**Sadiq Tijjani Umar**

**119200113**

**Biomimicry Project Report**

**The Spider And Its Web: An Approach For Biomimicry Design**

**1)\_Discover**

The Spider is part of the class Arachnida from the phylum Arthropoda, it is characterised by it’s having eight legs , chelicerae with sharp fangs that are able to inject venom, and spinnerets that extrude silk. They are the largest order of arachnids and have a substantial amount of species diversity compared to other orders of organisms. Unlike insects, spiders have no antennae, they also have no extensor muscles in their limbs and instead extend them by hydraulic pressure. Their abdomens have appendages that have been modified to extrude silk from up to six types of glands using spinnerets. Spider webs vary in size, shape and the amount of sticky thread used. Spiders have primarily four pairs of eyes on the top-front area of the cephalothorax, arranged in patterns that vary from one family to another. The principal pair at the front are of the type called pigment-cup ocelli , these eyes are capable of forming images. The other pairs, called secondary eyes, are derived from the compound eyes of the ancestral chelicerates, but no longer have the separate facets typical of compound eyes. Each of the eight legs of a spider consists of seven different parts. The part closest to and attaching the leg to the cephalothorax is the coxa; the next segment is the short trochanter that works as a joint for the following long segment, the femur. Next is the spider's knee, the patella, which acts as the joint for the tibia. The metatarsus comes after, and it connects the tibia to the tarsus , the tarsus ends in a claw made up of either two or three points, depending on the family to which the spider belongs. Spiders also have fangs, and the great majority of spiders can use them to inject venom into prey from venom glands in the roots of the chelicerae. Spiders occur in a large array of sizes. The smallest spider, *Patu Digua* , are less than 0.37 millimetres in body length. The largest spider, the tarantula, can have body lengths up to 90 millimetres.

**The Goliath Bird Eating Spider**

**The Black Widow Spider**



**The Banana Spider**

**2)Abstract**

The spider has shown itself to be very flexible and easily adapts to the environment around it, so much so that it is found on every continent except Antarctica , it has become established in every habitat with the exception of air and water habitats. We will now explore as to how it was able to achieve this.

Feeding Behaviour: Although they are spiders who are non-predatory(for example, the jumping spider) and feed on plants and plant nectar, majority of spiders are predatory, different spiders have different approaches to hunting prey, for example the water spider builds underwater webs that they fill with air and use for digesting prey. The Net casting spiders make small webs and manipulate them to trap prey, Tarantulas and trapdoor spiders ambush their predators by waiting in burrows and coming out for the kill when they sense movement at the periphery.

Defence Mechanisms: The Spider has developed an array of defence mechanisms to maintain itself, many spider species are colour co-ordinated with their habitats so as to protect them from predatory birds and insects, most spiders are insufficiently dangerous or unpleasant-tasting for warning coloration to offer much benefit. Some species of spider have adapted reactive strategies inside of proactive ones, for example the funnel web spider has fangs and strong jaws(some species are extremely venomous) that it will use in a display when threatened, the tarantula has fine hairs on it’s abdomen and legs that it kicks up at an attacker when it is threatened, these fine hairs cause intense respiratory irritation when inhaled by the attacker.

Reproductive Systems: Reproduction in the spider species does not involve the insemination of the female directly, male spiders do not produce ready-made spermatophores (packages of sperm), but spin small sperm webs onto which they ejaculate and then transfer the sperm to special syringe-styled structures, palpal bulbs or palpal organs, borne on the tips of the pedipalps of mature males. Spiders generally use elaborate courtship rituals to prevent the large females from eating the small males before fertilization, except where the male is so much smaller that he is not worth eating.

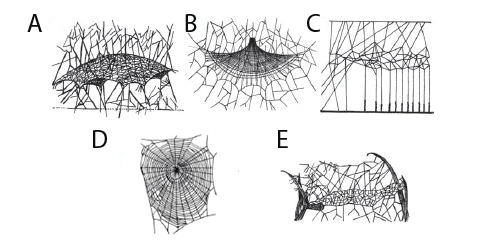
Web making: Spiders make an array of designs when it comes to webs, but on the whole they fall on one of two categories: Orb webs and Cob webs. Orb webs have hubs where the spiders lurk, usually above the center, if there is an obvious direction in which the spider can retreat to avoid its own predators, the hub is usually offset towards that direction. Cob webs are comingled and three dimensional , they take much longer to make than Orb webs.

****

**A Cricket caught in the web of a black widow spider**

****

**The Brazilian wondering spider in a threat display**

****

**A-Sheet web. B-Cob web. C-Tangle web. D-Orb web. E-Tubular Web.**

**3)Brainstorm**

The spider has given us insight into various design techniques which we can apply in biomimicry design, most especially in the design of it’s webs. Not only that, but the material used in the making of these webs also provides an interesting area of research , the spider builds it web such that it is elastic and tactile while at the same time the silk used in making the web is firm and resistant to wear and tear.

The design of the Tangle cob web presents an interesting on idea that can be applied in the arrangement of computers in a network. If we consider each point where the silk intersects with another string of silk a grid, then a decentralized grid-like network of nodes emerges. Decentralization of computer networks is a huge advantage in reducing the amount of spread in the case of a computer virus , if a system is centralized when a virus breaks , if one computer receives this virus, then all computers will eventually get infected. The design of the orb web presents an opportunity to make clothing less resistant to wear and tear also. A research team tested the resistance of a spider web’s supporting radial threads and compared that with the thinner spiral threads. They found that placing a certain amount of pressure on just one thread caused it to suddenly stiffen and distribute the stress to the rest of the web. A Japanese startup called Spiber said also that it has produced an artificial spider thread that it claims is equal to steel in tensile strength yet as flexible as rubber.

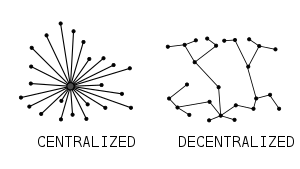
**4)Emulate**

There are a number of different ways we could go about making a design to cater to the aforementioned problems. A good reference point to begin from is how nature has managed to do similar things already;

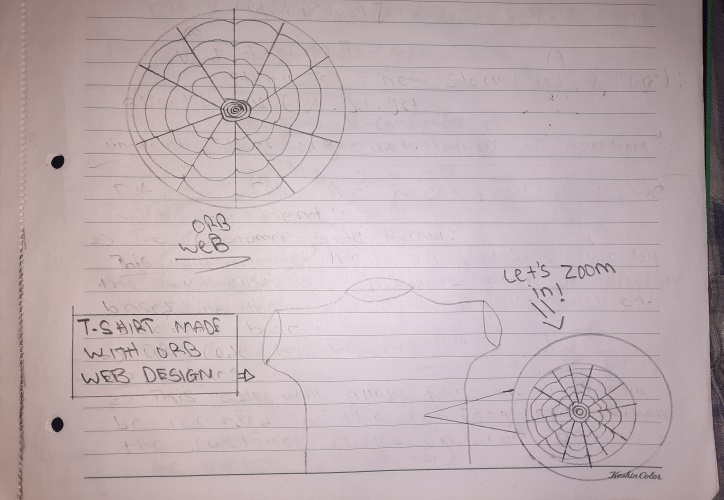
* We can firstly look to replicate the form of the web the spider weaves together, for example when trying to solve the problem of decentralization of a computer network, we have postulated to emulate the form of tangled cob web , these tangle webs are built by the spiders belonging to the theridiidae family of the arachida class, the theridiid gum-foot webs consist of frame lines that anchor them to surroundings and of support threads, which possess viscid silk, these webs can either have a central retreat or a peripheral retreat but since we want a de-centralized network, we should opt for a design similar to a gum-foot web with a peripheral retreat.
* We can secondly look to emulate process, the spiders intricately build up their webs, in building the tangled web, they use elastic, sticky silk trap lines leading to the top-most part of soil, the webs then remain in place for extended amounts of time and can be expanded upon and also repaired when broken. In Building the Orb web, they first produce an adhesive thread of silk to linger on a slight breeze across a space. When it attaches to a surface at the opposite end, the spider will feel the change in the vibration. The spider then brings in and tightens the first thread, then carefully moves across it and strengthens it with a second thread. This process is repeated until the thread is strong enough to support the rest of the web. After strengthening the first thread, the spider continues to make a Y-shaped netting. The first three radials of the web are then constructed. More radials are added, making sure that the distance between every radial is substantially enough to move cross. This means that the number of radials in a web directly depends on the size of the spider plus the size of the web, the size of the web can sometimes be 20 times the size of the spider building it. After the radials are complete, the spider fortifies the web center with four circular threads. It makes a spiral of non-sticky, widely spaced threads to enable it to move easily around its own web during construction, working from the inside to the outer side. Then, beginning from the outside and moving inward, the spider exchanges this spiral for a more closely spaced spiral made of sticky threads. It uses the initial radiating lines as well as the non-sticky spirals as guide lines. After the sticky spirals are formed, the non-sticky spirals are removed because there is no need for them any more. Replicating this process in large scale will be difficult because it is will be hard(and expensive) to collect enough spider silk to create a piece of clothing but we can emulate the process through which a spider makes its web with a different material. Also another thing that may be considered is the use of sticky spider silk as an adhesive.



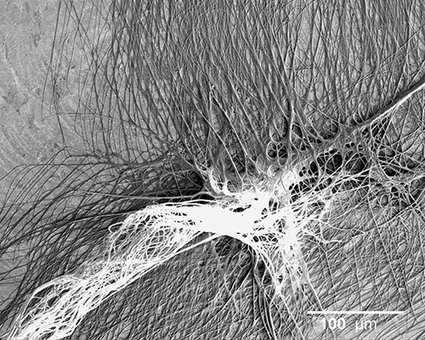
**Image Of a Tangled Web**



**Centralized Vs De-centralized Networks**



**Sketch Of Proposed Clothing Idea**



**Magnified Image Of a Sticky Spider Silk Thread**

**5)Evaluate**

To evalue our ideas based on life principles, we have to ask ourselves six questions;

Is the design locally attuned and responsive?

Yes, I think both of the proposed designs are locally attuned and responsive seeing as the final products depend on these designs being the foundation, for example in the computer network, a virus spread can only be contained if the network is distributed instead of concentrated, so each node responds to the node before it accordingly(if the previous node transmits a virus, it will shut it self down to save the others). This is the same principle found in the clothing design as is string/thread is dependent on the completion of another, thus the system has to be locally attuned and responsive to achieve the required goal.

Does the design adapt to changing conditions?

The computer design network will achieve this because in the case that a node in the distributed network gets infected, the spread will remain in the relative area the infected node is located in , for clothing idea on the other hand, the point is almost to not adapt to changing conditions, the clothes will be designed to be firm and resistant to wear and tear.

Does the design evolve to survive?

Both of the proposed idea can not self-evolve(Unless the computer network is Artificially Intelligent) because the foundation and the final product are both in-animate objects but human make changes and improve upon the two designs.

Is the design resource efficient?

For the Computer Network, instead of most of the power or energy going into a central server or computer, it will be more distributed in the proposed idea and thus output is increased and input is at the very least manageable and not extreme. Also in the case of a virus outbreak , the distributed nature of the network will allow for a quick quarantine, thus it will actually save resources. For the clothing design, structure of the orb web will make creating clothes based on the orb web a much more intricate endeavour and thus it may require more skill and resources.

Does the design use life friendly chemistry?

If earth friendly materials are used to make clothing using the orb web design then yes, it will use life friendly chemistry. The computer network on the other hand is a more obscure case, if the electricity is gotten for through Hydro-electric mean then it does use life friendly chemistry, if the electricity is gotten from say, a coal-powered burning station then no it will not use life friendly chemistry. How waste is managed in both designs is very key also in this regard.

Does the design integrate development with growth

Yes, both of the designs integrate development with growth because both are based on interconnected networks built from the ground up by combining nested components in a sense, but through organization. They can not self-organize but are organized by humans, eventually a symmetry emerges that manifests an inter-connected whole.