The Sutton Grammar School Biology Magazine

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Edited by
Christopher Slade
Nicholas Weise
Samuel Amis

Cheating Death

Why Even the Fastest Species Can't Outrun Extinction

By Michael Pinchbeck

Even if rescued from extinction at the last perilous minute, a species that has been reduced to a fraction of its original population loses much of what once made it unique. In all organisms that reproduce sexually, each individual plant or animal contains a different mix of genes. Known as genetic diversity, this incredible variation within species is what allows populations to adapt to changes in climate and other local environmental conditions. When a species - be it antelope, swordfish or daisies - loses too many individuals, it becomes genetically uniform and far less adaptable. The cheetah, *Acinonyx jubatus*, is the sole member of its genus. Twenty thousand years ago, cheetahs roamed throughout the savannahs and plains of four continents: Africa, Asia, Europe and North America. About 10,000 years ago - because of climate changes - all but one species of the cheetah, *Acinonyx jubatus*, became extinct. With the drastic reduction in their numbers, close relatives were forced to breed and the cheetah became genetically inbred, meaning all present-day cheetahs are closely related.

In genetics, the term 'genetic drift' refers to a change in allele frequencies of a population that happens by chance alone and occurs typically through one of two processes: the founder effect, where the genetic make-up of a new population is established with only a few founding individuals, or, a genetic bottleneck. The cheetah went through the latter as it experienced a drastic decrease in population size due to a catastrophic event (in this case climate change) which resulted in a reduction in the pool of alleles. The consequent population became much less genetically diverse and more vulnerable to changes in the environment. Evolution eliminates traits in organisms that are least suited for survival and some of the decline in the cheetah's genetic diversity is accounted for by its specialisation through natural selection. However, the effects of this occurrence are small when compared to the effects of the prolonged inbreeding that occurred 10,000 years ago from the bottleneck.

As populations decrease to fewer and fewer individuals, they flirt with extinction through what geneticists term 'inbreeding depression'. Conservation biologists have tried to draw danger lines below which a species is at a conspicuously higher risk of extinction from genetic depression. They speak loosely of a '500 rule' of genetic health in populations whereby genetic drift (the chance fluctuation of gene percentages) is strong enough to eliminate some genes and reduce the variability of the population as a whole if the population size drops below 500.

Inbreeding depression, turning the screw generation by generation, shortens the longevity of a species. So, the cheetah is still here today and must obviously have avoided the critical figure of 500, however, the species still exhibits much lower levels of variation than other mammals. In most species, related individuals share about 80% of the same genes whilst with cheetahs this figure rises considerably to approximately 99%. Genetic inbreeding in cheetahs has led to a low rate of infant survival, poor sperm quality and greater susceptibility to disease. For example, if a virus gets into a healthy population of leopards only a minority die because they are genetically diverse whereas a deadly virus can kill off a large proportion of a cheetah population.

To increase genetic diversity in captivity, zoos take great care to ensure only unrelated animals mate. However, because male cheetahs have very poor sperm quality the chance of fertilising an egg is low and so artificial insemination (AI), where the sperm is placed directly into the reproductive tract of a female, is used. AI and IVF treatments have produced cheetah cubs in the US whilst there is a program currently running in Namibia involving the collection of semen and eggs from wild cheetahs. The success of this program is vital because Namibia has the largest population of cheetahs in the world and so the genes represented in this population are important for captive cheetah survival worldwide.

Inside This Issue of Life

The Genome X-Prize

Scientists compete to find your full personal Genome

By Carl Alexander

Imagine in the next few years you go to the doctors to have a check up. He tells you to sit down and then you hand him a card with your genome on it; the blueprint to your entire existence. Well this is the target for the competitors racing for the $10 million Human Genome X-Prize. Any scientist who discovers the way to sequence one hundred genomes at a cost of $10,000 each time is in line to win the grand prize.

The X-Prize was the brainchild of a group of American philanthropists who wanted to make their lifelong dream of flying into space come true. Therefore they funded a competition for scientists to come up with a design for a personal space shuttle with a multi-million dollar prize. After reaping the benefits of this competition the same group of philanthropists have funded further competitions to further advance modern science technologies.

We are currently entering a very exciting period in genomics; whereby unravelling individual genetic codes could lead to new treatments against diseases and predict whether a person's genes make them more susceptible to certain diseases. The chance to use individual genomes to predict diseases and guide specific care has the power to change the world's healthcare systems forever.

There is the potential for many advantages with the ability to find out someone's entire genome. In the future knowing someone's genetic code will allow them to make lifestyle changes in order to prevent the risk of them contracting specific diseases that their genetic makeup might make them more susceptible to. For example, if a person has a weaker variant of a low-density lipoprotein receptor gene, then they can change their diet to prevent a rise in cholesterol levels.

We will be able to select safer and more effective medications and dosages. A greater knowledge of a patient's genome will allow GPs to prescribe the most effective medication with few side effects. The genome will show the rate of a patient's metabolism allowing exactly the right dosage to be supplied. By being able to prescribe drugs with fewer side effects the patient will be more likely to take the ideal choice of medication.

There is also the potential to create improved vaccines. By creating vaccines out of the genetic material of either DNA or RNA there will be less risk; they will successfully activate the immune system as with normal vaccines but are unable to cause infections. They are also likely to be inexpensive, easy to store and able to carry several strains of a pathogen at once to fight all strains of the disease.

By being able to predict whether a person is likely to contract a disease they can take active lifestyle changes to reduce the risk of contracting it. Doctors should also be able to provide more effective treatment therefore reducing the amount spent on medication. These improvements should greatly reduce net healthcare costs allowing further progress to be made in healthcare systems.

We are still a few years from being able to record an entire genome efficiently, but within the next 20-50 years we could see a great advance in the medical industry and healthcare systems. Although the changes cannot be predicted exactly one thing is certain: the winner of the Genome X-Prize is in for a large pay-packet and maybe even a Nobel Prize.

Amis' Ailment's № 1:

An unfortunate infant with the disease, 'Harlequin Ichthyosis'

Amis' Ailments

'Another look at the most gruesome and obscure illnesses that plague mankind.'

By Samuel Amis

In this article, I will be looking at what I believe to be the ten worst genetic disorders. Genetic disorders are often considered a more morbid diagnosis than many other illnesses because there is usually little that can be done to cure them. Any inherited genetic disorder is repeated during each mitotic division and so every cell in any organism contains the exact same genome. Whilst technology today allows us to replace genes in the genome of a bacterium, replacing a defected gene in every cell of a human body is currently impossible. Although gene therapy and stem cell research are advancing rapidly (and I have every faith that our technology will eventually allow us to cure some genetic disorders) this is still a long way off. As a result, a diagnosis of a genetic defect means that the sufferer will have to live with it for the rest of their, usually shortened, life and can potentially pass it on to their children.

So let us begin the countdown of the top ten genetic disorders starting with number 10: *Cri-du-chat* syndrome, which results from a missing section of chromosome 5. The disorder is initially characterised by a small head (*microcephaly*) and low birth weight. Even at an early age the defect causes mental retardation and delayed neurological development that persists into adulthood.

Huntington's Disease is up next at number 9. In this condition the Huntington gene defect is dominant and so can be passed on to offspring even if only one parent carries the gene. The gene, which codes for Huntingtin protein is defective and so produces mutant Huntingtin. This increases the rate of neuron cell death above what is normal and so by the age of around 50 symptoms including chorea (random jerky movements), slurred speech and loss of coordination accompany the general neurological decay. This leads to psychopathological symptoms such as depression severe anxiety and compulsive behaviour. The life expectancy is usually 10-15 years after onset.

So this brings us to number 8 of the genetic disorders. The aptly named *Maple Syrup Urine* disease, also known as *branched chain ketoaciduria*. This disease presents with sweet smelling urine due to a build up of branched chain amino acids in the blood, caused by a defect in the gene that codes for the dehydrogenase enzyme that usually breaks them down. If left untreated, brain damage and lethargy can follow, eventually resulting in death. If diagnosed early then a carefully regimented diet that substitutes these amino acids for alternatives can be effectively used.

Number 7 is *Klinefelter syndrome* which is caused by the presence of another chromosome and only affects men. The growth of the testicles is severely inhibited which results in infertility due to the *hypogonadism*. Enough said.

Number 6 *sickle cell anaemia*. This genetic condition causes the red blood cells to form a sickle shape rather than the circular biconcave shape, which they usually have. It is most prevalent in people from sub-Saharan Africa and which is believed to be an evolutionary solution to the problem of Malaria as the sickle erythrocytes are less susceptible to the parasite. The disease means that the flexibility of the red blood cells is reduced, which can have many impacts including restricted blood flow in capillaries. This results in ischemia (lack of oxygen) and damage to organs.

Cystic Fibrosis is the fifth worst genetic disorder partly because it is so prevalent; around 1 in 4000 children are born with the condition. The defective gene does not produce the chloride ion channel important in mucus production, for which it normally codes. As a result, overproduction of mucus in the lungs, pancreas, liver and intestines results in recurrent lung infections and digestive problems, leading to poor growth and deficiency diseases. Life expectancy is dramatically reduced and there is no cure, although treatments are making life much more comfortable for sufferers of the disease.

Down's syndrome is in at number 4. This disorder is caused by an additional chromosome that causes reduced cognitive ability, stunted growth, and mental retardation. The incidence of the disease is one of the highest in this list with 1 in 1000 children being born with *Down's syndrome*.

Starting off the final three is *Duchene's Muscular Dystrophy*. A defect in the largest gene of the entire genome, (which codes for dystrophin, a vital protein in the structure of muscle cells), causes progressive muscle wastage from infancy. By the age of 10, calf muscle wastage causes the loss of the ability to walk followed by the destruction of all other skeletal muscle until respiratory and cardiac muscle is eventually weakened sufficiently to cause death by around age 20.

The penultimate genetic disorder, coming in at number 2, is *Tay-Sachs disease*. A mutation on chromosome 15 causes this disease which presents with a small red spot on the retina, the first innocent sign of something much more sinister. After the first 6 months of life, the infant's body begins to accumulate dangerously high levels of fatty acid in the cells of the central nervous system. This causes them to become distended and a relentless deterioration of mental and physical abilities follows. The child soon becomes deaf, blind, unable to swallow, then muscles waste away before paralysis eventually kills the *Tay-Sachs* sufferer at around the age of 5.

And finally, the moment you've been waiting for, the number 1, official worst, genetic disorder to affect mankind is Harlequin Ichthyosis. A specific set of mutations that can occur randomly, result in the harlequin baby being born with deformed or absent ears and nose. The skin is pulled very tightly causing the eyes to bulge and they often bleed at birth, the lips are also stretched into a wide grimace. The deformations in the skin cause large diamond shaped plates of thick skin to form separated by vulnerable much thinner areas. The tightness and dryness of the skin means that normal finger and limb movement is impossible and the baby is also very susceptible to infections and cannot regulate its body temperature. There have only been 100 reported cases of this condition, making it very rare although few babies survive their first month.

Reproduction

By John Gorringe

Reproduction is the process through which genetic information can be passed on from parents to their offspring and occurs in all living organisms and is essential to keeping a species alive. There are two very different ways or reproducing – sexual and asexual reproduction.

It is most commonly thought that both animals and plants reproduce sexually, and only plants and bacteria reproduce asexually. This is far from the case.

In asexual reproduction, one individual produces offspring that are genetically identical to itself. These offspring are produced by a process called mitosis, a form of cell division which allows organisms to grow and reproduce.

In plants, asexual reproduction occurs through in various forms such as tubers and runners. Examples of these are shown below:

1) A runner is an aboveground horizontal stem.

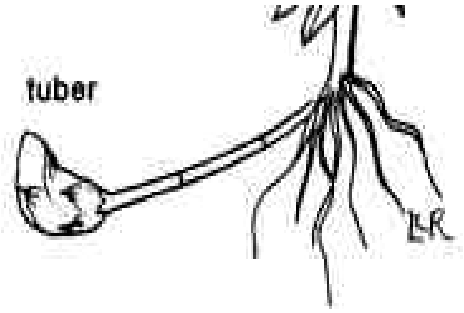
Where it contacts the ground a new plant is produced

Spider plants and strawberries reproduce asexually by runners.

2) A tuber is an underground horizontal, swollen stem.

New stems arise from "eyes" on the tuber.

Potatoes are tubers.



On the contrary to popular belief, there are many invertebrates, including sea stars and sea anemones for example, that produce by asexual reproduction as well as plants. Common forms of asexual reproduction in animals include:

1) Budding - In this form, an offspring grows out of the body of the parent.

Hydras reproduce in this form.

2) Gemmules (Internal Buds) - In this form, a parent releases a specialized mass of cells that can develop into an offspring.

Sponges use this type of reproduction.

Sponges are also capable of sexual reproduction. Being able to reproduce sexually and asexually is not just a quality of plants, some of the earliest animals were (and some still are) able to do both.

3) Regeneration - In this form, if a piece of a parent is detached, it can grow and develop into a completely new individual.

Echinoderms reproduce like this.

Other Weird and Wonderful Reproduction Facts

- Some animals, such as sea slugs that reproduce sexually, are able to act as both the male or the female when mating, although most tend to just act as the male; the easier task!
- Some fish change their gender half way through their lives.
- Many large frogs frequently have vestigial ovaries.
- Male seahorses become pregnant, not the female! The males have a brood pouch into which the female's eggs are inserted

As you can see reproduction is far more complicated than just sexual or asexual reproduction!!!

The Dog and Selective Breeding

By James Wickenden

Have you ever wondered why a Great Dane is so much bigger than a Yorkshire Terrier? And why dogs can be so different and cats are all alike? This is because 4000 years ago, prehistoric man realised that a wolf's natural abilities could be used very helpfully to defend them and help them hunt. So they started a breeding system so that wild wolves could be bred specifically to do special jobs (e.g. protecting and hunting). Any wolf with, say with a natural awareness and protective instinct would be given more food so that it could survive and the others would get no food and left to fend for themselves. Then the breeder would find another wolf and breed them together. After that, they would breed again and again with the first pair's puppies, each time choosing the best ones. After thousands of generations of this we have breeds such as the Doberman and the Rottweiler, which are specially bred to be guard dogs. Using this technique better and better hunting 'breeds' were developed, such as the Whippet and the Spaniel. Then every time someone thought of a new use for the dog a new breed was created until there were as many breeds as there are today. All the breeds that exist today are the subjects of a 4000 year long evolution program that makes them perfectly suited for their intended job. More recently however inbreeding has caused diseases among dogs, such as syringomyelia, which is the brain trying to expand out of the skull and is often found in King Charles Spaniels. Another breed affected is the Pug, because over the years the snout has been shortened and the smelling palette has been forced down their throat, often suffocating them. In general, specialised breeding is a good idea but the Kennel Club often sets impractical standards for some breeds forcing some breeders use inbreeding to reach these standards. It would be possible to create new healthy breeds in the future but there is little point as there are no practical uses for such dogs.

Solar Cells Need To Be More Dull

By Robbie Muir, 9 Green

Nowadays, pretty much everyone on this entire planet has been informed about the terrors of a phenomenon known as "Global Warming". As you may know, these effects are caused by greenhouse gases that are emitted into the atmosphere by the constant and forever increasing use of fossil fuels. These various terrors include the rising of sea levels and the deaths of several furry polar creatures that are set so very deeply in every environmentalist's heart. These are the reasons that inspire us to change the way in which we use our fuels and produce our energy for everyday use.

One way in which we can adapt our energy production is by installing solar panels onto the roofs of our homes. These shiny new panels help us heat up our homes by absorbing the heat energy emitted from the Sun and using it to raise the temperature of water in our pipes. This is what provides the hot water in our homes for central heating and many other domestic appliances such as showers and washing machines. However it has been shown that the old style of photovoltaic cells is not as effective as first thought to be. The design of the exterior is very shiny and metallic for aesthetically pleasing purposes but there are some serious faults with this design in the perspective of saving energy. The person who designed them obviously must not have been thinking about the transfer of heat through radiation. I know this because objects that have a shiny or metallic surface are not as good absorbers or emitters of heat radiation. This means that less heat energy is being absorbed and emitted by the photovoltaic cells than it would if they had a dull and dark surface.

This is why solar cells need to be duller so the heat energy from the sun can heat up our water more efficiently through radiation. In doing this accurately, we can reduce the amount of greenhouse gases being emitted which would therefore reduce the impacts of global warming, or maybe just slow them down enough for us to step in and make the world a better place.

The NHS– What A Mess!

By Ali Jawad

We have all heard of the long waiting lists, the MRSA devastations, the lack of doctors and nurses and conversely the surplus of doctors in our country who cannot find a junior doctor post, but why is the NHS constantly bringing us bad news?

The National Health Service was set up in 1948 as a free-to-all gift by Clement Atlee's labour government. Their intentions back then still remain today; in providing quality care to all citizens at no immediate charge to them. It was a bold and innovative proposition that is commended by most people for the good that it does as the NHS really does have some significant advantages.

Nevertheless, the problems mentioned above really do have some substance and demonstrate deep-rooted flaws in this massive organisation. During my research on this topic, I found some horrific stories with patients being mistreated and incompetence within the NHS, which, frustratingly, can be rectified when looking at simply one thing: organisation. Despite what many critics believe, the NHS does not have a huge financial problem; £92 billion from the department of health is pumped into the NHS, this is a huge sum of money, but the problem is: where does it all go?

Rising inflation rates and matching this with rising wages predominantly takes up a huge slice of the £92 billion cake, considering that the NHS is the 4th biggest employer in the world! One other fact is that the NHS is wasting a great deal of money on new drugs that sometimes have very little effect especially on problems such as Alzheimer's. One thing that I noticed through work experience more than anything was the extensive number of managers! It seems that the executives are taking organisation to a new level, in hiring managers to manage more managers. This is clearly a waste of money and demonstrates that the government understands that the solution involves more organisation however they just do not have anyone that can actually tame this big confused tiger that is the NHS.

During my own work experience, I witnessed patients having their appointments delayed by several weeks longer than expected (even though some already expected to wait for a month). This is comprehensible and it shows that the executives are doing something to change how the NHS works. You may have noticed that it is becoming much more centralised, in fact the doctor in a hospital may recommend a time for you to come back for a check up but the centralised reception desk can alter this. This seems like such an outrage, as what would a receptionist with a literature degree know about the seriousness of your medical condition? However this system takes time to meet the target of all patients to have their appointment within 18 weeks. The method in which it is done will be improved and the doctor's recommendation will carry more weight but, finally this new "centralised NHS" provides a more efficient healthcare system.

A recent poll put the NHS as the 17th best healthcare system out of 29 in Europe; this is due to the MRSA problems, the lack of cancer drugs available on the NHS and the abysmal dentistry in England. Nonetheless the NHS is an improving service; it is perfecting itself in many ways. The number of MRSA cases *are* reducing, and the government *is* doing something about long waiting lists. The problems with the lack of specialists is currently being corrected and when all these problems eventually become negligible the NHS will have more money to spend on more effective cancer drugs, and generally more money to spend on providing healthcare that we all deserve and expect.

A New Lease of Life

We would like to thank all those who contributed to the magazine over the past year and introduce the new editing team, headed by

Dominic-Somerville Brown.

Keep sending in your articles to Mr. Davis at pdavis@suttonlea.org