

# Taking burden in their stride

THE NEPALI PORTER IS FOUND TO WALK LIGHTER WHEN THE LOAD GETS HEAVIER, WRITES S ANANTHANARAYANAN

The African tribal and the Nepali coolie seem to be leaders in carrying great loads over long distances. Anybody who has been on a Himalayan trek cannot help but feel impressed by the sheer weight that the diminutive Sherpa porter cheerfully hauls up and down the mountains.



GJ Bastien, PA Willems, B Schepens and NC Heglund — from the Institute of Neuroscience, *Laboratoire de physiologie et biomecanique de la locomotion*, Université Catholique de Louvain in Belgium — have conducted an in depth study of how much and how usefully energy is consumed in the way that westerners, African women and the Nepali porter transport loads. The report has appeared in the *Journal of Experimental Biology*, which is published by *The Company of Biologists*, a 90-year-old not-for-profit publishing organisation dedicated to supporting and inspiring research in the life sciences.

Following up on earlier research in the field, the Louvain group notes that not many studies on the actual energy efficiency and biomechanics of people carrying loads have been published. The group has thus gone into just that, with the help of published studies of energy consumption and experiments on the actual forces at work in the gait of walkers, and analyses of energy efficiency at different speeds and under different loads.

The study cites earlier findings that fit European or North American adults can carry a backpack up to a quarter of their weight over a day's trek. If the load is more than 60 per cent of their weight, however, they last only an hour

and it is only with great difficulty that they can carry as much as their own weight. In other parts of the world, on the other hand, women have adapted to carry heavy loads efficiently and seemingly much frailer men, even boys, routinely carry well over 100 per cent of their body weight over long distances and for long periods. The group hence studied details of the known efficient technique of the African women and whether this was made use of by Nepali porters, who are noted for carrying heavy loads.

Kenyan women are renowned for carrying as much as 70 per cent of their weight with apparently little exertion. Earlier studies have shown that this is thanks to their technique of converting the energy of the up-and-down motion of the total load, of their body and the burden, into power to propel them forward and again to use their forward motion to help raise the load for each step. This has been explained to be similar to a pendulum, where the bob

gains speed as it falls to the lowest point of its swing, and then makes use of the speed to rise till the opposite end. A Kenyan woman, in turn, acts like a pendulum standing upside down, speeding forward as the load descends when the carrier steps forward and using the same speed to help raise the load, when the weight transfers to the other leg.

The earlier study, by Heglund and others, found that Kenyan women could carry a load up to 20 per cent of their body weight without any additional effort. The study has shown that when she carries no load, the Kenyan woman walks in the same way as westerners. With a load, however, her efficiency of energy use rises from 65 to 80 per cent, which means she uses only 20 per cent extra energy to keep moving, unlike westerners who need to use 35 per cent more energy. Walking with a heavy load on the head, of course, calls for balance and rhythm, but the result is a very high conversion of energy expended into useful work done.

On the other hand, the lower Himalayas and Nepal are areas of sparse produce and rough and undulating terrain. As there are few roads, there is the need to transport materials over distances, as head-loads. And, as the foot paths are rocky and uneven, the speed of elegant movement in the plains is not possible. For all this, professional Nepali porters, who carry



loads with the help of a strap looped over the forehead, similar to Kenyan women, do a 100 km trip in some eight days, with a total ascent of more than 8,000 metres and descents of over 6,300 metres, and carrying a load of 89 per cent of body weight, on the average, with 20 per cent of the men carrying over 125 per cent of their body weight, the study says. The team therefore went into the details of the gait and the energy use by westerners, African women and the Nepali porters.

The actual work done, in the sense of the up-and-down and other movements of the body and the load, was exactly assessed, by filming the movements of the subjects — the Nepali men, Kenyan women and westerners, as they walked, and then analysing the footage. While this showed the external work done — for the motion of the body mass and the load — other forms of work done were assessed with the



help of five force sensor plates in a force platform over which subjects walked. Each plate had four sensors to measure forward, backward and vertical forces and the measurements were digitised and recorded 20 times every second. These figures, obtained with the different classes of subjects and at different speeds and under different loads, thus measured the work done. This measurement was combined with available data, for the same conditions of speed and load and category of subjects — of the metabolic cost of the work — to arrive at the efficiency of load carrying.

The result of the detailed study is that the Nepali porter does not use the energy saving methods of the Kenyan woman, and indeed, he cannot, as the terrain he moves over is hilly and he "barely ever takes two steps in succession at the same level". The Nepali porter's muscular efficiency is about the same as that of the westerner, and does not depend upon the load, but it decreases if the speed is more than 1.4 metres per second. That efficiency is not related to the load and is in contrast to the westerner, whose muscular efficiency falls fast if the load exceeds 35 per cent of body weight.

The Nepali thus has a smaller metabolic cost in carrying the load over a given distance.

The study says that the Nepali is the most efficient with a heavy load. When they are behind time, and need to reach a market, for instance, the study says, Nepalis would prefer to walk long hours, maybe late into the night, but they would not step up their speed. Their lower metabolic cost, the study says, seems to arise from having adapted to make less muscular contractions and also their training and adaptation to the higher altitude.

THE WRITER CAN BE CONTACTED AT response@simplescience.in

## PLUS POINTS



### Length of a second

Time is running out for the current length of a second after an "optical clock" was sent into space for the first time. Such clocks are up to 1,000 times more accurate than the current international standard, which dates back to 1967 and is based on the natural oscillation of an atom of caesium, rather than the swing of a traditional pendulum.

While no one would notice the difference in everyday life, optical clocks would be extremely useful for a number of reasons. For example, it would enable global positioning system-based navigation to be accurate to within a few centimetres, rather than a few metres. It would also help manage electricity grids and computerised financial networks.

But changing the way a second is defined — currently 9,192,631,770 cycles of the microwave signal produced by caesium — to about 429,000 billion cycles from a strontium atom used in some optical clocks, would also inevitably introduce a tiny error, changing its length ever so slightly.

Writing in the journal *Optica*, researchers described how they had successfully sent an optical clock into space — a journey they would need to survive if they were to be used on the satellites providing GPS signals.

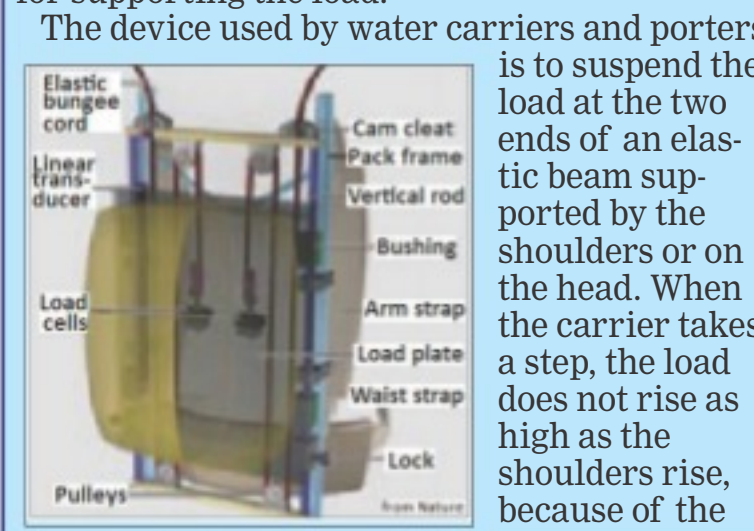
Researcher Matthias Lezius, of Menlo Systems, an international firm based in Germany, said, "Our device represents a cornerstone in the development of future space-based precision clocks and metrology. The optical clock performed the same in space as it had on the ground, showing that our system engineering worked very well."

One key part of an optical clock is a "frequency comb" laser, which divide the incredibly fast oscillations of the atoms used into lower frequencies that can be counted and turned into a measure of time.

IAN JOHNSTON/THE INDEPENDENT

## Mechanics of head loads

ADAPTATION to efficient load carrying is also seen in most parts of South-east Asia, as there has been a need to transport materials by head. Unlike only a pendulum-like gait, as in Africa, the Asian also uses mechanical devices to minimise the up-down movement of the centre of mass. This helps the effort made to be mainly for forward acceleration and less for supporting the load.



The device used by water carriers and porters is to suspend the load at the two ends of an elastic beam supported by the shoulders or on the head. When the carrier takes a step, the load does not rise as high as the shoulders rise, because of the



elasticity of the beam. Again, when the carrier descends, there is insulation of the plunge of the load, which is also less as it did not rise to the full extent in the first place. The dimensions of the beam and the speed of walking are matched so that energy is stored in the bent beam and released just when needed. Hitting the right rhythm can lead to the head-load making very little actual up-down movement while it speeds along.

The journal, *Nature* once carried an account of an ergonomic backpack, which was suspended by elastic straps, to mimic the retarded movements of the Asian porter's load. The arrangement was said to reduce the metabolic cost of moving with a 27kg load by about seven per cent.

# EARLY CELL BEHAVIOUR

TAPAN KUMAR MAITRA EXPLAINS THE PROCESSES OF CHROMOSOME DIMINUTION AND ELIMINATION

In presenting the basic facts of cytology and genetics it is usual to state that the chromosomal compositions of the germinal cells and the cells of the soma are equivalent. In plants, that is particularly true, because the same meristematic cells that give rise to the vegetative organs at one stage of the life cycle can give rise, at a later stage, to the sporogenous tissues in which meiosis occurs. Vegetative propagation is practical proof of this underlying assumption.

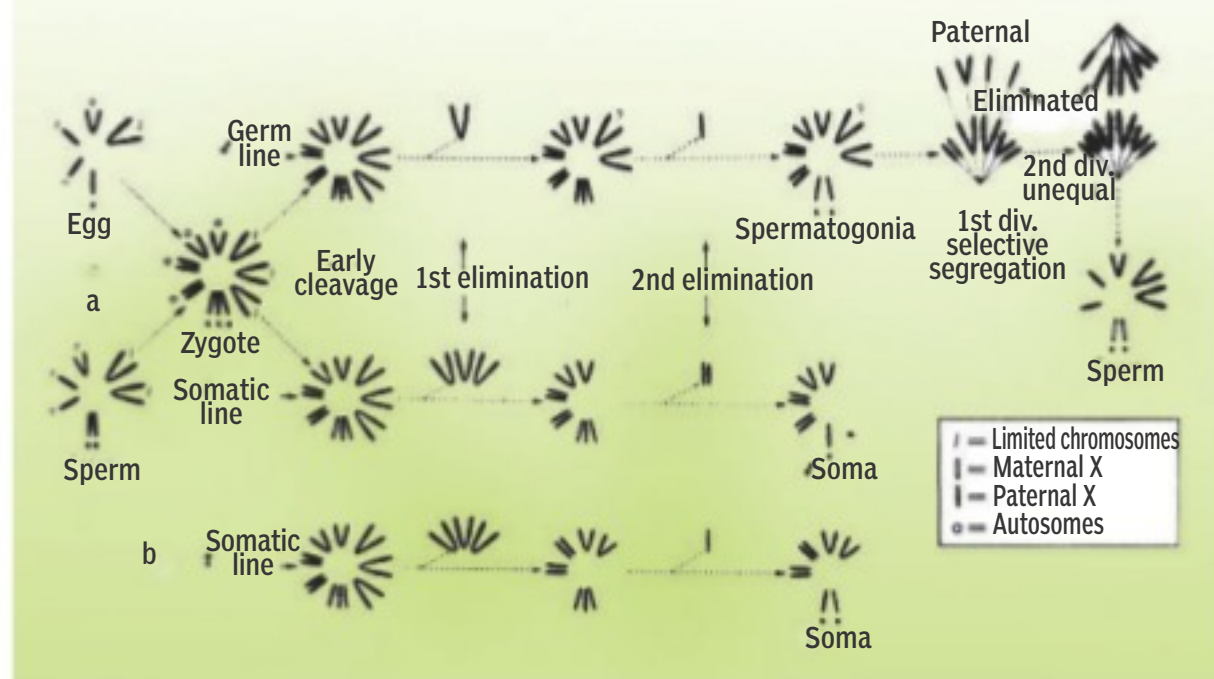
In many animals, however, the germ line is denned early in the embryonic development, and although these cells are not isolated from the soma in a physiological sense, they can be considered to be so genetically. The

single pole while the paternal ones back away from the pole, even though their centromeres are directed poleward. This is true for the X chromosome and the autosomes only; the limited chromosomes, whatever their origin, pass to the single pole with the maternal X and autosomes and are incorporated in the secondary spermatocyte. The paternal chromosomes collect in a tiny bud that pinches off and later disintegrates. Males of *Sciara*, therefore, never transmit traits of paternal origin.

The division in the single remaining secondary spermatocyte is also anomalous and unequal. The spindle, unlike that of the first division, is bipolar, and the chromosomes reach the metaphase plate in normal fashion. One chromosome, however, is precocious in its behaviour, and passes to one pole before anaphase movement has commenced for the remaining chromosomes. Because it is longitudinally divided, both chromatids pass to the same nucleus. Anaphase movement of the remaining chromosomes then takes place, giving two nuclei of unequal constitution. The nucleus bearing the two halves of the precocious chromosome becomes incorporated into a functional sperm while the other nucleus degenerates. By means of translocations between the X chromosome and the autosomes, it has been demonstrated that the precocious chromosome is the X chromosome, and that its centromere is responsible for its early passage into the functional sperm nucleus.

Elimination of chromosomes from both male and female follows a constant and unique pattern. The zygote contains three X chromosomes (two of paternal origin), three pairs of autosomes, and one or more limited chromosomes. This complement is maintained through the first few cleavage divisions only. At the fifth or sixth division, the limited chromosomes are eliminated. They reach the metaphase plate in normal fashion along with the other chromosomes, their centromeres divide, and anaphase movement begins, but owing to anaphase lag they are left in the middle of the spindle and are not included in the daughter nuclei.

At the seventh or eighth cleavage division, an additional elimination of chromosomes from the soma occurs. In this instance it is the paternal X chromosome that is involved, and the mode of elimination is similar to that which removes the limited chromosomes. The circumstances differ; however, depending upon whether the soma is to become male or female. If male, the elimination of two paternal X chromosomes takes place; if female, only one X chromosome is deleted from the complement, and this again is of paternal origin. The male soma consequently is XO, the female XX.



Chromosome history during somatic development in the male and female.

soma of an animal, on the other hand, represents an evolutionary dead end, lost from a population with the death of the individual, and any changes occurring in it affect only that individual. It has now become quite clear that the somatic cells of many species may undergo cytological changes of various sorts — some random, others peculiar to various organs — even while the germ cells or their progenitors may preserve the original chromosomal constitution. The constancy of the species is dependent upon the constancy of behaviour of cells in the germ line.

It was Boveri who first pointed out that in *Ascaris megalocephala* the chromosomal compositions of the soma and the germ line were not identical, and it has since been found to be a regular occurrence in a number of species, particularly in certain groups of insects. The variations are, however, not confined to the soma; equally dramatic changes are known to occur in the cells of the germ line. A good example is the genus *Sciara* (fungus gnat), although the dog rose, *R. canina*, the gird midgets, and a number of coccid (Homoptera) species also display interesting forms of chromosomal elimination and/or unusual behaviour.

Here's the course of events as they occur in the soma and germ line of both sexes. The first spermatocyte division is monoentric mitosis, the spindle being unipolar, and the maternal homologues are separated from those of paternal origin. The maternal chromosomes move to the

# Before it all disappears

CLIMATE CHANGE EXPERTS SAY THE REPERCUSSIONS OF WARMER SEA TEMPERATURES ARE ALREADY BEING FELT AS GLOBAL SEA ICE SHRINKS AT UNPRECEDENTED SPEEDS. LUCY PASHA-ROBINSON REPORTS

While ice in the Arctic is close to record lows, the Antarctic has seen sea ice running at lowest ever levels for this time of year since records began. Professor Peter Wadhams, head of the polar ocean physics group at Cambridge University, said that rates of ice growth in winter had slowed and rising temperatures were causing it to melt faster in the summer, thereby effecting a dramatic reduction in area and thickness.

Wadhams warned the global repercussions of the reduction of sea ice were already being felt, long before the ice has fully disappeared. "As the ice area gets less, you're changing the albedo of the earth, which is the fraction of solar radiation that gets reflected straight away back into space, so you're absorbing radiation which warms the earth quicker thereby creating a feedback effect as the ice retreats," he told *The Independent*.

"The only secure way of stopping the sea ice to retreat is stopping warming and that is really by reducing our carbon dioxide emissions." He also warned of the disastrous implications

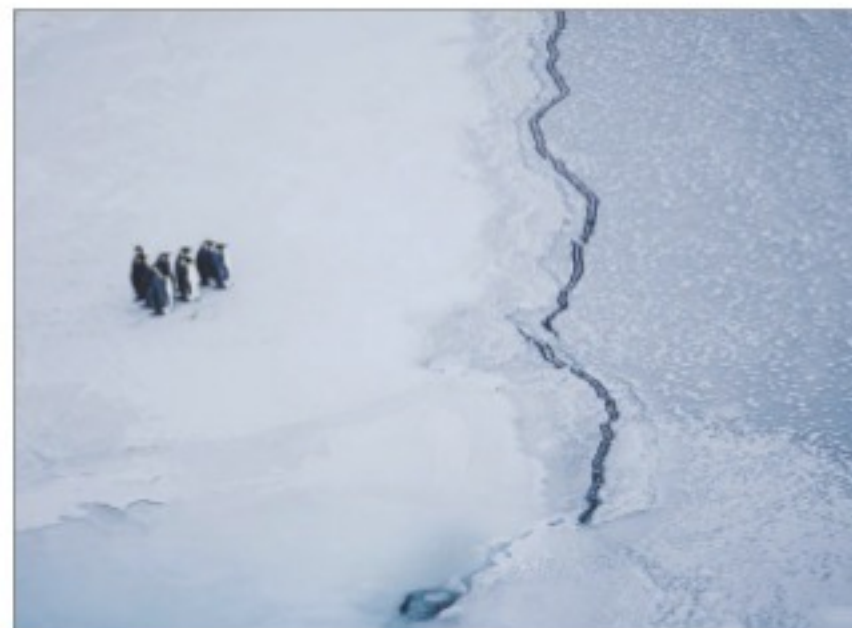
contributing to global sea level rise," he said.

Wadhams also warned of the release of the powerful greenhouse gas methane from the seabed as the ice melts, a gas that scientists recognise as a key driver of climate change. "We are now seeing huge plumes coming up to the surface from methane being released from the seabed," he told *The Independent*.

"The ice in summer has shrunk back from all the seas around the edges of the Arctic and without the sea ice, those seas around the edge can now warm up because the water is shallow, which allows this warmer water to bathe the seabed."

"The seabed at the moment is covered with permafrost, frozen ground, hiding a large volume of methane underneath. As soon as the warmer water starts to act on the seabed the permafrost melts and methane is released."

However Wadhams, who recently published a book on the shrinking of sea ice called *A Farewell to Ice*, said that there was hope for the future if proper



measures were put in place.

"One measure to stem the methane emissions from the seabed would be a kind of fracking method that the oil industry suggests, which would be to drill down through these sediments, open up cavities that would then be filled with methane when you pump it out," he said.

"Global warming and climate change is not going to be easy to reverse, especially sea level rise as that just seems to continue inexorably. The only way that's been suggested that might work is 'marine cloud brightening' — a form of geo-engineering where you inject very fine water particles into the bottom of low clouds. The particles evaporate and it makes them brighter, which will reflect more solar radiation."

THE INDEPENDENT

## Augmenting intelligence

Researchers could soon enlist help from digital assistants to review vast swathes of literature, according to a new report on artificial intelligence.

In tests run by academics at the Universities of Strathclyde and Glasgow, simulated search agents went head-to-head with humans in a computer search challenge — and won.

They were found to be considerably more effective than human participants, and, while they differed significantly in behaviour, they could be configured to offer a credible and realistic simulation of a human researcher. Leif Azzopardi, a senior lecturer in Strathclyde's department of computer and information sciences and a partner in the research, said, "There's currently a great deal of discussion about artificial intelligence and the role it could play in the future."



"An autonomous search agent could be useful for researchers reviewing vast amounts of literature in subjects such as law and medicine. In this type of information-intensive review, it could read through and assess information while the researcher is working on other things, then suggest other sources of information that would be relevant."

"Previously the simulated users we created were unrealistic and lacking in agency. Their decisions were made stochastically — by the 'roll of dice' — rather than based on the actual information found and the underlying need for information."

"The model we have developed takes account of what the autonomous agents knows, has done and has seen, along with what it considers to be relevant. It is constantly evolving."

David Maxwell, a PhD student from the University of Glasgow's school of computing science, said, "Our findings are very promising and show that it is possible to create realistic simulations of how humans search. Now we can look to apply this technology to augment the search capabilities of humans to help them process more information and find more relevant material."