There are more than 80 known species of Hagfish in the world with more being discovered every year. Hagfish are benthic, meaning they live in deep waters burrowing into the ocean floor. Hagfish live off of scavenging dead animals and preying upon small, burrowing fish. Up until recently, it was not known that Hagfish are predators; but because they are actively seeking out food, it is now known that Hagfish can be caught with lures just like any other fish.

Hagfish are a distant relative of vertebrates. It is estimated that Hagfish diverged from the vertebrate evolution approximately 500 million years ago before the formation of the opposable jaw and potentially before the formation of the backbone (although both of these adaptations may have developed in Hagfish originally and then been lost in a secondary process due to lack of use). Since their divergence from the vertebrate evolution, Hagfish have remained primarily unchanged.

Dr. Douglas Fudge from the University of Guelph has done extensive research on Hagfish Slime. Now, this sounds like an unusual product to do research on; but it has many unusual properties, such as its ability to suffocate and repel predators. Dr. Fudge presented a video that demonstrated this property, whereby a shark and a Hagfish interact at a depth of nearly 700 meters, just off the coast of the Great Barrier Island in New Zealand. In the video, the shark attacks the Hagfish. Not only is the Hagfish not injured in the attack, but within seconds its skin has secreted this thick mucus, which immediately repels the shark. Dr. Uyeno even related
an experience where a Hagfish, which was being stored in a bucket, secreted enough mucus to fill the bucket and subsequently suffocated itself.

Another unusual property of Hagfish slime is its great strength. This strength is in part due to its composition, which is part mucin and part silk-like fibrous thread. Much of Dr. Fudge’s research has been conducted to discover how this thread is created. In his research, he has learned that each Hagfish has approximately 150 slime glands each containing gland mucous cells and gland thread cells. These cells are contained within a structure referred to as a skein (having been named after a “skein” of wool). Mucous vesicle deployment begins with skein deployment. One point of the research was to discern what exactly caused the skein deployment to occur. It was hypothesized and later proven that skein unraveling occurs as a result of the salty seawater dissolving a protein adhesive, which then releases a stored strain energy.

Much of the research that Dr. Fudge is conducting is currently inconclusive and being actively studied. A few remaining points that Dr. Fudge did share in regard to his research were: it takes four weeks to fill the mucous glands due to the Hagfish’s slow metabolism, the nucleus of the slime glands acts as a template determining the changing shape of the slime glands, and much product research has been inspired by the Hagfish. A few of these products are: damage-resistant materials (based off of the Hagfish’s ability to avoid injury during attack), high-performance fibers (based off of the great abilities of the fibrous slime), and novel hydrogels (based off of the great strength and clogging abilities of the Hagfish slime).

Dr. Ted Uyeno of Valdosta State University has focused his research on the Hagfish’s unusual process of eating. He is a biomechanic researcher who feels that Hagfish are so very weird, and he is definitely right. His top ten reasons for feeling that Hagfish are weird are there ancient features such as lack of a backbone; the high level of blood in their bodies; their loose,
floppy skin and lack of scales; their mucous secretions; their lack of opposable jaws – conversely their toothplates; the manner in which they feed off of dead animals, particularly whales; the knowledge that they feed off of live prey; and their body-knotting behavior.

Dr. Uyeno described Hagfish as having long, slender bodies with smooth, loose, scaleless skin. Hagfish have a complex circulatory system consisting of four different pumping ports to distribute the large amount of blood that flows through their bodies. One reason for these multiple ports could be the Hagfish’s ability to tie itself into knots – the multiple ports would provide a safety against loss of circulation. Hagfish have no opposable jaw and no appendages.

Dr. Uyeno’s “statement of purpose” was that hagfish lack an opposable jaw. He has set out to research the unique way in which Hagfish eat. He has found that Hagfish have a forceful bite as a result of their toothplate, which contains both hard and soft components. They have an unusual mechanism of obtaining their food and then folding it back into their bodies. This is what the current research has revealed, but Dr. Uyeno is careful when it comes to counting for the role of diversity – he feels that with the great number of Hagfish still being discovered there may be some that feed differently than the others.

One area of research that has particularly fascinated Dr. Uyeno is the ability of the Hagfish to tie itself into knots, which the Hagfish does in order to gain a greater purchase when reaching for and obtaining food. Very few creatures have this ability and those that do all have many similarities. Of all creatures only about four are known to tie themselves into knots: the snake, the eel, the worm-shaped inverts, and the hagfish. Through his research Dr. Uyeno was able to hypothesize that there are only two knots that a Hagfish would be capable of tying itself into; and through careful observation it was discerned that Dr. Uyeno was right. The Hagfish only has the ability to tie itself into a figure-8 knot or an overhand knot. He then hypothesized
that most would use the less complicated overhand knot, but this was not the case. It was learned that 81.8% of the time, Hagfish will tie themselves into a less-stressful figure-8 knot – and every Hagfish uses the exact same 12-step process to achieve the knot tying. The remaining 20% of knots tied by Hagfish are misdirected attempts at achieving a figure-8 knot that result in an overhand knot.

In conclusion, Dr. Uyeno stated that knotting is efficient, stereotyped control of a hyper-redundant system; that toothplate movement depends on a hydraulic structural support mode of soft tissues; and that knotting provides autogenetic leverage to the toothplate movement, which then creates a more forceful bite allowing the Hagfish to continue its survival as it has done at the depths of the ocean for the last 500 million years.