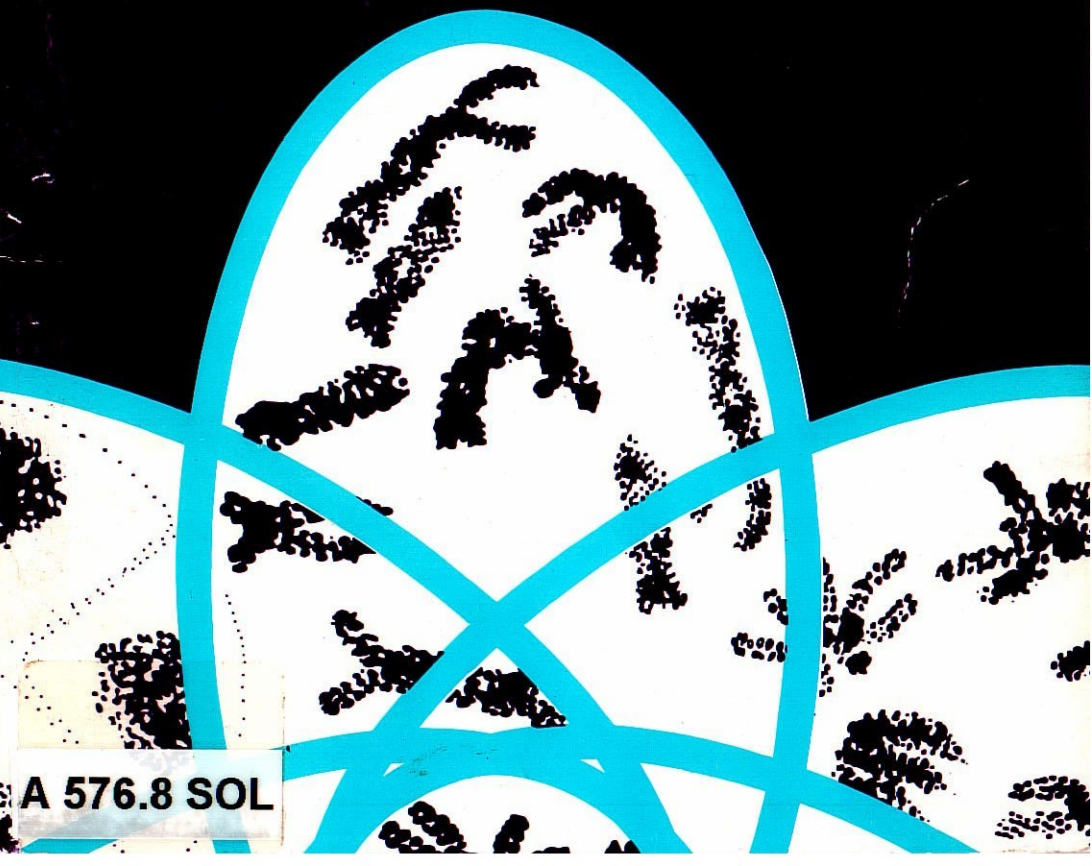
Science In a Social CONtext

EVOLUTION AND THE HUMAN POPULATION



Science In a Social CONtext

Evolution and the Human Population

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ASSOCIATION FOR SCIENCE EDUCATION

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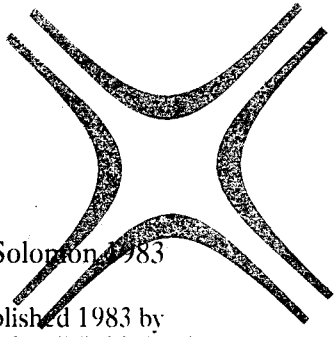

NATIONAL STEM CENTRE

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Introduction

The theory of Evolution and Natural Selection is one of the most controversial scientific explanations ever made. It goes beyond the actual evidence, as all scientific theories do, and provokes strong disagreements with orthodox religion; but it has also been grossly distorted at times in order to lend support to doubtful social theories, in a way which Darwin never intended.

We start this book with an account of how Darwin reached his revolutionary ideas. We cover religious and scientific reactions to his theory as well as its social manifestations. There is also an account of some of the achievements of modern genetics and the light it sheds on some distressing medical problems. Finally we take a look at recent developments which could have unpredictable effects on the future of the human race.

1 What is Evolution?

THE ANIMALS AND US

Most societies have legends about the beginning of life; many of these include the creation of the different kinds of animal species; some African tribes believe that animals are descended from groups of men who were either stupid or wicked. But it is hard to find a single one, apart from our own theory of evolution, which holds that humans came into being from the animals.

It is easy to point to the differences between humans and animals. Slowly, over perhaps five million years, our species has brought into being elaborate civilisations which now stretch around the world, over the sea, in the air, and even out into space. We attribute all this to our advanced intelligence. Of course other animals also have intelligence, so, to make the distinction clearer, the following features have been suggested:

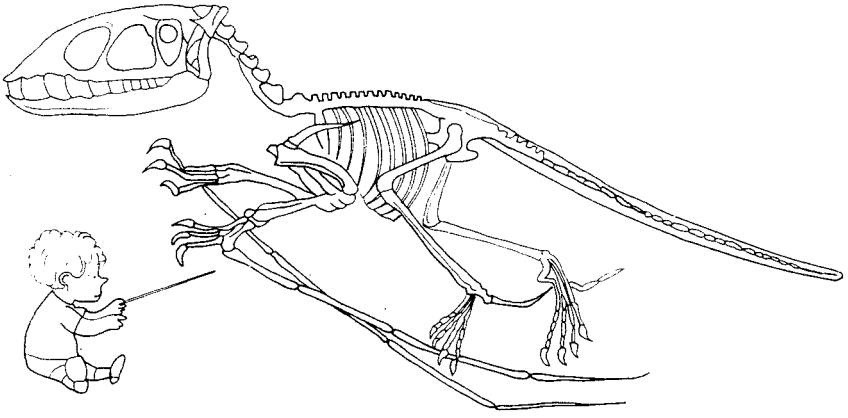
1 Only humans make and use tools.
2 Only humans communicate through speech.
3 Only humans have a sense of their own identity.

These factors were essential for the formation of our *technology*, our *society* and all of our creative thinking and *philosophy*. Some people see them as proof of our God-given superiority over the animals.

Recent research has shown that none of these distinctions is quite as sharp as had been thought. Several kinds of animals use special stones or twigs for useful purposes. Many communicate, and one special chimpanzee, Washoe, has been taught to 'speak' in human sign language. Chimpanzees can also be shown to recognise their own reflection and to wipe a smudge of paint off their own nose when they see their image in a mirror.

Probably none of these observations will convince you that animals are very like us. What they do show is that scientists of different kinds are *looking for similarities*. They believe that there is a connection between our species and the others; one reason for this belief is the theory of evolution.

The basic meaning of evolution is unfolding or gradual change, but it is a process which is too slow to watch either in the lifetime of one person or in the whole recorded history of mankind. You might imagine that fossils would have provided clear evidence for this, but it was not so easy. In the first place it was not until the end of the eighteenth century that geologists first tried to date the layers of rocks in which fossils were found. Secondly the fossil forms themselves were so weird and often gigantic, that it was hard to see any connection between them and us. A dinosaur, for example, is not much like a human!



The most obvious point about these fossilised animals was that nothing like them existed on earth. It was thought that they had been wiped out by some 'catastrophe'. When Charles Darwin began his famous journey round the world there were only two ideas about evolution, plus the story of creation from the bible. They were as follows:

1 A French biologist, Buffon, believed that there was some kind of 'creative force', which had been stronger in earlier times when the world was hotter. This gave rise to the enormous dinosaurs. As the earth cooled down these died out and a weaker creative force formed the smaller modern animals in their place.

2 The second theory is a little closer to our own. Jean Lamarck held that there was a creative force inside all living animals helping them to grow stronger and larger. He realised how well animals are suited to their environments and supposed that the characteristics

that they got through their struggles to survive, were passed on to their offspring, so that they became better and better adapted to their way of life.

Have you heard an explanation similar to Buffon's for the extinction of the dinosaurs?

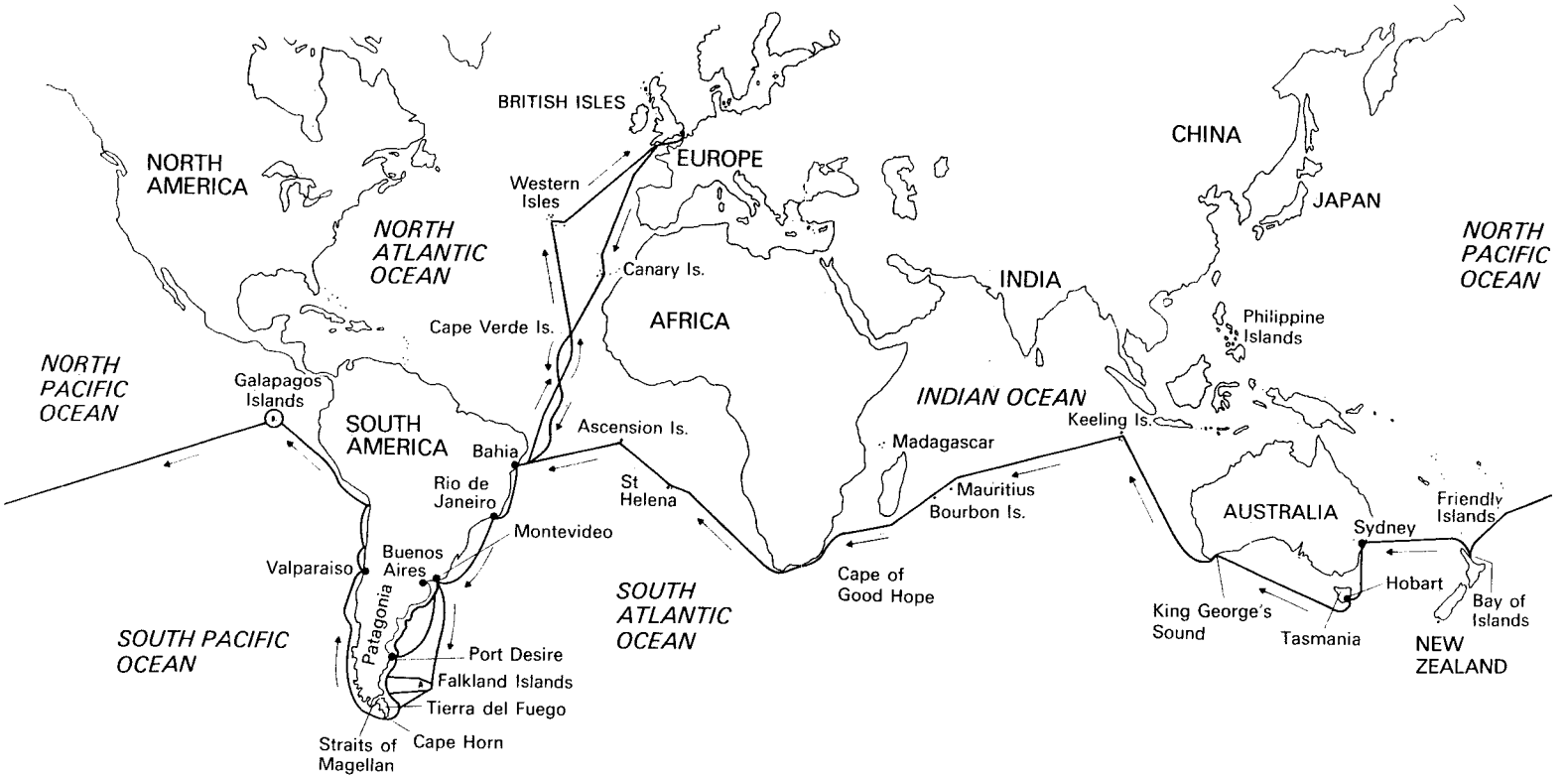
How would Lamarck have explained the length of an elephant's trunk?

THE VOYAGE OF THE BEAGLE

Both these theories were known to Charles Darwin when he set sail on *HMS Beagle* in 1831. He was only 22 years of age, an amateur entomologist with an obsession for beetles and a rather mediocre degree from Cambridge, but he was appointed naturalist on this small ship which was commissioned to survey and chart the coast of South America. He was delighted. Among the few books he could take with him, the one he prized most was the first volume of a new work on geology by Charles Lyell with whom he was later to become a friend and colleague. (His very first landing was on the volcanic Cape Verde Islands in the mid-Atlantic and he was so captivated by the scenery that he decided at once to write a book on geology himself.)

It is impossible to do justice to the delight and interest which Darwin found in all the incidents of his voyage in these few pages. Fortunately there are several books written about the journey, using material from his own journal, which make splendid reading. Here we can only pick out what seem to have been the most significant incidents, and the comments which he made about them, following his own line of thought as best we can. Darwin himself always reckoned this five-year voyage to be the highlight of his life which sowed the seeds of his great theory of evolution. He never travelled again.

During the first six months, as the *Beagle* slowly made its way southward charting the coast of Patagonia, Darwin wrote the only entries in his diary referring to the existing theories of evolution. Near Montevideo he purchased several live specimens of a local rodent, somewhat like a mole, which lived completely underground and was often, but not always, blind. Perhaps this animal was in the process of evolving towards the totally blind state of so many animals who live in darkness;



The voyage of the Beagle.

Darwin called it 'acquired blindness', and commented, 'Lamarck would have been delighted with this fact!'

A couple of months later Darwin was some 200 miles further south excavating the fossilised skeleton of an animal related to the modern rhinoceros but looking more like a camel or a llama. What chiefly struck him was the close connection between all the fossil animals he found and their smaller living relatives. The presence of modern shells beside them showed their comparatively recent origin – how had they become extinct?

He wrote in his diary:

> 'If Buffon had known of the gigantic sloth and armadillo-like animals he might well have said that the creative force in America had lost its power. What has exterminated them? . . . some great catastrophe? . . . but all the features of the land result from slow and gradual change.'

His diary is full of unanswered questions but, at the end of this passage, he adds an original and thoughtful comment.

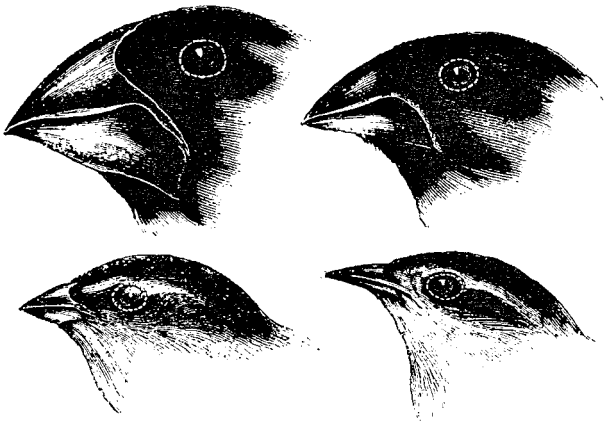
> 'Every animal in a state of nature regularly breeds; yet in a species long established any great increase in numbers is obviously impossible and must be checked by some means . . . yet how rarely if ever, can we point out the precise cause and manner of the check! . . . If we see, without the smallest surprise, one species abundant and another closely-allied species rare in the same district – why should we feel such great astonishment at the rarity being carried a step further to extinction?'

With this happy mixture of geology and biology, curiosity and speculation, Darwin continued on his long journey. He watched the wretched Indians of Terra del Fuego surviving precariously in conditions of extreme cold, the naked mothers suckling their babies in the open, quite heedless of the falling snow. Later he was horrified to see the gauchos of the Pampas organising massacres of the local Indians in a deliberate effort to wipe them out. He climbed the Andes and found fossil shells at a height of 14,000 feet and saw, at first hand, the devastation caused by an earthquake and its effect on the level of the coastline.

The one episode, more than any other, which provided Darwin with inspiration for his final theory was his visit to the Galapagos Islands.

Indians from Terra del Fuego.

You will see from the map that these are separated from the mainland of South America by more than 500 miles of Pacific Ocean. They were clearly of recent volcanic origin, indeed some were still almost bare black basaltic rock, but the larger islands were fertile with human settlements and a natural population of reptiles, birds and insects. Darwin was amazed to find that though he could recognise the genus of each, there was an abundance of new species. He was even more surprised to learn that much of the wildlife, flowers, tortoises, finches and mocking-thrushes, differed in small but noticeable ways from one island to another. There was one obvious reason for this variation: very strong ocean currents flowed between the islands and no prevailing winds blew from one to the other to transport birds or seeds. But if they were so biologically isolated how could one account for the emergence of different species, all so closely related, on each separate island? Was each created individually? As yet Darwin had no explanation, he could only write: 'One is astonished at the amount of creative force, if such an expression can be used, displayed on these small, barren, and rocky islands'.



Examples of the same species of birds from different islands.

After this the *Beagle* crossed the Pacific to New Zealand and Australia. Once again Darwin's compassionate nature was shocked to see the aboriginal races of man being exterminated by contact with 'civilisation'. He wrote in his journal: 'The varieties of man seem to act on each other in the same way as different species of animals – the stronger always extirpating the weaker'. This idea also was to recur in his scientific theories. Finally, after completing their journey round the world and back to South America again, the *Beagle* and her crew returned to England in 1836.

THE THEORY OF EVOLUTION TAKES SHAPE

During the next years Darwin wrote several papers on the geological formations he had seen and on the animals he had collected – but all the time he was turning over in his mind the problems of evolution. Certain points seemed clear to him.

1 *The world and its life-forms are not static*

In spite of his early intention of entering the church he could not accept a once-for-all act of creation, neither the geology of the earth nor the distribution of animals seemed to support it.

2 *The changes had been gradual*

Darwin rejected the ancient idea of sudden 'catastrophes' and saw the

extinction of species as the same kind of change as that which commonly held animal species in check or favoured the survival of one type rather than another.

3 *The species are in competition*

He had witnessed the disastrous effects of white man on native populations and how the whole living environment of an island could be totally changed by the introduction of so innocent a beast as the grazing goat. When he noticed the remarkable tameness of birds in both the Galapagos and Falkland Islands he wrote, 'What havoc the introduction of any new beast of prey must cause!'

At first he could not decide how these changes were brought about. 'Creative force' was too vague a term to describe it. If you have read about scientific theories in the book *How Can We Be Sure?* in this series, you may remember that suggesting the way in which changes take place, the mechanism by which they work, is an important part of any scientific explanation.

Had Darwin made any observations on his voyage which could have given him a clue about the way animals change, survive or die out?

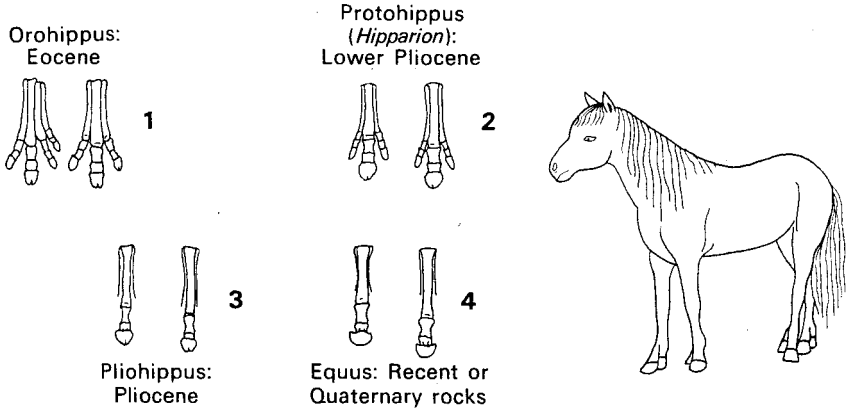
THE MECHANISM FOR EVOLUTION

From as early as 1837 Darwin started making private notes about evolution. The next year, when he read a work by Thomas Malthus on the growth of human populations he was very encouraged to find the same ideas on reproduction and natural check which had occurred to him. Malthus had written the first essay on the mathematics of population and food resources. His message was simple enough: if there were unlimited food and living-space any animal species would increase in geometrical ratio, doubling itself every few years. In the newly-settled regions of North America this seemed to be happening among the thriving farming communities; only in the crowded, disease-ridden towns did shortages hold this 'population explosion' in check.

> 'Wherever therefore there is liberty, the power to increase is exerted; and the superabundant effects are repressed afterwards by want of room and nourishment.'
>
> Malthus, 1798.

Now Darwin adapted the processes of *continual reproduction* and the *struggle for food* to his theory of evolution. Young animals do not exactly resemble their parents any more than we do; if there was a limited supply of food the offspring which had some slight advantage in strength, reach or cunning would have the best chance of surviving. This would ensure that its lucky characteristics had a chance of being passed on to the next generation. At the other extreme the weak, stunted or stupid would fail in the struggle to survive and their characteristics might die with them. In this way the shapes and attributes of a species might change and, eventually, evolve into a new species.

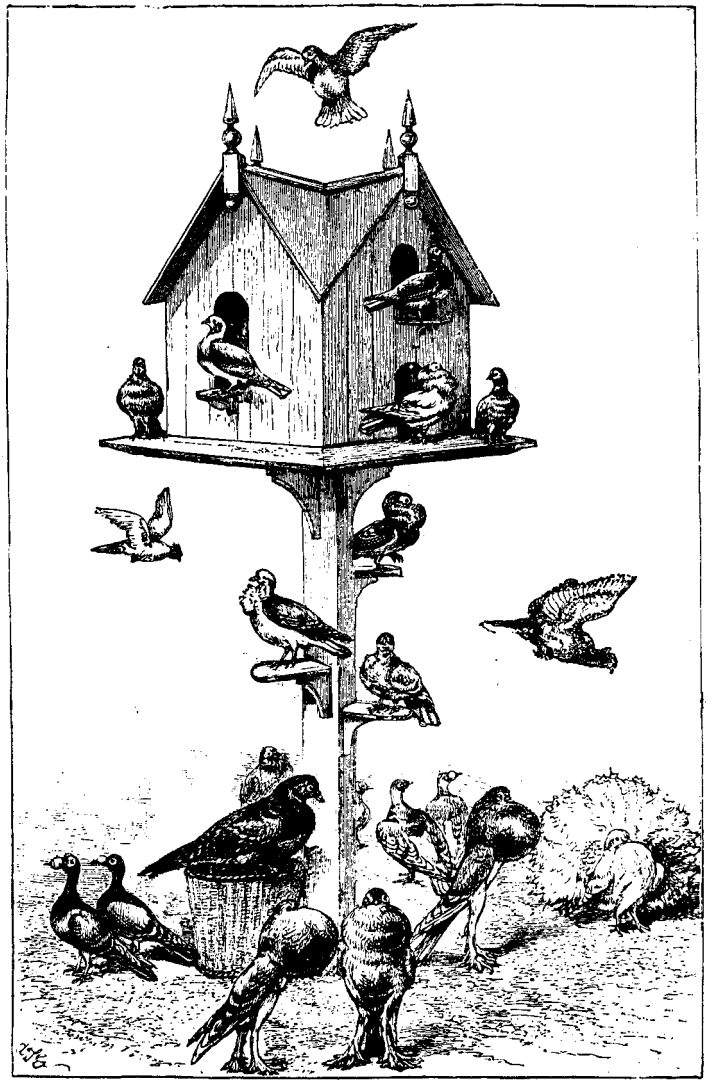
Darwin assumed that this process took place so gradually, over such a long period of time that it could not be observed directly. Our best evidence is the fossil record of the evolution of the horse. Over millions of years its feet have changed until only the middle 'finger' remained. The drawing below shows a recent horse born with extra toes – a 'throw-back', perhaps, to the ancestral type?



Fossil record of the evolution of the horse.

Darwin spent more than twenty years working out the consequences of this idea. Different situations would favour different evolutionary traits. To escape from their predators the deer and the horse would need to become fleet of foot; defenceless insects might grow to mimic dead leaves or unrelated poisonous species. Sometimes social behaviour might evolve – as in colonies of ants or packs of wolves –

where the species succeeded more because of their combined strength than from any individual prowess. Always nature presented harshness of environment and conflict for food; this alone was enough to select those life forms with any peculiar advantages. Such was the evolutionary mechanism which came to be known as 'the survival of the fittest'.



Some of the results of pigeon cross-breeding.

For centuries farmers had practised a kind of *artificial selection* in order to produce better domestic cattle. By picking out the best in a litter and breeding from them they changed the appearance of animals almost beyond recognition. Darwin himself took up pigeon-fancying where breeding and crossing had achieved either swiftness, homing instinct or the curious 'pouting' feathers which the fanciers so valued. If we could so alter animal characteristics, could not nature, by selecting the fittest, also effect changes? In the vast stretches of time, since life first started on the earth, this 'natural selection' could have brought about all the variety of life-forms from one original species.

Darwin might have been content to continue his experiments for yet another twenty years had not a paper been sent to him, in 1858, on the very same topic by a young naturalist called Wallace. The ideas were very like his own and he was ready to abandon his book until friends persuaded him to present Wallace's work alongside his own. So Darwin set to work and finished, within a year, his revolutionary book '*On the Origin of Species by means of Natural Selection*'.

2 Who Believes in Darwin's Theory?

THE RELIGIOUS REACTION

The edition was sold out within a week and reactions were immediate. Up and down the country, parsons thundered from their Sunday pulpits denouncing this heretical work! The official position was that the Lord God had created the heavens and the earth 'and all that in them is' during one brief week, probably about 4000 BC. The story was enshrined in the Bible and, for many, this made Darwin's theory blasphemous.

There were two other points which seemed repugnant to Christian and non-Christian alike:

1 A bitter *struggle* for life and food, combined with the *chance* emergence of small variations took all the wonder, beauty and divine intention out of creation.
2 Man is the high peak of creation, formed 'in the image of God'. How humiliating to think that our ancestors were like the apes!

Ridicule was cast on his theory and scores of offensive letters were sent to Darwin, which hurt him considerably. His own attitude towards the evolution of life had always been one of genuine reverence, and continued so even after he lost his faith in religion.

> 'Thus from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows. There is a grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, whilst this planet has gone on cycling according to the fixed law of gravity, from so simple a beginning endless forms beautiful and most wonderful have been, and are being evolved.'
>
> from *The Origin of Species*, Darwin 1859.

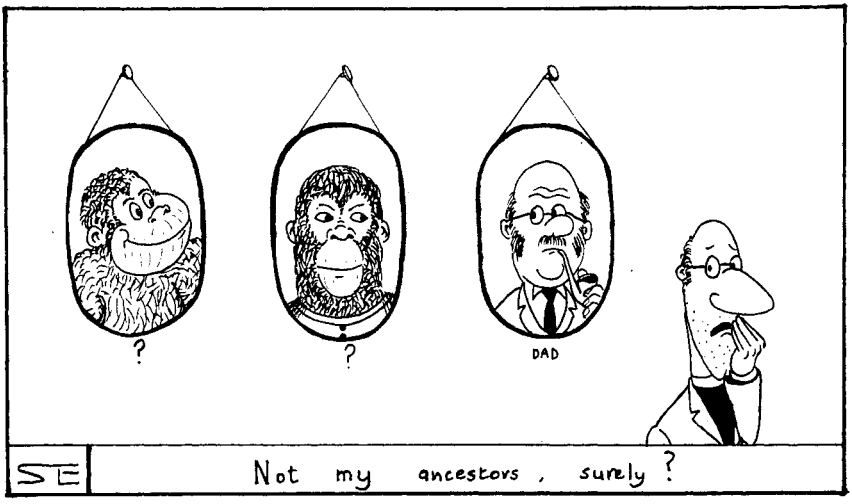
> 'We must however acknowledge, as it seems to me, that man with all his noble qualities, with sympathy which feels for the most debased, with benevolence which extends not only to other men but to the humblest living creature, with his god-like intellect which has penetrated into the movements and the constitution of

the solar system – with all these exalted powers – man still bears in his bodily frame the indelible stamp of his lowly origin.'

from *The Descent of Man*, Darwin 1871.

The controversy came to a head in 1860 at a meeting of the British Association in Oxford where Darwin's religious opponents planned a public confrontation and rebuttal of this scandalous theory. Darwin was ill but his supporter T. H. Huxley was there to uphold his case against the formidable Bishop Wilberforce. This eloquent cleric produced a resounding address full of ridicule for the idea that so puny a force as natural selection could have brought about the work of the creation. He had been coached with a little anatomical evidence to lend a scientific flavour to his opposition but his real aim was simply to 'smash Darwin'. He finished by turning to Huxley and demanding, sarcastically, whether he claimed descent from an ape on his grandfather's side or on his grandmother's!

Huxley rose brilliantly to the occasion. He answered cooly that he would rather be related to an ape than to a man who used his position, eloquence and a few hours acquaintance with biology to ridicule a theory which he did not understand. There was uproar and the Bishop had to withdraw leaving Huxley in triumph on the speaker's platform.



The religious opposition to Darwin's theory has never completely disappeared. Many thought his theory was blasphemy but he was not

persecuted and indeed, when he died, he was given a state funeral in Westminster Abbey. That did not mean that all clergymen accepted his theory.

The controversy has always been strongest in the USA. In the southern states it became so bitter that those who attempted to teach his theory in schools were brought to trial and convicted for it. Even today the conflict still goes on in another form. Several states have passed laws that equal time should be given in schools to the teaching of the biblical story of creation *during science lessons*, as to explaining the theory of evolution. There are strong public pressure groups on both sides. Books, pamphlets and TV programmes can be found insisting that Darwin got it wrong, that the fossil record is not convincing proof, and that only a divine act of creation could have produced the animal species.

Do you *believe* or *think* that evolution took place?
What is the difference?

IS THE EVIDENCE CONVINCING?

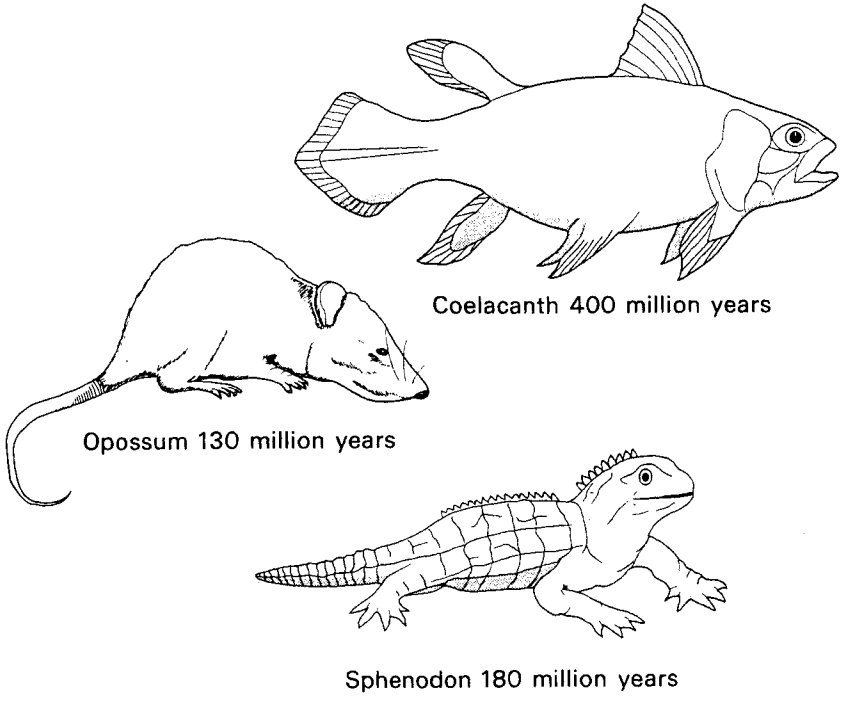
Most of the scientists of Darwin's day were soon won over to his theory. That is not to say that there were no problems. Scientific theories almost always include an element of imagination which goes beyond the evidence, and in the case of evolution this was clearly so. No one had actually observed the evolving of a new species, although the fossils showed that new species had turned up at certain times, and older species had died out. Since those who do not want to believe in the process of evolution often argue about it in scientific terms it is worthwhile having a look at the evidence.

Darwin had proposed that the different species arose through natural selection, and he compared this with the changes that we have produced by artificial selection; but there is a problem. Our domestic animals may look very different from their wild forebears, but they are really only different breeds of the *same species*. They can still interbreed. Completely different species cannot do this, or if they do, like the horse and the donkey, their offspring are not fertile (mules can have no young). Even Huxley, Darwin's champion, was never convinced that

natural selection could, by itself, bring a new distinct species into existence.

We now have a little more evidence than Darwin had. We know something about genetics (page 29) and how sudden mutations sometimes occur in individuals (page 31). Scientists have also made interesting observations of the variations between separate populations of fruit flies. These breed very fast but also get easily trapped by mountain ranges, or by the direction of the prevailing wind, into isolated groups. In South America it is possible to find regions where these groups are just beginning to become separate species – they can produce few or no fertile offspring if they interbreed.

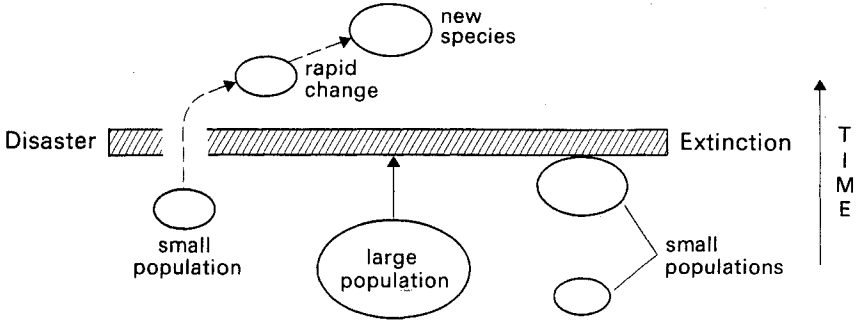
Another difficult problem is to explain why some species go on for millions of years *without any perceptible change*. Darwin had supposed that all the life-forms were evolving gradually all the time, but these 'living fossils' remain unchanged even though there does not seem to be anything particularly well-adapted about them. Why didn't they evolve further?



Living fossils: creatures which have remained unchanged for millions of years.

The same sort of question arises when we see an abrupt change in the fossil record. Species that seem to have existed for millions of years without a break, suddenly disappear from the next layer of rocks and a completely new species appears. Why isn't the change gradual?

Scientific explanations have to be altered if they don't fit the evidence; over the last few years some modifications to Darwin's theory have been discussed. It is suggested that some kind of disaster is necessary for any big evolutionary movement. If some event wipes out whole species and leaves only small pockets of previously rare animals they may have a particularly good chance to evolve since any new characteristic is not so likely to be swamped by the size of the population. There will also be less competition once so many species have been killed off. For example, the more mammal-like creatures, which had been rare before, took over and evolved rapidly after the population of reptiles suddenly became extinct millions of years ago.



Survival of small populations may mean that they have a better chance of evolving.

3 Evolution and Human Society

SOCIAL DARWINISM

Some of Darwin's contemporaries did more than accept his theory, they tried to extend its use from the past evolution of species to the present and future shaping of society. It was a big step to take since the form of social order in which we live is a matter for argument and democratic decision, whereas natural selection is brought about by conditions and disasters beyond any control.

Herbert Spencer had been a convinced evolutionist even before the publication of *The Origin of Species*. He viewed evolution on a large scale and tried to use it to provide scientific principles on which to base a new sociology. In the past there had been a real struggle for existence between different tribes and nations including wars, massacres and exploitation. This had been a kind of natural selection but in the future, Spencer thought, man would adapt peacefully to the social order. Now it was *our duty* to see to it that the precept of evolution, the 'survival of the fittest', continued to operate for the benefit of the whole community.

> 'For if the unworthy are helped to increase by shielding them from that mortality which their unworthiness would naturally entail, the effect is to produce, generation after generation, a greater unworthiness. . . . It is a deliberate storing-up of miseries for future generations. . . . My purpose is simply to show that a rational policy must recognise certain truths of Biology'.

This attitude assumed not only that the theory of evolution was 'true' for all time, but also that the *competition* for survival which had led to the development of human intelligence, was 'good' for society as a whole. It was a case of every man for himself and no help for the weak. In some respects this fitted in well with the Victorian system of *laissez-faire* capitalism. (*Laissez-faire* can be roughly translated as 'leave well alone'). If you provide no help for the ill, the handicapped and the unemployed, they will either die without passing on their characteristics to future generations, or be goaded into greater efforts to overcome them. It is not a point of view that would lead naturally to the development of the Welfare State!

Perhaps you feel that a truly moral and caring society should evolve in another way; Huxley did.

> 'The practice of that which is ethically best – what we call goodness or virtue – involves a course of conduct which, in all respects, is opposed to that which leads to success in the cosmic struggle for existence. In place of ruthless self-assertion it demands self-restraint . . . its influence is directed, not so much to the survival of the fittest, as to the fitting of as many as possible to survive . . . reminding the individual of his duty to the community, to the protection and influence of which he owes, if not existence itself, at least the life of something better than a savage.'
>
> from *Evolution and Ethics*, Huxley.

The advantages of competiton for personal survival are rarely upheld today but there are many who see value in competition for jobs, and competition within industry. It is suggested that there is a competitive streak in everyone and that without it we would grow lazy and inefficient. What do you think?

What sort of school system would Herbert Spencer have wanted – fee paying, Grammar (with 11+ examination) or Comprehensive?

What do the theories of capitalism and socialism have to say about competition?

What is your idea of a 'better' society?

EUGENICS

There was another way in which the concept of evolution could be applied to the future of humanity. Should man himself take a hand in his own breeding? It sounds like a cold-blooded piece of Science Fiction but it originated from a man who was, by all accounts, both charming and sympathetic – the cousin of Charles Darwin, Francis Galton.

Galton had a passion for measuring and statistics and he used this on his fellow men. He measured height and width of chest, number of children in families related to the occupation of the parents, and even tried to measure the spread of intelligence (in the days before IQ tests) by using the examination grades from university. What emerged, you will not be surprised to hear, was a thick cluster of results on and near

the average (the mode), and a thinning out on either side. Applying Darwin's theory of natural selection to this Galton saw how, in the past, the existence of this variation could have supplied individuals, at one extreme or the other, with special advantages for survival and subsequent breeding. A full range of characteristics still existed.

In Victorian England a vigorous process of selection was at work, killing off those who could not survive the appalling urban conditions. Was this the kind of selection which would improve the highest qualities of the race? Galton thought not.

> '. . . the ordinary struggle for existence under the bad sanitary conditions of our towns, seems to me to spoil and not to improve our breed. It selects those who are able to withstand zymotic diseases and impure and insufficient food, but such are not necessarily foremost in the qualities which make a nation great.'
>
> from *Hereditary Improvement*, Galton 1873.

By 'zymotic' (contagious) diseases Galton was referring to the appalling outbreaks of cholera, typhus and typhoid fever in Victorian towns. All of these were largely due to bad sanitation (see *Health, Food and Population* in this series).

Galton passionately believed that we have both the power and the responsibility to improve the human race. He wanted the 'best' of society, the most intelligent, moral and fit, to be encouraged to have large families, while the retarded, feeble and criminally insane should be prevented from reproducing their kind. (Obviously he held very simple ideas about heredity, which have been corrected since that time.) He used the word 'eugenics' for this process.

> 'The first object is to check the birth rate of the unfit. . . . The second object is the improvement of the race by furthering the productivity of the fit.'
>
> from *Memories*, Galton 1908.

Today the Eugenics Society, which Galton founded, still exists but has shifted its emphasis into the field of genetic counselling (see page 33).

To survive the modern urban environment is intelligence, parental devotion, ruthlessness, or physical strength the best adaptation?

Are you sure enough to want to breed for any characteristic? Is it possible?

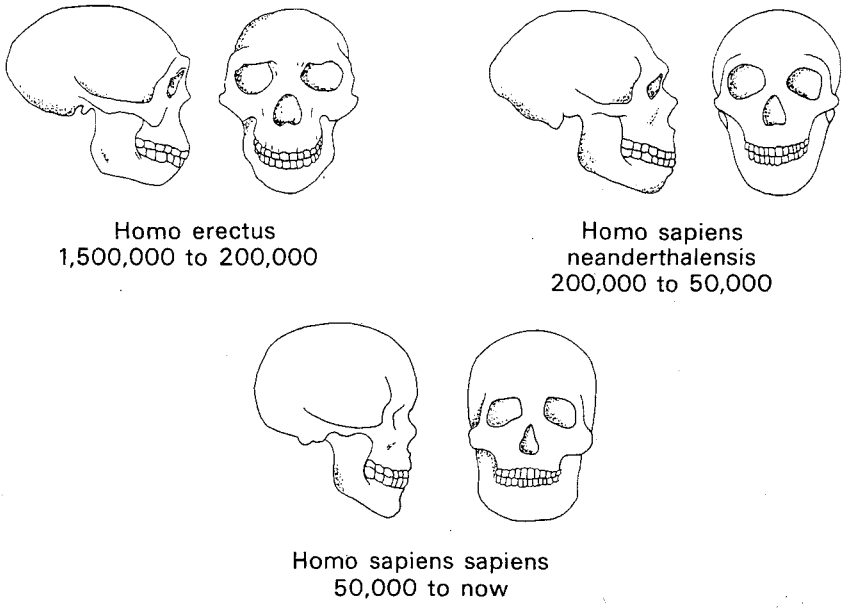
'Checking the birth rate' could only mean compulsory sterilisation in Galton's day; but although he, and others, pointed out that it was precisely the least intelligent who had the largest families, most governments have drawn back from such compulsion. Only in Nazi Germany and some states of the USA during the 1930s was such eugenic legislation passed. In Idaho, for example, marriage was prohibited and sterilisation recommended for 'mental defectives, epileptics, habitual criminals, moral degenerates and sex perverts'. It is estimated that about 60,000 sterilisations were carried out in America during this period.

During this century the situation has been changed significantly by the movement for birth control and contraception, so energetically championed by Marie Stopes during the 1920s. She wrote two famous and persuasive books (*Married Love* and *Wise Parenthood*), addressed scores of public meetings and also founded societies for Radical Progress and Constructive Birth Control. Partly out of sympathy for the over-burdened working-class mother and partly from eugenic motives, Marie Stopes hoped to limit the family size of the poor. For many years contraception produced quite the *opposite* effect. It was the rich and educated who planned and reduced the numbers of their children, not the poor and ignorant. Only recently has the advent of the 'pill' and legal abortion reversed this trend. Now almost all sections of the population in this country are having smaller families, the birth rate is just less than the death rate, and some of the better educated young adults are actually having a larger than average number of children.

Do you think that the mentally retarded should be prevented from having children . . . for the benefit of the race, . . . for their own good, . . . for the sake of their children, . . . or not at all?

RACIALISM

In Darwin's day only one human fossil skull had been discovered, that was Neanderthal Man (see opposite) and opinion was divided as to whether it was a diseased man or a variety of ape. In the *Descent of Man* Darwin seemed undecided whether or not the living races of men should be classed as different species – which they clearly are *not* since



Changes in skull formation as man evolved.

they are so similar and can all interbreed successfully. Worse than that, he had a habit of referring to primitive people as though they were intermediate between 'civilised' men and the apes, although he did admit that they were much closer to the former. This was despite his sympathy and sense of outrage when, during the voyage of the *Beagle*, he had seen some of them suffering horribly through contact with the colonisers.

Francis Galton took this very much further when he began a comparative study of the different human races. He was somehow convinced that inherited ability could always rise above any disadvantages and be detected. He simply counted the percentages of geniuses produced by the different races, and then took the absence of any known Beethovens or Newtons as proof of inferior quality.

This was a particularly shallow piece of work which completely ignored the effects of living conditions, cultural values and education. It is doubtful whether any kind of research which tries to compare the races can come up with results which do more than reflect these different environmental conditions; and it seems certain that such studies would raise a great deal of ill-feeling. Even within one race and one society

social scientists are still divided as to whether heredity or environment – 'nature or nurture' – have the biggest influence on growing children.

At their worst racialist doctrines, which used Darwin's theory for their justification, have been responsible for appalling cruelty and mass murder.

> 'The struggle for daily livelihood leaves behind, in the ruck everything that is weak or diseased or wavering: while the fight of the male to possess the female gives to the strongest the right, or at least the possibility, to propagate its kind. . . . Every manifestation of human culture, art, science and technical skill . . . is almost exclusively the product of the Aryan creative power . . . The State must assert itself as the trustees of a millennial future. . . .'
>
> from *Mein Kampf*, Hitler.

The Nazi party lost no time in putting these ideas into action. German men and women with 'good' Aryan features were encouraged to breed both inside marriage and outside. The feeble-minded were sterilised and the 'lesser' races, Negroes, Slavs and Jews were ruthlessly exterminated.

In this century the different races have mixed in almost every country as a direct consequence of earlier colonisation or slavery. Britain has a multi-racial society in which we attempt to eradicate racialism by education and by law. We live together, gradually adopting each other's customs, music, sport and literature. Yet old prejudices are slow to die.

What do you think are the best ways to combat racialism: more laws, stricter enforcement, more education, learning about each other's customs, living apart, or abolishing differences?

---

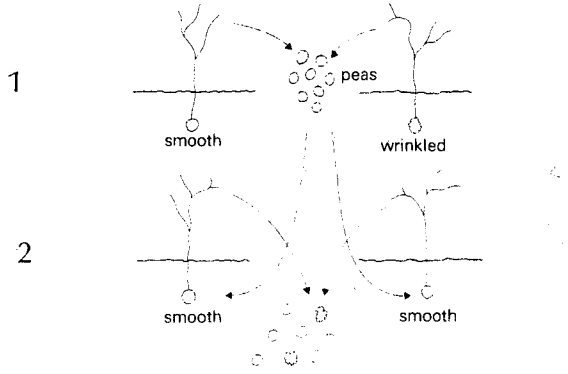
4 How Inheritance Works

THE GARDENING MONK

It is quite clear that heredity is an uneven hopping and jumping process. We have all met with examples of characteristics which get handed down from parent to child, others that skip a generation to turn up in the grandchildren. Extremes of tallness or intelligence often get modified in children so that they are nearer the average. Sometimes a characteristic turns up which cannot be traced back to any known relative. To find out what is now understood about inheritance we need to go back more than a century.

In 1866 Brother Gregor Mendel published the results of seven years of careful cross-fertilisation between slightly different varieties of sweet peas. He used plants with simple distinctive characteristics – smooth or wrinkled pea, green or yellow pea, flowers radial or axial on the stem – and with a pair of forceps and a camel hair paint-brush he carefully cross-pollinated the pairs and sowed the seed that developed. Whichever pair of characteristics Mendel used he got the same pattern of results.

The diagram shows the cross-fertilisation of the smooth and wrinkled pea.



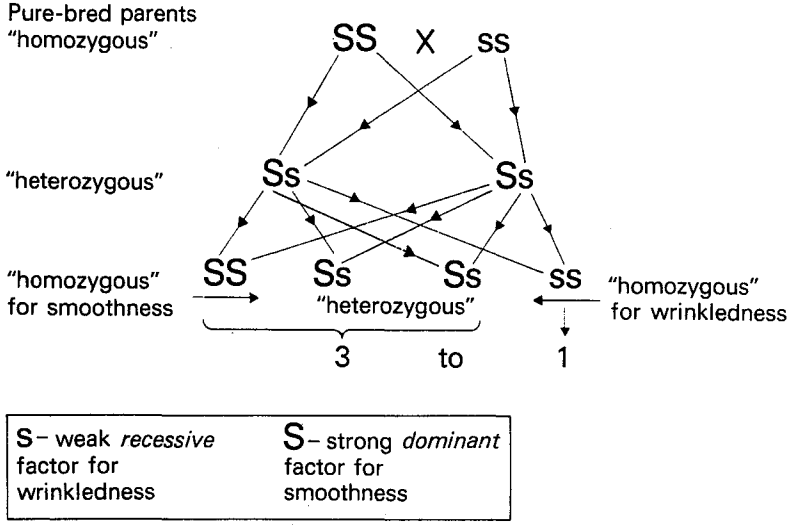
1 In the first crossed generation *all* looked like *one* of the parents – smooth.
2 In the next generation the lost characteristic turned up again but only in small numbers (one out of four).

3 Transitional (in between) forms of pea were *not* observed.

The fact that the first crossed generation looked smooth was misleading. Obviously they must have contained the 'genetic factor' for wrinkledness otherwise how could it turn up in their offspring? Mendel concluded that the factor for smoothness must be *dominant* so that when it was present alongside the weaker *recessive* factor for wrinkledness the peas came out smooth. To appear wrinkled a plant had to inherit two factors for wrinkledness, one from each parent.

Do not be misled by this scheme: it is not a simple family tree. There were not just two offspring from the first cross and just four from the second cross. Mendel's garden plot outside the monastery was only 120 feet by 20 feet, but that was quite large enough to raise a fair number of plants which yielded a high crop of seeds. The scheme shows the *number of different ways* the genetic factors in the parent plants can pair off and hence the *probability* of each turning up if the pairing were quite random.

Mendel compared the counts of peas he got with this calculated probability. From 253 hybrid plants he gathered 5474 *smooth* peas and 1850 *wrinkled* peas. This is almost exactly the predicted ratio 3 : 1 (Try it and you will get a value of 2.96 : 1 – very close indeed.)



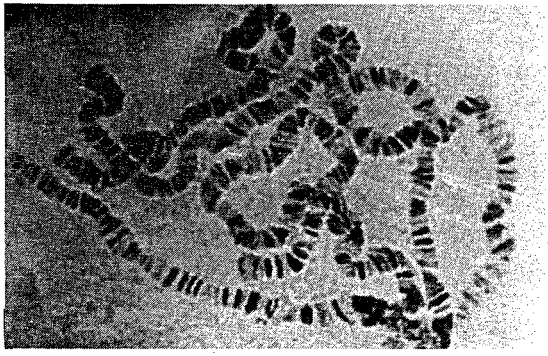
A diagram to show Mendel's conclusions from his experiments with the smooth and wrinkled pea.

When Mendel went on to experiment with two different pairs of characteristics (smooth/wrinkled and yellow/green) in the same plants, he once again got good agreement with random probability calculated from chance shuffling of pairs.

GENETICS

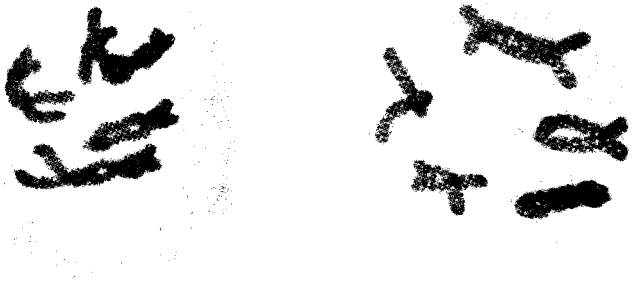
Mendel's work did not become known and accepted until 1900, but since then intensive research into the constituents of living cells has brought great advances.

1 Mendel's 'genetic factors' – now called *genes* – may be related to the bands on the chromosomes within the nucleus of a cell, which are sometimes visible under the microscope (A).



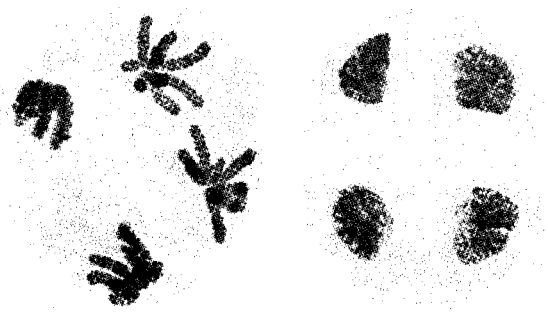
A

2 Before the gametes (sex cells) are formed, the chromosomes in the parent cells 'shuffle' the genes by crossing over and splitting up (B).



B

3 The gametes contain just half the number of chromosomes of the parent cell before they combine in fertilisation (C).



C

It is not possible to transfer Mendel's simple results to *all* human characteristics. People's height, length of nose, strength and intelligence, for example, are continuously variable quantities; all sorts and sizes exist which suggests that there may be a whole group of genes which collectively govern such characteristics. However, there are other effects which are more abrupt (either you have it or you don't) like the Rhesus negative factor in the blood, dwarfism or albinism, and they do seem to behave like smoothness and wrinkledness in Mendel's peas.

Studies of human families have shown that dwarfism is carried by a dominant gene (heterozygous children are affected) while Rhesus negative blood and albinism are carried by recessive genes (in these cases any of us could carry the gene without knowing it).

If the recessive gene is on the special sex-determining X chromosome it will have different effects on the male children, who have only one X chromosome, from the effect on female children who have two. It will seem to be dominant for the males and recessive for the females, and so much rarer. Colour-blindness is such an effect.

One simply inherited factor which is carried by one pair of genes (but not on the sex chromosomes) is the ability to roll up the edges of the tongue.

Can you do it?

Can your parents do it? . . . Is it dominant or recessive?

Genetic defects are all due to factors present in the gametes, the sperm or the ovum, which fuse together during fertilisation. The commonest ones we know about fall into five main categories.

Affected by having a single gene (dominant)	*Per 10,000 births*
Deafness	1
Blindness	1
Huntington's Chorea	1
Dwarfism (Achondroplasia)	0.5
(These are rare, or else not usually fatal, otherwise the gene would have been eliminated from the population.)	
Affected by having two genes (recessive)	*Per 10,000 births*
Severe mental defects	8
Cystic Fibrosis	5
Deafness	5
Blindness	2
Albinism	1
Male affected by single gene (X chromosome)	*Per 10,0000 births*
Duchenne's muscular dystrophy	2
Haemophilia	1
Affected by having a whole extra chromosome	*Per 10,000 births*
Down's Syndrome (Mongolism)	11
Affected by a group of genes	*Per 10,000 births*
Spina Bifida (and Anencephaly)	25 (each)

Of the 800,000 babies born alive on average each year in Britain some three to four thousand have genetic defects, and many die. Every one will involve a family in distress and heartache. What can medicine do about it? Although there are now drugs to help some of these conditions, such as haemophilia, and surgery for many others, such as spina bifida, most cannot be helped and none can be cured. They will be handicapped for life.

There is now a method of detecting Down's syndrome, spina bifida and anencephaly while the baby is still in the womb. After the sixteenth week of pregnancy, when there is sufficient fluid in the amniotic sac around the foetus, a little of it is withdrawn for testing. This is done by inserting a long fine needle through the mother's abdomen under local anaesthetic, after having found out where the foetus is lying by the new scanning techniques. The laboratory tests then take from two to four weeks before the doctors can be sure whether or not the foetus is defective. This procedure, which is called amniocentesis, is only carried out in a small minority of cases when it is already thought that the mother is at risk of having a defective baby, either because the trouble is known to be in the family, or, in the case of Down's syndrome, because the mother is over 40 and so much more likely to have an affected child.

If the result of the tests show that a defect is present the doctor will then discuss the case with the mother. If she does not wish to have the baby and the pregnancy is less than 24 weeks advanced, she can be given a legal abortion.

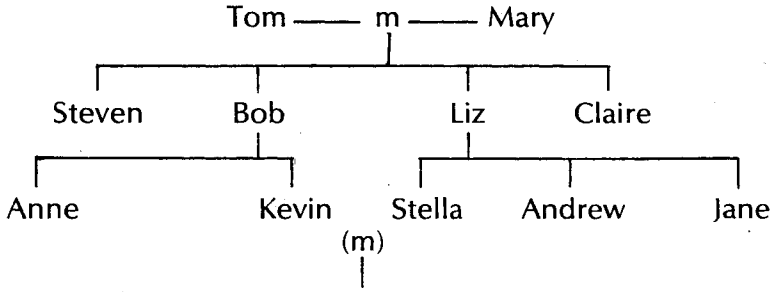
Most defective babies are not diagnosed until birth, and others not until much later. For parents of such babies, as for those with other kinds of severe congenital damage, there is sometimes a terrible question to be faced. Would it be better if the baby were not encouraged to live? Some mothers have devoted their lives uncomplainingly to the care of a handicapped child and found it rewarding. However defects vary in their severity. Other mothers may feel that they would rather be free to try again for a normal and healthy child.

Do you believe that all life is sacred, or would you prefer to consider the quality of possible life?

What effects can a severely handicapped child have on a marriage, and on a family?

Do you think that the law needs changing in order to safeguard doctors and parents who agree *not* to give all possible medical help to a defective newborn baby?

There is another way to help parents before the child is conceived. Some quite healthy people may be carriers of a harmful recessive gene and an examination of family histories can sometimes show this. In such cases marriage between first cousins can be particularly dangerous for any children. Consider the following family tree:

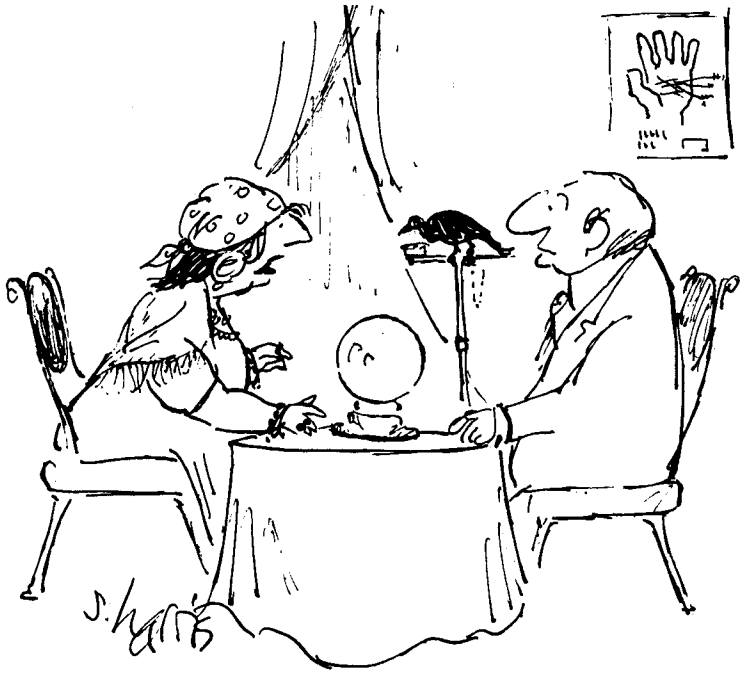


The baby must have inherited 2 recessive genes for this defect so both Kevin and Stella were carriers. So, most probably, were Bob and Liz, and it seems probable that the gene can be traced back to either Tom or Mary. Now there is a strong chance (50%) that the others may also be carriers of this potentially fatal gene. Should they be told? Should they tell their husbands or wives? Would *you* want to know the chances of having such a child? Schemes for giving help and advice in such cases are called 'genetic counselling' and are available on the National Health Service.

It is not always true that a carrier is indistinguishable from a non-carrier. In certain cases it has proved possible to run tests for those in affected families to detect the slight effects of a single recessive gene in the heterozygous carriers. This is a help for genetic counselling.

When the genetic defect is the result of several genes, such as spina bifida or anencephaly, counselling is more difficult still. The latest

research also shows that the diet of the mother during pregnancy may have some effect on the chances of having such a defective baby. You can see that counselling can never be exact.



How do you want it – the crystal mumbo-jumbo or statistical probability?

It has been suggested that a nationwide *register of genetic diseases* and their possible human carriers should be compiled. With our modern computers such a scheme would be quite possible. Some young couples might welcome it; others fear it as an infringement of privacy.

What do you think?

Would it be fair or unfair?

Whose job would it be to ensure that such intimate details would be hidden from prying eyes?

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5 Future Evolution?

NEW WAYS TO START LIFE

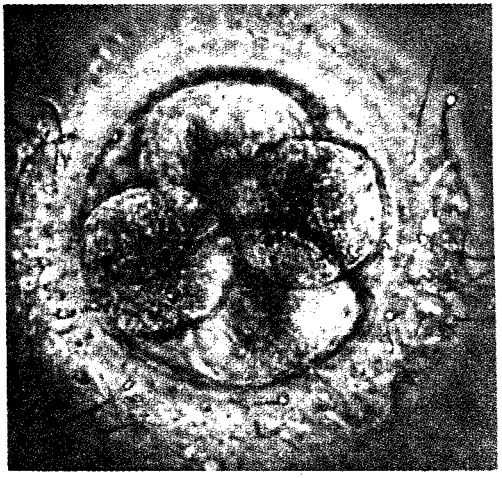
Indirectly our contraceptive practices have brought a new problem. The efficiency of the contraceptive pill, and the effect of the Abortion Law has so reduced the number of unwanted babies that there are now very few available for adoption. The number of infertile marriages are about 11% of the total and many of these couples naturally feel a great sense of loss. If they cannot adopt, the pressure to have children by other means becomes even stronger. This urge is recognised in the United Nations' declaration of human rights which includes the right of every married couple to have a child. In practice this is not so easy.

In a minority of infertile marriages the problem lies with the father. For these couples AID (artificial insemination by an unknown donor) may be a possible answer. The procedure is carried out by a doctor, either privately or occasionally on the Health Service, using sperm that has been frozen and stored. It is usually successful and is probably on the increase, although statistics are hard to come by. The reason for this is natural secrecy and also the uncertain legal status of the child. The sperm donor's identity is kept secret, the child has not been adopted, so who is its legal father?

Most infertility occurs because the woman's fallopian tubes are blocked or damaged. Operations to correct this are not always successful and although both ova and sperm are produced, they cannot meet. For this the new techniques of *in vitro* (in glass) fertilisation were developed.

The method involves examining the ovaries and usually stimulating them by drugs to produce several ripe ova, the removal of these, and the incubation and mixing of them with the husband's sperm. They are then usually incubated for a further two days until microscopic examination shows that some have divided into four or eight cells. One or more are then placed back in the woman's womb. In 1978 the first 'test-tube baby', Louise Brown, was born. At the time of writing there are about 25 such babies.

New technical advances often provoke violent reactions and this has been no exception. The most heated criticism has come from the



A fertilised egg which has divided to the four cell stage.

United States where phrases like 'tampering with nature' and 'flouting God's laws' were used at a public hearing. However there are other ethical problems that worry both doctors and laymen alike. What should be done with the surplus fertilised ova? It may be that useful information could be obtained from a laboratory observation of them in the early days of development. Should one experiment with living human embryos?

Both human sperm and ova can be frozen for future use. From whom might they be collected?

Would we want to breed new eugenic generations in this way?

MUTATIONS

New types of genes, not present in the parents, turn up from time to time. These are called mutations. From laboratory experiments with bacteria, maize and flies, it has been shown that intense radiation – X-rays or γ-rays – can sometimes cause a normal gene to change, mutate. Such severe treatment is like thumping the television set; usually it does harm and the new gene is a disaster. Only occasionally does some useful result occur. Better strains of penicillin mould have been produced, in just this way, by cultivating the very rare mutations

which prove valuable when the wild mould is subjected to radiation. Some chemicals have also been shown to cause mutations.

Mutation goes on all the time at a rate of about 1 in every 50,000 gametes. This seems too high to be due to the natural background radiation of the earth, or to the slightly increased levels produced in some localities by nuclear weapons or reactors. Perhaps the mutation rate in man, as in other species, is just a measure of the number of *mistakes* that the cell makes as it duplicates its own chromosomes, with all their thousands of gene bands, before it divides into the all-important gametes. It is a failure rate that any human industrial technique would regard as almost unachievable perfection!

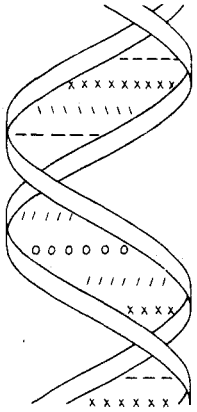
Might nuclear radiation from warfare alter the genetic future of our race?

GENETIC MANIPULATION

There is tremendous variation among people. The 'gene pool' of the population is so great that the laws of chance predict more than 2^{6700} different individuals – a number too long to write on a single page of this book – could exist. This is more than all the human beings who have ever lived! Such wide natural variation is a result of random shuffling of the genes. To produce radical differences it would be necessary to introduce new genetic material, new lengths of the DNA that forms the chromosomes, which could carry the new genes.

This extraordinary feat has already been achieved for some simple unicellular organisms, bacteria or yeasts. Here the DNA in the form of a loop called a plasmid, is extracted and, by complex biochemical methods, a new piece of DNA is inserted into it before it is returned to the cell. In this way it has proved possible to give the bacterium E coli the capability to make human insulin. It is now hoped to base an industrial process on this discovery. Many other advances of the same kind are being made in several countries in this exciting field of *biotechnology*.

Can this kind of genetic engineering be applied to humans? So far it has not. Human DNA has sequences of some 3000 million cross-units on it, a single gene may be a thousand units long, while the largest piece of



The double helix of DNA showing, diagramatically, part of the long sequence of cross-units which produce what we call a gene.

synthetic DNA, made so far, is less than 100 units long. Suppose we wanted to cure a genetic defect by this method. We would first have to identify the gene in the fertilised ovum, then we would have to remove it, replace the defective part with the corrected DNA, and then return it. This is still beyond our best skills, but not beyond the bounds of possibility.

Another type of genetic manipulation, which is still further into the future, is 'cloning'. Here the whole nucleus of a cell is removed and implanted in an embryo in place of its own nucleus. This bypasses the shuffling process in sexual reproduction and ensures that the embryo will become identical to the individual from whom the nucleus was taken. In effect it is like growing a cutting from a plant, and could produce a whole clone of identical individuals. So far scientists have only been able to do this with a few amphibians whose eggs are much larger than human ova. Would we want to do it with humans?

Try writing a science fiction story on this theme.

Suggested Reading

Darwin and the 'Beagle' A. Moorehead (Hamish Hamilton and Penguin)

A beautifully illustrated book about Darwin's journey and ideas.

Ever Since Darwin S. Jay Gould (Pelican)

A wide-ranging collection of essays, easy enough for most over the age of 16; includes Darwin, human evolution, punctuated evolution, plate tectonics, racialism and feminism from the biological standpoint.

The Science of Genetics Charlotte Auerbach (Hutchinson)

A very readable book on genetics, suitable for those over 15 years.

Human Heredity C. O. Carter (Penguin)

This is a well-known book on genetic counselling and its problems by an expert.

Life and Death before Birth CSS Report (Council for Science & Society)

Our Future Inheritance A. Jones and W. F. Bodmer (Oxford University Press)

Both of these are authoritative reports on present and future problems, full of useful information but fairly heavy going. The first is shorter.

Scientific American September 1978. Special issue on Evolution.

Science In a Social CONtext is a series of eight books based on the project SISCON-in-Schools. The books provide a new course in science and society for general studies at sixth-form level. The course has been specially designed to make scientific problems accessible to the non-scientist, as well as to explain the social aspects of science to the scientist.

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