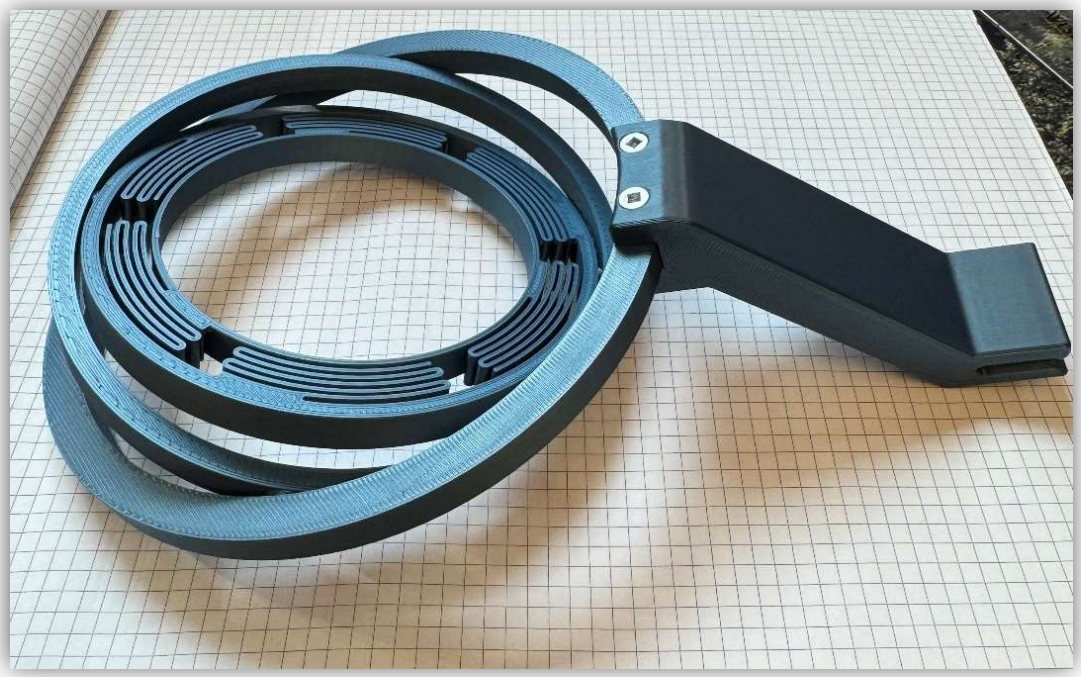

ENGG 523: Bio-Inspired Design

Zoology Group Project: “Extra Hand” Gyroscopic Cup Holder

Submission Date: December 6, 2024

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Executive Summary

This report focuses on the design and development of a lightweight, portable hand tool that acts as an "extra hand" in the car, specifically designed to securely hold beverages and prevent spills while driving. Inspired by the orangutan's ability to maintain balance in dynamic environments and the hippo's powerful grip, this tool solves the common and frustrating problem of spilled drinks during car travel, providing stability and security for cups and bottles. The design enables drivers to focus on the road without the need to hold their drink, offering a seamless and stress-free solution to an everyday issue.

The purpose of the project was to create a bio-inspired tool that functions as an extension of the user's grip, stabilizing beverages in motion and preventing inevitable spills caused by sharp turns, sudden stops, or rough roads. Research was conducted to identify the functional requirements, including dynamic stabilization, secure gripping mechanisms, and adaptability to different cup sizes. The problem was framed around enhancing the user experience in vehicles, where traditional cup holders often fail to provide sufficient security for beverages. The project began with an analysis of user frustrations related to spilling coffee or other drinks while driving. The research process included studying biological adaptations, such as the orangutan's ability to grip and stabilize itself in trees and the hippo's strong yet protective jaw. These insights helped brainstorming and initial sketches helping create a morphological chart, leading to a series of CAD models that translated these natural strategies into practical design features. The design process used a series of ideas created from a morphological chart, with each version improving on the last to create a product that met the project's objectives.

The final design features a gyroscopic stabilization system integrated into the base of the tool, which counteracts shifts and tilts, keeping the cup level even during sharp turns or sudden movements. Adjustable, spring-loaded clamps ensure a secure fit for a variety of cup sizes, preventing wobbling or tipping. Additionally, a friction-fit car vent clamp, inspired by the hippo's powerful grip, securely mounts the tool to vehicle air vents without damaging or scratching the surface. The result is a tool that functions as an "extra hand," stabilizing your drink so you can focus on driving.

Constructed entirely from PLA using 3D printing, the tool is lightweight, durable, and eco-friendly, with screws used to secure its components. The design was chosen for its simplicity, affordability, and manufacturability, ensuring that it could be easily reproduced. The tool offers practical value for commuters, coffee enthusiasts, and anyone who experiences the challenge of managing drinks while driving.

This product highlights the integration of biomimicry and engineering to solve a real-world problem or spilt coffee in cars. By mimicking natural strategies for grip and stability, it provides a user-friendly and effective solution for a common annoyance. Acting as an "extra hand," it helps drivers to avoid spills without holding their drinks or placing them in a stationary cupholder, making commuting safer and more convenient. Future iterations could explore modular designs, improved stabilization mechanisms, and expanded functionality to further enhance its versatility.

Species' Place Reports

The 15 GOPs below are inserted into the report via images however the PDF versions are appended to the report in the appendix.

Levi Manchester

Levi Manchester

FUNCTION

The trunk of an African elephant is a highly developed, flexible appendage that combines the functions of a nose and an arm. It is used for smelling, breathing, touching, grasping, and producing sound. This multifunctionality makes it an essential tool for elephants, allowing them to interact with their environment in various complex ways.

ORGANISM

African Elephant

Loxodonta Africana

BIOLOGY STRATEGY

Elephants use their trunks to perform delicate and strength requiring tasks, such as uprooting trees or gently picking up small objects. The trunk's ability to perform these tasks comes from its structure of around 40,000 muscles and no bones, providing flexibility and strength. This adaptability is important for their survival within the environment.

MECHANISM

How does nature achieve such versatility? The elephant's trunk functions without any bony support, relying solely on an intricate network of muscles that allow it to extend, contract, and bend with remarkable precision, enabling tasks from uprooting trees to picking up a pin.

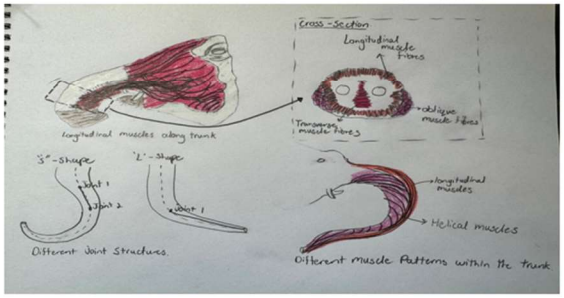


Figure 1. : Strategy Illustration

https://www.researchgate.net/figure/Muscular-architecture-within-the-elephant-trunk-a-Skinned-elephant-trunk-with_fig1_381450492

https://www.researchgate.net/figure/Biomimetic-continuum-robot-constructed-by-tensegrity-A-An-elephant-trunk-is-configured_fig1_368260640

DESIGN PRINCIPLE

Integrate segmented construction with a network of independent yet coordinated actuation points to replicate the elephant trunk's blend of muscular flexibility and strength, facilitating dynamic and adaptable tool applications that can range from heavy lifting to precise, delicate manipulations.

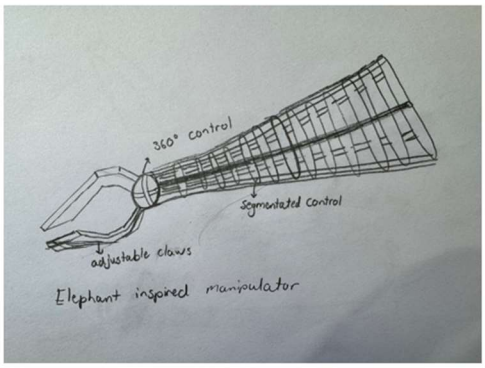


Figure 2. : Design Principle Illustration (drawing)

The illustration supports the written design principle and facilitates application of it in design.

APPLICATION IDEA

Inspired by the elephant's trunk, develop a versatile, robotic arm for use in diverse fields such as manufacturing, where it can adapt its grip strength and dexterity. This could involve a soft robotics design that mimics the trunk's muscular structure, enabling it to handle both sturdy and delicate materials without switching tools.

REFERENCES/URLs

https://www.nationalgeographic.com/animals/mammals/facts/african-elephant

https://asknature.org/strategy/how-elephant-trunks-twist-and-twirl/

https://asknature.org/innovation/flexible-gripper-inspired-by-the-elephant-trunk/

Levi Manchester

FUNCTION

Chameleons capture prey by projecting their tongues with exceptional speed and accuracy to catch insects typically out of reach.

ORGANISM

Chameleon

Chamaeleonidae

BIOLOGY STRATEGY

Chameleons possess a highly specialized tongue that can extend rapidly to capture prey at distances more than twice their body length. This rapid projection is facilitated by a complex of muscle and elastic tissues. According to "Elasticity and Movements of Chameleon Tongues" published in Animal Biomechanics, the tongue operates as a biomechanical 'spring-loaded' system where potential energy is stored in elastic tissues and rapidly converted to kinetic energy, allowing for the ballistic projection of the tongue at high speeds.

MECHANISM

How does nature strike so rapidly and accurately? The chameleon's tongue launches using a ballistic mechanism where elastic collagen fibers store energy when compressed, then rapidly expand to project the tongue forward at high speeds, achieving precise strikes on distant prey.

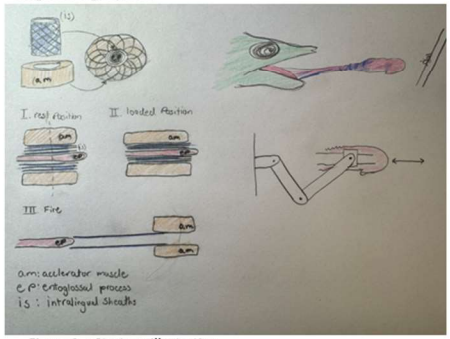


Figure 1. : Strategy Illustration
A diagram or illustration to support the Biology Strategy.

DESIGN PRINCIPLE

Incorporate advanced recoil mechanisms that allow for rapid extension and retraction, mimicking the chameleon's tongue. This principle is ideal for developing devices that need to quickly reach out and retract, ensuring precise operations over a distance with minimal energy expenditure.

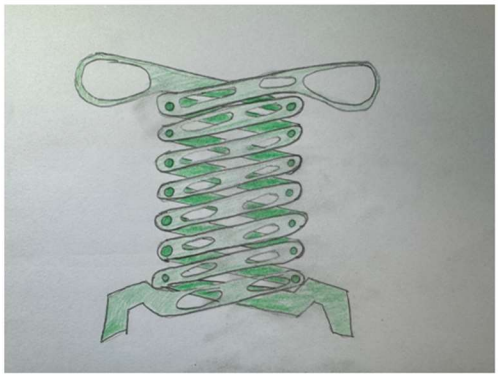


Figure 2. : Design Principle Illustration
The illustration supports the written design principle and facilitates application of it in design.

APPLICATION IDEA

Design a rapid-deployment medical device based on the chameleon's tongue, capable of extending quickly to precisely deliver treatments or perform minimally invasive surgeries. This device would be particularly useful in situations where traditional surgical access is difficult or where quick, precise actions are necessary.

REFERENCES/URLs

https://asknature.org/strategy/chameleons-launch-ballistic-tongues/

https://www.deviantart.com/ambr0/art/The-hyoid-bone-and-the-tongue-of-the-Chameleon-746445314

Levi Manchester

FUNCTION

Archerfish excel in precision targeting by shooting jets of water to knock down aerial prey. This specialized skill can inform the design of precision delivery systems in various applications, such as targeted irrigation systems, precise cleaning devices, or non-invasive medical treatments that require focused application of agents.

ORGANISM

Archer Fish

Toxotes chatareus

BIOLOGY STRATEGY

The archerfish exhibits an extraordinary ability to knock down prey with a stream of water expelled from its mouth. Research documented in "Hydrodynamics of Prey Capture in Archerfish" in the Journal of Experimental Biology demonstrates that this fish adjusts the hydrodynamics of water in its mouth to create a powerful, targeted jet, a mechanism that allows it to feed on insects and small animals outside its aquatic environment.

MECHANISM

How does nature target from a distance? The archerfish shapes the water in its mouth into a focused jet by adjusting the orifice formed by its gills and tongue, enabling it to shoot with precision accuracy at insects above the water's surface.

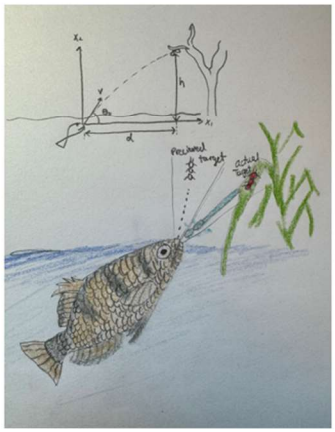


Figure 1. : Strategy Illustration (drawing)
A diagram or illustration to support the Biology Strategy.
https://www.researchgate.net/figure/The-hunting-mechanisms-of-archerfish_fig1_349025695

DESIGN PRINCIPLE

Develop an attachable, adjustable nozzle for faucets that emulates the Archerfish's ability to precisely control water jets. This nozzle would transform the faucet into a hydration station, allowing users to adjust both the angle and force of the water stream for easy drinking directly from the tap. This concept leverages the Archerfish's precise targeting mechanism to create a versatile, user-friendly device that enhances everyday convenience and water accessibility in homes or public facilities.

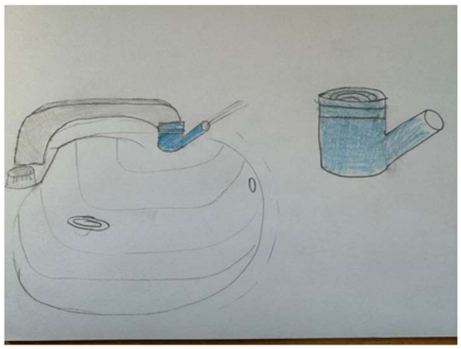


Figure 2. : Design Principle Illustration (drawing)
The illustration supports the written design principle and facilitates application of it in design.
https://www.allthat3d.com/3d-printing-make/

APPLICATION IDEA

Utilizing the archerfish's precise shooting technique, develop a cleaning device that targets hard-to-reach areas, such as high ceilings or intricate machinery parts. This device would use a controlled jet system to apply cleaning agents or water precisely where needed, minimizing waste and avoiding the need for physical contact with the surface.

REFERENCES/URLs

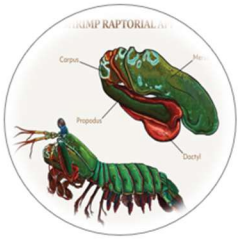
https://asknature.org/strategy/external-hydrodynamic-lever-increases-force/

https://www.nbcnews.com/science/weird-science/nice-shot-archerfish-use-complex-process-turn-water-tool-n196291

Levi Manchester

FUNCTION

The mantis shrimp is known for its exceptionally fast and powerful strikes, thanks to its specialized limbs. This biological function is ideal for inspiring the design of high-speed, high-impact tools used in demolition, material testing, or any field where rapid and forceful action is advantageous.



ORGANISM

Mantis Shrimp
stomatopoda

BIOLOGY STRATEGY

The mantis shrimp's striking appendage operates through an advanced mechanical system that allows for extremely rapid and powerful strikes. According to "The Mechanics of Punching by the Mantis Shrimp" published in Marine Biology Reports, this crustacean uses a latch mechanism that stores elastic energy in specialized tendons, releasing it in a fraction of a second to generate the forceful impact necessary for breaking shells or stunning prey.

MECHANISM

How does nature deliver such powerful strikes? The mantis shrimp uses a spring-like mechanism involving elastic energy storage in tendons; this energy is rapidly released, propelling its hammer-like appendage forward with enough force to shatter glass.

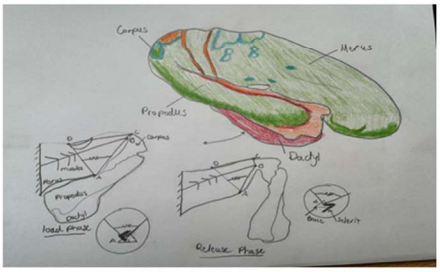


Figure 1. : Strategy Illustration (drawing)
A diagram or illustration to support the Biology Strategy.
https://link.springer.com/article/10.1007/s42235-022-00227-8

DESIGN PRINCIPLE

Harness the potential of elastic energy storage and rapid-release mechanisms to create tools that deliver sudden, high-impact forces efficiently, akin to the mantis shrimp's strike. This concept is applicable in designing high-performance impact tools in engineering, which require both precision and power, without the need for electronic components.

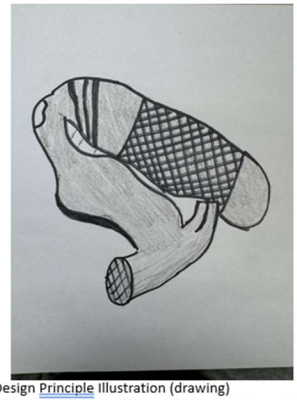


Figure 2. : Design Principle Illustration (drawing)
The illustration supports the written design principle and facilitates application of it in design.

APPLICATION IDEA

Drawing on the mantis shrimp's powerful strike, engineer a new type of hammer or impact tool that uses stored energy to deliver powerful blows without the need for repeated action or great physical strength from the user. This could be used in demolition, in driving stakes, or in any application where compact, high-energy impacts are required.

REFERENCES/URLs

https://asknature.org/strategy/appendage-creates-tremendous-forces/

Levi Manchester

FUNCTION

Orangutans demonstrate remarkable abilities in climbing and manipulating objects, using their strength and dexterity. Such capabilities inspire the development of tools and devices that enhance human interaction with challenging environments, particularly in areas requiring versatile and dynamic manipulation abilities.

ORGANISM

Orangutan

Pongo Pygmaeus

BIOLOGY STRATEGY

Orangutans are adept at manipulating their environment using their limbs and hands, which are capable of grasping with significant strength and dexterity. Studies highlighted in "Orangutan Adaptations to an Arboreal Lifestyle," Journal of Primate Biology, indicate that their limb flexibility and joint design allow for remarkable feats of strength and mobility, necessary for navigating the complex canopy structures of their forest habitats.

MECHANISM

How does nature enable complex manipulation?

Orangutans utilize a combination of muscular strength and skeletal flexibility, allowing their limbs to rotate and extend in ways that enable them to grasp and manipulate objects or swing from tree limbs efficiently.

Figure 1. : Strategy Illustration (drawing)

A diagram or illustration to support the Biology Strategy.

https://www.dimensions.com/element/bornean-orangutan-pongo-pygmaeus

https://www.researchgate.net/figure/An-example-of-tree-sway-in-an-orangutan-The-orangutan-oscillates-the-branch-of-an_fig3_328111085

DESIGN PRINCIPLE

Integrate dynamic balance control and flexibility into a cup holder design, inspired by the orangutan's ability to maintain stability while navigating through complex environments. This cup holder would automatically adjust to movements and tilts, ensuring that the contents remain level and secure, much like how an orangutan manages to keep its balance and composure in the treetops.

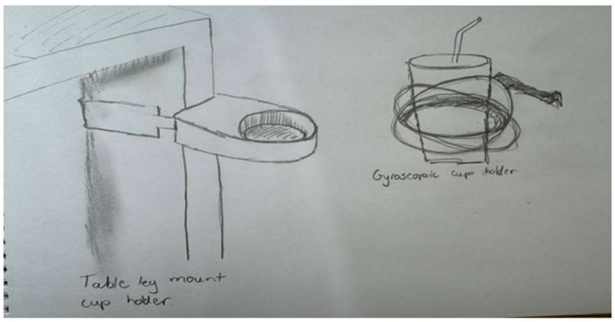


Figure 2. : Design Principle Illustration (drawing)

The illustration supports the written design principle and facilitates application of it in design.

https://www.printables.com/model/513181-customizable-leg-clamping-desk-cup-holder?lang=en

APPLICATION IDEA

Develop a self-balancing cup holder that uses a weighted and articulated base, mimicking the balance and agility of orangutans. This cup holder would be designed to automatically adjust to movements and tilts, keeping the container upright even in moving vehicles or unstable conditions. Ideal for use in cars, boats, wheelchairs, and other mobile environments, it enhances usability for all, especially those with mobility challenges or in dynamic environments.

REFERENCES/URLs

https://nationalzoo.si.edu/animals/orangutan

https://www.wwf.org.uk/learn/fascinating-facts/orangutans

Rajdeep Singh

Rajdeep Singh

FUNCTION

The shell of the tortoise is rigid and strong, protecting the tortoise from predators and environmental hazards. The shell is made up of individual plates (scutes) that interlock, allowing limited flexibility and resistance to cracking under pressure. The shell has multiple layers, including a hard outer layer and a more flexible inner layer, providing impact absorption and durability.

ORGANISM

Egyptian Tortoise
Testudo kleinmanni

BIOLOGY STRATEGY

The dome-shaped shell provides structural integrity and strength, allowing the tortoise to withstand pressure from predators and environmental factors. The shell is composed of a combination of keratin (the same material found in human nails and hair) and bony plates, which offer both flexibility and durability. The hard, protective shell serves as a barrier against predators, making it difficult for them to access the tortoise's soft body.

MECHANISM

The hard, protective outer layer of the shell acts as a formidable defense against predators. When threatened, the tortoise can retract its limbs and head into the shell, further enhancing its protection

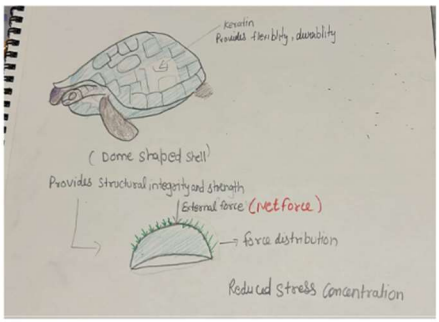


Diagram of force distribution on shell of tortoise

DESIGN PRINCIPLE

Use dome shapes in designs with ductile material to enhance strength and resilience against environmental pressures, inspired by the tortoise's shell.

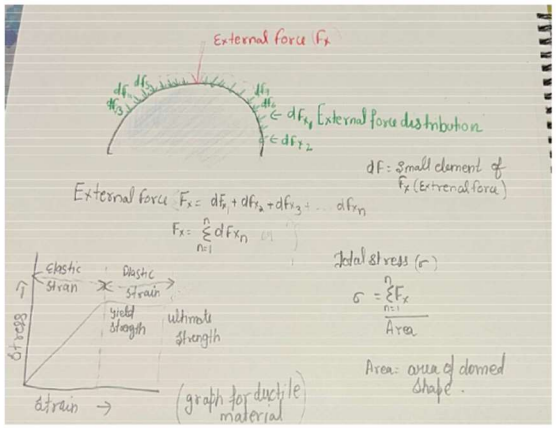


Diagram of force distribution on a domed shape area for design principle

APPLICATION IDEA

Using Dome shaped , designing a helmet for industrial use , which is brittle and can handle extreme stress to prevent injuries to head in case of an accident.

Rajdeep Singh

FUNCTION

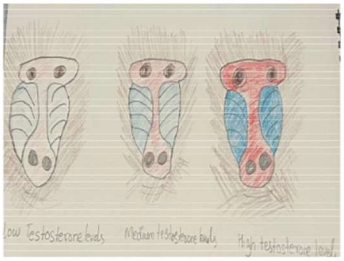
Mandrills use visual signals, specifically their vibrant facial and rump coloration, to convey social status, health, and emotions within their social groups. This function supports social cohesion, establishes hierarchy, and helps prevent conflicts by clearly communicating dominance and submission. For a biomimetic design, the function we want to emulate is a system that visually conveys specific conditions, status, or levels, facilitating efficient and non-verbal communication in group settings..

ORGANISM

Mandrill
Mandrillus sphinx

BIOLOGY STRATEGY

Mandrills exhibit one of the most striking examples of coloration in primates. Male mandrills display vivid blue and red coloration on their faces and rumps, which is directly correlated with their social rank and health status. The colors are intensified by testosterone levels, serving as a natural signal of physical condition and dominance to other mandrills. This adaptation allows them to signal their status and intentions visually, reducing the likelihood of physical confrontations within their group.



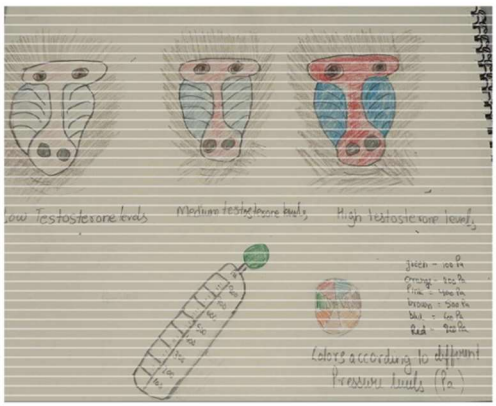
Levels of testosterone depicting change in facial color of mandrill

MECHANISM

Coloration in mandrills is primarily achieved through pigments influenced by hormones, such as testosterone, which enhances red and blue hues. This dynamic coloration adjusts with changes in the mandrill's health and social rank, making it an accurate, hormone-based visual cue

DESIGN PRINCIPLE

Develop a visual system that adjusts its appearance based on environmental or internal metrics to indicate current conditions or levels in real-time.



As pressure changes , color changes in a device. Temperature can be also opted in device giving a better Thermometer or a Manometer

APPLICATION IDEA

- a handheld tool with a surface that shifts color based on temperature, pressure, or other measured metrics could provide real-time feedback. This could be applied in settings like healthcare or manufacturing to quickly communicate status visually without the need for additional equipment.

Rajdeep Singh

FUNCTION

The ability to see in all directions enhances spatial awareness, allowing the Meerkat to navigate complex terrains effectively. This is particularly beneficial in densely vegetated or obstructed environments.

ORGANISM

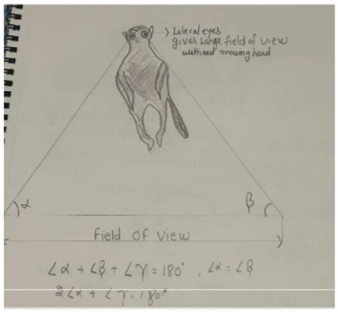
Slender-Tailed Meerkat
Suricata suricatta

BIOLOGY STRATEGY

Meerkats have lateral (side) eye placement, which grants them a wide field of view, allowing each meerkat to monitor a large area without needing to move its head extensively. Meerkats rely on sharp distance vision to spot predators, such as birds of prey or snakes, from afar. This ability to perceive threats before they are close allows meerkats to initiate escape strategies early.

MECHANISM

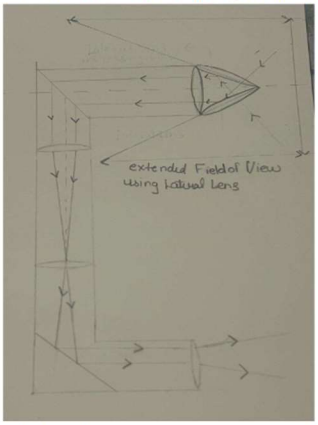
Meerkats have large, forward-facing eyes offer binocular vision and a nearly 360-degree field of view, allowing them to spot predators from afar. They can see some colors, mainly in the blue and green spectrum, and use visual signals for communication within their social groups, aiding in foraging and evasion of threats.



Field of View for a meerkat is bigger because of lateral eyes

DESIGN PRINCIPLE

An increasing field of view using lateral lens for periscope with a system of mirrors or prisms that captures maximum field of view, mimicking how meerkats can see around them without moving their heads.



Ray diagram for lateral lens in a periscope to increase its field of view

APPLICATION IDEA

Maximum Field of view periscope design using lateral lens leverages principles observed in meerkats, focusing on an omnidirectional field of view, stability, user-friendliness, and environmental integration, making it a practical tool for observation and exploration.

Rajdeep Singh

FUNCTION

Masai giraffes use height to access food sources and scan for predators, giving them an advantage in both foraging and avoiding threats. This function could inspire designs that enhance visibility or extend reach.

ORGANISM

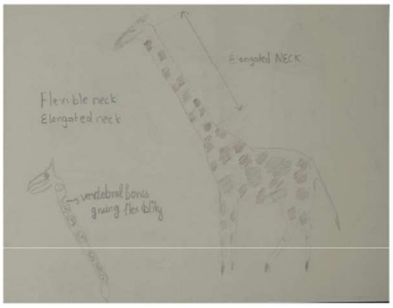
Masai Giraffe
Giraffa camelopardalis tippelskirchi

BIOLOGY STRATEGY

Giraffes' long and flexible necks and legs allow them to browse leaves from tall trees, minimizing competition with other herbivores. Their height also enables them to spot predators from a distance, providing a safety advantage. Male giraffes often engage in a behavior known as "necking," where they use their necks in combat to establish dominance and win mates. Longer necks are advantageous in these contests, contributing to the selection for longer necks over generations.

MECHANISM

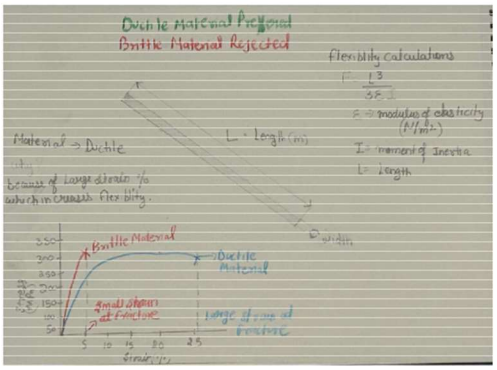
The giraffe's height and long limbs allow access to resources that are out of reach for others, enhancing foraging efficiency and predator awareness.



Elongated neck of a giraffe and showing its vertebrates.

DESIGN PRINCIPLE

Optimize height or reach to access resources or improve visibility with a material which is flexible and can handle stress concentration without breaking.



Elongated rod or a beam with ductile material which increases its flexibilty

APPLICATION IDEA

- Design an extendable tool for reaching high objects
- Design a fishing rod
  Design a Baton
  Design a clamp with elongated tongs for surgical tool.

Rajdeep Singh

FUNCTION

The powerful jaws and large teeth are critical for protection against predators. Hippos can be aggressive, especially when defending their territory, and their bite can inflict severe damage.
Hippos primarily graze on grass, and their strong jaws allow them to uproot and chew tough vegetation.

ORGANISM

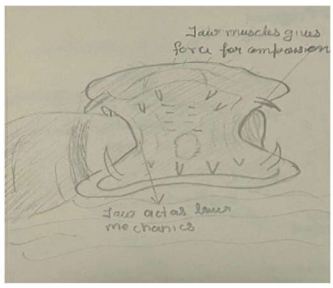
Hippopotamus
Hippopotamus amphibius

BIOLOGY STRATEGY

Hippos have evolved strong jaws and teeth to defend themselves and access tough vegetation. The biological strategy emphasizes strength and durability. The ability to crush hard materials enables hippos to exploit food resources that other herbivores might not access. The shape and size of the hippo's jaw contribute to its strength. The jaw is wide and robust, providing a larger surface area for muscle attachment and force distribution.

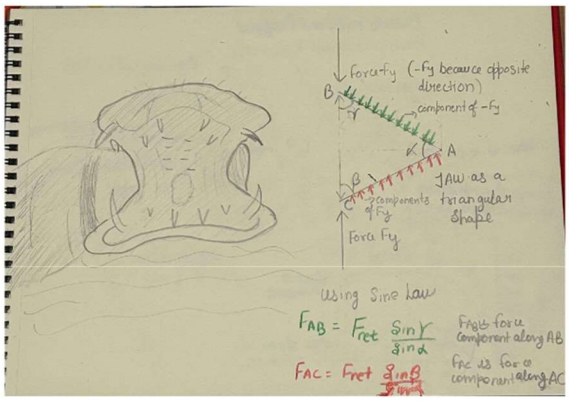
MECHANISM

Lever System: The jaw operates like a lever, with powerful muscles providing the force needed to close the jaw. This mechanical advantage allows hippos to exert extreme pressure.
Muscle Composition: The jaw muscles are highly developed, providing both strength and speed in closing the jaw, similar to hydraulic mechanisms in engineering.



Muscles of Hippo's Jaw gives compressive strength

DESIGN PRINCIPLE
Muscles of Jaws of a Hippo give extreme compressive power through high crushing forces while maintaining efficiency.



Force distribution along jaws which shows why hippos can give compressive force of 2,000 pounds per square inch (psi)

APPLICATION IDEA
Highly pressurized clamps

- Image references
- https://th.bing.com/th/id/OIP.AcF6xCrGYGSSZ1EH7lSBqQHaEV?w=312&h=183&c=7&r=0&o=5&dpr=1.3&pid=1.7
- https://africageographic.com/wp-content/uploads/2021/03/Male-mandrill-South-Eastern-Gabons-Rainforest-Giovanni-Mari.jpg https://th.bing.com/th/id/OIP.AcF6xCrGYGSSZ1EH7lSBqQHaEV?w=312&h=183&c=7&r=0&o=5&dpr=1.3&pid=1.7
- https://assets-global.website-files.com/5adf752e38b7222e27f146ee/5ba69649f49b779112f0136f_slender-tailed-meerkat-4.jpg
- https://th.bing.com/th/id/OIP.GUNMaKgj34GTH0ZJQSXXQwHaEV?w=317&h=186&c=7&r=0&o=5&dpr=1.3&pid=1.7
- https://th.bing.com/th/id/R.45aac287bb27ef7b9016269aecd9e230?rik=oCRw%2fVlYxOwvtw&riu=http%3a%2f%2f2.bp.blogspot.com%2f-ahfMk27FXQo%2fUPY3mB-S6OI%2fAAAAAAAACgg%2fT-Pezxut3jw%2fs1600%2fHippopotamus%2b1.jpg&ehk=qIZiJaphjV5VR8e23TqFouC5iiRqWjOPY%2fc07jgwhS4%3d&risl=&pid=ImgRaw&r=0

References

- Egyptian Tortoise Care: Size, Diet, Lifespan & More!
- Mandrill | San Diego Zoo Animals & Plants
- Giraffe | Facts, Information, Habitat, Species, & Lifespan | Britannica
- Hippopotamus, facts and photos
- Meerkat: Fascinating Facts, Behavior, and Conservation Status
- What is Brittleness - Definition | Material Properties
- Ductility - Ductile Definition and Examples
- What is Compressive Strength?- Definition, Formula
- Total internal reflection - IGCSE Physics Revision Notes
- 3.3 Distributed Loads – Engineering Mechanics: Statics

Daniel Nguyen

Daniel Nguyen

FUNCTION

The function of hyrax feet is primarily to provide traction and stability on rocky and uneven surfaces, allowing these animals to navigate steep terrains safely. Their feet helps them climb effectively and access food sources in trees or rocky outcrops, which is crucial for their foraging habits. This correspond to Move or Stay Put.

ORGANISM

Rock Hyrax

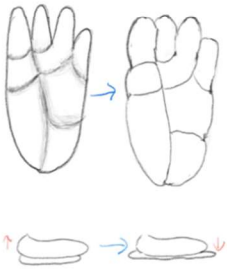
Procavia capensis

BIOLOGY STRATEGY

Hyrax feet are uniquely adapted to provide both traction and stability, which is essential for their survival in rocky habitats. The thick, padded soles of their feet enhance grip on uneven surfaces, allowing hyraxes to move confidently across cliffs and rocky terrains. The combination of soft pads and short claws helps them maintain balance, making it easier to climb and forage in their arboreal and rocky environments. This adaptation not only facilitates their movement but also reduces the risk of slipping, enabling hyraxes to escape predators and access food sources that would otherwise be difficult to reach.

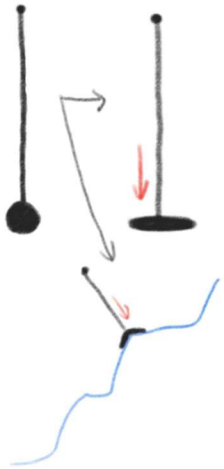
MECHANISM

The soft pads increase the surface area of contact and absorb shock for better grip and stability. Short claws provide just enough grip to dig in without being overly sharp or elongated, which can hinder movement



DESIGN PRINCIPLE

Use the principle of having a soft surface of contact to improve surface area and stability.



APPLICATION IDEA

A walking/hiking stick with a soft/rubber tip that can compress to increase surface area when pressed on.

REFERENCES/URLs

- https://encyclopedia.litcaf.com/science/animals/rock-hyrax/
- https://en.wikipedia.org/wiki/Hyrax
- https://en.wikipedia.org/wiki/Hyrax

Daniel Nguyen

FUNCTION

The function of porcupine teeth is to efficiently gnaw and process tough plant materials, such as bark and wood. Their teeth allow them to strip bark and access the nutrients within. The chisel-like shape of these teeth enables porcupines to exert the necessary force to break down fibrous plant matter, which is essential for their herbivorous diet and overall survival. This corresponds to Break Down.

ORGANISM

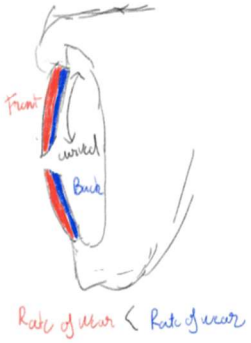
North American porcupine
Erethizon dorsatum

BIOLOGY STRATEGY

Porcupine teeth are biologically adapted to effectively strip bark and maintain sharpness through continuous growth and specialized structure. The front surface of the incisors is covered with hard enamel, while the back surface is softer dentin. When porcupines gnaw on wood, the harder enamel wears more slowly than the softer dentin. This differential wear causes the cutting edge to maintain a sharp profile, as the softer material wears away faster, keeping the leading edge keen. The slight curvature of the teeth helps facilitate a slicing motion as they cut through bark. This design allows the porcupine to exert force efficiently, increasing the effectiveness of their gnawing action.

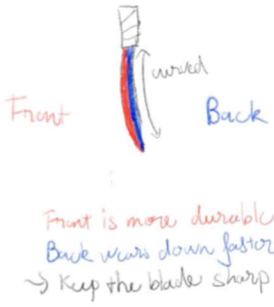
MECHANISM

The differential wear of their teeth keeps them sharp. Their teeth also has a slight curvature to allow for efficient gnawing.



DESIGN PRINCIPLE

Use the principle of differential wear to keep the sharpness of the tool and mimic the slight curvature of their teeth for carving and slicing



APPLICATION IDEA

A wood chisel with a curve edge and a self-sharpening feature based on differential wear

REFERENCES/URLs

- https://animarticle.com/porcupine-teeth/
- https://www.atholdailynews.com/speaking-of-nature-june-10-55491575
- https://sandiegozoowildlifealliance.org/story-hub/zoonooz/the-point-of-porcupines

Daniel Nguyen

FUNCTION

The function of the Alexandrine parakeet beak is to efficiently grasp, manipulate, and crack open various food sources, including seeds, nuts, and fruits. Its beak enables the parakeet to handle tough shells and extract nutritious contents. This beak design also facilitates foraging in trees and other vegetation, helping the parakeet access a wide variety of food while maintaining a secure grip. This corresponds to Break Down and Move or Stay Put.

ORGANISM

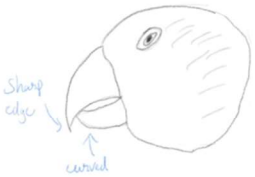
Alexandrine parakeet
Psittacula eupatria

BIOLOGY STRATEGY

The Alexandrine parakeet's beak is a remarkable adaptation that enables it to effectively crack nuts and tough seeds, essential for its diet. This strong, curved beak allows the parakeet to exert significant pressure when biting down, maximizing its ability to break open hard shells. The beak's shape is designed for both strength and precision, with sharp edges that facilitate gripping and slicing through tough outer layers. This is particularly important for accessing the nutrient-rich seeds within, as the beak's design allows the parakeet to manipulate food items with dexterity.

MECHANISM

The curvature of the beak gives them a mechanical advantage to exert force. The sharp edge improves grip and aid in slicing



DESIGN PRINCIPLE

Use the mechanically advantageous shape of its beak for breaking strength and its sharp edge design for slicing and grip

APPLICATION IDEA

A curve nutcracker that mimic the beak of the parakeet

REFERENCES/URLs

- https://www.parrots.org/ask-an-expert/cracking-beak-and-avian-nutrition
- https://parrotsupplies.co.za/blogs/chloes-story/the-science-behind-new-world-parrots-and-their-beaks?srsltid=AfmBOoqRwQZHfb6j31JxOLL4cgtdL4mqX8X_LHKsfuHxAAqaWNDFGDaI
- https://en.wikipedia.org/wiki/Alexandrine_parakeet

Daniel Nguyen

FUNCTION

The function of the Southern Bald Ibis beak is to probe, forage, and capture a variety of food sources, including insects, crustaceans, and small invertebrates found in mud and shallow water. Its beak allows the ibis to reach into narrow crevices and soft substrates, enabling it to extract food efficiently. This specialized beak design is crucial for foraging, as it helps the ibis locate and access hidden prey, contributing to its dietary needs and overall survival in diverse habitats. This corresponds to Get, Store or Distribute Resources

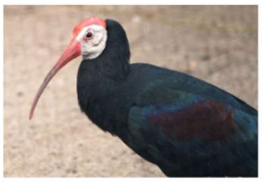
ORGANISM

Southern Bald Ibis

Geronticus calvus

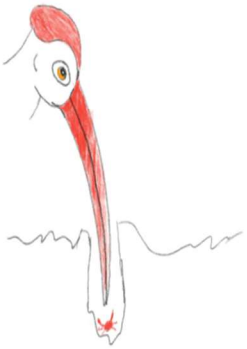
BIOLOGY STRATEGY

The Southern Bald Ibis beak is specially adapted for probing and foraging, allowing the bird to effectively access its food sources in wetland and mudflat environments. Its long, slender, and slightly curved shape enables the ibis to reach into soft substrates and crevices. This beak design not only facilitates precise movements but also helps the ibis navigate challenging terrain, such as muddy areas, without disturbing its surroundings too much. The curvature of the beak allows for efficient extraction of prey, as it can hook and pull food from difficult positions. This adaptation is essential for the ibis's foraging behavior, enhancing its ability to locate and capture food, which is vital for its survival.



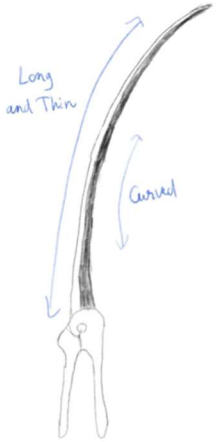
MECHANISM

The slender, long and curved beak gives them the ability to accurately navigate hard to reach spots.



DESIGN PRINCIPLE

Use the long, slender and slightly curved shape of their beak to allow for precise movement into hard to reach spaces



APPLICATION IDEA

A long, thin and curved pruning shear for trimming and shaping branches. A pair of specialized forceps that mimics the shape of the Ibis' beak to navigate hard to reach areas

REFERENCES/URLs

- https://en.wikipedia.org/wiki/Southern_bald_ibis
- https://animalia.bio/southern-bald-ibis?letter=s
- https://ebird.org/species/balibi1

Daniel Nguyen

FUNCTION

The function of Rocky Mountain goat hooves is to provide stability, traction, and agility on steep, rocky terrain. Their unique hooves design allows for excellent balance and maneuverability, enabling the goats to navigate narrow ledges and rugged surfaces with ease. Their hooves also prevent slips and falls while climbing or jumping. This combination of features allows Rocky Mountain goats to efficiently escape predators and access food in challenging environments. This corresponds to Move or Stay Put

ORGANISM

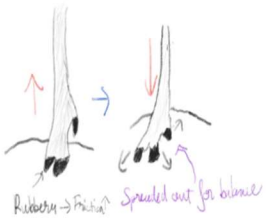
Rocky Mountain goat
Oreamnos americanus

BIOLOGY STRATEGY

The hooves of Rocky Mountain goats are finely adapted to support their survival in steep, rugged environments. The cloven structure of the hooves allows for superior balance and agility. The rubbery soles of the hooves enhance grip on slippery surfaces, significantly reducing the risk of slips and falls. Moreover, the ability of the hooves to spread apart increases their contact area with the ground, which helps distribute the goat's weight more evenly and provides additional support on uneven surfaces. The flexibility of the hooves also allows them to conform to varying terrain, further enhancing their effectiveness in maintaining footing

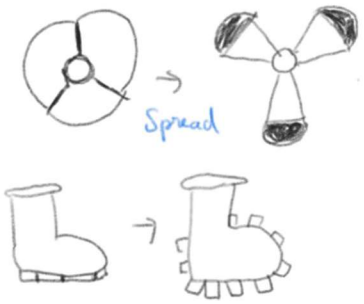
MECHANISM

The cloven design, the ability to spread and the rubbery nature of the hooves improve stability, increase surface area and improve grip



DESIGN PRINCIPLE

Use the cloven design and spreading mechanism to improve grip of devices



APPLICATION IDEA

A specialize shoe attachment that mimics the cloven and spreading design for hiking

REFERENCES/URLs

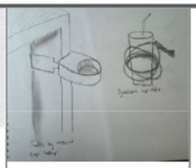
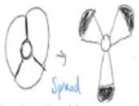
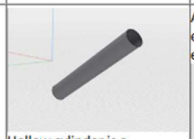
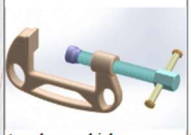
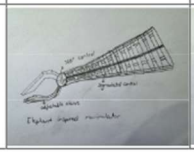
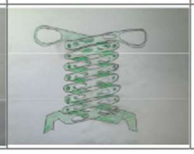
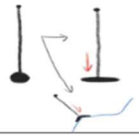
- https://animaldiversity.org/accounts/Oreamnos_americanus/
- https://www.robbiegeorgephotography.com/blog/blog_posts/mountain-goat-all-about-oreamnos-americanus
- https://en.wikipedia.org/wiki/Mountain_goat

Morphological Chart

The morphological chart below is inserted into the report via images however the PDF versions are appended to the report in the appendix.

DESIGN PROBLEM DEFINITION: Design a manual hand tool inspired by the unique functionalities of animals observed at the Wilder Institute/Calgary Zoo. The tool should incorporate biomimetic principles to enhance ergonomics and versatility for users in various manual labor and DIY tasks, operating efficiently without electricity and using sustainable materials.

Solutions →

TASK/SUBTASK(function):				
Dynamic Balance and Control (stability)	 A stand to give foundation support for structure inspired from hippo or giraffe legs	 Advanced design inspired from giraffe legs for structural support which distributes forces to keep stable and balanced foundation	 Gyroscopic cup holder to balance drinks in car based on the orangutan's ability to balance in the treetops	 Design inspired by mountain goat's hoof that would spread in a cloven like structure to provide balance and stability
TASK/SUBTASK(function):				
Lightweight and Portable	 Hollow cylinder is a lightweight material of elongated neck for extended reach.	Advanced Hollow design of elongated neck which can expand and contract 		
TASK/SUBTASK(function):				
Enhanced Grip	 Gripper with rod holder Inspired From Jaws of hippo	 A c clamp which uses compressive forces just like Hippo's Jaws	 A design inspired by the soft pads of the hyrax's feet that would increase grip to by increasing surface area using a compressible material	
TASK/SUBTASK(function):				
Adaptability/Flexibility				

Notes: Problem Definition 1: Manual Hand Tool Inspired by Animal Functionalities

Objective: Design a versatile, sustainable hand tool that draws from animal biomechanics to enhance ergonomic use, stability, grip, flexibility, durability, and safety.

Top Solutions and Design Concepts with Notes

1. Dynamic Balance and Control

Stand with Structural Support:

Notes: Mimics giraffe legs, where each leg functions as a stabilizing pillar that distributes weight evenly. This design allows the tool's base to absorb and balance force effectively on uneven ground.

Gyroscopic Mechanism:

Notes: Inspired by the balance of orangutans in treetops. This gyroscopic system helps keep drinks or tools level even when the user is moving, reducing spills and enhancing control.

Cloven Hoof-Inspired Balance Stand:

Notes: Like a mountain goat's hoof, which spreads on rough terrain to stabilize the body, this design creates a stand that slightly expands under pressure, increasing stability on irregular surfaces.

2. Lightweight and Portable Design

Expandable Hollow Cylinder:

Notes: Draws from the lightweight and elongated neck of giraffes. By creating a hollow, telescoping structure, the tool remains portable and easy to store. Expansion allows access to hard-to-reach areas without compromising strength.

Elongated, Hollow Handle:

Notes: Made from eco-friendly, sustainable materials, this elongated design reduces weight without sacrificing reach, allowing users to maneuver it easily over extended periods.

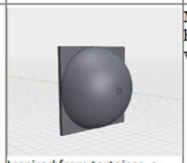
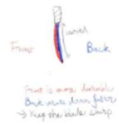
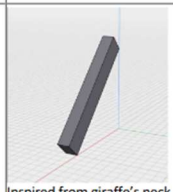
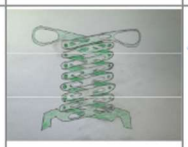
3. Enhanced Grip

Hippo Jaw C-Clamp:

Notes: Inspired by the powerful bite force of hippo jaws, this C-clamp secures objects firmly using compressive forces. Ideal for holding materials in place during tasks that require precise positioning.

Hyrax-Inspired Gripping Pads:

Notes: Hyrax feet have soft, grippy pads that provide increased surface contact. These pads can be applied to the tool's handle to improve grip,

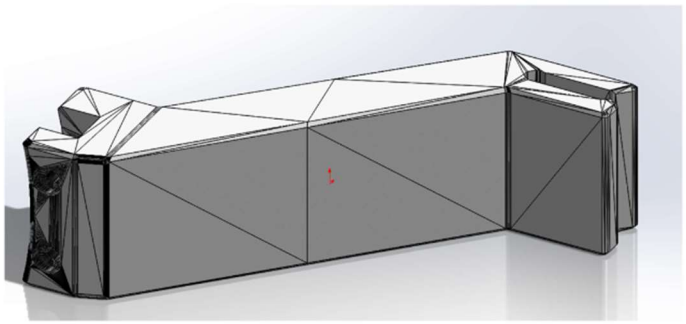
	Elephant trunk inspired flexible grasper	Chameleon inspired Flexible Grasper	A design inspired by the soft pads of the hyrax's feet that can adapt and provide grip to various surfaces because of its flexible material		especially useful for users in wet or sweaty conditions. 4. Adaptability and Flexibility Elephant Trunk or Chameleon Tail-Inspired Grasper: Notes: A flexible tool head that can wrap around or conform to various shapes, enabling users to grab, twist, or manipulate objects that are otherwise hard to reach or irregularly shaped. Hyrax Foot Pads for Surface Adaption: Notes: Provides grip on multiple surfaces by conforming to irregular textures. The material's compressibility allows for a more versatile grip across different types of materials and surfaces. 5. Durability in Varied Environments Tortoise Shell-Inspired Dome for Stress Distribution: Notes: The dome shape distributes force across the structure, reducing the chance of localized wear or stress. This makes the tool durable for long-term use, particularly in high-pressure applications. Mantis Shrimp-Inspired Hammer: Notes: The mantis shrimp's club is known for durability and impact resistance. A hammer based on this design would be built to handle repeated impacts and resist chipping or deformation. Porcupine-Inspired Blade: Notes: A blade inspired by porcupine teeth would have areas of different hardness, allowing it to self-sharpen as it wears. This prolongs sharpness, reducing the need for frequent maintenance. 6. Safety Cambered Edges for Protection: Notes: Rounded edges on the tool handle or attachments to prevent accidental cuts or scrapes. Particularly useful in tools that might be used in cramped or tight spaces. Self-Stabilizing Gyroscopic Cup Holder: Notes: This feature ensures that hot or cold drinks remain upright while the user is in motion, reducing the risk of spills and burns. It could be especially useful on construction sites or other active environments. 7. Reach Extension Giraffe Neck-Inspired Telescoping Rod: Notes: This design allows for controlled extension, giving users the option to adjust the reach as needed. The telescoping feature also aids in storage and portability. Curved Shears Modeled After Southern Bald Ibis Beak: Notes: Ideal for trimming or cutting in narrow spaces, as the curved design of the blade can reach around obstacles. The slender profile reduces bulk, making it suitable for intricate or detailed tasks.
TASK/SUBTASK(function): Durability in Varied Environments	 Inspired from tortoises, a domed shape design to withstand stress by distributing forces from rod	Mantis shrimp inspires hammer that is durable in varied environments. 	 A blade design that is inspired by the principle of differential wear in porcupine's teeth that would prolong the wear of the blade and keep it sharp for longer		
TASK/SUBTASK(function): Safety	 Cambered edges protect from cuts	 Gyroscopic cup holder to not spill hot coffee in your car while driving.			
TASK/SUBTASK(function): Reach Extension	 Inspired from giraffe's neck an elongated rod for higher reach	 Inspired from giraffe an enhanced version of rod which extends and contracts which gives control overreach		 A trimming shear inspired by the Southern Bald Ibis long, slender and curved beak that is designed to access hard to reach places.	

DESIGN PROBLEM DEFINITION: Design a self-stabilizing, gyroscopic cup holder inspired by the orangutan's gripping abilities to keep beverages upright and spill-resistant in dynamic environments. This holder should be compact, adaptable to different cup sizes, and provide stability in moving or uneven settings.

DESIGN CONCEPTS

TOP THREE SOLUTIONS

1.



Self-Stabilizing Gyroscope:

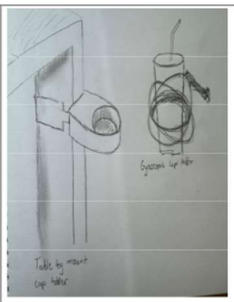
- A small gyroscope in the base that automatically stabilizes the cup by counteracting shifts and tilts. Inspired by orangutans' ability to maintain balance in trees, this feature keeps drinks level regardless of the vehicle or holder movement.

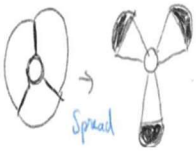
Adjustable springs for Various Cup Sizes:

- Spring-loaded clamps allow for a secure fit with various cup sizes, providing versatility for different beverage containers. Keeps drinks from wobbling or tipping during travel.

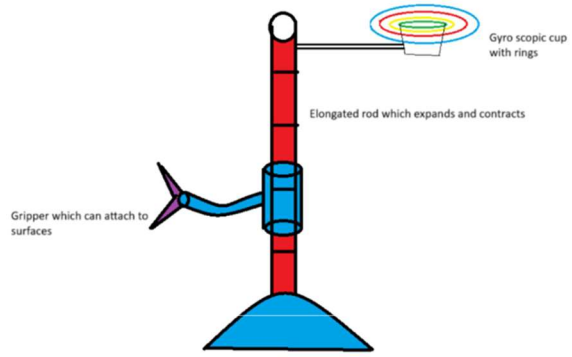
Car vent clamp:

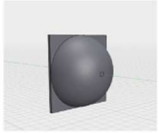
- The friction-fit car vent clamp, inspired by the hippo's powerful jaws, uses a rubberized, contoured surface to create a secure, non-slip connection on car air vents. This design offers a strong hold without springs, allowing easy mounting and dismounting while protecting the vent from scratches or wear. The rubber surface enhances friction, keeping the holder stable even on rough roads.

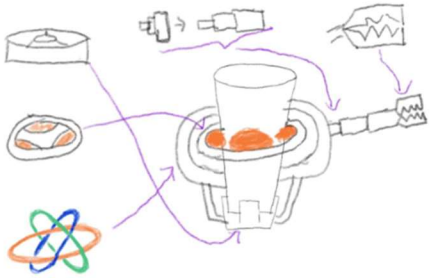




This is a Gyroscopic cup holder dynamic stability control , it is attached with extendable rod and it is supported with a dome shaped structural foundation base ,on middle of this rod a gripper is attached which can attach this whole system to a surface







The design incorporates 5 concepts from the chart.

1/ Soft/elastic pads to grip the sides of the cup based on hyrax's feet.

2/ A cloven-shaped base that would hold, grip and stabilize the cup based on mountain goat's hoof.

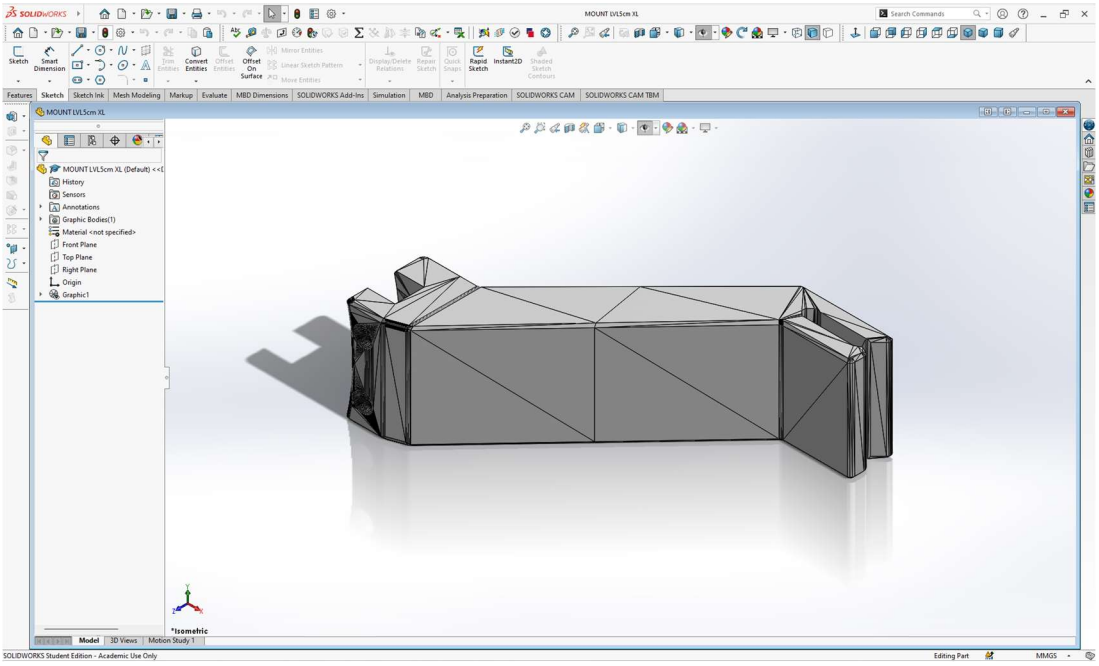
3/ A self-stabilized gyroscope outer rings that would automatically level the cup based on the orangutan.

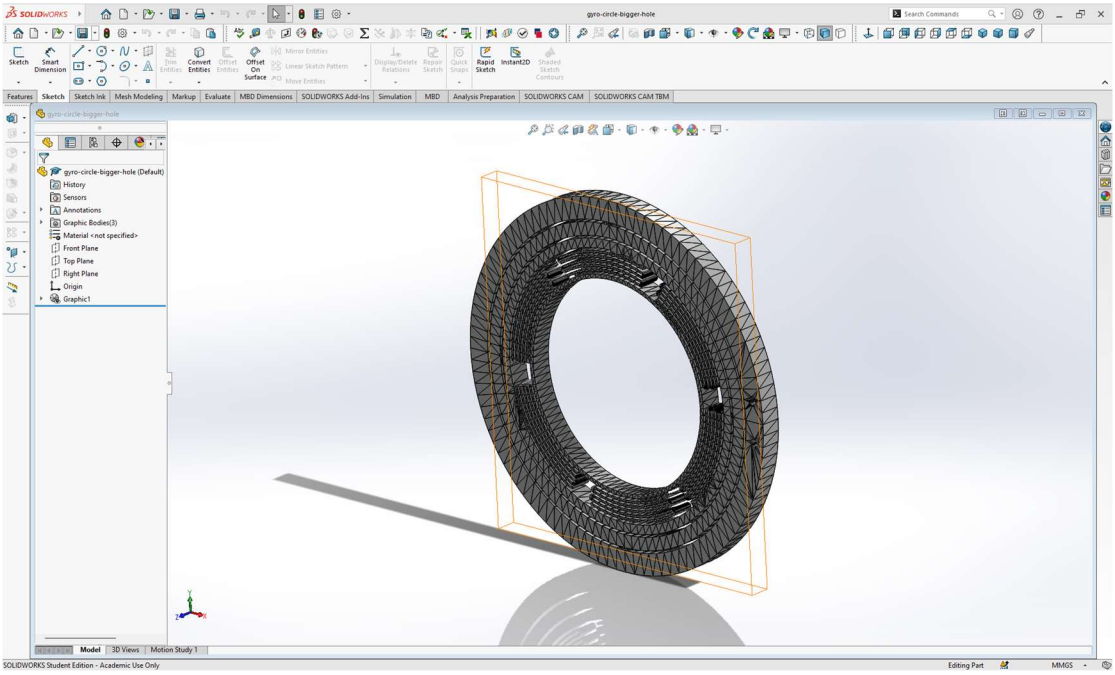
4/ An extendable/collapsible rod to attach to hard-to-reach places inspired from the giraffe's neck

5/ The clamp is inspired by the hippo's jaw

STL Files

The stl files below are inserted into the report via images however the SolidWorks file versions are attached to the report.





Appendix

Daniel Nguyen

FUNCTION

The function of hyrax feet is primarily to provide traction and stability on rocky and uneven surfaces, allowing these animals to navigate steep terrains safely. Their feet helps them climb effectively and access food sources in trees or rocky outcrops, which is crucial for their foraging habits. This correspond to Move or Stay Put.

ORGANISM

Rock Hyrax

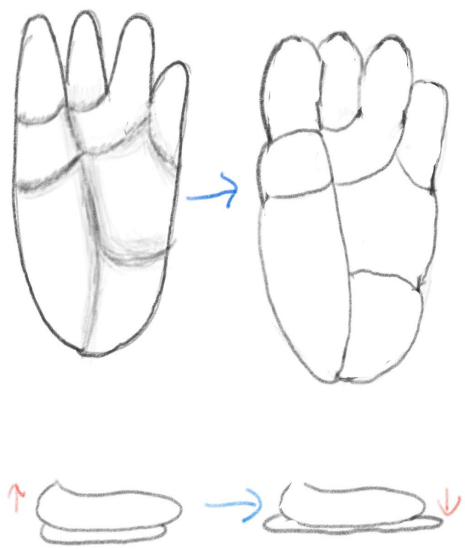
Procavia capensis

BIOLOGY STRATEGY

Hyrax feet are uniquely adapted to provide both traction and stability, which is essential for their survival in rocky habitats. The thick, padded soles of their feet enhance grip on uneven surfaces, allowing hyraxes to move confidently across cliffs and rocky terrains. The combination of soft pads and short claws helps them maintain balance, making it easier to climb and forage in their arboreal and rocky environments. This adaptation not only facilitates their movement but also reduces the risk of slipping, enabling hyraxes to escape predators and access food sources that would otherwise be difficult to reach.

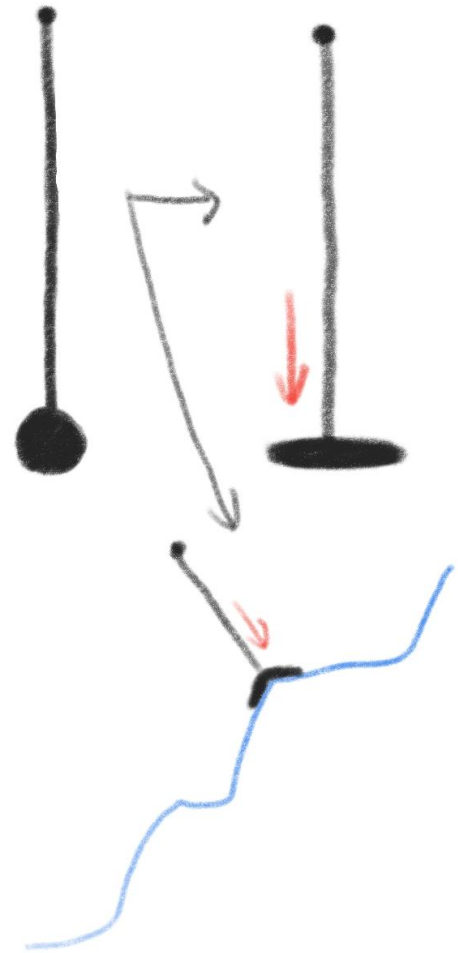
MECHANISM

The soft pads increase the surface area of contact and absorb shock for better grip and stability. Short claws provide just enough grip to dig in without being overly sharp or elongated, which can hinder movement



DESIGN PRINCIPLE

Use the principle of having a soft surface of contact to improve surface area and stability.



APPLICATION IDEA

A walking/hiking stick with a soft/rubber tip that can compress to increase surface area when pressed on.

REFERENCES/URLs

- https://encyclopedia.litcaf.com/science/animals/rock-hyrax/
- https://en.wikipedia.org/wiki/Hyrax
- https://en.wikipedia.org/wiki/Hyrax

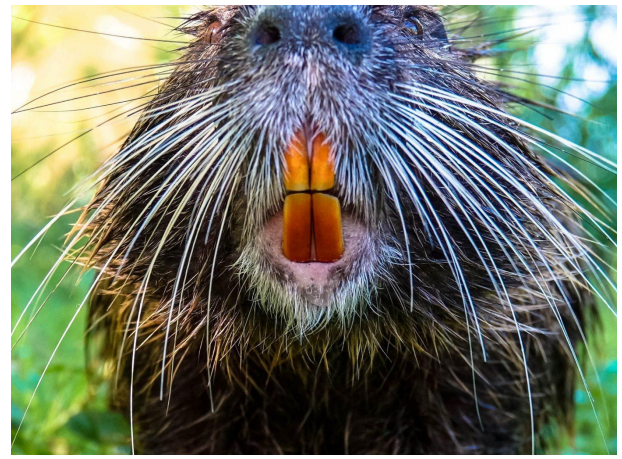
Daniel Nguyen

FUNCTION

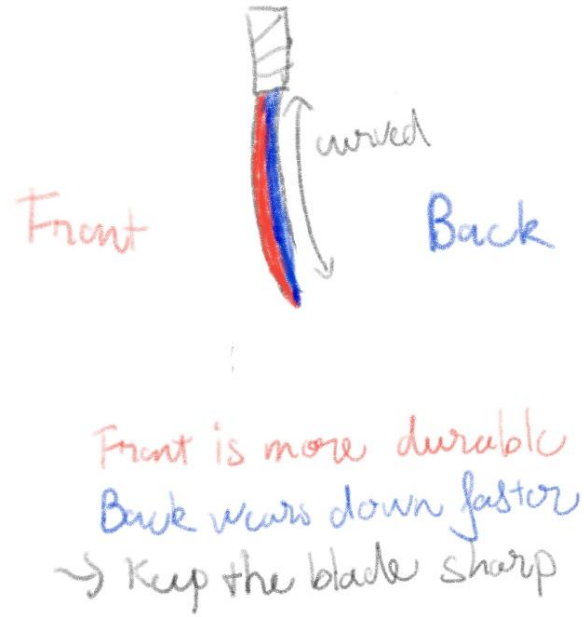
The function of porcupine teeth is to efficiently gnaw and process tough plant materials, such as bark and wood. Their teeth allow them to strip bark and access the nutrients within. The chisel-like shape of these teeth enables porcupines to exert the necessary force to break down fibrous plant matter, which is essential for their herbivorous diet and overall survival. This corresponds to Break Down.

ORGANISM

North American porcupine
Erethizon dorsatum



DESIGN PRINCIPLE
Use the principle of differential wear to keep the sharpness of the tool and mimic the slight curvature of their teeth for carving and slicing

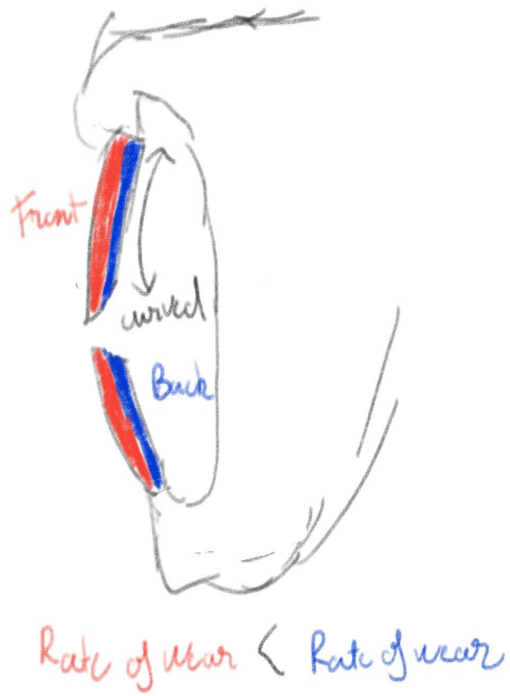


BIOLOGY STRATEGY

Porcupine teeth are biologically adapted to effectively strip bark and maintain sharpness through continuous growth and specialized structure. The front surface of the incisors is covered with hard enamel, while the back surface is softer dentin. When porcupines gnaw on wood, the harder enamel wears more slowly than the softer dentin. This differential wear causes the cutting edge to maintain a sharp profile, as the softer material wears away faster, keeping the leading edge keen. The slight curvature of the teeth helps facilitate a slicing motion as they cut through bark. This design allows the porcupine to exert force efficiently, increasing the effectiveness of their gnawing action.

MECHANISM

The differential wear of their teeth keeps them sharp. Their teeth also has a slight curvature to allow for efficient gnawing.



APPLICATION IDEA

A wood chisel with a curve edge and a self-sharpening feature based on differential wear

REFERENCES/URLs

- https://animarticle.com/porcupine-teeth/
- https://www.atholdailynews.com/speaking-of-nature-june-10-55491575
- https://sandiegozoowildlifealliance.org/story-hub/zoonooz/the-point-of-porcupines

Daniel Nguyen

FUNCTION

The function of the Alexandrine parakeet beak is to efficiently grasp, manipulate, and crack open various food sources, including seeds, nuts, and fruits. Its beak enables the parakeet to handle tough shells and extract nutritious contents. This beak design also facilitates foraging in trees and other vegetation, helping the parakeet access a wide variety of food while maintaining a secure grip. This corresponds to Break Down and Move or Stay Put.

ORGANISM

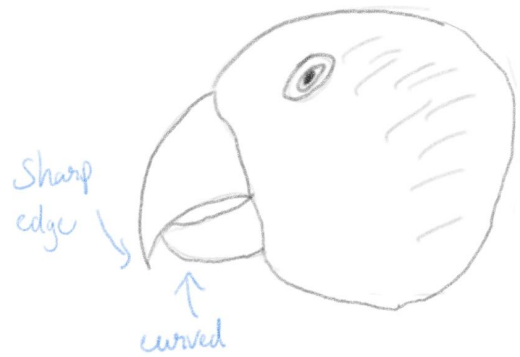
Alexandrine parakeet
Psittacula eupatria

BIOLOGY STRATEGY

The Alexandrine parakeet's beak is a remarkable adaptation that enables it to effectively crack nuts and tough seeds, essential for its diet. This strong, curved beak allows the parakeet to exert significant pressure when biting down, maximizing its ability to break open hard shells. The beak's shape is designed for both strength and precision, with sharp edges that facilitate gripping and slicing through tough outer layers. This is particularly important for accessing the nutrient-rich seeds within, as the beak's design allows the parakeet to manipulate food items with dexterity.

MECHANISM

The curvature of the beak gives them a mechanical advantage to exert force. The sharp edge improves grip and aid in slicing



DESIGN PRINCIPLE

Use the mechanically advantageous shape of its beak for breaking strength and its sharp edge design for slicing and grip

APPLICATION IDEA

A curve nutcracker that mimic the beak of the parakeet

REFERENCES/URLs

- https://www.parrots.org/ask-an-expert/cracking-beak-and-avian-nutrition
- https://parrotsupplies.co.za/blogs/chloes-story/the-science-behind-new-world-parrots-and-their-beaks?srsltid=AfmBOoqRwQZHfb6j31JxOLL4cgtdL4mqX8X_LHKsfuHxAAqaWNDFGDaI
- https://en.wikipedia.org/wiki/Alexandrine_parakeet

Daniel Nguyen

FUNCTION

The function of the Southern Bald Ibis beak is to probe, forage, and capture a variety of food sources, including insects, crustaceans, and small invertebrates found in mud and shallow water. Its beak allows the ibis to reach into narrow crevices and soft substrates, enabling it to extract food efficiently. This specialized beak design is crucial for foraging, as it helps the ibis locate and access hidden prey, contributing to its dietary needs and overall survival in diverse habitats. This corresponds to Get, Store or Distribute Resources

ORGANISM

Southern Bald Ibis
Geronticus calvus

BIOLOGY STRATEGY

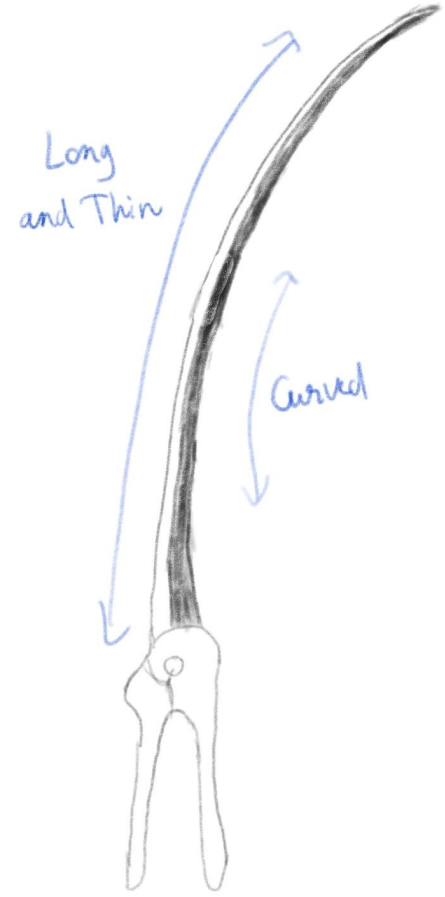
The Southern Bald Ibis beak is specially adapted for probing and foraging, allowing the bird to effectively access its food sources in wetland and mudflat environments. Its long, slender, and slightly curved shape enables the ibis to reach into soft substrates and crevices. This beak design not only facilitates precise movements but also helps the ibis navigate challenging terrain, such as muddy areas, without disturbing its surroundings too much. The curvature of the beak allows for efficient extraction of prey, as it can hook and pull food from difficult positions. This adaptation is essential for the ibis's foraging behavior, enhancing its ability to locate and capture food, which is vital for its survival.

MECHANISM

The slender, long and curved beak gives them the ability to accurately navigate hard to reach spots.

DESIGN PRINCIPLE

Use the long, slender and slightly curved shape of their beak to allow for precise movement into hard to reach spaces



APPLICATION IDEA

A long, thin and curved pruning shear for trimming and shaping branches.
A pair of specialized forceps that mimics the shape of the Ibis' beak to navigate hard to reach areas

REFERENCES/URLs

- https://en.wikipedia.org/wiki/Southern_bald_ibis
- https://animalia.bio/southern-bald-ibis?letter=s
- https://ebird.org/species/balibi1

Daniel Nguyen

FUNCTION

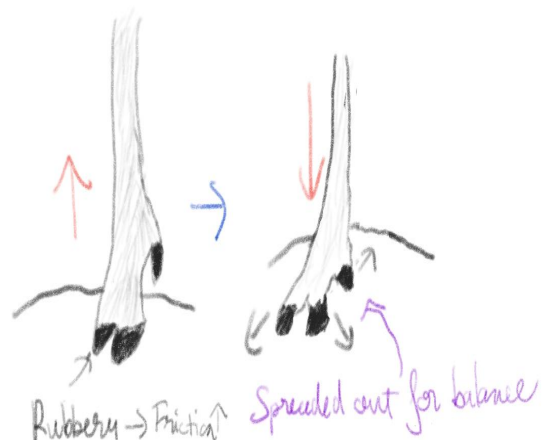
The function of Rocky Mountain goat hooves is to provide stability, traction, and agility on steep, rocky terrain. Their unique hooves design allows for excellent balance and maneuverability, enabling the goats to navigate narrow ledges and rugged surfaces with ease. Their hooves also prevent slips and falls while climbing or jumping. This combination of features allows Rocky Mountain goats to efficiently escape predators and access food in challenging environments. This corresponds to Move or Stay Put

ORGANISM

Rocky Mountain goat
Oreamnos americanus

BIOLOGY STRATEGY

The hooves of Rocky Mountain goats are finely adapted to support their survival in steep, rugged environments. The cloven structure of the hooves allows for superior balance and agility. The rubbery soles of the hooves enhance grip on slippery surfaces, significantly reducing the risk of slips and falls. Moreover, the ability of the hooves to spread apart increases their contact area with the ground, which helps distribute the goat's weight more evenly and provides additional support on uneven surfaces. The flexibility of the hooves also allows them to conform to varying terrain, further enhancing their effectiveness in maintaining footing

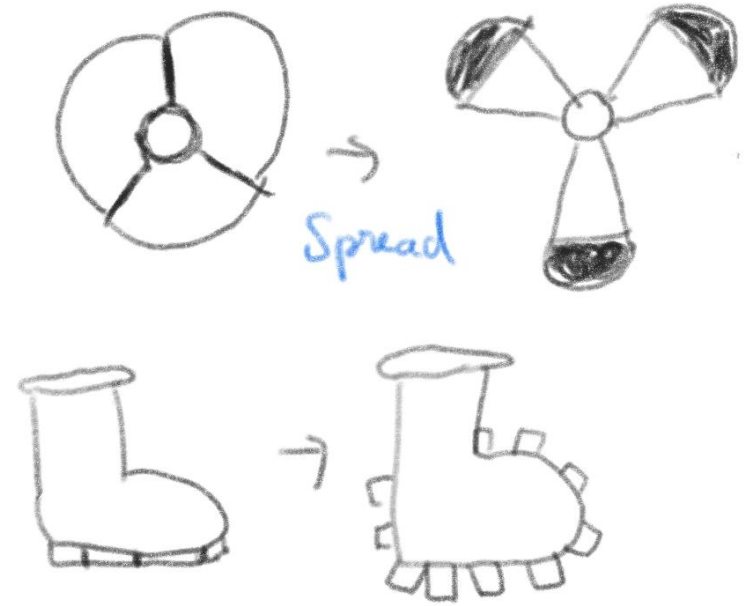


MECHANISM

The cloven design, the ability to spread and the rubbery nature of the hooves improve stability, increase surface area and improve grip

DESIGN PRINCIPLE

Use the cloven design and spreading mechanism to improve grip of devices



APPLICATION IDEA

A specialize shoe attachment that mimics the cloven and spreading design for hiking

REFERENCES/URLs

- https://animaldiversity.org/accounts/Oreamnos_americanus/
- https://www.robbiegeorgephotography.com/blog/blog_posts/mountain-goat-all-about-oreamnos-americanus
- https://en.wikipedia.org/wiki/Mountain_goat

Levi Manchester

FUNCTION

The trunk of an African elephant is a highly developed, flexible appendage that combines the functions of a nose and an arm. It is used for smelling, breathing, touching, grasping, and producing sound. This multifunctionality makes it an essential tool for elephants, allowing them to interact with their environment in various complex ways.

ORGANISM

African Elephant

Loxodonta Africana

BIOLOGY STRATEGY

Elephants use their trunks to perform delicate and strength requiring tasks, such as uprooting trees or gently picking up small objects. The trunk's ability to perform these tasks comes from its structure of around 40,000 muscles and no bones, providing flexibility and strength. This adaptability is important for their survival within the environment.

MECHANISM

How does nature achieve such versatility? The elephant's trunk functions without any bony support, relying solely on an intricate network of muscles that allow it to extend, contract, and bend with remarkable precision, enabling tasks from uprooting trees to picking up a pin.

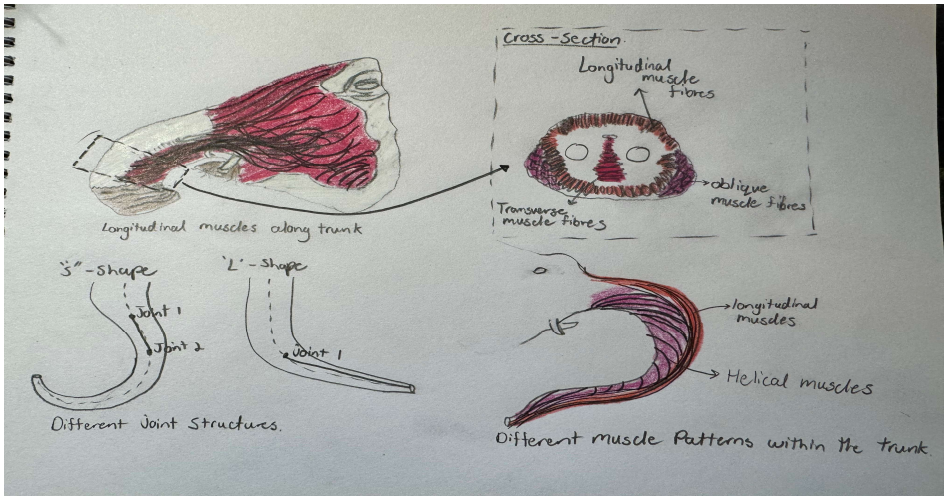


Figure 1. : Strategy Illustration

https://www.researchgate.net/figure/Muscular-architecture-within-the-elephant-trunk-a-Skinned-elephant-trunk-with_fig1_381450492

https://www.researchgate.net/figure/Biomimetic-continuum-robot-constructed-by-tensegrity-A-An-elephant-trunk-is-configured_fig1_368260640

DESIGN PRINCIPLE

Integrate segmented construction with a network of independent yet coordinated actuation points to replicate the elephant trunk's blend of muscular flexibility and strength, facilitating dynamic and adaptable tool applications that can range from heavy lifting to precise, delicate manipulations.

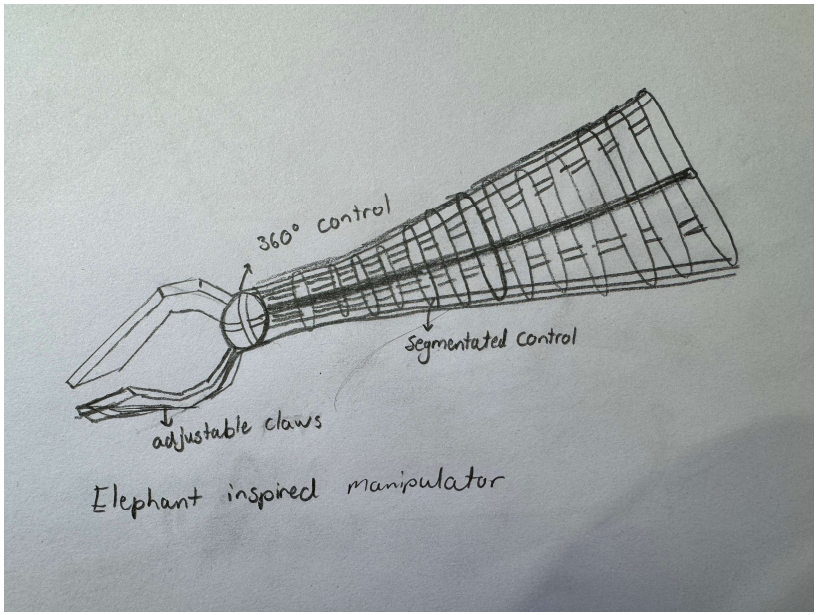


Figure 2. : Design Principle Illustration (drawing)

The illustration supports the written design principle and facilitates application of it in design.

APPLICATION IDEA

Inspired by the elephant's trunk, develop a versatile, robotic arm for use in diverse fields such as manufacturing, where it can adapt its grip strength and dexterity. This could involve a soft robotics design that mimics the trunk's muscular structure, enabling it to handle both sturdy and delicate materials without switching tools.

REFERENCES/URLs

https://www.nationalgeographic.com/animals/mammals/facts/african-elephant

https://asknature.org/strategy/how-elephant-trunks-twist-and-twirl/

https://asknature.org/innovation/flexible-gripper-inspired-by-the-elephant-trunk/

Levi Manchester

FUNCTION

Chameleons capture prey by projecting their tongues with exceptional speed and accuracy to catch insects typically out of reach.

ORGANISM

Chameleon

Chamaeleonidae

BIOLOGY STRATEGY

Chameleons possess a highly specialized tongue that can extend rapidly to capture prey at distances more than twice their body length. This rapid projection is facilitated by a complex of muscle and elastic tissues. According to "Elasticity and Movements of Chameleon Tongues" published in Animal Biomechanics, the tongue operates as a biomechanical 'spring-loaded' system where potential energy is stored in elastic tissues and rapidly converted to kinetic energy, allowing for the ballistic projection of the tongue at high speeds.

MECHANISM

How does nature strike so rapidly and accurately? The chameleon's tongue launches using a ballistic mechanism where elastic collagen fibers store energy when compressed, then rapidly expand to project the tongue forward at high speeds, achieving precise strikes on distant prey.

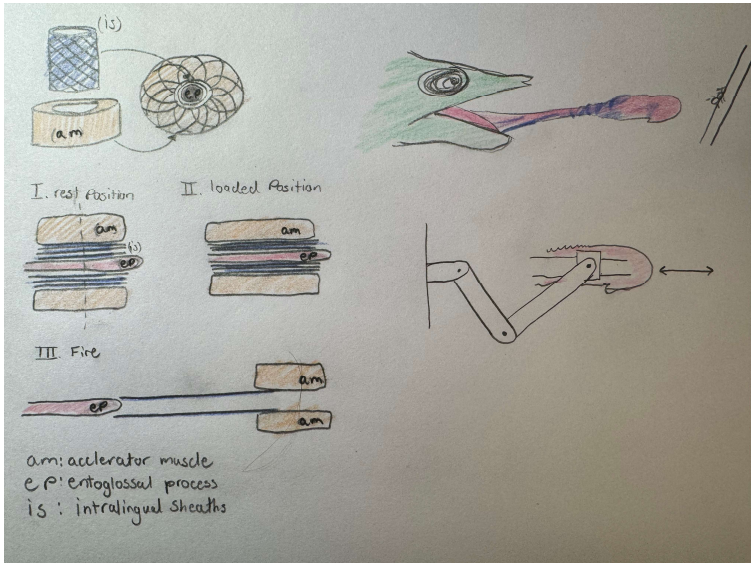


Figure 1. : Strategy Illustration
A diagram or illustration to support the Biology Strategy.

DESIGN PRINCIPLE

Incorporate advanced recoil mechanisms that allow for rapid extension and retraction, mimicking the chameleon's tongue. This principle is ideal for developing devices that need to quickly reach out and retract, ensuring precise operations over a distance with minimal energy expenditure.

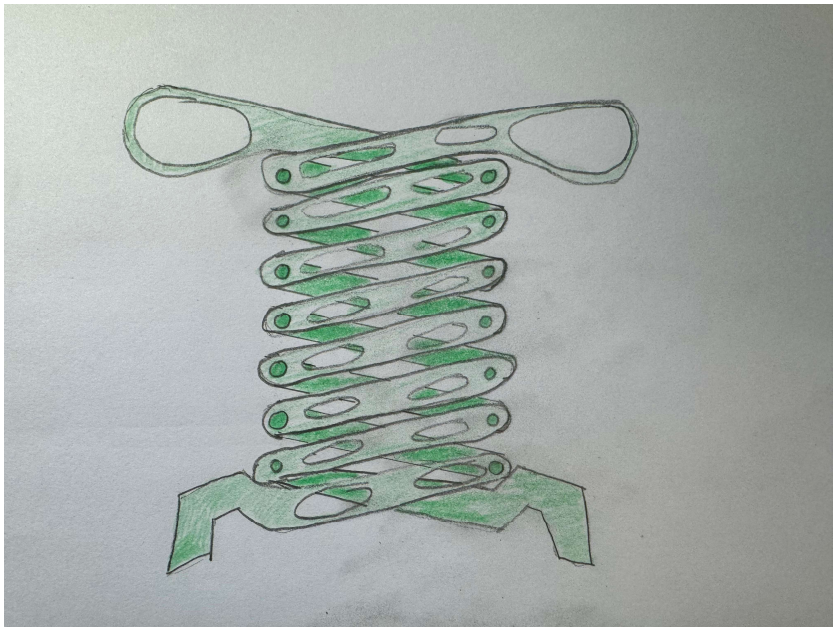


Figure 2. : Design Principle Illustration
The illustration supports the written design principle and facilitates application of it in design.

APPLICATION IDEA

Design a rapid-deployment medical device based on the chameleon's tongue, capable of extending quickly to precisely deliver treatments or perform minimally invasive surgeries. This device would be particularly useful in situations where traditional surgical access is difficult or where quick, precise actions are necessary.

REFERENCES/URLs

https://asknature.org/strategy/chameleons-launch-ballistic-tongues/

https://www.deviantart.com/ambr0/art/The-hyoid-bone-and-the-tongue-of-the-Chameleon-746445314

Levi Manchester

FUNCTION

Archerfish excel in precision targeting by shooting jets of water to knock down aerial prey. This specialized skill can inform the design of precision delivery systems in various applications, such as targeted irrigation systems, precise cleaning devices, or non-invasive medical treatments that require focused application of agents.

ORGANISM

Archer Fish

Toxotes chatareus

BIOLOGY STRATEGY

The archerfish exhibits an extraordinary ability to knock down prey with a stream of water expelled from its mouth. Research documented in "Hydrodynamics of Prey Capture in Archerfish" in the Journal of Experimental Biology demonstrates that this fish adjusts the hydrodynamics of water in its mouth to create a powerful, targeted jet, a mechanism that allows it to feed on insects and small animals outside its aquatic environment.

MECHANISM

How does nature target from a distance? The archerfish shapes the water in its mouth into a focused jet by adjusting the orifice formed by its gills and tongue, enabling it to shoot with precision accuracy at insects above the water's surface.

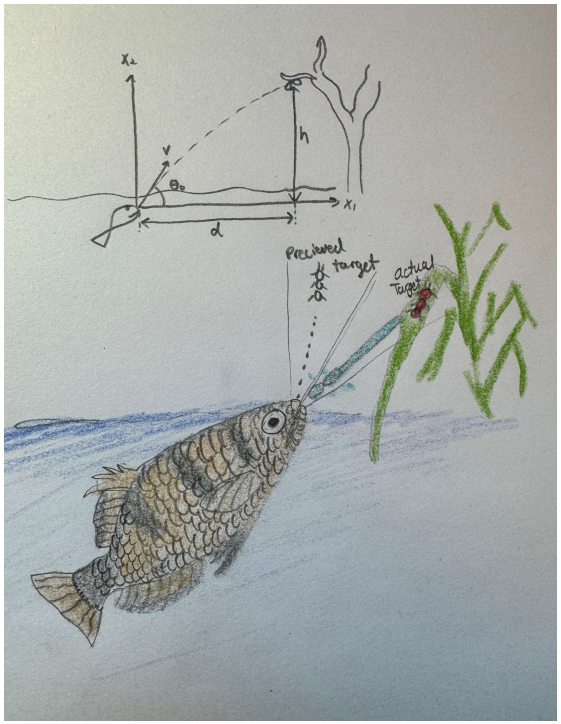


Figure 1. : Strategy Illustration (drawing)
A diagram or illustration to support the Biology Strategy.
https://www.researchgate.net/figure/The-hunting-mechanisms-of-archerfish_fig1_349025695

DESIGN PRINCIPLE

Develop an attachable, adjustable nozzle for faucets that emulates the Archerfish's ability to precisely control water jets. This nozzle would transform the faucet into a hydration station, allowing users to adjust both the angle and force of the water stream for easy drinking directly from the tap. This concept leverages the Archerfish's precise targeting mechanism to create a versatile, user-friendly device that enhances everyday convenience and water accessibility in homes or public facilities.

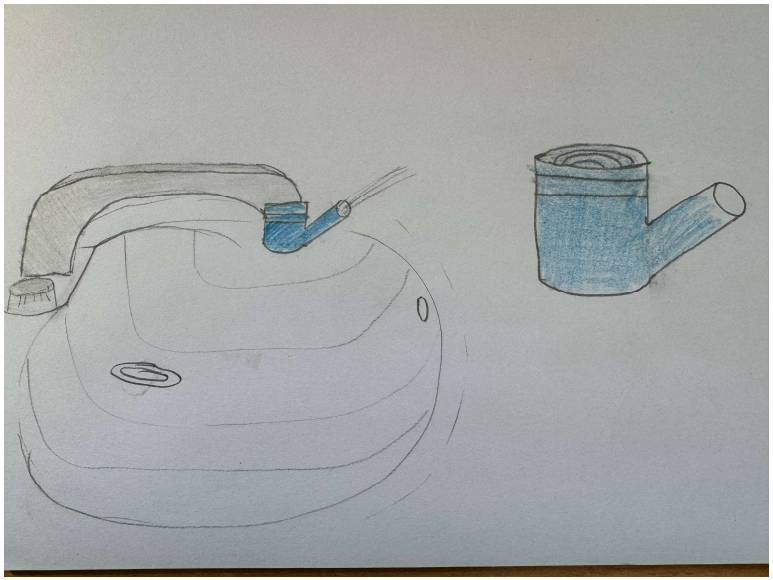


Figure 2. : Design Principle Illustration (drawing)
The illustration supports the written design principle and facilitates application of it in design.
https://www.allthat3d.com/3d-printing-make/

APPLICATION IDEA

Utilizing the archerfish's precise shooting technique, develop a cleaning device that targets hard-to-reach areas, such as high ceilings or intricate machinery parts. This device would use a controlled jet system to apply cleaning agents or water precisely where needed, minimizing waste and avoiding the need for physical contact with the surface.

REFERENCES/URLs

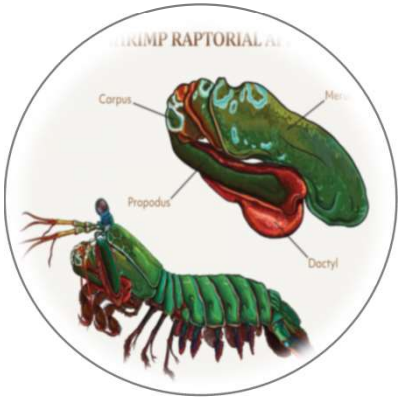
https://asknature.org/strategy/external-hydrodynamic-lever-increases-force/

https://www.nbcnews.com/science/weird-science/nice-shot-archerfish-use-complex-process-turn-water-tool-n196291

Levi Manchester

FUNCTION

The mantis shrimp is known for its exceptionally fast and powerful strikes, thanks to its specialized limbs. This biological function is ideal for inspiring the design of high-speed, high-impact tools used in demolition, material testing, or any field where rapid and forceful action is advantageous.



ORGANISM

Mantis Shrimp

stomatopoda

BIOLOGY STRATEGY

The mantis shrimp's striking appendage operates through an advanced mechanical system that allows for extremely rapid and powerful strikes. According to "The Mechanics of Punching by the Mantis Shrimp" published in Marine Biology Reports, this crustacean uses a latch mechanism that stores elastic energy in specialized tendons, releasing it in a fraction of a second to generate the forceful impact necessary for breaking shells or stunning prey.

MECHANISM

How does nature deliver such powerful strikes? The mantis shrimp uses a spring-like mechanism involving elastic energy storage in tendons; this energy is rapidly released, propelling its hammer-like appendage forward with enough force to shatter glass.

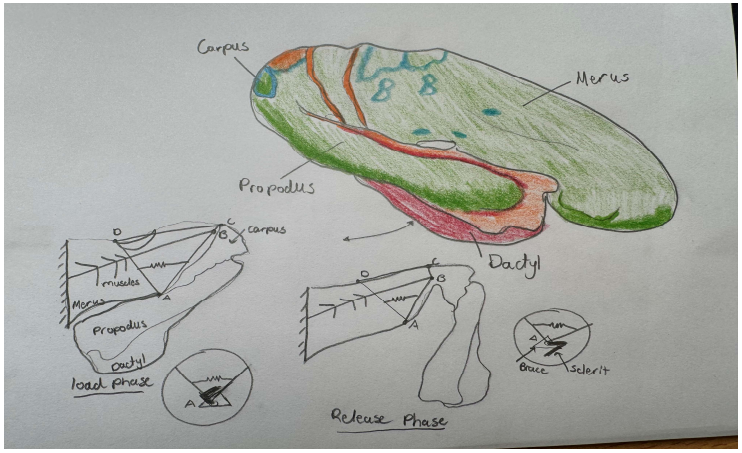


Figure 1. : Strategy Illustration (drawing)
A diagram or illustration to support the Biology Strategy.
https://link.springer.com/article/10.1007/s42235-022-00227-8

DESIGN PRINCIPLE

Harness the potential of elastic energy storage and rapid-release mechanisms to create tools that deliver sudden, high-impact forces efficiently, akin to the mantis shrimp's strike. This concept is applicable in designing high-performance impact tools in engineering, which require both precision and power, without the need for electronic components.

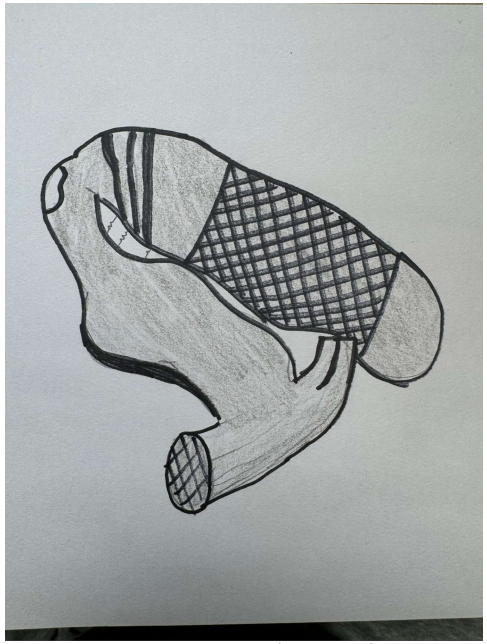


Figure 2. : Design Principle Illustration (drawing)
The illustration supports the written design principle and facilitates application of it in design.

APPLICATION IDEA

Drawing on the mantis shrimp's powerful strike, engineer a new type of hammer or impact tool that uses stored energy to deliver powerful blows without the need for repeated action or great physical strength from the user. This could be used in demolition, in driving stakes, or in any application where compact, high-energy impacts are required.

REFERENCES/URLs

https://asknature.org/strategy/appendage-creates-tremendous-forces/

Levi Manchester

FUNCTION

Orangutans demonstrate remarkable abilities in climbing and manipulating objects, using their strength and dexterity. Such capabilities inspire the development of tools and devices that enhance human interaction with challenging environments, particularly in areas requiring versatile and dynamic manipulation abilities.

ORGANISM

Orangutan

Pongo Pygmaeus

BIOLOGY STRATEGY

Orangutans are adept at manipulating their environment using their limbs and hands, which are capable of grasping with significant strength and dexterity. Studies highlighted in "Orangutan Adaptations to an Arboreal Lifestyle," Journal of Primate Biology, indicate that their limb flexibility and joint design allow for remarkable feats of strength and mobility, necessary for navigating the complex canopy structures of their forest habitats.

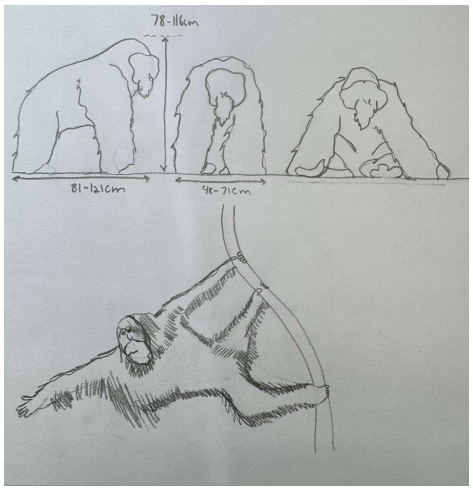
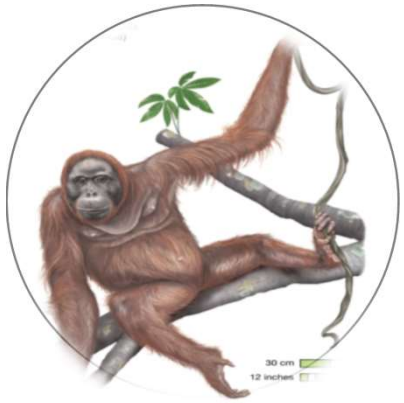


Figure 1. : Strategy Illustration (drawing)
A diagram or illustration to support the Biology Strategy.
https://www.dimensions.com/element/bornean-orangutan-pongo-pygmaeus
https://www.researchgate.net/figure/An-example-of-tree-sway-in-an-orangutan-The-orangutan-oscillates-the-branch-of-an_fig3_328111085



MECHANISM

How does nature enable complex manipulation?
Orangutans utilize a combination of muscular strength and skeletal flexibility, allowing their limbs to rotate and extend in ways that enable them to grasp and manipulate objects or swing from tree limbs efficiently.

DESIGN PRINCIPLE

Integrate dynamic balance control and flexibility into a cup holder design, inspired by the orangutan's ability to maintain stability while navigating through complex environments. This cup holder would automatically adjust to movements and tilts, ensuring that the contents remain level and secure, much like how an orangutan manages to keep its balance and composure in the treetops.

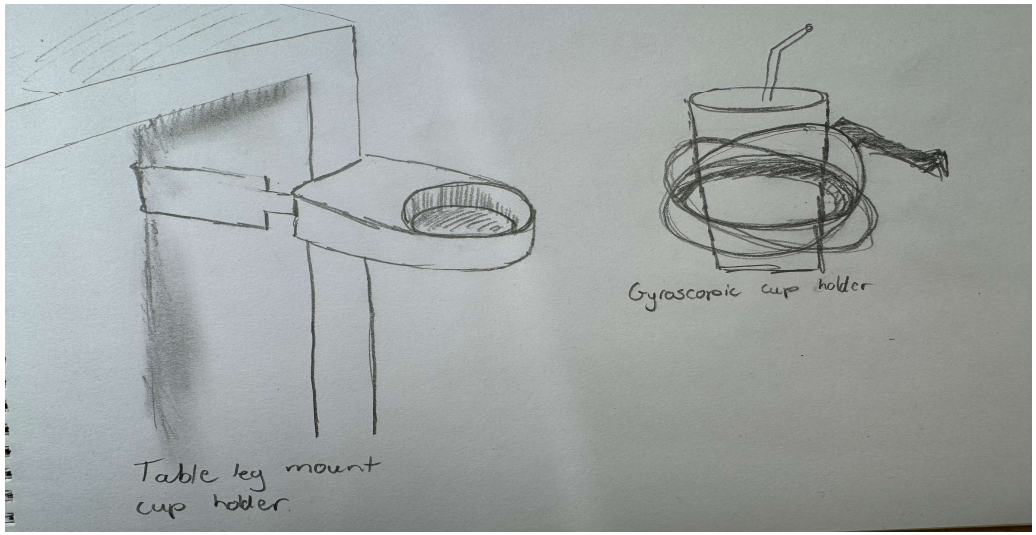


Figure 2. : Design Principle Illustration (drawing)
The illustration supports the written design principle and facilitates application of it in design.
https://www.printables.com/model/513181-customizable-leg-clamping-desk-cup-holder?lang=en

APPLICATION IDEA

Develop a self-balancing cup holder that uses a weighted and articulated base, mimicking the balance and agility of orangutans. This cup holder would be designed to automatically adjust to movements and tilts, keeping the container upright even in moving vehicles or unstable conditions. Ideal for use in cars, boats, wheelchairs, and other mobile environments, it enhances usability for all, especially those with mobility challenges or in dynamic environments.

REFERENCES/URLs

https://nationalzoo.si.edu/animals/orangutan
https://www.wwf.org.uk/learn/fascinating-facts/orangutans

Space for additional research and figures

Rajdeep Singh

FUNCTION

The shell of the tortoise is rigid and strong, protecting the tortoise from predators and environmental hazards. The shell is made up of individual plates (scutes) that interlock, allowing limited flexibility and resistance to cracking under pressure. The shell has multiple layers, including a hard outer layer and a more flexible inner layer, providing impact absorption and durability.

ORGANISM

Egyptian Tortoise
Testudo kleinmanni

BIOLOGY STRATEGY

The dome-shaped shell provides structural integrity and strength, allowing the tortoise to withstand pressure from predators and environmental factors. The shell is composed of a combination of keratin (the same material found in human nails and hair) and bony plates, which offer both flexibility and durability. The hard, protective shell serves as a barrier against predators, making it difficult for them to access the tortoise's soft body.

MECHANISM

The hard, protective outer layer of the shell acts as a formidable defense against predators. When threatened, the tortoise can retract its limbs and head into the shell, further enhancing its protection

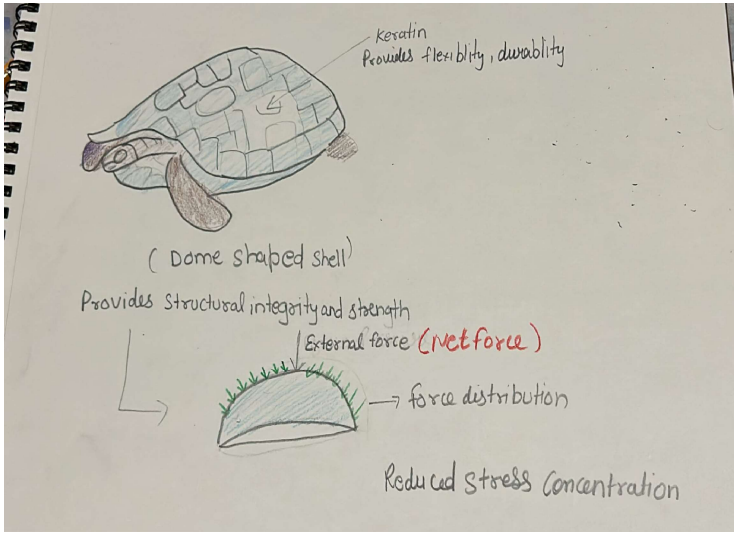


Diagram of force distribution on shell of tortoise

DESIGN PRINCIPLE

Use dome shapes in designs with ductile material to enhance strength and resilience against environmental pressures, inspired by the tortoise's shell.

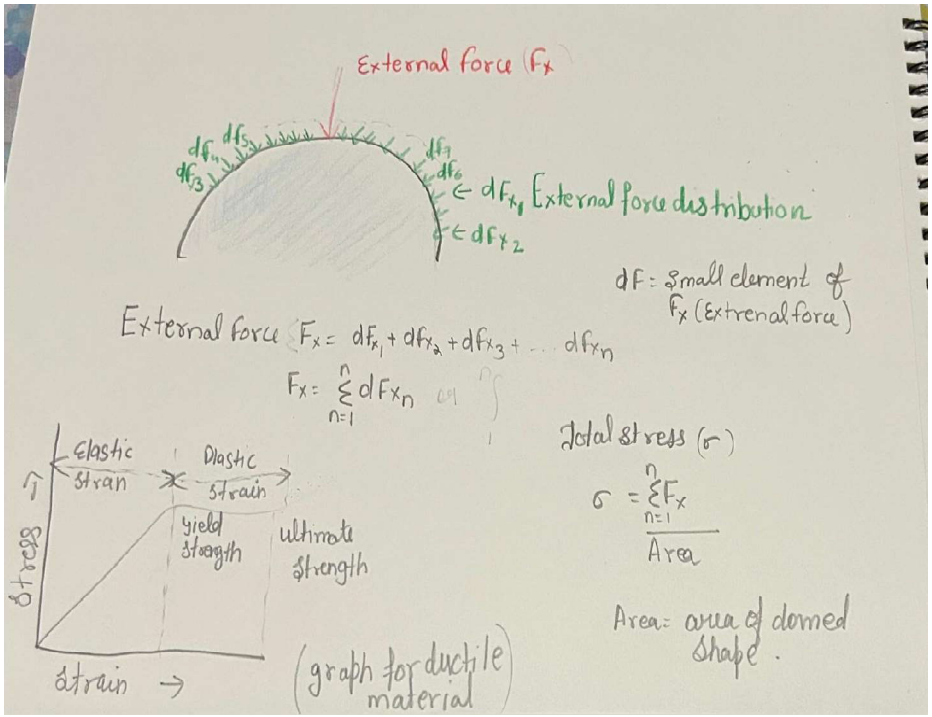


Diagram of force distribution on a domed shape area for design principle

APPLICATION IDEA

Using Dome shaped , designing a helmet for industrial use , which is brittle and can handle extreme stress to prevent injuries to head in case of an accident.

Rajdeep Singh

FUNCTION

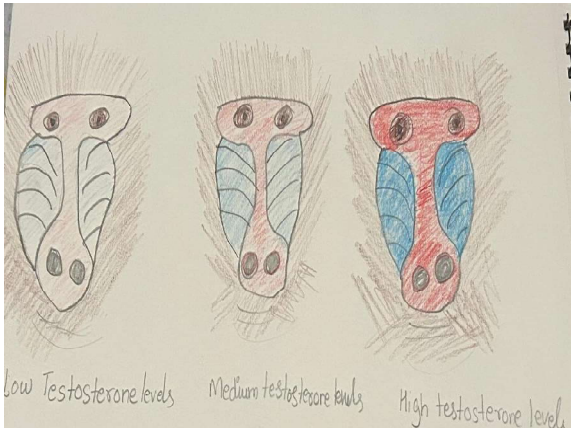
Mandrills use visual signals, specifically their vibrant facial and rump coloration, to convey social status, health, and emotions within their social groups. This function supports social cohesion, establishes hierarchy, and helps prevent conflicts by clearly communicating dominance and submission. For a biomimetic design, the function we want to emulate is a system that visually conveys specific conditions, status, or levels, facilitating efficient and non-verbal communication in group settings..

ORGANISM

Mandrill
Mandrillus sphinx

BIOLOGY STRATEGY

Mandrills exhibit one of the most striking examples of coloration in primates. Male mandrills display vivid blue and red coloration on their faces and rumps, which is directly correlated with their social rank and health status. The colors are intensified by testosterone levels, serving as a natural signal of physical condition and dominance to other mandrills. This adaptation allows them to signal their status and intentions visually, reducing the likelihood of physical confrontations within their group.



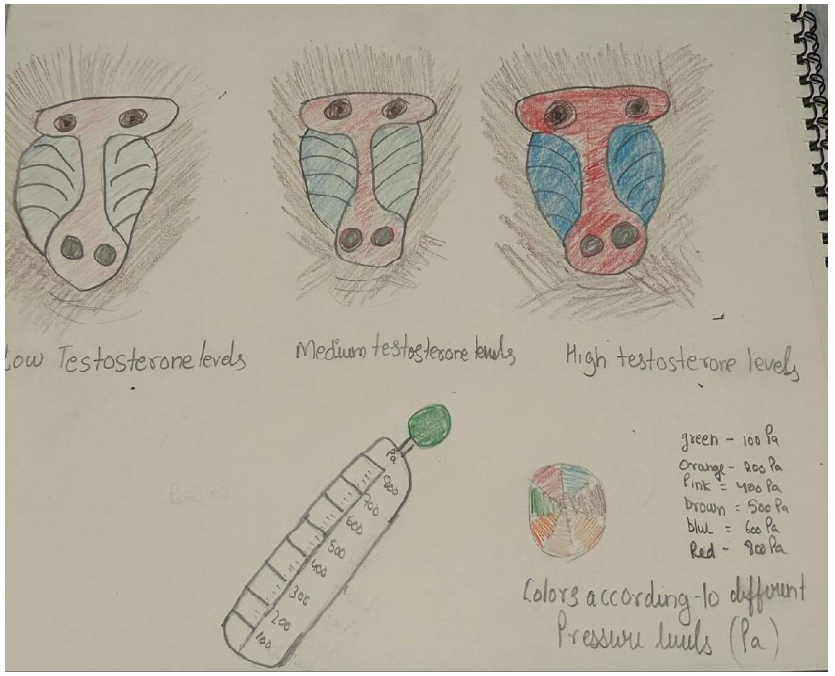
Levels of testosterone depicting change in facial color of mandrill

MECHANISM

Coloration in mandrills is primarily achieved through pigments influenced by hormones, such as testosterone, which enhances red and blue hues. This dynamic coloration adjusts with changes in the mandrill's health and social rank, making it an accurate, hormone-based visual cue

DESIGN PRINCIPLE

Develop a visual system that adjusts its appearance based on environmental or internal metrics to indicate current conditions or levels in real-time.



As pressure changes , color changes in a device. Temperature can be also opted in device giving a better Thermometer or a Manometer

APPLICATION IDEA

- a handheld tool with a surface that shifts color based on temperature, pressure, or other measured metrics could provide real-time feedback. This could be applied in settings like healthcare or manufacturing to quickly communicate status visually without the need for additional equipment.

Rajdeep Singh

FUNCTION

The ability to see in all directions enhances spatial awareness, allowing the Meerkat to navigate complex terrains effectively. This is particularly beneficial in densely vegetated or obstructed environments.

ORGANISM

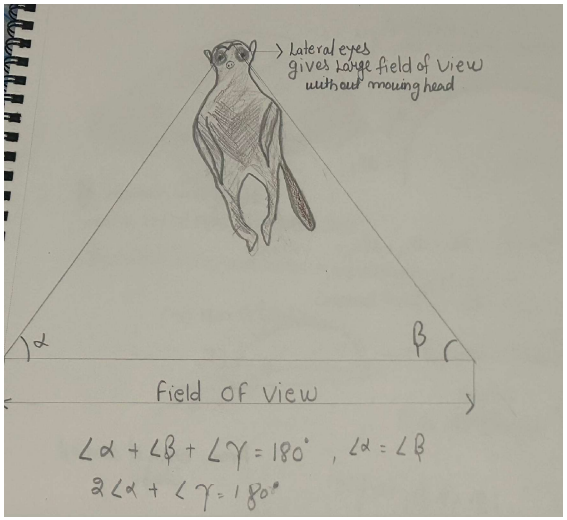
Slender-Tailed Meerkat
Suricata suricatta

BIOLOGY STRATEGY

Meerkats have lateral (side) eye placement, which grants them a wide field of view, allowing each meerkat to monitor a large area without needing to move its head extensively. Meerkats rely on sharp distance vision to spot predators, such as birds of prey or snakes, from afar. This ability to perceive threats before they are close allows meerkats to initiate escape strategies early.

MECHANISM

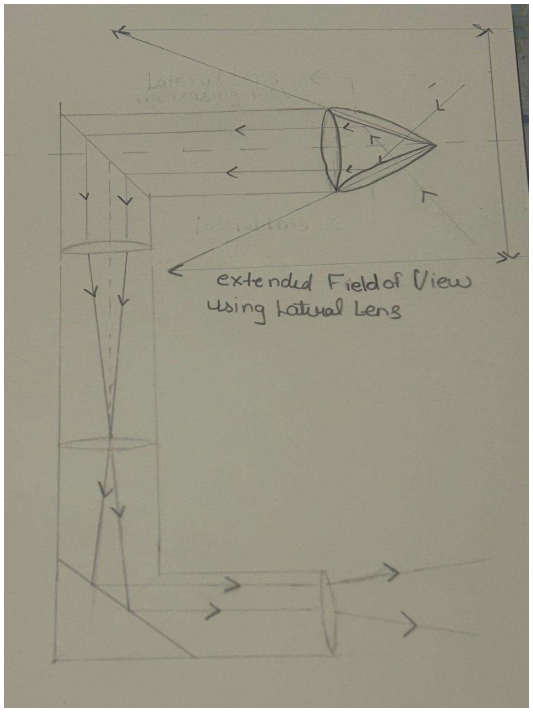
Meerkats have large, forward-facing eyes offer binocular vision and a nearly 360-degree field of view, allowing them to spot predators from afar. They can see some colors, mainly in the blue and green spectrum, and use visual signals for communication within their social groups, aiding in foraging and evasion of threats.



Field of View for a meerkat is bigger because of lateral eyes

DESIGN PRINCIPLE

An increasing field of view using lateral lens for periscope with a system of mirrors or prisms that captures maximum field of view, mimicking how meerkats can see around them without moving their heads.



Ray diagram for lateral lens in a periscope to increase its field of view

APPLICATION IDEA

Maximum Field of view periscope design using lateral lens leverages principles observed in meerkats, focusing on an omnidirectional field of view, stability, user-friendliness, and environmental integration, making it a practical tool for observation and exploration.

Rajdeep Singh

FUNCTION

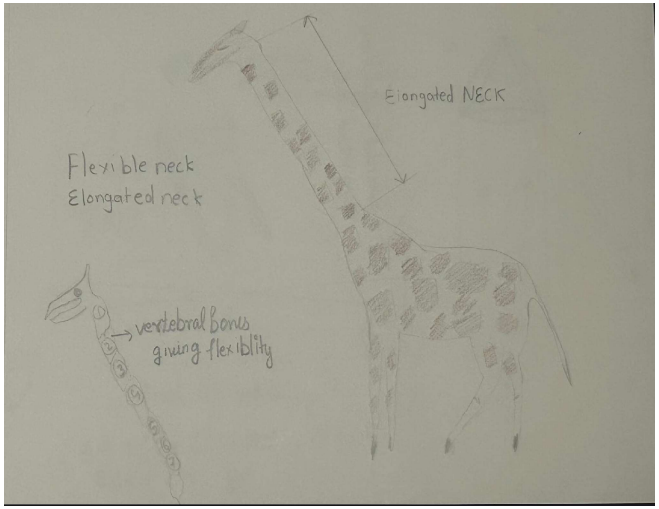
Masai giraffes use height to access food sources and scan for predators, giving them an advantage in both foraging and avoiding threats. This function could inspire designs that enhance visibility or extend reach.

ORGANISM

Masai Giraffe
Giraffa camelopardalis tippelskirchi

BIOLOGY STRATEGY

Giraffes' long and flexible necks and legs allow them to browse leaves from tall trees, minimizing competition with other herbivores. Their height also enables them to spot predators from a distance, providing a safety advantage. Male giraffes often engage in a behavior known as "necking," where they use their necks in combat to establish dominance and win mates. Longer necks are advantageous in these contests, contributing to the selection for longer necks over generations.



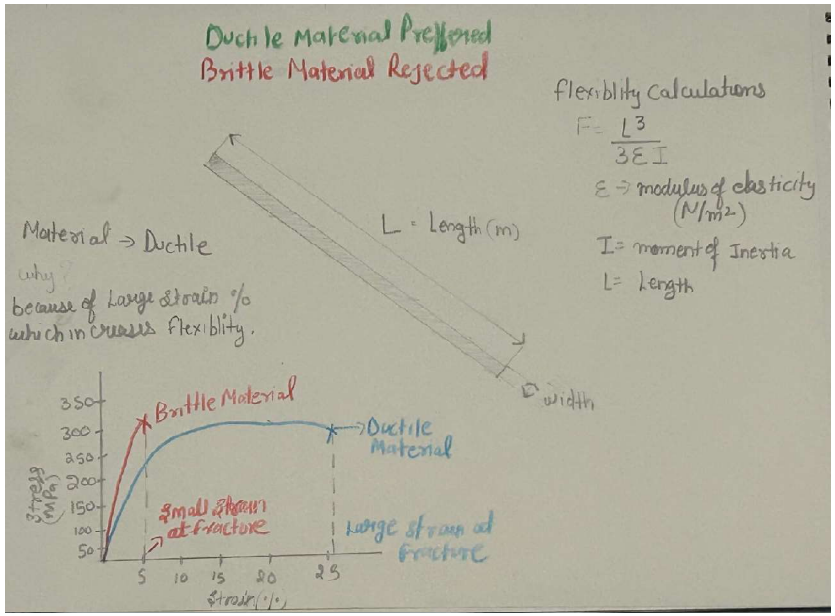
Elongated neck of a giraffe and showing its vertebrates.

MECHANISM

The giraffe's height and long limbs allow access to resources that are out of reach for others, enhancing foraging efficiency and predator awareness.

DESIGN PRINCIPLE

Optimize height or reach to access resources or improve visibility with a material which is flexible and can handle stress concentration without breaking.



Elongated rod or a beam with ductile material which increases its flexibilty

APPLICATION IDEA

- Design an extendable tool for reaching high objects

- Design a fishing rod
  Design a Baton
  Design a clamp with elongated tongs for surgical tool.

Rajdeep Singh

FUNCTION

The powerful jaws and large teeth are critical for protection against predators. Hippos can be aggressive, especially when defending their territory, and their bite can inflict severe damage.
Hippos primarily graze on grass, and their strong jaws allow them to uproot and chew tough vegetation.

ORGANISM

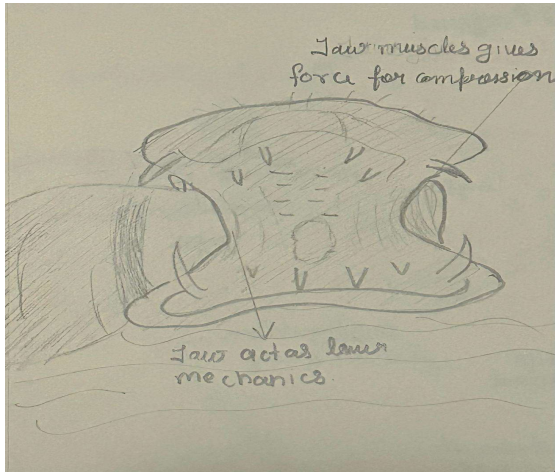
Hippopotamus
Hippopotamus amphibius

BIOLOGY STRATEGY

Hippos have evolved strong jaws and teeth to defend themselves and access tough vegetation. The biological strategy emphasizes strength and durability. The ability to crush hard materials enables hippos to exploit food resources that other herbivores might not access. The shape and size of the hippo's jaw contribute to its strength. The jaw is wide and robust, providing a larger surface area for muscle attachment and force distribution.

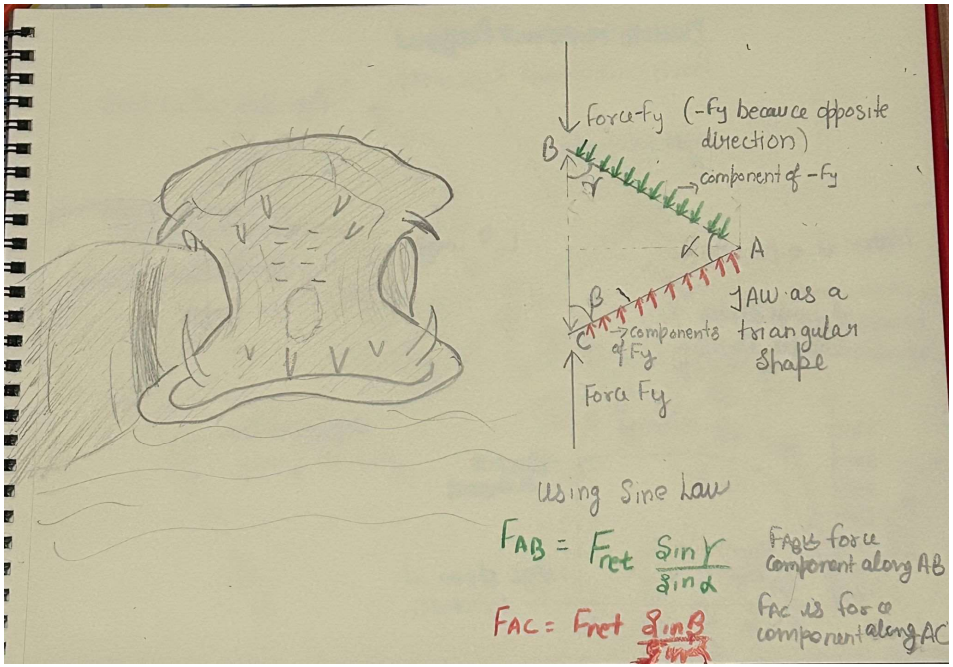
MECHANISM

Lever System: The jaw operates like a lever, with powerful muscles providing the force needed to close the jaw. This mechanical advantage allows hippos to exert extreme pressure.
Muscle Composition: The jaw muscles are highly developed, providing both strength and speed in closing the jaw, similar to hydraulic mechanisms in engineering.



Muscles of Hippo's Jaw gives compressive strength

DESIGN PRINCIPLE
Muscles of Jaws of a Hippo give extreme compressive power through high crushing forces while maintaining efficiency.



Force distribution along jaws which shows why hippos can give compressive force of 2,000 pounds per square inch (psi)

APPLICATION IDEA
Highly pressurized clamps

- Image references
- https://th.bing.com/th/id/OIP.AcF6xCrGYGSSZ1EH7lSBqQHaEV?w=312&h=183&c=7&r=0&o=5&dpr=1.3&pid=1.7
- https://africageographic.com/wp-content/uploads/2021/03/Male-mandrill-South-Eastern-Gabons-Rainforest-Giovanni-Mari.jpg
  https://th.bing.com/th/id/OIP.AcF6xCrGYGSSZ1EH7lSBqQHaEV?w=312&h=183&c=7&r=0&o=5&dpr=1.3&pid=1.7
- https://assets-global.website-files.com/5adf752e38b7222e27f146ee/5ba69649f49b779112f0136f_slender-tailed-meerkat-4.jpg
- https://th.bing.com/th/id/OIP.GUNMaKgj34GTH0ZJQSXXQwHaEV?w=317&h=186&c=7&r=0&o=5&dpr=1.3&pid=1.7
- https://th.bing.com/th/id/R.45aac287bb27ef7b9016269aecd9e230?rik=oCRw%2fVlYxOwvtw&riu=http%3a%2f%2f2.bp.blogspot.com%2f-ahfMk27FXQo%2fUPY3mB-S6OI%2fAAAAAAAACgg%2fT-Pezxut3jw%2fs1600%2fHippopotamus%2b1.jpg&ehk=qIZiJaphjV5VR8e23TqFouC5iiRqWjOPY%2fc07jgwhS4%3d&risl=&pid=ImgRaw&r=0

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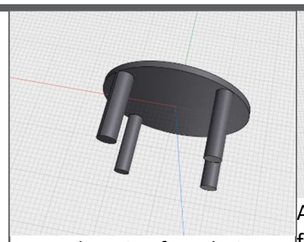
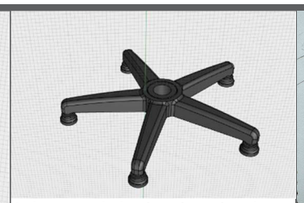
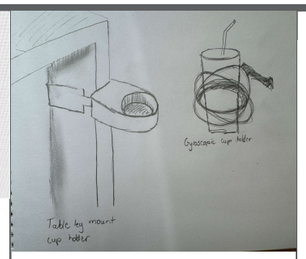
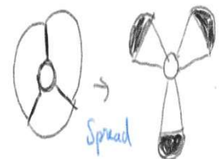
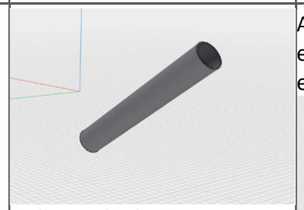
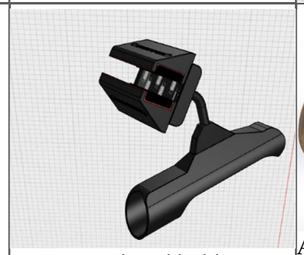
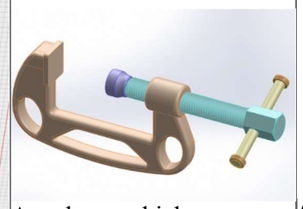
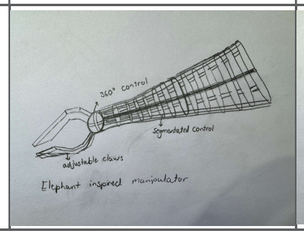
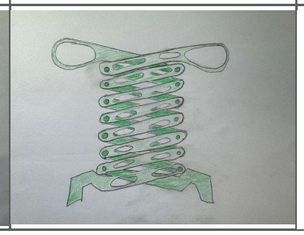
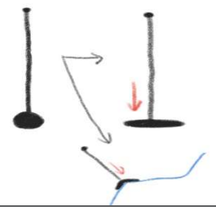
- Mandrill | San Diego Zoo Animals & Plants
- Giraffe | Facts, Information, Habitat, Species, & Lifespan | Britannica
- Hippopotamus, facts and photos
- Meerkat: Fascinating Facts, Behavior, and Conservation Status
- What is Brittleness - Definition | Material Properties
- Ductility - Ductile Definition and Examples
- What is Compressive Strength?- Definition, Formula
- Total internal reflection - IGCSE Physics Revision Notes
- 3.3 Distributed Loads – Engineering Mechanics: Statics

MORPHOLOGICAL CHART
TEMPLATE

DESIGN PROBLEM DEFINITION: Design a manual hand tool inspired by the unique functionalities of animals observed at the Wilder Institute/Calgary Zoo. The tool should incorporate biomimetic principles to enhance ergonomics and versatility for users in various manual labor and DIY tasks, operating efficiently without electricity and using sustainable materials.

Solutions →

TASK/SUBTASK(function):					
Dynamic Balance and Control (stability)	 A stand to give foundation support for structure inspired from hippo or giraffe legs	 Advanced design inspired from giraffe legs for structural support which distributes forces to keep stable and balanced foundation	 Gyroscopic cup holder to balance drinks in car based on the orangutan's ability to balance in the treetops	 Design inspired by mountain goat's hoof that would spread in a cloven like structure to provide balance and stability	
TASK/SUBTASK(function):					
Lightweight and Portable	 Hollow cylinder is a lightweight material of elongated neck for extended reach.	Advanced Hollow design of elongated neck which can expand and contract 			
TASK/SUBTASK(function):					
Enhanced Grip	 Gripper with rod holder Inspired From Jaws of hippo	 A c clamp which uses compressive forces just like Hippo's Jaws	 A design inspired by the soft pads of the hyrax's feet that would increase grip to by increasing surface area using a compressible material		
TASK/SUBTASK(function):					
Adaptability/Flexibility					

Notes: Problem Definition 1: Manual Hand Tool Inspired by Animal Functionalities

Objective: Design a versatile, sustainable hand tool that draws from animal biomechanics to enhance ergonomic use, stability, grip, flexibility, durability, and safety.

Top Solutions and Design Concepts with Notes

1. Dynamic Balance and Control

Stand with Structural Support:

Notes: Mimics giraffe legs, where each leg functions as a stabilizing pillar that distributes weight evenly. This design allows the tool's base to absorb and balance force effectively on uneven ground.

Gyroscopic Mechanism:

Notes: Inspired by the balance of orangutans in treetops. This gyroscopic system helps keep drinks or tools level even when the user is moving, reducing spills and enhancing control.

Cloven Hoof-Inspired Balance Stand:

Notes: Like a mountain goat's hoof, which spreads on rough terrain to stabilize the body, this design creates a stand that slightly expands under pressure, increasing stability on irregular surfaces.

2. Lightweight and Portable Design

Expandable Hollow Cylinder:

Notes: Draws from the lightweight and elongated neck of giraffes. By creating a hollow, telescoping structure, the tool remains portable and easy to store. Expansion allows access to hard-to-reach areas without compromising strength.

Elongated, Hollow Handle:

Notes: Made from eco-friendly, sustainable materials, this elongated design reduces weight without sacrificing reach, allowing users to maneuver it easily over extended periods.

3. Enhanced Grip

Hippo Jaw C-Clamp:

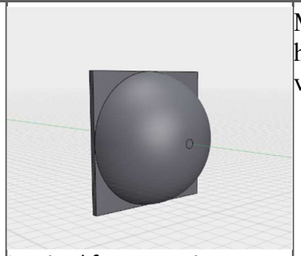
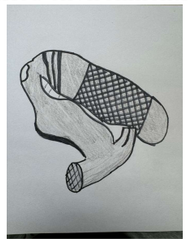
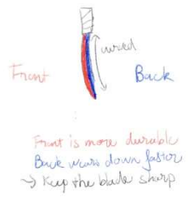
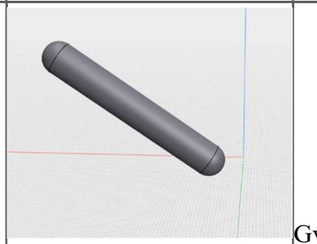
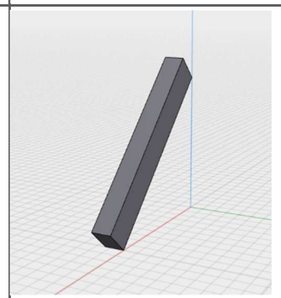
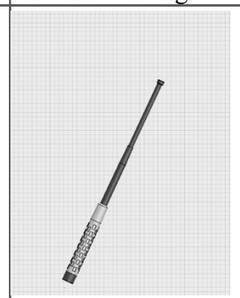
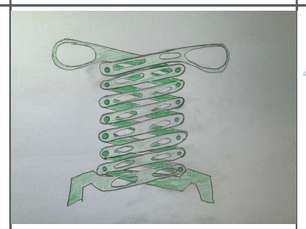
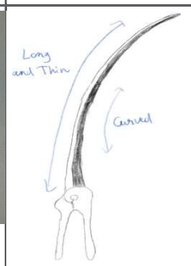
Notes: Inspired by the powerful bite force of hippo jaws, this C-clamp secures objects firmly using compressive forces. Ideal for holding materials in place during tasks that require precise positioning.

Hyrax-Inspired Gripping Pads:

Notes: Hyrax feet have soft, grippy pads that provide increased surface contact. These pads can be applied to the tool's handle to improve grip,

MORPHOLOGICAL CHART

TEMPLATE

	Elephant trunk inspired flexible grasper	Chameleon inspired Flexible Grasper	A design inspired by the soft pads of the hyrax's feet that can adapt and provide grip to various surfaces because of its flexible material	
TASK/SUBTASK(function): Durability in Varied Environments	 Inspired from tortoises, a domed shape design to withstand stress by distributing forces from rod	Mantis shrimp inspires hammer that is durable in varied environments. 	 A blade design that is inspired by the principle of differential wear in porcupine's teeth that would prolong the wear of the blade and keep it sharp for longer	
TASK/SUBTASK(function): Safety	 Cambered edges protect from cuts	 Gyroscopic cup holder to not spill hot coffee in your car while driving.		
TASK/SUBTASK(function): Reach Extension	 Inspired from giraffe's neck an elongated rod for higher reach	 Inspired from giraffe an enhanced version of rod which extends and contracts which gives control overreach		 A trimming shear inspired by the Southern Bald Ibis long, slender and curved beak that is designed to access hard to reach places.

especially useful for users in wet or sweaty conditions.

4. Adaptability and Flexibility

Elephant Trunk or Chameleon Tail-Inspired Grasper:

Notes: A flexible tool head that can wrap around or conform to various shapes, enabling users to grab, twist, or manipulate objects that are otherwise hard to reach or irregularly shaped.

Hyrax Foot Pads for Surface Adaption:

Notes: Provides grip on multiple surfaces by conforming to irregular textures. The material's compressibility allows for a more versatile grip across different types of materials and surfaces.

5. Durability in Varied Environments

Tortoise Shell-Inspired Dome for Stress Distribution:

Notes: The dome shape distributes force across the structure, reducing the chance of localized wear or stress. This makes the tool durable for long-term use, particularly in high-pressure applications.

Mantis Shrimp-Inspired Hammer:

Notes: The mantis shrimp's club is known for durability and impact resistance. A hammer based on this design would be built to handle repeated impacts and resist chipping or deformation.

Porcupine-Inspired Blade:

Notes: A blade inspired by porcupine teeth would have areas of different hardness, allowing it to self-sharpen as it wears. This prolongs sharpness, reducing the need for frequent maintenance.

6. Safety

Cambered Edges for Protection:

Notes: Rounded edges on the tool handle or attachments to prevent accidental cuts or scrapes. Particularly useful in tools that might be used in cramped or tight spaces.

Self-Stabilizing Gyroscopic Cup Holder:

Notes: This feature ensures that hot or cold drinks remain upright while the user is in motion, reducing the risk of spills and burns. It could be especially useful on construction sites or other active environments.

7. Reach Extension

Giraffe Neck-Inspired Telescoping Rod:

Notes: This design allows for controlled extension, giving users the option to adjust the reach as needed. The telescoping feature also aids in storage and portability.

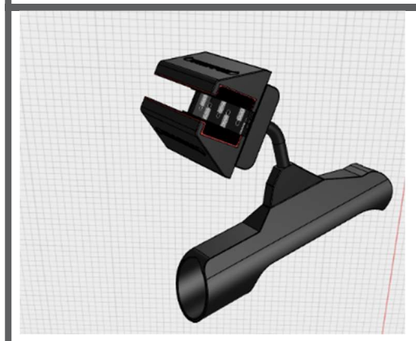
Curved Shears Modeled After Southern Bald Ibis Beak:

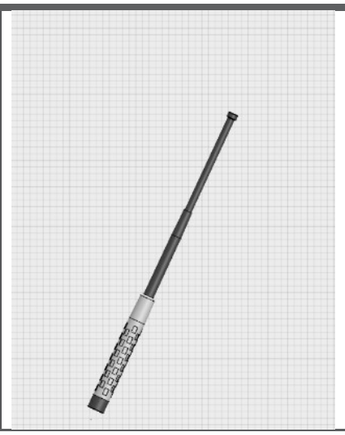
Notes: Ideal for trimming or cutting in narrow spaces, as the curved design of the blade can reach around obstacles. The slender profile reduces bulk, making it suitable for intricate or detailed tasks.

MORPHOLOGICAL CHART
TEMPLATE

DESIGN PROBLEM DEFINITION: Design a self-stabilizing, gyroscopic cup holder inspired by the orangutan's gripping abilities to keep beverages upright and spill-resistant in dynamic environments. This holder should be compact, adaptable to different cup sizes, and provide stability in moving or uneven settings.

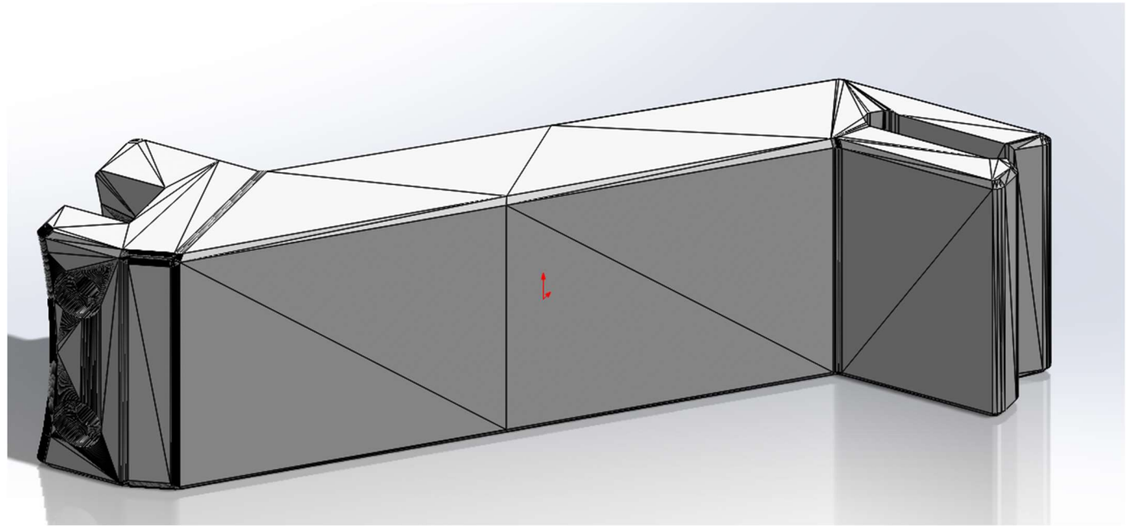
DESIGN CONCEPTS





TOP THREE SOLUTIONS

1.



MORPHOLOGICAL CHART

TEMPLATE

Self-Stabilizing Gyroscope:

- A small gyroscope in the base that automatically stabilizes the cup by counteracting shifts and tilts. Inspired by orangutans' ability to maintain balance in trees, this feature keeps drinks level regardless of the vehicle or holder movement.

Adjustable springs for Various Cup Sizes:

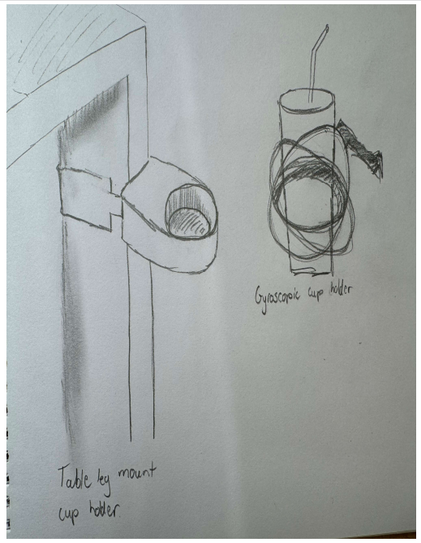
- Spring-loaded clamps allow for a secure fit with various cup sizes, providing versatility for different beverage containers. Keeps drinks from wobbling or tipping during travel.

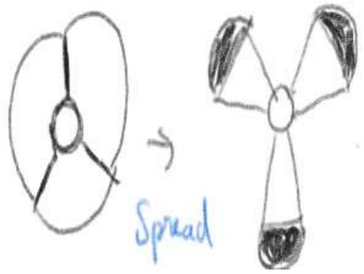
Car vent clamp:

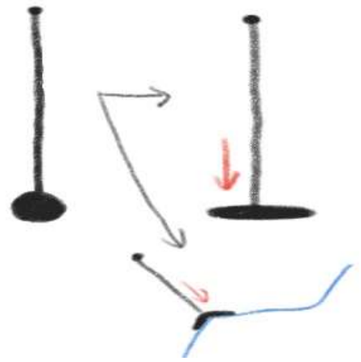
- The friction-fit car vent clamp, inspired by the hippo's powerful jaws, uses a rubberized, contoured surface to create a secure, non-slip connection on car air vents. This design offers a strong hold without springs, allowing easy mounting and dismounting while protecting the vent from scratches or wear. The rubber surface enhances friction, keeping the holder stable even on rough roads.

MORPHOLOGICAL CHART

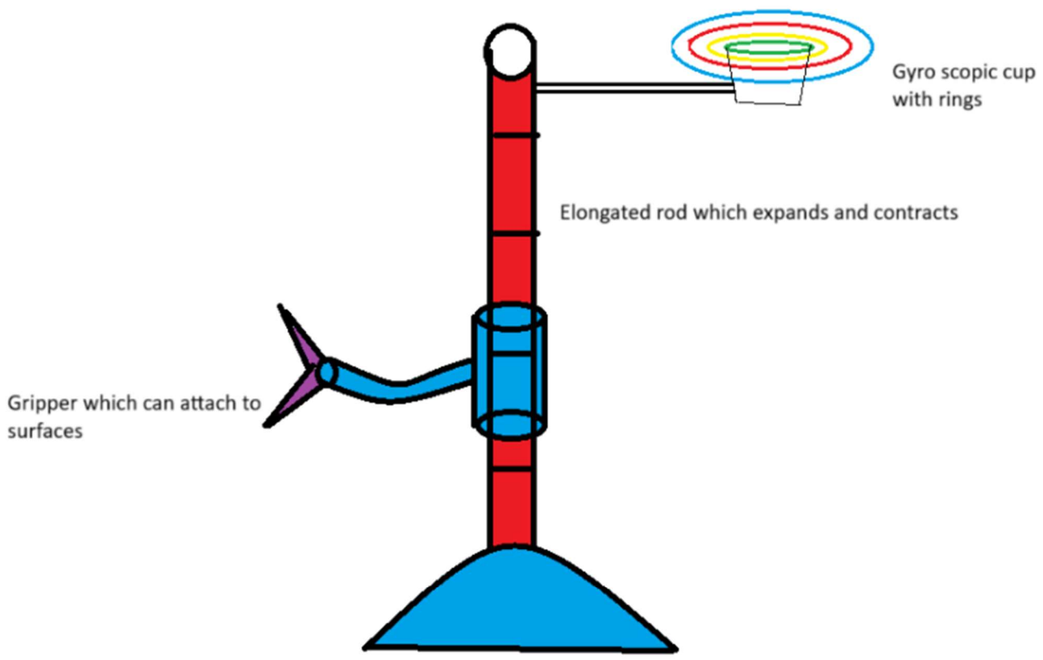
TEMPLATE





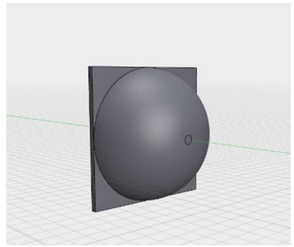


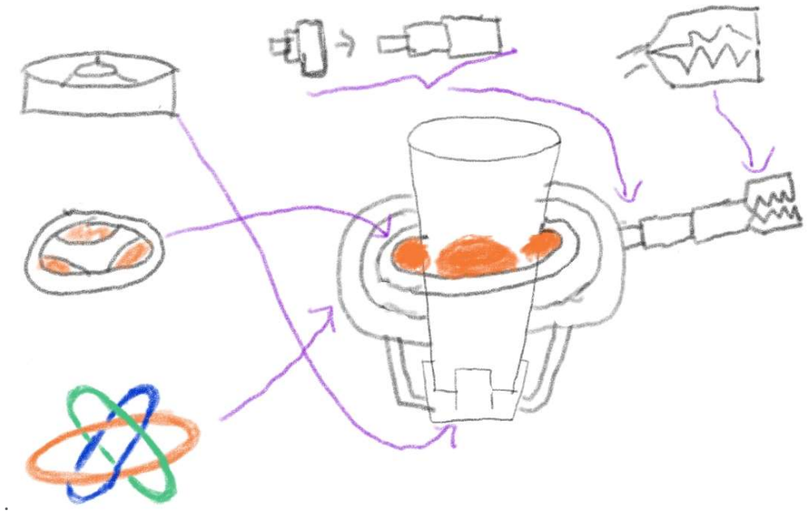
This is a Gyroscopic cup holder dynamic stability control , it is attached with extendable rod and it is supported with a dome shaped structural foundation base ,on middle of this rod a gripper is attached which can attach this whole system to a surface



MORPHOLOGICAL CHART

TEMPLATE





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The design incorporates 5 concepts from the chart.

1/ Soft/elastic pads to grip the sides of the cup based on hyrax's feet.

2/ A cloven-shaped base that would hold, grip and stabilize the cup based on mountain goat's hoof.

3/ A self-stabilized gyroscope outer rings that would automatically level the cup based on the orangutan.

4/ An extendable/collapsible rod to attach to hard-to-reach places inspired from the giraffe's neck

5/ The clamp is inspired by the hippo's jaw

MORPHOLOGICAL CHART

TEMPLATE