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How does Medusa turn men to stone?

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Abstract

Medusa is a notorious character from Greek Mythology. Her story involves turning onlookers to stone and this paper explores the possible methods Medusa may have used. Most of the content considers the phrase as a metaphor and does not consider supernatural techniques to accomplish her task. Freezing, sculpting and heterotopic ossification is considered in this paper with sculpting being the most plausible. [*Content warning: mentions of sexual assault*]

Keywords: *Mythology; Biology; Medusa; Ossification; Clay; Cryogenics*

Introduction

The story of Medusa has been told and retold many times: we were told she was born as a monster among fellow Gorgon sisters [1] or that she was born mortal became a monster due to Athena's curse [2]. The way Athena's curse arose varies. Some tellings of the story mention Medusa having been obsessed with her beautiful appearance and while looking at statues of Athena in her temple boasted about her appearance. Athena overheard and turned Medusa into a monster to serve as an example of what too much pride may do to an individual [2]. Another version of the story is that Poseidon, Athena's husband, laid with Medusa in Athena's temple [2]. Renditions vary as to whether this was a willing affair or rape; whether Athena's curse was a punishment, victim blaming or an attempt to give Medusa the means to protect herself from men. Some versions state that Medusa only turned men to stone. Her story ends with her being beheaded and having babies jump out of her neck [1]. The renditions also alternate between describing her as a monster to being gorgeous [2].

Greek mythology was usually passed down by word of mouth [3] and due to a level of ambiguity or diluting content for age-appropriate teaching, we cannot say with certainty what the whole context behind Medusa's story is. One point that retains its consistency was her ability to turn onlookers to stone. This paper will investigate how this could have



Figure 1 – A sculpture of Medusa [4].

taken place by considering 'stone' as a metaphor indicating a *hard, frozen, rock-like state*.

Cryogenics

Medusa may have used techniques humans use to freeze dead bodies for future revival. Cryonics take precautionary measures to prevent blood from clotting by injecting heparin into the body. The body is then transported to the cryonics facility. If the body was immediately placed into a box of liquid nitrogen for freezing taking this would lead to the freezing of water in cells which leads to expansion which would lead to cell death by shattering. Cryoprotectant is incorporated to prevent the cell death from occurring and essentially replaces the water for a glycerol-based substance. The body is then put onto dry ice until it cools down and then it is placed into the liquid nitrogen [5].

Heterotopic Ossification

Ossification (osteogenesis) is the process of bone development that begins at the embryonic stage of life. There are two pathways [6]. Intramembranous ossification occurs when mesenchymal cells in the embryonic skeleton gather together, and some become osteogenic cells and eventually osteoblasts [6]. The osteoblasts occur in a cluster called the ossification centre and they'll eventually spread out. Osteoblasts release osteoid which experience the effect of mineral salts deposited on them and they harden; trapping the osteoblasts which become osteocytes. Meanwhile, surrounding osteogenic cells differentiate into new osteoblasts at the edge of the growing bone. This leads to the osteoid clusters uniting by the capillaries while osteoblasts on the surface of the formed spongy bone become the cellular layer of the periosteum which then secretes compact bone superficial to the spongy bone. The blood vessels are crowded, condense and become the red marrow. Osteoclasts mean the new bone is constantly remodelled [6].

Endochondral ossification is the type related to heterotopic ossification and utilises cartilage as a structure to be replaced by new bone. Endochondral ossification occurs in the development of the embryonic skeleton and during the healing of fractures [7]. Heterotopic ossification involves disorganised and inhomogeneous tissues [8]. Typically, after some kind of injury immune response cells like lymphocytes, mast cells etc. occupy the perivascular region of the early lesion with skeletal muscle and connective tissue [8]. The proliferation of fibroblastic cells is triggered and tissue degeneration initiates release, local production or delivery of skeletogenic inducing factors [8]. This results in active proliferation of fibroblastic cells that differentiate into chondrocytes; this differentiation leads to the regular steps of endochondral ossification [8].

Clay

Clay bricks were used for the walls in ancient Greece, and this may have been Medusas MO. Mudbricks were made by pressing a mixture of dirt, sand, and water into blocks and letting them dry in the sun. The bricks were typically strengthened by adding straw to the mixture or by being burned in a kiln to create a stronger substance [9].

The earliest large-scale Greek bronze statues had very simple designs because of the Sphyrelaton

method of construction, which involves making each component of the statue individually from hammered metal sheets and joining them together [10].

After producing a clay core for a sculpture, vents are made for the flow of molten metal and to let gases out, resulting in a casting [10]. The model is then thoroughly covered in wax then a coarse outer layer of clay. The model is heated to melt the wax and create a hollow matrix. The mould is reheated a second time for a longer duration [10]. The bronzesmith next fills the mould with the molten metal by pouring it into it until it is completely full. The bronze is ready for finishing when the bronze has sufficiently cooled, and the mould has been removed [10].

Discussion

There is a variety of methods and techniques Medusa could have used to turn people to stone (or a *hard, frozen, rock-like state* as stated previously). Cryogenics is unlikely as this was not available during the time. Medusa could have alternatively frozen her victim by taking them to a location with very cold temperatures like Antarctica or the Arctic. If the temperatures are as low as -20 degrees Celsius and the wind speed is 37 km/h extreme frostbite can develop on the victim in 10 minutes and they can eventually be frozen [11]. It is also likely that the precautionary measures mentioned in the cryogenic freezing process are not required as the purpose of freezing was not revival. Alternatively, Medusa may trigger heterotopic ossification by inflicting sufficient trauma on her victim and they may become stiff as heterotopic ossification takes place at a rapid rate. Medusa also may have some skills in sculpting and made a sculpture using their victim by potentially strangling them and making a clay cast or Medusa may take it a step further and use molten metal to produce the sculpture. If Medusa particularly targeted men, she would simply kidnap or attack them instead of for all the methods mentioned.

Conclusion

Considering the distance Medusa would have to travel to a cold environment and the unpredictability of heterotopic ossification taking place, Medusa most likely turned her victims to stone by making sculptures. Medusa was an artist.

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