot from the air, but other manmade pollutants remain. After the monsoon, there is less dust but manmade pollutant levels skyrocket until seaward breezes disperse some of the pollution during winter.

The satellite data also revealed a puzzling density of manmade aerosols over the Himalayan foothills. "We don't understand why it's there. It's a discovery that keeps us asking questions," said Di Girolamo.

A paper detailing the study was published in a recent issue of the *Journal of Geophysical Research.*

Asteroids speed by

TWO asteroids passed very close to earth last week, according to scientists of the National Aeronautics and Space Administration. Asteroid 2010 RX30, which they estimated to be 10-20 metres across, came within approximately 246,000 km of earth at roughly 3:21 pm (IST) last Wednesday; and Asteroid 2010 RF12, which they said was between six to 14 metres in size, passed within approximately 78,000 km at 2:42 am (IST) the day after. By comparison, the moon is approximately 384,000 km away.

Asteroid 2010 RX30.

Nasa officials said both asteroids were discovered last Sunday by the Catalina Sky Survey, which operates out of Tucson, Arizona.

The writer is based in New York and can be contacted at saswatodas@gmail.com