A biological strategy is a characteristic, mechanism, or process that an organism or ecosystem exhibits to accomplish a particular function within a particular context.

The main elements of a biological strategy are:

- The function of the organism, as in what is the organism trying to accomplish?

- The mechanism of the organism, describe how the organism does the function.

- The context of the organism performing the function. This could be a place, condition, or situation.

- The organism or ecosystem is performing the function.

- The part of the organism that is used to perform the function if it is stated in the text.

Make sure the biological strategy is composed of the function, mechanism, context, organism, and part of the organism.

Text: Building a home from foam-túngara frog foam nest architecture and three-phase construction process. frogs that build foam nests floating on water face the problems of over-dispersion of the secretions used and eggs being dangerously exposed at the foam : air interface. nest construction behaviour of tungara frogs, engystomops pustulosus, has features that may circumvent these problems. pairs build nests in periodic bursts of foam production and egg deposition, three discrete phases being discernible. the first is characterized by a bubble raft without egg deposition and an approximately linear increase in duration of mixing events with time. this phase may reduce initial over-dispersion of foam precursor materials until a critical concentration is achieved. the main building phase is marked by mixing events and start-to-start intervals being nearly constant in duration. during the final phase, mixing events do not change in duration but intervals between them increase in an exponential-like fashion. pairs joining a colonial nesting abbreviate their initial phase, presumably by exploiting a pioneer pair's bubble raft, thereby reducing energy and material expenditure, and time exposed to predators. finally, eggs are deposited only in the centre of nests with a continuously produced, approximately 1 cm deep egg-free cortex that protectively encloses hatched larvae in stranded nests.

Function: protect hatched larvae

Mechanism: building nests

Context: periodic bursts of foam production and egg deposition on water

Organism: Túngara frog

Part of: Nest

Strategy: Túngara frogs protectively enclose hatched larvae by building nests during periodic bursts of foam production and egg deposition on water

Text: Harbor seal vibrissa morphology suppresses vortex-induced vibrations. Harbor seals (Phoca vitulina) often live in dark and turbid waters, where their mystacial vibrissae, or whiskers, play an important role in orientation. Besides detecting and discriminating objects by direct touch, harbor seals use their whiskers to analyze water movements, for example those generated by prey fish or by conspecifics. Even the weak water movements left behind by objects that have passed by earlier can be sensed and followed accurately (hydrodynamic trail following). While scanning the water for these hydrodynamic signals at a swimming speed in the order of meters per second, the seal keeps its long and flexible whiskers in an abducted position, largely perpendicular to the swimming direction. Remarkably, the whiskers of harbor seals possess a specialized undulated surface structure, the function of which was, up to now, unknown. Here, we show that this structure effectively changes the vortex street behind the whiskers and reduces the vibrations that would otherwise be induced by the shedding of vortices from the whiskers (vortex-induced vibrations). Using force measurements, flow measurements and numerical simulations, we find that the dynamic forces on harbor seal whiskers are, by at least an order of magnitude, lower than those on sea lion (Zalophus californianus) whiskers, which do not share the undulated structure. The results are discussed in the light of pinniped sensory biology and potential biomimetic applications.

Function: to reduce vibrations

Mechanism: undulated surface structure

Context: while scanning the water for hydrodynamic signals

Organism: harbor seal

Part of: whiskers

Strategy: Harbor seal whiskers reduce vibrations by having an undulated surface structure while scanning the water for hydrodynamic signals.

1. W2130285640
   * Sample: "title": "Foam nest components of the t\u00fangara frog: a cocktail of proteins conferring physical and biological resilience", "abstract": "the foam nests of the tungara frog (engystomops pustulosus) form a biocompatible incubation medium for eggs and sperm while resisting considerable environmental and microbiological assault. we have shown that much of this behaviour can be attributed to a cocktail of six proteins, designated ranaspumins (rsn-1 to rsn-6), which predominate in the foam. these fall into two discernable classes based on sequence analysis and biophysical properties. rsn-2, with an amphiphilic amino acid sequence unlike any hitherto reported, exhibits substantial detergent-like surfactant activity necessary for production of foam, yet is harmless to the membranes of eggs and spermatozoa. a further four (rsn-3 to rsn-6) are lectins, three of which are similar to fucolectins found in teleosts but not previously identified in a land vertebrate, though with a carbohydrate binding specificity different from previously described fucolectins. the sixth, rsn-1, is structurally similar to proteinase inhibitors of the cystatin class, but does not itself appear to exhibit any such activity. the nest foam itself, however, does exhibit potent cystatin activity. rsn-encoding genes are transcribed in many tissues of the adult frogs, but the full cocktail is present only in oviduct glands. combinations of lectins and cystatins have known roles in plants and animals for defence against microbial colonization and insect attack. tungara nest foam displays a novel synergy of selected elements of innate defence plus a specialized surfactant protein, comprising a previously unreported strategy for protection of unattended reproductive stages of animals."
   * Output:
     + Organism: Túngara frog
     + Part Of: Oviduct glands
     + Function: to form a biocompatible incubation medium for eggs and sperm
     + Mechanism: a cocktail of six proteins
     + Context: while resisting considerable environmental and microbiological assault
     + Strategy: Túngara frogs form a biocompatible incubation medium for eggs and sperm by producing a cocktail of six proteins in their oviduct glands.
   * Notes:
     + Correct
       - Organism, Part Of, Function, Mechanism, Context
       - Strategy is missing information.
         * context
     + 6/6
2. W2168114966
   * Sample: "title": "The suctorial organ of the Solifugae (Arachnida, Solifugae)", "abstract": "the ability of members of the arachnid order solifugae to climb smooth, vertical surfaces and the organs involved in this behavior are investigated. macroscopic, microscopic, and scanning electron microscopic observations are made of a palpal organ called the suctorial organ. observations of the behavior but not the microstructure have been made in the past. histological examination illustrates the internal gross anatomy of this structure and scanning electron microscopy demonstrates the fine structure in adults of four genera: eremobates (eremobatidae), eremochelis (eremobatidae), eremorhax (eremobatidae), ammotrechula (ammotrechidae), as well as an unidentified late stage immature and third stage instar. the suctorial organ is most likely primarily used for prey capture in the wild. q 2005 elsevier ltd. all rights reserved."
   * Output:
     + Organism: Solifugae
     + Part Of: Suctorial organ
     + Function: prey capture
     + Mechanism: suction
     + Context: in the wild
     + Strategy: Solifugae use suction to capture prey in the wild
   * Notes:
     + Correct
       - Organism, Part Of, Function, Mechanism, Context
       - Mechanism is abstracted from suctorial organ
       - Strategy is missing information.
         * Part Of
     + 6/6
3. W1589686983
   * Sample: "title": "On the Mound of Macrotermes michaelseni as an Organ of Respiratory Gas Exchange", "abstract": "patterns and rates of air movements in the mounds and nests of macrotermes michaelseni were studied using tracer methods. wind is a significant source of energy for powering nest ventilation, despite the mound being a completely enclosed structure. nests are ventilated by a tidal movement of air driven by temporal variation in wind speed and wind direction. density gradients sufficiently steep to drive bulk flow by natural convection will be rare. however, metabolism-induced buoyant forces may interact with wind energy in a way that promotes homeostasis of the mound atmosphere."
   * Output:
     + Organism: Macrotermes michaelseni
     + Part Of: Mound
     + Function: Homeostasis of the mound atmosphere
     + Mechanism: Wind energy
     + Context: Temporal variation in wind speed and wind direction
     + Strategy: The mound of Macrotermes michaelseni is an organ of respiratory gas exchange that is powered by wind energy and maintains homeostasis of the mound atmosphere.
   * Notes:
     + Correct
       - Organism, Part Of, Function, Mechanism, Context
       - Strategy is missing information
         * Context
       - Also it adds information that is not part of the main elements extracted.
     + 6/6
4. W1589686983
   * Sample: "title": "A multi-enzyme cascade of hemoglobin proteolysis in the intestine of blood-feeding hookworms.", "abstract": "blood-feeding pathogens digest hemoglobin (hb) as a source of nutrition, but little is known about this process in multicellular parasites. the intestinal brush border membrane of the canine hookworm, ancylostoma caninum, contains aspartic proteases (apr-1), cysteine proteases (cp-2), and metalloproteases (mep-1), the first of which is known to digest hb. we now show that hb is degraded by a multi-enzyme, synergistic cascade of proteolysis. recombinant apr-1 and cp-2, but not mep-1, digested native hb and denatured globin. mep-1, however, did cleave globin fragments that had undergone prior digestion by apr-1 and cp-2. proteolytic cleavage sites within the hb \u03b1 and \u03b2 chains were determined for the three enzymes, identifying a total of 131 cleavage sites. by scanning synthetic combinatorial peptide libraries with each enzyme, we compared the preferred residues cleaved in the libraries with the known cleavage sites within hb. the semi-ordered pathway of hb digestion described here is surprisingly similar to that used by plasmodium to digest hb and provides a potential mechanism by which these hemoglobinases are efficacious vaccines in animal models of hookworm infection."
   * Output:
     + Organism: Hookworm
     + Part Of: brush border membrane
     + Function: digest hemoglobin
     + Mechanism: aspartic proteases, cysteine proteases, and metalloproteases
     + Context: intestinal brush border membrane
     + Strategy: Hookworms digest hemoglobin by using aspartic proteases, cysteine proteases, and metalloproteases in their intestinal brush border membrane.
   * Notes:
     + Correct
       - Organism
       - Part Of
       - Function
       - Mechanism
       - Strategy is missing.
     + Incorrect
       - Context → not sure, but could be → blood-feeding pathogens
     + 5/6
5. W2052657884
   * Sample: "title": "The Diversity of Hydrostatic Skeletons", "abstract": "a remarkably diverse group of organisms rely on a hydrostatic skeleton for support, movement, muscular antagonism and the amplification of the force and displacement of muscle contraction. in hydrostatic skeletons, force is transmitted not through rigid skeletal elements but instead by internal pressure. functioning of these systems depends on the fact that they are essentially constant in volume as they consist of relatively incompressible fluids and tissue. contraction of muscle and the resulting decrease in one of the dimensions thus results in an increase in another dimension. by actively (with muscle) or passively (with connective tissue) controlling the various dimensions, a wide array of deformations, movements and changes in stiffness can be created. an amazing range of animals and animal structures rely on this form of skeletal support, including anemones and other polyps, the extremely diverse wormlike invertebrates, the tube feet of echinoderms, mammalian and turtle penises, the feet of burrowing bivalves and snails, and the legs of spiders. in addition, there are structures such as the arms and tentacles of cephalopods, the tongue of mammals and the trunk of the elephant that also rely on hydrostatic skeletal support but lack the fluid-filled cavities that characterize this skeletal type. although we normally consider arthropods to rely on a rigid exoskeleton, a hydrostatic skeleton provides skeletal support immediately following molting and also during the larval stage for many insects. thus, the majority of animals on earth rely on hydrostatic skeletons."
   * Output:
     + Organism: anemones, wormlike invertebrates, tube feet of echinoderms, mammalian and turtle penises, feet of burrowing bivalves and snails, legs of spiders
     + Part Of: fluid-filled cavities
     + Function: support, movement, muscular antagonism, and the amplification of the force and displacement of muscle contraction
     + Mechanism: internal pressure
     + Context: animals and animal structures
     + Strategy: animals rely on hydrostatic skeletons for support, movement, muscular antagonism, and the amplification of the force and displacement of muscle contraction by using internal pressure to control the various dimensions
   * Notes:
     + Correct
       - Organism is technically correct, but it should be more general → animals
       - Function
       - Mechanism
       - Part Of is technically Correct, but it should be more general → fluid-filled cavities of the hydrostatic skeleton → hydrostatic skeleton
       - Context
       - Strategy abstracted is good, but it is not consistent with what is abstracted.
     + 6/6
6. W2005779387
   * Sample: "title": "On the buoyancy of the pearly nautilus", "abstract": "nautilus macromphalus sowerby when freshly caught was close to neutral buoyancy having a weight in sea water of about 0\u20132% of its weight in air. the animals without their shells varied considerably in density but the volume of the shell was an approximately constant fraction of the total volume of the whole animal and whole animals were brought approximately to the same density by havingmore or less liquid inside the chambers of the shell. about 80 % of the gas space in the shell was used to support the weight of the shell itself in sea water.in an adult animal the centre of buoyancy was found to be about 6 mm above the centre of gravity, which made the animal very stable in its natural swimming position, a couple of about 350 g. cm being required to turn it through 90\u00b0. the pearly partsof the chamber walls were impermeable to sea water but the chalky and horny siphuncular tubes joining the septal necks were very porous. the most newly formed tenor so chambers were the only ones to contain liquids in appreciable volume and theydid this in diminishing amounts from the newest to the oldest. the watery liquids found within the chambers were always hypotonic to sea water and sometimes markedly so; they contained principally sodium and chloride ions. one animal was in the process of forming a new chamber, this incomplete chamber was completely full of liquidwith an osmolarity close to that of sea water but differing in composition from seawater."
   * Output:
     + Organism: pearly nautilus
     + Part Of: shell
     + Function: support the weight of the shell
     + Mechanism: having more or less liquid inside the chambers of the shell
     + Context: in an adult animal
     + Strategy: pearly nautilus support the weight of the shell by having more or less liquid inside the chambers of the shell.
   * Notes:
     + Correct
       - Organism, Function, Mechanism, Part Of
       - Strategy is missing information.
         * Context
     + Incorrect
       - Context → was close to neutral buoyancy
     + 5/6
7. W2152749757
   * Sample: “title": "How strong is intracanopy leaf plasticity in temperate deciduous trees", "abstract": "intracanopy plasticity in tree leaf form is a major determinant of whole-plant function and potentially of forest understory ecology. however, there exists little systematic information for the full extent of intracanopy plasticity, whether it is linked with height and exposure, or its variation across species. for arboretum-grown trees of six temperate deciduous species averaging 13-18 m in height, we quantified intracanopy plasticity for 11 leaf traits across three canopy locations (basal-interior, basal-exterior, and top). plasticity was pronounced across the canopy, and maximum likelihood analyses indicated that plasticity was primarily linked with irradiance, regardless of height. intracanopy plasticity (the quotient of values for top and basal-interior leaves) was often similar across species and statistically indistinguishable across species for several key traits. at canopy tops, the area of individual leaves was on average 0.5-0.6 times that at basal-interior, stomatal density 1.1-1.5 times higher, sapwood cross-sectional area up to 1.7 times higher, and leaf mass per area 1.5-2.2 times higher; guard cell and stomatal pore lengths were invariant across the canopy. species differed in intracanopy plasticity for the mass of individual leaves, leaf margin dissection, ratio of leaf to sapwood areas, and stomatal pore area per leaf area; plasticity quotients ranged only up to \u22482. across the six species, trait plasticities were uncorrelated and independent of the magnitude of the canopy gradient in irradiance or height and of the species' light requirements for regeneration. this convergence across species indicates general optimization or constraints in development, resulting in a bounded plasticity that improves canopy performance."
   * Output:
     + Organism: temperate deciduous trees
     + Part Of: leaf
     + Function: improve canopy performancel
     + Mechanism: plasticity in tree leaf form
     + Context: arboretum-grown trees
     + Strategy: Temperate deciduous trees improve canopy performance by plasticity in tree leaf form.
   * Notes:
     + Correct
       - Organism, Function, Mechanism, Part Of
       - Strategy is missing information.
         * Context
     + Incorrect
       - Context → whole-plant function and potentially of forest understory ecology
       - Strategy is incorrect → plasticity in tree leaf form improves canopy performance in Temperate deciduous trees.
     + 4/6
8. W2025490238
   * Sample: "title": "A biomechanical perspective on the role of large stem volume and high water content in baobab trees (Adansonia spp.; Bombacaceae)", "abstract": "the stems of large trees serve in transport, storage, and support; however, the degree to which these roles are reflected in their morphology is not always apparent. the large, water-filled stems of baobab trees (adansonia spp.) are generally assumed to serve a water storage function, yet recent studies indicate limited use of stored water. through an analysis of wood structure and composition, we examined whether baobab morphology reflects biomechanical constraints rather than water storage capacity in the six madagascar baobab species. baobab wood has a high water content (up to 79%), low wood density (0.09-0.17 g \u00b7 cm(-3)), high parenchyma content (69-88%), and living cells beyond 35 cm into the xylem from the cambium. volumetric construction cost of the wood is several times lower than in more typical trees, and the elastic modulus approaches that of parenchyma tissue. safety factors calculated from estimated elastic buckling heights were low, indicating that baobabs are not more overbuilt than other temperate and tropical trees, yet the energy investment in stem material is comparable to that in temperate deciduous trees. furthermore, the elastic modulus of the wood decreases with water content, such that excessive water withdrawal from the stem could affect mechanical stability."
   * Output:
     + Organism: baobab tree
     + Part Of: wood
     + Function: support
     + Mechanism: large, water-filled stems
     + Context: water storage
     + Strategy: The large, water-filled stems of baobab trees support the tree by serving as a water storage mechanism.
   * Notes:
     + Correct
       - Organism, Function, Mechanism, Context
       - Strategy is missing information.
         * Context
     + Incorrect
       - Part Of → stems
     + 6/6
     + But, It probably should be
       - The large, water-filled stems of baobab trees support the tree with mechanical stability rather than serving as a water storage mechanism.
9. W2112209842
   * Sample: "title": "Hydrophobic trichome layers and epicuticular wax powders in Bromeliaceae", "abstract": "the distinctive foliar trichome of bromeliaceae has promoted the evolution of an epiphytic habit in certain taxa by allowing the shoot to assume a significant role in the uptake of water and mineral nutrients. despite the profound ecophysiological and taxonomic importance of this epidermal structure, the functions of nonabsorbent trichomes in remaining bromeliaceae are not fully understood. the hypothesis that light reflection from these trichome layers provides photoprotection was not supported by spectroradiometry and fluorimetry in the present study; the mean reflectance of visible light from trichome layers did not exceed 6.4% on the adaxial surfaces of species representing a range of ecophysiological types nor was significant photoprotection provided by their presence. several reports suggesting water repellency in some terrestrial bromeliaceae were investigated. scanning electron microscopy (sem) and a new technique-fluorographic dimensional imaging (fdi)-were used to assess the interaction between aqueous droplets and the leaf surfaces of 86 species from 25 genera. in the majority of cases a dense layer of overlapping, stellate or peltate trichomes held water off the leaf epidermis proper. in the case of hydrophobic tank-forming tillandsioideae, a powdery epicuticular wax layer provided water repellency. the irregular architecture of these indumenta resulted in relatively little contact with water droplets. most mesic terrestrial pitcairnioideae examined either possessed glabrous leaf blades or hydrophobic layers of confluent trichomes on the abaxial surface. thus, the present study indicates that an important ancestral function of the foliar trichome in bromeliaceae was water repellency. the ecophysiological consequences of hydrophobia are discussed."
   * Output:
     + Organism: Bromeliaceae
     + Part Of: leaf epidermis
     + Function: water repellency
     + Mechanism: dense layer of overlapping, stellate or peltate trichomes
     + Context: majority of cases
     + Strategy: the foliar trichome in bromeliaceae provides water repellency by creating a dense layer of overlapping, stellate or peltate trichomes on the leaf epidermis.
   * Notes:
     + Correct
       - Organism, Function, Mechanism, Part Of
       - Strategy is missing information → Context, added extra info
     + Incorrect
       - Context → an important ancestral function
     + 5/6
10. W2127657288
    * Sample: "title": "The incidence and implications of clouds for cloud forest plant water relations.", "abstract": "although clouds are the most recognisable and defining feature of tropical montane cloud forests, little research has focussed on how clouds affect plant functioning. we used satellite and ground-based observations to study cloud and leaf wetting patterns in contrasting tropical montane and pre-montane cloud forests. we then studied the consequences of leaf wetting for the direct uptake of water accumulated on leaf surfaces into the leaves themselves. during the dry season, the montane forest experienced higher precipitation, cloud cover and leaf wetting events of longer duration than the pre-montane forest. leaf wetting events resulted in foliar water uptake in all species studied. the capacity for foliar water uptake differed significantly between the montane and pre-montane forest plant communities, as well as among species within a forest. our results indicate that foliar water uptake is common in these forest plants and improves plant water status during the dry season."
    * Output:
      + Organism: tropical montane and pre-montane cloud forest plants
      + Part Of: leaves
      + Function: improve plant water status
      + Mechanism: foliar water uptake
      + Context: during the dry season
      + Strategy: Foliar water uptake is common in tropical montane and pre-montane cloud forest plants and improves plant water status during the dry season.
    * Notes:
      + Correct
        - Organism, Function, Mechanism, Part Of, Context
        - Strategy is missing information
          * Part Of
      + 6/6
11. W2024134236
    * Sample: "title": "Functional morphology of scale hinges used to transport water: convergent drinking adaptations in desert lizards (Moloch horridus and Phrynosoma cornutum)", "abstract": "the australian thorny devil, moloch horridus gray, 1841, and the texas horned lizard, phrynosoma cornutum harlan, 1825, have the remarkable ability to rapidly move water through interscalar spaces on their skin\u2019s surface to their mouth for drinking. the morphology of these scale hinges has not been studied. we used histological and sem techniques to examine and compare the scale hinges of both species. additional taxa in their respective lineages were examined in order to evaluate the potential that convergent evolution has occurred. in the two species that transport water, each scale hinge has a basally expanded and semi-enclosed channel formed by the hinge joint that is interconnected with all scale hinges on the body. we hypothesize that it is within this semi-tubular channel system of hinge joints, where the \u03b2-layer keratin of the integument is very thin, that water is transported. hinge joint walls are covered by a complex topography of fractured surfaces that greatly expand the channel\u2019s surface area and probably enhance capillary transport of water. in addition, we note differing morphology of scale surfaces at the rear of the jaws of both species. we hypothesize that capillary forces fill the scale-hinge system and additional forces, generated within the mouth by observed motions during drinking, depress local water-pressure to pull water through the channels of the hinge-joint system. we conclude that the combined features in the two species, semi-tubular hinge-joint channels with convoluted walls and a jaw-buccal cavity pumping-mechanism, have convergently evolved for capture, transport, and drinking of water from sporadic rainfall."
    * Output:
      + Organism: Thorny devil and Texas horned lizard
      + Part Of: Scale hinge
      + Function: capture, transport, and drink water
      + Mechanism: semi-tubular hinge-joint channels
      + Context: interscalar spaces on their skin's surface
      + Strategy: Thorny devils and Texas horned lizards capture, transport, and drink water by using semi-tubular hinge-joint channels to move water through interscalar spaces on their skin's surface to their mouth.
    * Notes:
      + Correct
        - Organism, Function, Mechanism, Part Of, Context
        - Context needs to their mouth however
        - Strategy is missing information
          * Part Of
      + 6/6
12. W2075613570
    * Sample: "title": "Function of spiral grain in trees", "abstract": "through spiral grain, conduits for sap lead from each root to all branches. this uniform distribution of sap is indicated by the paths of vessels and tracheids, and has been proven experimentally by means of dyed sap injected into the base of stems or taken up by roots. trees receiving water only from roots at one side of the root collar nevertheless stay green and continue growing. spiral grain in bark distributes food from each branch to other flanks of the stem and to most roots. experimental interruptions of the sap and food conduits caused the cambial zone to reorient new conduit cells in new directions, bypassing the interruption. in particular, spiral grooves cut into the stem surface caused spiral grain. the new cells reorient through division and growth. although spiral grain is largely under genetic control, trees appear to have a spiral grain especially where needed for distribution of water when root spheres are dry at one side. compared with straight-grained trees, spiral-grained stems and branches bend and twist more when exposed to strong wind, in this way offering less wind resistance and being less likely to break. through the bending and twisting, snow slides down from branches rather than breaking them, but the main function of spiral grain is the uniform distribution of supplies from each root to all branches, and from each branch to many roots."
    * Output:
      + Organism: trees
      + Part Of: stem and bark
      + Function: uniform distribution of supplies
      + Mechanism: spiral grain
      + Context: from each root to all branches and from each branch to many roots
      + Strategy: trees distribute supplies evenly by spiral grain from each root to all branches and from each branch to many roots
    * Notes:
      + Correct
        - Organism, Function, Mechanism, Part Of, Context
        - Strategy is missing
          * Part Of
      + 6/6
13. W2071362227
    * Sample: "title": "Bacterial Recognition of Mineral Surfaces: Nanoscale Interactions Between Shewanella and \u03b1-FeOOH", "abstract": "force microscopy has been used to quantitatively measure the infinitesimal forces that characterize interactions between shewanella oneidensis (a dissimilatory metal-reducing bacterium) and goethite (alpha-feooh), both commonly found in earth near-surface environments. force measurements with subnanonewton resolution were made in real time with living cells under aerobic and anaerobic solutions as a function of the distance, in nanometers, between a cell and the mineral surface. energy values [in attojoules (10(-18) joules)] derived from these measurements show that the affinity between s. oneidensis and goethite rapidly increases by two to five times under anaerobic conditions in which electron transfer from bacterium to mineral is expected. specific signatures in the force curves suggest that a 150-kilodalton putative iron reductase is mobilized within the outer membrane of s. oneidensis and specifically interacts with the goethite surface to facilitate the electron transfer process."
    * Output:
      + Organism: Shewanella oneidensis
      + Part Of: Outer membrane
      + Function: facilitate electron transfer
      + Mechanism: force measurements
      + Context: real time with living cells under aerobic and anaerobic solutions
      + Strategy: Shewanella oneidensis facilitates electron transfer by force measurements with living cells under aerobic and anaerobic solutions.
    * Notes:
      + Correct
        - Organism, Function, Part Of, Context
      + Incorrect
        - Mechanism → putative iron reductase is mobilized
        - Strategy is missing information
          * Part Of
      + 4/6
14. W1994029841
    * Sample: "title": "Overcoming the brittleness of glass through bio-inspiration and micro-architecture", "abstract": "highly mineralized natural materials such as teeth or mollusk shells boast unusual combinations of stiffness, strength and toughness currently unmatched by engineering materials. while high mineral contents provide stiffness and hardness, these materials also contain weaker interfaces with intricate architectures, which can channel propagating cracks into toughening configurations. here we report the implementation of these features into glass, using a laser engraving technique. three-dimensional arrays of laser-generated microcracks can deflect and guide larger incoming cracks, following the concept of 'stamp holes'. jigsaw-like interfaces, infiltrated with polyurethane, furthermore channel cracks into interlocking configurations and pullout mechanisms, significantly enhancing energy dissipation and toughness. compared with standard glass, which has no microstructure and is brittle, our bio-inspired glass displays built-in mechanisms that make it more deformable and 200 times tougher. this bio-inspired approach, based on carefully architectured interfaces, provides a new pathway to toughening glasses, ceramics or other hard and brittle materials."
    * Output:
      + Organism: glass
      + Part Of: microstructure
      + Function: make glass more deformable and tougher
      + Mechanism: three-dimensional arrays of laser-generated microcracks
      + Context: brittle materials
      + Strategy: make glass more deformable and tougher by creating three-dimensional arrays of laser-generated microcracks
    * Notes:
      + Correct
        - Organism, Function, Mechanism, Part Of, Context
        - Strategy is missing information
          * Part Of
          * Context
      + 6/6
15. W2051302904
    * Sample: "title": "Extreme impact and cavitation forces of a biological hammer: strike forces of the peacock mantis shrimp Odontodactylus scyllarus.", "abstract": "summary - mantis shrimp are renowned for their unusual method of breaking shells with\nbrief, powerful strikes of their raptorial appendages. due to the extreme\nspeeds of these strikes underwater, cavitation occurs between their appendages\nand hard-shelled prey. here we examine the magnitude and relative contribution\nof the impact and cavitation forces generated by the peacock mantis shrimp\n odontodactylus scyllarus . we present the surprising finding that each\nstrike generates two brief, high-amplitude force peaks, typically\n390\u2013480 \u03bcs apart. based on high-speed imaging, force measurements and\nacoustic analyses, it is evident that the first force peak is caused by the\nlimb9s impact and the second force peak is due to the collapse of cavitation\nbubbles. peak limb impact forces range from 400 to 1501 n and peak cavitation\nforces reach 504 n. despite their small size, can\ngenerate impact forces thousands of times their body weight. furthermore, on\naverage, cavitation peak forces are 50% of the limb9s impact force, although\ncavitation forces may exceed the limb impact forces by up to 280%. the rapid\nsuccession of high peak forces used by mantis shrimp suggests that mantis\nshrimp use a potent combination of cavitation forces and extraordinarily high\nimpact forces to fracture shells. the stomatopod9s hammer is fundamentally\ndifferent from typical shell-crushing mechanisms such as fish jaws and lobster\nclaws, and may have played an important and as yet unexamined role in the\nevolution of shell form."
    * Output:
      + Organism: peacock mantis shrimp
      + Part Of: raptorial appendages
      + Function: break shells
      + Mechanism: striking with raptorial appendages
      + Context: underwater
      + Strategy: The peacock mantis shrimp breaks shells by striking with raptorial appendages underwater, which generates two brief, high-amplitude force peaks.
    * Notes:
      + Correct
        - Organism, Function, Mechanism, Part Of, Context
        - Strategy adds extra information
      + 6/6

|  |  | Organism | Part Of | Function | Context | Mechanism | Strategy |  | DocLen |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1. | W2130285640 | 1 | 1 | 1 | 1 | 1 | 1 | 6/6 |  |
| 2. | W2168114966 | 1 | 1 | 1 | 1 | 1 | 1 | 6/6 |  |
| 3. | W1589686983 | 1 | 1 | 1 | 1 | 1 | 1 | 6/6 |  |
| 4. | W1589686983 | 1 | 1 | 1 | 0 | 1 | 1 | 5/6 |  |
| 5. | W2052657884 | 1 | 1 | 1 | 1 | 1 | 1 | 6/6 |  |
| 6. | W2005779387 | 1 | 1 | 1 | 0 | 1 | 1 | 5/6 |  |
| 7. | W2152749757 | 1 | 1 | 1 | 0 | 1 | 0 | 4/6 |  |
| 8. | W2025490238 | 1 | 0 | 1 | 1 | 1 | 1 | 5/6 |  |
| 9. | W2112209842 | 1 | 1 | 1 | 0 | 1 | 1 | 5/6 |  |
| 10. | W2127657288 | 1 | 1 | 1 | 1 | 1 | 1 | 6/6 |  |
| 11. | W2024134236 | 1 | 1 | 1 | 1 | 1 | 1 | 6/6 |  |
| 12. | W2075613570 | 1 | 1 | 1 | 1 | 1 | 1 | 6/6 |  |
| 13. | W2071362227 | 1 | 1 | 1 | 1 | 0 | 0 | 4/6 |  |
| 14. | W1994029841 | 1 | 1 | 1 | 1 | 1 | 1 | 6/6 |  |
| 15. | W2051302904 | 1 | 1 | 1 | 1 | 1 | 0 | 5/6 |  |
|  |  | 15/15 | 14/15 | 15/15 | 11/15 | 14/15 | 13/15 |  |  |

What is the strategy missing?

|  |  | Part Of | Context | Mechanism | Strategy |
| --- | --- | --- | --- | --- | --- |
| 1. | W2130285640 | 0 | while resisting considerable environmental and microbiological assault | 0 | Túngara frogs form a biocompatible incubation medium for eggs and sperm by producing a cocktail of six proteins in their oviduct glands. |
| 2. | W2168114966 | Suctorial organ | 0 | 0 | Solifugae use suction to capture prey in the wild |
| 3. | W1589686983 | 0 | Temporal variation in wind speed and wind direction | 0 | The mound of Macrotermes michaelseni is an organ of respiratory gas exchange that is powered by wind energy and maintains homeostasis of the mound atmosphere. |
| 4. | W1589686983 | 0 | Strategy is wrong because possibly incorrect context → blood-feeding pathogens | 0 | Hookworms digest hemoglobin by using aspartic proteases, cysteine proteases, and metalloproteases in their intestinal brush border membrane. |
| 5. | W2052657884 | fluid-filled cavities or hydrostatic skeletons | 0 | 0 | animals rely on hydrostatic skeletons for support, movement, muscular antagonism, and the amplification of the force and displacement of muscle contraction by using internal pressure to control the various dimensions |
| 6. | W2005779387 | 0 | was close to neutral buoyancy | 0 | pearly nautilus support the weight of the shell by having more or less liquid inside the chambers of the shell. |
| 7. | W2152749757 | 0 | whole-plant function and potentially of forest understory ecology | 0 | Temperate deciduous trees improve canopy performance by plasticity in tree leaf form.  →  plasticity in tree leaf form improves canopy performance in Temperate deciduous trees. |
| 8. | W2025490238 | 0 | mechanical stability rather than serving as a water storage mechanism | 0 | The large, water-filled stems of baobab trees support the tree by serving as a water storage mechanism. |
| 9. | W2112209842 | 0 | an important ancestral function | 0 | the foliar trichome in bromeliaceae provides water repellency by creating a dense layer of overlapping, stellate or peltate trichomes on the leaf epidermis. |
| 10. | W2127657288 | leaves | 0 | 0 | Foliar water uptake is common in tropical montane and pre-montane cloud forest plants and improves plant water status during the dry season. |
| 11. | W2024134236 | Scale hinge | 0 | 0 | Thorny devils and Texas horned lizards capture, transport, and drink water by using semi-tubular hinge-joint channels to move water through interscalar spaces on their skin's surface to their mouth. |
| 12. | W2075613570 | stem and bark | 0 | 0 | trees distribute supplies evenly by spiral grain from each root to all branches and from each branch to many roots |
| 13. | W2071362227 | Outer membrane | 0 | putative iron reductase is mobilized | Shewanella oneidensis facilitates electron transfer by force measurements with living cells under aerobic and anaerobic solutions. |
| 14. | W1994029841 | microstructure | brittle materials | 0 | make glass more deformable and tougher by creating three-dimensional arrays of laser-generated microcracks |
| 15. | W2051302904 | 0 | 0 | 0 | The peacock mantis shrimp breaks shells by striking with raptorial appendages underwater, which generates two brief, high-amplitude force peaks. |
|  |  | 7/15 | 9/15 | 1/15 |  |

* Conclusion
  + Find the most important/complex info first until all elements are found, then construct the strategy with this information
    - Function → Mechanism → Context → Organism → Part Of ⇒ Strategy
  + This prompt is the best prompt we had so far
    - Organism → 15/15
    - Part Of → 14/15
    - Function → 15/15
    - Context → 11/15
    - Mechanism → 14/15
    - Strategy → 13/15
  + Strategies produced were **high quality**, but they were missing information;
    - Missing
      * Part Of → 7 samples
      * Context → 9 samples
      * Mechanism → 1 sample
    - Strategies always had the Organism and Function, and almost always mechanism within it. These are oftentimes the most important parts of a biological strategy.
  + Wrapping up prompt engineering by trying to get context more accurately
  + Possibly make another prompt to combine each individual part abstracted
  + Change Context prompt
  + Modify prompt
  + A biological strategy is a characteristic, mechanism, or process that an organism or ecosystem exhibits to accomplish a particular function within a particular context.

The main elements of a biological strategy are:

- The function of the organism, as in what is the organism trying to accomplish?

- The mechanism of the organism, describe how the organism does the function.

- The context of the organism performing the function. This could be a place, condition, or situation.

- The organism or ecosystem is performing the function.

- The part of the organism that is used to perform the function if it is stated in the text.

Make sure the biological strategy is composed of the function, mechanism, context, organism, and part of the organism.

Text: Building a home from foam-túngara frog foam nest architecture and three-phase construction process. frogs that build foam nests floating on water face the problems of over-dispersion of the secretions used and eggs being dangerously exposed at the foam : air interface. nest construction behaviour of tungara frogs, engystomops pustulosus, has features that may circumvent these problems. pairs build nests in periodic bursts of foam production and egg deposition, three discrete phases being discernible. the first is characterized by a bubble raft without egg deposition and an approximately linear increase in duration of mixing events with time. this phase may reduce initial over-dispersion of foam precursor materials until a critical concentration is achieved. the main building phase is marked by mixing events and start-to-start intervals being nearly constant in duration. during the final phase, mixing events do not change in duration but intervals between them increase in an exponential-like fashion. pairs joining a colonial nesting abbreviate their initial phase, presumably by exploiting a pioneer pair's bubble raft, thereby reducing energy and material expenditure, and time exposed to predators. finally, eggs are deposited only in the centre of nests with a continuously produced, approximately 1 cm deep egg-free cortex that protectively encloses hatched larvae in stranded nests.

Function: protect hatched larvae

Mechanism: building nests

Context: periodic bursts of foam production and egg deposition on water

Organism: Túngara frog

Part of: Nest

Strategy: Túngara frogs protectively enclose hatched larvae by building nests during periodic bursts of foam production and egg deposition on water