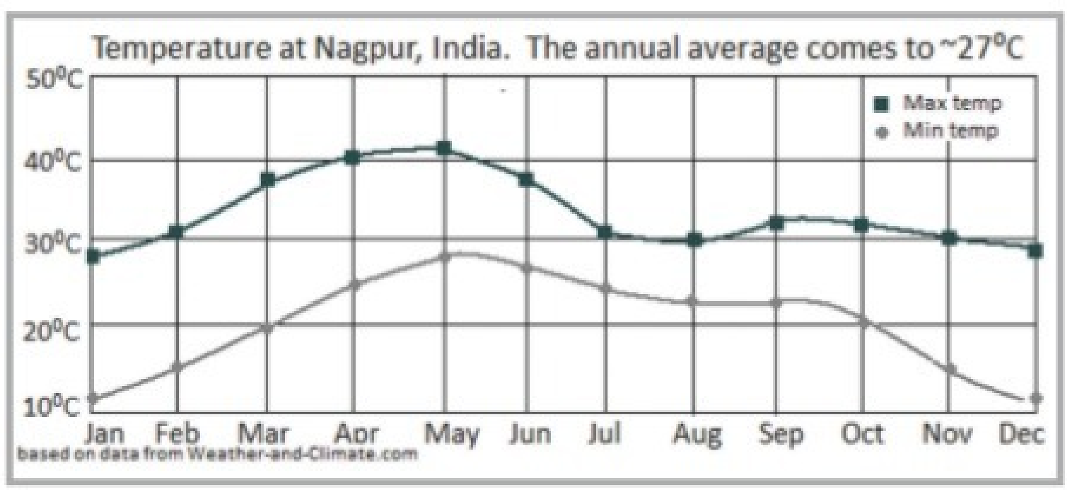
Silent witnesses of steamy days

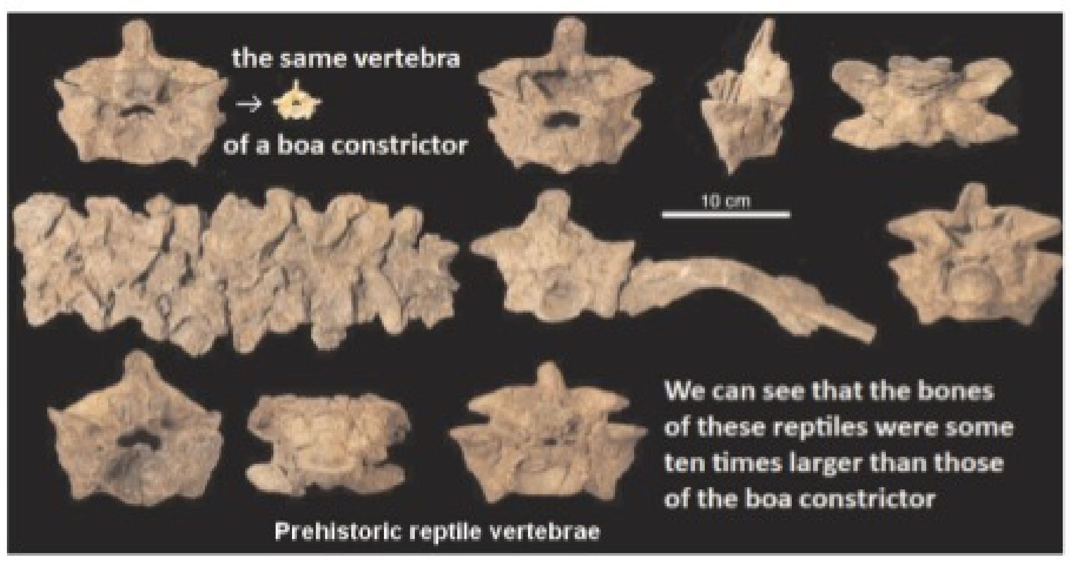

Bloch juxtaposing the vertebra of Titanoboa (left) with that of an Anaconda

A life-size model of Titanoboa swallowing prey



S ANANTHANARAYANAN

Reptile fossils are helping map prehistoric temperatures of the Amazon and predict what might happen if global warming continues unabated



The bones of these prehistoric reptiles were almost 10 times larger than those of the boa constrictor

Powerful agencies have started working against the world's resolve to contain global warming. A belief has grown that the Earth has seen warm times in ages past but the results were not catastrophic. And a theory is about that the tropics, which account for 50 per cent of the surface of the Earth, would absorb heat and keep temperatures from getting extreme. It is hence important to know how hot the Earth got during the warm phases of its geological history.

There are several indicators of how warm the Earth has been at different times. The temperature range that has been worked out for the tropics, however, seems be too low, considering that the temperature at the poles at the time was like the present-day equatorial belt. The question was resolved some years ago by Jason Head and a team of researchers in Canada and the US. The team described in the journal, Nature, a piece of evidence of considerably higher temperature in the tropics than had been estimated.

While temperature records have been kept for only a few centuries, we can identify older instances of very hot or cold years, or decades, from historical records or farming and trade documents. And reaching back, even thousands or millions of years ago, we can work out the temperature graph from remains of plants and animals that were common at different times in the history of the planet, and from geological features.

This collection of evidence has revealed a series of warm periods where the average annual temperature was some six to seven degrees Centigrade above what we see today. This average, annual temperature in the 1950-1980 period was 14°C and 2015, a very hot year in recent times, saw a rise in the average by 1°C. We can imagine that the extremes at a time when the average rises by six to seven oC would be hot indeed!

The trouble, however, is that this estimate of the average is not enough to explain the great increase in the temperature in the Arctic Circle during those warm periods. Fossil records show that there was lush vegetation, with crocodiles and palm trees in Wyoming and Siberia. Those regions must have hence known temperatures like the equatorial belt, which is a "natural" home to crocs and palms trees. If the Arctic was thus some 30°C warmer than today, then the temperature in the tropics was certainly more than only six to seven oC warmer than at present.

Head and his team reported a finding in Colombia, which is very near the equator, of a fossil of a snake, Titanoboa Carrejonensis, which was as large as 13 metres long and weighed over a ton. Snakes belong to the category of "cold-blooded" animals, whose bodies stay nearly at the temperature of their surroundings. This feature — of the body temperature being related to the environment — places constraints on how large an animal can get. The presence of giant snakes in Colombia thus becomes a proxy for the temperature at the time when the snakes were alive.

It was formerly thought that cold-blooded animals had no means of controlling body temperature and were known as "poikilotherms", a word that means "varied temperature". The mechanism is now better understood and the preferred term is "ectotherm", or animals that receive heat from outside, rather than generate heat from within. Cold-blooded animals thus have a very frugal energy economy and they need to seek out places of optimum temperature to maintain their metabolism. We may have seen lizards sunning themselves on a rock and it is known that fish seek out the depths of water where the temperature is the most suitable. Insects are known to warm the muscles that are used in flight by rapid vibration or by focusing sunlight on the muscles. And cold-blooded animals generally tone down their level of activity, even hibernating, when the temperatures falls.

They are thus more dependent on the environment and, in challenging conditions, are likely to be driven to extinction by more adapted, warm-blooded species. But, as they do not use energy to maintain body temperature, they need only 10 per cent of the nutrition that warm-blooded animals need. They can hence drive the latter out where the conditions are right, like in tropical rain forests.

While cold-blooded animals can adapt metabolic rates according to available heat and even store energy for basic metabolism, there are different optimum conditions for animals of different sizes. Large "ectotherms" have greater body weight for their surface area. They are thus able to store heat. Sea turtles, for instance, can take in heat at the surface of the sea and make long dives into cooler, deep waters where the hunting is good. Conversely, the large body mass needs more energy for basic metabolism and large "ectotherms" cannot exist at all unless there is a minimum high temperature source of heat.

We can see that large "ectotherms" need a higher temperature environment from the fact that the larger snakes on the Earth are always found in warmer climates and cold countries are host only to smaller "ectotherms". In fact, it is possible to link the size of cold-blooded animals found in a region with the mean temperature and then to use information about animals in an unknown area to conjecture what the temperature may be.

Head and colleagues used this relationship to derive what the temperature may have been at the time the snakes were alive from the snake fossil discovered in Columbia. The fossils date to 58-60 million years ago, which is in the heart of the last period of great warming of the Earth. The temperatures that Head and his team derive turns out to be five to six? C higher than what other evidence has indicated.

They estimate an average annual global temperature of 32-34°C, which is a whole 17-19°C warmer than the 2015 average of 15°C. The average annual temperature at Nagpur, the geographical centre of India, is around 27°C. This year, Nagpur experienced a scorching maximum of 47°C. As any relief was welcome, it was ironic that Nagpur-dwellers rejoiced when the temperature was 45°C!

The levels of rise in temperature that are predicted if global warming continues unchecked would clearly drive familiar forms of life away from most of the parts of the Earth that are now inhabited. Even if the Amazon teemed with vegetation and life during those steamy days, it got there through evolution over millions of years. In comparison, the Earth's present challenge is to adapt to a large rise in temperature within a human lifetime.

The writer can be contacted at response@simplescience.in

What would aliens be like?

SIMON GOODWIN

In the last 20 years, we have discovered over 3,500 planets around other stars. At the moment we know how far away from their parent star they are and one (or sometimes both) of their mass and size.

An increasing number of the planets we are finding are "Earth-like" in that their mass and size are similar to Earth's. At the moment we have no idea if they have similar temperatures, oceans or if they have life — but there is the fascinating possibility that they could.

To search for life on other planets, astronomers are working on the next generation of huge telescopes, the largest of which will be the 40m "European Extremely Large Telescope" in Chile. These telescopes will have the ability to determine the composition of the atmospheres of Earth-like planets and search for signatures of life — on Earth the 20 per cent oxygen content of our atmosphere is a giveaway that we are a living planet as it needs plants to produce it.

This new generation of telescopes with the ability to detect aliens should be working in less than a decade. This has led many scientists in many disciplines to start considering in detail the question, "what would aliens be like?"

At the moment we (that is, Earth life) are the only example of life, and most of our ideas tend to centre on what Earth-life is like, and considering to what extent aliens might be the same.

All life on Earth is based around four main chemical elements — carbon, hydrogen, oxygen, and nitrogen. Other elements like phosphorus, calcium, sulphur, iron, and magnesium are important for life but the Chon elements make up the vast majority of humans, trees, bacteria et al.

Those elements are the main constituents of all the molecules that make us work — carbohydrates for energy, amino acids in proteins, nucleic acids and DNA, fatty acids in cells. What is extremely interesting about the Chon elements is that they are by far the most common reactive elements in the Universe (helium is very common but cannot do chemistry).

So we know life can work using Chon and we see them everywhere in the Universe, so it seems a reasonable guess that alien life could well be based on the same basic elements as we are. So most scientists who think about aliens agree looking for Chon life is a pretty good bet.

The most important non-biological molecule for life on Earth is liquid water (two hydrogens and an oxygen). A liquid is important for moving things around your cells and body, water can dissolve some molecules (like sugar which makes it easy to transport), while others won't dissolve in water (like fats, which means we can make cell membranes and other structures from them).

Water is interesting because it is very common (H and O which we know are very common), and one of the few molecules that is a liquid at the sort of temperatures life like us would need. If the temperature is too low (below about -200 °C) there isn't enough energy to break and make the molecules of life, if the temperature is too high (above about 400 °C) then all the molecules of life fall apart. In this range, water is a liquid in the middle of it, and methane and ammonia right at the bottom.

Of the Chon elements, carbon is the most important. Carbon can bond with itself to make rings, and complex two and three dimensional molecules, which are the basis of the structure of life's molecules.

The only other element, which might do the same job is silicon that has the same ability to bond with itself (hence the sci-fi trope of "silicon-based life"). But there are two big problems with using silicon. First it is difficult to get — carbon life tends to occur when plants take carbon dioxide and break off the carbon (and throw-away the oxygen) but silicon is usually found in silicon oxides, otherwise known as rocks, which take much more energy to get. Silicon is a bigger atom than carbon, so big silicon molecules often fall apart quite easily and they don't react well with water, so another liquid would be needed.

We are a carbon-based/Chon biochemical life form that uses liquid water, and this is what we tend to think alien life would be like as well.

But we could well be wrong. Maybe most life is very different. Maybe there are many ways to make life and we are just one particular way. Maybe there are many computer-based technological life forms out there.

The one way we can know is to go and try and find life on other planets, and in a decade we should start to get some answers.

The writer is professor of theoretical astrophysics, University of Sheffield, UK

PLUS POINTS

Martian oxygen

Nasa is planning to make oxygen from the atmosphere on Mars when its next robot arrives on the mysterious red planet in 2020.

Scientists will send microbial life — possibly algae or bacteria — on the 2020 Rover mission in a bid to create air fit for human consumption. They aim to feed the micro-organisms in Martian soil in the hope that they will pump out oxygen as a by-product. It could then be made available for breathing or used as rocket fuel to power return flights to Earth.

If the experiment is successful it will mark a major step towards making Mars habitable for human colonies in the future. Mars's atmosphere contains just 0.13 per cent oxygen, compared with 21 per cent on Earth. Nasa acting chief administrator, Robert Lightfoot told Futurism, "Mars 2020, has an experiment where we are going to try and actually generate oxygen out of the atmosphere on Mars, clearly that's for human capability down the road."

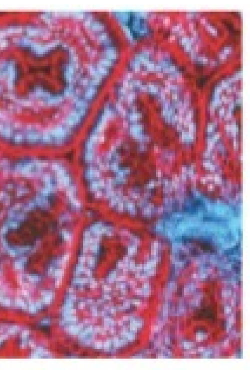
The US government department also has plans to build a magnetic shield around Mars and to install a nuclear reactor on the planet. They hope to launch a lunar space station near the Moon that could act as a starting point for missions to the rest of the solar system.

Lightfoot said it was a logical next step after the success of the International Space Station, adding, "When you look at our plans today (for getting to Mars), we use the International Space Station as much as we can."

Canadian-American businessman Elon Musk has announced plans to colonise Mars and said an optimistic cost would be around $10 billion per person.

The independent

Microscopy image



This is a fluorescent microscopy image of gastric tissue with several pre-cancerous lesions. Such precancerous lesions originate from mutated Lgr5-positive stomach cells. The DNA-containing nuclei are coloured in blue, while borders between cells are coloured in red. The Barker Laboratory at the Agency for Science, Technology and Research's Institute of Medical Biology studies the role of Lgr5 stem cells in the cancers of various organs, including the stomach.

One of its goals is to develop ways to block the cancer-promoting activities of mutated Lgr5 stem cells. Indeed, a team of scientists from IMB recently discovered a new population of Lgr5-expressing cells within the lining of the major digestive region of the stomach, which is known as the body or corpus. They found that they are recruited to function as stem cells for epithelial (tissue) renewal following injury.

However, they are also a major source of gastric cancer when they are mutated. According to the World Health Organisation, gastric cancer is the fourth leading cause of cancer globally.

The straits times/ann

All in a name

The invention of vaccines was one of science's greatest ever breakthroughs, saving the lives of countless millions of people over the last 200 years.

But the name may actually be a misnoma. Vaccine comes from the Latin for cow, vacca, as Edward Jenner is famously said to have used the cowpox virus to inoculate an eight-year-old boy, his gardener's son, against deadly smallpox in one of the most ethically dubious, but successful, experiments in history.

However, a new article in the journal Lancet Infectious Diseases suggests that the smallpox vaccine might actually have come from horses, not cows, which would mean we should perhaps be talking about "equination" and "equines".

Its author, Clarissa Damaso, of the Federal University of Rio de Janeiro in Brazil, said "I think if he had used cowpox then we should have some vaccine today made of cowpox virus. But all the vaccine genetically sequenced today doesn't have cowpox in it."

The independent