Turritopsis nutricula

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Abstract: *Turritopsis nutricula* is a hydrozoan that can revert to the sexually immature (polyp stage) after becoming sexually mature. It is the only known metazoan capable of reverting completely to a sexually immature, colonial stage after having reached sexual maturity as a solitary stage. It does this through the cell development process of transdifferentiation. This cycle can repeat indefinitely tha offers it biologically immortal. It is not clear if stem cells are involved in this immortality or not. Upto now, there is little academic report in the Turristopsis nutricula studies. To study the mechanism of the biological immortality of Turritopsis nutricula possibly supplies the way finding the biological immortality for human. [Nature and Science 2010;8(2):15-20]. (ISSN: 1545-0740).

Keywords: immortal; immortality; sexual maturity; stem cell; transdifferentiation; *Turritopsis nutricula*

1. Introduction

Turritopsis nutricula is a hydrozoan that can revert to the sexually immature (polyp stage) after becoming sexually mature. It is the only known metazoan capable of reverting completely to a sexually immature, colonial stage after having reached sexual maturity as a solitary stage. It does this through the cell development process of transdifferentiation. This cycle can repeat indefinitely that offers it biologically immortal. To study the reason of the biological immortality of *Turritopsis nutricula* possibly supplies the way finding the biological immortality for human.

Turritopsis nutricula is a species of jellyfish with a very unusual quality: it is biologically immortal. Also known as the immortal jellyfish, this fascinating animal, in theory, has the ability to sustain life indefinitely, so long as its nerve center remains intact.

Typically, jellyfish die after reproducing, but the immortal jellyfish is capable of returning to a polyp after producing offspring. This essentially means that this type of jellyfish is able to return itself to a much younger state. As a result of reversing its life cycle, the immortal jellyfish can evade death. If the jellyfish continues to reverse its life cycle following reproduction, it can live on for an indefinite period. In laboratory tests, the species reverted back to the immature polyp stage 100% of the time.

Turritopsis nutricula is capable of rejuvenating itself due to a process called transdifferentiation. Transdifferentiation occurs when a non-stem cell turns itself into another type of cell. But, it is not clear if stem cells are involved in this immortality or not. As my opinion, the transdifferentiation in *Turritopsis nutricula* has related mechanism to stem cell when the life cycle reverted. It is important to reveal the relationship of this *Turritopsis nutricula* transdifferentiation and stem cell. Transdifferentiation is rare, and when it does occur, it most commonly occurs in parts of the organsism, like in the eye of the salamander. However, the immortal jellyfish has incorporated transdifferentiation into its lifecycle. In the process, all of the old cells are regenerated. At the end of the cycle, the immortal jellyfish is a young polyp, ready to start life anew (Wendy, 2009).

While colonial animals can have their immortality, solitary animal individuals are to die. Hydrozoan cnidarians usually have a complex life cycle, wherein a colonial stage leads to the sexually mature, solitary, adult stage. Eggs and sperms from solitary, sexual, adult medusa (jellyfish) develop into an embryo and planula larva, and they then form the colonial polyp stage. Medusae are formed asexually from polyps. These medusae have a limited lifespan and die shortly after releasing their gametes.

The hydrozoan *Turritopsis nutricula* is diferent, which is biological immortality. The solitary medusa of this species can revert to its polyp stage after becoming sexually mature (Bavestrello et al., 1992; Piraino et al., 1996). In the laboratory, 100% of these medusae regularly undergo this change. The cells that accomplish the building of a new stolon are probably those of the exumbrella. However, it is not known whether the sensory cells, myoepithelial cells, and cnidocytes are derived from the exumbrella or the endodermal component.

In the past, because of men's desire to be forever young, inspired by legends, epics, myths, stories of the gods and goddesses, they engaged in the quest for the so-called 'fountain of youth' but nobody was able to find one. Based on scientific studies, some organisms or creatures are considered or thought to be immortal.

As the nature will, to live eternally is an extracting dream in all the human history. Stem cell is the original of life tissue and all adult cells come from stem cells (Hongbao Ma 2005a). Germline stem cell is the cell in the earliest of the cell stage. It is possible to inject the

germline stem cell into adult human body to get the eternal life (Ma Hongbao 2007). However, the reveal of the transdifferentiation mechanism of the jellyfish *Turritopsis nutricula* will offer the chance to explore the possibility of the eternal life for human.

2. Description

Diameter *of Turritopsis nutricula* is about 5 mm. It has an equally high and bell-shaped figure. The walls are uniformly thin. The bright red, big stomach has a cruciform shape in its cross section. Young specimens have only 8 tentacles along the edge, while adult specimens have 80-90 tentacles.

Turritopsis nutricula is the first case in which a metazoan is capable of reverting completely to a sexually immature, colonial stage after having reached sexual maturity as a solitary stage (Gilbert, 2006).

Jellyfish usually die after propagating but Turritopsis *nutricula* reverts to a sexually immature stage after reaching adulthood and is capable of rejuvenating itself. The jellyfish and its reversal of the ageing process is now the focus of research by marine biologists and geneticists. It is thought to achieve the feat through the cell development process of transdifferentiation, in which cells transform from one type to another.

The switching of cell roles is usually seen only when parts of an organ regenerate. However, it appears to occur normally in the Turritopsis life cycle (Lech Mintowt-Czyz, 2009).

Turritopsis nutricula, a type of jellyfish, is gaining notoriety for its uncanny and unprecedented capacity to de-evolve instead of dying. These jellyfish are the first evidenced metazoan, or multi-celled creature, to demonstrate the ability to revert back to a colonial stage after reaching sexual maturity. After sexually reproducing, most animals inevitably die. Turritopsis nutricula, however, undergo a transformation in which they return to a stage of sexual immaturity after reproducing, only to mature and reproduce again, then return to sexual immaturity, and so on. What does this mean? Turritopsis nutricula do not die, by nature, and are believed to have an indefinite potential lifespan.

Turritopsis nutricula are about 5 mm in diameter in sexually mature stage. They have 8-24 tentacles when they are young and up to 90 tentacles as mature adults. Shaped like a bell, their external walls are transparent and their stomachs are large and have a distinctive red color.

Turritopsis nutricula rejuvenate from sexually mature to colonial through two processes: cell transformation and cell transdifferentiation. Transdifferentiation is one cell transform into a completely different type of cell. By transdifferentiating, these cells are able to change their entire make-up, much like the much-publicized stem cells. After sexually reproducing, the jellyfish reabsorbs all of its external parts and turns into a cyst, which looks like an ameba-esque blob. The cyst then attaches to the ground and grows into a stalk-shaped polyp colony. These polyps begin a new cycle, where they form into mature jellyfish - all genetically identical. This specimen of *Turritopsis nutricula* vibrantly shows its majestic being, with its deep red stomach clearly showing.

2.1 *Turritopsis nutricula*

Classification
Kingdom – Animalia
Phylum – Cnidaria
Class – Hydrozoa
Order – Hydroida
Family – Clavidae
Genus – Turritopsis
Species – T. nutricula

Turritopsis nutricula is a Hydrozoan, which is a class of Cnidarians including the Portuguese Man-of-War, Hydra, and freshwater jellyfish. Hydrozoans are, for the most part, colonial animals. *Turritopsis nutricula* is a colonial organism as a polyp, though it is an independent, pelagic creature. The organism has a diameter of 5 millimeters, or one fifth of an inch. Although a young specimen would only have 8 tentacles, an adult would have between 80 and 90 tentacles. It has an obvious red stomach in the center of the main part of its body. Once eggs are fertilized, they develop in the stomach and in the screen formed by the cave in the planula, or free-swimming, ciliated form of some Cnidarian species. The eggs must then be deposited on the seabed in colonies of the larval stage of polyps. The jellyfish will then hatch in 2 days and will become sexually mature after just 2 weeks, which it then can revert back to a polyp in the process of transdifferentiation. T. Nutricula can be found worldwide.

2.2 Hydra

Classification:
Kingdom – Animalia
Phylum – Cnidaria
Class – Hydrozoa
Subclass – Leptolinae
Order – Anthomedusae
Suborder – Capitata
Family – Hydridae
Genus – Hydra

3. Distribution, range and related species

Turritopsis nutricula are originally from the Caribbean but have spread all over the world. *Turritopsis nutricula* are found in temperate to tropical

regions in all of the world's oceans. It is believed to be spreading across the world as ships are discharging ballast water in ports. Since the species is immortal, the number of individuals is spiking. "We are looking at a worldwide silent invasion" said Smithsonian Tropical Marine Institute scientist Dr. Maria Miglietta.

3.1 Plants

- Great Basin Bristlecone Spine – 4,862 years
- Fitzroya Cupressoides – 3,622 years
- Fortingall Yew – 2,000 – 5,000 years (not verified)
- Sacred Fig – 2,293 years, if the planting date of 288 B.C. is correct

3.2 Animals

- Antarctic Sponge – 1,550 years (approx.)
- Icelandic Cyprine – 405 years
- Koi Fish – 215 years
- Bowhead Whales – 210 years (unconfirmed)

3.3 *Turritopsis nutricula*

One of the most bizarre organisms that ever existed is the *Turritopsis nutricula*. It is a hydrozoan with a life cycle in which it reverts to the polyp stage after becoming sexually mature. It is said that it is the only known case of a metazoan that is capable of reverting completely to a sexually immature, colonial stage after having reached sexual maturity as a solitary stage. This cycle can repeat indefinitely, rendering it biologically immortal until its nerve center is removed from the rest of the body. This hydrozoan can be found in tropical and temperate regions and a diameter of about 5 mm.

3.4 Hydra

Hydra is a kind of cnidarians that is claimed to be immortal. It is simple fresh-water animal that possesses radial symmetry. A Hydra is a predatory animal that can be found in most unpolluted freshwater ponds, lakes and streams in the temperate and tropical regions. It can be captured by gently sweeping a collecting net through weedy areas. A Hydra undergoes aging very slowly and has the ability to regenerate.

3.5 Hydra oligactis

The Brown Hydra or scientifically known as Hydra oligactis can be found in the northern temperate zone. It is a common organism found in still waters from early spring to late autumn. A Brown Hydra is commonly found attached to the stems of water plants, the undersides of leaves, submerged twigs and on the surface of stones.

3.6 Hydra viridissima

The Green Hydra or formally called Hydra viridissima can be found in both temperate and tropical fresh waters. The characteristic green color comes from cells of the unicellular alga Chlorella within the cells of the gastrodermis. It also retracts to a small green blob when disturbed.

3.7 Hydra Viridis

The Hydra viridis, like the Hydra oligactis, can be found widely dispersed in the northern temperate zone and is also a common organisms found in still waters from early spring to late autumn. The characteristic green color comes from cells of the unicellular alga Chlorella within the cells of the gastrodermis. Like also the Hydra oligactis, this species when disturbed retracts to a small green blob which is easily overlooked.

3.8 Hydra vulgaris

Hydra vulgaris is a freshwater hydroid that has 4-12 tentacles that protrudes from just outside of its mouth. It is about 12 mm in length and feed by extending their tentacles and waiting for food to touch the tentacles, they than bring the food to their mouth, inject, and digest the organism. Anything that cannot be digested is egested. Ingestion and ejection occur through the mouth. This peculiar organism can reproduce by sexual reproduction, budding and indirectly through regeneration.

3.9 Actinobacteria

A certain Rachel Sussman has traveled the world to take photographs of actinobacteria - the oldest living things in the world. These bacteria are from Siberia and thought to be around 400,000 years old. Actinobacteria are a group of Gram-positive bacteria with high G+C ratio and can be terrestrial or aquatic.

3.10 Bacteria

In the Earth, bacteria exist everywhere even in the hottest and coldest places. As colony, bacteria are thought to be immortal. They reproduce through a very unusual way called cell division. A parent bacterium will split itself into two identical daughter cells and then these daughter cells will split themselves in half. This process repeats, thus making the bacterium colony essentially immortal. But, essentially to say, the life cycle of bacteria is not really immortal. Individually, the daughter bacteria are not the parent bacteria, as the daughters/sons of human are not heir parents.

3.11 Bristlecone Pine

A Bristlecone Pine's oldest known living specimen is over 4,800 years old. This species of tree is thought to reach an age far greater than that of any other single

living organism known and is speculated to be potentially immortal (Nobert Soloria Bermosa, 2009).

4. Life cycle

The fertilized eggs develop in the stomach and in the screen formed by the cave in the jellyfish planula. The eggs are then planted on the seabed in polyp colonies. The jellyfish hatches after two days. The jellyfish becomes sexually mature after a few weeks (the exact duration depends on the ocean temperature; at 20°C it is 25-30 days and at 22°C it is 18-22 days). It is the only known animal that is capable of reverting to its juvenile polyp state. Theoretically, this cycle can repeat indefinitely, rendering it potentially immortal. Found in warm tropical waters Turritopsis nutricula is believed to be spreading across the world as ships' ballast water is discharged in ports. Though solitary, they are predatory creatures and mature asexually from a polyp stage. While most members of the jellyfish family usually die after propagating, the *Turritopsis nutricula* has developed the unique ability to return to a polyp state (Qossay Takroori, 2009).

5. Biological immortality

Jellyfish usually die after propagating; however, the *Turritopsis nutricula* has developed the ability to return to a polyp state. This is done through a cell change in the external screen, exumbrella. In it's life cycle, the medusa is transformed into a stolon and the polyps into a hydroid colony. The umbrella turns inside out; middle section and tentacles are reabsorbed before the polyp spawns. Stolons form two days before the polyps differentiate. The ability to reverse the life cycle is probably unique in the animal kingdom, and allows the jellyfish to bypass death, rendering the *Turritopsis nutricula* biologically immortal. Laboratory tests showed that 100% of specimens reverted to the polyp stage (Wikipedia, 2009). It can do this because it can alter the differentiated state of a cell, transforming it into another cell type, called transdifferentiation, and it is usually seen only when parts of an organ regenerate. However, it appears to occur normally in the Turritopsis nutricula life cycle. In this transdifferentiation process, the medusa is transformed into the stolons and polyps of a hydroid colony. First, the umbrella everts and the tentacles and mesoglea are resorbed. The everted medusa attach to the substrate by the end that had been at the opposite end of the umbrella, and spawning occurs shortly thereafter. The cnidarian then secretes a perisarc and stolons. Two days after the stolons are first seen, polyps differentiate. These polyps feed on zooplankton and soon are budding off new medusae.

6. The Secrets of Immortality

Turritopsis nutricula can achieve immortality by reverting back to a polyp, which is its larval stage, after become sexually mature. This cycle is called transdifferentiation, and theoretically, can be repeated indefinitely. It is the only known case of a sexually mature metazoan, which is basically an animal, changing back into a colonial, immature state. On the other hand, Hydrae become immortal by other means. These animals do not undergo senescence, or the process of aging. They have a regenerative ability that can dilute poisons by going through the process of mitosis or cell division.

7. Application of *Turritopsis nutricula* researches in immortal life

The application of a study of the *Turritopsis nutricula* could be boundless, as stem-cell research appears at the forefront of many medical studies on organ reproduction, cancer treatments, and brain injury treatments to name a few. By using the cells of the jellyfish, which transdifferentiate, scientists can continue to research solutions for these problems without mucking about in the moral dilemmas that come with researching embryonic stem cells. The jellyfish's cells are also similar in make to cancer cells, which are able to affect the order and process of genetic systems. By studying these cells, scientists may be able to gain insight in the never-ending search for a cure for cancer. These jellyfish, rumored to be plotting world-domination, are in fact spreading in droves. What some scientists now refer to as a "widespread invasion" could affect the structure and functionality of the oceanic ecosystem. It is believed that they spread when the jellyfish stow away in the ballast tanks of large ships and are carried from place to place. This is a major pathway for the global spread of "invasive" species. Native to the Caribbean, these jellyfish are now being found in waters surrounding Italy and Spain, Japan, Panama, and even Florida. It's anyone's guess where they end up next (Jenny Riegel, 2009).

All the life in the Earth, human, animals, plants and everything grows would be dying finally? Meet *Turritopsis nutricula*, the only immortal jellyfish on planet earth. Its only 5 mm long and spreading around the world really fast because they don't die.

Research were done on the phylum of Cnidaria, which includes, in their common names, jellyfish, coral, sea pens, hydras, and animals of the like. This phylum contains some of the most primitive, diverse, and beautiful animals on this planet. It also has some of the strangest animals this planet has to hold. I will be presenting these eccentric animals and hope you will view them with awe and interest. These animals are not "immortal", but "biologically immortal", meaning they can still die from accidents and being killed or destroyed. No animal is perfectly immortal. Some people say that the prospect of a possibly immortal

creature disproves the Qur'an, a holy Islamic text that states that no living thing is immortal. Anyways, I have made several editions to this, hoping to reduce the reading difficulty of the content to the level of the common viewer. If you see any errors within this article, please tell me and I shall edit it accordingly. Other than these biologically immortal animals, long various multi-cellular eukaryotes (have cells with nucleus) have been known to live for a very time, here with their longest known lifespan:

8. Discussions

Everything in earthly existence, including human life in all of its facets, is involved in a process of ongoing change. Hence, permanence seems unattainable, and thereby especially desirable. The wish for immortality thus becomes one of the most important original reasons for the appearance of religions, and the motives of many scientific research fields can also be traced to this motive (Edmondson 2005). Life is a physical and chemical process. From ontology aspect, the world is timeless and the life exists forever as any other body in the nature. The nature of life is that life is a process of negative entropy, evolution, autopoiesis (auto-organizing), adaptation, emergence and living hierarchy. Up to now, there is no scientific evidence to show that life body and non-life body obey the same natural laws. But, all the researches are made by the methods of biology, biochemistry and molecular biology, etc. I t is very possible that the life and non-life are essential different in the biophysics, i.e. the quantum level. In the future, it is possible to make artificial life by either biological method or electronic technique (Hongbao Ma 2005b).

Immortal jellyfish, like most other species of jellyfish are either male or female. They do not have a specialized reproduction system. The male releases his sperms into the column of water. They come in contact with eggs that are present in the stomach of the female jellyfish. During the embryonic stage, they are either settled onto the mouth or the oral arms of the female. After they have passed this stage, they transform into free swimming planulae and separate themselves from the body of their mother. They float along the surface of the water for a few days and then settle on a hard, stationary object like the surface of a rock.

At this stage, they become transformed into polyps. These polyps become stationary as well. They continue to feed on microscopic plankton and zooplankton at this stage. This polyp then begins to grow multiple identical polyps until it becomes a colony. This colony of multiple polyps is also stationary and attached to the hard surface at its base. All the polyps are connected with minute feeding tubes and they receive equal nourishment from their microscopic diet. The colony of polyp can remain in this stage for years at a time. When the condition is right, this colony of polyp begins to grow horizontal grooves. The groove at the top is the fastest to mature, and will soon free itself and become a free swimming jellyfish.

This process of reproduction is common to most species of jellyfish. What is unique about the immortal jellyfish is that after reproducing sexually, they are able to return to their polyp stage. When most fish die after their sexual maturity, immortal jellyfish get transformed back into a polyp and restart the process of asexual reproduction. In this way, the jellyfish is able to convert itself back into a polyp, start a polyp colony again and give birth to a number of new jellyfish.

How does the immortal jellyfish accomplish this feat? It is through cell development process of transdifferentiation. What this means is that it can alter the differentiated state of the cell and transform it into a new cell. In this process of transdifferentiation, the medusa of the immortal jellyfish is transformed into the polyps of a new polyp colony. First, the umbrella reverts itself and then the tentacles and mesoglea get resorbed. The reverted medusa then attaches itself to the substrate by the end that had been at the opposite end of the umbrella and starts giving rise to new polyps to form the new colony. Theoretically, this process can go on infinitely, effectively rendering the jellyfish immortal.

The immortal jellyfish is one of the most unique animals not just within the species of jellyfish, but within the entire history of the animal kingdom. It has actually managed to accomplish the one feat that has been yearned by many and accomplished by none.

The genus Hydra includes 17 species. Hydras also show radial symmetry like T. Nutricula. Hydras are simple, predatory Hydrozoans that feed on minute aquatic invertebrates, such as copepods. They are sessile animals that retract into a ball if startled. They can move their location by either detaching from their substrate and floating away in the current or by sticking to the substrate with its mouth and tentacles, detaching its foot, and reattaching its foot in a new location. Repeating this, a Hydra can move a couple of inches a day. If it loses a body part, or is even totally obliterated into separate cells, it can still regenerate all of the missing body parts into a fully functional organism.

This regenerative ability, which can regenerate any body part or tissue, is known as morphallaxis, a key function of the Hydra that helps to enable it biologically immortal. When there is a large bounty of food available, or a small amount of potential mates, the Hydra may undergo asexual budding. Hydrae exemplify asexual budding, in which an identical copy of the parent is replicated in an organism that will eventually separate from the parent. Asexual budding is a great survival tool for a case in which a mate cannot be found. If conditions are bleak, then Hydrae may

undergo sexual reproduction. The body wall will produce testes or a rudimentary ovary (Kaio Ken, 2009).

Immortality has been a subject of fascination to humanity since at least the beginning of history and has been a major point of focus of religion, as well as the subject of speculation, fantasy, and debate.

Upto now, there is little academic report in the *Turristopsis nutricula* studies. To study the reason of the biological immortality of *Turritopsis nutricula* possibly supplies the way finding the biological immortality for human.

Related to human activities, there are two aspects of the world: One is the observed world (epistemology) and the other is the existed world (ontology). From the epistemology angle, time and space are relative (observed) (Ma 2003). From the ontology angle, time and space are absolute (existed) and the universe is a timeless world, which means that all the past, the present and the future exist eternally. All the life is a kind of existence in the universe, and from this aspect the life exist eternally.

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References

Pattern Media. *Turritopsis nutricula* (Immortal jellyfish). **http://www.jellyfishfacts.net/turritopsis-nutricula-immortal-jellyfish.html#**. 2009.

Wikipedia, the free encyclopedia. *Turritopsis nutricula*.http://en.wikipedia.org/wiki/Turritopsis_nutricula. 2009.

Wendy O. Immortal Species: *Turritopsis nutricula*. ***http://bioloser.com/?p=104***. 2009.

Gilbert SF. Cheating Death: The Immortal Life Cycle of Turritopsis. **http://8e.devbio.com/preview_article.php?ch=2&id=6**. 2006.

Lech Mintowt-Czyz. *Turritopsis nutricula*: the world's only 'immortal' creature. **Times Online. http://www.timesonline.co.uk/tol/news/science/article5594539.ece#. 2009.**

Jenny Riegel. Methuselah's Calamari Special: The "Immortal" Jellyfish. http://www.wakemag.org/minds-eye/methuselah%E2%80%99s-calamari-special-the-%E2%80%9Cimmortal%E2%80%9D-jellyfish/. 2009.

Nobert Soloria Bermosa. Immortal Organisms: Do They Really Exist? http://scienceray.com/biology/immortal-organisms-do-they-really-exist/. 2009.

Kaio Ken. Immortal Creatures. http://scienceray.com/biology/immortal-creatures/. 2009.

Qossay Takroori. Meet The Only Immortal Species on Planet Earth. http://palscience.com/2009/01/28/the-only-immortal-species-on-planet-earth/#. 2009.

Edmondson JZ. Life and Immortality : A Comparison of Scientific ,Christian , and Hindu Concepts. Life Science Journal 2005;2(1):2-6.

Hongbao Ma GC. Stem Cell. Journal of American Science 2005a;1(2):90-92.

Hongbao Ma SC. Nature of Life. Life Science Journal 2005b;2(1):7 - 15.

Ma H. The Nature of Time and Space. Nature and science 2003;1(1):1-11.

Ma Hongbao CS. Eternal Life and Stem Cell. Nature and science 2007;5(1):81-96.

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