Rose Torres
Course 18

Carl Linnaeus and the Evolution of his Classification System

Carl Linnaeus's Life and Education

Carl Linnaeus lived in a time of significant advancement of western knowledge about the diversity of life throughout the world. It was also the golden age of botanical illustration in Europe. This influx of information about the natural world revealed a significant problem with the system scientists used to understand how things related to each other. Namely, there was no standardized system. Every scientist had their own way of naming and classifying plants and animals. Linnaeus sought to organize and make sense of all the plants and animals that were new to him with a method that made sense.(1)

Linnaeus, the "Father of Taxonomy," was born in Sweden in 1707. His Father, Nils, was a lutheran pastor and gardener who taught Carl about botany from a young age. Carls family was disappointed when he chose not to pursue a career in the church, like his father, but they took some consolation on his studying to become a doctor. Studying medicine allowed Linnaeus the opportunity to further study botany. "Training in botany was part of the medical curriculum, for every doctor had to prepare and prescribe drugs derived from medicinal plants."(1)(2)

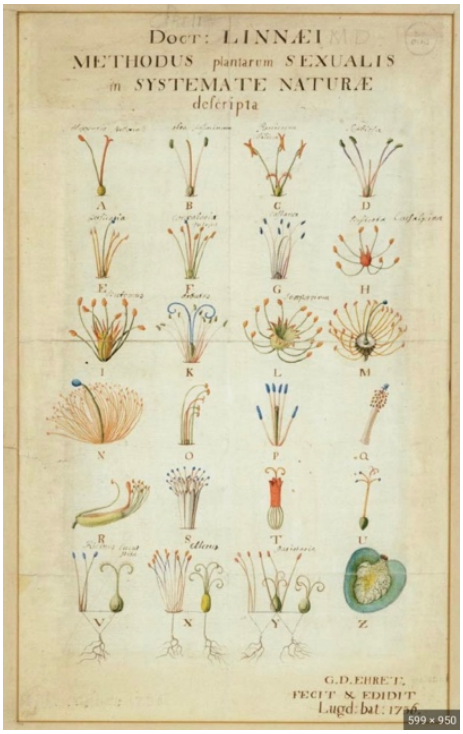
Linnaeus studied at four universities and specialized in medicine and botany. This education gave him broad knowledge of living things. Linnaeus quit practicing medicine and focused on botany as a professor at his alma mater, Uppsala University. He was able to study an ever increasing sample of plants that his students brought back from their world wide expeditions. Linnaeus unsuccessfully experimented with high value crops in an attempt to climatize them to Swedens cold climate. He also attempted to use native plants as substitutes for crops that could potentially boost Swedens economy.(1)

Linnaeus was married to Sara Elisabeth Moraea. He was the father of five children: His son Carl, who succeeded his professorship at Uppsala University, and four daughters. Linnaeus was opposed to his daughters Elisabeth Christina, Lovisa, Sara Christina, and Sophia receiving and education, but indulged their desire to learn botany. He continued to practice medicine throughout his life, and was the personal physician for the Swedish royal family. Linnaeus was granted nobility in his later years. He became known as Carl Von Linné. It is believed he suffered a series of strokes in 1774. He died in 1778.(15)

His Binomial Naming System and Classification of Living Organisms

Linnaeus believed "Since God has created the world, it is possible to understand God's wisdom by studying His creation." This belief that everything in the world is there by design certainly influenced his

motivation to organize living things into groups. If Linnaeus could understand how things were connected, he might catch a glimpse of how God operates.(1)



Linnaeus' system standardized the naming of species. The simple binomial system of a name consisting of its genus and species(instead of a long list of latin words). Another part of his system placed living things into related groups: quadrupeds, birds, reptiles and amphibians, fish, insects, worms and mollusks. How carl decided which plant went where was determined by "the number and arrangement of the reproductive organs" of the plant. Its "class was determined by its stamens(male organs) and its order by its B. pistils(female organs)." This method resulted in "artificial classification" of many plants. (1) It also received criticism from his contemporaries. Some criticism was more constructive that others. For example, using just one data point(reproductive organs) did not consistently give good results, and it was scandalous to suggest plants had sex in a manner similar to humans.(3)

Linnaeus continued to develop and refine his system throughout his career. Quadrupeds became mammals, and mammals were further divided. He included humans in his system, which was a new idea, and introduced *Homo sapiens* into scientific terminology. Unfortunately, Linnaeus further developed his categorization of humans into varieties based on skin color, and then placed them in a hierarchy with white europeans described positively and Asians, Native Americans, and Africans described negatively. This promoted the birth scientific racism, or the justification for white europeans to enslave and commit genocide against people of other races. Humans are complex and Linnaeus's hierarchy of races was both inaccurate and disastrous. Linnaeus was human, and as such, was complex. His scientific work had both a positive effect on how people understand the natural world and our place as humans within that world and at the same time, a horrifically negative effect on real people who suffered at the hands of those who believed in scientific racism. Despite contemporary sciences strong rejection of scientific racism and the pseudoscience used to justify it, scientific racism still exists today.(3)(4)(5)

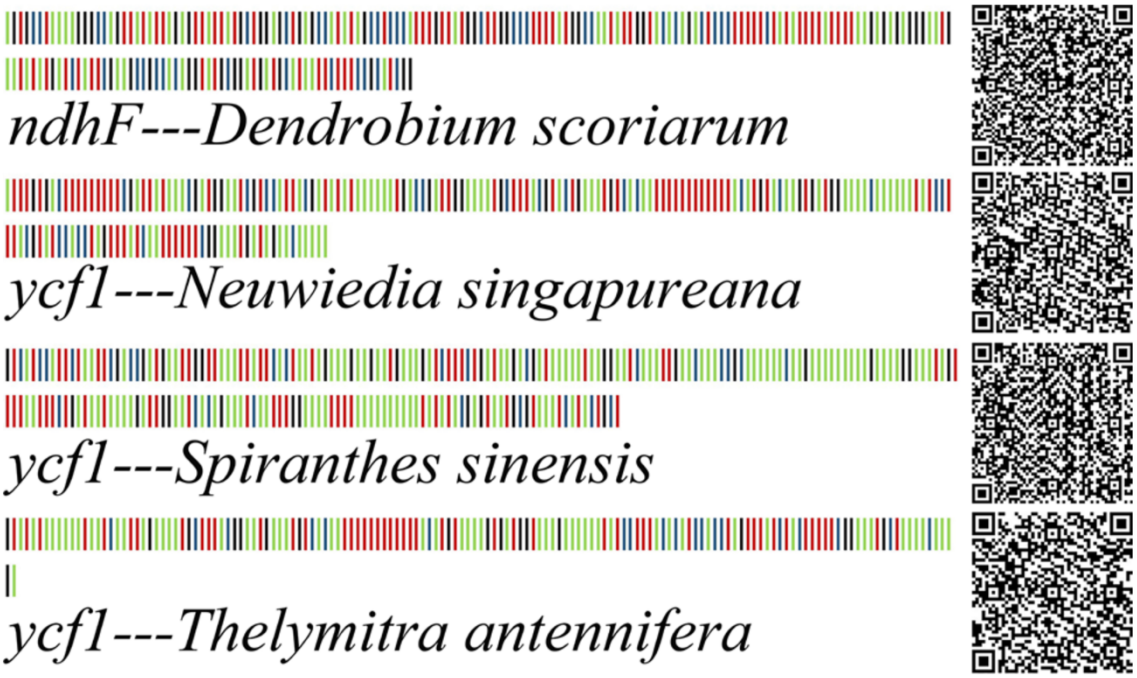
Building on Linnaeus's System

Linnaeus's classification system has since been improved and modified. Humans are no longer divided into his four varieties and placed in a hierarchy. The classification of plants based on reproductive parts was replaced with John Ray's morphological classification, which uses all parts of the plant throughout its life.(1) Using more data to classify plants and animals results in more accurate groupings. Microscopic organisms have been studied and classified with the aid of electron microscopy. Two kingdoms, fungi and protista, were added. Even during his lifetime, Linnaeus's system underwent many revisions. Scientists use his 10th edition of *Systema Naturae* as a starting point for his nomenclature.(10) The many adaptations during Linnaeus's lifetime serve as an indication of the flexibility of his system. Today, scientists use DNA analysis to gather even more accurate data about plants and animals and where they fit in the tree of life from and evolutionary standpoint. (3)(6)

An example of how DNA analysis has altered Linnaeus's classification system is the case of Split-leaf Philodendron. In 2018, Split-leaf Philodendron, or *Philodendron bipinnatifidum* underwent DNA analysis, and as a result was moved to a different genus to group it "based on their evolutionary lineage rather than just their outward appearance." Its new name is *Thaumatophyllum bipinnatifidum*. This genus name was previously discontinued as its own genus and simply used as a pseudonym for *Philodendron,* it has now been restored as a genus. More research on the Philodendron family has revealed a group *Meconostigma* merits its own genus as well.(6) It could take many years to sort out the organization of which plants belong in what genus based on DNA instead of just morphology.

Classification Systems Using Modern Technology

The way scientists communicate plant data has changed from written descriptions and illustrations alone to including much more complex DNA data. DNA Barcoding is a relatively new development in the plant identification sphere. This technology uses "molecular recognition technology that use short standard DNA fragments for species identification." DNA can be extracted from fresh or air dried herbarium specimens.(7) It produces a colored barcode that is unique to each species and a corresponding QR code that can be recognized by any smartphone. The QR code will take you to a google search page for the species it is specific to. (8)



Another promising technology for quick and accurate plant identification is leaf reflectance spectroscopy. The idea is that "the electromagnetic radiation reflected off leaves carries information about their structural and chemical traits." The light absorbed and the light reflected at different wavelengths reveals various features of the plants structure and makeup. "Thus, leaf specra are dense,

complex and dynamic phenomic datasets influenced by both environmental and genetic factors." The accuracy of leaf spectroscopy varies (*Dryas* and *Populus* had highly accurate results, but *Quercus* was low accuracy). In essence, scientists use a special device to shine light on a leaf and then read the wavelengths that reflect back. Scientists hope to further develop this technology to be used on a mass scale. Perhaps a drone equipped with this technology could capture highly specific data about plant communities in remote locations.(9)

With such an enormous influx of data, taxonomy is at a crossroads. Scientists must choose wether to try to fit the data derived from DNA into the Linnaean system, or scrap over 250 years of information to rebuild a taxonomic system based on DNA. The classification of bacteria has moved towards exclusively DNA based classification. This is due to the difficulty of identifying differentiating physical traits to name these organisms despite the clear differences in DNA. There is also the question of where viruses fit in. Linnaeus asked questions in order to understand God's wisdom, over time the question morphed into scientists seeking to understand the process of evolution. Today plants are classified on far more data than just the number of reproductive parts. Despite these changes, Linnaeus's system is still in use. It is still in use because it is simple and effective at organizing the vast number of organisms known to science today, however, it has been adapted before, and will continue to evolve in order to remain relevant.(10)

Conclusion

I appreciate Linnaeus's desire to organize and understand the world we live in. I find I am more connected with nature when I know the names, habits, and histories of the living organisms in that place. Simple names and logical organization make understanding the wonders of nature more accessible to ordinary people. I am reminded of the book Braiding Sweetgrass by Robin Wall Kimmerer. She weaves a narrative that teaches the beauty of being aware of and connected to our environment, while also warning of the consequences of being disconnected. Terms like "plant blindness" and "nature deficit disorder" along with studies that show many children know the names of more Pokémon than wildlife species serve as an indicator that there is a growing disconnect between people and the environment in which we live.(11) I would like to use my skill as a botanical artist to help slow and even shrink that growing divide. There is evidence that botanical illustration can help people see plants.(12) I know from personal experience that when people are exposed to images of specific plants over and over, we not only become aware of the of the plant, but aware of the presence of that plant when we see it in its natural habitat. It seems logical to conclude that people care more about what they recognize than what they don't. Simply recognizing more plants would improve the odds of someone caring, and therefore increase stewardship of plants in the world around us.

While I lack the expertise to analyze and organize DNA, use leaf reflectance spectroscopy in an intelligent way, or weigh in on the debate of the taxonomic organization method moving forward, I can contribute to my local community by illustrating our native plants. I live in a state that has approximately 3,227 native vascular plants, and 340 endemic species. There is such incredible plant diversity because there is a high level of geologic, topographic, and hydrologic diversity. There's everything from desert, sand dunes, salt flats, alpine meadows and sandstone arches to marshes, permanent snowfields, and shrublands. There are officially 25 endangered plant species, and upon looking them up, I, a fairly knowledgeable native plant enthusiast, don't recognize the names of more than two of the listed endangered plants in my state. I am forced to ask myself how Utah as a state can

sustainably preserve our native plants without ordinary people knowing what they are. That's somewhere I can make a difference. I can gather information then create and distribute botanical illustrations of native Utah plants like Linnaeus gathered, organized, and distributed his way of understanding the natural world. (13)(14)

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Picture 1- Linnean.org
Picture 2- nhm.ac.uk
Picture 3- (8)