



Mantis Shrimp and Metamaterials

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Why in News?

A new study has revealed that the **mantis shrimp's hammer-like limb delivers powerful blows and also** uses a **natural recoil-dampening system**, challenging previous beliefs about [metamaterials](#) and energy control.

- This work not only highlights the evolutionary genius of the mantis shrimp, but also opens new frontiers in **material science** and [bioengineering](#).

What are the Key Research Findings on Mantis Shrimps?

- Researchers found that the **mantis shrimp's striking appendage acts as a natural phononic metamaterial** (materials that block or control mechanical waves like sound or vibrations).
 - The club structure provides dual mechanical advantages—it both withstands force and controls energy propagation.
- Its hierarchical structure includes:
 - **A hydroxyapatite surface** (a hard mineral also found in human bones and teeth) that disperses impact
 - **Spring-like tendons** (elastic structures that help absorb shock)
 - **Biopolymer fibers arranged in a periodic pattern** (repeating natural fibers that reduce impact damage from repeated strikes)
- The study confirms that nature has evolved metamaterials, changing how scientists understand biological material design.

What are Mantis Shrimps?

- **About:**
 - Mantis shrimp are **ancient marine crustaceans** belonging to the order **Stomatopoda**, closely related to crabs and lobsters.
 - With over 450 known species, they range in size from 10 cm to nearly 46 cm.
 - Despite their name, **they are not true shrimp but are distinguished by their vibrant colors**, complex behavior, and powerful hunting appendages.
- **Habitat:**
 - Mantis shrimp inhabit warm, **shallow tropical and subtropical waters, particularly in the Indian and Pacific Oceans**.
 - They live in self-dug burrows within **seabeds**—smashers in harder substrates and spearers in soft ones—near coral reefs.
- **Hunting Mechanisms:** Mantis shrimp are categorized into two main types based on their hunting adaptations:
 - **Spearers:** Possess spiny, barbed forelimbs used to impale soft-bodied prey like fish, squid, and worms.
 - **Smashers:** Have heavily calcified, club-like appendages capable of delivering one of the

fastest strikes in the animal kingdom, used to break open hard-shelled prey like snails, crabs, and clams.

- **Ecological and Scientific Significance:** Their club mechanism has **inspired biomimicry in armor and aerospace engineering**
 - Eye structure is influencing **optical sensor and cancer detection technology**
 - They help **control prey populations in reef ecosystems** and contribute to nutrient cycling.
 - Researchers are also **investigating methods to convert trapped mechanical energy into other usable forms**, potentially leading to energy-harvesting applications.



What are Metamaterials?

- **About:** Metamaterials are **artificially engineered materials** designed to exhibit properties not found in nature.
 - Their unique behaviour arises from their internal structure and arrangement, not from the base materials they're made of.
- **Key Properties:**
 - They often display unusual **electromagnetic properties**, such as a **negative refractive index**.
 - This makes them valuable in fields like **optics**, **telecommunications**, and **electromagnetism**.
 - Their behaviour is comparable to materials like **graphite**, **diamond**, and **graphene**—which all consist of carbon but differ drastically due to structural arrangement.