ANNEX 7 - Guild-Based BID Database for Separation

GB-BID categories of information

		Kingdom	Biological Organism	Phenotype	Main Function		Process conditions	Sub/Extra-Function 1		Process conditions	Sub/Extra-Function 2		Process conditions	Biological strategy	Biological mechanism	Short description of mechanism		Process Attribute	Process Attribute	Object's Property	Process conditions	Process conditions	Environmental Conditions	Extracted Design Principle	Process Diagrams/Pics	References
N	asknature	Kingdom	Biological Organism	Phenotype	Main Action	Object - What is Separated	Context of main action (Medium)	Sub/Extra Action 1	Object of Action 1	Context of Action 1	Sub/Extra Action 2	Object of Action 2	Context of Action 2	Biological strategy	Biological mechanism	Short description of mechanism	Separation principle	Active/ Passive	Scale	Info about separated (size/density/...)	Flow details	Energy/Driving Force	Environmental Conditions	Extracted Design Principle	Process Diagrams/Pics	References
1	N	animal	**Osmoconformers**	Osmoregulation system	Separate	Ions/molecules	Water	Regulate	ions/molecules	Water/Plasma			channels	Osmoconformers are organisms that **maintain an internal**	Osmoconformity is carried out by either **active or passive means**, these match their body osmolarity	Active/PAssive Transport	Membrane diffusion (dyalisis)	AC/PA	Atomic	ions of NaCl at various	Re < 1	ATP (metabolic energy)	Seawater, freshwater variable flow speed,	Principles related to mechanisms to adjust ions	https://classconnection.s3.amazon	Bradley, T.J. 2010. 'Animal Osmoregulation'. Animal Osmoregulation, January, 1–184.
2	N	eukariota	**Cell**	Cellular membrane	Filter	Ions/molecules	Water/Plasma	Exchange	ions/molecules	Water/Plasma	Transport	ions/molecules	Water/Plasma	Passive Transport strategies to allow exchange of ions across the	**Uniporter (passive transport-facilitated diffusion).** A uniporter is an integral membrane	Membrane Passive Trasport	Membrane diffusion (dyalisis)	PA	Atomic	various ions.	Re < 1	Gradients of concentration	Biological tissues	Filtration/facilitated diffusion via gradients of	https://sites.google.com/site/conne	Bradley, T.J. 2010. 'Animal Osmoregulation'. Animal Osmoregulation, January, 1–184.
3	N	eukariota	**Cell**	Cellular membrane	Filter	Ions/molecules	Water/Plasma	Exchange	ions/molecules	Water/Plasma	Transport	ions/molecules	Water/Plasma	Primary Active Transport strategies to allow exchange of ions across	Primary active transport, also called **direct active transport**, directly uses metabolic energy to	Membrane Active Trasport	Membrane diffusion (dyalisis)	AC	Atomic	various ions.	Re < 1	ATP (metabolic energy)	Biological tissues	Unidirectional or bidirectional (exchange of	https://sites.google.com/site/conne	Bradley, T.J. 2010. 'Animal Osmoregulation'. Animal Osmoregulation, January, 1–184.
4	N	eukariota	**Cell**	Cellular membrane	Filter	Ions/molecules	Water/Plasma	Exchange	ions/molecules	Water/Plasma	Transport	ions/molecules	Water/Plasma	Secondary Active Transport strategies to allow exchange of	In secondary active transport, also known as coupled transport or **co-transport,** energy is used	Membrane Active Trasport	Membrane diffusion (dyalisis)	AC	Atomic	various ions.	Re < 1	Electrochemical potential gradient	Biological tissues	Unidirectional or bidirectional (exchange of	https://sites.google.com/site/conne	Bradley, T.J. 2010. 'Animal Osmoregulation'. Animal Osmoregulation, January, 1–184.
5	N	animal	**Euryhaline organisms**	Osmoregulation system	Separate	Ions/molecules	Water	Filter						Osmoregulation by Sodium-Potassium pump. Euryhaline	The basic mechanism for ions exchange is the **Sodium-Potassium pump.** The process of moving	Membrane Active Trasport	Membrane diffusion (dyalisis)	AC	Atomic	various ions.	Re Intermediate	ATP (metabolic energy)	Seawater/Fresh water variable flow speed,	Filtration/ diffusion against gradients of concentration	dia.org/wiki/Euryhaline#/media/Fil	Bradley, T.J. 2010. 'Animal Osmoregulation'. Animal Osmoregulation, January, 1–184.
6	Y	animal	**Fish**	Gills	Filter	Ions	Water	move	Liquids		Exchange	gasses/molecules		The gill of fish is a gas exchanger capable of extracting dissolved	Gills are tissues formed by short threads, protein structures called filaments composed by parallel	Cross-flow filtration Diffusion	Surface - Dead end Cross-flow filtration	AC	Atomic/ Molecular	various molecules (Oxigen, CO2, Na, Cl,	Re Intermediate	Dynamic pressure gradient	Seawater, freshwater variable flow speed,	Structure formed by arrays of rods with inserted a pile	https://www.researchgate.net/figur	Evans, David H, Peter M Piermarini, and W T W Potts. n.d. 'Ionic Transport in the Fish Gill Epithelium', 12.
7	Y	plant	**Plants/trees**	Leaf/Root - Aquaporins	Filter	Water	Soil/Water/air							There are three routes for water to flow in these tissues, known as the	Xylem vessels in the root act as a network of tubes connected one to another, through which water	Membrane Passive Trasport	Membrane diffusion (aquaporins)	AC/PA	Atomic/Molecular	water molecules	Re < 1	Water potential Solar Energy	various terrestrial habitat	Selective membranes which allow only passage of	https://slideplayer.com/slide/69913	https://slideplayer.com/slide/6991359/ Water Uptake and Transport in Vascular
8	N	animal	**Sharks**	Gills	Filter	Ions	Water	move	Liquids					Sharks effectively exchange gasses passively thanks to ram gills	Gill filaments of one highly active and two less active shark species exhibit a conservative	Membrane Active transport	Membrane diffusion	AC	Atomic/Molecular	various ions.	RE High (turbulent)	Dynamic pressure gradient	Seawater		https://www.quora.com/How-did-	Benz, George W. 1984. 'On the Conservative Nature of the Gill Filaments of Sharks'.
9	N	animal	**Fast fish (tuna)**	Gills	Filter	Ions	Water							Tuna and mackerels effectively exchange gasses passively thanks	Ram-ventilation is the production of respiratory flow in some fish in which the mouth is opened	Membrane Active transport	Membrane diffusion	AC	Atomic/Molecular	various ions.	RE High (turbulent)	Dynamic pressure gradient	Seawater	Structure formed by arrays of rods with inserted a pile	https://www.researchgate.net/figur	Wegner, Nicholas C., Chugey A. Sepulveda, Scott A. Aalbers, and Jeffrey B. Graham. 2013.
10	Y	animal	**Cacti**	spines	Extract	Moisture	Air	Condense	moisture	air	move	Liquid	Suface	Cactus Opuntia efficiently collects water from the fog. This unique	(Refer to the linked picture) An overview of the efficient fog collection system	microtextured spikes to coalesce water	Coalescence of droplets	PA	Atomic/Molecular	water vapour		Surface energy Laplace pressure	Desert	micro conical structures (of hidrophobic material)	https://www.researchgate.net/figur	Ju, Jie, Hao Bai, Yongmei Zheng, Tianyi Zhao, Ruochen Fang, and Lei Jiang. 2012. 'A Multi-
11	Y	animal	**Tasar Silkmoth**	Cocoon	Expel	Gasses	Air	regulate	heat					Cocoon of silk moth allows carbon dioxide to diffuse out but not in and	The structure of the cocoon allows for gases that are harmful to pupal development, such as carbon	Selective exchange of gasses though	Membrane diffusion	PA	Atomic/Molecular	CO2	Re Intermediate	Gradients of concentration	Various terrestrial			Roy, Manas, Sunil Kumar Meena, Tejas Sanjeev Kusurkar, Sushil Kumar Singh, Niroj
12	Y	plant	**Orchids (epiphytic)**	Roots	Trap	Water/moisture	Air							The roots of some orchids efficiently absorb air moisture and	Many orchid species are equipped with velamentous roots. In this root type, a whitish,	Absorbtion via capillarity	Absorption Coalescence of droplets	PA	Atomic/Molecular	water droplets		Capillarity Surface energy	Various terrestrial	Aggregate of cilindrical-eliptical elements or	http://cdn.biologydiscussion.com/w	Joca, Thais Arruda Costa, Denis Coelho de Oliveira, Gerhard Zotz, Uwe Winkler, and Ana
13	Y	plant	**Tillandsia Lanbekii**	Leaf	Extract	Moisture	air	Condense	water	air				Leaves of rosette-forming plants like the Tillandsia capture fog by	Fog is conveyed to the plant through wind, and wind speed decreases as it gets closer to surfaces,	Water interception via narrow structures	Coalescence of droplets	PA	Atomic/Molecular	water droplets		Surface energy Laplace pressure	Desert	High density of elongated structures - rods - disposed	https://www.researchgate.net/figur	Martorell, Carlos, and Exequiel Ezcurra. 2007. 'The Narrow-Leaf Syndrome: A Functional and
14	N	plant	**Cotula fallax**	Leaf	Extract	Moisture	air							The hierarchical three dimensional layout of its leaves, along with its	Conventional fog-harvesting mechanisms are effectively pseudo-2D surface phenomena in terms	Condensation via Nano scale structure	Coalescence of droplets	PA	Atomic/Molecular	water droplets		Surface energy Laplace pressure	Desert	3d hierarchical structure to collect and move droplets	https://www.researchgate.net/figur	Andrews, H. G., E. A. Eccles, W. C. E. Schofield, and J. P. S. Badyal. 2011. 'Three-
15	N	plant	**Desert geophytes**	Leaf	Extract	Water	air	move	Liquids					Leaves of desert geophytes collect and retain water from fog and dew	Leaves and in some cases axes, display a circinate, helical, tortuose, or serpentine shape	Condensation and transport via helical,	Coalescence of droplets	PA	Atomic/Molecular	water droplets		Gravity Surface energy	Desert	spiraling/helical strips which allows the air	https://www.sciencedirect.com/sci	Vogel, Stefan, and Ute Müller-Doblies. 2011. 'Desert Geophytes under Dew and Fog: The
16	Y	animal	**Flying saucer trench beetle**	Behaviour	Extract	Water	air							Trenches created by the flying saucer trench beetle collect water	The trenches of these Lepidochora species are significantly oriented perpendicular to fog winds. A	Condensation via physical barrier to	Coalescence of droplets	PA	Atomic/Molecular	water droplets		Gravity Surface energy	Desert	create barriers above ground to intercept fog-	https://asknature.org/strategy/tren	Seely, M. K., and W. J. Hamilton. 1976. 'Fog Catchment Sand Trenches Constructed by
17	N	animal	**Insects (also acquatic)**	Respiratory system	Extract	Ions/gasses	air	move	Liquids					The respiratory system of flying insects consists of a series of rigid	the basic insect respiratory system consists of a series of rigid tubes, called **tracheae** (singular	Several	membrane diffusion	AC	Atomic/Molecular	air	Re Intermediate	Metabolic	Various terrestrial/aquatic		https://socratic.org/questions/how-	http://cronodon.com/BioTech/insect_respiration.html
18	Y	animal	**Elephant seal**	Respiratory system	Extract	Moisture	air	Condense	Water (moisture)	Air				The nasal turbinates of the northern elephant seal reduce water loss via	The nasal turbinates are important structural and functional components of this mechanism. This is	Condensation of water vapour via	Phase change	AC/PA	Atomic/Molecular	Water vapour	RE High (turbulent)	Surface energy muscular	Seawater/terrestrial	Spiraling/convoluted folded layer (with transversal	http://www.elephantseal.org/Resea	Huntley, A, Daniel Costa, and R Rubin. 1984. 'The Contribution of Nasal Countercurrent
19	N	plant	**Syntrichia caninervis**	Leaf	Extract	Water	air	move	Liquids					Syntrichia caninervis Mitt. (Pottiaceae) is one of the most	The leaf possesses a unique multiscale structures of the hair which are equipped to collect and	Condensation via functional roughness	Coalescence of droplets	PA	Atomic/Molecular	water vapour/water droplets		Pressure gradient Surface energy	Desert	fibrelike structures (of hidrophobic material) carved with microgrooves	archgate.net/figure/Morphology-of-	Pan, Zhao, William G. Pitt, Yuanming Zhang, Nan Wu, Ye Tao, and Tadd T. Truscott. 2016.
20	N	animal	**Hyper-regulators**	Osmoregulation system	Separate	Ions/molecules	Water	Filter						Osmoregulation means the physiological processes that an	The basic mechanism for ions exchange is the Sodium-Potassium pump. The process of moving	Membrane Active Trasport	Membrane diffusion (dyalisis)	AC	Atomic/Molecular	various ions.	Re Intermediate	ATP (metabolic energy)	Seawater	Filtration/ diffusion against gradients of concentration	millanhighered.com/BrainHoney/Re	Bradley, T.J. 2010. 'Animal Osmoregulation'. Animal Osmoregulation, January, 1–184.
21	N	animal	**Hypo-regulators**	Osmoregulation system	Separate	Ions/molecules	Water	Filter						Osmoregulation means the physiological processes that an	The basic mechanism for ions exchange is the Sodium-Potassium pump. The process of moving	Membrane Active Trasport	Membrane diffusion (dyalisis)	AC	Atomic/Molecular	various ions.	Re Intermediate	ATP (metabolic energy)	Fresh water	Filtration/ diffusion against gradients of concentration	millanhighered.com/BrainHoney/Re	Bradley, T.J. 2010. 'Animal Osmoregulation'. Animal Osmoregulation, January, 1–184.
22	N	animal	**Brine Shrimp (Artemia)**	Osmoregulation system	Separate	ions	Water	Filter						Euryhaline in hypersaline environment, hyporegulator. The	The brine shrimp has a cuticle covered integument with retard water loss, but extreme gradients do	Membrane Active Trasport	Membrane diffusion (dyalisis)	AC	Atomic/Molecular	high salinity (up to 25%)		ATP (metabolic energy)	Seawater high salinity (up to	Filtration/ diffusion against gradients of concentration		Gajardo, Gonzalo M., and John A. Beardmore. 2012. 'The Brine Shrimp Artemia: Adapted to
23	Y	animal	**Vertebrates**	kidneys - renal filtration -	Separate	Ions/water	Blood	Filter						In order to remove excess organic molecules from the blood several	Ultrafiltration process via glomerula or aglomerular filtration. In glomerulus hydrostatic	Several	Osmosis - Surface Membrane filtration	AC	Atomic/Molecular	various ions/molecules	Re < 1	Dynamic pressure gradient	Biological organism	Multiphases integrated processes of filtration in	https://commons.wikimedia.org/wi	http://www.rpi.edu/dept/chem-eng/Biotech-Environ/Projects00/memfilt/kidneys.htm
24	Y	animal	**Terrestrial-Amphibian Crab**	Gills	Filter	Ions/gasses	water/air	Exchange	Ions/gas	water/air				The gill lamellae of air-breathing crabs are modified to breathe air	Water-breathers require thin lamellae with a large surface area to obtain adequate oxygen, whilst in	Ultrafiltration/Osmosis/countercurrent	Surface - Dead end Cross-flow - Osmosis	AC	Atomic/Molecular	various ions/molecules	Re Intermediate		Water bodies	Multifunctional filtration/gas exchange unit	http://sallylightfootcrabresource.w	Farrelly, Caroline A., and Peter Greenaway. 1992. 'Morphology and Ultrastructure of the
25	N	plant	**Salt tolerant plants Halophites**	Root/tissues	Filter	Ions	Water (in soil)	Exclude	salt ions	Water (in soil)				In order to take up water halophytes must adjust their tissue	Exclusion of salts by the roots by **ultrafiltration.**Two process for water uptake can	Ultrafiltration	Membrane diffusion	AC	Atomic/Molecular	NaCl	Re < 1	ATP (metabolic energy)	Soil with saline water content	Use ions to change water potential on one side of the	https://www.vedantu.com/biology	Roohi Aslam. 2011. 'A Critical Review on Halophytes: Salt Tolerant Plants'. Journal of
26	N	plant	**Salt tolerant plants Halophites**	Tissues	Exclude	Ions	Water (in soil)							In order to take up water halophytes must adjust their tissue	Halophytes synthetise organic osmotic compounds (Osmolytes) that can reduce the need for salt ions	Osmolytes to adjust osmotic potential	Membrane diffusion (dyalisis)	AC	Atomic/Molecular	NaCl	Re < 1	ATP (metabolic energy)	Soil with saline water content	Use/Store osmolyte (from natural material) to lower	https://www.researchgate.net/figur	Roohi Aslam. 2011. 'A Critical Review on Halophytes: Salt Tolerant Plants'. Journal of
27	N	plant	**Salt tolerant plants Halophites**	Leaf/Stem - Salt glands	Concentrate	Ions	Water (in soil)	Excrete	ions/water	Water (in soil)				Halophytes use **Salt glands and Salt hairs**. A. lagopoides, C. cretica,	**Compartmentalisation** of excess salt ions into tissues, organs. NACL is confined into cell	Segregation, Excretion,	Membrane diffusion (dyalisis)	AC	Atomic/Molecular	NaCl	Re < 1	ATP (metabolic energy)	Soil with saline water content	Collect and concentrate excess ions in	https://www.frontiersin.org/files/Ar	Roohi Aslam. 2011. 'A Critical Review on Halophytes: Salt Tolerant Plants'. Journal of
28	N	plant	**Dunaliella salina**	Tissues	Exclude	Ions	Water (in soil)							This biflagellate unicellular alga is responsible for most of the primary	Production of intracellular glycerol, proline and glycine betain to lower osmotic potential and keep	Osmolytes to adjust osmotic potential	Membrane diffusion (dyalisis)	AC/PA	Atomic/Molecular	NaCl	Re < 1	ATP (metabolic energy)	seawater	Produce osmolytes to regulate water potential in	https://www.sciencephoto.com/m	https://onlinelibrary.wiley.com/doi/abs/10.1002/jcp.21715
29	N	Fungi	**Black Yeast**	Osmoregulation system	Exclude	Ions	Water							the Black Yeast uses of Osmoprotectants (compatible	Increases in intracellular glycerol increases (in the sense that it make more negative compared to	Osmolytes to adjust osmotic potential	Membrane diffusion (dyalisis)	AC/PA	Atomic/Molecular	various ions.	Re < 1	ATP (metabolic energy)	air	Produce osmolytes to regulate water potential in	https://www.dovepress.com/cr_da	Reed, R H, J A Chudek, R Foster, and G M Gadd. 1987. 'Osmotic Significance of Glycerol
30	N	animal	**Desert Iguana**	Respiratory system - Salt	Concentrate	Ions	Water/air	Excrete	ions/water	air				The salt glands allow this organisms to maintain water and	The salt gland is an organ for excreting excess salts. It is found in elasmobranchs (sharks, rays,	Segregation, excretion,	Membrane diffusion (dyalisis)	AC	Atomic/Molecular	NaCl and also Potassium	Re < 1	ATP (metabolic energy)	Desert (California)	folded structure which maximize surface/volume	https://naturalhistoryintechnology.	Hazard, Lisa C. 2001. 'Ion Secretion by Salt Glands of Desert Iguanas (Dipsosaurus
31	N	animal	**Galapagos marine Iguana**	Respiratory system - Salt	Concentrate	Ions	Water/air	Excrete	ions/water	air				The salt glands allow this organisms to maintain water and	The salt gland is an organ for excreting excess salts. It is found in elasmobranchs (sharks, rays,	Segregation, excretion,	Membrane diffusion (dyalisis)	AC	Atomic/Molecular	NaCl	Re < 1	Chemical Reaction	Seawater coastal area	folded structure which maximize surface/volume	https://naturalhistoryintechnology.	Hazard, Lisa C. 2001. 'Ion Secretion by Salt Glands of Desert Iguanas (Dipsosaurus
32	Y	animal	**Pengiuns, Seagulls and other seawater**	Respiratory system - Salt	Concentrate	Ions	Water/air	Excrete	ions/water	air				The salt glands allow this organisms to maintain water and	The salt gland is an organ for excreting excess salts. It is found in elasmobranchs (sharks, rays,	Segregation, excretion,	Membrane diffusion (dyalisis)	AC	Atomic/Molecular	NaCl	Re < 1	Chemical Reaction	Seawater coastal area	folded structure which maximize surface/volume	http://www.nicerweb.com/doc/class/bio1152/L	Bradley, T.J. 2010. 'Animal Osmoregulation'. Animal Osmoregulation, January, 1–184.
33	Y	plant	**Mangrove (Rhizophora)**	Roots	Exclude	Ions	Water	Filter	water	soil				The growth and physiological mechanisms of mangroves differ in	Ultrafiltration. The non-secretor mangrove Bruguiera cylindrica was used for comparative	Ultrafiltration	Membrane diffusion (aquaporins)	PA	Atomic/Molecular	NaCl	Re < 1	Sodium-Potassium pump	Seawater/estuary	Halophytes try to adjust salinity delicately between	https://www.nature.com/articles/sr	Kim, K. et al. Novel water filtration of saline water in the outermost layer of mangrove
34	Y	plant	**Mangrove (avicennia)**	Leaf - Salt glands	Concentrate	Ions	Water	excrete/expel	ions/water	air				Salt gland (vacuoles) collect salt ions and crystallize excreting them	The salt glands of Avicennia officinalis are microscopic (20–40 μm) structures found on the	Segregation, excretion,	Membrane diffusion (dyalisis)	AC	Atomic/Molecular	NaCl	Re < 1	Sodium-Potassium pump	Seawater/estuary	Collect ions into compartment allow them to	https://www.researchgate.net/figur	Parida, Asish Kumar, and Bhavanath Jha. 2010. 'Salt Tolerance Mechanisms in
35	N	plant	**Salicornia**	Tissues	Dilute	Ions	Water	Store	ions/water					In order to take up water halophytes must adjust their tissue	Multiple sodium compartmentalization. Can accumulate up to 50% of dry weight in its shoots.	Multiple sodium compartmentalizatio	Membrane diffusion (dyalisis)	AC	Atomic/Molecular	NaCl	Re < 1	Chemical Reaction	Seawater/estuary	Store salt in compartment and use it also to attract	http://www.biologydiscussion.com/	Lv, Sulian, Ping Jiang, Xianyang Chen, Pengxiang Fan, Xuchu Wang, and Yinxin Li.
36	N	animal	**Tubeworms**	Housing	Extract	Ions	Water	Tranform	ions	Water				Biomineralization to create calcareous structure. Among	Biomineralization begins with precipitation, starting from different ions, and the driving force	Biomineralization/Chemical	Phase change - Chemical transformation	AC	Atomic/Molecular	various ions.	Re Intermediate	Chemical Reaction	Seawater	Remove ions from solvent via process of	https://www.frontiersin.org/articles	Bright, Monika, and François Lallie. 2010. 'The Biology of Vestimentiferan Tubeworms'. In
37	Y	animal	**Teleostei, Cyprinidae**	Gills	Filter	Particles/ions	Water	exchange	gasses	water	move	Liquid		The gill lamellae, the site of gas exchange, are bordered by a double	A number of filtration mechanisms have been proposed to explain how pump suspension-feeding	Filtration by Interception - Inertial	Surface - Dead End Cross-flow filtration	AC/PA	Atomic/Molecular /Micro	Various size particles, μm	Re Intermediate	Dynamic pressure gradient	Seawater/Fresh water		https://en.wikipedia.org/wiki/Fish	Hofer, Rudolf, Willi Salvenmoser, and Fritz Schiemer. 2003. 'Regulation of Diurnal Filter
38	Y	plant	**Bromeliades (epiphytic)**	Leaf - Trichomes	Extract	Water	Air	move	Liquids					The absorptive bromeliad leaf is covered with multicellular	These trichomes – also termed as "scales" – consist of dead empty cells: a central disc,	Absorption	Absorption	PA	Atomic/Molecular/Micro	(maybe) water vapour/water		Capillarity	Forest environment	micro one-way superficial valve which lifts up when	https://www.medicinalplantsarchiv	Gorb, Stanislav N., ed. 2009. Functional Surfaces in Biology. Dordrecht: Springer
39	Y	animal	**Birds**	Respiratory system	Filter	Gasses	Air	Move	air					The respiratory system of birds efficiently transports oxygen via	The 'dual' ventilation of the avian respiratory system has been allowed by its complex	Unidirectional air flow	Membrane diffusion	AC	Atomic/Molecular/Micro	Gasses	RE High (turbulent)	Muscular/Metabolic	air	uncoupled Gas exchanger/ventilation	https://www.youtube.com/watch?v	Maina, J. N. 2005. The Lung-Air Sac System of Birds: Development, Structure, and Function. Berlin; New York: Springer-Verlag.
40	Y	animal	**Camel**	Respiratory system - nasal	Extract	Moisture	Air	Condense	Water (moisture)	Air	exchange	heat	air	Nasal turbinates which extract and recover air moisture from breathing	Nasal turbinates have a 3 D convoluted spiraling structure which optimizes surface/volume ration	Condensation/Evaporation	Phase change - condensation/evaporation	AC/PA	Atomic/Molecular/Micro	water vapour	RE High (turbulent)	Dynamic pressure gradient	Desert environment with high T excursion	Spiraling/convoluted folded layer (with transversal	https://www.semanticscholar.org/p	Schmidt-Nielsen, K., R. C. Schroter, and A. Shkolnik. 1981. 'Desaturation of Exhaled Air in
41	N	animal	**Orb-wevear Spider**	Silk web	Trap	particles	air	dissipate	kinetic energy	air	manage	light	air	Orb-web spiders produces silk/non-silk nets to stop and trap insects.	Silk is loosely defined as fibrous proteins that are extruded outside an organism's body and that are	Sieving - Interception - Inertial impaction	Surface Dead end filtration - Sieving	PA	Meso	insects of different sizes	Re Intermediate		various terrestrial habitat	net-like structure composed of intertwined		Blackledge, Todd A., Matjaž Kuntner, and Ingi Agnarsson. 2011. 'The Form and Function of
42	Y	animal	**Flamingo**	Feeding system - beak	Filter	particles	Water	sort	particles	particles	move	Liquid	channels	The beak in Flamingos can gather large quantities of small food	The beak architecture produces a lower pressure in the mouth while it is pushed through the water,	Sieving - straining assisted by vortexes	Sieving - straining	AC	Meso	particle size: 1-4 mm	RE High (turbulent)	Dynamic pressure gradient	Water bodies	Sieving structure composed of two overlapping movable	https://www.semanticscholar.org/p	Zweers, G., F. de Jong, and H. Berkhoudt. 1995. 'Filter Feeding in Flamingos
43	N	animal	**Moon Snail (Naticidae Sp)**	Reproduction system	Transform	Particles	Water							The Naticidae are a cosmopolitan gastropod family that lives from the	The process starts with the female expand her foot to cover her entire shell. Cilia on the foot pick up	Trapping with mucus	Transformation	AC	Meso	mm	Re Intermediate		Seawater	trap particles engolphing them in mucus material	https://www.amusingplanet.com/2	Huelsken, Thomas, Carina Marek, Stefan Schreiber, Iris Schmidt, and Michael
44	N	animal	**Dabbling Duck**	Feeding system - beak	Filter	particles	Water	move	Liquids					The filter mechanism of this species is constructed in such a	Filter feeding in the Dabbling duck consists of a sequence of several mechanisms. A suction-	Sieving - straining assisted by	Sieving - Density Separation/centrifugation	AC	meso/macro	0.3-1.5 mm	RE High (turbulent)	Muscular/Metabolic	Water bodies		https://www.semanticscholar.org/p	Brent Gurd, D. 2006. 'Filter-Feeding Dabbling Ducks (Anas Spp.) Can Actively Select Particles
45	N	animal	**Carp fish**	Feeding system	Filter	particles	Water	Concentrate	particles	Water				The carp uses crossflow filtration to concentrate small food particles in	Cyprinus carpio fed on all food particles by using 'slow suction', which occurs in cyprinids swimming	Cross-flow filtration, flow reversal	Surface - Dead end Cross-flow filtration	AC	Micro	5–3000 μm particles	Re Intermediate	Dynamic pressure gradient	Fresh water	Cross-flow filtration with pulsating flow reversal		Callan, W. T. 2003. 'Feeding Mechanisms in Carp: Crossflow Filtration, Palatal Protrusions
46	N	animal	**Human**	Lungs	Trap	particles	Air							The alveolar macrophage (dust cells) stands as the guardian of the	By secretion of oxygen metabolites, lysozyme, antimicrobial peptides and proteases, and through	Phagocytosis via vescicle	Depth filtration	AC	Micro	μms			Biological tissues	Surface which folds its structure trapping	https://www.researchgate.net/figur	Naeem A, Rai SN, Pierre L. Histology, Alveolar Macrophages. [Updated 2019 Sep 19]. In:
47	Y	animal	**Birds**	Feathers	Exclude	Water	Air/Water	Repel	Water	Air/Water				Feathers prevent water to pass through	Hierarchical micro structure of the feather which provides superhydrophobicity	Hydrophobicity	Surface tension regulation	PA	Micro	water droplets		Surface energy	Water bodies	Fractally structured surface whose surface energy	https://phys.org/news/2016-02-	http://www.asknature.org/strategy/36325543f2778c96dd2a8730a8bd2bbf#.VQA4lPnF-ho
48	N	animal	**Sponges choanocytes (freshwater)**	Feeding system - choanocytes	Filter	particles	Water	move	Liquids					The freshwater sponges (Spongillidae) feed by filtering out	Collar sieving: where a beating flagellum creates a feeding current through a collar filter.	Sieving - interception - direct impaction	Surface - Dead end filtration - Sieving	AC	Micro	2 to 200 μm phytoplankton but	Reynolds numebr 0.1-50	Dynamic pressure gradient	Seawater	Circular sieving structure through which water is	https://yaybiology11.weebly.com/lo	Weissenfels, Norbert. 1992. 'The Filtration Apparatus for Food Collection in Freshwater
49	N	animal	**Sediment infaunal sponges:**	Feeding system	Filter	particles	Water	move	Liquids					As an adaptation to life embedded in sediment, it possesses inhalant	The inhalant current is ingested through the distal portions of ingestion siphons which reach out of	3 Dimensional capillary filtering	Surface - Dead end filtration	AC	Micro	2 to 200 μm phytoplankton but	Re Intermediate	Dynamic pressure gradient	Seawater	1) spherical filtering device with multiple inlets and	https://www.semanticscholar.org/p	Werding, Bernd, and H. Sanchez. 1991. 'Life Habits and Functional Morphology of the
50	N	animal	**Sponges**	anchoring system	Trap	particles	Water							Soft-bottom sponges generally use foreign bodies to anchor and to	The soft bottom sponges that are specialised to live in unconsolidated sediments (ex. Oceanapia	Incorporation Phagocytosis	Trap and incorporate Depth filtration	AC	Micro	μms	Re Intermediate	Dynamic pressure gradient	Seawater		https://www.researchgate.net/publ	Cerrano, Carlo, Barbara Calcinai, Cristina Gioia Di Camillo, Laura Valisano, and Giorgio
51	N	animal	**Blue mussel**	Gills	Filter/Trap	particles	Water	Move	Liquids					The gills of the oyster and other bivalves perform several important	Cirri trapping in bivalves with gill spaces possessing laterofrontal cirri that beat against the	trapping/separation assisted by cirri/cilia	Separation/Concentration via cilia	AC	Micro	above 4micron 100%, 50% below 2micron	Re Intermediate	Dynamic pressure gradient	Seawater	Bi directional transport of particles. Interception of	https://www.researchgate.net/figur	Evan Ward, J, and Sandra E Shumway. 2004. 'Separating the Grain from the Chaff: Particle
52	N	animal	**Bryozoans, phoronids and brachiopods**	Feeding system	trap	particles	Water	Move	Liquids	Water				Filter feeding by sieving assisted by ciliari presence and movement	Ciliary sieving where particles are retained by a filter formed by a band of stiff cilia upstream of	Sieving assisted by cilia	Surface - Dead end Concentration via cilia	AC	Micro	2 to 200 μm phytoplankton but	Re Intermediate	Dynamic pressure gradient	Seawater	Cross flow filtration system with cilia for trapping	https://www.researchgate.net/publ	Riisgård, Hu, and Ps Larsen. 2010. 'Particle Capture Mechanisms in Suspension-Feeding
53	N	animal	**bivalve and gastropod veliger larvae**	Feeding system	trap	particles	Water							Filter feeding by sieving assisted by ciliari presence and movement	Ciliary downstream collecting in a diverse group of suspension- feeding invertebrates, where food	Catch up system. Sorting by cilia space	Separation/Concentration via cilia	AC	Micro	2 to 200 μm phytoplankton but	Re Intermediate	Dynamic pressure gradient	Seawater	Interception of particles made by creating tranzizion	https://www.researchgate.net/publ	Riisgård, Hu, and Ps Larsen. 2010. 'Particle Capture Mechanisms in Suspension-Feeding
54	N	animal	**Polychaetes**	Feeding system	Filter	particles	Water	trap						Filter feeding assistd by mucus net	Mucus-net filter-feeding in some species of polychaete worms, gastropods, ascidians, salps,	Sieving - Interception - Inertial impaction	Surface - Dead end - Sieving	AC	Micro	2 to 200 μm phytoplankton but	Re Intermediate	Dynamic pressure gradient	Seawater	Dead end Filtration process composed of continuous	https://www.researchgate.net/publ	Riisgård, Hu, and Ps Larsen. 2010. 'Particle Capture Mechanisms in Suspension-Feeding
55	N	animal	**Ascidians**	Feeding system	Filter	particles	Water	move	Liquids					Sea Squirts filter-feed by rhythmically pumping water into an	The filtering surface of the basket consists of three adjacent and connected screens (sheets).	Sieving - Interception - Inertial impaction	Surface - Dead end - Sieving	AC	Micro	Particle size: down to 2 or 3 μm	Re Intermediate	Dynamic pressure gradient	Seawater	Dead end Filtration process composed of continuous	https://www.researchgate.net/publ	Riisgård, Hu, and Ps Larsen. 2010. 'Particle Capture Mechanisms in Suspension-Feeding
56	Y	animal	**Salp**	Feeding system	Filter	particles	Water	trap						Salps filter-feed by rhythmically pumping water with food particles	In salps, the feeding water flow is produced by rhythmic contractions of muscle bands around	Interception - Inertial impaction	Surface - Dead end	AC	Micro	particle size: 0.01μm	Re Intermediate	Dynamic pressure gradient	Seawater	Dead end Filtration process composed of continuous	https://www.researchgate.net/publ	Riisgård, Hu, and Ps Larsen. 2010. 'Particle Capture Mechanisms in Suspension-Feeding
57	N	animal	**Doliolids**	Feeding system	Filter	particles	Water	trap						Filter feeding assistd by mucus net	Mucus-net filter-feeding in some species of polychaete worms, gastropods, ascidians, salps,	[illegible]	[illegible]	AC	Micro	μms	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	Riisgård, Hu, and Ps Larsen. 2010. 'Particle Capture Mechanisms in Suspension-Feeding
58	N	animal	**Cephalochordates**	Feeding system	Filter	particles	Water	trap						Filter feeding assistd by mucus net	Mucus-net filter-feeding in some species of polychaete worms, gastropods, ascidians, salps,	[illegible]	[illegible]	AC	Micro	μms	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	Riisgård, Hu, and Ps Larsen. 2010. 'Particle Capture Mechanisms in Suspension-Feeding
59	N	animal	**Gastrotrichs**	Feeding system	Filter	particles	Water	trap						Filter feeding assistd by mucus net	Mucus-net filter-feeding in some species of polychaete worms, gastropods, ascidians, salps,	[illegible]	[illegible]	AC	Micro	μms	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	Riisgård, Hu, and Ps Larsen. 2010. 'Particle Capture Mechanisms in Suspension-Feeding
60	N	animal	**Pteropods and Echiurans**	Feeding system	Filter	particles	Water	Move	Liquids					Filter feeding assistd by mucus net	Mucus-net filter-feeding in some species of polychaete worms, gastropods, ascidians, salps,	[illegible]	[illegible]	AC	Micro	μms	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	Riisgård, Hu, and Ps Larsen. 2010. 'Particle Capture Mechanisms in Suspension-Feeding
61	N	animal	**crustaceans - branchiopods**	Feeding system	Filter	particles	Water	Concentrate	particles	Water	Move	Liquid		Filter feeding assisted by setea filter	[illegible]	[illegible]	[illegible]	AC	Micro	[illegible]	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	Riisgård, Hu, and Ps Larsen. 2010. 'Particle Capture Mechanisms in Suspension-Feeding
62	N	animal	**Barnacles**	Feeding system	Filter	particles	Water	Concentrate	particles	Water	Move	Liquid		Filter feeding assisted by setea filter	[illegible]	[illegible]	[illegible]	AC/PA	Micro	[illegible]	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	Riisgård, Hu, and Ps Larsen. 2010. 'Particle Capture Mechanisms in Suspension-Feeding
63	N	animal	**Euphausiaceans**	Feeding system	Filter	particles	Water	Concentrate	particles	Water	Move	Liquid		Filter feeding assisted by setea filter	[illegible]	[illegible]	[illegible]	AC	Micro	[illegible]	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	Riisgård, Hu, and Ps Larsen. 2010. 'Particle Capture Mechanisms in Suspension-Feeding
64	N	animal	**Amphipods**	Feeding system	Filter	particles	Water	Concentrate	particles	Water	Move	Liquid		Filter feeding assisted by setea filter	[illegible]	[illegible]	[illegible]	AC	Micro	[illegible]	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	Riisgård, Hu, and Ps Larsen. 2010. 'Particle Capture Mechanisms in Suspension-Feeding
65	N	animal	**Decapods**	Feeding system	Filter	particles	Water	Concentrate	particles	Water	Move	Liquid		Filter feeding assisted by setea filter	[illegible]	[illegible]	[illegible]	AC	Micro	[illegible]	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	Riisgård, Hu, and Ps Larsen. 2010. 'Particle Capture Mechanisms in Suspension-Feeding
66	N	animal	**planktonic larvae of echinoderms**	Feeding system	Filter	particles	Water	Concentrate	particles	Water	Move	Liquid		[illegible]	[illegible]	[illegible]	[illegible]	AC	Micro	[illegible]	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	[illegible]
67	N	animal	**polychaete** [illegible]	Feeding system	Filter	particles	Water							[illegible]	[illegible]	[illegible]	[illegible]	AC	Micro	[illegible]	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	[illegible]
68	N	animal	**Atlantic menhaden**	Feeding system	Filter	particles	Water							[illegible]	[illegible]	[illegible]	[illegible]	AC	Micro	[illegible]	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	[illegible]
69	N	animal	**Porcellio Scaber (Isopod)** [illegible]	Feeding system	Filter	particles	Food (mix of water, matter)							[illegible]	[illegible]	[illegible]	[illegible]	AC	Micro	[illegible]	Re Intermediate	Dynamic pressure gradient	Soil	Double filter with grooves	[illegible]	[illegible]
70	N	animal	**Caddis fly**	housing net	Filter	particles	Water	Adapt to	flow variations	water with sediments				[illegible]	[illegible]	[illegible]	[illegible]	AC	Micro	[illegible]	Re Intermediate	Dynamic pressure gradient	Water streams	[illegible]	[illegible]	[illegible]
71	Y	plant	**Lotus**	Leaf	Repel	Water/particles	Air	Reduce adhesion	water and particles					[illegible]	[illegible]	Hydrophobicity/Self cleaning	Surface tension regulation	PA	Micro	[illegible]	Re Intermediate	Surface energy	Water bodies	[illegible]	[illegible]	[illegible]
72	Y	animal	**Namibian Desert beetle** [illegible]	Body surface (integument)	Extract	water	Air	Condense	moisture	Air	move	Liquid	surface	[illegible]	[illegible]	[illegible]	Phase change - Surface tension regulation	PA	Micro	[illegible]	Re Intermediate	Surface energy Gravity	Desert	[illegible]	[illegible]	[illegible]
73	Y	animal	**Tick**	mouth	Extract	Moisture	Air	Condense	moisture		store	Liquid		[illegible]	[illegible]	[illegible]	Phase change/Absorption	AC/PA	Micro	[illegible]	Re Intermediate	Osmotic	Various	[illegible]	[illegible]	[illegible]
74	Y	animal	**Thorny devil**	Body surface (integument)	Extract	Water	Soil/Air	Move	Liquids					[illegible]	[illegible]	[illegible]	[illegible]	PA	Micro	[illegible]	[illegible]	Surface pressure gradient	Desert	[illegible]	[illegible]	[illegible]
75	N	animal	**Pipe Fish**	Gills	Filter	particles	Water							[illegible]	[illegible]	[illegible]	[illegible]	AC	Micro	[illegible]	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	[illegible]
76	N	animal	**Oikopleura appendicularia**	Feeding system	Filter	particles	Water	concentrate	particles	Water				[illegible]	[illegible]	[illegible]	[illegible]	AC	micro	[illegible]	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	[illegible]
77	Y	plant	**Roridula plant (carnivour plant)**	Body surface	Trap	Particles	Air							[illegible]	[illegible]	sticky cilia	hydrosol trapping	PA	Micro	[illegible]	[illegible]	Gravity	Various terrestrial	[illegible]	[illegible]	[illegible]
78	N	animal	**Sea cucumber**	Feeding system	Filter	particles	Water	adhere						[illegible]	[illegible]	[illegible]	[illegible]	PA	Micro	[illegible]	Re Intermediate	[illegible]	Seawater	[illegible]	[illegible]	[illegible]
79	Y	bacteria	**Cyanobacteria**	housing	Trap	particles	Water	adhere						[illegible]	[illegible]	hydrosol trapping	hydrosol trapping	PA	Micro	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
80	N	plant	**Lichens**	Leaf	Extract	Water	Air	Condense	Water					[illegible]	[illegible]	[illegible]	[illegible]	PA	Micro	[illegible]	[illegible]	[illegible]	Various terrestrial	[illegible]	[illegible]	[illegible]
81	N	animal	**Lugworm arenicola**	Feeding system	Filter	particles	Water/Soil	move	Liquids					[illegible]	[illegible]	[illegible]	Depth filtration (?)	AC	Micro	[illegible]	Re Intermediate	[illegible]	Seawater	[illegible]	[illegible]	[illegible]
82	N	animal	**Desert Cockroach**	body/mouth	Extract	moisture	Air	Condense	moisture					[illegible]	[illegible]	[illegible]	[illegible]	AC/PA	micro	Water vapour	[illegible]	Concentration gradient	Desert	[illegible]	[illegible]	[illegible]
83	Y	animal	**Shark**	Skin	Repel	bacteria/organisms	Water	Reduce drag	surface	water	Repel	oil	water	[illegible]	[illegible]	[illegible]	Adhesion and Surface tension regulation	PA	micro	[illegible]	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	[illegible]
84	N	animal	**Echinoderms**	Madreporite	Filter	particles	water	move	Liquids					[illegible]	[illegible]	[illegible]	[illegible]	AC	Micro	[illegible]	[illegible]	[illegible]	Seawater/tidal	[illegible]	[illegible]	[illegible]
85	N	animal	**Vorticella**	Feeding system	Filter	particles	Water	move	Liquids					[illegible]	[illegible]	[illegible]	Active trapping assisted by vortex	AC	micro	[illegible]	Re Intermediate	ATP and Ca pump	Seawater	[illegible]	[illegible]	[illegible]
86	N	animal	**Filefish**	skin	repel	Oil	water							[illegible]	[illegible]	[illegible]	[illegible]	PA	micro	oil in water	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	[illegible]
87	N	animal	**Teleostean fish**	epithermal cells of gills	Filter	Ions	Water	trap	mucus	surface	provide mechanical		surface	[illegible]	[illegible]	Cross-flow filtration Diffusion	Membrane diffusion	AC	Atomic/Molecular	[illegible]	Re Intermediate	Dynamic pressure gradient	Seawater, freshwater	[illegible]	[illegible]	[illegible]
88	N	animal	**Spiny Dogfish (Squalus acanthias)**	Skin	Repel	Oil, organic liquids / skin	Water							[illegible]	[illegible]	[illegible]	Surface tension regulation	PA	micro	oil in water	Re Intermediate	Dynamic pressure gradient	Seawater	[illegible]	[illegible]	[illegible]

89	N	plant	**Rosa montana**	**Petals**	Repel / attract	water	Air							Small water droplets (Volume < 10µl) adhere on its petals thanks to	The superficial morphology can be described as a hierarchical structure at micro and nano scale	Hydrophobocity by functional roughness	Surface tension regulation via micro morphology	PA	micro	Water droplets		Surface energy Gravity	Various terrestrial Altitude 1000 - 2000	micro/nano textured surface with ridges and/or	https://www.researchgate.net/figur	L. Feng, Y. Zhang , J. Xi, Y. Zhu, N. Wang, F. Xia and L. Jiang, "Petal Effect: A
90	Y	plant	**Viola tricolor**	**Petals**	Repel	water	Air							Water droplets and contaminants doesn't adhere on its petals thanks	Petal's surface show a specific morphology characterized by cone cells with a hierarchical	Hydrophobocity by functional roughness	Surface tension regulation via micro morphology	PA	micro	Water droplets		Surface energy Gravity	Various terrestrial Altitude = 0 - 2000 m	micro/nano textured surface with ridges and/or	https://www.researchgate.net/figur	A. J. Schulte, D. M. Droste, K. Koch and W. Barthlott, "Hierarchically structured
91	Y	animal	**A. bindusara (cicada)**	**wings**	Repel	water	Air							Water droplets and contaminants doesn't adhere on its wings thanks	Wings surface show a roughness at nano scale caused by a single level of conical cells.	Hydrophobocity by functional roughness	Surface tension regulation via micro morphology	PA	micro	Water droplets		Surface energy Gravity	Various terrestrial Heat resistance 200°C	micro/nano textured surface with ridges and/or	https://journals.plos.org/plosone/ar	Mingxia Sun, Aiping Liang, Gregory S. Watson, Jolanta A. Watson, Yongmei Zheng, Jie Ju,Lei
92	Y	animal	**M. opalifer (cicada)**	**wings**	Repel	water	Air							Water droplets and contaminants doesn't adhere on its wings thanks	Wings surface show a roughness at nano scale caused by a single level of conical cells.	Hydrophobocity by functional roughness	Surface tension regulation via micro morphology	PA	micro	Water droplets		Surface energy Gravity	Various terrestrial Heat resistance 200°C	micro/nano textured surface with ridges and/or	https://journals.plos.org/plosone/ar	Mingxia Sun, Aiping Liang, Gregory S. Watson, Jolanta A. Watson, Yongmei Zheng, Jie Ju,Lei
93	Y	animal	**C. atrata (cicada)**	**wings**	Repel	water	Air							Water droplets and contaminants doesn't adhere on its wings thanks	Wings surface show a roughness at nano scale caused by a single level of conical cells.	Hydrophobocity by functional roughness	Surface tension regulation via micro morphology	PA	micro	Water droplets		Surface energy Gravity	Various terrestrial Heat resistance 200°C	micro/nano textured surface with ridges and/or	https://journals.plos.org/plosone/ar	Mingxia Sun, Aiping Liang, Gregory S. Watson, Jolanta A. Watson, Yongmei Zheng, Jie Ju,Lei
94	N	animal	**Leafhoppers (cicadellidae)**	**wings**	Repel	water	Air	Repel	oil	air				Water and oil droplets doesn't adhere on its surface thanks to a	Leafhopper integument ("skin") show a hierarchical roughness generated by a coating of	Hydrophobocity/Oleophobicity by	Surface tension regulation via micro morphology	PA	micro	Water droplets/oil		Surface energy Gravity	Various terrestrial	micro/nano textured surface with ridges and/or	https://www.researchgate.net/figur	Roman Rakitov and Stanislav N. Gorb, "Brochosomal coats turn leafhopper (Insecta,
95	N	animal	**Collembola (springtail)**	**Body**	Repel	water	Air	Repel	oil	air				The adhesion of water and organic liquind droplets is prevented, even	Surface topography can vary greatly within Collembola families.	Hydrophobocity (Omniphobicity) by	Surface tension regulation via micro morphology	PA	micro	Water droplets		Surface energy Gravity	Various terrestrial	micro/nano textured surface with ridges and/or	https://link.springer.com/article/10	Julia Nickerl, Ralf Helbig, Hans-Ju¨rgen Schulz, Carsten Werner, Christoph Neinhuis"Diversity
96	N	plant	**Colocasia esculenta (Taro)**	**Leaf**	Repel	Water	air	Repel	bacteria	water				Water droplets and contaminants doesn't adhere on its leaves thanks	Leaves surface show a hierarchical structures at micro and nano scale, composed respectively by	Hydrophobocity by functional roughness	Surface tension regulation via micro morphology	PA	micro	Water droplets		Surface energy Gravity	Tropical environment Temperature	micro/nano textured surface with ridges and/or	https://www.semanticscholar.org/p	Ma, J. et al. (2011) 'Nanostructure on taro leaves resists fouling by colloids and bacteria
97	N	plant	**Fagus sylvatica**	**Leaf**	Attract	Water	air							Water droplets adhere on its surface because of its superficial	Fagus leaves show a micro roughness due to a micro bumbs separated by sunken nervature, all	Hydrophilicity by functional roughness	Phase change Surface tension regulation	PA	micro	Water droplets		Surface energy Gravity	Various terrestrial Temperature	micro/nano textured surface with ridges and/or	https://www.researchgate.net/figur	Bharat Bhushan, Yong Chae Jung, "Natural and biomimetic artificial surfaces for
98	N	plant	**Magnolia grandiflora**	**Leaf**	Attract	Water	air							Water droplets adhere on its surface because of its superficial	Magnolia leaves show a micro roughness due to a micro bumbs separated by raised nervature, all	Hydrophilicity by functional roughness	Phase change Surface tension regulation	PA	micro	Water droplets		Surface energy Gravity	Various terrestrial Temperature	micro/nano textured surface with ridges and/or	https://www.researchgate.net/figur	Bharat Bhushan, Yong Chae Jung, "Natural and biomimetic artificial surfaces for
99	Y	plant	**Pitcher plant (Nepenthes)**	**Tissues - Peristome**	Attract	Water	air	Repel	Oil/ organic liquids	air				Water can completely wet the Peristome thanks to its micro	The superficial morpholgy of the Peristome and the material whom is composed ensure an high	Hydrophilicity by functional roughness	Phase change Surface tension regulation	PA	micro	Water droplets		Surface energy Gravity	Tropical environment	micro/nano textured surface with ridges and/or	https://europepmc.org/article/med	Holger F. Bohn and Walter Federle, "Insect aquaplaning: Nepenthes pitcher plants
100	N	plant	**Namib Desert Grass**	**Leaf**	Extract	water	air	condense	water	air				The Namib grass Stipagrostis sabulicola relies, to a large degree,	The surface is not hydrophobic. It shows a substantial contact angle hysteresis and therefore,	Hydrophilicity by functional roughness	Surface tension regulation via micro morphology	PA	micro	water vapour		Surface energy Gravity	Desert Temperature	micro and nano grooves along an elungated fibre	https://www.researchgate.net/figur	Ebner, M., T. Miranda, and A. Roth-Nebelsick. 2011. 'Efficient Fog Harvesting by Stipagrostis
101	N	plant	**Bamboo**	**Leaf**	Extract	water	air	Repel	water					Dual hydrophobic-hydrophilicwet-tability ofyoung Phyllostachys aurea	The young leaves of the bamboo plant, Phyllostachys aurea, exhibit a distinct dual wetting	Hydrophobicity/Hydrophillicity	Phase change - Surface tension regulation	PA	Micro	Water droplets around 1–40 µm	Re Intermediate	Surface energy Gravity	Desert Air moisture at sunset		https://core.ac.uk/download/pdf/8	J.M. Wigzell, R.C. Racovita, B.G. Stentiforda, M. Wilsona, M.T. Harris, I.W. Fletcher, D.P.K.
102	N	plant	**Nolana Mollis**	**Leaf**	Extract	Moisture	air	condense	water	air				the surface of the leaves is covered with salt glands which allow the	hygroscopic salt on the leaves attracts atmospheric water. Salty water then drops on the	hygroscopicity	phase change - Osmotic potential	PA	micro	water vapour		Surface energy Gravity	Desert	use hyperosmotic fluid to attract water molecules	https://www.researchgate.net/publ	Mooney, H. A., S. L. Gulmon, J. Ehleringer, and P. W. Rundel. 1980. 'Atmospheric Water
103	N	animal	**Brisingid sea star**	**Feeding system**	Trap	particles	Water	Filter	particles	Water				Novodinia antillensis is an opportunistic macroscopic	In the most frequently observed natural posture, the arms combine to produce a regular basket-like	Assembled Sieving	Surface - Dead end filtration - Sieving	PA	Micro/meso	particles	Re Intermediate	Dynamic pressure gradient	Seawater	Adaptable to flow sieving structure made of arms	http://fau.digital.flvc.org/islandora/	Emson, R. H., and C. M. Young. 1994. 'Feeding Mechanism of the Brisingid Starfish Novodinia
104	Y	animal	**Bowhead Whales**	**Feeding system**	Filter	particles	Water	move	Liquids	channel	regenerate	damaged parts	baleen surface	The filtering apparatus of whales - called Baleen - unlike nets and	Baleen consists of racks of hundreds of keratinous plates that are worn at their internal edge into	Continuous ram filtration with dead-	Surface - Dead end filtration - Cross flow	AC/PA	Micro/Meso	from mm to cm (krill/fish)	RE High (turbulent)	Dynamic pressure gradient	Seawater	Structure made of an array of plates oriented	https://jeb.biologists.org/content/2	Werth, A. J. 2013. 'Flow-Dependent Porosity and Other Biomechanical Properties of
105	N	animal	**Humpback Whale**	**Feeding system**	Filter	particles	Water	move	Liquids	channel	regenerate	damaged parts	baleen surface	The filtering apparatus of whales (Cetacea: Mysticeti) is usually	Baleen consists of racks of hundreds of keratinous plates that are worn at their internal edge into	intermittent lunge filtration with dead-	Surface - Dead end filtration - Cross flow	AC/PA	Micro/Meso	from µm to cm (krill/fish)	RE High (turbulent)	Dynamic pressure gradient	Seawater	Structure made of an array of plates oriented	https://jeb.biologists.org/content/2	Werth, A. J. 2013. 'Flow-Dependent Porosity and Other Biomechanical Properties of
106	N	animal	**Baskin shark**	**Feeding system**	Filter	particles	Water	move	Liquids					The basking shark is a filter-feeder relying on bristle-like gill rakers to	Feeding behavior features swimming slowly near the surface with the mouth held wide open. **This**	ram filtration - vortical cross step	Surface - Dead end filtration - Cross flow	AC/PA	Micro/Meso	5–3000 µm particles	RE High (turbulent)	Dynamic pressure gradient	Seawater	Structure for cross-flow separation presenting a so	https://www.nature.com/articles/n	Sanderson, S. Laurie, Erin Roberts, Jillian Lineburg, and Hannah Brooks. 2016. 'Fish
107	N	animal	**Whale Shark**	**Feeding system**	Filter	particles	Water							Consideration of the filter feeding mechanism in whale sharks has	We now know that whale sharks use at least three methods of filter feeding. The most readily	Ram filtration dead-end sieving, hydrosol	Surface - Dead end filtration - Cross flow -	AC/PA	Micro/Meso	plankton around 2-3mm (maybe down	RE High (turbulent)	Dynamic pressure gradient	Seawater	sieving mesh...pulsing back wash to clean it	https://www.semanticscholar.org/p	Motta, Philip J., Michael Maslanka, Robert E. Hueter, Ray L. Davis, Rafael de la Parra,
108	Y	animal	**FanWorm (sabella spallanzanii)**	**Feeding system**	Extract	particles	Water	sort	particles	particles	build	structure/ coating	water	The radiating filaments of fanworms filter water for food	In polychaetes, the gills are formed by radiant filaments that have lateral branches, called	Straining	Surface - Dead end straining	AC	micro	2 to 200 µm phytoplankton	Re Intermediate	Dynamic pressure gradient	Seawater	Straining structure composed of radiating rods	https://www.semanticscholar.org/p	Mechanism, Formation of the Tube, and Physiology of Digestion in Sabella Pavonina'.
109	N	animal	**Manta ray**	**Feeding system**	filter	particles	water	move	Liquids					Manta rays are large elasmobranchs that feed by	The filtering apparatus in these animals is a highly modified gill raker, comprising long, parallel arrays	called "ricoscet" filtration	Cross-Step Filtration	AC	micro	50 to >500 µm	RE High (turbulent)	Dynamic pressure gradient	Seawater		archgate.net/figure/The-manta-ray-	Divi, Raj V., James A. Strother, and E. W. Misty Paig-Tran. 2018. 'Manta Rays Feed
110	N	animal	**Caddis fly (macronema)**	**Feeding system**	filter	particles	water	move	Liquids					Feeding chamber. Rather complex structure, see articles	Trichopteran larvae (Macronema transversum) construct a feeding chamber and larval retreat of	Interception - Inertial impaction	Surface - Dead end	PA	micro	particles µm		Dynamic pressure gradient	Fresh water streams	Pitot tube like structure with net inside...	archgate.net/publication/32421690	WALLACE, J. BRUCE, and F. F. SHERBERGER. 1975. 'THE LARVAL DWELLING AND FEEDING
111	Y	animal	**Mammals**	**Eyelashes**	deflect	particles/moisture	air	move	Liquids					Eyelashes on mammals protect the eye from airborne particles by	Eyelashes act differently from other biological filter system such as hairs in the nose and airway,	Barriers creating votexes for deflection	Deflection	PA	micro/meso	particles/water vapour	Re Intermediate	Dynamic pressure gradient	Various terrestrial	Barrier made with arrays of fibres/filaments disposed at specific intra-distances	typublishing.org/doi/10.1098/rsif.20	Amador, Guillermo J., Wenbin Mao, Peter DeMercurio, Carmen Montero, Joel Clewis,
112	Y	eukariota	**Cell**	**Cellular membrane**	Trap	particles/liquids /molecules	Water/Plasma	Transport	particles/liquids/ molecules	intramembrane space	connect	vescicles	membrane layer	Take in material via Endocytosis	**Endocytosis** is the process by which cells take in materials. The cellular membrane folds around the	Phagocytosis/Pinocytosis via vescicles	(Surface) Trapping and transport	AC	micro	various particles and liquid (lipid drops)		ATP (metabolic energy)	biological tissues	Moving of substances/particles from	.org/c/biology/exocytosis-and-	https://en.wikipedia.org/wiki/Endocytosis
113	N	eukariota	**Cell**	**Cellular membrane**	Expel/Excrete	particles/molecules	Water/Plasma	Transport	particles/liquids/ molecules	intramembrane space	connect	vescicles	membrane layer	Get rid of material via Exocytosis	**Exocytosis** is the durable, energy-consuming process by which a cell directs the contents of	Expulsion via vescicle	(Surface) Trapping and transport	AC	micro	various particles and liquid (lipid drops)		ATP (metabolic energy)	biological tissues	Moving of substances/particles from	https://www.ck12.org/c/biology/ex	https://en.wikipedia.org/wiki/Exocytosis
114	N	animal	**Cribellate Spider**	**Silk web**	Extract	water	air	move	Liquids	surface	Condence	moisture	surface	The cribellate spider continuously collect water from air (moisture and	The water-collecting ability of the silk of the cribellate spider is the result of a unique fibre	Hydrophillicity/ Condensation and	Phase change	PA	Molecules/Micro	water droplets (5–20 µm in size)		Surface energy Laplace pressure	Forest environment	net-like structure composed of intertwined	https://www.researchgate.net/figur	Zheng, Yongmei, Hao Bai, Zhongbing Huang, Xuelin Tian, Fu-Qiang Nie, Yong Zhao, Jin Zhai,
115	N	animal	**Saiga**	**Respiratory system**	Extract	water/particles	air	Trap/Condence	water/particles	air	move	air		The Saiga's nose is an adaptation to the extremely cold and dusty	The musculature of the proboscis is less differentiated, but its large-area fan-shaped	Condensation of water vapour	Phase change/Surface Dead end	AC/PA	molecules/Micro	water vapour/ dust particles		Muscular/Metabolic	Dry steppes, semi-desert grasslands	Chamber structure sucking dust and/or cold air in from small openings. When	https://www.researchgate.net/figur	Frey, Roland, Ilya Volodin, and Elena Volodina. 2007. 'A Nose That Roars: Anatomical
116	Y	animal	**Humpback whales**	**Feeding behaviour**	trap	school of fishes	water	move	Liquids					humpback whales capture prey by engaging in complex feeding	Humpback whales use vocalizations to communicate to one another and effectively and	Trapping using bubble nets	Trapping using net	AC	macro	fishes several cm long	RE High (turbulent)	Dynamic pressure gradient	Seawater		https://www.researchgate.net/figur	Friedlaender, Ari, Alessandro Bocconcelli, David Wiley, Danielle Cholewiak, Colin Ware,
117	N	bacteria	**C. metallidurans**	**Feeding system**	Extract	minerals	soil/rock	transfrom	minerals	rock				High concentrations of heavy metals, like copper and gold, are	Please refer to references for detailed explanation	Chemical process via enzimes	Chemical transformation	AC	Molecules			Metabolic	Soil/Rock		https://phys.org/news/2018-02-	https://phys.org/news/2018-02-bacteria-gold-digesting-toxic-
118	Y	animal	**Desert Scorpion**	**skin**	deflect	particles	air	regulate	adhesion					Desert scorpion (Androctonus australis) is an animal living in	The erosion resistance characteristic of grooved surface can be attributed to the particle impact	deflecting particles via surface	Deflection	PA	meso-macro			Dynamic pressure gradient	Desert	Surface with micro texture made of grooves to resist	https://asknature.org/strategy/bum	Zhang, Jun-qiu, Zhi-wu Han, Rong-feng Ma, Wei Yin, You Lü, and Lu-quan Ren. 2013.