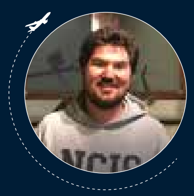

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The Effects of Bio-Inspiration on Structural Design

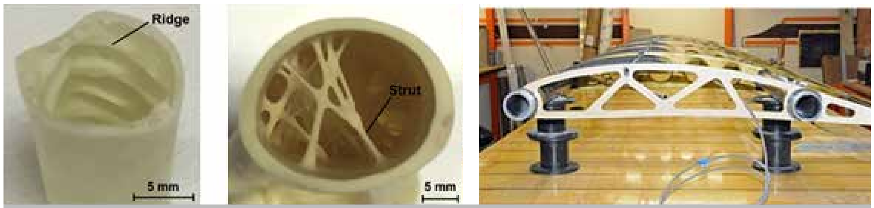

Figure-1 Bird Wing Bone Structures and Wing Manufacturing of the STOL Ultralight.

In the development of aircraft, the evaluation of different materials in manufacturing is a particularly important aspect. Such applications play an important role in weight reduction, material strength as well as aerodynamic gain. Researchers have been conducting projects on bio-inspired materials by studying a variety of different creatures not only birds. Especially plants, arthropods and fish are just as important as birds in this type of research.

In birds, bones need to be strong and stiff to lean forces during take-off, flight, and landing, with a minimum of weight. Flying birds and mammals have a lightweight skeleton system to provide less weight force, making flight easier. By comparison, birds weigh 1/3 the weight of a mammal of the same size. These birds do not have marrow filled long bones (e.g. humerus, ulna, radius). Therefore, reinforcing structures (struts and ridges) are found within bird wing bones to provide resistance. These kinds of applications can be seen in fuselage and rib construction in historical planes, ultralights and short take-off and landing (STOL) planes. This method reduces wing weight by up to 30% in the wing design of an ultralight type of aircraft.

Solid particle erosion causes millions of dollars of damage each year to helicopter rotors, rocket motor nozzles, turbine blades, pipes and other mechanical parts. It's tough to be a machine in the desert: particles of dirt and sand work their way into moving parts. The desert scorpion (Androctonus australis) live their entire lives subjected to blowing sand, yet they never appear to be eroded. Researchers studied the bumps and grooves on the scorpions' backs, scanning the creatures with a 3-D laser device and developing a computer program that modelled the flow of sand-laden air over the scorpions. Computer simulations are used to develop actual patterned surfaces to test which patterns perform best. At the same time, the erosion tests were conducted in the simple erosion wind tunnel for groove surface bionic samples at various impact conditions. Their results showed that a series of small grooves at a 30-degree angle to the flowing gas or liquid give steel surfaces the best protection from erosion. Furthermore, an application exploring the use of bionic blades on a centrifugal fan was conducted. The blades with optimum parameters could effectively improve anti-erosion property by 29%.

Figure-2 Point Clouds of Scorpion Back

Many flora and fauna flourish due to their low drag and antifouling properties, with commonly studied examples including shark skin and lotus leaves. The skin of fast swimming sharks is both low drag and antifouling; and lotus leaves are antifouling via self-cleaning. Sharks remain clean due to their microstructured riblets, flexion of dermal denticles, and a mucous layer. Lower drag is necessary for shark survival as it allows sharks to swim faster in order to catch prey. Increased fluid flow velocity on the skin reduces microorganism settlement time and promotes antifouling, along with riblet spacing smaller than microorganisms. Conversely, lotus leaf surfaces are comprised of hierarchical micro papillae with a waxy nanostructure that repel water droplets and provide self-cleaning by removing unwanted contaminants. These findings have been applied on airplane fuselages, windows and wings to provide better aerodynamic performance.

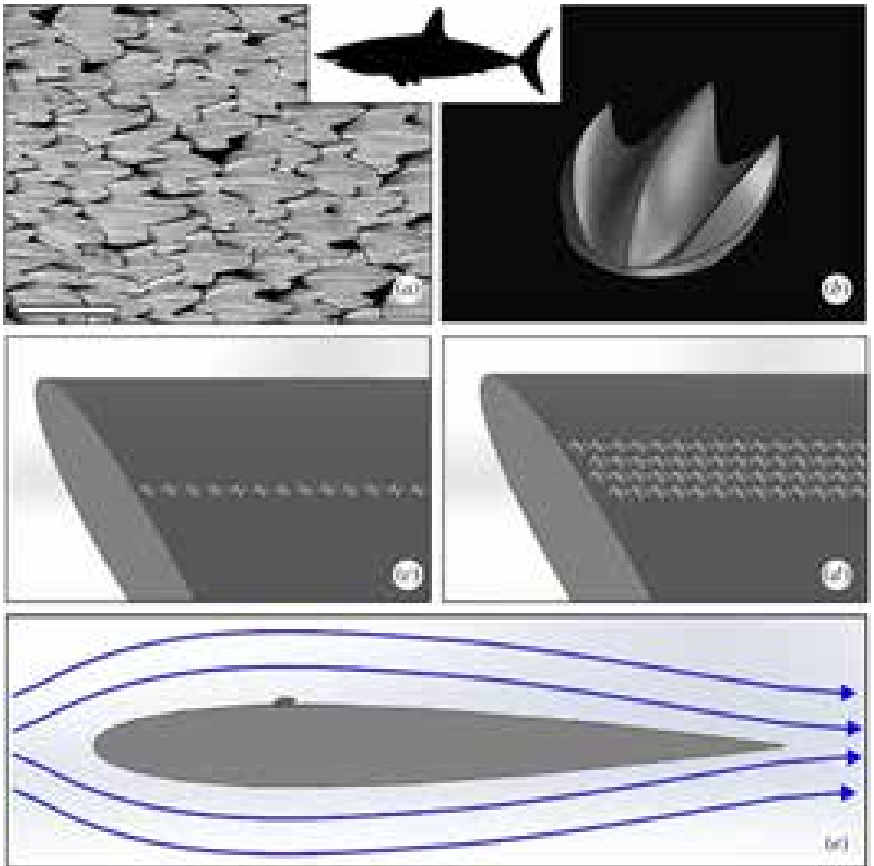

Figure-3 Application of a teeth like structure of the shark skin on wing surface (August et al. 2008).

To create the most durable and lightweight design possible, researchers sought inspiration from nature. Bionics, which involves examining natural mechanics to see how they could be mimicked in technological devices, has been crucial in the production of the 3D printed component. The jet partition was created with custom algorithms, which generated a design that mimics cellular structure and bone growth. Airbus has also been exploring weight-saving aircraft structures based on the construction of super-strong water lilies, and torsion springs based on fish jaws. Airbus revealed designs for a totally revamped 3D printed partition, which are used in Airbus A320 aircraft. The "bionic" partition, 45% (30kg) lighter than its traditionally manufactured ancestors, has now been 3D printed for testing, with the contributing companies offering further insights into the design process behind the giant 3D printed component.

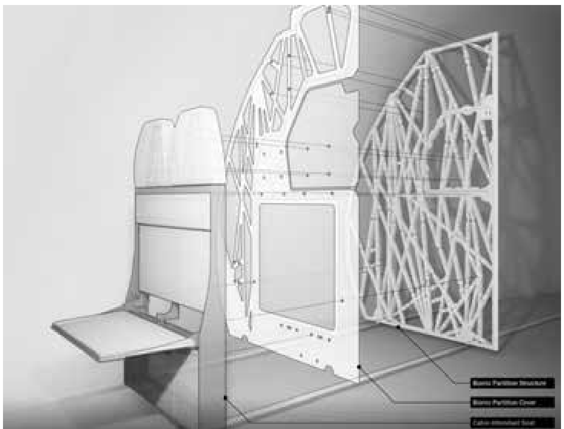

Figure-4 Concept design of fuselage frames that mimic cellular structure and bone growth

Birds have undergone almost 7 different adaptations like having a beak instead of teeth, one ovarium instead of two, one sweat gland etc. only for weight reduction in the evolutionary process. Such adaptations for weight reduction have become significant in aviation thanks to technological developments. With both biomimetic studies and developments in materials, we will see much lighter and more performance aircraft in the future