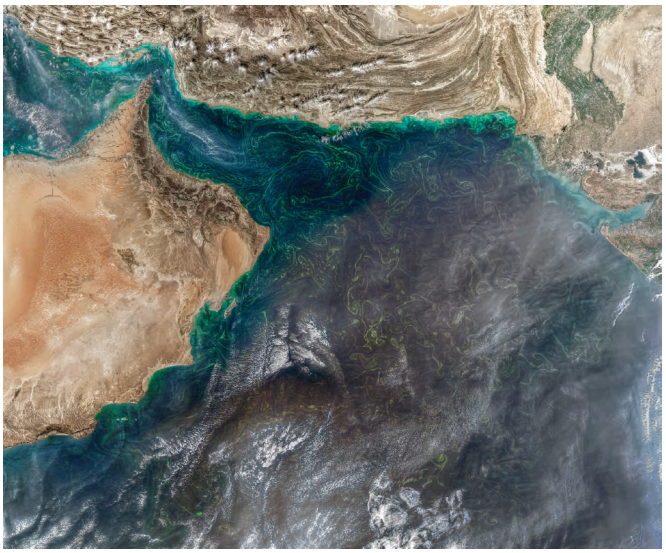
operational forecast for toxic plankton blooms in the Gulf of Maine using a similarly advanced model, says Richard Stumpf, a NOAA oceanographer in Silver Spring, Maryland.

Simulating, and then predicting, such blooms is difficult, Stumpf says, because researchers must understand not just local water chemistry and ocean circulation but also the behaviour of different plankton species.



AQUA/MODIS/GSFC/NASA

***Noctiluca* blooms (green swirls) in the Arabian Sea, as seen from space.**

BOOM AND BUST

A huge bloom in the Arabian Sea that began last November is only now winding down. At its peak in January, it covered an area three times the size of Texas. "*Noctiluca* is completely overwhelming the system," says Goes.

Goes and his team spent five weeks in Oman in January and February this year collecting samples and talking to local fishermen, as well as industry and government officials. They discussed the forecasting system and the kind of bloom-prediction information community members would need.

The team's current forecasting model is promising, and the researchers hope to improve its resolution and to incorporate information on *Noctiluca*'s tricky biology.

This minute organism has both plant and animal characteristics. It is a predator that thrives in the low-oxygen waters that have become more common in the region (H. R. Gomes *et al. Nature Commun.* **5,** 4862; 2014). But *Noctiluca* also has a symbiotic relationship with algae that live inside the cells. These algae contain the green pigment chlorophyll, which sensors on satellites can monitor from space, enabling researchers to track the blooms.

A GROWING PROBLEM

It's unclear why major *Noctiluca* blooms now occur in oceans around the world, including off the coasts of India, Thailand and Indonesia. Researchers suspect that the release of raw sewage, which provides nutrients, and global warming might have roles.

The right conditions can stimulate *Noctiluca* blooms so thick that when they die, the decomposing bodies suck most of the oxygen out of the seawater. In years past, the bloom's expanding low-oxygen zone drove sardines onto some beaches in Oman; aquaculture farms have also been affected.

This year, desalination plants had to scale back their activities to prevent *Noctiluca* from physically clogging their systems.

The current model devised by Goes and his team for the Indian Ocean has a resolution of 3.5 kilometres. It's able to forecast the bloom potential of two types each of plant and animal plankton. The model reproduces the large-scale behaviour of the current bloom in the Arabian Sea fairly well, but it's not yet detailed enough to produce a useful forecast for a local shrimp farm or a desalination plant, says Sergio deRada, an ocean modeller at the Naval Research Laboratory at the Stennis Space Center in Mississippi.

The next step is to boost resolution to 1 kilometre or even 500 metres, and to represent *Noctiluca* itself in the model. The problem, says deRada, is that *Noctiluca*'s behaviour is more complex than that of the plankton currently included in the model. "That's why modelling it is going to be tough." ■

MEDICINE

Reduced-calorie diet shows signs of slowing ageing

Restricting food intake dials down people's metabolism in clinical trial.

BY ALISON ABBOTT

A study of people who reduced the calories they consumed has found the strongest evidence yet that such restrictions can slow down human metabolism. The results raise hopes that a low-calorie lifestyle — or treatments that mimic the biological effects of restricted eating — could prolong health in old age, and even extend life.

Past work in many short-lived animals, including worms, flies and mice, has shown that calorie restrictions reduce metabolism and extend lifespan. But experiments in longer-living humans and other primates are more difficult to conduct and have not yet drawn clear conclusions.

The study was part of the multi-centre trial called CALERIE (Comprehensive Assessment of Long term Effects of Reducing Intake of Energy), sponsored by the US National Institutes of Health. The randomized, controlled trial tested the effects of 2 years of caloric restriction on metabolism in more than 200 healthy, non-obese adults.

"The CALERIE trial has been important in addressing the question of whether the pace of ageing can be altered in humans," says Rozalyn Anderson, who studies ageing at the University of Wisconsin–Madison. She leads one of two large, independent studies on calorie restriction in rhesus monkeys. "This new report provides the most robust evidence to date that everything we have learnt in other animals can be applied to ourselves."

Published on 22 March in *Cell Metabolism*, the latest study looked at 53 CALERIE participants who had been recruited at the Pennington Biomedical Research Center in Baton Rouge, Louisiana (L. M. Redman *et al. Cell Metab.* http://doi.org/cmrx; 2018). This

CARLOS SANCHEZ

Reduced food intake has affected people's metabolism in a controlled study.

facility is home to 4 of the world's 20 or so state-of-the-art metabolic chambers, which are like small, sealed hotel rooms that measure minute-by-minute the amount of oxygen that occupants use and how much carbon dioxide they exhale. This allows researchers to track how the occupants use energy with unprecedented precision, says Anderson. The ratio between the two gases, combined with analysis of nitrogen in occupants' urine, indicates whether the occupant is burning fat, carbohydrate or protein.

The trial participants, aged between 21 and 50, were randomized into two groups: 34 reduced their calorie intake by an average of 15%, and 19 ate as usual. At the end of each of the two years, they all underwent tests related to metabolism and biological markers of ageing. They were also placed in a metabolic chamber for 24 hours.

The scientists found that participants on the diet used energy much more efficiently while sleeping than did the control group. This reduction in their base metabolic rate was greater than would be expected as a result of the test group's weight loss, which averaged nearly 9 kilograms per participant. All the other clinical measurements were in line with reduced metabolic rate, and indicated a decrease in damage due to ageing.

MODEL METABOLISM

Caloric restriction has been known for decades to extend life in different species. In the 1990s, scientists began to identify the genes and biochemical pathways that are actively involved in longevity in the short-lived worm *Caenorhabditis elegans*, and in the fly *Drosophila melanogaster*. These include pathways relevant to insulin sensitivity and the function of mitochondria — cellular structures that use oxygen to generate energy. Later studies revealed that calorie restrictions alter similar pathways in mice and monkeys. Mice on restricted diets can live up to 65% longer than mice allowed to eat freely, and the ongoing monkey studies hint at longer survival and reduced signs of ageing.

"The Rolls-Royce of a human longevity study would carry on for many decades to see if people do actually live longer," says Pennington physiologist Leanne Redman, the lead author of the latest study. CALERIE ran for two years, and aimed to see whether a calorie-restricted diet in humans induces some of the same metabolic, hormonal and gene-expression adaptations that are thought to be involved in slowing ageing in other species during long-term caloric restriction.

Few people would want, or be able, to restrict their diet as severely as the participants in the study. "But understanding the biology of how restricting calories extends life will allow us to find easier ways to intervene," says Anderson.

Redman would like to repeat the study, combining less-ambitious calorie restriction with a diet containing antioxidant food to reduce damage from oxygen free radicals, or with a drug such as resveratrol, which mimics key aspects of calorie restriction.

Other scientists are starting to test restricting calories for a few days every month. Such intermittent limitations have been found to be as effective as continuous calorie restriction in protecting mice against diseases of ageing such as diabetes and neurodegeneration (V. D. Longo and M. P. Mattson *Cell Metab.* **19,** 181–192; 2014). "I think that's going to be a way to get all the benefits, without the problems of constant dieting," says gerontologist Valter Longo of the University of Southern California in Los Angeles, who is embarking on clinical trials of intermittent calorie restriction in various disorders. ■

EXTRASOLAR PLANETS

Green light for exoplanet probe

Europe's ARIEL mission will study planetary atmospheres.

BY ELIZABETH GIBNEY

The world's first space telescope dedicated to studying the atmospheres of exoplanets is set to launch in 2028, after the European Space Agency (ESA) selected the mission for development on 20 March.

The Atmospheric Remote-sensing Infrared Exoplanet Large-survey (ARIEL) — to be built with a budget of €450 million (US$558 million) — will chart more than 1,000 known planetary systems outside our own. Its mission is to understand the links between a planet's chemistry and its environment, says Giovanna Tinetti, a planetary scientist at University College London and principal investigator for the mission. So far, exoplanet probes have mainly focused on finding new planets and measuring their sizes, masses and orbits. "ARIEL can really give us a full picture of what exoplanets are made of, how they form and how they evolve," says Tinetti.

A spectrograph aboard the observatory will study the light that filters through a planet's atmosphere as it passes across the face of its host star, revealing chemical fingerprints of gases that shroud the body. The mission will also try to refine estimates of a planet's temperature by teasing out how light from its star changes when the body moves behind it, revealing details about a planet's overall radiation. Tinetti says that it will monitor the worlds at snapshots in time, and also measure how the chemistry and atmospheres of planets vary across their surfaces and with the seasons.

Since the first exoplanet discoveries in the 1990s, some 3,700 worlds have been confirmed in 2,800 systems. ARIEL will focus on planets that have an estimated temperature of more than 350 °C — and are thus unlikely to host life as we know it — and a range of masses, in particular those heavier than a few Earth masses. The observations will build a 'standard model' of how a planet's chemistry depends on its star and the conditions of its birth, Tinetti says.

ARIEL is one of several exoplanet missions in the works around the world, but its focus on planetary atmospheres is rare. Other missions are studying planet size, density and mass. Together, this generation of telescopes will allow scientists to test models of planetary formation and composition, says Elizabeth Tasker, an exoplanet researcher at the Japan Aerospace Exploration Agency's Institute of Space and Astronautical Science in Sagamihara. ■