Protective wear inspired by fish scales

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They started with striped bass. Over a two-year period the researchers went through about 50 bass, puncturing or fracturing hundreds of fish scales under the microscope, to try to understand their properties and mechanics better.

"The people at the fish market must have wondered what we were up to," says François Barthelat smiling ruefully." He teaches in the Dept. of

Mechanical Engineering at McGill, and is one of a growing number of scientists who look to nature for inspiration as they search for solutions to engineering problems they see around them today. For several years, he and his team have been trying to replicate the kind of protection combined with flexibility offered by certain kinds of animal scales. Their goal is to create protective gloves that are both resistant to piercing and still flexible enough for factory workers to work in. After five years of work, they believe they have done it.

The solution came when they started looking more closely at the scales of an alligator gar.

Smaller is sometimes better

Through a series of experiments the researchers were able to identify a set of critical mechanisms in the way natural fish scales deform, interact, and fracture. They also developed a new technique to cover large surfaces with a shell of overlapping ceramic tiles. By using computer modeling, they were able to determine the optimal size, shape, arrangement and overlap to make protective gloves which are much more resistant to piercing than those currently in use.

"Fish scales surprised us," says Roberto Martini, a post-doctoral fellow and the lead author on a paper the team recently published about their work. "It may sound counter intuitive, but we discovered that smaller scales are actually more difficult to pierce than the larger ones, something we can now fully explain using engineering analysis. We also learned that they are the toughest collagen-based material known."

Nature solves engineering problems

"Nature has been finding solutions to 'engineering problems' over

millions of years of evolution" adds Barthelat. "For a long time biologists and engineers largely ignored each other, but this is now changing. Biologists are using more and more engineering tools and methods, and engineers are revisiting old engineering problems using bioinspiration. Biologists and engineers are now talking to each other more than ever before, which is very stimulating and makes it is a very exciting time to be working in this field."

More information: Roberto Martini et al. Stretch-and-release fabrication, testing and optimization of a flexible ceramic armor inspired from fish scales, *Bioinspiration & Biomimetics* (2016). DOI: 10.1088/1748-3190/11/6/066001

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