



Bio-inspired Exploration



Revolutionary
Opportunities in
Aerospace

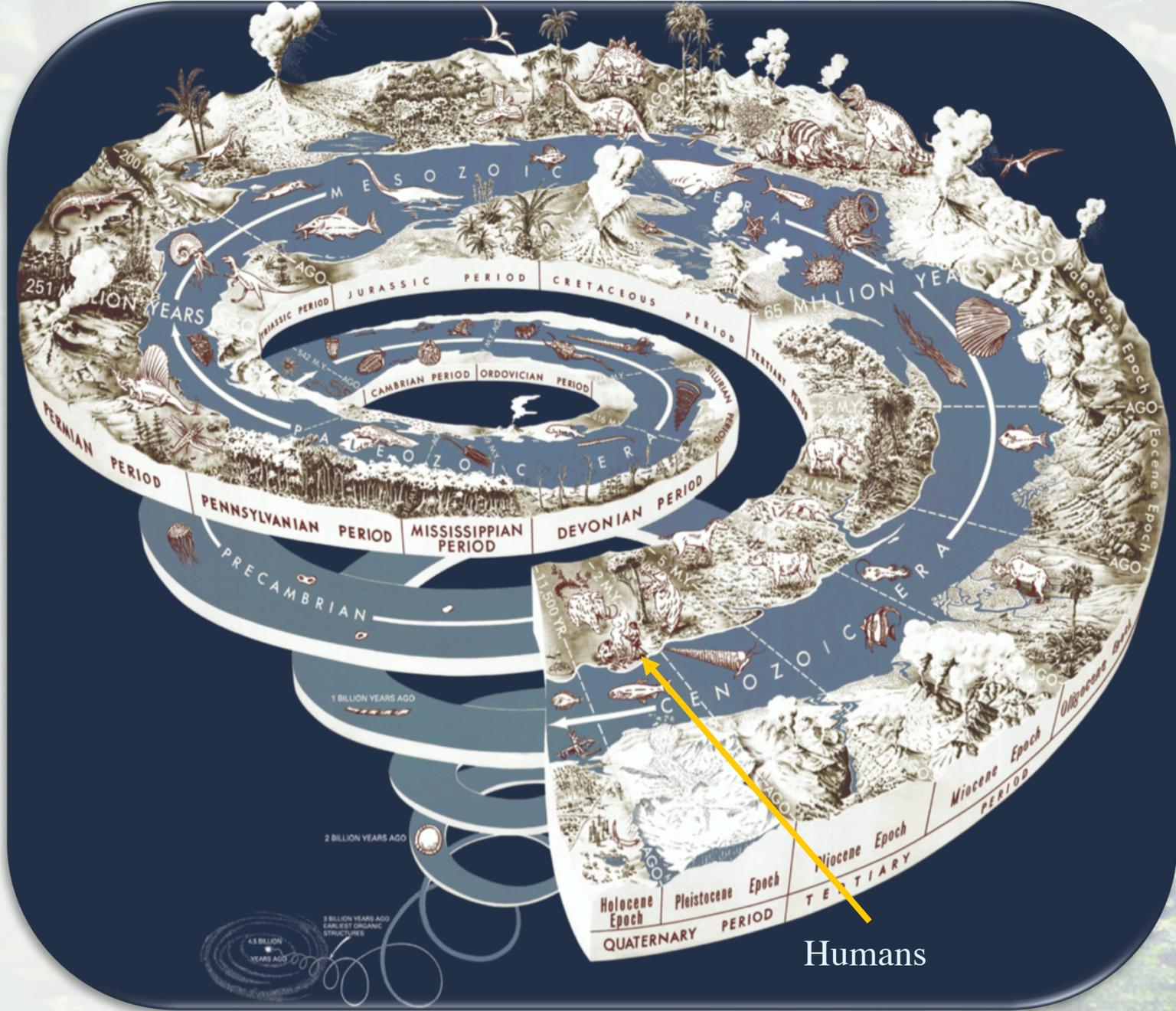
Seeking sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies.

Dr. Vikram Shyam
Dr. Kathleen Tacina
Mr. Jeff DeMange

Glenn Research Center at Lewis
Field

Thanks to...

Dr. Isaiah Blankson
&
Mr. Pat Dunlap



Humans



Synthetic Biology



Hybrid Manufacturing



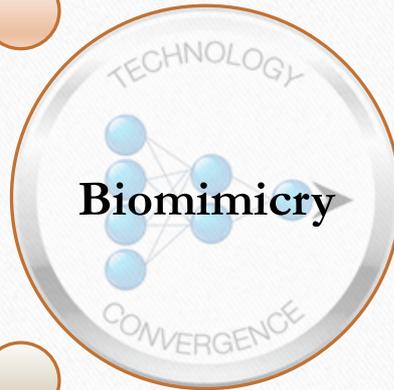
Big Data Analytics



3D Scanning



Art and Design



Technology that's out of this world

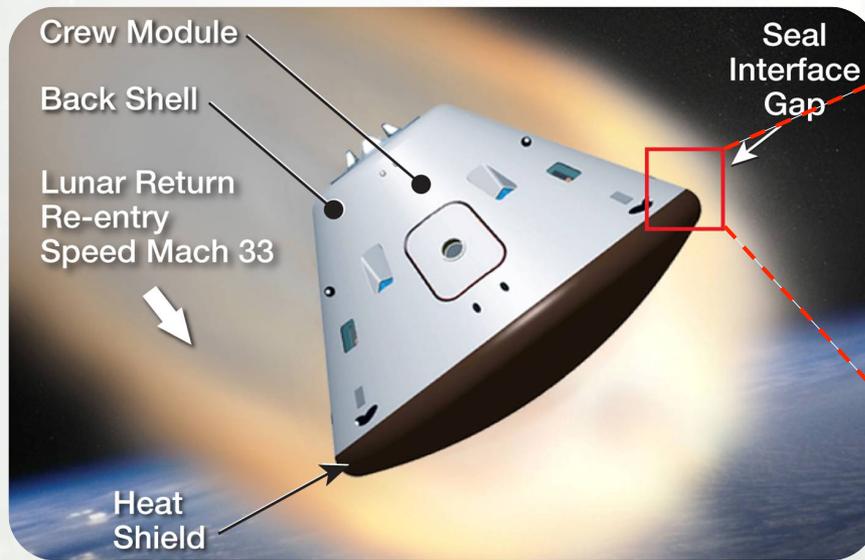


Some examples from GRC

What Are Thermal Seals & Why Do We Need Them?



Space Vehicle Planetary Reentry

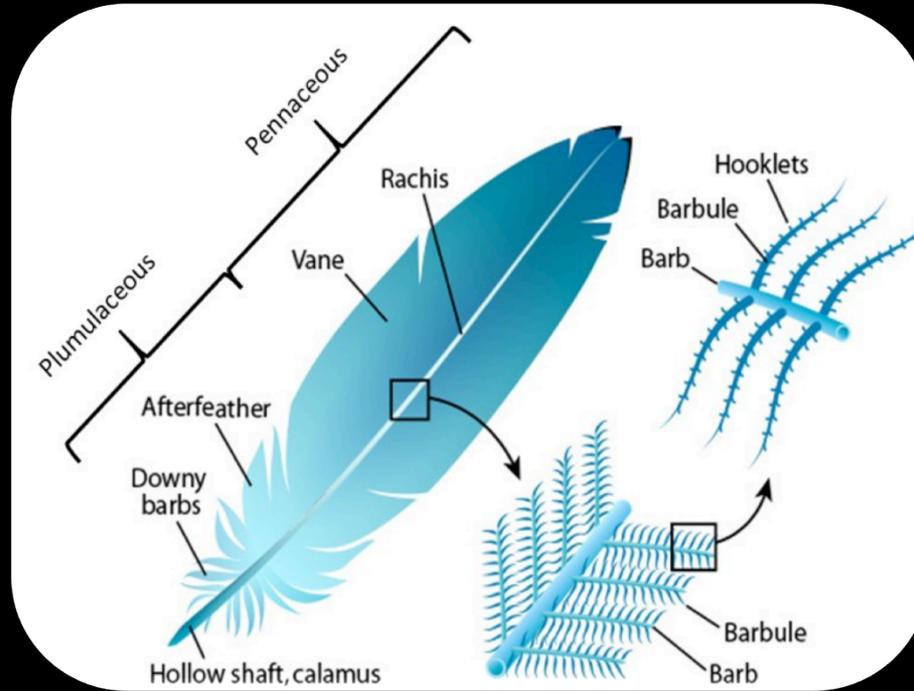


Space Vehicle TPS



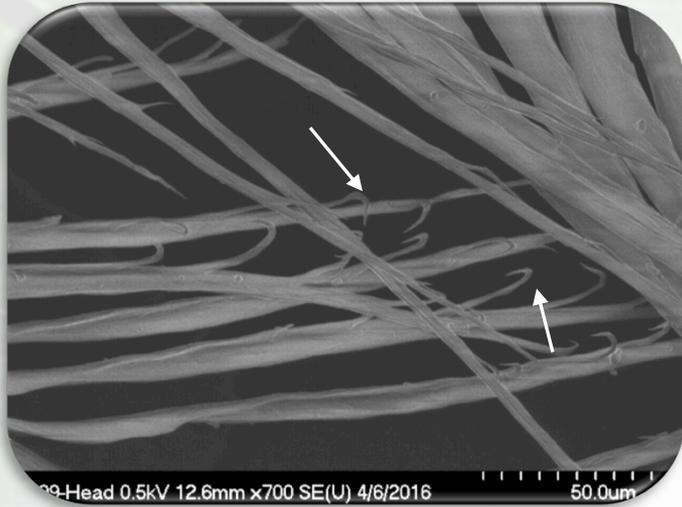
Thermal Seals/Barriers

Lets look to nature...

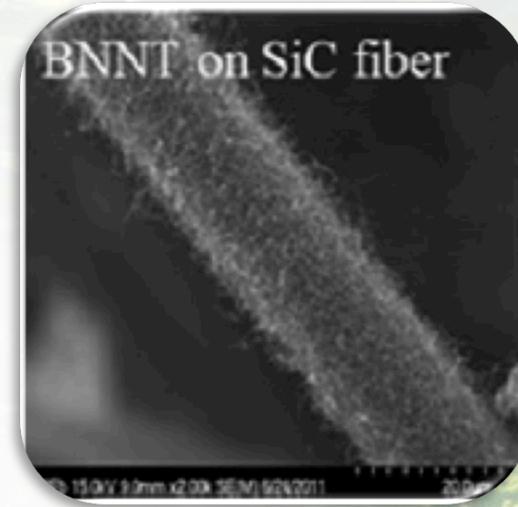


Penguin Feather Morphology

How Are We Trying to Implement This?



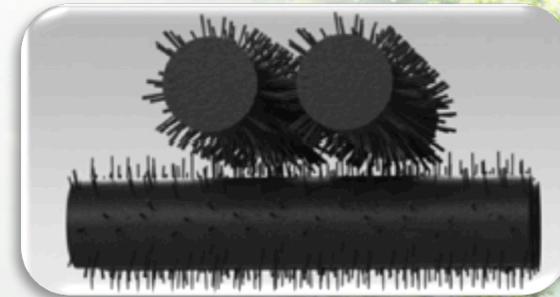
Gentoo Penguin Feather



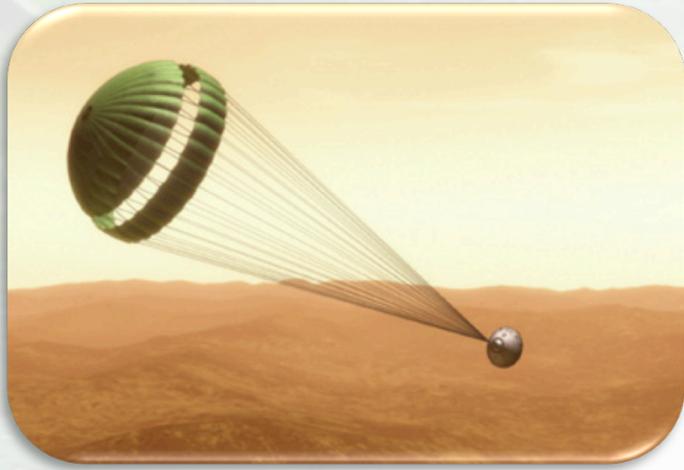
Boron Nitride Nanotube "Fuzzy" Fibers



Ceramic Sheath on Thermal Seal



Other Potential Applications



Parachutes



Air Filters

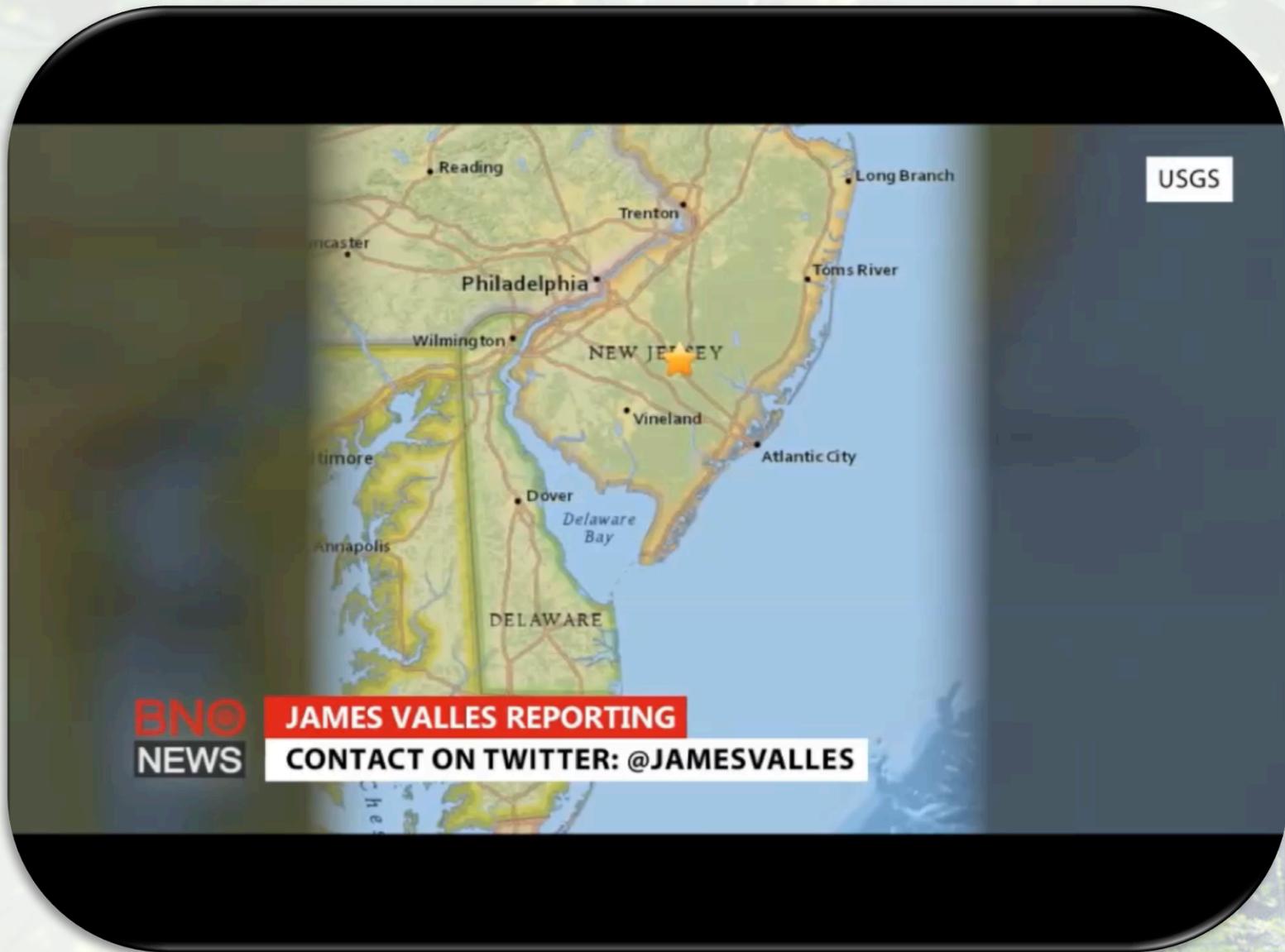


Space Suits

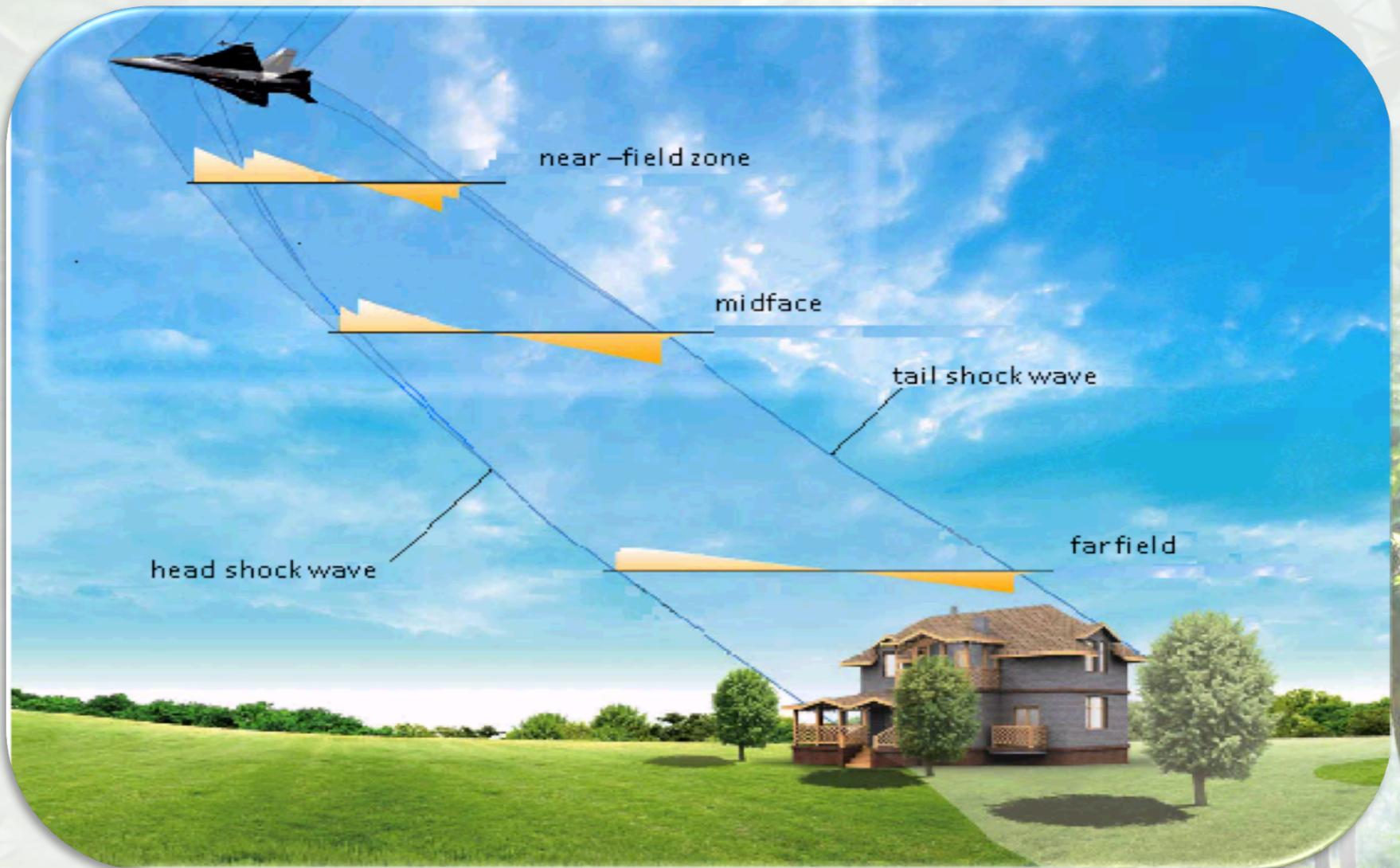


Apparel

The Sonic Boom



The Sonic Boom

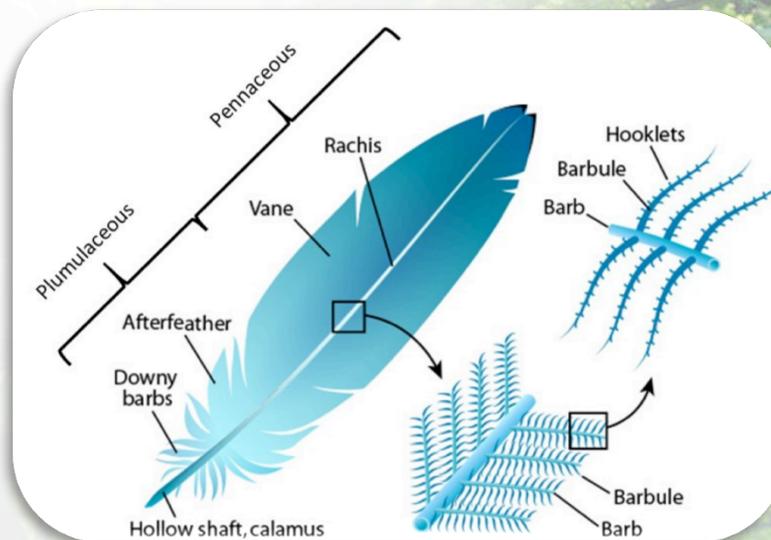


How Might Penguins Help Improve Sonic Boom?

- Interlocking feathers trap air that can be released on demand
 - *Reduces drag by coating penguin in low density air bubbles*
 - *Strategy of modifying fluid environment to reduce drag*
 - *Can also change environment to modify speed of sound $M = u/a$*



Gentoo Penguin



Penguin Feather Morphology



Supersonic now!

Supersonic Private Jet by Aerion



<http://www.apollojets.com/supersonic-private-jet-by-aerion-will-change-aviation-as-we-know-it-executive-jet-charter/>

Spike Aerospace is building a new supersonic private jet



<http://www.breitbart.com/blog/2014/02/19/new-supersonic-jet-tricked-out-with-massive-live-streaming-screens/>



Lockheed Martin conceptual design



HyperMach SonicStar

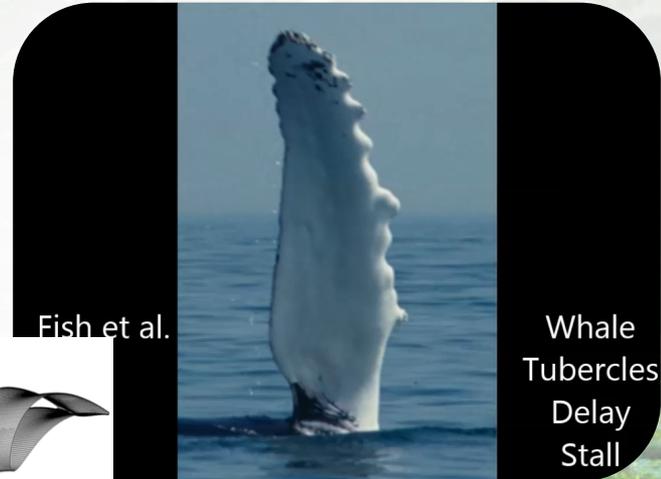
Shark Skin for Aeronautics and Medicine



Credit: wikipedia



Challenge: Create an efficient airfoil with a wide operating range



a. Untreated



b. Sin1R0P5



c. Sin1R1P0



d. Sin2R1P0



a. SW-2 test facility

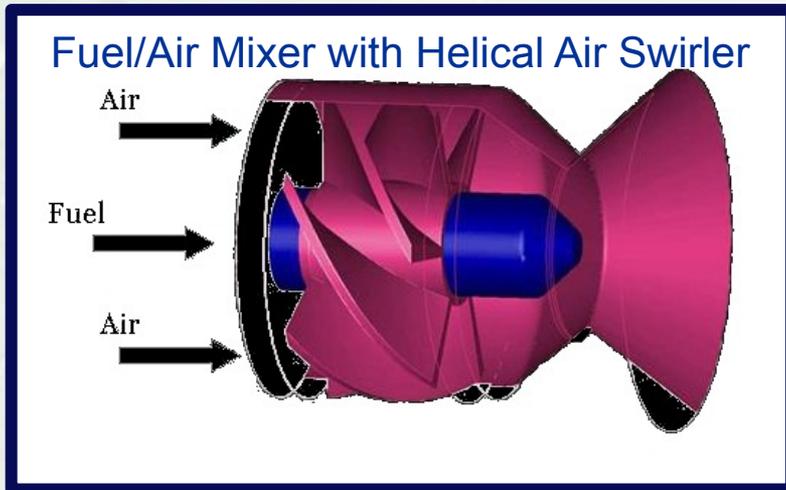


b. Test blades installed in SW-2 wind tunnel



Whiskers - The Seal's Spidey Sense

Biomimicry & Mixing: Enabling cleaner aircraft engine combustion



- Aircraft engine combustors typically use air swirlers to mix the jet fuel with the combustor air
- The helical blade angle used by certain air swirlers is very similar to helices found in nature

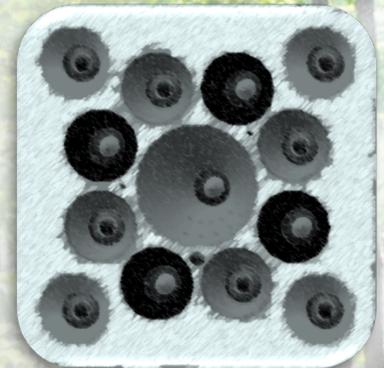


Can Biomimicry be used to improve combustor air swirler designs?

Biomimicry & Combustor Air Swirlers

- Fuel-air mixing is critical to reducing emissions of NO_x (NO_x create smog, destroy the protective ozone layer, and are regulated)
- However, some fuel-air mixing strategies that reduce NO_x also seem to limit the combustor operability and so cannot be used
- Biomimicry may be useful in optimizing air swirler designs
- Nature could also help with answering the next question: how to optimize fuel-air mixer arrays

Although three arrays have similar fuel-air mixers, their flow fields are very different. Finding a similar biological system could be extremely helpful.



Previous application: the PAX Water Mixer

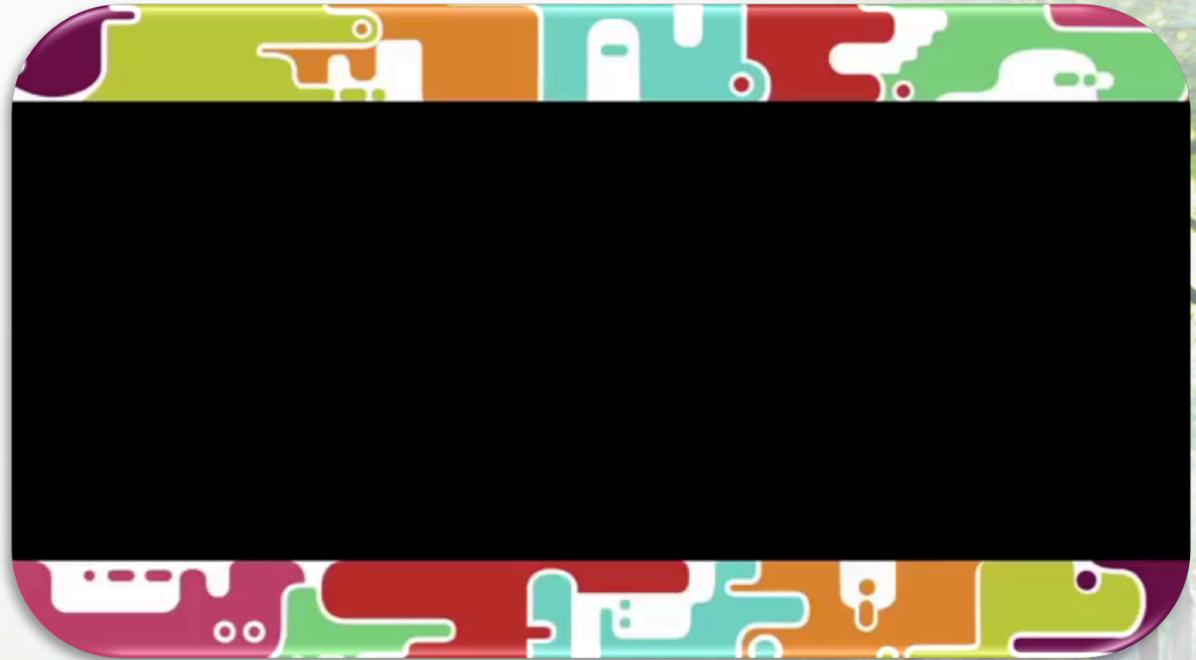
- Inspired by the Calla lily
- Developed by Jay Harman



Calla Lily

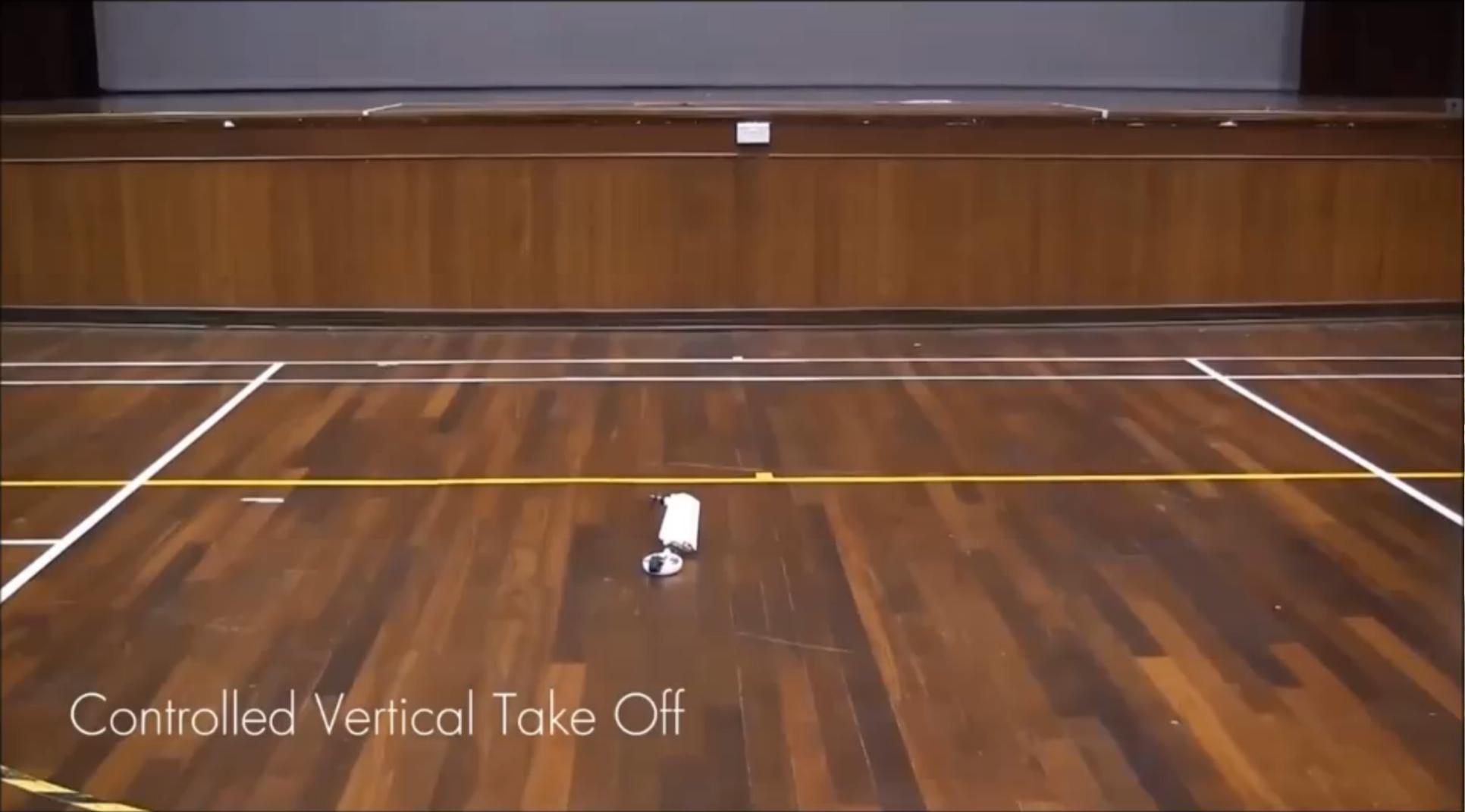


Lily Impeller



[EarthSky](https://www.youtube.com/watch?v=5CXOr4qJp7s) - <https://www.youtube.com/watch?v=5CXOr4qJp7s>

Credit – Mr. Anthony Colozza



Controlled Vertical Take Off

<https://www.youtube.com/watch?v=SJpqp8sWp5I>



NEO Biomimicry Summit

Informed by Nature: NEO Biomimicry Summit and Education Forum

August 2-4, 2016, Cleveland, OH

Join us for a groundbreaking multi-day event including a series of technical talks, panel discussions, and site visits that highlight new approaches to developing enabling technologies for aerospace applications. Speakers will include experts, innovators, and disruptive thinkers from academia, industry and government.

Topics include, but are not limited to:

- Materials Processing and Structures Inspired by Nature
- Human Survivability and Persistence of Life in Hostile Environments
- Guidance & Navigation, Communications and Swarm Dynamics
- Novel Propulsion and Sustainable Energy Conversion Concepts
- Biomimetic Technologies for Surface Mobility and Operations

Please submit a one-page abstract (~ 500 words) by April 1, 2016 via email to: Al Hepp (aloysius.f.hepp@nasa.gov) or Peter [Niewiarowski](mailto:phn@uakron.edu) (phn@uakron.edu). We will capture the content from the meeting as [ppt's](#) and/or [pdf's](#) posted on a publicly-available website.

The organizing committee includes: Al Hepp, Vik Shyam, and Anita Alexander (NASA GRC); Peter [Niewiarowski](#) (U Akron); Howard Thompson (OAI); Trisha Brown ([GLBio](#))



NASA GRC Partners in Biomimicry





<https://www.grc.nasa.gov/vibe>

Contact

Vikram Shyam – Vikram.shyam-1@nasa.gov

Biomimicry Lead