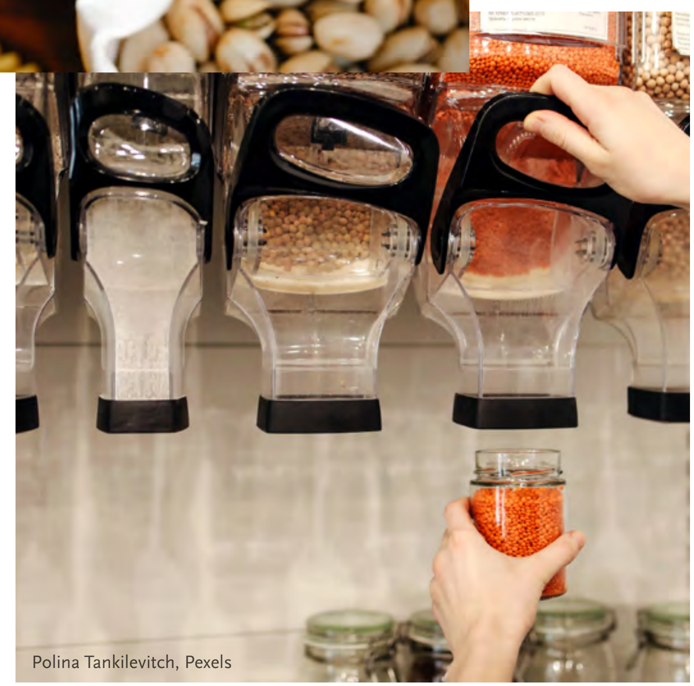
INDIVIDUAL PROJECT:

Waste-Free Food Distribution



Paula Welling / MASD Biomimetic Design / Spring 2023

Abstract

THE PROBLEM: FOOD PACKAGING WASTE

According to the EPA, packaging accounts for 23% of landfilled material in the United States. While that figure represents all forms of packaging, trends in the U.S. food system point to an increase in food packaging. Americans' consumption of ultra-processed foods is on the rise—and ultra-processed food is always packaged. Centralized food production increases food miles, which increases the need to package food to protect it during transit.

Food packaging waste creates many negative effects: overwhelmed recycling systems, health and ecosystem impacts from landfilling and incineration, microplastics and plastic pollution, and continued reliance on fossil fuels for plastic production.

(PART OF) THE SOLUTION: ZERO WASTE FOOD DISTRIBUTION

Innovations in materials (e.g. mushroom- or seaweed-based packaging) will likely be an important piece of solving our food packaging problem—but we also need to eliminate as much packaging as we can from our food system.

"Zero waste" or bulk grocery stores mainly focus on the consumer side of that equation—waste is eliminated from the shopping experience because customers fill their own reusable containers in the store. These stores are a huge step forward, but products are still packaged when shipped between producers, distributors, and retailers.

This design integrates reusable, refillable shipping containers into the supply chain to eliminate packaging from producers for a truly zero (packaging) waste system. To be effective, the system needs to include efficient, durable containers *and* create a streamlined distribution system.

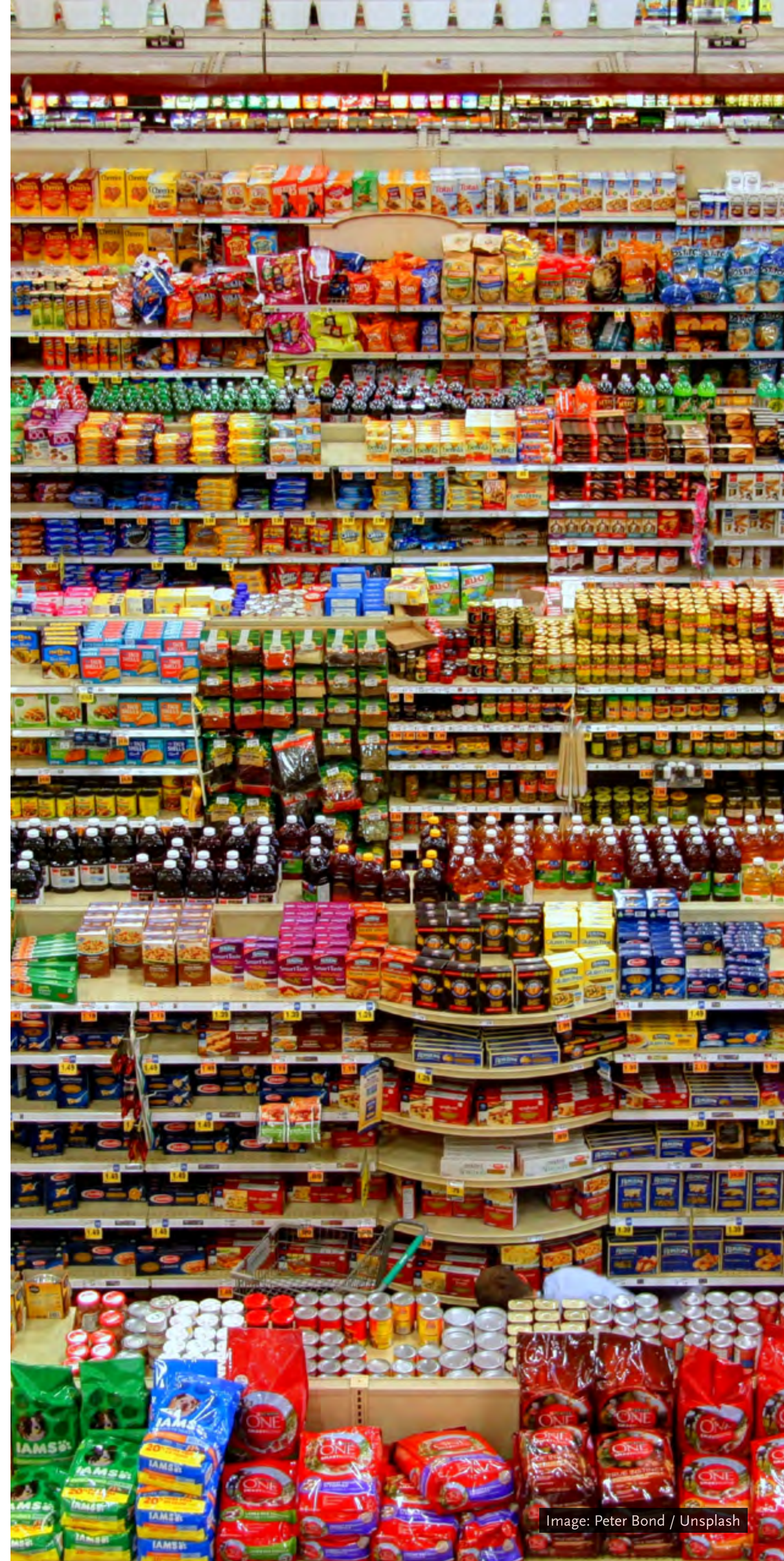
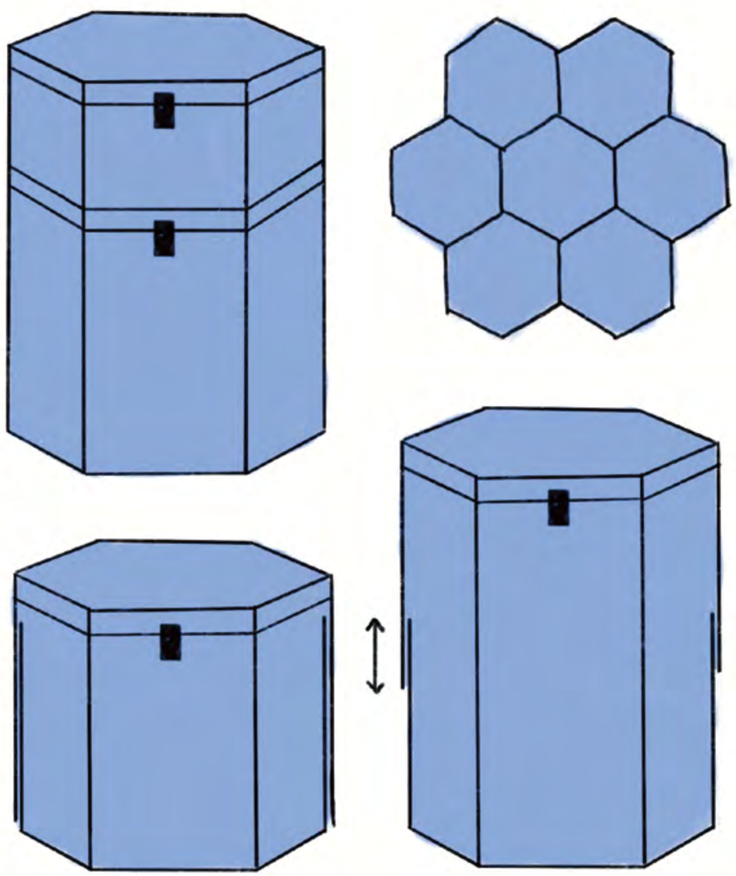
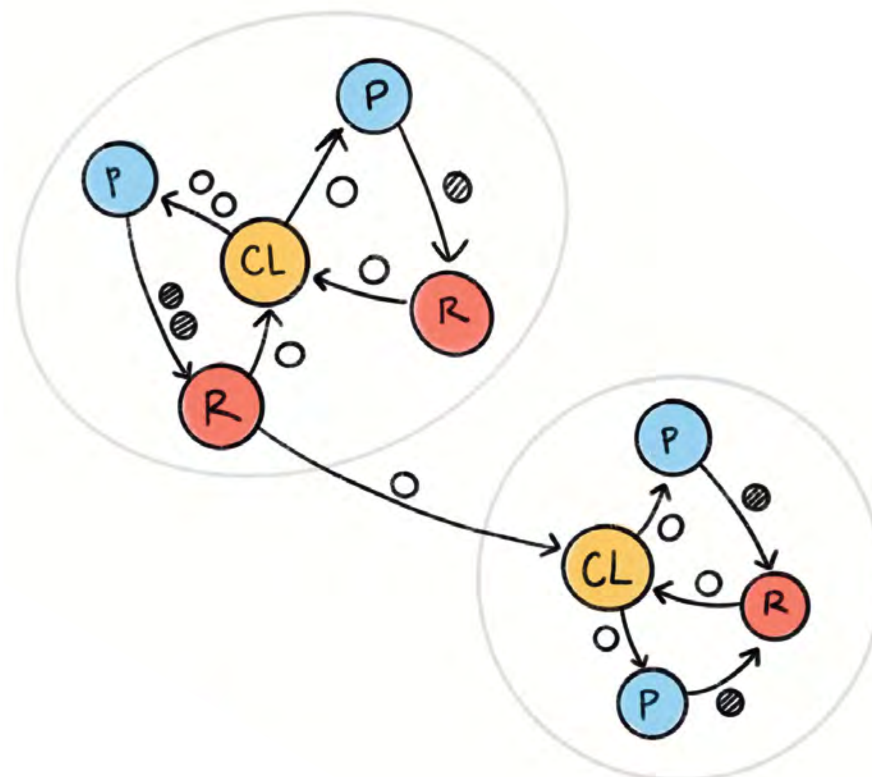


Image: Peter Bond / Unsplash

DESIGN CONCEPT





Efficient, Expandable, Stackable
Reusable Shipping Containers

+

Decentralized, Local/Regional
Distribution System

Lap 1

Identify + Translate

In this step, I identified what I want the design to do (its purpose) and the functions it should perform. I then translated the functions into biological terms.

The items in **bold** were explored in this lap.

Purpose	Functions	Translation
• **Contain/store food** • Keep food dry/fresh • Distribute food from producer to retailer • Reuse all packaging materials efficiently • Enable coordination/cooperation between producers and retailers	• Protect from excess liquids • Protect from dirt/contamination • Manage structural forces (impact, tension) • Prevent structural failure (fracture/rupture) • Coordinate activities/systems • Send signals • Process/sense signals • Distribute solids • Store solids • Physically assemble (structure) • **Optimize space/materials** • Attach temporarily (to form a seal)	• How do milkweed seeds, pine cones, and paper wasps protect from excess liquids? • How does nature protect from dirt/contamination? • How does nature manage impact and tension? • How does nature prevent structural failure (fracture/rupture)? • How do ant colonies, starlings, and honeybees coordinate activities? • How do ant colonies and flowers send signals? • How do ant colonies and pollinators process/sense signals? • How do hermit crabs distribute shells? • How does nature store solids? • How does bamboo create structure? • **How do honeybees and wasps optimize space and materials?** • How does nature form temporary seals?

DESIGN SPIRAL LAP 1

Discover

FUNCTION:

How does nature optimize space and materials?

ORGANISM 1:

Chambered Nautilus

(Nautilus pompilius)

Unlike other shelled animals, chambered nautiluses do not abandon their shells as they grow—instead, they adapt them by adding additional chambers. This allows the nautiluses to reuse their existing shells throughout their entire (20+ year) lifespan.

ORGANISM 2:

Honeybees

(Apis spp.)

Honeybees need to use wax efficiently, because it requires a lot of energy to create and is therefore a precious resource. Compared to other shapes, hexagons enclose the most volume with the least perimeter.

Photo by Klaus Stiefel on Flickr

Photo by Meggyn Pomerleau on Unsplash

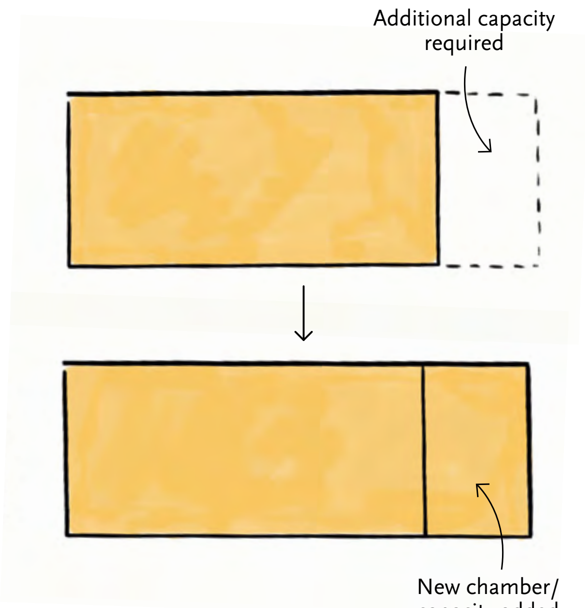
DESIGN SPIRAL LAP 1

Abstract

Function:
Optimize space and materials

Organism: Chambered Nautilus
(Nautilus pompilius)

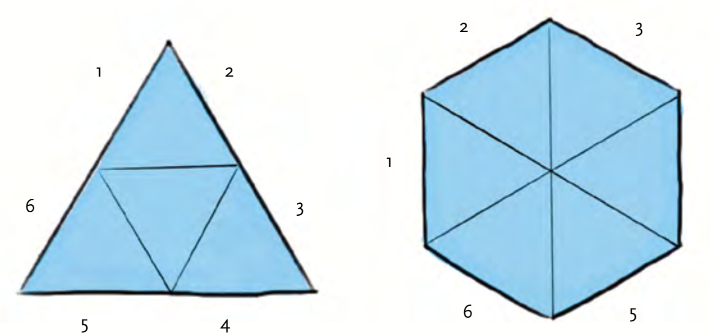
When more storage space is required, an adaptable container can be expanded to meet the need rather than discarded. This expansion can be in the form of a chamber added to the original container. Or, the container design could allow for expansion.



Function:
Optimize space and materials

Organism: Honeybees *(Apis spp.)*

Compared to other shapes, hexagons enclose the most volume using the least perimeter. This means that a hexagonal container design uses valuable materials efficiently. A hexagonal container would also most likely weigh less compared to a similar container of a different shape and would stack efficiently with other hexagonal containers.



Area: 4 triangles
Perimeter: 6 units

Area: 6 triangles
Perimeter: 6 units

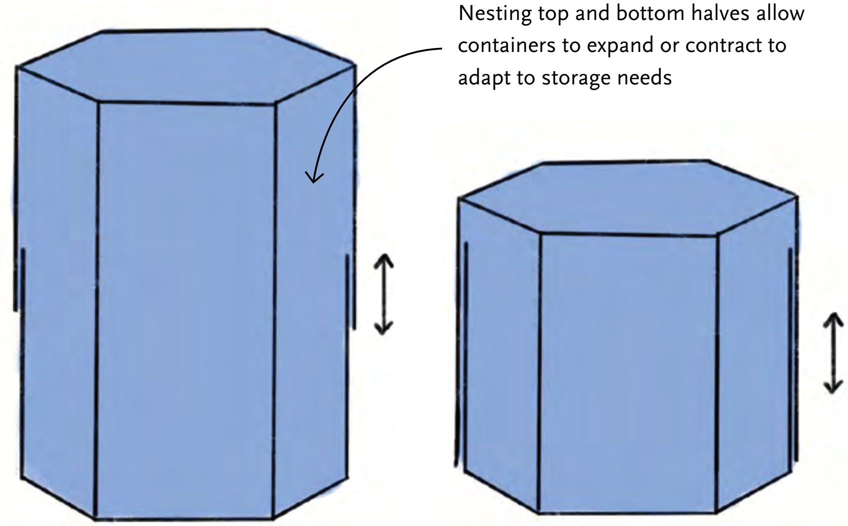
Emulate

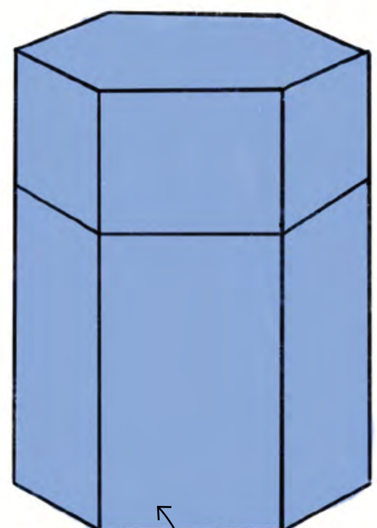
Efficient, Expandable, Stackable Reusable Shipping Containers

Inspired by Honeybees and Chambered Nautiluses, expandable hexagonal containers use materials efficiently, meaning they can contain more food with fewer inputs.

Containers Adapt to Storage Needs
Nesting tops and bottoms allow the containers to expand or contract based on the need. This allows one container to be used for a wide range of volumes—for example, a small shipment of walnuts and then a large shipment of beans. This adaptability also maximizes shipping efficiency by eliminating empty space in containers

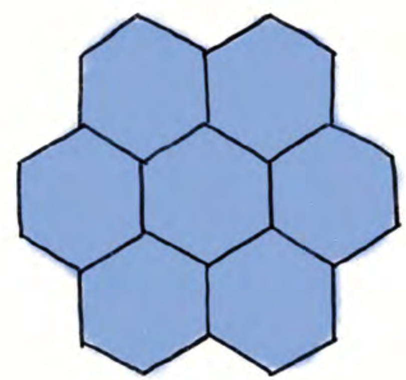
Common Base Perimeter Allows Efficient Stacking
While containers can vary in vertical dimensions, the base size is always the same. This means that the containers can stack efficiently, like cells in honeycomb. This creates efficiency for packing large shipments of multiple containers.





TOP VIEW

Interlocking containers, all with the same base size



Evaluate

DOES THE DESIGN ADAPT AND EVOLVE?

Is the design locally attuned and responsive?

☑ **Is the design resourceful?**
Expandable containers can be used for a range of product volumes.

☑ **Does it leverage feedback loops?**
The expandable design adapts to the current storage needs.

⊟ **Are materials locally available and abundant?**
Containers made from recycled plastic would take advantage of an abundant resource, though plastic poses other challenges and hopefully will be phased out of intensive production.

Does the design integrate cyclic processes?

⊟ **Are processes cyclical?**
The containers use recycled plastic, but it most likely isn't possible to recycle the material again.

☑ **Does it integrate local feedback loops?**
The expandable design adapts to the current storage needs.

Is the design resilient?

⊟ **Can it withstand disturbance while maintaining function?**
The recycled plastic containers would protect against water damage and withstand changes in temperature, moisture and physical stress (dropping, etc.). The seal design needs to be considered to ensure the containers are air- and water-tight.

☐ **Does it heal after disturbance?**
No, the containers cannot heal and most likely could not be repaired (e.g. after cracking).

☐ **Are there opportunities for cross-pollination and mutation?**
No, the containers are a relatively static component of the larger distribution system.

☑ **Achieved**

⊟ **Partially Achieved**

☐ **Not Achieved**

DESIGN SPIRAL LAP 1

Evaluate

DOES THE DESIGN CREATE CONDITIONS CONDUCIVE TO LIFE?

Does the design optimize rather than maximize?

☑ **Does it integrate multiple functions?**
The containers can be used for transport as well as storage of bulk foods at retailers (i.e. in the back of the store to hold food for restocking displays).

⊟ **Does it recycle all materials? Is it recyclable?**
The containers are made from recycled plastic, which at least diverts plastic from landfills and incinerators. But it would most likely not be possible to effectively recycle the plastic again, so the containers would create waste at end of life.

☑ **Does it perform functions with minimal material and energy?**
The hexagonal design encloses the most volume with the least perimeter compared to other shapes. It could also create efficiency in shipping. The reusable containers also keep the materials in use for much longer than disposable options.

Does the design use benign manufacturing?

☐ **Does it use life-friendly materials?**
Plastic is petroleum-based, contains chemicals that are not life-friendly, and can't be returned to nature's cycles.

☐ **Is chemistry done in water?**
Plastic is created by refining fossil fuels into petroleum products.

☐ **Are processes done at ambient (local) pressures and temperatures?**
The process of refining fossil fuels requires high temperatures and pressures.

Does the design leverage its interdependence in the system?

⊟ **Does it foster symbiotic, cooperative, community-based relationships?**
Depending on the distribution system, the containers could foster could help foster collaboration between retailers and local/regional food producers.

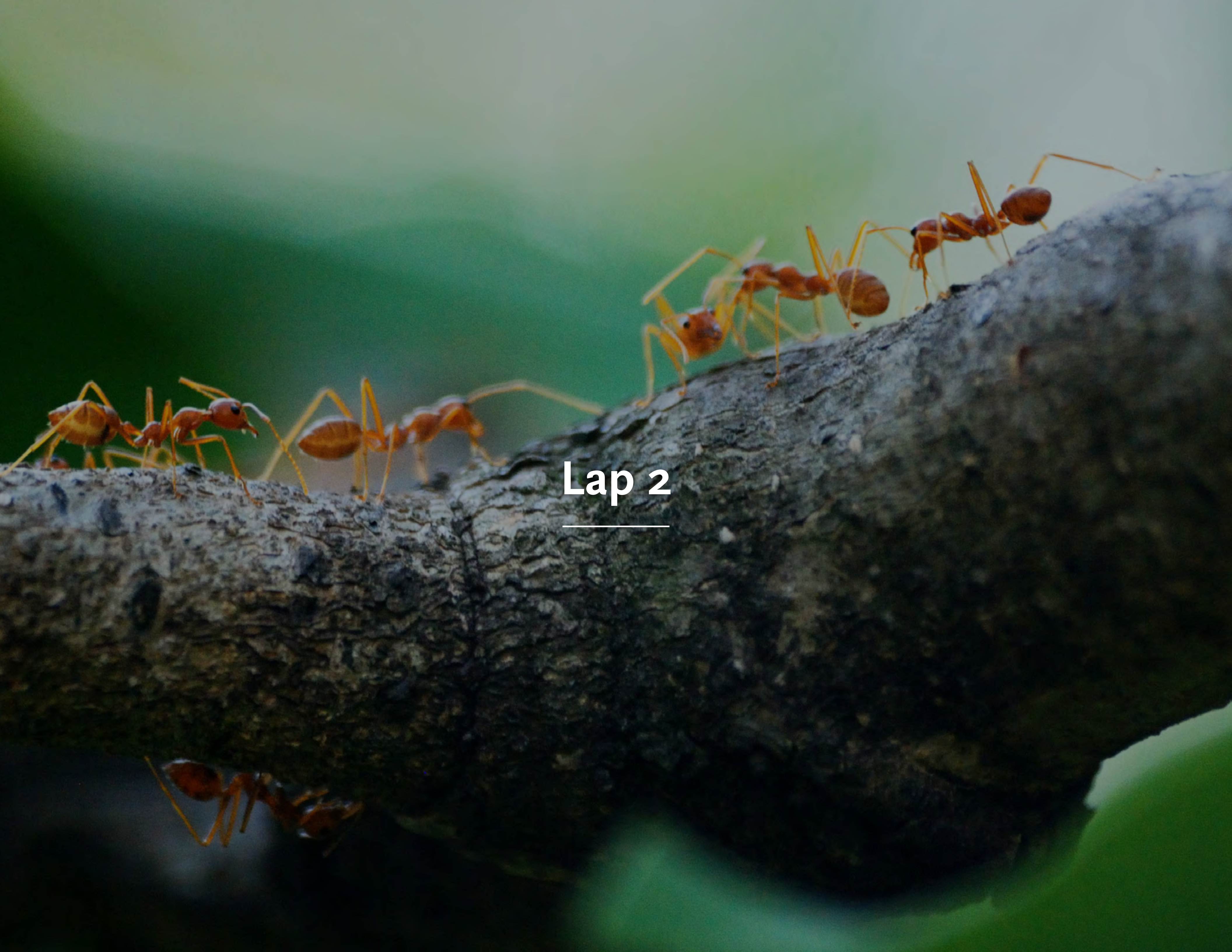
☐ **Does it foster emergent relationships?**
No, the design is not self-organizing or part of a self-organizing system.

Life's Principles Achieved	**5 / 16**
Partially Achieved	**5 / 16**

☑ **Achieved**

⊟ **Partially Achieved**

☐ **Not Achieved**



Lap 2

DESIGN SPIRAL LAP 2

Identify + Translate

In this lap, I focused on the distribution system for the containers—a key piece of the full system and essential to the containers' successful reuse. I focused on identifying related functions, then translated the functions into biological terms.

The items in **bold** were explored in this lap.

Purpose	Functions	Translation
• **Distribute food from producer to retailer** • Reuse all packaging materials efficiently • Enable coordination/cooperation between producers and retailers	• **Coordinate activities/systems to distribute resources (solids)** • Send signals • Process/sense signals • Optimize space/materials	• **How do ant colonies, starlings, and honeybees coordinate activities?** • How do ant colonies and flowers send signals? • How do ant colonies and pollinators process/sense signals? • **How do hermit crabs distribute shells?** • How do honeybees and wasps optimize space and materials?

DESIGN SPIRAL LAP 2

Discover

FUNCTION:

How does nature coordinate activities/ systems to distribute resources?

ORGANISM:

Rock Ant

(Temnothorax albipennis)

Ant colonies don't have a "control center" that directs the activities of the colony. Instead, individual ants can make independent decisions about where to forage for food. Each ant releases pheromones that allow other ants to follow it to a food source, and foraging ants don't need to wait for a centralized cue to follow a new path. This allows the colony to remain adaptable to shifts in food availability and distribute food more quickly.


Photo by Poranimm Athithawatthee on Pexels

ADDITIONAL ORGANISMS CONSIDERED:

- How do Carribean Hermit Crabs coordinate to distribute resources?
- How do European Starlings coordinate within a flock?

DESIGN SPIRAL LAP 2

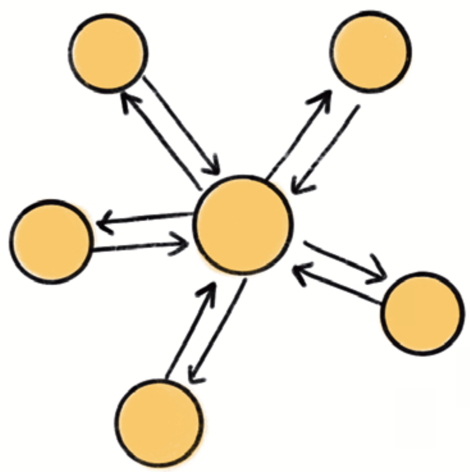
Abstract

Function: Coordinate to distribute resources

Organism: Rock Ant *(Temnothorax albipennis)*

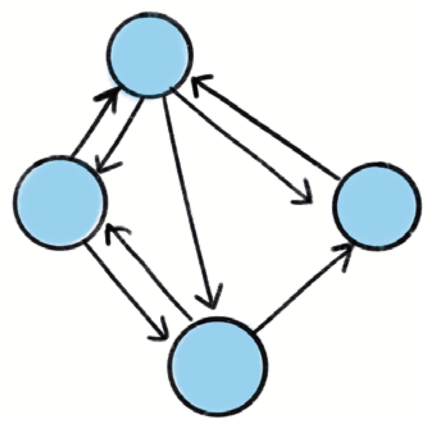
Decentralized systems are characterized by coordination between individuals rather than top-down direction. These systems rely on timely exchange of information between participants, so that those individuals can act accordingly.

CENTRALIZED SYSTEM



In a centralized system, decisions and resources are routed through a single individual or control system.

DECENTRALIZED SYSTEM



In a decentralized system, individuals collaborate directly to perform a function or achieve a goal.

DESIGN SPIRAL LAP 2

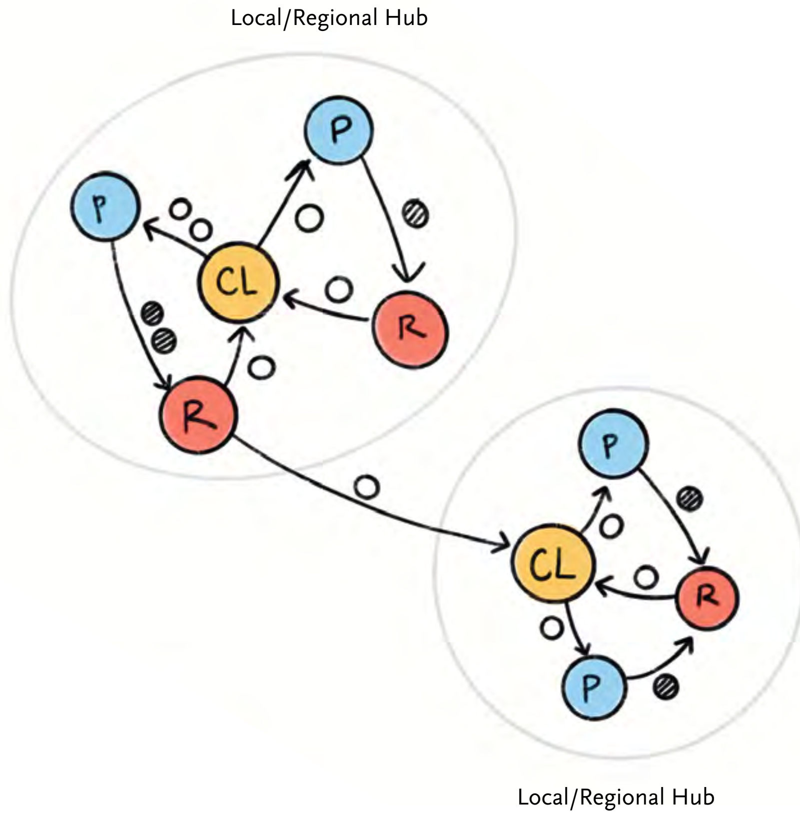
Emulate

Decentralized, Local/Regional Distribution System

The wholesaler in this model provides refillable containers and facilitates shipment directly from producers to retailers. This direct connection decentralizes the process of food distribution and streamlines management of refillable containers.

Local/Regional Hubs with Cleaning Centers
For food safety reasons, the containers need to be thoroughly cleaned between uses. The wholesaler would operate cleaning centers that would create local/regional hubs of container reuse. Empty containers can be shipped to neighboring hubs if needed.

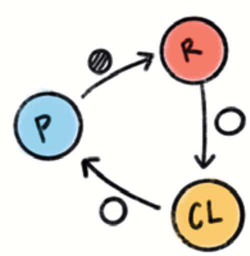
Scannable Containers, Real-Time Database
All containers will be built with unique, scannable codes, enabling real-time tracking whenever a container is received or shipped. That information will populate a database that allows instant information-sharing and that would automate decisions about where containers should be shipped.



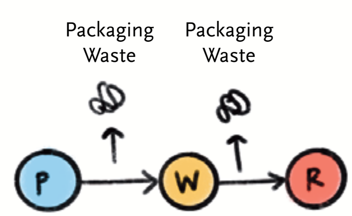
Distribution process:

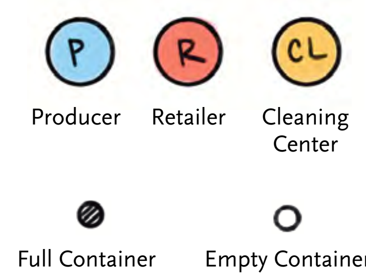
- Wholesaler receives order from retailer
- Wholesaler places order with producer
- A refillable container is sent to the producer from the nearest cleaning center
- Producer ships the order directly to the retailer in the refillable container
- Once the container is empty, the retailer ships it to the nearest cleaning center
- The container can be sent to another producer as soon as it is cleaned

NEW MODEL



EXISTING MODEL





DESIGN SPIRAL LAP 2

Evaluate

Life's Principles Achieved	**6 / 16**
Partially Achieved	**4 / 16**

☑ **Achieved**

⊟ **Partially Achieved**

☐ **Not Achieved**

Focusing on the distribution process in this lap added clarity around how the design accomplishes Life's Principles. Updates are listed here.

DOES THE DESIGN ADAPT AND EVOLVE?

Is the design locally attuned and responsive?

☑ **Does it leverage feedback loops?**
The expandable container design adapts to the current storage needs. Additionally, the distribution system runs on information, with a database that allows instant, information-based decisions about where containers should be shipped next. This could help reduce container downtime and increase overall efficiency.

Does the design integrate cyclic processes?

⊟ **Are processes cyclical?**
The containers use recycled plastic, but it most likely isn't possible to recycle the material again. The re-use based distribution system replaces a linear model with a circular model that keeps resources in use.

DOES THE DESIGN CREATE CONDITIONS CONDUCIVE TO LIFE?

Does the design optimize rather than maximize?

☑ **Does it perform functions with minimal material and energy?**
The hexagonal design encloses the most volume with the least perimeter compared to other shapes. It could also create efficiency in shipping. The reusable containers also keep the materials in use for much longer than disposable options. Additionally, in the distribution model, local/regional container cleaning centers reduce container transit, which saves energy.

Does the design leverage its interdependence in the system?

☑ **Does it foster symbiotic, cooperative, community-based relationships?**
The distribution system, which prioritizes local and regional hubs for container reuse, could strengthen cooperative relationships in local/regional food systems by connecting producers and retailers more directly and encouraging retailers to stock more locally-produced foods.

Lap 3

DESIGN SPIRAL LAP 3

Identify + Translate

In this lap, I focused on the design of the container lids, which need to be air- and water-tight to keep food fresh during transport and storage.

The items in **bold** were explored in this lap.

Purpose	Functions	Translation
• **Keep food dry/fresh**	• Protect from excess liquids • Protect from dirt/contamination • **Attach temporarily**	• How do milkweed seeds, pine cones, and paper wasps protect from excess liquids? • How does nature protect from dirt/contamination? • How does nature form temporary seals? • **How does nature create temporary grip/attachment between surfaces?** • **How does nature latch and unlatch/cover and uncover?** • How does nature seal air in/out?

DESIGN SPIRAL LAP 3

Discover

FUNCTION:

How does nature attach surfaces temporarily?

ORGANISM:

Dragonflies & Damselflies

(Anisoptera, Zygoptera)

To stabilize their heads when needed (like during feeding or flight), dragonflies and damselflies have microstructures on their heads and necks that can lock to anchor the surfaces together, then release. These microstructures create stability through friction.

Photo by Riley Crawford on Unsplash

ADDITIONAL ORGANISMS CONSIDERED:

- How do human fingertips create grip on surfaces?

DESIGN SPIRAL LAP 3

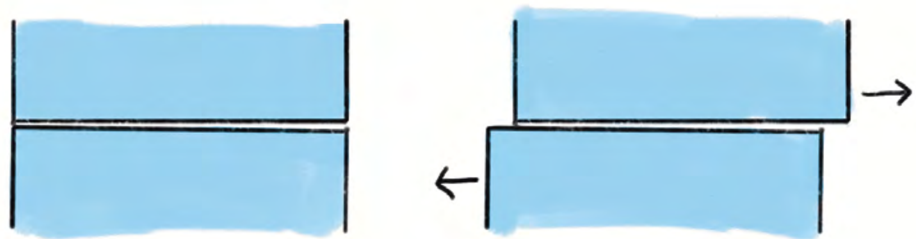
Abstract

Function: Attach temporarily

Organism: Dragonflies and Damselflies

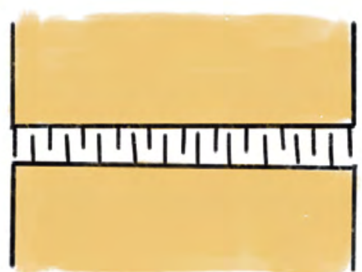
Interlocking structures that create friction can temporarily attach two surfaces by locking them together. That locking action resists mechanical stresses, helping to form a stronger attachment.

SMOOTH SURFACES



Two smooth surfaces cannot attach securely on their own without another material or dynamic, like adhesive or suction.

INTERLOCKING SURFACES



Two interlocking surfaces create friction and can resist mechanical forces to create a strong but releasable attachment.

Emulate

Materials-efficient interlocking container lids

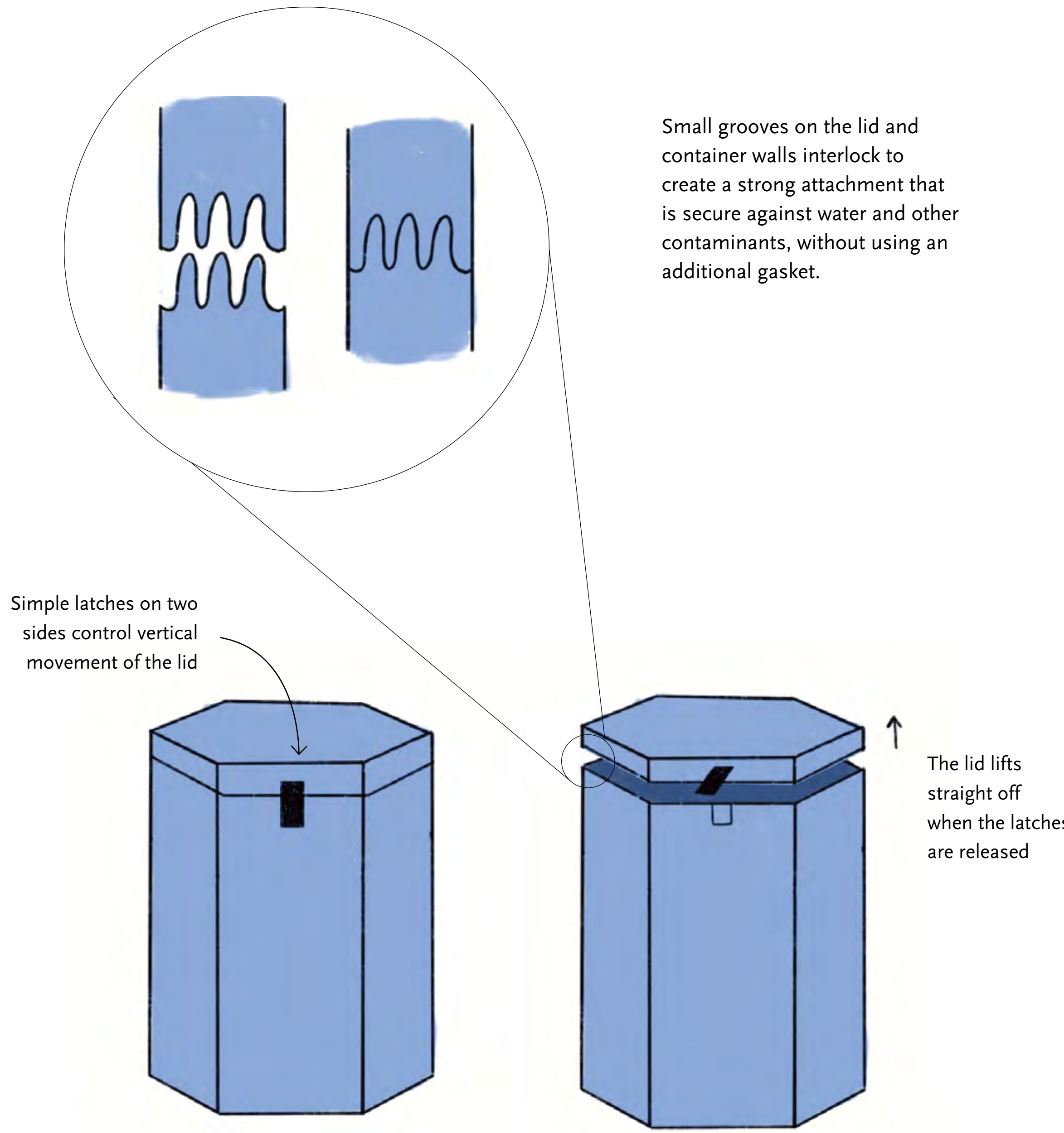
Inspired by dragonflies and damselflies, the containers feature interlocking lids to enhance the seal against water and other contaminants without requiring an additional component/material (e.g. a silicone gasket).

Shape Instead of Material
Many reusable food container designs feature a lid with a latch and gasket that forms a tight seal against contaminants. However, those lids require extra materials (the gasket), and the gaskets may wear over time and require replacement. The interlocking design of this container lid can be molded as one piece and creates a tight seal without an additional gasket.

(Note: Current bulk food packaging likely is not incredibly air-tight, but that functionality would need to be examined in this design.)

Stronger Attachment = Minimal Latch Design
Because the interlocking lid design may increase the lid's resistance to mechanical forces (i.e. force from either side), the latch may not need to be as strong. This could reduce overall materials required for the containers.

SIDE VIEW OF INTERLOCKING LID AND CONTAINER WALLS



DESIGN SPIRAL LAP 3

Evaluate

Life's Principles Achieved	6 / 16
Partially Achieved	4 / 16

☑ **Achieved**

⊟ **Partially Achieved**

☐ **Not Achieved**

The design of the lid does not help the overall design achieve additional Life's Principles, but it reinforces some Principles. Updates are listed here.

DOES THE DESIGN ADAPT AND EVOLVE?

Is the design locally attuned and responsive?

☑ **Is the design resourceful?**
Expandable containers can be used for a range of product volumes. The interlocking lid design uses shape (molded interlocking grooves) rather than material (an additional gasket) to create a secure seal.

Is the design resilient?

⊟ **Can it withstand disturbance while maintaining function?**
The recycled plastic containers would protect against water damage and withstand changes in temperature, moisture and physical stress (dropping, etc.). The interlocking lid design creates additional resistance to mechanical forces, strengthening the attachment of the lid to the container. Ultimately, however, the containers could still break if exposed to strong enough forces.

DOES THE DESIGN CREATE CONDITIONS CONDUCIVE TO LIFE?

Does the design optimize rather than maximize?

☑ **Does it perform functions with minimal material and energy?**
The hexagonal design encloses the most volume with the least perimeter compared to other shapes. It could also create efficiency in shipping. The reusable containers also keep the materials in use for much longer than disposable options. Additionally, in the distribution model, local/regional container cleaning centers reduce container transit, which saves energy. The interlocking lid design uses shape (molded interlocking grooves) rather than material (an additional gasket) to create a secure seal.

Final Evaluation

Using Life's Principles to assess the impact of the final design

DOES THE DESIGN ADAPT AND EVOLVE?

Is the design locally attuned and responsive?

☑ **Is the design resourceful?**
Expandable containers can be used for a range of product volumes. The interlocking lid design uses shape rather than material (an additional gasket) to create a secure seal.

☑ **Does it leverage feedback loops?**
The expandable container design adapts to the current storage needs. The distribution system runs on information, with a database that allows instant, information-based decisions about where containers should be shipped next.

⊟ **Are materials locally available and abundant?**
Containers made from recycled plastic would take advantage of an abundant resource (plastic waste), though plastic poses other challenges and hopefully will be phased out of intensive production.

Does the design integrate cyclic processes?

⊟ **Are processes cyclical?**
The containers use recycled plastic, but it most likely isn't possible to recycle the material again. The re-use based distribution system replaces a linear model with a circular model that keeps resources in use.

☑ **Does it integrate local feedback loops?**
The expandable design adapts to the current storage needs.

Is the design resilient?

⊟ **Can it withstand disturbance while maintaining function?**
The recycled plastic containers would protect against water damage and withstand changes in temperature, moisture and physical stress (dropping, etc.). The interlocking lid design creates additional resistance to mechanical forces, strengthening the attachment of the lid to the container. Ultimately, however, the containers could still break if exposed to strong enough forces.

☐ **Does it heal after disturbance?**
No, the containers cannot heal and most likely could not be repaired (e.g. after cracking).

☐ **Are there opportunities for cross-pollination and mutation?**
No, the containers are a relatively static component of the larger distribution system.

☑ **Achieved**

⊟ **Partially Achieved**

☐ **Not Achieved**

FINAL EVALUATION

DOES THE DESIGN CREATE CONDITIONS CONDUCIVE TO LIFE?

Does the design optimize rather than maximize?

☑ **Does it integrate multiple functions?**
The containers can be used for transport as well as storage of bulk foods at retailers (i.e. in the back of the store to hold food for restocking displays).

⊟ **Does it recycle all materials? Is it recyclable?**
The containers are made from recycled plastic, which at least diverts plastic from landfills and incinerators. But it would most likely not be possible to effectively recycle the plastic again, so the containers would create waste at end of life.

☑ **Does it perform functions with minimal material and energy?**
The hexagonal design encloses the most volume with the least perimeter compared to other shapes. It could also create efficiency in shipping. The reusable containers also keep materials in use. Local/regional container cleaning centers reduce container transit. The interlocking lid design uses shape (molded interlocking grooves) rather than material (an additional gasket) to create a secure seal.

Does the design use benign manufacturing?

☐ **Does it use life-friendly materials?**
Plastic is petroleum-based, contains chemicals that are not life-friendly, and can't be returned to nature's cycles.

☐ **Is chemistry done in water?**
Plastic is created by refining fossil fuels into petroleum products.

☐ **Are processes done at ambient (local) pressures and temperatures?**
The process of refining fossil fuels requires high temps and pressures.

Does the design leverage its interdependence in the system?

⊟ **Does it foster symbiotic, cooperative, community-based relationships?**
The distribution system could strengthen relationships in local/regional food systems by connecting producers and retailers more directly.

☐ **Does it foster emergent relationships?**
No, the design is not self-organizing or part of a self-organizing system.

Final Score

Life's Principles Achieved	**6 / 16**
Partially Achieved	**4 / 16**

☑ **Achieved**

⊟ **Partially Achieved**

☐ **Not Achieved**

Discussion

Reflection

The process of moving through multiple laps of the design spiral helped me to focus on one aspect of the design at a time. That allowed me to stay focused on solving each challenge more fully, rather than getting lost in the big picture. Though I focused on adding a new function with each lap, I can see the potential in this process for truly iterative work, where each lap helps you deepen and improve the design.

While I had a rough idea of the system I wanted to design—a way for food distributors to use reusable packaging—I definitely felt that this process helped me find unexpected solutions for the individual challenges of the system (for example, the shape and functionality of the containers). The lid design was the toughest for me at first—I knew I wanted and needed a lid for the containers, and I just wasn't sure how that basic design could be made better. But stepping back and spending a healthy amount of time digging on Ask Nature with an open mind led me to a strategy I did not at all expect. And I do think that design could achieve more of Life's Principles than a standard lid!

Overall, I really enjoyed moving through the process of each successive lap, which was a new way of working for me. I think the structure of staying in one lap at a time really helps open up creativity and in-depth problem solving. I'm looking forward to more opportunities to follow that process. For this concept, I can see that I'd need to take many more laps to truly develop and refine the design.

Potential & Limitations

POTENTIAL

Packaging waste in the food industry is a serious problem. I believe this design has significant potential to accelerate and improve the move toward "zero waste" and/or reduced packaging shopping models, like bulk food sections in supermarkets. Zero waste stores are still fairly uncommon, but there's interest behind the model and signs that it is expanding. Legislation around packaging waste may also help encourage food producers and retailers to cut their dependence on single-use packaging. We need solutions that can support food distribution systems with radically reduced waste.

Because the logistics of cleaning and reusing containers would most likely be easier on local and regional scales, this system also has the potential to strengthen local and regional food systems—which create more resiliency in our food supply, reduce emissions from transport, and support local economies and communities.

If this system were adopted at a wide scale, the positive impacts would most likely include:

- Dramatically reduced food packaging waste, including impacts from single-use plastics (emissions, microplastics, health impacts, etc.)
- Reduced energy and material consumption because the materials in reusable containers are kept in circulation
- Potentially reduced energy use from transportation with development of stronger local and regional food systems

LIMITATIONS

I think the most significant challenge for this system is adoption. Our current food system is incredibly large and complex, and a shift to this new distribution system would require huge changes to be implemented at scale (e.g. the structure of grocery stores, consumer expectations, producer-distributor-retailer relationships, etc.).

Obstacles to adoption include:

- Cost—this system would need to be competitive relative to conventional packaging in order to be adopted at a wide scale
- Logistics—the distribution system would need to be carefully considered and crafted to ensure efficient shipping and container availability. The system will fail if containers aren't available when needed.
- Regulation—current food safety regulation could be an obstacle to reusable containers. This would need to be examined in more depth.
- Industry interests—packaging manufacturers would likely resist wide-scale adoption
- Consumer expectations—shoppers would need to change the way they shop for food (i.e. in bulk, not pre-packaged).

I believe the second potential limitation is around the containers' design and functionality: Is recycled plastic truly a sustainable option? Will the containers be durable and lightweight enough to function over time? And will the seal and latch be adequate to maintain the quality of the food? These questions could be examined in further laps through the Design Spiral and in product testing.

Future Exploration & Development

Material Options

By virtue of being durable and reusable, these containers offer benefits compared to single-use packaging—over time, they will require fewer resources for production, they keep materials in use, and they reduce strain on overburdened recycling systems. But, we should still consider what will happen to the containers at end-of-life. Two potential options for material are recycled plastic and bamboo. Both should be explored more fully, along with additional options.

RECYCLED PLASTIC:

- Affordable
- Repurposes discarded plastic
- Durable
- Airtight and watertight
- Can possibly be recycled at end of life, but will eventually create landfill waste

BAMBOO:

- Organic (can be composted at end of life)
- Bamboo grows quickly and is a relatively durable material
- Airtight, possibly watertight *(may require testing)*
- Affordable *(cost comparison with plastic required)*

Container Tracking & Labeling

A system for labeling and tracking reusable containers should be explored fully in future laps. For example, a decentralized network could be supported by scannable RFID chips in containers and a digital platform for tracking and management. Exploring the details of those collaborative strategies will be a key next step. Physical labels will for shipping will also need to be explored if the containers will be transported by standard mail services (e.g. UPS, FedEx). Factors to consider include material use and ease of removal for cleaning and container reuse.

Expansion Beyond Retailers

While the design so far has focused on the container system in the context of food retailers (supermarkets, etc.), the system could expand to other businesses and organizations that order food in bulk, like schools and restaurants. The needs of those groups would need to be considered more fully to ensure that the container design and distribution system would integrate well with their processes. Expanding the model beyond food retailers creates more potential for waste reduction.

Feedback

I appreciate any and all feedback!
These areas are top of mind for me:

- Potential for implementation and adoption of the system at scale—I'm thinking this could be another area to explore via biomimcry
- Lid design and container material (recycled plastic or alternative)
- Challenges to the distribution system

CHANGE LOG

- Clarified placement of container/lid seal in the Emulate step of the third lap
- Added Future Exploration & Development section documenting areas to explore further in future laps, based on feedback
- Updated Identify, Translate, and Discover steps to clarify which functions and organisms were carried forward in each lap
- Added Life's Principles tallies and final assessment

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