FEATURES

Medical science has made huge strides in the past century, but new research promises to give people a vastly improved quality of life. Science editor **Roger Highfield** predicts the benefits his three-month-old daughter can expect at 60

The future looks good, Holly

HOLLY is young and bonny now — but how will she be in 2060? Fortunately, developments in cloning, reproductive technology and genetics will do much to keep her in good shape. She can also expect a higher quality of life as the emphasis of research shifts from halting big killers, such as cancer, to arresting the underlying ageing process

Picture: CHRISTINE BOYD

Holly Highfield at nine weeks: science will tempt her generation with everything from easy weight loss to a new personality

Farewell to fat

THE expanding number of love handles, pot bellies and flabby thighs can be blamed on the way our brains and bodies are optimised for Stone Age conditions, when life was tough, fat was scarce and famine common. Evolution smiled on those who craved energy-rich foods and put down stores of fat in case of shortages. Today's high-fat, low-exercise culture has led to an epidemic of obesity. But researchers are learning much more about the maze of metabolic pathways that control appetite, store fat and burn it. Drug companies are investigating dozens of compounds, based on the dozens of genes so far linked with weight control. A safe and effective anti-fat pill is only a matter of time.

Genetic hair care

NATURAL dyes and thicker thatches are bound to result from recent fundamental advances in our understanding of baldness, such as the discovery of a mutated gene that causes hereditary hair loss, techniques to turn skin cells into hair follicles, and the successful growth of hair from individual follicle cells. Some speculate that it is already within the reach of scientists to design ways to grow hair, remove hair, even dye hair genetically.

Designer drugs

FEW PEOPLE will suffer side effects in 2060 because, by then, gene chips will be used to screen a blood sample for signs that a patient will react badly to a medicine. Some even envisage implantable arrays of microscopic sensors that will constantly monitor health. Doctors will also check that your 100,000 or so genes provide the proteins and enzymes to mount an effective defence against a disease. The result: customised medicines and a vast new family of agents to boost mood, enhance pleasure or reduce dependence on drugs and alcohol. Doctors are already beginning to use customised medicine, notably a patient's own tumour cells in vaccines designed to provoke their immune systems to mount an effective attack on cancer.

Delayed ageing

IN THE PAST decade, the lifespan of creatures such as fruit flies, worms and mice has been boosted by genetic tinkering. If fiddling with one gene can do so much for them, what about us? For example, mutations in the genetic code of our cellular power packs — mitochondria — have been linked to ageing. Perhaps scientists will find a way to stop them from winding down. There is also interest in repairing telomeres, the ends of chromosomes that fray with age, and in boosting the mechanisms at work in the body to mop up damaging chemicals called free radicals. Other hints of how to arrest ageing come from studies that show how strict diet can boost lifespan.

Restored vision

SPARE parts for eyes are already being grown in the lab. A Canadian team has announced that it has cultured an artificial cornea that works much like a real one, offering hope for people with injured or diseased corneas waiting for transplants. Eye disease is also being tackled. Vision is most often compromised by new blood vessel growth in the eye, notably in macular degeneration and diabetic retinopathy, the leading causes of blindness. Scientists have already found ways to prevent vessels sprouting. They could go further and reverse blindness. Take retinitis pigmentosa, an inherited condition in which light-gathering cells at the back of the eye degenerate. Trials are under way to repair this damage with foetal eye cells and, in future, cloning methods could enable doctors to transplant a patient's own eye cells.

See more, hear more

DEAF people can now understand a reasonable amount of speech without lip reading, thanks to cochlear implants, which directly stimulate auditory nerve fibres in the inner ear. Other senses are set to follow. At the Johns Hopkins's Wilmer Eye Institute in Baltimore, work on retinal implants is under way to offer limited vision to people blinded in later life by eye diseases. Rival projects are under way at the Massachusetts Eye and Ear Infirmary, Optobionics in Wheaton, Illinois, and in Germany. Others are investigating how to use an artificial retina to stimulate the brain directly.

A new personality?

IF HOLLY does not like her personality, she may one day be able to change it. Perhaps with the help of a ''behavioural engineer'', she will fine-tune it with hormones, biofeedback and genetic engineering. Scientists are already experimenting with growing nerve cells on silicon chips, so brain prostheses may even be available.

Stronger and fitter

DRUG abuse in athletics has already shown how anabolic steroids can enhance muscle mass and endurance can be boosted with the hormone erythropoietin, which stimulates red blood cell production. As genetic factors that influence athletic performance are revealed, doctors will be able to design treatments to help the elderly remain lithe and lively, without side effects.

We have known for years which genes were linked with body size and muscle mass. Animal muscles crippled by a form of muscular dystrophy can now be repaired, both in size and strength, using a virus to ''reprogram'' wasted tissue with new genes. In older mice, the improvement was more remarkable — a 27 per cent increase in strength over untreated muscle — fully restoring strength to what it was in young adulthood. Scientists are now working out how to extend this to fight muscular dystrophy and perhaps the frailty of old age. The temptation to exploit these advances further to use genetic engineering to ''improve'' ourselves will be irresistible.

Fragile bones

BY 2010, for the first time, there will be more Europeans over 60 than under 20, placing greater numbers of women at risk of fragile bones caused by osteoporosis. Tests have begun to highlight drugs, some already in use to treat other diseases, that can stimulate the production of osteoblasts, the specialised cells that create new bone. This research could mark a new approach to treating the disease by replacing bone that has already deteriorated. Current treatments stop or slow bone loss.

Some doctors are experimenting with an injectable replacement for cartilage. Other teams are developing vaccines to combat rheumatoid arthritis, where the body's defence mechanism turns on its own tissue to cause a painful and chronic disease of the joints. The vaccines will turn off the immune response, preventing the inflammation that causes joint destruction.

The menopause

OVARY grafts could be used to treat sterility caused by premature menopause, protect fertility in those undergoing cancer treatment and delay the menopause so that elderly women could conceive. Building on pioneering work in Britain, an American team has already carried out the first grafts of tissue from the ovaries, almond-shaped glands within which the female sex hormones are produced and which contain cavities, called follicles, in which eggs develop.

The ovary ages faster than any other organ in the body. Menopause is thus triggered far earlier in humans than in any other species. Hormone Replacement Therapy has become part of mainstream medical practice, preserving healthy arteries and bones, so some have suggested that a graft of stored ovarian tissue may prove more effective than boosting hormones to premenopausal levels with pills, patches and implants.

Brain power

MANY scientists have been sceptical that simple genetic changes could have much effect on intelligence, pointing out that the human brain uses some 30,000 genes. But mice have been made demonstrably smarter by adding a single gene, suggesting that genetic improvement of intelligence and memory in humans is feasible. This work offers another example of how gene therapy — the introduction of genes by virus, artificial chromosome and so on — may affect society and will stimulate ethical debate about the extent to which medical advances should be used to enhance people as well as fight disease.

Other research has shown how scientists may one day exploit their understanding of cellular processes to treat degenerative diseases, such as Alzheimer's. By blocking the action of enzymes called secretases, for example, they hope to prevent the build-up of deposits linked with dementia.

Scientists could go further and harness natural repair mechanisms to fix a broken brain. Doctors used to believe that nerve cells in the adult brain could not regenerate themselves: as cells were lost through ageing, we became dimmer and dimmer. But work on animals over the past three decades has overturned this belief and now a team at Princeton University has even seen brain cell growth in the most complex areas. Strategies to stimulate new growth and to use ''stem cells'' to cultivate brain tissue are under discussion. Others are finding out how to conduct ''directed neuroplasticity'', that is, to retrain the brain through special exercises whether to fix the damage caused by a stroke or enhance golfing ability.

Spicier sex

IN THE coming century, sex will become less and less to do with reproduction and more to do with fun. Reproduction will increasingly be carried out in test tubes as current infertility techniques boost the numbers of infertile people (they inherit the problem). For the wealthy, vain and ambitious, test tube methods will also offer the means to weed out genes linked to disease, or select taller, smarter and prettier children. For sterile men, animals could be used to grow their sperm. For narcissistic women who don't want to spoil their figures, it may be possible to raise a clone in an artificial womb.

Virtual reality technology may even see bedroom romps replaced by computer-mediated encounters between geographically distant people clad in stimulating body suits. Although virtual sex will eliminate the risk of disease, it could cause psychological problems — imagine if you discovered that the object of your desire preferred on-line encounters only after you had been digitally altered to look like a former lover.

Reliable alternatives

ADVOCATES of unconventional therapies confidently predict that herbal remedies and homoeopathic potions will flourish and take their rightful place alongside conventional medicine. Few have been adequately tested but by 2060 it seems likely that any that can be proved valid will have been incorporated into mainstream medicine. The rest, some say the majority, will have been exposed as old-fashioned quackery.

You look perfect

PLASTIC surgeons will soon plan and practise nose and breast operations using computers and virtual reality to get under the skin of their patients, who in turn can use the Internet to consult any specialist on the planet.

The current range of chemical peels, wrinkle fillers, laser skin treatments and muscle paralysers will give way to treatments that harness molecular understanding of skin healing, texture and ageing.

Opportunities to fix tissues or replace an organ in an ailing body, without the risk of rejection, will also come from the ability to grow stem cells — the precursors of all cell types — or to generate new tissue with growth factors. Efforts are under way to use cloning and tissue engineering to grow a patient's own tissue, teeth or bones to cultivate replacement parts to overcome organ shortages.

Even if donor or ''humanised'' GM animal organs have to be used to fix a body (and the latter may have been banned by 2060 if they are found to seed new diseases), scientists are devising ways to ''reprogram'' the body's immune system so that it will tolerate a transplant but remain capable of fighting infections.

Of all the repairs under consideration, perhaps the most extraordinary focus is on fixing a damaged spinal cord. There is real hope that many of the paralysed could eventually be on their feet. In conducting such repairs, surgeons may be put out of business by microscopic robots. Proponents of nanotechnology (''nano'' is Greek for dwarf) suggest that one day an army of tiny robots, each no larger than a bacterium, could be injected into patients to measure vital signs, scour arteries for dangerous build-ups or zap blood clots with lasers.