

WORDS: COLIN BLAKEMORE

I recently went on the trip of a lifetime, steaming up the Nile from Luxor to Aswan. I have to admit that I was a bit templed-out by the end of the week, not just because of the sheer number of monumental buildings, but because of the repetitive similarity of their ground plans, their papyrus-shaped columns and the decoration of their walls.

Perhaps the most common symbol in these temples, both as a hieroglyphic character and an object dangling from the hand of a god, is the ankh — the key of life. This familiar cross hanging from a ring is an icon of

eternal life. For more than 3,000 years the ankh lived on.

The Chinese character for this looks like an aerial view of Hampton Court maze. For the Celts it was a yew tree. In Japan it's a turtle; in Korea a mushroom. Almost every culture has its symbol for longevity. (Actually the Chinese have a hundred of them.)

Why this universal human obsession with cheating death, whether through immortality, resurrection, afterlife or reincarnation? Pandering to the desire for eternal life is the most ancient and the most persistent of human cultural activities. Through Christianity or cryopreservation, conventional medicine or

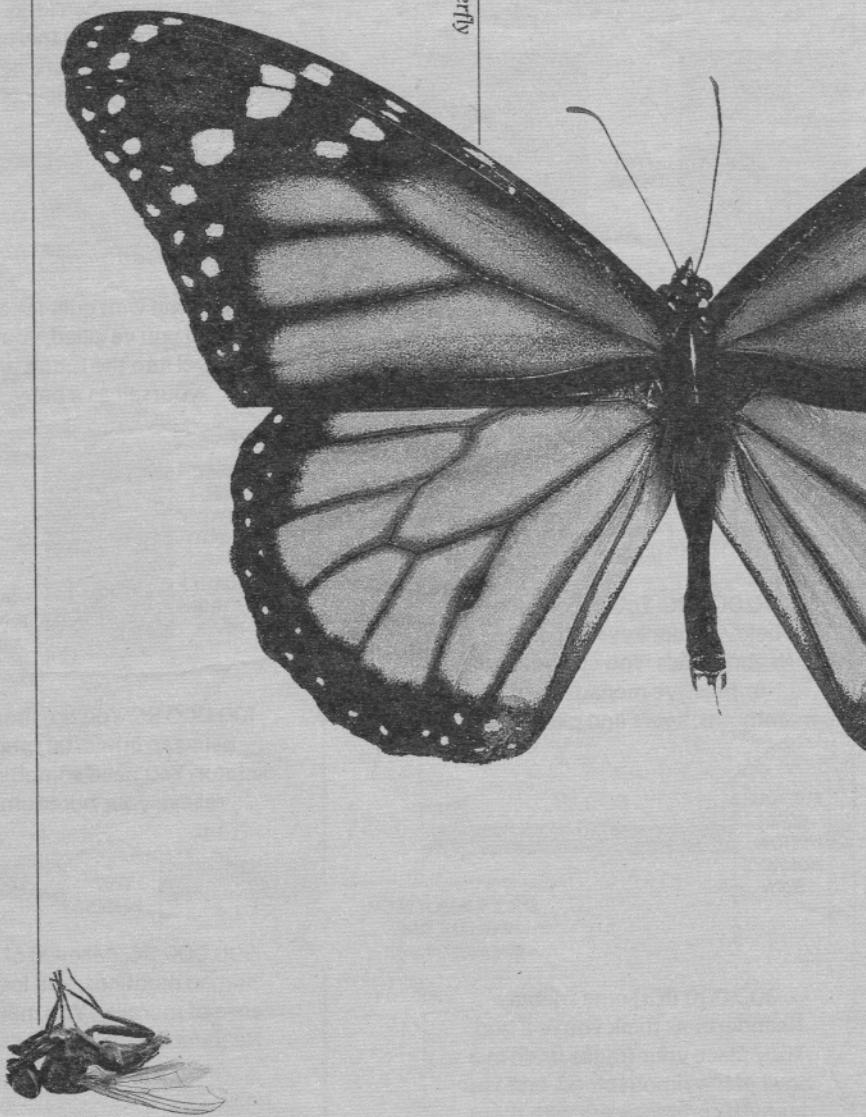
cosmetic surgery, people have always hoped to be eternally young, or even to live for ever.

Fear of death and lust for immortality are the unproductive consequences of self-awareness and the particularly human ability to agonise about the future. Of course, animals of all species do their level best to stay alive. But nothing survives indefinitely. Even those legendary Californian bristlecone pines, which live for thousands of years, are cheating. They replace their cells all the time: some scientists estimate that no cell in an apparently ancient bristlecone is more than 30 years old.

Animals in the wild are usually killed by

## WHY CAN'T WE LIVE FOR EVER?

5 weeks Housefly  
1 week Luna moth



1 day Common mayfly (5 mins Female *Dolania Americana* mayfly)

## How science can buy us time

Words: Mike Hodgkinson

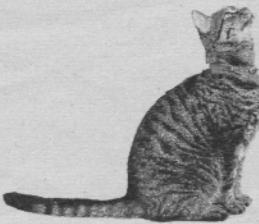
### 1. SENS (STRATEGIES FOR ENGINEERED NEGLIGIBLE SENESCENCE)

"Negligible senescence" is the slow ageing process observed in certain animals. Aubrey de Grey, the bearded, beer-loving chief science officer of SENS, is attempting to engineer this condition in humans using a variety of medical techniques and what he calls "rejuvenation biotechnologies". "The whole idea is that there is this bunch of things that are lifelong, accumulating side-effects of metabolism — the things I'm calling 'damage', " he says. "If we go in when the damage is still not abundant enough to be pathogenic, but we remove most of that damage, then we're essentially buying time." The SENS research team is focusing on what de Grey calls "intracellular junk" (disease-causing molecules within cells). Ultimately, SENS hopes to defeat ageing and de Grey says this could happen within 25 years. "I don't think it's over-optimistic," he says. [sens.org](http://sens.org)

Might even human beings be programmed to die by a genetic time-bomb, ticking away in our DNA?

This kind of Darwinian explanation for death is almost certainly correct for some species.

Take, for instance, the unfortunate mayfly, whose fate is evident in the Greek name of the order of insects to which it belongs — the emphemeroptera or “short-lived winged creatures”. The larval stage survives in fresh-water streams or rivers for a year or more. The beautiful adults have the pleasure of wings and flight. The males have large eyes to spot females and long front legs to grab them

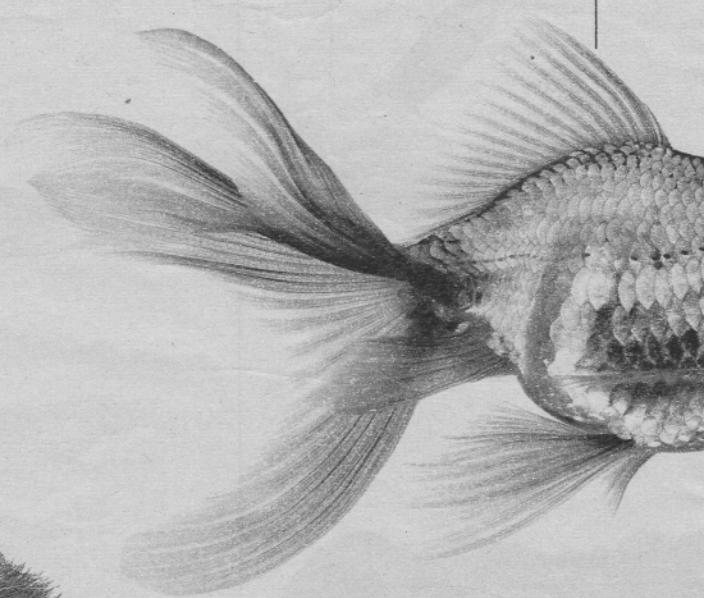


39 years Lucy the cat (from South Wales)

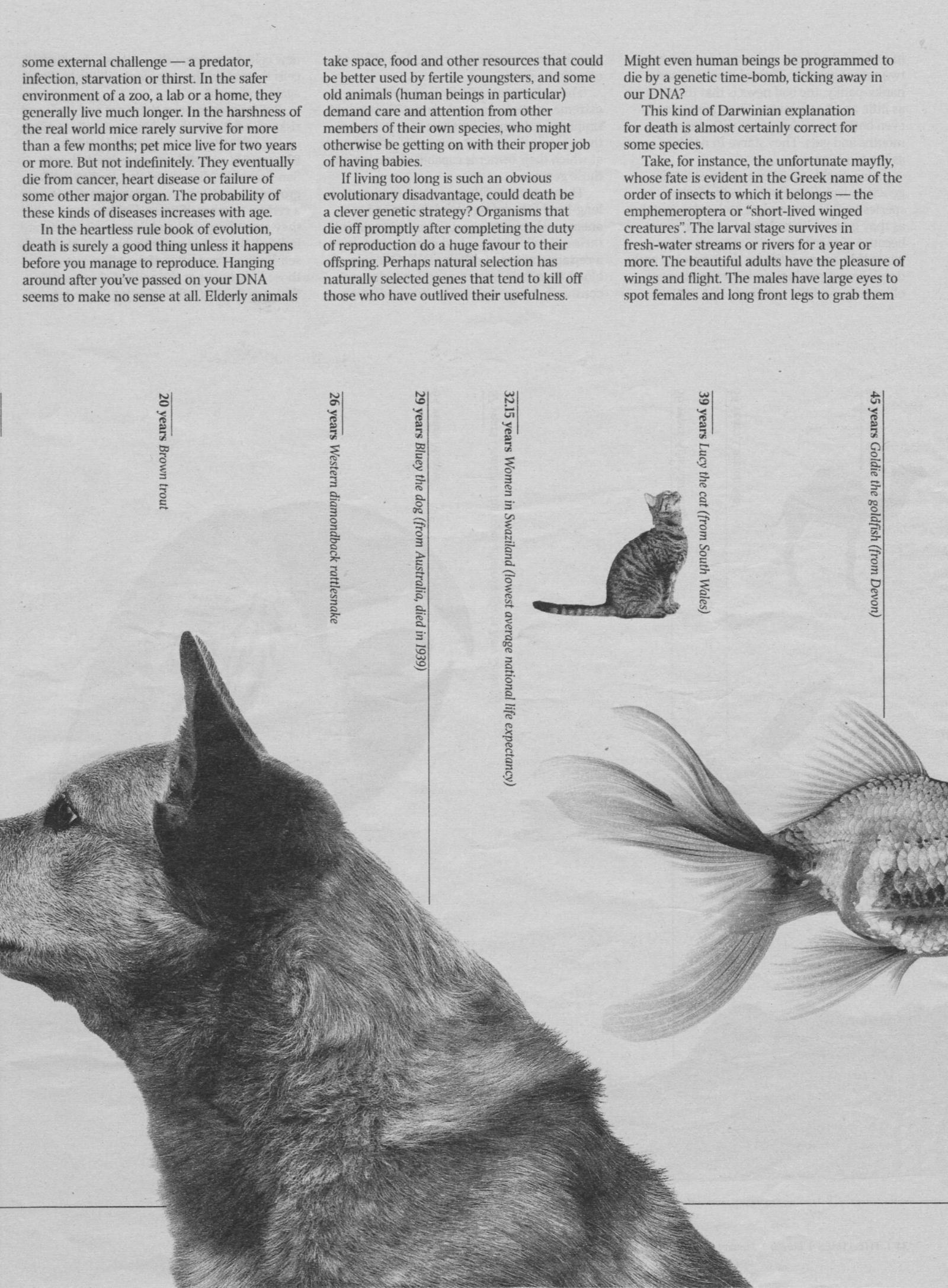
32.15 years Women in Swaziland (lowest average national life expectancy)

29 years Bluey the dog (from Australia, died in 1939)

26 years Western diamondback rattlesnake



20 years Brown trout



in mid-air. And both males and females have two sets of genitals. The good news is aerial hanky-panky; the bad news is that they live for as little as a few minutes. Their genes don't even bother to endow them with proper mouths and guts. They starve to death as soon as the fun is over.

Being unable to eat is a pretty extreme genetic adaptation. But the cells of every species tend to accumulate molecular mistakes as they grow older and some of these occur because of specific genetic programs. Some genes that are essential for the control of early development produce proteins that damage older cells. And the repair of DNA, which is

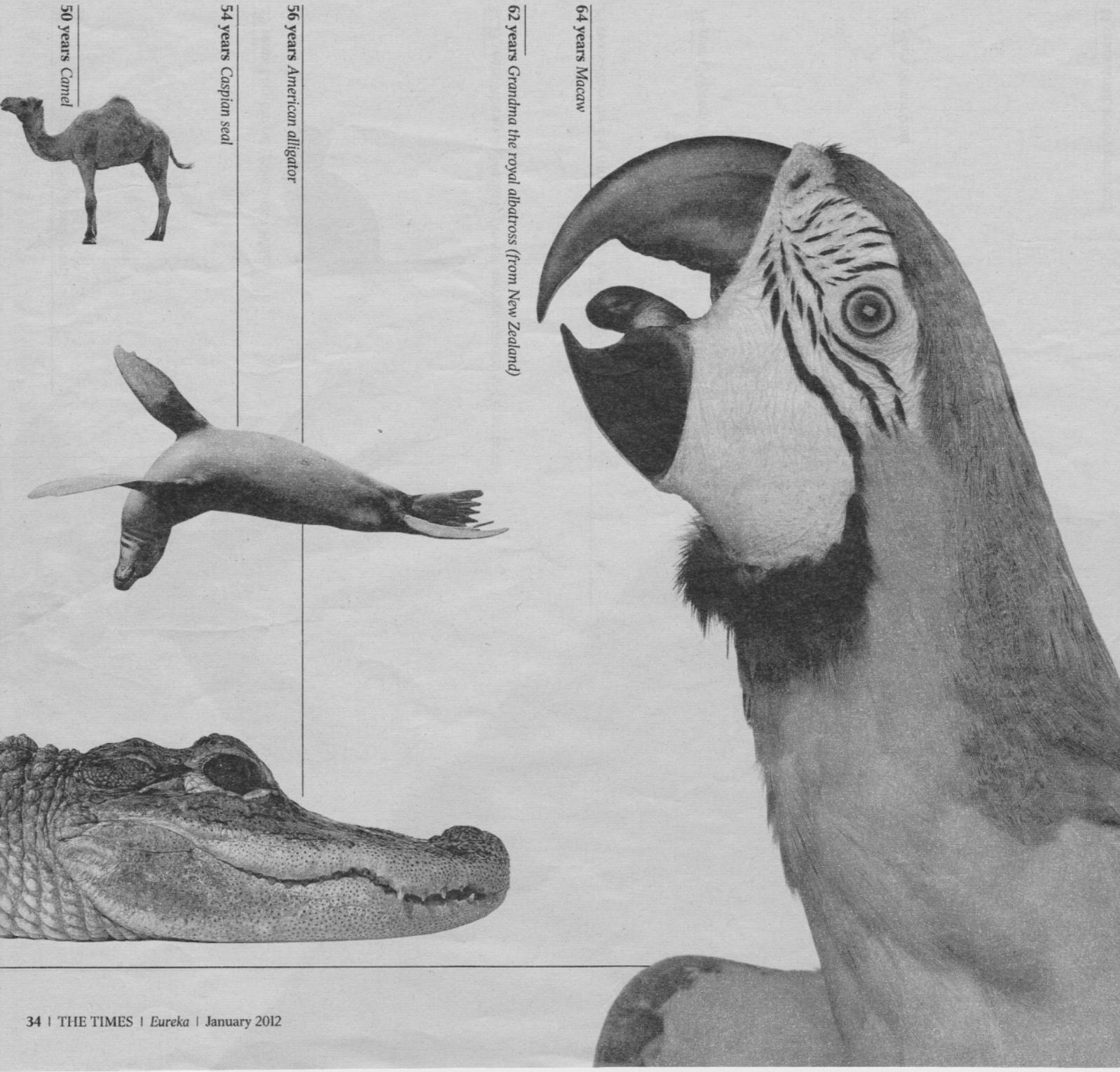
essential to prevent cancer, gets less efficient over time.

The unfortunate mayfly is obviously an extreme example. In most species there might simply have been no pressure to select genes that specifically protect older cells, after the age at which their owner is capable of passing on those genes.

Those canny bristlecone pines (and certain long-lived fish and reptiles, lobsters and sea anemones) seem to cheat nature by replacing their cells all the time. And even mammals do a certain amount of cellular DIY. Our skin, blood, liver, hair, intestines and muscles are constantly being repaired by the production of

new cells from stem cells — those charmed cells that retain the embryonic ability to divide again and again.

But for most species there are problems and risks associated with making new cells to patch up the body. Professor Leonard Hayflick, 83 years old and still an active researcher in San Francisco, discovered that human cells growing in test-tube conditions can divide only a certain number of times. Unlike cancer cells, they aren't immortal and they won't proliferate indefinitely. This is probably because of the self-limiting properties of the telomeres — those little knobs at the ends of chromosomes that stop the DNA from fraying. They get



shorter with each cell division, and the shorter they are, the more difficult it is for the cell to divide.

Some cells, especially stem cells, make an enzyme — telomerase — that patches up the telomeres and extends the “Hayflick limit” on the number of divisions. Genetic regulation of telomerase provides one mechanism for the normal control of lifespan. Could tinkering with telomerase provide a route to the holy grail of ageing research — an elixir of immortality?

Well, rejuvenated telomeres might encourage repair but they might also lower the cell’s self-defence against becoming cancerous.

The jury is still out on the relationship between self-repair and cancer. But, as things stand, it’s hard to imagine an anti-ageing treatment based on telomerase getting approval from the regulators.

Telomerase might not be the answer but around the world (mainly in the United States, it must be said) prophets of immortality are predicting an end to ageing within a few decades. And the potential profits of immortality have not escaped the notice of the pharmaceutical and biotech industries.

In the 1930s scientists discovered that rats live longer if they are fed on a low-calorie diet. So do mice, fish, dogs, flies, worms

and even yeast. However, a recent paper with preliminary evidence of the benefit of a low-calorie diet in monkeys has been greeted with some scepticism, and calorie restriction in humans might actually be risky. Nevertheless, these discoveries have prompted a flurry of research on anti-ageing treatments.

The exact mechanism of the benefit of calorie restriction is still unclear, but there is some evidence that it involves activation of a family of seven enzymes called sirtuins. Resveratrol, a substance found in the skins of red grapes (but only at very low levels in wine itself) seems to activate one of

122 years, 164 days Jeanne Calment, the longest-living person

88 years Putte the European eel (from Sweden)



94 years Vatsala the Asian elephant (from Panna National Park, India)  
93.84 years Women in Monaco (highest average national life expectancy)

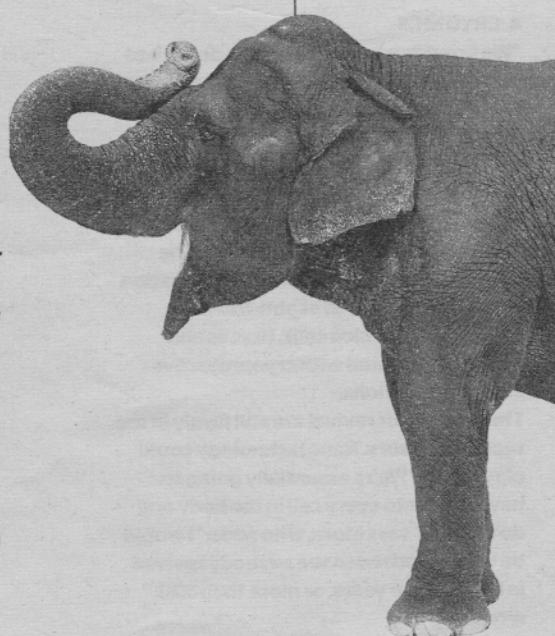
100 years Amazon Parrot

112 years Charlie the blue and yellow parrot (from Surrey)

## 2. EVOLUTIONARY BIOLOGY

“The idea that ageing is this cumulative breakdown process, I think is fundamentally wrong,” says Michael Rose. The professor, from the University of California, Irvine, contends that age-specific rates of death stop increasing late in life. “Basically,” he says, “ageing stops”. “I think I’ve figured out a way for people to stop their ageing in better health. I don’t mean waving a magic wand and obliterating cancer, heart disease, stroke or so on. I mean causing the rate at which those things happen to you to stabilise.” Rose thinks that we can reach the age of, say, 70 with a body time-arrested in its mid-50s. To do so, we must follow a hunter-gatherer-style palaeolithic diet — only foods such as meat, fish, vegetables and fruit. Then evolutionary signals kick in and the body can reach its post-ageing phase sooner rather than later.

55theses.org



## 3. REGENERATIVE MEDICINE

Dr Michael West is a cell biologist, and CEO of the California biotechnology company BioTime, whose work focuses on human embryonic stem cells (hES). “What I’m really trying to do is to tackle age-related degenerative diseases, and do it in a biotech setting,” he says. There is serious science behind hES technology. “There’s evidence that ageing occurs on a cellular level: it’s innate within each cell,” says West. “The cumulative effect of cells ageing is what causes us to age. With regenerative medicine, the idea is making new, fresh, young cells to restore function. But not all human cells age. Today, we have the technology to take a cell from you back to the beginning of life,” he continues. He has worked out how to “make” more than 200 different human cell types. “One of the more exciting ones is vascular: the ageing of the vascular system brings down more people than probably everything else put together.” [michaelwest.org](http://michaelwest.org)

the sirtuins, and there are claims that resveratrol extends life expectancy in at least yeast, worms and fruit flies (but probably not mice).

An alternative theory suggests that caloric restriction inhibits a molecular pathway that regulates energy utilisation. Rapamycin, a bacterial product first found in soil samples from Easter Island, which also inhibits this pathway, extends life in yeast. Significantly, in mice, it decreases mortality even if given at the equivalent of middle age.

Despite the fact that this field of research is peppered with controversy and failures to replicate, and in the absence of any published

evidence that calorie restriction even works for human beings, GlaxoSmithKline paid \$720 million (then around £360 million) in 2008 for the small company Sirtris, which is developing drugs to mimic the action of sirtuins.

The Methuselah Foundation, based in Springfield, Virginia, offers multimillion-dollar prizes for research on delaying ageing — in mice.

Their main prize, the Mprize for longevity, is held by Dr Andrzej Bartke of the Southern Illinois University School of Medicine, who discovered that genetic modification of growth control produces dwarf mice that

live to a prodigious age — nearly five years. At first blush, this burgeoning field of research seems noble and profound — the response of science to the deepest desire of humanity. But success in achieving the goal of immortality would be a disaster of apocalyptic proportions. Dr Aubrey de Grey, the British-born doyen of the Californian quest for immortality, calls ageing “the world’s biggest problem”, but the problems created by eliminating it would be infinitely greater.

At the heart of all the major crises of our planet — climate change, supply of food, energy and water — is the population explosion. Every day there are about

5,000 years Great Basin Bristlecone Pine

4,265 years Deep-water black coral

2,000 years Olive tree (from Crete)

1,550 years Antarctic sponge

400 years Ocean quahog, mollusk (commonly eaten as the black clam)

250 years Freshwater pearl mussel

226 years A Koi fish (the longest-living vertebrate; normal lifespan is 47 years)

211 years Bowhead whale

200 years Red Sea urchin

178 years Jonathan the giant tortoise (from Saint Helena)

#### 4. CRYONICS

“We provide what’s sometimes described as medical time travel,” says Dr Max More, the president and CEO of Alcor, a non-profit company in Arizona. “We preserve you in an unchanging state and take you from the present, with its primitive level of technology, into the future.” At which point you might be safely revived. The current preferred method of preservation is vitrification, a kind of anti-freeze technique, by which cells, tissues and organs are treated with cryoprotective chemical solutions.

The options for revival are still firmly in the realms of theory. Nanotechnology could play a role. “We’re essentially going to have to go into every cell in the body and do repairs,” says More, who adds: “I would be very surprised to see anybody revived in less than 30 years, or more than 300.”

[alcor.org](http://alcor.org)

► 250 YEARS

350,000 births and only 150,000 deaths. And of those, two-thirds die from some age-related condition. If those deaths were eliminated, the growth in world population would increase by 50 per cent.

De Grey's response is frighteningly simplistic. Population growth will be counterbalanced by women delaying reproduction as the menopause is deferred. Treatments to eliminate ageing will be made available for free to the entire population of the world. And there will, he says, be huge economic benefits from delay in the demand for medical care.

Improvements in public health and medical treatment have already achieved near-

miraculous improvements in human life expectancy — up by nearly 45 years on average since 1840. But even this rate of improvement — modest compared with the aspirations of de Grey and the Methuselah Foundation — is contributing to a crisis in pensions, housing, balance of employment, social services and healthcare. Moreover, gradual progress in dealing with the other chronic diseases of middle and old age is exacerbating the frightening burden of brain diseases, for which there is still little understanding and few effective treatments.

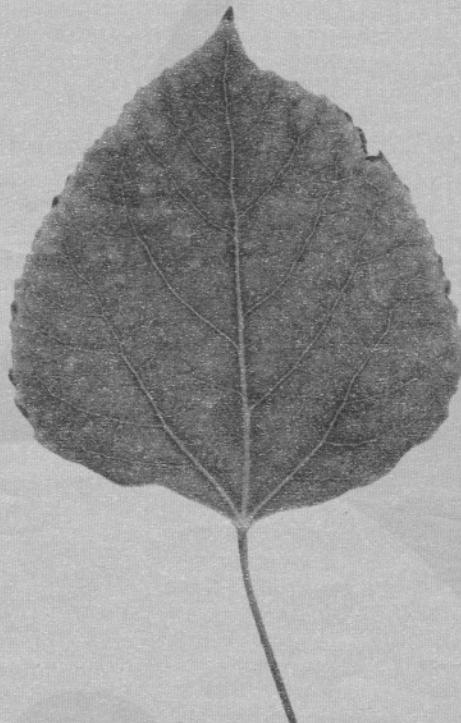
It's vital to distinguish between essential research on the medical problems associated

with old age and the ethically dubious aims of those who want to make death a thing of the past.

Our familiar concepts of the passage of time are set partly by properties of the inanimate world — the cycles of the Earth and the Moon. But we also perceive time, and particularly the direction of its arrow, through the pattern of our lives — birth, death and the ladder of experience in between, sleeping and waking. And the relationships between the generations. Although it is what people have always yearned for, eternal life would utterly distort the balance between humanity and the world in which we live. ●



11,700 years King Clone, creosote bush ring in the Mojave Desert



80,000 years Pando, Quaking Aspen colony in Utah

##### 5. THE ARTIFICIAL BIOLOGIST

Ben Goertzel suspects that a solution for ageing might lie somewhere beyond the limits of the human mind: that's why he is working on artificial intelligence (AI). His Maryland-based company Biomind is already using unique AI technology to analyse genomic data, but he's also working on a more ambitious AGI (artificial general intelligence) plan. Ultimately, he hopes, those twin elements will converge to produce an AGI bio-scientist. This artificial biologist would comprehend vast amounts of data and, as Goertzel says, "figure out by intuition things that we need to figure out by calculation". The breakthrough, he thinks, could arrive sooner rather than later, depending on funding. "I would say in two or three years we could have a very powerful artificial biology system." After that, he says, progress could snowball.

[wp.biomind.com](http://wp.biomind.com)

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