A fair share

Why do we share?

Sharing is an insurance policy, according to Professor Ken Binmore. If an animal shares its food, then when it's short on food it can expect others to share reciprocally.

Sharing among humans - 'fairness' - is a natural evolutionary response to interacting with others. It is in our interest to share, as long as our sharing is likely to be reciprocated in times of need.

Hunter-gatherer societies surviving into the twentieth century all operated social contracts where food was mostly shared on an equal basis.

Don't be unfair

The lesson is that people who don't expect a reciprocal payoff in the future will be reluctant to share on a long-term basis. In other words if there's little chance of being repaid for sharing, people are unlikely to bother.

Even reforms for an improved society will not be agreed upon if it means redistributing costs and benefits in a way that feels unfair. A society will not simply change the unwritten codes by which it operates unless the general sense of what is fair has changed, suggests Professor Binmore.

Professor Ken Binmore works at the ESRC Centre for Economic Learning and Social Evolution (ELSE).

Further reading

- Ken Binmore: "The origins of fair play" (ELSE Working Paper)

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How do the media present evolution?

How do the media present evolution?

Natural history programmes are a major part of the international media industry – but how do they present evolution? Dr Meryl Aldridge and Professor Robert Dingwall from the University of Nottingham have studied how wildlife documentaries, in the tension between education and entertainment, manage to convey potentially controversial issues related to evolution.

The research focused on two main programme types: The “blue chip” authoritative documentary with high production values, and the lower-cost “presenter-led” documentary with more human/animal interaction and dynamic editing.

High-prestige: low-engagement?

Surprisingly, high-prestige, blue chip programs may actually be less effective than presenter-led models in conveying science practice and outcomes to mass audiences.

The cost of achieving the high production values lead to a way of editing and narrating programmes that maximises their market potential, but lowers the profile of content that may challenge sections of the audience. Typically, the outcome is a text that does not challenge creationist accounts and may even implicitly endorse them.

Bringing the audience in

In presenter-led documentaries the viewer is treated as a ‘co-investigator’ rather than as a spectator to an orderly world. Although the presenter-led format is regarded as lower status by media professionals, the more open narrative form offers greater opportunity for conveying the complexity associated with evolution.

Further reading

- Meryl Aldridge, Robert Dingwall: “Television wildlife programming as a source of popular scientific information: a case study of evolution” (Public understanding of Science Vol. 15 No 2 2006)
- Meryl Aldridge, Robert Dingwall: “Implicit Models of Evolution in Broadcast Wildlife and Nature Programmes”

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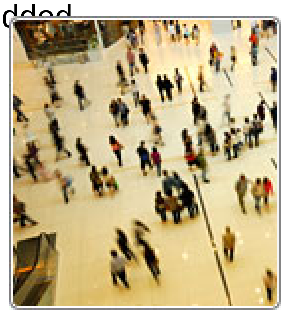
Social evolution – does Darwin have all the answers?

We need the core principles of evolution – variation, selection and inheritance, to explain how social institutions emerge and adapt, says Professor Geoffrey Hodgson at the University of Hertfordshire. But he argues, Darwin's theories can't explain all aspects of social evolution.

The Core principles explain complex systems in human society, such as business firms which, as they evolve, retain and replicate problem solutions that are embedded in habits and routines.



As long as there is variation between businesses and institutions selection takes place, weeding out those less adapted to survive.

Such evolutionary processes cannot be explained adequately by using other theories, such as self-organization, artificial selection, or Lamarckian inheritance of acquired skills, argues Professor Hodgson.

What about the details?

Despite his overarching framework, Darwin's evolutionary theories are not sufficient on their own to explain the mechanisms in detail.

Biological evolution and social evolution are very different with regards to details. Some elements of social evolution require additional explanations.

Nevertheless, social evolution involves populations of entities, including customs and social institutions, competing for scarce resources – which means social evolution largely adheres to Darwin's theories.

Further reading

- Geoffrey M Hodgson, Thorbjørn Knudsen: "Why we need a generalized Darwinism, and why generalized Darwinism is not enough" (Journal of Economic Behaviour & Organization, Vol. 61, 2006)

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The language organism

How do humans manage to rapidly learn and understand their native language? One hypothesis is that the brain has adapted through natural selection to develop mechanisms for language acquisition, and that we contain an innate, biologically determined universal grammar. Others agree that these brain mechanisms have evolved, but not through evolutionary adaptation.

Professors Morten Christiansen and Nick Chater propose it is rather the language itself that has evolved and adapted to the brain rather than the other way round. They argue that a universal grammar would not evolve biologically; language is too variable to provide the necessary selectional pressure for common linguistic constraints. Instead language should be viewed as an ‘organism’, a complex system which has evolved in a mutually beneficial relationship with humans. Languages are shaped by selection pressure from each generation of language users - traits that are easy to learn and use will become more prevalent, while more difficult traits will disappear.

Christiansen and Chater argue that the process of language evolution may apply similarly to a wider cultural context, and that, “culture has been shaped to fit our prior cognitive biases”.

You can watch a podcast interview (in the Evolution and Society topic) in which Professor Nick Chater, from the ESRC Centre for Economic Learning and Social Evolution (ELSE), talks about the evolution of language.

Further reading

- Morten H, Christiansen, Nick Chater: “ Language as Shaped by the Brain”

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How leaders emerge in groups

Leadership is an evolved trait helping groups (including organisations and companies) function effectively. Whenever a group of people interact, a leader-follower relationship almost always emerges: the leader is someone who chooses to choose first, while a follower is someone who chooses to 'wait and see'.

A study of leadership can provide insights on the success and failure of business leaders, consumer fashions and trends, strategies of financial traders, or pricing in competitive markets. An evolutionary perspective on leadership can give us new understanding about what leadership is, why it matters and how it comes about.

You can watch a podcast interview (in the Evolution and Society topic) in which Dr Edward Cartwright, University of Kent, talks about leadership, followership and evolution.

Further reading

- Edward Cartwright, Mark Van Vugt: "Why some people chooses to be leaders: The emergence of leadership in groups and organizations"

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Complexity science and evolution

How can we understand complex systems such as stock markets or ecosystems?

Professor Peter Allen argues that to understand the behaviour of such systems it's important to consider all levels - from atoms and molecules to organisms and individuals. He uses evolutionary theory to help him understand complex social and industrial systems. In these, as in nature, some individuals survive better than others and the interaction between different individuals leads to a co-evolutionary process of mutual change and adaptation.

Professor Allen's work suggests, perhaps surprisingly, that in systems, evolution selects for the ability to evolve and favours populations continually generating diverse individuals.

Learning populations

In other words, in evolutionary systems - ecological, social or economic - we will not find populations with 'optimal behaviour', but instead populations that can 'learn'.

For instance, in the car industry different manufactures take different approaches to making and selling cars. This is governed by the multitude of underlying opinions of the people who make up each company, from designers and engineers to market researchers and managers. The differential success of the different manufacturers leads to the evolution of cars and car companies – as those that have 'learnt' to be successful succeed.

This ongoing learning process of exploration and experimentation takes place at the underlying "microscopic" level. It generates the higher level of strategic organisation. These mechanisms alone can explain (though not predict) the co-evolutionary processes in markets and organisations.

Professor Peter M. Allen works at the Complex Systems Research Centre at Cranfield University.

Further reading

- PM Allen, M Strathern, JS Baldwin: "Evolutionary drive: New understanding of change in socio-economic systems" (Emergence Complexity & Organization, Vol 8 No 2 July 2006)
- Keith Ridgway, Belinda Winder, Peter Allen: "Modelling the Evolution of the Aerospace Supply Chain"

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Will climate change drive evolution?

We are currently witnessing an unprecedented rate of climate change and we just don't know exactly how that will influence evolution and extinction.

There are likely to be winners and losers with rapid climate change. The rate of environmental change may be just too fast for other species to evolve and there is a danger that they could become extinct. However, some research indicates that certain species are already adapting to a warmer climate, but this is still quite difficult to demonstrate.

Mixed-up migration

Researchers have recorded what may be a curious evolutionary consequence of climate change: the arrival order of two birds to UK shores, the sand martin and the barn swallow, has reversed.

Historically, barn swallows winter in southern Africa, arriving in Britain in late February or early March. The sand martin winters in western Africa, departing for the UK later in March. Warmer weather in Europe is driving changes in migration timing. When scientists from the Centre for Ecology & Hydrology (CEH) and Adam Mickiewicz University, Poland, examined 56 years of migratory data, they found that sand martins now arrive on average before barn swallows.

Tim Sparks from CEH says the findings clearly show the birds are changing at different rates and proposes this may be evidence of an evolutionary response or adaptation to a warming climate. The arrival date, at least in barn swallows, is heritable.

Relatively minor environmental influences such as one harsh winter can accelerate evolution in animal populations and rapidly change population sizes.

Chilly sheep

Scientists studying Soay sheep in the Outer Hebrides noticed that in years with long, cold winters the sheep population grew fastest when there were many large individuals within the population. In the 1980s big sheep were genetically favoured in this population because big sheep had more chance of surviving the harsh winters. But as the climate changes and the Soay sheep are not subject to such tough winters, there will be a reduced natural selection for larger animals.

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Research has shown that changes in the size of a population is affected by body size, and that body size, in turn, is affected by various factors including genetics, climate, and the availability of food. The scientists have, for the first time, linked the big ecological picture with the genetic make-up of individual animals.

Further Reading

- Patterns of spring arrival dates differ in two hirundines. Climate research, Vol. 35.

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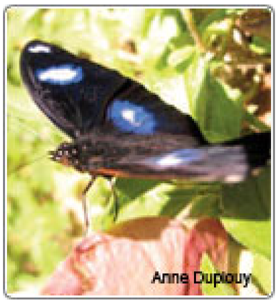
Evolution in the fast lane

Evolution isn't something which just happened in the past, it's taking place right now. But because the changes are usually very slow, we are often not aware of it happening.


Anne Duplouy

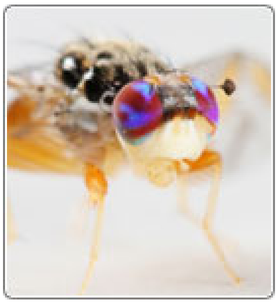
Evolution can be slow and consistent or punctuated by a rapid change. Rapid changes can occur if a random genetic mutation leads to a major alteration in the way an organism functions, or if a change in the environment creates harsh selection pressures. By harsh selection pressures, we mean that survival becomes so critically dependent on a particular trait that those species without that trait are wiped out in a very short space of time. Only those individuals with the genes for the advantageous traits are able to reproduce and continue their line of heritage.

Not so slow

Scientists have discovered that a population of butterflies on a South Pacific island that has evolved very rapidly in response to a deadly bacterial disease. The disease acted as a harsh selection pressure by killing off nearly all the male Blue Moon butterflies. The sole survivors had an advantageous mutation which enabled them to fend off the bacterium. Being the only reproductive males on the island, all subsequent offspring carried this advantageous gene. On one of the islands, this resistance gene spread in a year (just 8-9 generations of butterfly). The effects of this tiny bacterium produced some of the most rapid evolutionary and ecological changes recorded in natural systems.

In the lab…

Some species such as bacteria, viruses and flies have a short life-cycle and reproduce very quickly. Such a short space of time between generations can result in speedy evolutionary change. Because of this, scientists often study evolution in laboratories using fruit flies as evolutionary change can be witnessed within a scientist's life-time.



Further Reading

- Survival of the fastest: Male-killing drives rapid evolution
- Like father, like son – attractiveness is hereditary: NERC press release:

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Variety is the spice of life

Variety really is the spice of life: less diverse ecosystems are less productive and less stable. But just 30 crops supply about 90% of the calories in our diet. And just 14 animal species make up 90% of the livestock we raise. Since we depend on so few plant and animal species, we are vulnerable to environmental change and crop and livestock diseases.

Consequences − life support

Current losses in biodiversity and consequent changes in ecosystems are now expected to lead to problems such as water shortages, flooding, increased nutrient loading, invasive species, and the emergence of new diseases or re-emergence of old ones, as well as the loss of genetic resources.

Loss of genetic diversity

Genetic diversity provides the basis for adaptation, allowing species to respond to natural selection, such that they evolve to fit their environment. This genetic diversity, therefore, plays a strong role in the resilience of biodiversity to global changes, such as climate change or novel diseases. Genes also provide direct benefits to people, such as the genetic material needed for improving yield and disease resistance of crops or for developing medicines and other products.

Over the past two decades, many of the world's most important agricultural crops have lost genetic diversity due to changes in agricultural practices. The continued loss of genetic diversity of such crops may have major implications on food security. We have a poor understanding of the amount or rate of loss of genetic diversity, but the best evidence to date suggests that substantial genetic loss is occurring.

Further Reading

- Wildflower power: A report on how farmers can increase hay yields by planting more wildflowers

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Evolution – how far have we come?

Scientists say the sheer diversity of life is richer now than at any other period in Earth's history: there are probably between five and thirty million species alive today. We have named two million but some species may have been described more than once so the actual number is lower. We don't know the total number of species that have ever lived, but estimates range from two to five billion.

There have been at least five mass extinctions in the past. Some of these extinctions wiped out as much as 95% of all species. Researchers now say we are in the midst of another mass extinction. Unlike other mass extinctions, which were caused by asteroids, volcanic eruptions or climate change, many scientists think today's mass extinction is caused by one particular species − humans − you and me.

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Habitat loss

Habitat loss is the greatest threat to the variety of life. We use more and more land for houses, agriculture and factories. The problem is that we are not just removing species, we are removing entire habitats.

A recent major report (the Millennium Ecosystem Assessment 2005) stated that changes in important components of biological diversity have been more rapid in the past 50 years than at any time in human history. All evidence suggests that these rates of change will continue or accelerate in the future.

What's the cost?

The natural environment provides us with food, medicine, fuel, clothes, timber, climate regulation, water purification and crop pollination. All these services rely on the enormous diversity afforded us by evolution. Ecologists and economists estimate the monetary value of nature's value to society is at least $33 trillion each year.

Scientists are currently working on an international programme to better understand the relationship between healthy ecosystems and poverty alleviation.

Ecosystems − life − drive the natural cycles that make this planet habitable. These cycles rely on a huge number of species to operate effectively.

Further reading

- NERC's Ecosystems Services & Poverty Alleviation programme

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Natural cycles

Carbon, oxygen and energy cycles

Before plants evolved, the Earth's atmosphere had more carbon dioxide than today and very little oxygen, not enough for animals to live. Plants, bacteria and phytoplankton − tiny marine plants − photosynthesise, transforming the energy from the sun into stored chemical energy, absorbing carbon dioxide and releasing oxygen.

When organisms respire they take the oxygen up and combine it with carbon to release energy and form carbon dioxide. So the combination of photosynthesis and respiration means carbon, oxygen and energy form an interwoven cycle.

Nitrogen cycle

Nitrogen is essential for all organisms and plants are no exception. Bacteria living on, or even in, some plant roots convert nitrogen from the atmosphere into a form the plant can use. Creatures feeding on these plants release nitrogen in their waste products. When the waste is broken down by microbes the nitrogen is recycled back into the atmosphere.

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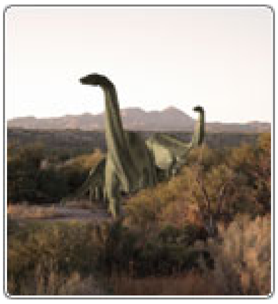
Extinction – who's next



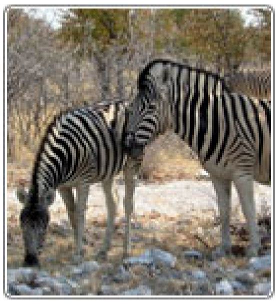
We know that one in four mammal species is at significant risk of dying out within a human lifetime. But can we predict which animals will be threatened next? Knowing this could allow conservationists to protect vulnerable species even before they start to decline.

The Red List

Georgina Mace, director of NERC's collaborative centre, the Centre for Population Biology, was one of the key scientists involved in producing the Red List. This is an internationally recognised inventory of all the species that we know are currently under threat.

Scientists have studied the mammals on the Red List to get to know the danger signs for extinction. They have revealed that geographical distribution, human pressures, large size in primates, slow reproductive rates in carnivores and wing shapes in bats, are all indicators of extinction risk.

Size matters



Big mammals such as the Burchell's zebra are potentially in big trouble.

By looking at evolutionary family trees, scientists can compare threatened species with their safe close relatives and then try to pin-point the differences that might lead to extinction. In doing this, they have discovered that large and small mammals need different conservation approaches. Small species will be well served by simply looking after their habitat, but large ones will need more specific help.

Further Reading

- On being the wrong size: Why big mammals are in big trouble

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The Gaia hypothesis

Some scientists argue that all living things have an equal importance because they all play a part in regulating the planet. This idea was first made popular by Dr James Lovelock in the 1960s with his Gaia hypothesis. The world can be seen as a complex interacting system, behaving in some ways, like a single organism.

Small, but mighty

Removing what seems like some pretty inconspicuous organisms, could result in changes across the whole system. Only very recently, researchers discovered a group of micro-organism called crenarchaea, which are playing a major role in helping to support life on Earth. By carrying out genetic analysis of soil samples, we now know that these organisms are responsible for most of the world's oxidation of ammonia in soil, a process which provides vital nutrients for plants.

There could be many species that we simply don't know enough about their biology and ecology to anticipate what the effects of their extinction might be. For example, marine life might play a bigger role than we think in regulating the circulation of water in the oceans, which in turn, influences the global climate. Some scientists have suggested that the movement of big shoals of fish and large marine life, such as whales, could help to circulate warm and cold water in the oceans. Not everyone might agree with such ideas, but we need to test them if we are to truly appreciate the extent that biodiversity influences our planet.

Keystone species

Every species depends on other species for survival; however, there are some plants and animals where an extremely large number of other species are dependent on them. These are known as key-stone species. An example is the fruiting fig tree, which is important for maintaining biodiversity in tropical forests as the figs are the main food source for a large variety of animals. Also, there is a mutual relationship between figs and fig wasps which pollinate them. Without one, the other cannot survive. If figs disappear, so do many species of animal, jeopardising entire ecosystems.

Further Reading

- Bacteria may get demoted as a key player in the nitrogen cycle in soil
- Causing a stir: Are we ignoring the influence of life on ocean mixing?

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Directed evolution – the basics

Directed evolution - the basics

How does it work?

Take a protein that you want to change in some way, say make it work in higher temperatures. Create many mutated copies of this protein. Then test all of these new proteins for their temperature resistance. Those few that do work better in higher temperatures then go through the whole process again. This technique has been used to improve proteins by over 1000 fold.

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How resistance evolves

How resistance evolves

Populations, be they bacteria or humans, contain genetic variation. It’s this variation that allows populations to survive change. When a population encounters something harmful some individuals survive while others perish. Survivors pass on genes that helped them survive to the next generation and so the new population becomes more resistant.

Beating the 'bugs'

By looking at genes in many different *Staphylococcus aureus* strains (very closely related to MSRA) it has been possible to identify a set of genes that help the bug infect humans. These genes are under continuous selective pressure and have remained important for the bacteria for a long time. Such genes may be good candidates to try to disrupt with antibiotics, learn more about this work by watching the video podcast

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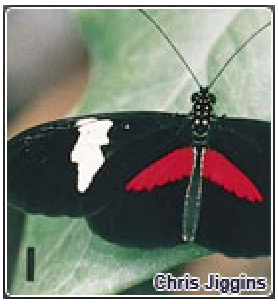
What is a species?

'*The origin of species by means of natural selection*' is Darwin's most famous book. But what is a species?

Four definitions

Here are four different concepts that have been put forward to define a species:



1. Typological species: If it looks like it's the same species – then it is.

2. Biological species concept: simply, two individuals are members of the same species if they can mate to produce fertile offspring.

3. Evolutionary species: this definition has been used by palaeontologists studying fossils through geological time. G. G. Simpson has defined it as, "a lineage evolving separately from others and with its own unitary evolutionary role and tendencies".

4. Nominalist species concept: This thinking argues that the concept of a species is merely an arbitrary bracketing of individuals, and therefore species as such don't exist. Whilst philosophically interesting this concept is of little use practically and is commonly refuted by the observation that cultures from across the globe recognise a species – suggesting that it is more than an arbitrary western concept.

Defining problems

Today, biologists most commonly use the biological species concept. However, even this simple definition encounters problems.

Many species reproduce clonally, without sex. Good examples are bacteria, amoeba and many other microorganisms. But even bigger animals can challenge the concept of a biological species. Sometimes, sexually reproducing greenfly (aphids) experience a mutation that causes females to produce clones of themselves. If the aphid finds itself in a good environment, the rapid production of identical clones builds up large populations, this is one reason they are such a successful pest.

Since, in this scenario, there is no mating we can't use the biological species concept, as that would mean that each greenfly was a member of its own individual species!

Many aphids do in fact revert to producing sexually at the end of the season. Yet some species consist entirely of females and only reproduce clonally. This type of reproduction is called parthenogenesis and is even found in some vertebrates, including species of fish and lizard, and means the biological species concept really can't be applied.

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Instead we can revert to other definitions of species based of what organisms look like. This is what Linnaeus mainly used in his original classification and what we are forced to use today when classifying fossils, since fossils do not mate.

Promiscuous butterflies and choosy partners

However relying just on looks can be deceptive.

Two species of butterfly, *Heliconius himera* (top right) and *Heliconius erato* (left), look completely different. However, they have been found to mate and form hybrids in the wild!

At the other end of the scale, so called 'cryptic species' look very similar but don't mate. For example, one species of fig tree is pollinated by four cryptic species of tiny wasps.

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