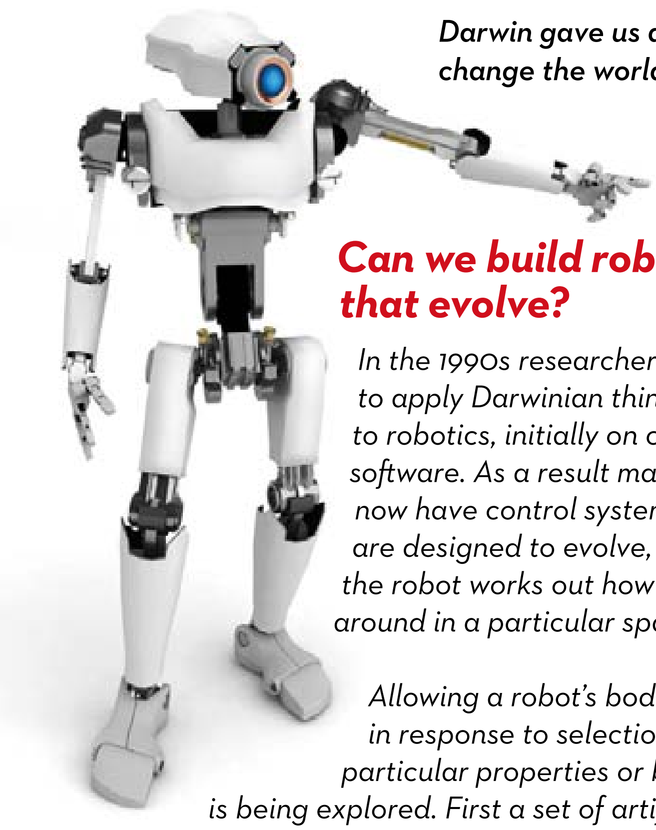
Putting evolution to work

Darwin gave us a powerful tool to understand and change the world we live in.



Can we build robots that evolve?

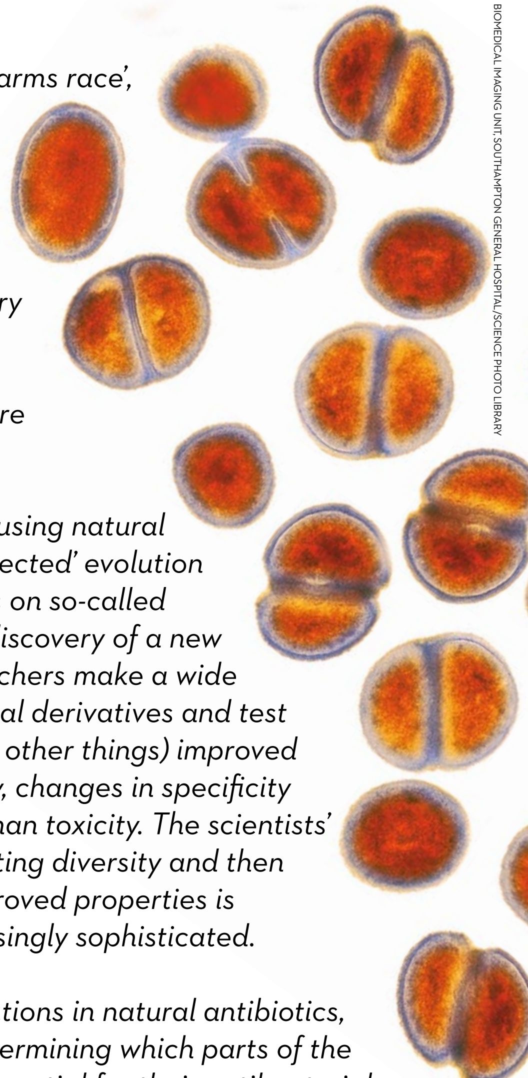
In the 1990s researchers began to apply Darwinian thinking to robotics, initially on control software. As a result many robots now have control systems that are designed to evolve, e.g. as the robot works out how to move around in a particular space.

Allowing a robot's body to evolve in response to selection for particular properties or behaviour, is being explored. First a set of artificial 'genes', describing control systems, body layout or behaviour are produced along with a way to create variants of these 'genes'. The 'genes' are then shuffled and the 'fitness' of different combinations is tested and the best are selected and maintained.

Bug wars!

Natural selection generally works against us in our fight against disease. Disease organisms reproduce (and so can evolve) much more quickly than humans; they can quickly evolve around any genetic resistance to infection that humans might develop. High reproductive rates and very large population sizes also give bacteria (and other disease organisms) an evolutionary advantage when humans use antibiotics and other therapies. Widespread treatment of bacterial infections with a particular antibiotic is a powerful selection for naturally-occurring variants of the bacteria, which carry genes that make them resistant to the antibiotic. Antibiotics may become ineffective as these resistance genes spread through the bacterial population.

Staphylococcus aureus



This leads to an 'arms race', with researchers constantly searching for new antibiotics to control bacteria that carry genes that make them resistant to antibiotics that are already in use.

Researchers are using natural selection and 'directed' evolution to turn the tables on so-called 'superbugs'. On discovery of a new antibiotic, researchers make a wide variety of chemical derivatives and test these for (among other things) improved antibiotic activity, changes in specificity and reduced human toxicity. The scientists' strategy for creating diversity and then selecting for improved properties is becoming increasingly sophisticated.

By studying variations in natural antibiotics, scientists are determining which parts of the antibiotics are essential for their antibacterial activity. Varying the other parts of the molecule allows them to design new antibiotics with better activity and fewer side effects.

Scientists are now trying to develop antibiotics that target genes essential to bacteria's ability to cause infection. For example, from genetic studies of many different strains of Staphylococcus aureus *(a bacterium closely related to MSRA) several genes have been identified that help the bug to infect humans. As these genes are essential for infectivity they may be good targets for disruption by new types of antibiotics. Any gene variants that might make the bacterium antibiotic resistant might also disrupt its ability to infect humans.*

Directed evolution

As with antibiotic development, scientists working in agriculture, medicine and industry are also using directed evolution - creating many chemical variants of existing molecules and then selecting for variants that have new or improved properties. This can be repeated over and over again; selecting over several 'generations' for desired changes in properties. Scientists have used directed evolution to increase the efficiency of enzymes that are used as catalysts to make sialic acid. The variant enzymes produce new types of sialic acid molecules - including some used as antiviral drugs. Directed evolution of proteins that inhibit plant enzymes is being used to increase their ability to fight nematode infections, which cause devastating crop diseases.

Taming the wild

The earliest farmers collected seeds from the wild plants that they liked to eat and planted them in their fields. Each year they

sowed seed from plants that in the previous year had produced higher or more reliable yields, better tasting food or were easier to process. Unwittingly, they were selecting for plants that carried the individual genes and gene combinations that determined the characteristics they wanted in their crops. Crop cultivation brought plants close together, encouraging hybridisation, which created new gene combinations and, in extreme cases, new species (eg modern wheat). The qualities farmers value in crop plants are often the opposite of the characteristics that make a plant competitive in the wild; as farmers selected for (and against) particular qualities crop plants quickly became very different from their wild ancestors.

About 100 years ago, plant and animal breeding became much more efficient when breeders were able to combine the understanding from Darwin's theory of natural selection with Mendel's theories of genetic inheritance.

In the future will our understanding of genetics and inheritance allow us to make more use of the natural resources around us? Fourteen animal and 30 plant species account for most of the human diet. Compare this with the estimated 1.5 million known species (this ignores vast numbers of unidentified species and many microorganism). In a constantly changing world, dependence on so few plants and animals makes us very vulnerable to crop and livestock diseases and the effects of climate change.

One solution is to try to use this natural diversity. Recent advances in understanding chromosome pairing in cereal plants has important implications for wheat breeding as it may allow breeders to hybridise modern bread wheat with many of its wild relatives. This will give breeders access to a larger pool of desirable traits, such as salt tolerance, drought resistance and disease resistance, that would be otherwise unavailable.

Read more at http://www.darwin.rcuk.ac.uk

***Darwin Today** is raising awareness of the importance of Darwin's theory of evolution by natural selection, in current research and innovation across many disciplines. **Darwin Today** is targeting general audiences around the UK. It is led by the Biotechnology and Biological Sciences Research Council on behalf of the UK Research Councils.*

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