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Term Project Summary

Plant "living fossils" are plant fossils that bear striking resemblance in appearance and in DNA structure to extant plant species. While "living fossils" have rightfully earned their title because they look anatomically unchanged from their distant fossilized ancestors, they are not exempt from evolutionary forces that come with earth's shifting environments. In order to have survived these shifting environments, their physical appearances may not have needed to evolve, but natural selection would have favored physiological mutations that better suited shifting environmental conditions. Other theories suggest that extant species have retained their physical appearances because they had developed "a winning formula early on" or their competition for resources is minimal in a predictable environment (Werth & Shear). Despite inevitable adaptive and neutral evolutionary changes at a molecular level, scientists can still use existing species of their fossilized counterparts to test theories about fossils' living conditions and traits that have allowed them to survive relatively "unchanged" (Cafasso and Chinali; Yirka).

The three "living" plant fossils I have chosen to concentrate on are the *Metasequoia glyptostroboides*, *Wollemia nobilis*, and *Ginkgo biloba*—otherwise known as the dawn redwood, wollemi pine, and ginkgo tree. In order to gain some insight into how the dawn redwood's ancestors survived under a continuous low to moderate-intensity light environment that would shine for up to four months straight in high northern latitudes during the Eocene epoch, M. Alejandra Equiza et al conducted an experiment to discover the effects of continuous light on plants' photosynthetic capacity using the extant dawn redwood. Their results revealed that the dawn redwood's increased growth under continuous light decreased its photosynthetic capacity but decreased less than other coniferous species under continuous light exposure, which lead the researchers to understand how this species has surpassed others in existence. The dawn redwood's resilience is a result of its increased ability—in comparison to other trees in identical environments— to adjust to these fluctuating climates at a photosynthetic level. Within the dawn redwood species itself, specimens that had the best ability to adjust their photosynthetic capacity endured despite the constancy of their physical appearance.

Peng He and other researchers used the extant ginkgo species to study the biological and evolutionary significance of RNA editing sites because of its abundance in these editing sites. By comparing the DNA of the ginkgo fossil and of the living species, they concluded that RNA editing physiologically benefited the gingko because it allowed it to maintain the production of essential proteins through an editing process in response to its shifting environment over time. The sole ginkgo tree species that exists today bears an almost unchanged resemblance to its fossilized ancestor yet is the only species to survive of its genus because its plentiful RNA editing sites gave it a superior ability to, again, adjust to vacillating environments.

McLoughlin & Vajda suggest that the Wollemia barely survived the theorized asteroid that fell onto Earth and ignited a "global firestorm" that extinguished dinosaurs and numerous other species. Though this "firestorm" subsequently created a colder, drier climate because soot obscured the sun and fires occasionally combusted, a few Wollemia survived as most of its family vanished. The few that survived these far from ideal conditions did so because their seeds were buried in soil as the Earth recovered the moist and mild climates that the Wollemia prefers.

The survival of the wollemi pine in such small numbers constitutes it especially rare because adult plants are almost completely genetically synonymous, whereas genetically varied populations can develop mutations that help the species adapt and survive through natural selection. The wollemi pine seemed to withstand Earth's environmental fluctuations through the chance that its seeds did not dry out or freeze during severe and sudden atmospheric transitions. However, its extant species persevered because natural selection favored the specimens that persisted until favorable humid conditions returned.

All of these plants, though remarkably similar at first glance to their preserved ancestors, have changed and evolved in response to Earth's extreme fluctuating climates. Not only does the inevitability of changes characterize all organisms that prevailed amidst Earth's inconsistent elements, but also characterizes my term project. I have created jewelry based on the three "living fossils" the dawn redwood, wollemi pine, and ginkgo tree and their extant species. I have fabricated a pair of asymmetrical earrings for each pair of species, establishing the right ear as the "fossil" ear and the left ear as the "living" ear. Earrings seemed to be the best way to present the comparison of the ancient to the living because of the natural divide that the face provides between two objects and also because the symmetry of ears provides a simultaneous unity. I etched the fossil imprints in copper to emulate real fossil slabs and made interpretations in the positive of the fossils' corresponding descendants to match. The earrings of the extant species involve more moving parts to refer to the constant motion of evolution and to contrast with the stagnancy of the etched slabs. I am, for instance, representing the dawn redwood's extant leaf structure with a mobile construction so that each unit will sway separately, embodying the non-static quality of my concept. The moving element in the wollemi pine's extant leaf materializes as leaves on tubes that are free to spin, keeping the spiraling element of the leaves on its branches. The extant ginkgo tree leaves express movement through the classic use of en tremblant, a method of attaching heavier elements on springs or thin wire so that the elements will tremble with the wearer's motion. The kinetics in all three pieces serve my concept of movement as well as semi-reflect the actual undulations and vibrations of the physical leaves themselves. I used copper because of its susceptibility to oxidation. Its change through oxidation will further represent evolution's inevitable presence, even in the fossil vessel because scientists date fossils using the half-lives of the elements they have been preserved in. Half-lives of elements are anatomical evidence that all elements are vulnerable to change simply by naturally decaying. Copper is also the most malleable metal, is difficult to melt, and can endure copious amounts of fire before melting. These qualities of copper represent the malleability and endurance of all three species even through Earth's extreme "fires."

Sources

Cafasso, Donata, and Gianni Chinali. "An ancient satellite DNA has maintained repetitive units of the original structure in most species of the living fossil plant genus Zamia." *Genome*, vol. 57, no. 3, 2014, p. 125+. *Academic OneFile*, ezproxy.pratt.edu/login?url=http://go.galegroup.com/ps/i.do?p=AONE&sw=w&u=nysl_me_pml&v=2.1&it=r&id=GALE%7CA375951648&asid=869a76c56c0d55d4c6ee1a195f4bddbd. Accessed 19 Feb. 2017.

- This source is a primary source that studies that genetic variability of satellite DNA in the specific genus of Zamia, which is part of one of the oldest living groups of seed plants, Cycads. This experiment proves the heritability of genes from millions of years ago and possibly indicates similarities in environment or ability to survive diverse climates.

Equiza, M. Alejandra, et al. "Photosynthetic downregulation in the conifer Metasequoia glyptostroboides growing under continuous light: the significance of carbohydrate sinks and paleoecophysiological implications." *Canadian Journal of Botany*, vol. 84, no. 9, 2006, p. 1453+. *Academic OneFile*, ezproxy.pratt.edu/login?url=http://go.galegroup.com/ps/i.do?p=AONE&sw=w&u=nysl_me_pml&v=2.1&id=GALE%7CA156136132&it=r&asid=f22b3f41c6cb37bc6ac9345d95643b2a. Accessed 25 Feb. 2017.

- This experiment tests the effects of continuous light on the dawn redwood's photosynthetic capacity based on the assumed continuous light environment that its ancestors endured. Results revealed that the dawn redwood's increased growth under continuous light decreased its photosynthetic capacity but decreased less than other coniferous species under continuous light exposure, which lead researchers to conclude that this species' ancestors were more fit to survive.

He, Peng, et al. "Abundant RNA editing sites of chloroplast protein-coding genes in Ginkgo biloba and an evolutionary pattern analysis." *BMC Plant Biology*, vol. 16, no. 1, 2016. *Academic OneFile*, ezproxy.pratt.edu/login?url=http://go.galegroup.com/ps/i.do?p=AONE&sw=w&u=nysl_me_pml&v=2.1&id=GALE%7CA472285293&it=r&asid=87910cbd11902465c7b5895809230929. Accessed 25 Feb. 2017.

- This experiment determines the number of RNA editing sites that the Ginkgo biloba species has acquired and its evolutionary affects. Scientists draw conclusions about how these editing sights have allowed this species to earn the "living fossil" label.

McLoughlin, Stephen, and Vivi Vajda. "Ancient wollemi pines resurgent: ten years after its discovery, a vanishingly rare tree from the Cretaceous Period is a scientific darling and may soon become a commercial success too." *American Scientist*, vol. 93, no. 6, 2005, p. 540+. *Academic OneFile*, ezproxy.pratt.edu/login?url=http://go.galegroup.com/ps/i.do?p=AONE&sw=w&u=nysl_me_pml&v=2.1&id=GALE%7CA143276341&it=r&asid=e43b09813277e881e78c0ff97277276a. Accessed 26 Feb. 2017.

- This source describes the impact of the discovery of the living wollemi pine after its fossil had already been discovered and thought to have been extinct. The wollemi pine is

also considered a “living fossil” because the living species looks so similar to its ancestor preserved as a fossil.

Werth, Alexander J., and William A. Shear. "The evolutionary truth about living fossils: appearances to the contrary, no species is exempt from selection, even when changes are difficult to detect in the fossil record." *American Scientist*, vol. 102, no. 6, 2014, p. 434+. *Academic OneFile*, ezproxy.pratt.edu/login?url=http://go.galegroup.com/ps/i.do?p=AONE&sw=w&u=nysl_me_pml&v=2.1&id=GALE%7CA389260650&it=r&asid=b8b7238538b1322cde7bf8e50abbf774. Accessed 25 Feb. 2017.

- This source elaborates on rightful applications of the term “living fossil” as well as its inaccuracies. This article clarifies that though extant species physically match their fossil ancestors, they are not exempt from other evolutionary changes on the molecular level.