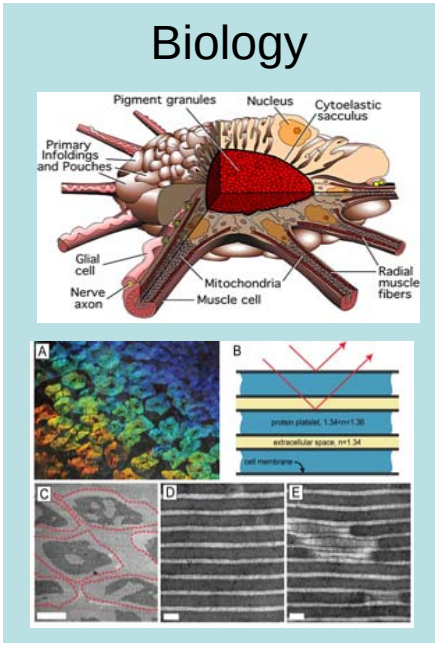
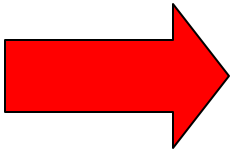
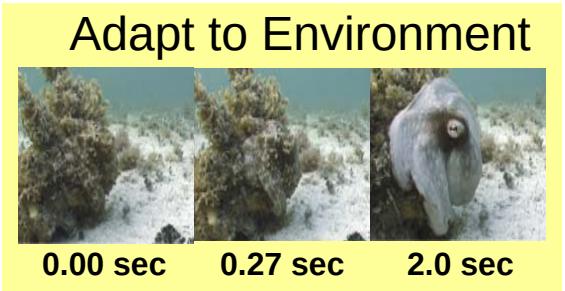
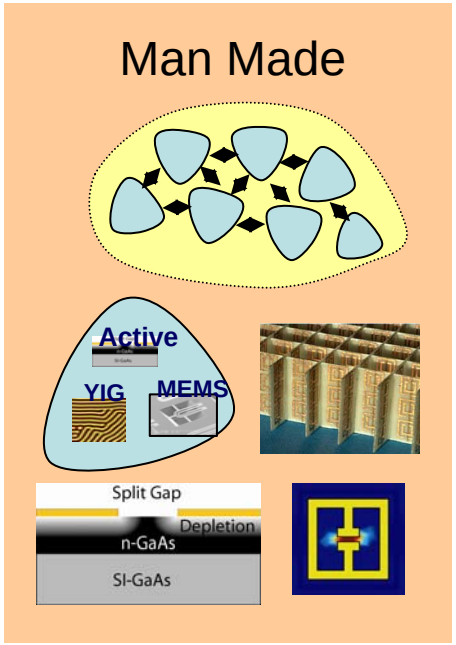
Biologically Inspired Intelligent Metamaterials









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Notional Concepts

- The following charts are ONLY intended to articulate notional ideas for biological inspired intelligent metamterials.

- Offerors are not limited to these notional concepts and should consider ideas and approaches as well.

To survive, biological systems must:

- sense and hide in clutter
- adapt in dynamic environment
- communicate covertly

Mantis Shrimp

Cephalopod

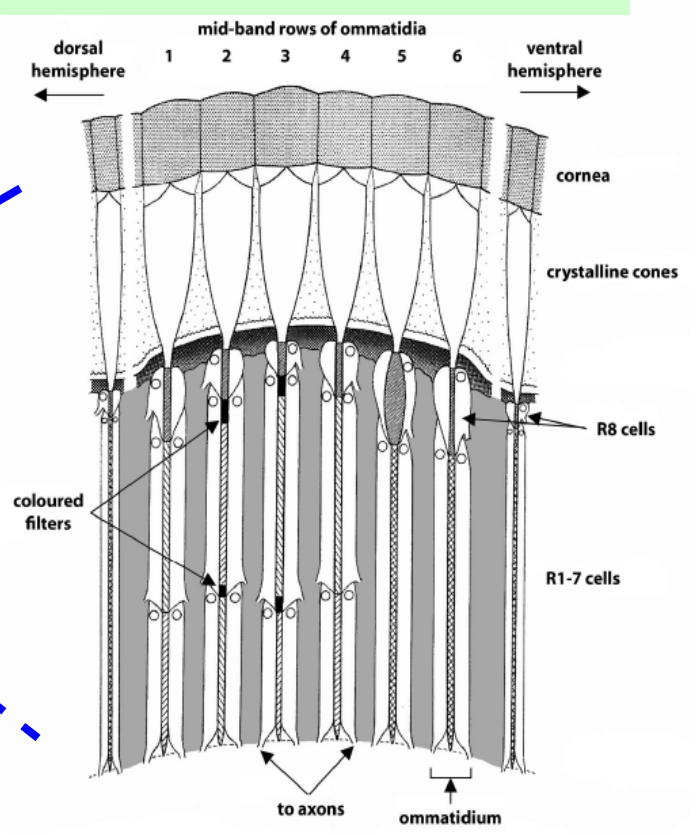
0.00 sec **0.27 sec** **2.0 sec**

Insight: Does biology teach us a more elegant method of manipulating EM Fields to adapt to the environment

Mantis Shrimp "Communicate Covertly"

Mantis Shrimp eye:

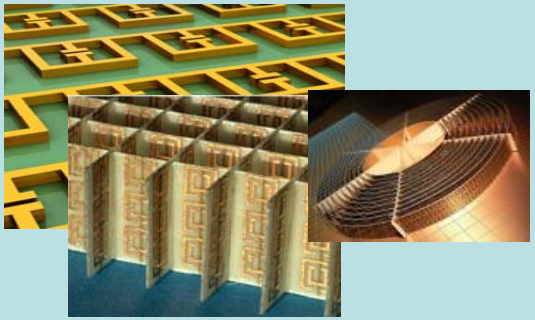
One of the most complicated, capable EM sensing organ in nature



Basic Research Challenge Goal

Metamaterials (Prior Art)

- Artificial engineered composites
- manipulate electromagnetic fields
- Fundamental limitations include limited bandwidth, high losses, lack of arbitrary polarization.



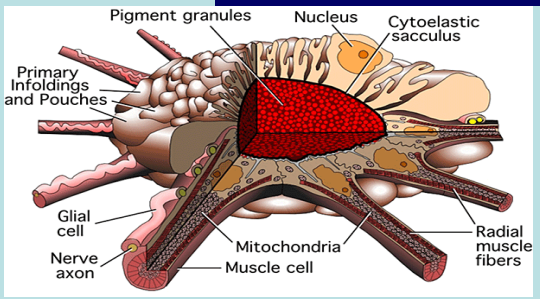
Intelligent Metamaterials (Novel – This BRC)

- Dynamic, sense and adaptive properties
- ***React*** to the electromagnetic environment

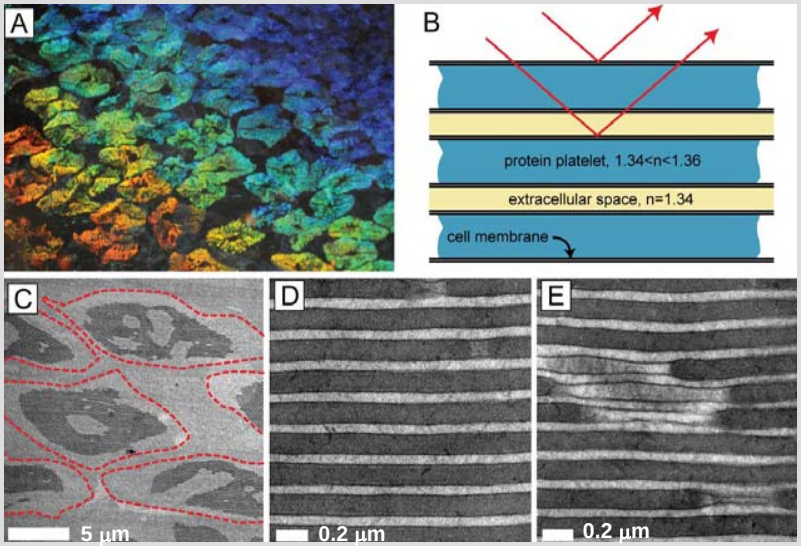
To explore concepts for *intelligent metamaterials* (IMM), inspired by examples in the marine environment, capable of sensing and reacting to a dynamic EM environment.

Biological Inspiration for Design of Intelligent Metamaterials

Biological Models



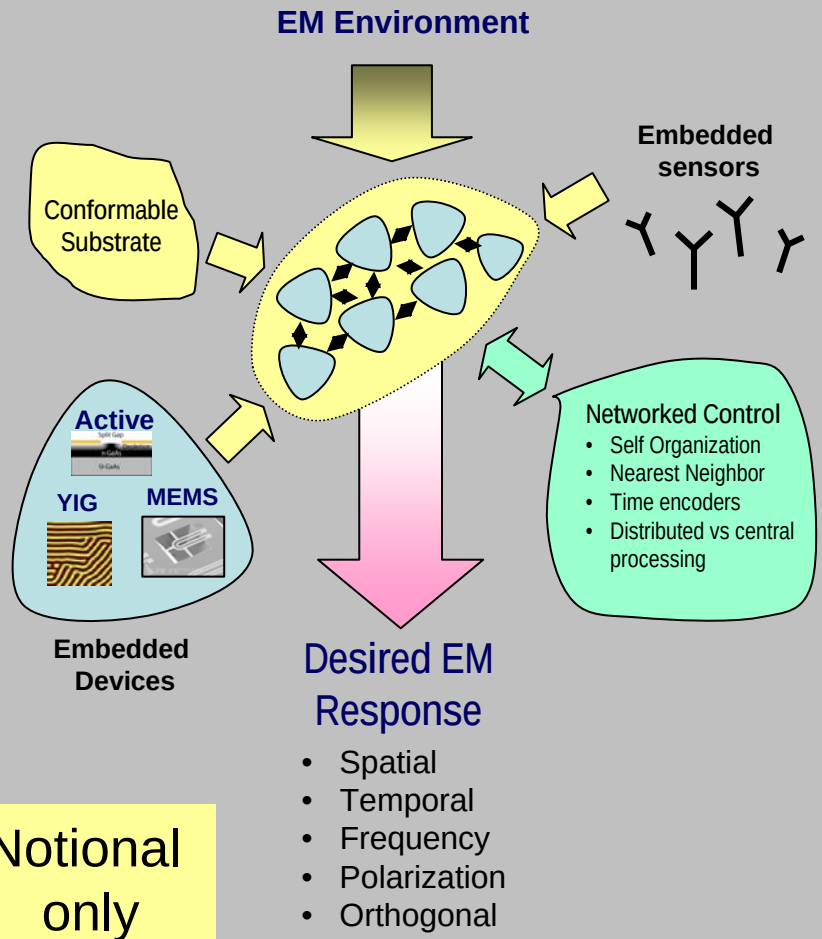
The cephalopod chromatophore has a central dye sack that can be expanded or contracted by radial mussels, creating more or less color.



A) Darkfield microscope image of iridophore cells; B) Illustration of intercellular Bragg reflector; C - E) TEM images of ultrathin cross-sections of iridophore cells.

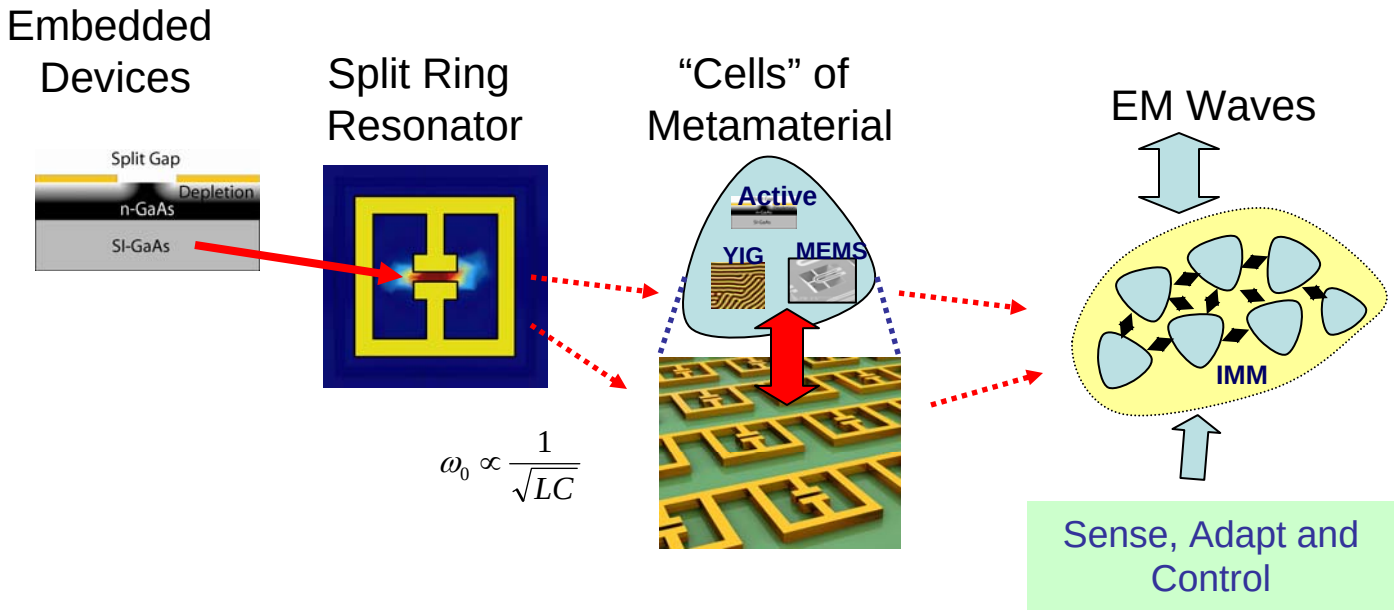
?

Intelligent Metamaterial (IMM)



Notional Idea:

Embedding Active Metamaterials

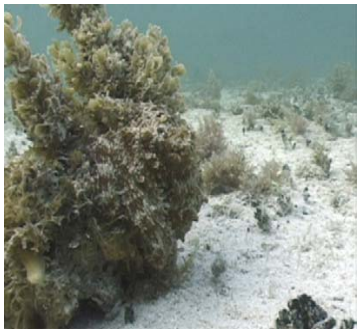


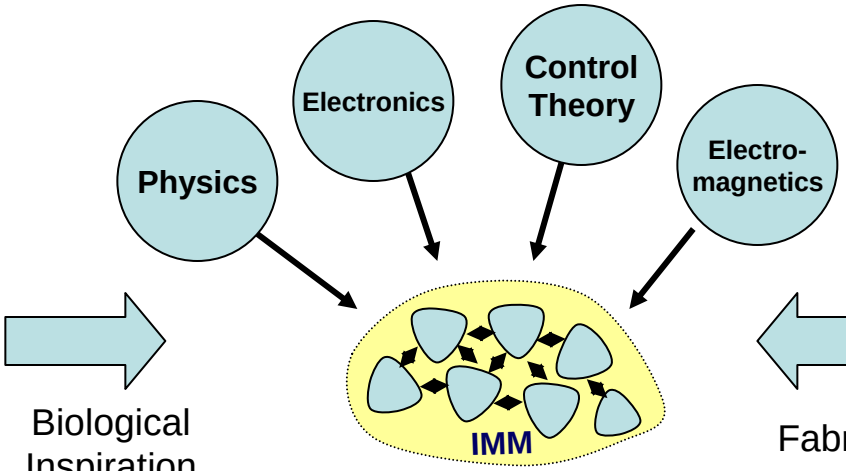
What if we added Sense, Adapt and Control?

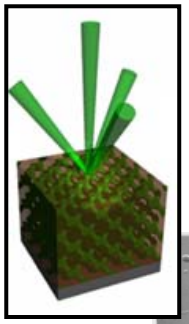
- Intelligent control knobs? Networked control?
- New multi-dimensional signal processing techniques?
- Tunability? Gain? Encoders? Decoders? Modulators?
- Environmental sensing and response?

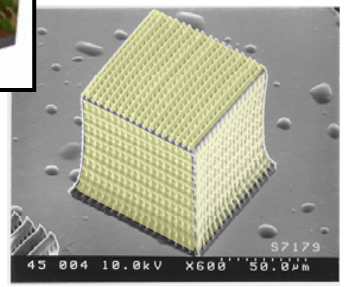
Objectives

- Explore how examples found in nature can lead to intelligent metamaterials (sense, control and adapt to environment)
- Investigate concepts of multidimensional sensing and signal processing
- Understand fundamental sense and control stability issues associated with central vs distributed vs networked concepts
- Determine fundamental strategies for manipulation of the EM response via intelligent metamaterials









Risks and Challenges

- How do the biochemical systems translate into an analogous electronic counterpart?
- What are optimal sensors, control architectures and conditions for stability?
- Are control functions handled via centralized or localized control architecture?
- Is it possible to harvest ambient energy to better function in the environment?

References: (optional)

[1] Cephalopod …

[2] mantis shrimp …