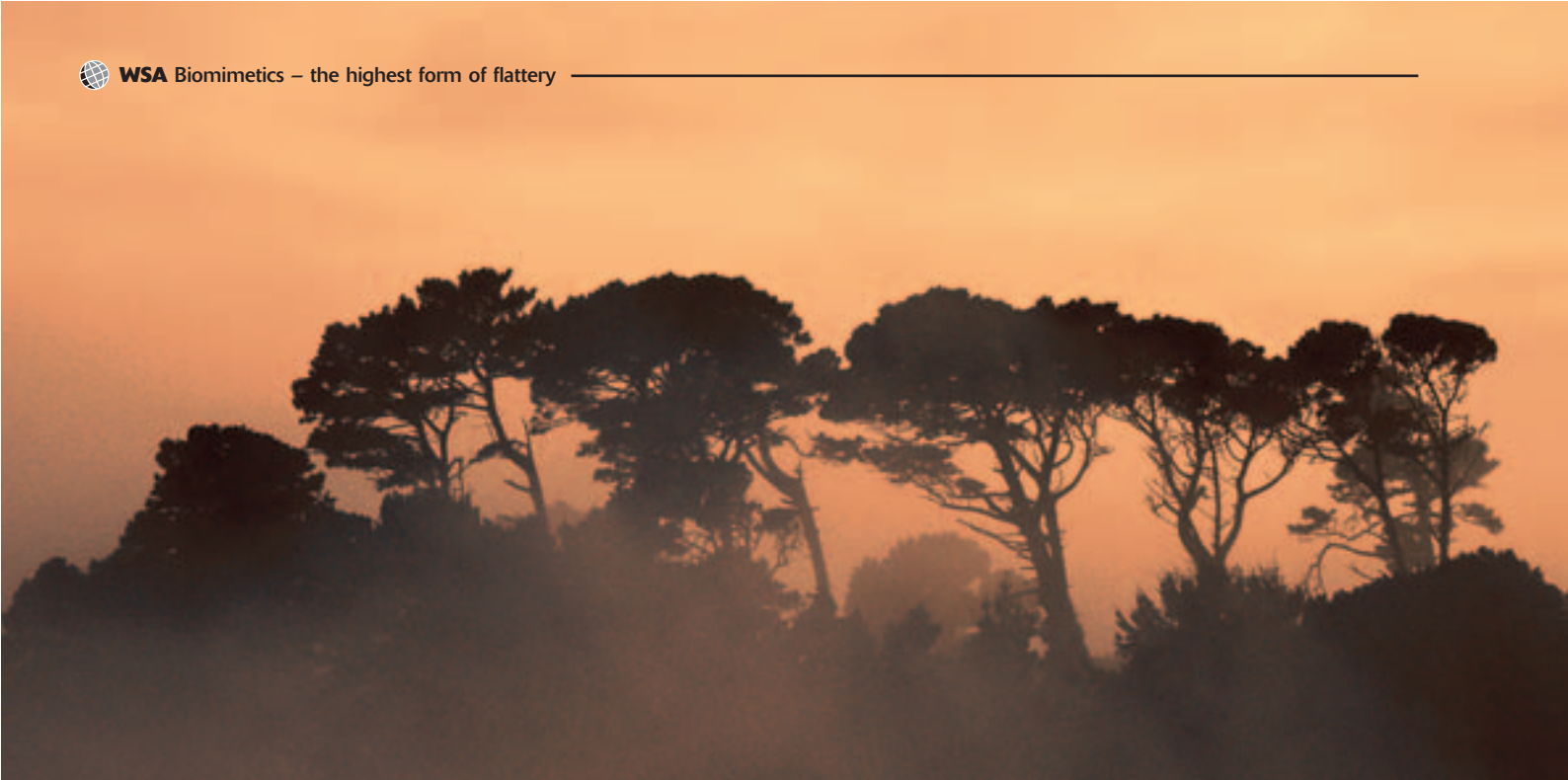


Mimicry has existed as long as life on Earth and animals, birds and insects have always imitated each other in order to survive. They copy each other's calls, and take on the appearance of other species to ward off predators, some blending subtly into the background, using camouflage to survive. Mike Parsons and Mary Rose from the Institute for Entrepreneurship and Enterprise Development at Lancaster University in the UK investigate biomimetics to see what is new, what is understandable, and its likely impact on the sports and outdoor industry.

Biomimetics – the highest form of flattery

Hydrophilic membranes developed in the 1980s were viewed as a breakthrough in technology and are now a familiar component in apparel and equipment in the outdoor trade. But semi-permeable membranes are also found in nature in, for example, our stomachs. They have a pedigree reaching back for centuries. The Aleut American Indians needed a totally waterproof jacket for kayakers. They used dried seal or whale intestines and sealed the seams with animal glues to make 'kamleika'. However, we have no test reports to show how 'breathable' these garments actually were!

For many millennia man's survival has depended on both animal and plant resources, but in the last 150 years there have been many instances when human demand has run ahead of natural supplies. Synthetic substitutes and manufactured alternatives to natural resources have been developed—sometimes involving biomimicry. In the 1860s there was a shortage of the thornbush used to divide cattle areas on the ranches of the American West. Ranching was expanding so quickly it was simply impossible to grow enough thornbushes so a 'naturfact'—barbed wire—was developed. Designs multiplied before the standard or dominant design emerged. Almost an exact replica of the thornbush, in terms of the length of the thorns and the distance between them, it was produced using novel metal and manufacturing processes. Tubes exist in the natural world, whether in hair, feathers or in grasses but an engineering solution was needed if they were to be manufactured. Achieving this in the nineteenth century allowed bicycles to be made.

Emulating nature gathered pace in the nineteenth century. Design icons like the Eiffel Tower and the microphone drew on research on the human body, while bird wings provided the inspiration for the Wright Brothers' pioneer aircraft. Billiard balls are a lesser known example



Waterproof pullover, Kamleika. Sea lion intestine provides the waterproof material.

Pictures of Record Inc.

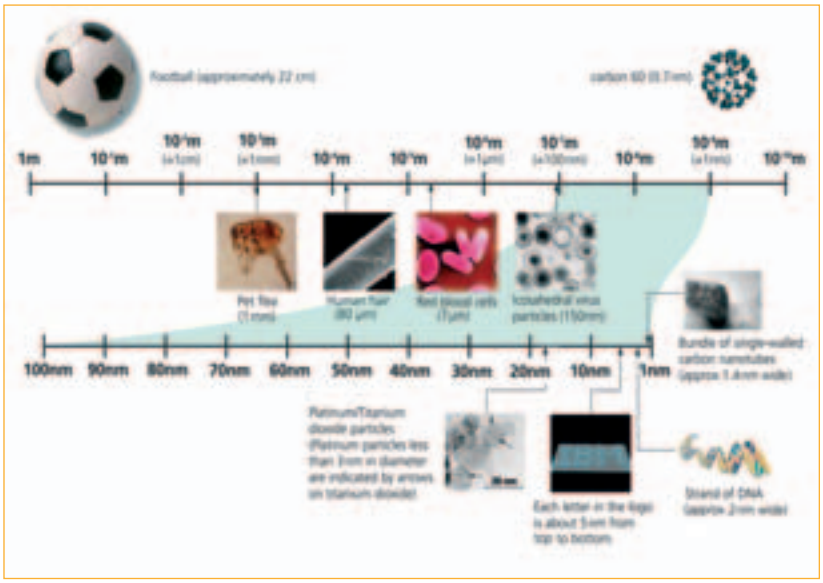
when 'synthetic' ivory, in the form of Bakelite, was introduced following the rapid growth of the game in the 1880s and the pressure on ivory supplies.

Biomimicry is partly about making products which copy nature, but it also involves process development, as in the case of artificial silk. Invented by Swiss scientist Georges Audemars and developed further by the French in the 1890s it was renamed rayon in 1924. This cellulose-based man-made fibre was made from wood pulp and has many of the characteristics of natural cellulosic fibres such as cotton and linen.

Hook-n'-loop technology (made famous by Velcro), which has transformed outdoor sports and products, is one of the best known examples of biomimicry. Velcro was invented in 1948 by George de Mistral, an inventor and mountaineer. Returning from taking his dog for a walk he found he and his dog were covered with burrs—the hooked seed of the burdock. The tiny burdock hooks cling to anything they come in contact with and he saw the potential for a new kind of fastening. The success of this well-known 'naturfact' depended on the use of relatively new materials and combined nylon cloth with hooks to another with tiny loops. Patented in 1955, it really took off when the American military experimented with it, calling it the 'zipper-less zip'. The textile processes used to create Velcro were all well known and it was their combination which created the innovation.

Insulation is crucial for survival and nature has a myriad of methods, including air trapped in tiny hollow tubes in the hair and the fur of animals such as the polar bear, or between soft down on birds. The natural down of geese and the eider-duck has been used in bedding since the Vikings and in clothing since at least the nineteenth century. Kapok, the light, fluffy fibre from the seeds of the silk-cotton tree, was introduced as an alternative to down for pillows, eiderdowns and sleeping bags and continued to be used through to the 1960s. It had a major advantage over down, as it can be compressed without losing its insulation qualities and was used in the high altitude boot worn by Edmund Hillary, on Everest, in 1953.

The greatest temperature extremes occur in deserts and light, hollow camel hair is a perfect insulator, while the fur of creatures such as reindeer and wolverine provide wonderful insulation. As with hook-n'-loop and rayon, textile processes were crucially important to the evolution of imitation furs. The development of continuous filament nylon fibre in the USA led to experiments with synthetic fur and the first substitute called Furleen appeared in 1948. It wasn't a commercial success, probably because it was so crude, but Helly Hansen patented a double-faced knitting process (similar to that used in carpet making). This improved flexibility and made the fabric long lasting and durable for workwear for fishermen when introduced in 1961. Fibre pile, launched in the late 1960s, was popular in mountaineering until replaced by fleece. It did not drastically improve function but looked much better. Patagonia developed a new version of pile which they branded Synchilla and which Malden Mills later launched as Polartec fleece.

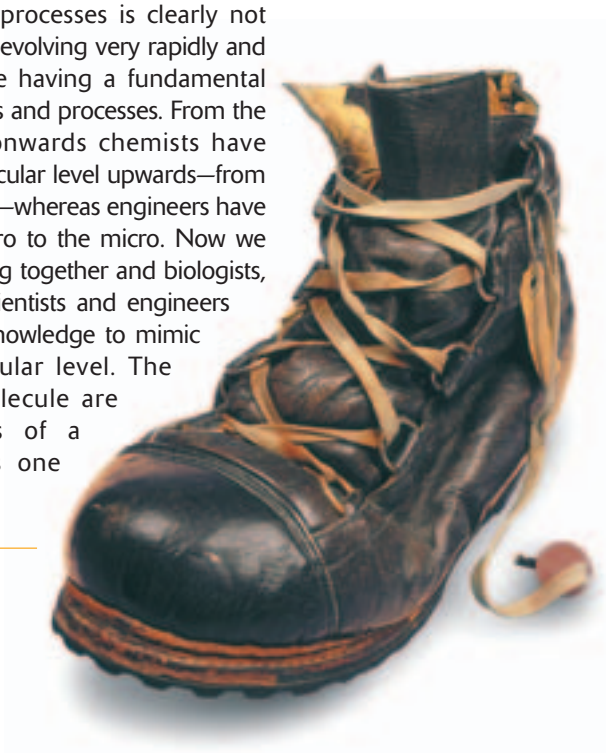


Length scale showing the nanometre in context. The length scale at the top ranges from 1m to 10^{-10}m, and illustrates the size of a football compared to a carbon molecule.

The Royal Society

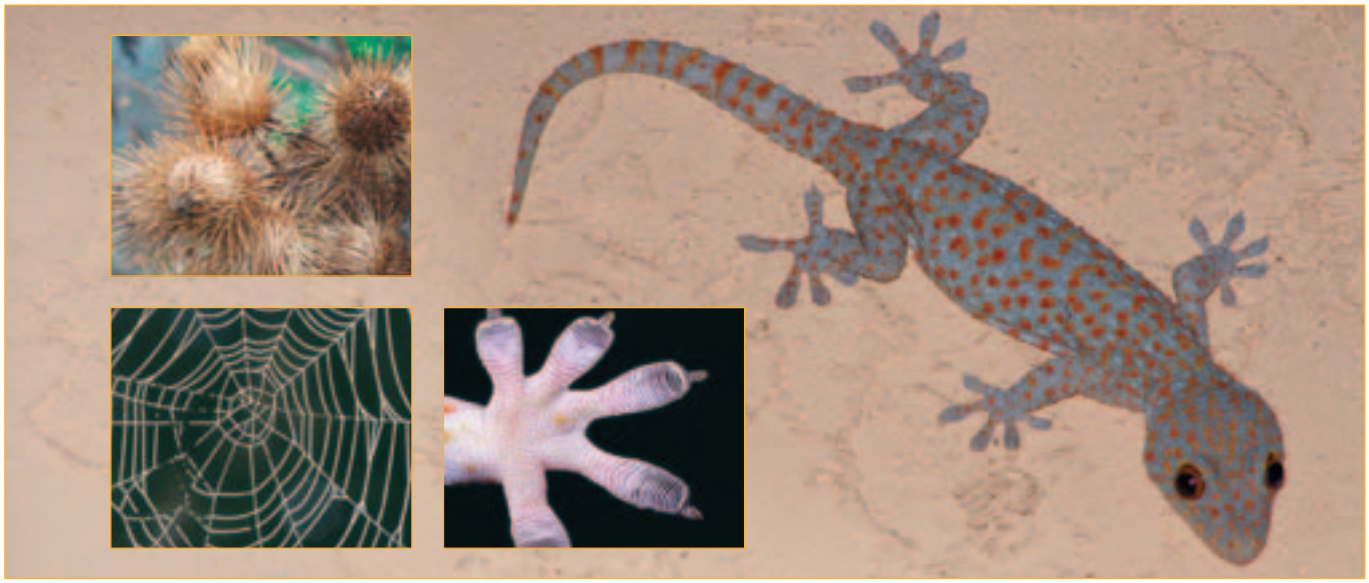
Natural loofahs and sponges were found in every bathroom until the 1960s, when they were replaced by synthetic substitutes. Synthetic foams were also used for cushioning packs, but since they absorb water like a natural sponge, this made them uncomfortable for sustained use. By contrast water runs through the loofah and this became the natural model for the modern reticular foams now used on pack designs to improve comfort.

Mimicking natural processes is clearly not new, but it is currently evolving very rapidly and scientific advances are having a fundamental effect on both products and processes. From the early 19th century onwards chemists have worked from the molecular level upwards—from the micro to the macro—whereas engineers have worked from the macro to the micro. Now we find the two are coming together and biologists, chemists, computer scientists and engineers are combining their knowledge to mimic nature at the molecular level. The dimensions of a molecule are measured in terms of a nanometre which is one billionth of a metre.



The last surviving high altitude boot from the successful ascent of Everest in 1953.

SATRA



Inspired by nature – the hooked seed of the burdock; strong, light and biodegradable spider silk and the minute setae structures covering a geckos feet.

This new technology—nanotechnology, is the foundation of biomimetics, where science has brought artefacts closer to imitating natural things than has been possible in the past. Recent years have witnessed the convergence of nanotechnology, biotechnology, information technology and new technologies based on cognitive sciences (NBIC). This brings the potential for revolutionary advances at the interface between previously separate fields. Combined with developments in mathematics and computing, this improves our understanding of the natural world and science, with the potential to improve human performance and radically transform processes and materials.

The gecko and gecko tape is an example of the growing sophistication of biomimicry. The gecko is a lizard which is able to walk on walls and ceilings as a result of minute, hair-like structures called setae, which cover their feet. Weak intermolecular attractive forces between the spatula like tips of the setae and the surface they are walking on are enough to hold the gecko's weight.

Scientists have now established that these can be synthetically reproduced, although they are some years away from commercialisation. Researchers are already viewing it as a potential replacement for Velcro and for Elastoplast and are exploring applications with robotics. But what about mountain sports, is it an evolution of 'sticky rubber'?

Another example of the impact of nanotechnology on biomimicry is synthesising a spider's web. A spider's web is exceptionally tough, strong, light and also biodegradable and has evolved over 400 million years. Mimicking these properties has been a major priority for many years.

The first spider silk fibres were made from man-made materials in 2002, in a collaboration between Nexia Biotechnologies Inc. and the US Army Soldier Biological Chemical Command. Called Biosteel these fibres were as tough as spider silk.

A Nexia scientist commented, "Spider silk is a material science wonder. It's self-assembling, biodegradable, high performance, with a nanofibre structure one tenth the width of human hair that can stop a bee travelling at 20 miles per hour without breaking. Spider silk has dwarfed man's achievements in material science to date."

Combinations of technology have the potential to transform clothing systems and what we have always understood the capabilities of textiles to be. Soldiers' entire equipment is being reviewed to make them better prepared for modern urban, guerrilla-style, warfare. Every aspect of a soldier's equipment has been revisited and the soldier has been stripped down to the skin. Textiles are used as scaffolding for a range of sensors and other wearable technologies to detect injury, dehydration, energy levels and overall medical condition alongside a range of 'electro textiles' to provide data for these sensors. A further step would be to connect them electronically so that each soldier becomes 'a living, breathing, fighting internet nodes'.

It is impossible to predict the future impact of biomimetics on outdoor sports and products. In the past, radical innovation has often been preceded by a phase of almost frantic and seemingly fruitless launching of products. Many failed to be commercialised, never reaching their 'tipping point' because what was technically possible was not needed in the market or what was needed could not be achieved. The technological convergence we are currently witnessing has the potential to remove many of the barriers to successful biomimicry. This may in turn alter both human needs and performance.