

**Problem
Card**

**Problem
Card**

**Problem
Card**

**Problem
Card**

**Problem
Card**

**Problem
Card**

**Problem
Card**

**Problem
Card**

Need to:

See

Need to:

**Attach/
Stick to**

Need to:

Move

Need to:

Hear

Need to:

**Support/
Hold**

Need to:

**Detect/
Sense**

Need to:

Protect

Need to:

**Change
Shape**

**Situation
Card**

**Situation
Card**

**Situation
Card**

**Situation
Card**

**Situation
Card**

**Situation
Card**

**Situation
Card**

**Situation
Card**

**Where/
When:**

**Under
Water**

**Where/
When:**

**In the
Dark**

**Where/
When:**

On Ice

**Where/
When:**

**Without
Water**

**Where/
When:**

**In Extreme
Heat**

**Where/
When:**

**In a
Forest**

**Where/
When:**

**Under
Ground**

**Where/
When:**

**Inside a
volcano**

**Species
Card**

**Species
Card**

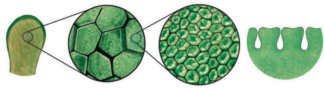
**Species
Card**

**Species
Card**

**Species
Card**

**Species
Card**

TREE FROG



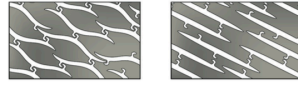
Hierarchical structure increases surface contact



- Tree frogs easily stick to wet surfaces
- Toe pad can increase in surface area to increase attachment strength
- Releases mucus to increase friction on surface

- Stick to slick surfaces • Attach temporarily •
- Increase surface area •

SEA CUCUMBER



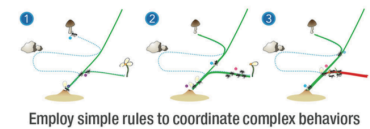
Fibers interlock to increase stiffness temporarily



- Protect selves from predators by adjusting body pressure to make skin rigid (hard)
- Collagen fiber "arms" (on skin) reversibly connect to make skin rigid

- Create temporary flexibility •
- Modify stiffness • Manage compression •

ANTS



Employ simple rules to coordinate complex behaviors



- Release different chemical signals when searching for food, after finding food, and to show that trail was a failure to communicate with others
- Lift 20x times own weight

- Lift large mass • Self-organize work team
- Breath through skin • Leave trail signs

PINE CONE



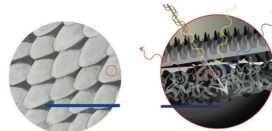
Varying response of layered materials controls shape



- Scales made of 2 layers of same material that is organized in different directions on each layer
- Different layers expand/shrink to bend differently in response to moisture to protect seed

- Change shape •
- Respond to environment •

SCARAB BEETLE



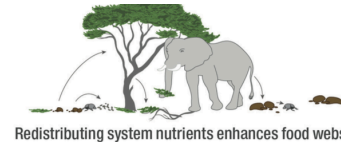
Randomized surface structures scatter all visible light



- Camouflage to match fungi near its home
- Thin, loose scales on body causes all wavelengths of visible light to reflect and spread in scale to make beetle appear white

- Create brilliant white •
- Send visible signals • Scatter light •

ELEPHANT TRUNK



Redistributing system nutrients enhances food webs



- 100,000 muscles for strength and movability
- Layered structure for stretching
- Can suck up/hold water
- Fingers on tip for fine-motor pinching
- Senses scent and vibrations

- Multifunctional apparatus • Change shape •
- Breath through skin • Leave trail signs

**Species
Card**

**Species
Card**

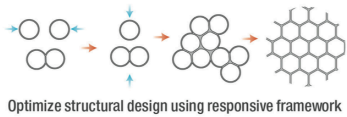
**Species
Card**

**Species
Card**

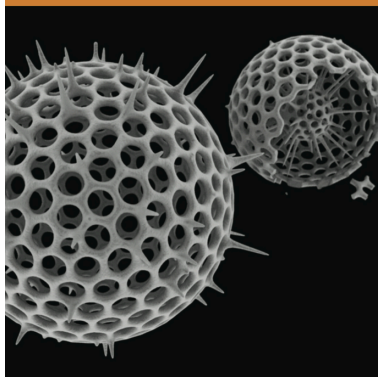
**Species
Card**

**Species
Card**

RADIOLARIAN

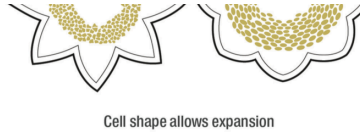


- Single-celled marine species with glass skeleton
- Measure force of bubbles on surface to auto-release materials to improve/repair shape
- Basic skeleton preserves resources



- Self-assemble • Build to shape •
- Optimize distribution of forces •

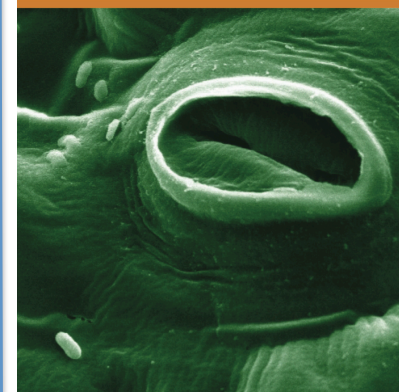
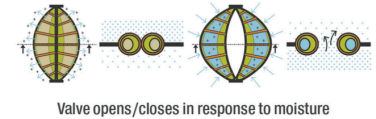
BARREL CACTUS



- Store lots of water in tissue to survive drought
- Cells in surface have folds to allow for stretching to hold water
- Water storage cells release water only when needed

- Maintain structural integrity •
- Collapse • Expand • Store water •

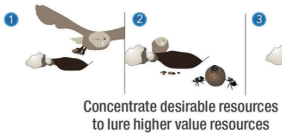
LEAF STOMATA



- Leaf cools by releasing water vapor through stomata
- Cells on surface absorb or lose water to adjust size of hole to control amount of water released

- Respond to cues •
- Change shape • Regulate flow •

BURROWING OWL



- Lure prey for easy meal
- Produces sounds similar to rattle snakes to scare predators
- Eyes have more light-sensitive rods for seeing in the dark and a mirror at back of eye for concentrating light
- Skeletal structure allows neck to turn 270 degrees

- Attracts resources • Flexible shape •
- Optimize eye structure

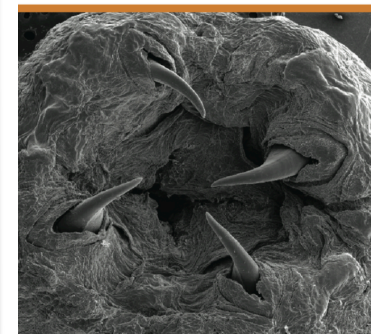
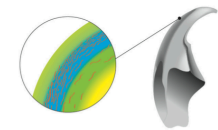
DOCK BUG WINGS



- Two sets of wings that reversibly lock together during flight
- Multiple wing pieces allows for flexibility to aid flight and for storage of wings in smaller spaces

- Maintain structural integrity •
- Temporarily attach • Provide flexibility •

BLOODWORM



- Flexible jaw with hard tips for piercing prey and resisting abrasion from environment
- Uses differences in copper concentration in body to adjust stiffness

- Manage mechanical wear •
- Maintain integrity • Be hard yet flexible •