WORLD TO WORD:

NOMENCLATURE SYSTEMS OF COLOR AND SPECIES

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by
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ABSTRACT

As the digitization of information accelerates, the push to encode our surrounding numerically instead of linguistically increases. The role that language has traditionally played in the nomenclature of an integrative taxonomy is being replaced by the numeric identification of one or few quantitative characteristics. Nineteenth-century scientific systems of color identification divided, grouped, and named colors according to multiple characteristics. Now color identification relies on numeric values applied to spectrographic readings. This means of identification of color lacks the taxonomic rigor of nineteenth-century systems. Identifying color by numeric value instead of by grouping and naming them, strips color taxonomy of all but one quantitative aspect of a color. I use the case of color taxonomy to argue against a similar trend of numeric identification in the biological sciences. Unlike historically more integrative approaches to taxonomy in biology, genomic sequencing identifies one or few quantitative characteristics to encode an organism. If genomic sequencing becomes the primary means of identification in the biological sciences, just as in numeric systems of color identification, scientific taxonomy would suffer. Basing my analysis on theories of perception of division and on theories of language, I use the cases of color and species to argue for the advantages of an integrative taxonomic system of naming and categorizing over a method of identification, which encodes limited characteristics numerically. I hold that language is the most sophisticated tool for systematic taxonomy and that taxonomic nomenclature should be retained.

The faculty listed below, appointed by the School of Graduate Studies, have examined a dissertation titled "World to Word: Nomenclature Systems of Color and Species," presented by Tanya Kelley, candidate for the Doctor of Philosophy degree, and certify that in their opinion it is worthy of acceptance.

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CHAPTER 1

INTRODUCTION

By evaluating how we divide and classify our surroundings, especially colors and species, I pose the hypothesis that using finite characteristics as a means of identification, as is currently in favor, does not result in taxonomy. In the case of color nomenclatures, there has been a move away from the integrative systems of color identification and grouping, which was prevalent in the nineteenth century, to the current system of identification of color through spectrographic readings. The use of spectrographic readings as the identifier of color has impoverished the field of color taxonomy because it eliminates aspects of color that are not easily measured, such as a color's association with things in the natural world, contextual information provided by a color name and description, and a color's relation to other colors. In the biological sciences, a similar impetus toward identification based on few characteristics is taking place. In the proposed DNA bar-coding system, a miniscule fraction of an organism's genome is sequenced as the means of identification. Identification by genomic sequencing omits a broad range of data about habitat, inter-breeding populations, morphology, and the historical and contextual information contained in the nomenclature and categories of an integrative taxonomy. Dividing and identifying our surroundings is the initial step in any taxonomy, but it should not be the only step. Taxonomy is not merely a mechanical and computational task, now greatly aided through technology, but rather it is a hypothesis-driven science. Reducing taxonomy to simple identification, whether it is of a color or a biological being, results in lists of individuals rather than a comprehensive system in which patterns can be established and from which predictions can be made. I will show that color taxonomy has become impoverished due to its use of a single characteristic for identification by numeric spectrographic codes and therefore no longer fulfills the definition of a taxonomic science. From the case of color taxonomy's demotion from a science to mere means of inventory, I will show that in the biological sciences a similar trend is taking place and that by switching to genomic identification, species taxonomy would be likewise diminished. I will argue for the retention of words in taxonomic nomenclature, by founding my argument on theory and case studies.

After this introductory Chapter 1, in which I give an overview of the chapters of this dissertation, I begin with two chapters of theory followed by the corresponding case studies, and a conclusion. The theory chapters are 2 and 3. In Chapter 2, I examine the perception of discontinuities and how discontinuities are divided and categorized. In Chapter 3, I provide an overview of linguists' approaches to naming. The case study chapters are 4, 5, 6, and 7. In Chapter 4, I examine the case of perception of color division, and in Chapter 5, I examine the evolution of the taxonomic naming and grouping systems of color and spectrographic identification. In Chapter 6, I examine the case of perception of species division, and in Chapter 7, I examine the evolution of the taxonomic naming and grouping systems of species and genomic identification. To conclude this dissertation, I will show in Chapter 8 that a taxonomy based on a single characteristic does not constitute a scientific taxonomy, and that current systems of color identification are therefore not truly a taxonomic science, and, should taxonomy in the biological sciences adopt a similar model, it would follow suit. A more detailed account of the contents of each chapter follows.

In the discussion of the theoretical background of the perception of division in Chapter 2, I will give evidence to support my ultimate conclusion that a taxonomic system should be based on multiple characteristics and have taxonomic nomenclature. The way in which we divide our surroundings is based on many factors, and this should be accounted for in a taxonomic system. Perceiving discontinuities is essential for the formation of categories, and for the beginnings of cognition. Long before assigning names to the objects we identify as discrete, we must have an understanding of how we separate different elements in our surroundings, and the nuances of these divisions are best described with language.

The formation of categories is based on perceiving discontinuities, or divisions, in our surroundings, and about this, I will provide a theoretical background. Philosophers, naturalists, and psychologists have argued about the nature of these divisions to our surroundings. Some say these divisions are real, some say they are subjective, and some say they are created. The common sense reaction for most people is to claim that, yes, this is an apple, and this is an apple tree, and that there is an obvious boundary between the two. Such a reaction provides the basis for the claim that divisions are real. Those who argue back and forth about the nature of a color that is somewhere between blue and green, may end by saying that the perception of the viewers is ultimately subjective, and that neither can be held as the true division. In the third case, for those who look at a row of books in a bookstore and notice that the books on a particular shelf are labeled "classics," the nature of division is created. I will show that language conveys information about the divisions and grouping that numbers do not.

This overview of the perception of division is followed, in Chapter 3, by an investigation of the theoretical background behind naming. By examining linguists' approaches to human language origins and evolution, relativism, and speech act theory, the real, subjective, and created divisions outlined in the discussion of perceiving discontinuities are correlated to theories underlying naming systems. The evolution of human language, the recognition that language influences the perception of the speaker, and the power of language to create divisions are influential to the language used in taxonomy. And the assumptions that underlie linguistics theories inform the taxonomists' task of devising nomenclature. Using taxonomic names facilitates communication of an integrative taxonomic system. With these theory chapters on division and naming, I prepare the ground for understanding the two specific cases of color division and nomenclature and species division and taxonomic nomenclature.

In Chapter 4, I examine how color has been divided in different times and places, and how a taxonomic system relying on multiple characteristics can more ably reflect the diversity of color perception. Color has long been an attractive topic for those interested in perception and division of our surroundings. Studies of color perception and words in ancient and "primitive"[1] cultures, as well as current experiments on color perception, seek to determine how people perceive the divisions between colors.

In general, studies in color perception have taken two forms. There was a period, which corresponded to the acceptance of the theory of evolution, in which it was proposed that the human ability to sense color has evolved over only the past two millennia. Such studies drew heavily upon ancient texts to make the case that the physical organs of perception in the retina had not yet developed to the degree that they had in the late nineteenth century. Many nineteenth-century explorers and anthropologists conducted the

[1] Although I use the word *primitive* throughout this document, as is in keeping with the contemporary form of reference, I do not consider non-industrialized cultures to be less sophisticated than industrialized cultures.

second group of studies into the perception of color divisions. They tested the capacity for color perception among the primitives in areas remote from Europe and America. Although these studies are derided for their imperial tone and arrogant remarks about the inhabitants of the regions studied, they also set the stage for a plethora of studies of color perception and categories still being conducted today. The nineteenth-century studies of color perception concluded that in general, primitive people had a lesser capacity to distinguish colors than their Anglo counterparts did. The possible explanations for this were that perhaps these primitives had less evolved sensory organs, much like the ancients, or that perhaps they perceived the environment differently due to their cultural upbringing. Although cultural conditioning and subjective perception were mentioned, reports from nineteenth-century studies did not directly link the number of words a language used to denote color with the capacity for color perception. It was not until the mid-twentieth century that the correlation between color names and color perception was more explicitly studied. The results from these famous studies into the link between color perception and color vocabulary come to conflicting conclusions about the link between language and color perception. The studies indicate that the connection between divisions of color increments is influenced by the vocabulary for color. The vocabulary for color, whether it is used casually or scientifically, reveals much about the culture or system of the perceiver, and thus enriches chromotaxonomy.

In Chapter 5, I examine naming systems for color and spectrographic identification. The perception of divisions and linguistic theory directly influence color taxonomy. Using nineteenth-century color nomenclatures, I analyze naming systems for colors. In an attempt to provide a stable and universal manner by which people could communicate about color, these chromotaxonomies were fashioned by naturalists, especially botanists, mycologists, and ornithologists, and artists. My research into these books of color nomenclature was greatly aided by the collection of color science works in the rare books room of the Linda Hall Library. In naming colors, chromotaxonomists took varied approaches, basing their nomenclatures on traditional Latin names, providing multi-language translations, tying color names to the natural objects they describe, deriving the name from the ingredients of the pigments used to make them, or by adopting whimsical color names from the trades. Naming colors with the aid of technology, especially with the advent of spectrographic data, changed chromotaxonomy. Color nomenclature for arts and sciences has changed to one of numeric designations. Using words for scientific color nomenclature has been replaced by readings from diverse systems of color space numerals. The move to numeric encoding of color has depleted cultural and structural information from chromotaxonomies.

From the case of color division and naming, I move to the case of species division and naming. In Chapter 6, I show how perceptions and groupings of plants and animals also vary over time and place. Although plant and animal types were long thought to be unchanging, there is a surprising amount of category variance found over time and from culture to culture in these groupings. In fact, it is not unusual to find divergences in the classification of beings as belonging to the animal or the plant kingdom. Many of the perceptual differences may be accounted for by the relationship people have with their environments. In folk taxonomies, these relationships are especially evident. While researchers found remote indigenous peoples often had very limited color divisions, these same people often had quite complex and sophisticated divisions of plants and animals. By their very nature, folk taxonomies evolved through direct interaction with nature, whereas the approach to scientific taxonomy stems from the impetus to create order. After considering folk taxonomy, I turn to the scientific taxonomies. I will analyze approaches of organization based on morphology and phenotype, those based on descent and phylogeny, and those based on numerical assessment of specimens to show how the species taxonomy would be depleted if replaced with genomic barcoding.

In Chapter 7, I examine naming systems for species and genomic encoding. The perception of divisions and linguistic theory directly influence species taxonomy. I analyze species nomenclature addressing folk taxonomy, systematic taxonomy, Linnaean binomial taxonomic nomenclature, and genomic identification. Whereas taxonomic systems include multiple characteristics to form groupings, genomic identification relies on encoding limited characteristics. Work in the classification of plants and animals by scientists, who approach the project as one of creating a comprehensive hierarchy, are formed from a different motivation than those arising organically from the folk, but these approaches often intermingled. Just as folk taxonomy relies on names to designate a connection to the beings of the world, so too does scientific taxonomy. Names are connotative or denotative. The nomenclature is descriptive, relative to the perceiver, or created in an arbitrary association between word and object, in order to provide a taxonomic nomenclature for species. Until recently, scientific taxonomy depended on the tacit agreement of its users that a particular pair of words indicated a particular species; however, the boundaries of species and words are ever shifting. Although species nomenclature of Latin binomials is still endorsed, there is mounting competition for naming systems that rely more on technology. The development of a means for identifying species of plants, animals, and bacteria through DNA is producing alternative systems based on numeric encoding. The field of species nomenclature is in a state of rapid change, with many scientists promoting genomic identification of individuals over a taxonomic nomenclature. I argue that such a change would have the same diminishing effect on species taxonomy that it has on color taxonomy.

To conclude, in Chapter 8, I will show that the change that occurred in color taxonomy is now happening in species taxonomy. As with the identification of color, genomic identification of organisms by DNA barcodes shifts the means of identification from words to numbers and so shifts from an integrative taxonomic system to a list of individuals. Such a method places the emphasis on uniqueness over category. For science and industry, spectography and genomic sequencing are undeniably useful. One might object that there is too much dissimilarity between color and species to compare the naming systems used for them. Yet the continuity of the spectrum, and the differences in the way colors are assessed in various cultures, are similar complications to those now fueling the debate over species. Before spectrography, color nomenclature produced taxonomic systems that could account for multiple characteristics and created a scientific system of meaningful groupings. With the existence of species being called into question, and with the advent of genomic sequencing to label individuals, taxonomy in the biological sciences is in danger of disintegrating in the same way that color taxonomy has. Instead of a true scientific system of classification, biological taxonomy could likewise become a database listing a string of individuals designated by a number. As I conclude in this final chapter, the change from a taxonomic system that relies on multiple characteristics that are grouped and named, to a single-characteristic listing of individuals, represents a loss in scientific organization as well as a loss to the ease of communication in an integrative taxonomic science.

CHAPTER 2

DIVISION AND TAXONOMY: A THEORETICAL BACKGROUND

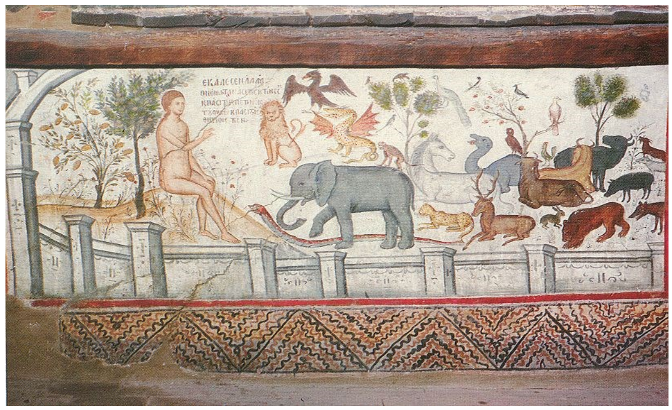

Figure 2.1. Fresco of Adam naming the animals, fifteenth-century Thessalonika[1]

Although I use two qualitatively different subjects in this study of the direction of taxonomic science, the most revealing point of comparison between species taxonomy and color taxonomy lies in understanding the principles of perceiving discontinuities. The perception of discontinuities, or divisions, is critical to any taxonomy, whether the system of organization is applied to geology, stars, bacteria, colors, or plants. The first work of the taxonomist is to distinguish one thing from another. This seems obvious enough on the surface, but what we face on a mossy bank or in a bog does not readily appear to us as individual items, like cereal boxes on a shelf, nor is it always clear where red ends and orange begins. When we look at the forest floor, we may be inclined to say that we see a jumble of life in which the exposed root of an elm is scarcely to be distinguished from the

[1] Fresco of Adam naming the animals, fifteenth-century Thessalonika. *Source:* https://www.skete.com/index.cfm/fuseaction/product.display/product_id/534/index.cfm

fungi growing upon it, and the pine needles decompose by increments until they are finally no longer pine needles but humus. As American psychologist William James once noted, we do not see a continuum of "blooming, buzzing confusion"[2] but an orderly world of discrete objects. When, however, we look at life forms or colors, such as woody mushrooms on the bark of a tree, or orange verging over into red, we may be inclined to say that we do indeed see a blooming, buzzing confusion and not a world of discrete objects. The practice of taxonomy, whether for plants, animals, or colors, first requires that one divide up the items into discrete units. Such division of one's surroundings is not as simple as one might assume. Since all average human beings are endowed with the same basic senses, it is to be expected that we sense the world in approximately the same way. Yet even among humans, from individual to individual, and from culture to culture, perceptions differ sufficiently for there to be entire academic disciplines devoted to their study. Some have concluded that divisions are neither real nor subjective, but arbitrarily created.

Whether discontinuities are real, subjective, or created is a question that bedevils all those concerned with orderliness. In a letter to Joseph Hooker dated December 24, 1856, Charles Darwin wrote:

> I have just been comparing the definitions of species ... It is really laughable to see what different ideas are prominent in various naturalists' minds, when they speak of 'species'; in some, resemblance is everything and descent of little weight -- in some, resemblance seems to go for nothing, and Creation [is] the reigning idea -- in some, descent is the key -- in some, sterility an unfailing test, with others it is not worth a farthing. It all comes, I believe, from trying to define the undefinable.[3]

[2] William James, *The Principles of Psychology* (New York: H. Holt and Company, 1890), 462.

[3] Charles Darwin, in a letter to Joseph Hooker dated December 24, 1856. Darwin Correspondence Database. http://www.darwinproject.ac.uk/entry-2022.

Darwin refers here to the definition of species, a debate that continues, but he opens a larger question when he states that we are trying to define the indefinable. In order to define something, one must distinguish it from its surroundings, give it delimitations, or identify its essence, according to Aristotelian terms. With defining the indefinable, Darwin was not speaking of giving the appropriate nomenclature, but simply of deciphering where one thing ends and another begins. While such divisions are useful, are they also real? To better appreciate the nature of taxonomic divisions from which to organize groupings, I will examine works on real, subjective, and created divisions.

Real Divisions

The question of whether or not there are real divisions in nature, or for that matter, in anything we are able to perceive or conceptualize, is fundamental to the way in which we understand the world. Especially in our approach to science, the underlying assumptions about the reality of the divisions we perceive in nature help to form the route of inquiry taken. Philosopher and mathematician René Descartes (1596-1650) wrote in his *Discourse on Method, Optics, Geometry, and Meteorology* about the question of the reality of divisions in nature:

> Our ideas and notions, being real things that come from God insofar as they are clear and distinct, cannot to that extent fail to be true. Accordingly, if we often have ideas that contain falsity, they can only be ideas that contain confusion and obscurity… that is to say, they are confused in us because we are not wholly perfect.[4]

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[4] René Descartes, and Paul J. Olscamp, *Discourse on Method, Optics, Geometry and Meteorology* (Indianapolis: Bobbs-Merrill, 1965), 32.

Descartes follows in the tradition of a long line of thinking, beginning with Plato, that true forms exist somewhere, whether outside the cave, or in the mind of God, and that it is up to us to perceive them clearly. It was thought that our perceptions were merely reflections of a reality seen through a mirror darkly by means of our imperfect senses. Isaac Newton (1642-1727) believed that God's works are done with great simplicity and that He is a God of order and not confusion. He was particularly fond of the harmonies he found in mathematics and music, of which he wrote in *Opticks.* To be consistent, he therefore also divided the spectrum of the rainbow in accordance with the seven harmonies of sound. The naturalist John Ray (1627-1705) believed that, "The essences of things are wholly unknown to us. Since all our knowledge derives from sensation, we know nothing of things that are outside us except though the power they have to affect our senses in some particular way, and by mediation of these impressions to cause a particular image to arise in the intellect."[5] For Descartes, for Ray, and for their intellectual predecessors, the underlying thought is that order exists – be it in the realm of the forms, in *veracitas dei*, or some transcendent truth – and that it was a rational person's task to discern the real divisions existing in this order.

Philosopher and physician John Locke (1632-1704) presented a view that anticipated the relativism of the twentieth century. Although he believed that there were real divisions to be sought and understood, he also bemoaned the subjective way in which nature had come to be ordered. Locke argued that the ordering of species according to abstract types is made wholly unintelligible due to culture-bound illusions. He describes the "presumptive ideas of several species [which] receive their birth and signification from ignorant and

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[5] John Ray, *De variis plantarum methodus dissertation brevis* (London: Smith and Walford, 1696), 5.

illiterate people, who sorted and denominated things by those sensible qualities they found in them."[6] In addition to our imperfect perception, which Descartes and Ray lament, Locke adds that the divisions seen in nature are also subject to the culture creating the system of order.

Despite our flawed perception and the deleterious effect of ignorant people, there existed the assumption that our surroundings are divisible into real and discrete units. The idea that divisions are real and that through rationality and true observation one can identify and group these divisions in a manner consistent with some natural or higher order is to this day a common way of viewing our surroundings. There is another line of thinking, which asserts that while there are distinct entities existing in our surroundings, ordering them is not based on a natural or higher plan, but instead that systems of order are contextual.

Subjective Divisions

If one removes the residence of truth from the realm of the ideal to the realm of the perceived, one can easily understand why the sophist philosopher Protagoras said, "Man is the measure of all things."[7] When we begins to look for truth and order not in external forms or the divine mind, but in our perception of the things themselves, difficulties rise alongside the awareness that there are so many men with so many measures of so many things. This was especially the case during times of great expansion, when varied cultures come into contact with one another.

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[6] John Locke, *An Essay Concerning Human Understanding* (New York: Dover Publications, 1959), 75.

[7] Plato, and Robin Waterfield. *Theaetetus* (Harmondsworth, Middlesex, England: Penguin Books, 1987), 152.

By the eighteenth century, voyaging was no longer just for Europe's warriors, merchants, pilgrims, and exiles. Voyages of discovery, in which plant and animal specimens were collected and native languages and cultures studied, were becoming the domain of the gentleman scholar as well. Alexander von Humboldt (1769-1859) and Wilhelm von Humboldt (1767-1835) were just such men. Alexander von Humboldt was a Prussian scholar and superintendent of mines in Franconia. He spent his inheritance on the exploration of Central and South America in an attempt to unify the sciences of botany, geography, paleontology, oceanography, and meteorology. After his death, Darwin praised him as the greatest scientific traveler who ever lived. Alexander von Humboldt is credited as the founder of cultural relativism. For him, no one culture was in itself worthier than another. Alexander von Humboldt wrote, "There are nations more susceptible of cultivation, more highly civilized, more ennobled by mental cultivation than others – but none in themselves nobler than others. All are in like degree designed for freedom."[8] His brother, Wilhelm von Humboldt, a philosopher and linguist and founder of a university and system of education, is credited with the beginning of linguistic relativism. To Wilhelm von Humboldt is attributed the idea that the grammar of any particular nation was an expression of its worldview.[9] The brothers Humboldt were two of many scholars impressed by the

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[8] Alexander von Humboldt, *Cosmos: A Sketch of a Physical Description of the Universe,* (Baltimore, MD: Johns Hopkins Press, 1997), 358.

[9] Although credited with the foundations of linguistic relativity, Wilhelm von Humboldt wrote, "To want to judge the extent of a people's ideas based in a definite epoch merely by perusing their dictionary is already highly doubtful." William von Humboldt, *Linguistic Variability and Intellectual Development* (Philadelphia: University of Pennsylvania Press, 1971), 11.

array of new languages, customs, creatures, and plants coming to be known by those of the Old World.

Voyages of discovery brought Europeans reports of breadfruit, llamas, maté, body painting, frenzied dancing, females courting males, and other such upsetting news. Thousands of exotic plant and animal specimens brought mountains of new data to integrate into European classificatory systems. The existing taxonomic systems were challenged by such species as the – now extinct – Australian Tasmanian wolf. The Tasmanian wolf was canine in appearance and a barking carnivore, yet it also bore its young as a marsupial. This is but one example of the myriad new specimens of plants and animals that were collected and brought "back home." These confounding delights were not limited to plants and animals. Voyagers discovered new ways of looking at the world. There were reports of strange new religions, rituals, and tribal and family customs. In *Reports of the Cambridge Anthropological Expedition to the Torres Straits*, British anthropologist A. C. Haddon (1855-1940) describes face painting of the young in Saibai:

> In the secular dances, or on other occasions when a man wanted to make himself "flash," the painting on body and face was unconventional, and that of the latter was generally limited only by the resources and ingenuity of the individual. I have seen young men and girls with the two sides of the face painted in different colours, and symmetry in lines or dots was rarely adhered to. The people were always very proud of their decorations and behaved in a serious manner, though the effect was generally ludicrous to the European.[10]

The reports from the Torres Straits stem from the late nineteenth century, and although painting one's body in asymmetrical patterns was then "generally thought ludicrous to

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[10]Alfred C. Haddon et al., *Reports of the Cambridge Anthropological Expedition to Torres Straits* (Cambridge [England]: University Press, 1901), 30.

Europeans,"[11] an increasing level of acceptance of other perspectives had developed towards reports of the exotic. Soon after, philosophers gave voice to opinions such as those of Ludwig Wittgenstein when he wrote, "All propositions are of equal value. In the world everything is as it is, and everything happens as it does happen."[12] Instead of maintaining that novelties must fit into the existing order of things, scholars and scientists entertained subjective ways of ordering things.

Going from the Cartesian doctrine of discovering God's order to the acceptance of culturally relative systems of order caused much upheaval. On the way, God was declared dead, Europeans started getting tattoos, and Isaac Newton's number of colors in a prism was disputed.[13] The study of philosophy, language, anthropology, and biology all underwent momentous shifts to incorporate the swift rise in our knowledge of the world. No longer were scholars seeking to discern the order of things, but instead trying to understand the sundry ways in which things are ordered in cultures dissimilar to their own.

Reports of the exotic continue to fascinate us today. *National Geographic*, the Discovery channel, and thousands of internet postings from remote places in the world, hold sway over our imaginations. We have become adept at assimilating new bits of information and accepting that other cultures organize plants, animals, minerals, metals, colors, senses, seasons, geometric shapes, and so on, within a different framework. There is, however,

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[11] Haddon, *Torres Straits*, 54.

[12] Ludwig Wittgenstein, *Tractatus Logico-Philosophicus*, translators D.F. Pears and B. F. McGuiness (London: Routledge and Kegan Paul, 1961), 145.

[13] Cultures were discovered in which there were but three or four named colors, a topic which will be discussed in detail in a later chapter.

another school of thought which maintains that in the very act of knowing and then organizing knowledge, reality becomes composed. In this line of thinking, discrete objects do not even exist.

Created Divisions

French physicist Bernard d'Epagnat (1921-2015) wrote, "The doctrine that the world is made up of objects whose existence is independent of human consciousness turns out to be in conflict with … facts established by experiment."[14] In this view, discrete objects exist only nominally. The view that divisions to the environment are dependent on human consciousness represents a radical departure to what I have described before. Realists, such as Descartes, Ray, Newton, and Locke, argued a form of platonism, which presumed that objects existed in an ideal form, an essence, or "in the mind of God." Relativists such as the von Humboldts argued that objects existed, but that they are subjectively perceived and organized. According to the view that divisions are neither real nor subjective, but created, discrete objects come into existence because they are the fabrication of human consciousness. The boundaries of a discrete object are brought into being by knowing them as human consciousness begets and delimits things from unknown formlessness. This is not to say that there is nothing without human consciousness, but that what is there is amorphous. Our minds create the divisions by which we identify our environments.

The notion that we create divisions to our environment and, thus identify discrete objects therein, is opposed to long-held perceptions. It seems counterfactual to maintain that the human mind creates divisions that are not there, because it has long been believed that

[14] Bernard d'Epagnat, "The Quantum Theory and Reality," *Scientific American* (November 1979): 158.

objects might be unequivocally segmented in the way that numbers are. Mathematics was considered an unambiguous example of real divisions that existed independently of human consciousness, and was seen as indicative of a transcendent order which the human mind had but to decipher. In this transcendent order, rational creatures needed only to detect and organize plants, animals, ideas, colors, and so forth in order to see things as they really are. Mathematical principles represented a pure revelation of this transcendent order and served as a guide for much of science including, increasingly, taxonomic science. Yet, the existence of mathematics as a transcendental truth has been assailed by none other than mathematicians. American mathematician Saunders MacLane (1909-2005) asserted, "mathematics is not a direct theory of some underlying Platonic reality, but rather an indirect theory of formal aspects of our world (or reality, if there is such)."[15] MacLane ended by discounting the objectivist line of thinking and concluded that even pure mathematics is based on human rationality.[16]

In discussing nominalism and Platonism in mathematics, Otávio Bueno drew a comparison between mathematical statements and scientific statements. He wrote,

> Given the existence of mathematical objects, mathematical statements are true in the same way as scientific statements are true. The only difference emerges from their perspective truth-makers: mathematical statements are true in virtue of abstract (mathematical) objects and relations among them,

[15] Saunders Mac Lane, "Mathematical Models," *American Mathematical Monthly* (Aug.-Sept. 1981): 467.

[16] George Lakoff, *Women, Fire and Dangerous Things: What Categories Reveal about the Mind* (Chicago: The University of Chicago Press, 1987), 365-9. Lakoff likewise concluded that mathematics is a human construct born of rationality.

> whereas scientific statements are ultimately true in virtue of concrete objects and corresponding relations among such objects.[17]

In reviewing the platonic concept of mathematics, Bueno maintained that mathematical truths are only true relative to other abstract mathematical objects, thus making a closed, self-reflexive theory, while, on the other hand, concrete objects could be used to verify or disprove scientific statements.[18] The distinction between mathematical truth and scientific truth is important to my argument that taxonomy should remain a holistic science of dividing, categorizing, and naming instead of one of quantitative computation.[19] If it is true that we create divisions to our environments, then these divisions must bear up to scientific scrutiny, which has explanatory power that is more than a self-referential system. Bueno wrote that concrete objects served to instantiate from the infinite mathematical structures only a finite aspect of the possible:

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[17] Otávio Bueno, "Nominalism in the Philosophy of Mathematics," ed. Edward N. Zalta, *The Stanford Encyclopedia of Philosophy* (Spring 2014): 4, https://plato.stanford.edu/archives/spr2014/entries/nominalism-mathematics.

[18] Bueno, "Nominalism in the Philosophy of Mathematics," 29. Bueno concludes, "I take true mathematical statements to be literally *true*…nonetheless, I can describe mathematical terms as referring to nothing at all."

[19] In a personal correspondence with me, philosopher and computational scientist George Towner wrote: "I believe that mathematical propositions are constructed, but they are constrained by the objectivity of unknown reality. For example, the question of whether a very large number is prime always has an answer but the answer may be extremely difficult to obtain, a fact that is useful in modern cryptography. Getting the answer typically requires using a computer to perform calculations beyond human capacities. But once the answer is obtained it is unassailable. Conversely, Gödel showed that some mathematical questions can never be answered. I tried to reflect some of this when discussing pi in my book. The value of pi, whatever it is, must be objective; otherwise mathematicians would never be certain that their constructions (e.g. summation series) 'converge' on it. But so far, human rationality is farther than ever from truly 'getting' the value of pi."

> For the physical world – being composed of objects located in space-time – is not constituted by the entities postulated by the platonist. Hence it is not clear why the correct description of relations among *abstract* (mathematical) entities is even *relevant* to understand the behavior of concrete objects in the physical world involved in the application of mathematics. Just mentioning the physical world *instantiates* structures (or substructures) described in general terms by various mathematical theories is not enough. For there are infinitely many mathematical structures, and there is no way of uniquely determining which of them is actually instantiated – or even instantiated in part – in a finite region of the world.[20]

Using numbers to quantify objects of the physical world creates a self-referential system that can neither be tested against other objects in the world, nor against the structures imposed by our human consciousness.

Yet, if we construct a theory of mathematics from human rationality, as MacLane and others maintained, what could that indicate for the construction of other areas of knowledge? If in the very act of knowing things, human consciousness gives them the shape that we perceive, how do things exist when they are unknown? To this question philosopher George Towner responded:

> The conversion of unknown reality into known reality begins as a process of "chunking." The discrete chunks that result may be physical things, or trains of behavior, or ideal abstractions. All of them are valid parts of known reality; but because they are products of chunking, none of them are exactly the same as the material in unknown reality from which they are drawn. Moreover, a given part of unknown reality can be converted into different chunks.
>
> The simplest way to understand how unknown reality can be chunked in various ways into discrete objects of known reality is to visualize it as "smooth" – devoid of natural boundaries within it. Then chunking it into discrete objects can introduce boundaries anywhere without constraint. In mathematical terms, this characteristic would identify unknown reality as a "continuum."[21]

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[20] Bueno, "Nominalism in the Philosophy of Mathematics," 4.

[21] George Towner, *The Reality of Knowledge: The Ways in Which Life Constructs Reality so It Can Be Known* (Lanham, MD: University Press of America, 2011): 22.

Towner concluded the thought above by stating, "lacking compelling evidence to the contrary, we can assume that unknown reality contains no inherent 'granular structure' that would constrain our ability to convert it into the objects that we know."[22] Claiming that there is no "granular structure," or in my terms, that there are no inherent divisions, to our environment goes much further than relativism. In this view, instead of divisions being subjective, divisions are created out of whole cloth. Human consciousness, through the act of "knowing," creates the divisions to the environment. Some mathematicians maintain that numbers exist outside of human devising, while others deem them a human construct, yet language suffers no such ambiguity. Language does not exist in the platonic realm. It is a dependent on humans for its existence. I shall argue that language, rather than numbers, is a superior tool for scientific nomenclature for organizing and naming the divisions we create, precisely because it is unambiguously and revealingly a human.

Conclusion

The way in which we perceive discontinuities can be described as real, subjective, or created by the perceiver. Proceeding now with an awareness of the various ways in which cultures assemble and disassemble their surroundings will be helpful to a better understanding of how words both reflect and form these perceptions. Linguists are themselves influenced in their theories of language by their underlying assumptions about the nature of discontinuities and categories. The three following traditions in linguistics reveal three corresponding underlying assumptions about the nature of discontinuities. To

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[22] Towner, *The Reality of Knowledge,* 23.

explain the role of language in taxonomy and how it has been used to name and group divisions, I will next look to linguistic theories.

CHAPTER 3

WHAT IS IN A NAME: A THEORETICAL BACKGROUND

Taxonomy has traditionally been a science of systems of organization in which the constituent members are identified by carefully defined rules of nomenclature. Extensive guidelines govern the types of words that may be used in assigning names to plants and animals in Linnaean taxonomic nomenclature. The names given to colors in color taxonomies are likewise chosen with consideration for their clarity and significance within an organizational system. Taxonomic organization is reliant on the systematic designation of words to identify and communicate about things in the world, yet there is scant attention paid in linguistics to taxonomic nomenclature. Because taxonomy uses words in a deliberate fashion, with guidelines for lexical, semantic, and syntactical aspects of nomenclature, and because many taxonomists are advocating for changing to a numeric system of identification, I find that taxonomy is an ideal subject of inquiry into linguistic theory. What do linguistic theories tell us about the language of taxonomy, and is the retention of nomenclature important?

In the previous chapter, I discussed the perception of divisions in our environment and described three basic approaches: divisions to the environment may be assumed to be real, they may be assumed to be subjective, and they may be assumed to be created. The way that we represent and communicate about these divisions is limited and determined by the medium we use. American linguist John Searle said in an interview that "the basis for taxonomy is that there are only a finite number of ways that the mind can represent reality. It can represent it with the mind to world direction of fit,…or represent it with the world to mind direction of fit…"[1] I maintain that the most sophisticated means we have of representing reality is with language, and that the goal of good taxonomic nomenclature should be both to describe the world, and to reflect the structures and logic our minds impose on our perception of the world. Language can represent the real divisions of our environment and, more importantly, it communicates the subjective and created divisions our mind inescapably imprints on the systems we devise. It is because of this duality, the combining of word to world, and world to word directions, that language should remain the basis for taxonomic science.

Yet computational potential has strengthened the appeal of changing from words to numbers in systems of identification in part because the sheer quantity of colors and species makes numeric identification utilitarian. While sequences of nucleic acids require only a finite number of distinctions, there are still so many such distinctions that ordinary naming is impracticable. Whereas the classical theory of electromagnetism asserts that the color of light is a continuum, thus implying that there are as many color distinctions as there are real numbers, the quantum-mechanical theory of light says that the only possible colors are those that arise from a large but finite set of electron-orbital transitions in atoms of elements. Both the classical theory of electromagnetism and the quantum-mechanical view would require so many distinctions that ordinary color-naming is too unwieldy.[2] With both species and color, the primary argument for using numeric identification is the facilitation of computation. Whether one agrees with mathematicians who believe that numbers exist apart from human

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[1] Julian Moore, "Interview with John Searle," *Philosophy Now* 25 (1999): 38.

[2] Jack Horner, who writes about computation in science, articulated the information on light in a correspondence with the author dating from October 2016.

construction, or those such as MacLane, who asserted that mathematics does not reflect an underlying Platonic reality, but instead reveals formal aspects of our world,[3] it is clear that numbers have computational advantages over words. Searle said in an interview "that the key to understanding nature is that it's a series of causal relations and the notion of computation is not a notion, it's an abstract syntactical or symbolic or formal notion."[4] In other words, understanding nature is a matter of understanding groupings and their inter-relationships, and computation is a tool that in which explanatory power is inherent. Thus, while numeric systems of identification are still called "taxonomy" by some of their proponents, this is not an accurate portrayal. Numeric systems list individuals and provide ease of computation, but taxonomy is the science of systematizing, organizing, and showing relationships. Language is therefore the better tool for explaining and communicating integrated information.

Taxonomic science is descriptive and systematic. If we assume that the divisions to our environment are real, the consequent matter of naming these divisions is an achievable endeavor. One merely has to find or devise an accurate word for all the things that really exist, which should result in a stable one-for-one correspondence between word and object. This approach to naming can be understood by looking at works on human language origins and evolution. If we assume that the divisions to our environment are subjective, the consequent matter of naming these divisions becomes a question of examining the

[3] Saunders Mac Lane, "Mathematical Models," *American Mathematical Monthly* (Aug.-Sept. 1981): 467.

[4] Moore, "Interview with John Searle," 39.

perspective of the viewer to determine how the words for the objects are affected by circumstances, culture, and time. This approach to naming can be understood by looking at works on relativism. If we assume that the divisions to our environment are created, the consequent matter of naming these divisions becomes a speech act, which is integrally related to the creation of the divisions and likewise the things themselves. Searle wrote that "Language doesn't just describe; it creates, and partly constitutes, what it both describes and creates."[5] To explain what is in a name, I examine works on human language origins and evolution, relativism, and speech act theory.

Language Origins and Evolution

The topic of human language origins and evolution has been a topic that has fascinated thinkers and charlatans for millennia. Many of the speculations and theories about language origins made over millennia have been rejected and then revised with the aid of technological advances. Here follows a representative survey of ideas about the origination of correspondence between word and object that underlies the naming practices that assume that divisions to the environment are real.

Following in the line of Aristotle's foundational ideas about language and perception, James Burnet Lord Monboddo (1714-1799) founded his theories in *On the Origin and Progress of Language* on the connection between sense, memory, and word. Much as had Aristotle, Monboddo began with an examination of how the senses become useful with the aid of memory. He maintained that we begin to distinguish things in our surroundings by the use of the senses, but if these perceptions were not preserved, they

[5] John R. Searle, *Making the Social World: The Structure of Human Civilization* (Oxford: Oxford University Press, 2010), 85.

would “vanish and disappear like traces in water, there would be no comprehension or knowledge of any kind.”[6] Instead, sensations are preserved in the mind so that, when an object presents itself again to the senses, traces of the former perception will be renewed. The beginning of cognition is memory, “and here for the first time the mind begins to act by itself, and to exert a little of its intellectual powers.”[7] In many ways, experiments of bio- and neurolinguistics have borne out the rudiments of Monboddo’s ideas of the significance of repeated exposure to sensory experiences. Yet taking in the world literally, specific experience by specific experience, is not always advantageous. To store an independent record of every incident would require a huge amount of memory storage space in the brain, thus burdening it with unnecessary details. Memories are instead stored in the brain in discrete units that do not directly reflect the environment, but instead provide an efficient means for classifying surroundings. Here the door to subjective divisions of our environment is already opened, but this is more directly addressed by relativists and structuralists.

Those interested in human language origins and evolution frequently turn to an analysis of communication and language capacities of other species. Monboddo considered the language capacities of several non-human species in an effort to define the nature of language, determine how it might have evolved, and consider whether language is the defining attribute of humans. Moving up the scale of articulation, Monboddo considered the

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[6] James Burnet Lord Monboddo, *On the Origin and Progress of Language,* 2nd ed., Vols. 1-6. (Edinburgh: J. Balfour and London: T. Cadell, 1774, *facsimile* New York: Garland Publishing, Inc., 1970), Vol. I, 57.

[7] Monboddo, *On the Origin and Progress of Language*, Vol. I, 58.

inarticulate cries of the sea-cat. "The Russian academicians say, that the *sea-cat* … can low like a cow, growl like a bear, and chirp like a cricket."[8] He reflected on the articulate cry of birds, but ended by saying that, although they have a great range of imitative capacities, bird sounds are too limited to be compared to human language.

Despite these limitations, Monboddo gave great credit to the communicative abilities of animals. "It is really surprising how many different passions, such as love, joy, anger, grief, the brutes express… and I am persuaded, the nearer the oeconomy of any of them comes to ours, the greater variety will be found in their cries, because they have more to express by them."[9] Nevertheless, Monboddo considered human language more complex than even the most articulate communication of "the brutes." Since he believed humans did not always have language, he speculated on how human language might have evolved. He entertained four possibilities: that language arose from inarticulate cries; from gestures; from imitative sounds; or from painting. He concluded that, "it is inarticulate cries only that must have given rise to language… [and] natural cries were varied by tones, before they were distinguished by articulation."[10] Much as did those who studied color perception of the ancients and the primitives, Monboddo believed that human languages existed at various stages of evolution in different populations. There are languages that are based more on tone, and others based more on articulation. Taking examples from "barbarous" languages, such as Huron and "sophisticated" languages, such as Latin, Monboddo sought to show that

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[8] Monboddo, *On the Origin and Progress of Language*, Vol. I, 462.

[9] Monboddo, *On the Origin and Progress of Language*, Vol. I, 462.

[10] Monboddo, *On the Origin and Progress of Language*, Vol. I, 475-477.

languages evolved along a single trajectory from tonal to articulated. Finally, Monboddo considered whether language was the defining attribute of humans and so compared the communication capacities of humans and orangutans.

Monboddo based his comparison on the studies of the orangutan by the naturalists Georges-Louis Leclerc Comte de Buffon (1707-1788) and Carolus Linnaeus (1707-1778). Even though he established reputable sources, he began by admitting that the comparison may cause offense:

> This opinion, I know, will appear very singular to many, and will give offense to some, as highly derogatory, according to their notions, from the dignity of human nature. But as I do not wish to flatter the vanity or prejudices of any man, I will fairly examine the question…I am persuaded [that the differences between the orangutan and the human] are less considerable than are to be found betwixt individuals that are undoubtedly of the human species.[11]

Possible offenses notwithstanding, Monboddo found, as did Buffon and Linnaeus, that humans have the same sized brains, similar organs of pronunciation, the same heart, lungs, liver, stomach and intestines. Humans and orangutans both have the proper legs and buttocks suited for upright walking. Monboddo then related a series of reports heard form travelers that "When [orangutans] are clothed, they immediately walk erect, they play very well upon the pipe, harp and other instruments."[12] Another traveler reported that orangutans mourn the dead, show shame if unclothed, and that they "concealed with their hand, those parts, which modesty forbids to shew."[13] Despite the unfortunate mix of reliable and

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[11] Monboddo, *On the Origin and Progress of Language*, Vol. I, 270-271.

[12] Monboddo, *On the Origin and Progress of Language*, Vol. I, 276.

[13] Monboddo, *On the Origin and Progress of Language*, Vol. I, 279.

unreliable sources about orangutan anatomy and habits, Monboddo proceeded to a sophisticated discussion of the essence of human nature. Monboddo likened the present condition of the orangutan to what the previous human condition could have been. He suggested that orangutans "may be reckoned to be in the first stage of human progression, being associated, and practising certain arts of life; but not so far advanced as to have invented the great art of language."[14] There is a similarity to color perception studies, such as those of Rivers that proposed that color perception was and is an evolving sense. As were the color studies, Monboddo's inferences roused intense curiosity as well as derision. The year the first edition of *On the Origin and Progress of Language* was published in 1773, literary giant Samuel Johnson, (1709-1774) commented to his biographer, "Sir, it is as possible that the Ouran-Outang does not speak as that it speaks," but that "it is a pity to see Lord Monboddo publish such notions as he has done; a man of sense, and of so much elegant learning. There would be little in a fool doing it; we should only laugh; but when a wise man does it, we are sorry."[15]

Yet, even Dante Alighieri had speculated on human language origins in *De vulgari eloquentia*. He proposed divine and unchanging Hebrew as the first language, but later concluded that this was probably not the case. Dante set forth a grand genealogical classification of the known languages of the world. The philologist Sir William Jones (1746-1794) joined a long cast of scholars in his interests in tracing the relationships among languages. His knowledge of Sanskrit, Latin, and Greek led him to articulate in "The Third

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[14] Monboddo, *On the Origin and Progress of Language*, Vol. I, 239.

[15] Arthur O. Lovejoy, *Essays in the History of Ideas*. (Baltimore, MD: The Johns Hopkins Press, 1948), 46. Lovejoy quotes Dr. Samuel Johnson from *Boswell's Life of Johnson*.

Anniversary Discourse, delivered 2 February 1786, by the President [on the Hindus]," that due to their underlying similarities in structure, there must have existed a now extinct language whence these evolved. Also working in this field was Friedrich Schlegel, who, in *Über die Sprache und die Weisheit der Indier,* was inspired by work taking place in comparative anatomy, such as George Cuvier's *Leçons d'anatomie comparée*, and called for a similar scheme to study language in order to furnish a completely novel insight into the genealogy of languages through comparative grammars. This comparative methods ushered in by Schlegel was further developed by the von Humboldts and led to relativism and structuralism.

However, proposals about language origins and evolution became highly conjectural and, at times, even disreputable. Works concerning the origin of human language and language capacities in other species fell into such disgrace that in 1866 the Société de Linquistique of Paris proclaimed it would accept no communication on these topics, and in 1872 the London Philological Society made a similar ban.[16]

[16] Perhaps the disregard for theories of language origins and evolution was exacerbated by the raft of jauntily-named theories. The mama theory held that we began the easiest syllables by attaching them to the most significant objects. The ta-ta theory from Richard Paget (1832-1908), who, influenced by Darwin, developed the idea that body movement preceded language, and that from vocal imitation of these movements, such as moving one's mouth when chipping a flint stone into a spear tip, language was derived. The bow-wow theory held that language first imitated natural sounds, in an onomatopoeic or echoing fashion, such as meow, moo, and whatever sounds wooly mammoths made. The ding-dong theory held, as the famous linguist Max Müller (1823-1900) noted, that there was a correspondence between sound and meaning, such as in the words moon and itsy bitsy.

A century later, and despite the fact that preeminent linguist Noam Chomsky deemed the inquiry into the origin of language simply "too hard,"[17] the subject regained popularity. Now, with more sophisticated tools of analysis, the study of the origins of human language is once more favored. In *The First Word,* Christine Keneally traced the resurgence of interest in work in animal language studies. Despite the resurgence of interest in this field carried out by primatologists, such as Sue Savage-Rambaugh, and linguists, such as Philip Lieberman and Steven Pinker and Paul Bloom, Keneally admitted that

> even now, scholars who work with animal language are often characterized as daft idealists or outright frauds, believing that beneath the fur or behind the beak are creatures with souls. Yet if you speak to these researchers, you won't find anyone downplaying the enormous differences between humans and other animals, despite the fact that they happen to be interested in the commonalities.[18]

Much of speculative research about human language origins and the comparison to other animals' capacities for communication is deemed daft, yet linguists, philosophers, and biologists continue to retrace these lines of inquiry.

Pinker and Bloom studied the subject of how cognitive capacities evolved to the point that human language was possible:

> Ape language…opened one fascinating window into the problems of language evolution. Steven Pinker and Paul Bloom opened another in 1990 when they published a paper in which they sidestepped the question of how much animal language training can teach us about language evolution and

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[17] Christine Keneally, *The First Word*. (New York: Viking Press, 2007), 58. This quote from Chomsky concerning the inquiry into the origins of language is from an email to Pinker and Bloom.

[18] Keneally, *The First Word*, 49.

> instead argued directly that not only could language evolution be studied, it *should* be studied.[19]

The resurgence in the interest and acceptance of studies in language origins and evolution has especially gained acceptance since the end of the twentieth century, thanks, in part, to neuro-imaging technology and genetic analysis. In "Natural language and natural selection," Bloom and Pinker wrote, "All we argue is that language is no different from other complex abilities, such as echolocation or stereopsis [the visual process that gives rise to depth perception], and that the only way to explain the origin of such abilities is through the theory of natural selection."[20] Since then several researches have taken up this "too hard" question of language origins and evolution. Pinker has written two full-length monographs on the topic, both of which relied heavily on animal studies. Pinker and Bloom's work on language evolution was highly publicized, yet others had been toiling away at this problem for years.

In 1984, Philip Lieberman published *The Biology and Evolution of Language*. He argued against Chomsky's idea that there was an inexplicable saltation that gave rise to human language. Lieberman instead reasoned that the capacity for abstraction evolved through encephalization. He said, "When we employ syntax, we are using the neural bases for a system that evolved a long time ago for reasons other than stringing words together."[21]

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[19] Keneally, *The First Word*, 50. Among the later trend of inquiry is an article from 2002 by Marc Hauser, Noam Chomsky, and W. Tecumseh Fitch addressing comparative faculties of language among species.

[20] Steven Pinker and Paul Bloom, "Natural Language and Natural Selection." *Behavioral and Brain Sciences* 13, no. 4,(1990): 710.

[21] Keneally, *The First Word*, 78. Keneally quotes Lieberman.

By the time Lieberman published *Toward an Evolutionary Biology of Language* (2007), his second major monograph on the subject of language origins and language capacities in non-human species, he was no longer viewed as a contrarian. Instead, Lieberman's later work has been received as a valuable piece of the puzzle in the pursuit of theories about the origins and evolution of human language. Building upon an increasing body of knowledge, in 2016, Lieberman wrote, "No evolutionary processes that are specific to humans shaped language and no brain mechanisms appear to be specific to speech or language."[22] Lieberman maintains that the capacity for language is not due to a uniquely human adaptation, but others disagree.

Linguists Thomas Stroik and Michael Putnam address biolinguistics in *The Structural Design of Language* (2013). Stroik and Putnam were especially interested in the rapidity with which the faculty of human language evolved. They wrote, "Although our ancestors appear to have mastered the use of symbols long ago, they do not seem to have developed the ability to combine these symbols in the structured way we modern humans do until relatively recently."[23] Stroik and Putnam agreed that the faculty of human language must have developed between 50,000 and 100,000 years ago, but they sought to investigate how, in evolutionary time, such a leap could have occurred. To account for the speed of the evolution of the human language faculty, they theorized that it would be "natural if it is based on principles and operations that promote computational tractability, that are built

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[22] Philip Lieberman. "The Evolution of Language and Thought." *Journal of Anthropological Sciences* 94 (2016): 142, doi 10.4436/jass.94029.

[23] Thomas S. Stroik and Michael T. Putnam, *The Structural Design of Language* (Cambridge: Cambridge University Press, 2013), 4.

from parts that are cognitively general and atomic, and that are basic enough to be (plausibly) embodied in neural circuitry."[24] Stroik and Putnam concluded that the structural design of language systems have to comply with physical and mathematical laws, and that given this stricture, "Narrow Syntax – LEX and the CS – must reside, for reason of conceptual necessity, within the performance systems."[25] The emergence of the faculty for language within the confines of the performance systems was coined by Stroik and Putnam as *Survive–minimalism.*

Marc Hauser, Noam Chomsky, and W. Tecumseh Fitch duly gave credit to the tradition upon which their hypothesis rests, in acknowledging that, "it has been recognized for thousands of years that language is, fundamentally, a system of sound-meaning connections; the potential infiniteness of this system has been explicitly recognized by Galileo, Descartes, and the 17th-century 'philosophical grammarians' and their successors, notably von Humboldt."[26] Although the capacity for communication is to some degree present in all species (the faculty of language broad, or FLB), Hauser, Chomsky, and Fitch argued that a further evolution has taken place in humans. Through the adaptation of recursion, human language has a developed a discrete infinity of combinatorials (the faculty of language narrow, or FLN).[27] The neural capacity for recursion is an adaptation upon

[24] Stroik, *The Structural Design of Language*, 5. Stroik and Putnam quote Hornstein's challenge and investigate how it can be met.

[25] Stroik, *The Structural Design of Language*, 156.

[26] Marc D Hauser, Noam Chomsky, W. Tecumseh Fitch, "The Faculty of Language: What Is It, Who Has It, and How Did It Evolve?" *Science* 298 (Nov. 22, 2002): 1571.

[27]The discrete infinity of combinatorials is subject to practical limits, such as lung capacity, and the limits of working memory on the length and complexity of sentences.

which human language depends, but it is likely not unique to humans. While other species do not use recursion for human-like language, it is possible that this adaptation is useful in navigation, number quantification, or social relationships.[28] Human language and the communication, by which species organize their social relationships, both rely on the internal adaptation of recursion and on external events. Chomsky wrote:

> Communication is not a matter of producing some mind-external entity that the hearer picks out of the world, the way a physicist could. Rather, communication is a more-or-less affair, in which the speaker produces external events and hearers seek to match them as best they can to their own internal resources. Words and concepts appear to be similar in this regard, even the simplest of them. Communication relies on shared cognoscitive powers, and succeeds insofar as shared mental constructs, background, concerns, presuppositions, etc. allow for common perspectives to be (more or less) attained.[29]

The cooperation required between the speaker, who produces an external event, and the hearer, who tries to match it to an internal resource, indicates a sophisticated social organization. Whether referring to human language, or to the social organization of other species, a similar evolutionary adaptation is implicated. Michael Tomasello explained,

> To be as clear as possible: we are not claiming that all aspects of human thinking are socially constituted, only the species-unique aspects. It is an empirical fact that the social interaction and organization of great apes and humans are hugely different, with humans being much more cooperative in every way. We find it difficult in the extreme to believe that this is unrelated to the huge differences in cognition and thinking that also separate great apes from humans, especially when we focus on the details. What nonsocial theory can explain such things as cultural institutions, perspectival and conventional

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[28] Hauser, "The Faculty of Language," 1578.

[29] Noam Chomsky, Massimo Piattelli-Palmarini, Pello Salaburu Etxeberria, and Juan Uriagereka, *Of Minds and Language: A Dialogue with Noam Chomsky in the Basque Country* (Oxford, UK: Oxford University Press, 2009), 27.

> conceptualizations in natural languages, recursive and rational reasoning, objective perspectives, social norms and normative self- governance, and on and on? These are all coordinative phenomena through and through, and it is almost inconceivable that they arose evolutionarily from some nonsocial source. Something like the shared intentionality hypothesis just must be true.[30]

Tomasello here made a link between the theories of language evolution, with their concomitant adaptation for recursion, and the critical link to social structures and cultural institutions. Volition and social constructs are elemental to my ultimate argument for the importance of retaining a taxonomy reflective of the adaptation of recursion, and the work of Bickerton and Searle lead further toward this conclusion.

In, *More Than Nature Needs* (2014), linguist Derek Bickerton conjectured that in the evolution from animal communication to protolanguage, utterances would have "occurred at various stages of the confrontational scavenging scenario and would have at first been tightly linked to those stages as, say, the vervet 'leopard' alarm signal is linked to the actual appearances of leopards."[31] He continued, "As is apparent from everyday experience, and has been repeatedly demonstrated in experimental neurology, representations of words and their associated concepts are tightly linked."[32] Even though the association of world to word is tightly linked, the association is also voluntary. Bickerton, as had Searle, pointed out that there is intention underlying language:

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[30] Michael Tomasello, *A Natural History Of Human Thinking* (Cambridge, Massachusetts: Harvard University Press, 2014), 153.

[31] Derek Bickerton, *More Than Nature Needs: Language, Mind, and Evolution* (Cambridge MA: Harvard University Press, 2014), 99.

[32] Bickerton, *More Than Nature Needs,* 99-100.

> Note too that utterances of words (we may now safely begin to call them that) had to be volitional. Voluntary utterance was not a total novelty. It has been know at least since Seyfarth and Cheney (1990) that warning signals are under voluntary control. (For instance, animals are less likely to warn if no close kin is around and will suppress signals altogether if they are alone.)[33]

Bickerton conjectured that these voluntarily utterances developed rapidly in *Homo sapiens* from isolated world to word associations to a fully syntacticized language, because "when a new source of information becomes available, brains inevitably redistribute their resources. …The new information was not due to the emergence of new sensory equipment but to the acquisition of words and their associated meanings."[34] Bickerton speculated that developments, such as the shortening of neural connections, might have made the brain more able to accommodate language and to further evolve because of language.[35] Bickerton described a symbiotic growth relationship of language and the brain, which conforms to the findings in other areas researching brain plasticity. This description of language development differs from other theories that base their explanatory power on the assumption that preexisting brain structure was imprinted on the structure of language. Bickerton responded, "If we wish to trace the further evolution of language … the brain's most probable reactions to its colonization by words is the area we need to examine. If there are universals of language and cognition, it is only within the brain that they could have been given birth."[36] In particular, Bickerton points to syntax and combinatorics as defining

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[33] Bickerton, *More Than Nature Needs*, 99-100.

[34] Bickerton, *More Than Nature Needs,* 107.

[35] Bickerton, *More Than Nature Needs,* 107.

[36] Bickerton, *More Than Nature Needs*, 108.

elements of language, and maintained that these elements serve to develop the brain and, in this way, language is both a mental and physical phenomenon.

In 2010, in *Making the Social World*, John Searle argued that the evolution of language could be explained through naturalistic processes. His approach "is naturalistic in the sense that it treats language as an extension of biologically basic, prelinguistic forms of intentionality, … showing how the human reality is a natural outgrowth of more fundamental – physical, chemical, and biological – phenomena."[37] Searle spent little time in speculating about how the natural evolution of language occurred, but he emphasized that thought is possible without language and that intentionality is the precursor to language. According to Searle, language evolved from intentionality, and once it had evolved, it inherently brought about social institutions. He wrote, "once you have a shared language, you already have a social contract, indeed, you already have a society."[38] Searle argued that phonology, syntax, and semantics of language reflected underlying aspects of cognition already evolved before language. He wrote, "Another feature common to prelinguistic forms of consciousness and to language is that in the possession of prelinguistic forms of consciousness, the animal is already able to operate with a rather large number of traditional philosophical (e.g., Kantian and Aristotelian) categories."[39] As I also have written in the previous chapter, the division and categorization of our environment is critical to the understanding the systems of naming we developed. Theories of language evolution help to

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[37] Searle, *Making the Social World,* 61.

[38] Searle, *Making the Social World,* 62.

[39] Searle, *Making the Social World*, 67.

reveal the foundations of taxonomy. In Searle's terms, "language is constitutive of reality, and consequently …all human institutions are essentially linguistic,"[40] and this includes the language that has been employed to construct scientific taxonomy.

The simultaneously outward and inward dynamic of the language faculty applies not only to brain development, as Bickerton maintained, but this outward and inward dynamic also applies to institutional development, as is visible in Searle's assertion that language forms society. Semantics and syntax, whether one places the impetus for their evolution within or without the individual, has for millennia, attracted many of the brightest minds to attempt to explain the difference language makes in distinguishing humans from other species. Through the study of theories of the origin and evolution of language, light is shed not only on what divides *Homo sapiens* from other animals and also on the correspondence words reveal about our perception of how the world is structured and divided. Progressing now further with the idea that such divisions are not real, but subjective, and perhaps influenced by language itself, I turn briefly to the influence of relativism on linguistics.

Relativism

The German romanticist approach to science emphasized that scientists should examine the idea of a whole in its natural context. A comprehensive and contextual approach to the natural sciences and to the study of languages was a hallmark of the romantic era, and many of its ideals can be seen again in the principles of relativism. In relativism, meaning is relative, or subjective, to the beholder. The relativist's perspective on natural science and language corresponds to the view of the breaks in the environment as

[40] Searle, *Making the Social World*, 63.

subjective divisions. Such comprehensive and contextual methods guided the German explorer and naturalist Alexander von Humboldt (1769-1859) to describe the vegetation of the new world in its native geography instead of merely bringing back plant specimens in order to classify their parts. Alexander von Humboldt wrote about the plants, animals, climate, terrain, people, and languages during his explorations of central and South America. His multi-volume work, *Travels to the Equinoctial Regions of America,* is a gem of information for botanists, zoologists, and anthropologists. His observations on the languages of the primitive peoples of these regions were influential, not just on the work of his brother, the famous linguist Wilhelm von Humboldt, but on generations of linguists and anthropologists to come. In *Linguistic Variability and Intellectual Development*, Wilhelm von Humboldt wrote, "Still, in order to pursue the interweaving of the intellect with language more precisely, we must distinguish the grammatical and lexical structure as the fixed and external attribute of language from its innate character which, similar to a soul, resides in language and produces the effect which every language produces peculiarly upon us as soon as we begin to master it."[41] Wilhelm von Humboldt contended that the language a person learned had a profound influence upon the way that person viewed the world. The idea that the words we have to describe our surroundings shaped the way that we perceived those surroundings was one taken up again a century later by linguists and anthropologists, who made a stronger claim for the power of language to determine our view of the world. As part of their process of experimentation, testing the relation of color names to color

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[41] Wilhelm von Humboldt, *Linguistic Variability and Intellectual Development,* trans. George C. Buck and Frithjof A. Raven (Philadelphia, PA: University of Pennsylvania Press, 1971), 127.

perception was a method often employed. The observations of Alexander and Wilhelm von Humboldt carried forth to influence studies in folk taxonomic nomenclature until the present day.

After the death of the von Humboldts, the study of nonliterary and primitive languages languished. Ideas about the evolution of the color sense and the evolution and genealogies of language were largely ignored until William Whitney (1827-1894), Edward Sapir (1884-1939), and Benjamin Whorf (1897-1941) revived interest in the influence of language on perception. These relativists claimed Humboldt as their intellectual sponsor. This new era of interest in the culture and languages took researchers to far-flung regions and into the examination of languages of which there were fewer speakers, such as tribes in New Guinea, Brazil, and North America. Their studies gave rise to a school of thought that claimed that the perceptions of these indigenous peoples were vastly different from those of western Europeans. As Humboldt had noted, the words people have to designate their surroundings, consequently also influence the way that these are perceived.

As had Humboldt, Whitney, an American linguists and philologist, stressed the influence of both environment and language on perception. An individual learns the language of his or her culture, and with the language are also learned the subjective divisions to his or her environs. These subjective divisions can change when an individual gains new words. "In a true and defensible sense, every individual speaks a language different from every other."[42] Because language change occurs in individuals, it happens because of idiolects but is then carried into the wider culture. Whitney wrote, "The

[42] William Dwight Whitney, *The Life and Growth of Language* (New York: D. Appleton and Company, 1989), 154.

effectiveness of the individual is always finite and interrupted. However, at least in appearance and to a certain extent in reality too, the individual in this respect moves in the same direction as does the entire race, since his effectiveness (as a determined and determinative entity) is inseparably associated with past and future time."[43] An individual speaker may learn new words, for instance, through contact with another culture, and bring these back to his or her own culture, where they are adopted. These new words brought by the individual back to his or her culture begin to effect change. With new words come new ways of perceiving. Whitney viewed the connection between word and thing as ever changing and as culturally relative.

Speech Act Theory

In grammatical parlance, a rough equivalency between grammatical mood and division to the environment exists in which the indicative corresponds to real divisions, the subjunctive to relative divisions, and the imperative to created divisions. In speech act theory, especially as articulated by John Searle, the imperative mood is linked to speech whose declarative power can create realty.[44] In particular, I will be examining how speech act theory pertains to taxonomic nomenclature.

Grammatical moods, as they pertain to divisions and ultimately taxonomy, help to illustrate the speaker's attitude toward the subject. The indicative mood is held to designate objective claims. To use an example from biology, we can say that horses are herbivores. That horses are herbivores can be observed in nature and, the formulation of an indicative

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[43] Whitney, *The Life and Growth of Language*, 15.

[44] John R. Searle, *Speech Acts: An Essay in the Philosophy of Language* (Cambridge: Cambridge University Press, 1969).

sentence to that effect, is deemed to be objective because the truth or falsity of such a statement can be determined as a matter of fact. If we view the appraisal of horses through other eyes, eyes that first saw horses as bearing aggressors from Europe in the Americas, their herbivority is not immediately apparent. Native American descriptions first related horses to carnivorous dogs. Although that quickly changed as horse husbandry was embraced by Native Americans, the early statements about horses as carnivorous were based less on observation of dietary habits than on subjective experience. Relativists approach the subjective experience as equally as valid as supposed matters of fact. The systems by which a culture refers to and categorizes elements of the environment say as much about the environment as about the perceivers, and we discover as much from subjunctive as from indicative statements. The attitude of the speaker to the subject, as expressed in grammatical mood, provides insight to the speaker's estimation of what is real and what is felt. Yet many, including Searle, maintain that there is a qualitative difference in epistemological and ontological fact.[45] Accordingly, understanding a system of knowledge is not the same as discerning the ontological existence of things. Taxonomists are concerned with the discernment, naming and organizing of entities that are considered to have ontological existence. I argue, however, that taxonomy is a practice of applying the imperative mood, or as Searle would describe it, declarative speech acts. In naming things, they are given existence.

In the discussion of created divisions, physicist Bernard d'Epagnat and philosopher George Towner described the universe as existing in a smooth, undifferentiated fashion

[45] John R. Searle, *Seeing Things as They Are: A Theory of Perception* (Oxford: Oxford University Press, 2015), 16-17.

without inherent granular structure. Under this model, any breaks, or identifiable chunks we make by naming things, represent an artificially created division. The ontological existence of these named divisions is dependent upon their being designated by the observer. In effect, words beget objects from a formerly undifferentiated continuum. Searle addresses this, when he wrote, "Non-linguistic consciousness is, or at least can be, a continuous flow, broken only by dreamless sleep or other forms of consciousness. But language is essentially segmented."[46] In naming things, and through using language in general, one fits the "segmentation of language" onto the external, and by doing so, divides it according to internal structures of the mind.

I maintain that the segmentation we apply when practicing taxonomy, relates to what Searle describes as declarative speech, and, by extension, to the imperative mood. Searle described declarations as speech acts that change reality to be in accord with the proposition of the declaration. As examples of declarations, Searle cited pronouncements such as those of a judge who pronounces someone guilty, or pronounces couples married spouses. Searle also cited the declarations of a priest or a pastor who pronounces someone baptized. With declarative speech acts, reality is altered by words. Taxonomists are increasingly grappling with is the ontological existence of the things being named. By assigning a place in a taxonomic hierarchy and by designating that place through the assignment of a name, taxonomists are, as speech act theory would have it, creating divisions by declaring their existence and seeking consensus as to the reality of these designations. Yet, according to

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[46] Searle, *Making the Social World,* 68.

evolutionary theory and to the view that all things exist on a continuum, taxonomic rankings are, at best, temporary signs for an artificially divided environment.

Searle wrote, "If I declare, 'This is my house,' then I represent myself as having a right to the house (word-to-world direction of fit) and, if I get others to accept my representation, then I create that right because the right only exists by collective acceptance (world-to-word direction of fit)."[47] Declarations having to do with the existence of taxonomic rank and nomenclature depend upon collective acceptance, as well. Although designations are made, they do not reflect divisions that exist, but instead provide artificial designations that must be agreed upon, or disputed, for the ease of communication and comprehension.

To communicate about and organize the way in which we perceive color, we have developed extensive divisions and systems designated by nomenclature. With this vocabulary, whether systematic color taxonomy or informal color terms, there must be a collective acceptance of the terminology for it to be viable for communication. Such color vocabulary does not describe the wavelength in angstrom units, but instead it describes the subjective visual experience of the viewer. As Searle pointed out, although we point to colors and shapes as having existence,

> The right way to deal with the problem of color and shape is to think of the basic features…there has to be for each of the basic perceptual features of objects, a subjective correlate of that basic visual property…There is nothing in the visual field that is literally red and nothing that is literally round. Redness and roundness are objective features of objects that can be literally seen, but to repeat the point made over and over nothing in the subjective

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[47] Searle, *Making the Social World,* 85-86.

> field is literally seen…The redness of the ball has a psychological correlate in my subjective visual field and so does the roundness.[48]

To have value for communication, speakers of the language must have come to a consensus about the subjective experience of color and name. Searle wrote, "It is a Background presupposition of our use of color vocabulary that there is a commonality to different people's perception of red, green, blue, etc."[49] Just as in common parlance, in the case of color taxonomy, the collective acceptance of nomenclature conveys more about common perception than about the ontological reality of colors.

I maintain that assigning nomenclature in a deliberate manner is a speech act, or an imperative declaration. Our creation of nomenclature and categories to communicate about our perception of, for my purposes here, color and species relies upon observation. Observation is delimited by our subjective experience. To provide a successful means of communicating about subjective experiences, assigning names must involve the naming of the salient, most mutually perceived qualities. By forming a consensus about the delineation and designation of a thing, in this case color and species names, we agree that the majority of humans see and communicate it in this manner. Taxonomists, I argue, do not strictly discern reality, but instead organize the exterior according to the constraints of the interior.

Through the awareness of this interplay between the external and internal, we see how the internal, subjective, recursive, and volitional nature of the human mind interprets the perceptions that work upon it. Thus, in devising nomenclature for taxonomic purposes, it is important to take into account the arbitrary and intentional connection between object

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[48] Searle, *Seeing Things as They Are*, 113-114.

[49] Searle, *Seeing Things as They Are,* 154.

and word. In taxonomy, the assignment of names is a declarative speech act that then requires consensus to maintain meaning. Since taxonomists are deliberate in their assignment of nomenclature, I will consider, in the broadest sense, the source of the vocabulary.

Assigning taxonomic names, especially in formal artificial systems such as in Linnaean binomial nomenclature or in Saccardo's *Chromotaxia seu nomenclator colorum*, is governed by elaborate regulations, but once things in the world are named, the words, as rather poetically described by William Dwight Whitney, formed a history of their own:

> Words were assigned their specific uses (so far as it is possible to trace their history), each at some definite time in the past, and for reasons that were satisfactory to the nomenclators, though they did not make the name either a definition or a description of the conception; and at that the name, once given, formed a new and closer tie with the thing named than with its own etymological ancestor.[50]

The arbitrary connection between words to other words and words to the objects they indicate is fluid, but carries within it a history of its own. The words for color and species, for instance, have etymological histories, but also have histories of how divisions to the environment were perceived. Names contain within them a wealth of information beyond their simple, but always partial ability, to allow people to indicate something to which they want to refer.

In 1895, W. J. McGee wrote an article published in the *American Anthropologist* entitled "Some Principles of Nomenclature." In it, he delineated a difference in types of names as either stemming from a description or as being arbitrary. In McGee's assessment, descriptive methods of nomenclature are called connotive, and arbitrary methods are called

[50] Whitney, *The Life and Growth of Language*, 77.

denotive. For example, the names of geological features can be descriptive, such as Rocky Mountains, or they can be arbitrary (at least for those who do not understand Native American languages) such as the Mississippi. McGee extolled the arbitrary association of name and thing. "The best names for hills, valleys, rivers, and towns are denotive, since these features are not related, and since therefore the independent designation is the most economical."[51] McGee described what has long fueled debates over nomenclature, namely that methods of scientific nomenclature have moved progressively away from the descriptive method and more toward the arbitrary method.

Searle addresses proper names in *Speech Acts* likewise, using the terms connotation and denotation:

> The view that there could be a class of logical proper names, i.e., expressions whose very meaning is the object to which they are used to refer, is false. It isn't that there just do not happen to be any such expressions, for if the utterance of the expressions communicated no descriptive content, then there could be no way of establishing a connection between the expression and the object. What makes *this* expression refer to *that* object? Similarly the view that proper names are "unmeaning marks" that they have 'denotation' but not 'connotation', must be at fundamental level wrong.[52]

Searle wrote that proper names could function as pegs on which to hang descriptions. Searle also conjectured that proper names could serve as descriptions in and of themselves. He wrote, "if the criteria for proper names were in all cases quite rigid and specific, then a proper name would be nothing more than a shorthand for these criteria, it would function

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[51] W. J. McGee, "Some Principles of Nomenclature," *American Anthropologist* 8, no. 3 (July, 1895): 285.

[52] Searle, *Speech Acts,* 93.

exactly like an elaborate definite description."[53] This is the ideal use of proper names for taxonomy. Such criteria serve the function of conveying description within the name itself, and they are more easily remembered and communicated than a series of numbers, which is a proposed alternative to taxonomic names.

Linguist Martin Haspelmath has written extensively about the existence or non-existence of categories in languages. In a similar fashion to McGee's preference for denotive names, some linguists attempted to improve the usefulness of categories for language features and grammatical terms by giving them opaque names. For example, the name "class 34" instead of "dative case" was preferred because of its lack of connotation with Latin and English grammar terms. Haspelmath opposed such opaque or denotive terminology, because, although "Opaque names may be justified by theoretical considerations, they are not practical because they are very hard to remember."[54] Despite the fact that he considered that there are no true categories across languages, Haspelmath, advocated for the use of names for categories instead of opaque or numeric designations. The act of naming something, whether a language category, a color, or a species, has the effect of making it more memorable and, according to speech act theory, even calling it into existence.

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[53] Searle, *Speech Acts*, 172.

[54] Martin Haspelmath, "Pre-established Categories Don't Exist: Consequences for Language Description and Typology," *Linguistic Typology* 11, no. 1 (July 2007):121, doi: 10.1515/LINGTY.

Conclusion

The foregoing chapters on theories of the perception of divisions to the world and the words used for these divisions are directly implicated in my argument that the nomenclature of taxonomy should continue as a scientific system of categorizing and organizing. The most advanced means we have of denoting reality is through language, and the goal of good taxonomic nomenclature should be both to specify the world, and to reveal the structures, such as segmentation, categorization, and recursion, that our brains impose on our perception of the world. Language is capable of indicating and communicating real divisions of our environment and, more importantly, language communicates subjective and created divisions our brains unavoidably stamp onto the organizations we devise. I maintain that it is because of this duality, the combining of word to world, and world to word directions, that language should remain the basis for taxonomic science. Through the discernment of language's interplay between the external and internal, more about the nature of outward and inward reality becomes accessible, thus making language the most viable tool for and organizational system such as taxonomy. I will argue through the cases of color and species nomenclature, the importance, despite its limitations, of maintaining a name-based approach to taxonomic science.

CHAPTER 4

COLOR DIVIDED

To further build upon the structure of the forgoing chapters in which I addressed theories of division and theories of naming, the following case studies of color and species will likewise be addressed in terms of division and naming. In this chapter, I am concerned with studies of color perception. Although color perception is almost inextricably linked to color names, I address taxonomic color nomenclatures as an independent topic. I will follow this same arrangement when addressing the division and nomenclature of species.

Here I will show how the created divisions, imprinted by human consciousness on our perceptions of color, have been studied by explorers, philosophers, anthropologists, psychologists, historians of science, linguists, and artists to understand the connection between reality, perception, and words. Studies of the color perception of the ancients and primitives have engendered scientific experiments on color perception. The studies and experiments reveal widely diverging color categories, which reflect the real, subjective, and created divisions I previously delineated. By showing here the differing ways that color is perceived and divided, I build toward my case that the nomenclature for color is not only a taxonomic treasure, but also a rich source of cultural information that is not replaceable through the numeric identification of color.

Division of Color in Ancient Cultures

The Roman naturalist and philosopher Pliny the Elder (23-79 AD), wrote in his invaluable *Natural History* a tract on the history of art. Pliny's chapters on ancient art are virtually the only classical source on this subject in existence. He included documentation on the use of pigmentation in Greek painting and architecture. Pliny portrayed how painters in the fifth and fourth centuries BC, such as Timanthes Polygnotes, and Zeuxis, and their successors, used only four colors: *milinum, atramentum, sil atticum,* and *Sinopis Pontica*, or white, black, yellow, and red. Pliny called this limited use of color by the early Greek painter *colores austeri*, or the austere use of color.[1]

Pliny's commentary on color was taken up again much later by the Prussian classicist Friedrich Wilhelm Doering (1757-1837). Doering drew attention to scarcity and vagueness of color terms used by the ancient Greeks. Doering attributed the lack of sophisticated color vocabulary to a voluntary stoicism "austera rudium illorum hominum simplicitas," or "those simple men who use somber pigments."[2] Although Doering's conclusion that the Greeks purposely limited their color vocabulary out of altruistic impulses did not gain ground, the subject of the scantiness of color terms among the ancient Greeks did. For a little more than a century, a cottage industry slowly arose in the study of color vocabulary in ancient writings. Alongside the study of color terms of the ancients, conjecture also grew about their ability to perceive colors.

In 1858 the British statesman William Gladstone published a monumental work, *Studies on Homer and the Homeric Age.* This work included an analysis of words used to denote color and brilliance in the *Iliad* and *The Odyssey*. Homer's use of expressions indicating color led Gladstone to say that the ancient Greeks were deficient in color

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[1] Pliny, *Historia naturalis*, 9 vols., trans. H. Rackham, (London: Loeb Classical Library, 1938-1952), 35.30, 44 and 50.

[2] Fredrich Wilhelm Doering, *Coloribus Veterum Prolusio Oratiunculis* (Gothae: Reyher, 1788), 88. My translation.

perception. Twenty years later, well after evolutionary theory had become familiar, Gladstone revisited the subject of color perception of the ancient Greeks. In 1877 in *The Nineteenth Century: A Monthly Review*, a lengthy article entitled "The Colour-Sense" appeared. Gladstone's propositions in this article are, first, "That Homer's perceptions of the prismatic colours, or colours of the rainbow (which depend on the decomposition of light by refraction), and *a fortiori* of their compounds, were, as a general rule, vague and indeterminate," and second, "That we must therefore seek another basis for his system of colour."[3] After carefully examining other scholarly works, he concluded that our color sense has evolved gradually from a primitive state among the ancients to the contemporary more highly developed sense of color:

> Within the last few years, this subject has been freely discussed both in Germany among philologists and physiologists, and likewise among oriental scholars. I understand the general tendency of the discussions to be in favour of the doctrine that colour was little known to the ancients, and that the sense of it has been gradually developed, until it has become a familiar and unquestioned part of our inheritance.[4]

Not surprisingly, given the time in which Gladstone lived, he decided that the more highly developed sense of color that is part of our inheritance, developed due to the forces proposed by Darwin. Gladstone lamented that Homer did not have the benefit of more highly developed organs of sight, yet, he extolled Homer's prose as still immeasurable beyond anything contemporary:

> If without the aids of lengthened history, of wide survey of the earth and man, of long hereditary development of the organs, he has achieved his present results, what would he have accomplished had he been possessed of

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[3] William E. Gladstone, "The Colour-Sense," *The Nineteenth Century* 2 (Oct. 1877): 366.

[4] Gladstone, "The Colour-Sense," 367.

> the vast and varied apparatus of all kinds which we enjoy. And what have natural selection, and the survival of the fittest, with their free play through three thousand years, done for us, who at an immeasurable distance are limping after him, amidst the laughter, I sometimes fear, of the immortal gods?[5]

Gladstone is a classicist at heart. He revered the writings of the ancient Greeks, as did many of his generation. His work as a philologist is invaluable, but most scholars today would say that he was too much influenced by contemporary theory when he proposed that human color vision evolved within three millennia. Gladstone also developed a similar theory of the ancient Greek sense of smell. He argued that there are very few words for smell used by Homer, and those that are, are mainly unpleasant. Gladstone was not alone in his enthusiasm for applying evolutionary theory liberally.

Lazurus Geiger (1829-1870), Hugo Magnus (1842-1907), and Oskar Weise (1851-1933), are perhaps the most significant among the many who also wrote about color perception in the ancients. Although their conclusions vary, they all agreed that the dearth of color vocabulary in many ancient cultures required some investigation. Their investigations into color perception and color vocabulary directly inform twentieth-century anthropological, psychological, and neurological research. It is therefore worthwhile to discuss each of their investigations and conclusions in more detail.

German Jewish philosopher and philologist Lazarus Geiger, inspired by the work of Gladstone, as well as by the color studies of German writer and scientist Johann Wolfgang von Goethe (1749-1832), continued the study of color terminology in ancient writings with his analysis of the *Rigveda* and *Zend Avesta*. Geiger discovered that these writings likewise suffered a lack of color words and concluded that the people of ancient India perceived a

[5] Gladstone, "The Colour-Sense," 372.

narrower range of the spectrum. His foremost example is that the people of ancient India, and in several other ancient cultures, had no color term for blue. He concluded that they could not perceive blue. In his work *Zur Entwickelungsgeschichte der Menschheit,* or *On the Evolutionary History of Humanity,* of which the third chapter is dedicated to the examination of the color sense of the ancients and to its development, Geiger drew a parallel between the reconstruction that can be gained through the piecing together of skull fragments and tools and the reconstruction that can be attained through the reassembly and comparison of ancient languages. Geiger pled for paleophysiologists to work together with philologists in order to draw a more complete evolutionary picture. [6]

Hugo Magnus, a German classicist and ophthalmologist, was one of the most ardent voices regarding the subject of color terms and color perception among the ancient Greeks. In his work *Die geschichtliche Entwickelung des Farbensinnes*, or *The History of the Evolution of the Color Sense,* Magnus, as did Gladstone, reviewed all of the color terms he could find in the writings of the ancient Greeks. He organized the terms from brightest to softest. As did his predecessors, Magnus initially concluded that there was a lack of such terms in ancient Greek. To explain this, Magnus proposed that their retinas must not have been fully developed. He extrapolated that, before that epoch, there must have existed a preceding one in which humans were without any trace of color sense and that their retinas could only distinguish between light and dark:

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[6] Lazurus Geiger, *Zur Entwickelungsgeschichte der Menschheit* (Stuttgart: I.G. Cotta, 1878), 45-60. In *Die Darwinische Theorie und die Sprachwissenschaft* (1863), the Indo-Europeanist August Schleicher likewise proposed that evolution works also upon the "language organism" as it does on species, and that philologists should work with physiologists to reconstruct physical and language evolution.

> We are forced to the supposition that before that epoch there may have been a prior, in which even these most primitive traces of color sense were missing, wherein the capacity of the human retina to see colors was completely absent and its function consisted in distinguishing shades of light and dark.[7]

He lamented that there are no literary records from much earlier human times to give support to his hypothesis, but cited the pre-Socratic philosopher Anaxagoras (c. 500 BC-428 BC) as having contended that in beginning times no color vision existed at all.[8] Magnus was careful, in one of his lengthy and sometimes genially quarrelsome footnotes, to distinguish his own opinion from that of Anaxagoras. Whereas it seemed that for Anaxagoras, color came into existence, for Magnus, color had always existed, but our perception of it had evolved:

> Let us speak here of a time of colorlessness: we must take this expression only in the subjective, not in the objective sense. Colors in the objective sense have existed in all periods, whether historic or prehistoric; the blue of the sky, the green of the plants, the vivid shimmering glory of the flowers, occurred in the oldest and youngest of our time reckonings. The bits of ether obeyed the exceedingly fast oscillations of a violet beam and moved in the statelier and calm wave tempo of the red beam back then as they do today. The human retina was not always able to react to the differences in the oscillation lengths and translate them into specific sensations. So we can only speak of a time with no color in the sense that the retina could perceive and take hold of only the oscillation amplitude but not the oscillation length.[9]

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[7] Hugo Magnus, *Die geschichtliche Entwickelung des Farbensinnes* (Leipzig: Von Veit, 1877), 43. Wir werden eigentlich schon von selbst zu der Vermuthung gedrängt, dass vor jener Epoche möglicherweise bereits eine andere vorangegangene sein könne, in welcher auch diese primitivsten Spuren des Farbensinnes gefehlt habe, wo also die Fähigkeit, Farben zu sehen, der menschlichen Netzhaut noch vollständig mangelte und deren Thätigkeit nur darauf beschränkt war, die verschiedene Grade von Hell und Dunkel zu unterscheiden. My translation into English.

[8] Hugo Magnus, *Die geschichtliche Entwickelung des Farbensinnes*, 46.

[9] Hugo Magnus, *Zur geschichtliche Entwickelung des Farbensinnes*, 44-45. Sprechen wir hier von einer Zeit der Farblosigkeit: so verstehen wir diesen Ausdruck natürlich nur in dem subjectivem, nicht aber in objectivem Sinne. Farben im objectiven Sinne hat es zu allen Perioden der historischen und prähistorischen Zeit gegeben; die Bläue des Himmels, das

As an ophthalmologist, Magnus was concerned also with the mechanics of evolutionary forces upon the retina. He maintained that it was the strongest of the light waves, with their constant beating against the retina, which caused the peripheries of the retina to eventually become as sensitive to light and color perception as the center portion. Much like German biologist Ernst Haeckel's (1834-1919) theory, that ontogeny recapitulates phylogeny, Magnus formulated the idea that individual development was mirrored in the development of the culture. Just as a child comes to see colors in a specific order, first distinguishing only between light and dark, later deciphering red, then yellow, then green and blue as one color, and finally the discernment of blue from green, a culture moves through the same phases of color discernment. Cultures in early stages of development, said Magnus, can first only perceive differences in light and dark and, as the retina slowly evolves, come to distinguish other colors in the same order that infants come to discern them.[10]

Primordial stage:	Dark and light distinguished with no color awareness.
First stage:	Differentiation of red, but no discernment between color and light.
Second stage:	Differentiation of red and yellow; discernment of orange. Emergence of the ability to distinguish color from light.

Grün der Pflanzen, die buntschillernde Pracht der Blumen, sie waren ebenso Vorkommnisse der ältesten wie jüngsten Perioden unserere Zeitrechnung. Die Aethertheilchen folgten früher ganz ebenso wie noch heute den überaus schnellen Schwingungen des violetten Lichtstrahles und sie bewegten sich in dem gemächlichern und ruhigeren Wellentempo des rothen Lichtes genau auf die gleiche Weise, wie sie dies auch noch heute thun. Nur war die menschliche Netzhaut nicht zu allen Zeiten auch in der selben Weise befähigt, auf diese Unterschiede in der Schwingungsdauer zu reagieren und sie in specifische Empfindungen umzusetzen. So dass wir eben nur in diesem Sinne da von einer Zeit der Farblosigkeit reden können, wo die Retina an den sie erschütternden Aetherwellen zwar die Grösse der Oscillationscomplitude, aber noch nicht die Oscillationsdauer als gesonderten Empfindungsvorgang aufzufassen und festzuhalten vermochte. My translation into English.

[10] Interestingly, as we will soon discuss, a century later, this theory was to be revived in the seminal work *Basic Color Term by* Brent Berlin and Paul Kay.

Third stage: Discernment of green and related colors.
No differentiation of blue from green.
Fourth stage: Differentiation of blue.[11]

Although it is perennially tempting to do so, Magnus did not believe that humanity had attained its pinnacle during his own lifetime. He humbly put forward that future generations may have an even greater range of color vision. Two things led Magnus to such an extrapolation. He believed that color vision had evolved from the time of the ancient Greeks to his day and, secondly, because his contemporaries often divided the blue and violet range quite differently, he believed that sight in this color range was undergoing evolution at that time. Some, usually men, were not able to see what for others, especially women, was clearly violet. Magnus proposed that this difference was due to the fact that perception in the peripheral range was in a state of development. He anticipated that his descendants would be able to see past the violet into the ultraviolet spectrum.[12]

German classicist and philologist Oskar Weise in his article “Die Farbenbezeichnungen bei den Griechen und Römern,” or “Color Terms of the Greeks and Romans,” limited his research to one of a more philological nature. He commented little on the reason for the lack of color terms in the ancients, having apparently adopted the

[11] Summarized and translated from Hugo Magnus, *Die geschichtliche Entwickelung des Farbensinnes,* 41-42.

[12] In recent studies of color blindness it was indeed found that there is also something like color giftedness. Whereas limited color vision generally affects more males than females, increased color perception usually affects more females then males. Color gifted people, or tetrachromats, are able to see parts of the spectrum that are invisible to normally sighted people. Studies can be found in this article: https://theneurosphere.com/2015/12/17/the-mystery-of-tetrachromacy-if-12-of-women-have-four-cone-types-in-their-eyes-why-do-so-few-of-them-actually-see-more-colours/, and on this radio broadcast http://www.radiolab.org/story/211213-sky-isnt-blue/.

prevailing opinion that the color perception of the ancients was not yet highly developed. Weise traced the increase in color terminology from one culture to another and attempted to construct a rational theory for the increase in color terminology that occurred over the course of several centuries of ancient Greek and Roman history. He tracked the use of compound names in Greek and Latin, such as yellowish-red, reddish-blue, and so forth, to a time when such compound color names developed into simple terms such as orange and purple. Weise cited instances of color terms being borrowed from culture to culture. He also attributed the expansion of color terms to the desire of naturalists to more accurately describe their surroundings, thus employing more varied and specific color terms for plants, animals, and minerals. All of these influences led to an expansion of color vocabulary, which occurred, much as Geiger, Magnus and Gladstone had depicted, in a predictable order. About the simultaneous expansion of color perception with color terms, he stated, "So over time a rich abundance of expressions were made in order to be able to describe all the nuances that by and by one also had the desire to verbally distinguish."[13] Although Weise implied that this increase in color vocabulary was being driven by a concurrent increase in color perception, he did not say so distinctly. This left the door open for future theories, which contended that color perception and color naming go hand in hand.[14]

[13] Oskar Weise, "Die Farbenbezeichnung bei den Griechen und Römern," *Philologos* 46 (1888): 603. "So hat sich die sprache [sic] im laufe der zeit eine reiche fülle von den ausdrücken geschaffen, um alle die verschiedenen nuancierungen bezeichnen su können, die man allmählich auch sprachlich zu unterscheiden das bedürfnis fühlte." Weise does not capitalize all nouns as was and is conventional in German. My translation into English.

[14] Theories of color and linguistic relativity, such as those initiated by the brothers Humboldt and later taken up by Franz Boas, William Whitney, V. F. Ray, Edward Sapir and Benjamin Whorf, contend that by "coding" an object, one is then able to perceive it in a way that one was not able to before.

Gladstone, Geiger, and Magnus naturally had their detractors. Scholars disagreed with them on several fronts. One line of disagreement stemmed from the notion that culture developed at a rate independent of physiological development. In a response to Gladstone's "The Colour-Sense," Scottish orientalist William Robertson Smith (1846-1894) objected that

> Mr. Gladstone has always shown that the language of Homer is an inadequate vehicle for conveying precise and nicely distinguished ideas of colour. Whether the nation that was content to describe colours so imperfectly was also incapable of subtle perception of tones of colour is clearly another question. Language does not keep pace with perception unless a practical or aesthetic necessity arises for expressing what is perceived in words to other people.[15]

Smith believed that the Greeks were aware of the insufficiency of their color vocabulary, and that an approximate use of color terms in writing was simply accepted. It was not until more sophisticated color technology came into being, such as in the painters' arts, that color vocabulary increased. Smith and German biologist Ernst Krause (1839-1903) agreed on this point. In his article "Die Geschichtliche Entwickelung des Farbensinnes," or "The Historical Evolution of the Color Sense," Krause dismantled the idea, particularly as it was presented by Hugo Magnus, that the human color sense should have perceptibly evolved in only three thousand years. Krause found two main points of disagreement. He explained that the retina does not develop in the manner in which Magnus described. He objected that it was not the shattering of light waves against the retina that causes the development of a sense of color. If this were the case, then, according to Darwinian natural selection, the retina would have had no survival incentive to have developed only in the last three

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[15] William Robertson Smith, "The Colour-Sense of the Greeks," *Nature* (Dec. 6, 1877): 100.

thousand years. Instead, Krause claimed it more likely that human color perception would have been as it is today from very near our beginnings. “Color sense is a general and original, or shall we say, a very early development of the organ of sight.”[16] A third objection Krause found is the fact that in ancient cultures, lapis lazuli was prized not only as a stone but also in the pigments that could be produced from it. Why would this brilliant blue stone be cherished if the ancients could not perceive its color?

Almost all who wrote about the color terms of the ancients conceded that there is a somewhat odd use of color expressions in ancient writings. Comparing color terms in ancient writings had become a favored topic among, especially German, philologists. The Canadian-born science writer Grant Allen (1848-1899) entered the debate. While Allen found no fault with the work of comparative philology accomplished by Gladstone, Geiger, and Magnus, he was at odds with some of their conclusions. In a review of Allen’s work, Carole Patricia Biggam wrote in 2012 that Allen rightly concluded that, “human colour perception is the result of neuro-physiological development, but color *terms* are coined only as each culture has need of them. There is no indissoluble link between perception and language.”[17] Also objectionable was their hypotheses about the time required for such

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[16] Ernst Krause, “Die Geschichtliche Entwickelung des Farbensinnes,” *Kosmos* I (1877): 270. “Die Farbenempfindung eine allgemeine und urspüngliche, oder sagen wir, eine sehr frühentwickelte Fähigkeit des Gesichtsorgan ist.” My translation into English. Strangely, after his thoughtful and well-researched refutation of Magnus, Krause then veered off into his own dubious color theory. Songbirds, he claimed, are always dressed in grey and muted colors, and it is monkeys and people who first appeared in bright colors. But now, Krause maintained, modern people (but not primitive people) dress in muted colors like the songbird.

[17] C. P. Biggam. *The Semantics of Colour* (Cambridge: Cambridge University Press, 2012), 14.

physiological changes to evolve. Allen wrote that evolutionary change happens over a much longer span of time. He objected that for Magnus there was an "utter inadequacy of the time assigned for the origin of such strong and fundamentally differentiated sensations as those of colour." Allen continued,

> Had Dr. Magnus said three million, or even thirty million years, the evolutionist could have hesitated on the score of insufficient elbow-room; but when our author suggests three thousand years for the growth of a radically separate set of sentient organs, our incredulity becomes absolute and irrevocable.[18]

After so much written debate, Hugo Magnus finally conceded and moved to the side of Smith, Krause, and Allen. Slowly the hypothesis that color perception had evolved within the last three thousand years lost ground. Perhaps there had been an overzealous application of new evolutionary theory. Nevertheless, two main lines of thought from the discussions pertaining to color words of the ancients continued to have influence on future color studies. First, it was thought that one could test the theory that the ancients had a limited color sense by examining the color perception abilities of people in primitive cultures. Second, the order of acquisition of the perception of colors in children and in developing cultures continued to be investigated.

Division of Color in Primitive Cultures

As voyages of discovery brought to European culture a rush of new data, not only did the eagerness to sort and organize overtake many, but also the desire to go out on one's own voyage. Adventurous European gentlemen increasingly set sail with expeditions in order to collect information on plants, animals, people, and languages. As had Alexander

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[18] Grant Allen, *The Colour-Sense; Its Origin and Development. An Essay in Comparative Psychology* (London: Trübner & Co., 1879), 204.

von Humboldt in the early nineteenth century, so many a scholar and naturalist set to sail in subsequent decades. Cambridge University sponsored just such an expedition in intervals from 1885 to 1889. The collected results appear in a six-volume work, *Reports of the Cambridge Anthropological Expedition to the Torres Straits*. The second volume contains the results of the research on vision conducted by English anthropologist and neurologist William Halse Rivers (1864-1922). In January 1900, Rivers delivered a lecture at the Royal Institute entitled "Primitive Color Vision."

Rivers introduced his color research within the context of the debated Humboldtian notion that a culture's thoughts were directly reflected in their language:

> The importance of language as an instrument of anthropological enquiry has been the subject of much difference of opinion. On the one hand, there are those who believe that the relation of language and thought is so close that the former has always been an almost exact mirror of the latter, and that every increase in intellectual development has been accompanied by, if not conditioned by, a corresponding increase in the development of language. On the other hand, the tendency which perhaps now prevails among anthropologists is to attach too little importance to language as an indication of the mental development of a race. The subject of the color sense of primitive races is one which is especially useful in studying how far the capacity for appreciating differences goes with the power of expressing those differences in language.[19]

Rivers gave credit to Gladstone, Geiger, Magnus, Allen, and the others who had already combed the literature of ancient primitive races in order to determine the level of evolution, whether physiologically or philologically, that had been reached. Rivers had assumed the prevailing view, that color vocabulary reflected the level of evolution of the organ of sight, but his expedition to the Torres Straits changed his opinion. He examined two tribes of Papuans inhabiting the eastern and western islands of the Torres Straits, and natives of the

[19] William Halse Rivers, "Primitive Color Vision," *Popular Science Monthly* 59 (1901): 44.

Island of Kiwai, and several Australian tribes. Rivers concluded, "The languages of these people showed different stages in the evolution of color terminology, which correspond in a striking manner with the course of evolution deduced by Geiger from the ancient writings," and further, that, "the characteristic defect in color language has been found to be associated with a corresponding defect in color sense."[20] The studies conducted by Rivers revived the notion, which was by then waning and rejected even by one of its former proponents, Hugo Magnus, that the ability to perceive colors seemed to be evolving at the pace of language, and that furthermore, "the order in which these four tribes are thus placed, on the ground of the development of color language, corresponds with the order in which they would be placed on the ground of their general intellectual and cultural development."[21] Rivers made a direct link between the expressive powers of a culture's language and the state of evolutionary development of their senses. Whereas Gladstone and Magnus turned to the principles articulated by Darwin of natural selection and survival of the fittest to explain the evolution of the senses, and in particular, the color sense, Rivers did not turn to these principles for an explanation. Rivers intended to revisit the debate over the evolution of the color sense, and, as evidence, he relied upon the influence of phylogeny, art, and instruction. "It is now more or less an accepted principle in biology that the history of the individual presents the same stages of development as have occurred in the history of the race."[22] Rivers conjectured that primitive races are at a child-like stage of perception, but that their

[20] Rivers, "Primitive Color Vision," 46, 53.

[21] Rivers, "Primitive Color Vision," 47.

[22] Rivers, "Primitive Color Vision," 55.

color sense is developing through art and instruction. "Another factor, which may have been of importance, is the absence in the savage of an aesthetic interest in nature." Rivers thought that to the "savage," perhaps as to the child, every natural object had an individual name, but not the level of abstraction that preceded an aesthetic sense. "If the savage has a special name for every coloured object, he will not require names for the abstract idea of colour. It is possible that it is only when he begins to use pigments that he begins to require names for colours,"[23] and "that the distribution of pigments has helped to determine the characteristic features of primitive color nomenclature."[24] Knowledge of pigment-making perhaps brought with it the concept of color in the abstract, not as attached to a natural object. Rivers cited cases of cross-cultural transfer for new color words:

> By many races a word for blue has been borrowed from some other language, as with the case in Murray Island; thus many African races are said to use the term "bru," obviously a corruption of the English word; in South America the Spanish word 'azul' has been borrowed, and the Battas of Sumatra have borrowed words both from Dutch and Malay. The use by the Ga people of the Gold Coast for blue and for indigo is said to mean literally 'something that must be learnt,' these people having been taught the use of indigo either by Europeans or by other Africans.[25]

If, as Rivers implied, the acquisition of new color terms, whether through the art of fabricating pigments, or by the introduction of a term from another culture, caused a corresponding increase of "general intellectual and cultural development," leads into very interesting territory indeed. No longer is intellectual and cultural development dependent on

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[23] Rivers, "Vision," in *Reports of the Cambridge Anthropological Expedition to the Torres Straits* edited by Alfred C. Haddon et al. (Cambridge: University of Cambridge Press, 1901), 96.

[24] Rivers, "Primitive Color Vision," 47.

[25] Rivers, "Primitive Color Vision," 48.

the evolution of the organs of sense through the processes of natural selection and survival of the fittest, but language itself becomes a contributing factor in the evolutionary process. Although Rivers himself did not formulate it in quite these terms, future research into cognition and language would.

Division of Color in Renewed Color Studies

A narrow band of the continuous spectrum of electromagnetic energy, from 400 to 700 nanometers, is visible to most people. This band of the visible spectrum fascinates us from many perspectives. The division of colors as examined in the works of Doering, Gladstone, Magnus, Geiger, and Rivers, among others, has been taken up again in renewed color studies conducted by linguists, psychologists, and anthropologists. Many renewed color studies ask the same questions as the previous, but the questions are approached with different investigative tools. Just like previous studies, current studies investigate the occurrence of color perception in different cultures, and how it correlates to the number of named categories for color, anomalies in color perception, and the order in which colors are divided and perceived by individuals and societies. Just as in the nineteenth century, investigations into color division and perception, contemporary investigations still tend to fall into three camps: those who find color division real, those who find it subjectively perceived, and those who view color divisions as created. Just as previous research by Doering, Gladstone, Magnus, Geiger, and Rivers and others was influenced by the spirit of the times, and sometimes dismissed on that account, later and current research on the subject of color perception is no less impartial. The use of carefully considered experiments, brain scans, and interdisciplinary studies of color add to the body of knowledge, but still provide no definitive answers, as will always be the case with matters of perception and language.

The fascination in the nineteenth century with ideas about earlier people's color perception as gleaned from terms in ancient Greek and Latin has been taken up again by Ronald W. Casson through terms gleaned from medieval English.[26] In "Color Shift: Evolution of English Color Terms from Brightness to Hue," Casson likewise uses color terms to trace changing referents. Of the term for "white," for example, Casson states, "the majority of occurrences of *hwit* in Old English suggest luminosity or reflectivity – the shining of light, of a roof, a helmit, a gem, or silver," and only secondarily suggest hue, such as milk, snow, or foam. Middle English used *hwit* less for brightness and more for hue, such as for referents as alabaster marble, ivory, and paper.[27] Surprisingly, given the greenness of the isle, *grene,* steming from the Germanic verb "to grow" was applied not mainly to the hue of grass and trees, but was a significant brightness term to refer to shining water or the head of a phoenix.

Casson documented shifts from brightness referents to hue referents for primary and secondary color terms, giving many examples from Old and Middle English. Casson, unlike his predecessors investigating the color perception of earlier people, concluded that the change in color terms is not due to evolutionary changes in the organ of sight, but due to increases in societal complexity. He determined,

> Small-scale societies with minimal social and technical complexity generally have only two, three, or four basic color categories... Human color vision has been the same since the origins of *Homo sapiens,* and our environment has always been rich in colorful entities. Culture members, responding to

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[26] Ronald W. Casson, "Color Shift: Evolution of English Color Terms from Brightness to Hue," in *Color Categories in Thought and Language*, ed. Clyde L. Hardin and Luisa Maffi (Cambridge: Cambridge University Press, 1997), 224-239.

[27] Casson, "Color Shift," 227.

> increases in societal complexity and diversity, restructure their systems of color categorization by differentiating new concepts and innovating new vocabulary.[28]

Among other things, Casson credits the influx of colorants and textiles for the shift in color division in Old English from designating primarily brightness, to designating primarily hue in Middle English. Carole Patricia Biggam in "Political Upheaval and a Disturbance in the Colour Vocabulary of Early English," adds to Casson's argument that increasing societal complexity, not physical and cognitive development, account for increases in color divisions and the corresponding terms.

The Old English term for blue is *haewen,* which had a connotation of luminosity more than hue. After the Norman Conquest, the word *bleu* and its variants began to appear in Early Middle English, but still referred to the lightness or luminosity of the referent. Blonde beards, clean robes, and fair goddesses were described as blue. It was not until the proliferation of stones and paints from afar that *bleu* began to refer more to hue than brightness. Biggam wrote about the paints of galley ships in 1295, "especially one translated as "foreign blue" which cost six shillings per pound (weight). The cheapest colours were red and white lead, the red costing just three (old) pence per pound."[29] The shift in complexity of color division was due to the introduction of foreign words and products into English.

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[28] Casson, "Color Shift," 237.

[29] Carole Patricia Biggam, "Political Upheaval and a Disturbance in the Colour Vocabulary of Early English," in *Progress in Color Studies Volume I,* ed. Carole Patricia Biggam and Christian Janet Kay (Amsterdam: John Benjamins Publishing Company, 2006), 164.

The study of color perception in earlier people relies, of course, on the writings that remain from them, and, if we are fortunate, objects to which they referred. It is possible that we see remnants of the costly blue paint of the war galleys, and know that *bleu* at that time and place referred to that hue, faded or begrimed as it may be. Historian John Gage (1938-2012) in *Colour and Culture: Practice and Meaning from Antiquity to Abstraction,* traced the simple and subjective division of color terminology in Europe to the standardization zeal that engendered the chromotaxonomies of the nineteenth century. Gage, in his comprehensive book, which took thirty years to complete, gave hundreds of examples of idiosyncratic color-name etymologies, traced the influence of trade and industry on color terms, and the homogenizing influence of ease of transportation and cross-cultural contact.

Like Gladstone and other nineteenth-century scholars who wrote on the topic of color, Gage searched for nuance and idiosyncrasies rather than trying to develop rules to apply to color division and perception. In her 2006 work "The Normativity of Colour," Barbara Saunders likewise made a nuanced critique of the authors whose work it is to quantify color perception into neat and predictable divisions. Saunders wrote that over two millennia of European culture, "People understood and wrote about colour so differently, and came so slowly to current concepts, which it is scarcely credible that they were all the time 'seeing colour' in the same way that contemporary people do. Until the end of the nineteenth century there was no standardization of 'colour' even in Europe."[30] Casson, Gage, and Saunders entertain the idea that people, relative to the time and place of their

[30] Barbara Saunders, "The Normativity of Colour," in *Progress in Color Studies Volume I,* ed. Carole Patricia Biggam and Christian Janet Kay (Amsterdam: John Benjamins Publishing Company, 2006), 94.

circumstances, actually did perceive and divide color differently, that color divisions were subjective.

The influence of Gladstone on studies of color in early texts continued with the works of Casson, Gage, Saunders, and others. The study of color perception in primitive cultures continued as well. As had Rivers a half a century earlier, Roger Brown (1925-1997) and Eric Lenneberg (1921-1975) conducted their own experiments with a team of assistants and compared their findings with those of the preceding century. Brown and Lenneberg found in experiments with color recognition among Zuni, that color memory and perception was better when there were words for color distinctions.[31] Lenneberg and Brown found that there were basic color terms in the languages and cultures they studied, and that, if colors fell outside of the basic color terms – if, in other words – the colors were not coded, their subjects had more difficulty recognizing color differences. Although Lenneberg and Brown believed that the colors were real, whether or not they were named, the division and perception of colors depended upon the subjective aspect of the viewer relative to his or her culture. In this regard, Lenneberg and Brown supported the Whorfian hypothesis that language forms our perceptions. The division to the continuous spectrum was, for Lenneberg and Brown, relative to cultural circumstances.

That words describe an orderly world of discrete objects was challenged by the idea that the link between word and object was arbitrary and ever shifting. Increasingly, scholars began to wonder about the connection between objects, perception, and language. In many cultures, colors are among the first subjects of instruction to children, which tells us that

[31] Roger Brown and Eric Lenneberg. "A Study in Language Cognition." *Journal of Abnormal Psychology* 49 (1954): 454-462.

they are presumably some of the most easily distinguished elements of our environment. Parents do not generally begin by teaching the nuances of texture, or pitch, for instance. While it is normal to teach children colors, such as "pink," "orange," "red," and point to objects in order to indicate these divisions of the spectrum, it is not as usual for parents to begin by instructing children to perceive and quantify textures, such as "pliable," "brittle," "gritty," nor pitches, such as "sharp," and "flat," by pointing these things out in our surroundings. The discrepancy in the earliness of instruction of these sensory perceptions lies either in the fact that colors are easily perceived, divided, and classified, or it lies in just such early conditioning to our perception, division, and classification of color. Precisely because of the apparent obviousness of color categories, color has been a natural topic upon which to base perceptual studies. Studies in color perception and division have attracted the comment and study by explorers, anthropologists, naturalists, philologists, and linguists. Examples supporting the subjective division of the spectrum and the relation of these divisions to the words people have for color were taken up by cognitive psychologist Jules Davidoff in "The neuropsychology of color."[32] He addressed the relationship between the ability to categorize color and the color-naming ability. Davidoff cited the tight link between the possession of a color word and the ability to recognize and sort colors that has been demonstrated in both children and adults.[33] At the Neuro-Aesthetics conference organized at Goldsmiths University, London UK, in May 2005, Davidoff gave another example of a

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[32] Jules B. Davidoff, "The Neuropsychology of Color," in *Color Categories in Thought and Language*, ed. Clyde L. Hardin and Luisa Maffi (Cambridge: Cambridge University Press, 1997), 118-134.

[33] Jules Davidoff, "The Neuropsychology of Color," 129.

color-sorting task that was influenced by the addition of new color words and placed his findings within the theory of relativism:

> Someone asked yesterday whether the Sapir-Whorf Hypothesis had any currency. Well, if it has a little bit of currency, it has it certainly here, in that what is happening, because the names of colors mean different things in the different cultures, because blue and black are the same in the Himba language, the actual similarity does seem to have been altered in the pictorial register. So, the blues that we call blue, and the claim is that there is no natural category called blue, they were just sensations we want to group together, those natural categories don't exist. But because we have constructed these categories, blues look more similar to us in the pictorial register, whereas to these people in Northwest Namibia, the blues and the blacks look more similar. So, in brief, I'd like to further add more evidence or more claim that we are constructing the world of colors and in some way at least our memory structures do alter, to a modest extent at least, what we're seeing.[34]

Davidoff, much as had Lenneberg and Brown, found that having a category for color makes the viewer more likely to notice the color. Davidoff is careful to say that the viewer becomes aware of the color, rather than that the viewer gains the ability to perceive the color. To that degree, at least, the awareness of color divisions is shown by Davidoff to be subjective and relative to one's environment and language.

The notion that color divisions are subjective had fallen into disfavor after the important work articulated in detail by anthropologist Brent Berlin (1936-) and linguist Paul Kay (1934-). Berlin and Kay wrote their influential book, *Basic Color Terms* in 1969. Berlin and Kay argued that color perception is not subjective but instead that real and universal divisions of color perception existed and that words for these divisions come in a

[34] Recording of Jules Davidoff speaking at the Neuro-Aesthetics conference organized at Goldsmiths University, London UK, in May 2005. http://www.artbrain.org/colour-categories-as-cultural-constructs/.

predictable order. They postulated the following set of rules for the emergence of color terms for all cultures:

(1) All languages contain terms for black and white.
(2) If a language contains three terms, then it contains a term for red.
(3) If a language contains four terms, then it contains a term for either green or yellow (but not both).
(4) If a language contains five terms, then it contains terms for both green and yellow.
(5) If a language contains six terms, then it contains a term for blue.
(6) If a language contains seven terms, then it contains a term for brown.
(7) If a language contains eight terms or more, then it contains a term for purple, pink, orange, grey, or some combination of these.[35]

Berlin and Kay followed in the footsteps of Magnus, who proposed a similar sequence of emergence for perceptions of color divisions in children and in cultures.[36] Berlin and Kay's work has been revised by themselves and others with whom they have further researched color perception and color terms, yet their sequence of color term acquisition remains intact as a framework for testing further hypotheses. In studies of color division, perception and naming, Berlin and Kay's work in 1969 still serves as the touchstone for subsequent research.

Cognitive psychologist Eleanor Rosch (1938-) investigated color division further. Her studies focused on the influence of culture in category formation using color categories and names as the basis of experiment. Rosch investigated perception of color division with experiments in 1972 with the Dani tribe of Papua New Guinea and found that they had a

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[35] Brent Berlin and Paul Kay, *Basic Color Terms* (Berkeley, CA: University of California Press, 1969), 2-3.

[36] Hugo Magnus, *Die geschichtliche Entwickelung des Farbensinnes*, 41-42. In this dissertation, see the section "Division of Color in Ancient Cultures" of this chapter for the sequence of color perception emergence Magnus proposed.

two-division color system. She experimented to determine if Dani perception followed Berlin and Kay's proposal that the first stage involved seeing only black and white. Rosch found that the two-color division was more complex than black and white among the Dani. Rosch determined that the Dani two-category color division grouped colors as warm, including white, red and yellow, and cool, including black, green, and blue. Although a refinement of Berlin and Kay, and others' earlier findings, Rosch's studies, and those subsequent, have resulted in the verification of the principles of the sequence of color perception in children and in cultures. Rosch, in her experiments with the Dani, also found that, despite the lack in color terms, the Dani were able to identify basic color divisions. With this finding, Rosch challenged the linguistic determinism proposed by Sapir and Whorf. Rosch found that the Dani could divide and remember color swatches for which they had no categories or vocabulary.

In 1976, the World Color Survey was initiated for two major purposes. The World Color Survey set out to first, test the existence of basic color terms, and second, to test whether these terms were indeed universal and added in a set sequence. Linguist Stephen Levinson (1947-) studied the Yélî Dnye color naming on Rossel Island in the Louisade Archipelago of Papua New Guinea. Yélî Dnye, or the "Rossel language," has not been affiliated to any other language. In this language, which is spoken by 3,500 people, color terms are linked to the objects they describe.[37] Yélî Dnye, until the influence of English, did not have an umbrella term for "color." Levinson emphasized the importance of extensive linguistic investigation that should accompany studies of perception of the division of

[37] This linking of color to object is the method that Robert Ridgeway systematically employed in his system of color nomenclature.

colors, and thus provided documentation of the structure of Yélî Dnye. In Yélî Dnye colors are not only linked to objects, they are linked to specific surfaces of that object. Levinson wrote, "Colors are thus not colloquially predicated of objects but, rather, of the relevant surfaces of objects. This insistence on exactitude, bordering on philosophical pedantry, is striking."[38] When new objects enter the lexicon of Yélî Dnye-speakers, their colors are incorporated in a manner that still includes a familiar color-referent in description. To describe a green book, Yélî Dnye-speakers said "that tree raw/unripe leaf/roof book. Levinson wrote,

> It is worth pointing out that some theorists think that the notion of comparison is basic to all color words…Moreover in some languages the general word for "color" is the word for "like"…, and in others a "looks like" suffix accompanies many color expressions…. These are clearly signs of the emergence of color vocabularies from the names of objects that exhibit the relevant hue.[39]

In his studies, Levinson found that, although speakers of Yélî Dnye could distinguish among colors, they used the surface of familiar objects to make the distinctions. This indicated that, although the words for colors do not exist, the ability to perceive them did. Yélî Dnye does not have basic color terms in the way predicted by Berlin and Kay.

The proposal that Berlin and Kay's basic color terms and their sequence of emergence were universal in languages was thought to have fatal implications to linguistic relativism, which links language directly to perception. As did Rosch, Levinson tested and determined to be true the hypothesis that, despite the lack of basic color terms, people still

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[38]Stephen C. Levinson, "Yélî Dnye and the Theory of Basic Color Terms." *Journal of Linguistic Anthropology* 10, no. 1 (2000): 12, http://www.jstor.org/stable/43103224.

[39] Levinson, "Yélî Dnye and the Theory of Basic Color Terms," 13.

perceived basic color divisions. Berlin and Kay's studies do not necessarily support the codability hypothesis of color recognition proposed by Lenneberg and Brown, but their work does propose that there are semantic and perceptual universals, and thus real divisions in color.

Here is the crossroad of perception and language, in which color studies continue to test how color words are related to color sensory capacities. Linguistic anthropologists discovered "significant semantic universals in color terms, the structure of ethnobotanical nomenclature, and (arguably), kinship terms. … however, there has been a recent change..toward an intermediate position, in which more attention is paid to linguistic and cultural difference…"[40] According to some, having words to describe a color division allows for enhanced memory of the color, and according to others, there is a universally similar perception and division of color division, and these divisions are encoded in a predictable sequence.

The importance of language to perception is emphasized by Barbara Saunders, whose research supports cultural relativism along the lines of Humboldt, Boas, Sapir, Whorf, Lenneberg, and Brown, in which perceptions of divisions are tied to the categories and words of a culture. Not only has Saunders stated that it is probable that people in Europe over the last two millennia perceived color differently than people today, she also encountered different perceptions of color division in her field studies. In addition to

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[40] John J. Gumperz and Stephen C. Levinson, "Introduction: Linguistic Relativism Re-examined," ed. John J. Gumperz and Stephen C. Levinson, in *Rethinking Linguistic Relativity* (Cambridge: Cambridge University Press, 1996), 3.

finding color divisions subjective, Saunders, as does Levinson, notes that color divisions are often created:

> The normative nature of colour terms was vividly brought home to me in my field work among the Kwakwaka'wakw of the Canadian northwest. Even to attend to and talk about "colour" in the manner of colour science was immediately to place myself in the colonizing discourse. …The Kwakwaka'wakw are, in many contexts, such as judging the conditions of the sea, or the merit or appropriateness of some situation, exquisitely sensitive to what we call "colour", but it is never focally attended to, never disembodied from its context.[41]

Saunders conveyed in her observations that color perception is culturally dependent and that it is unfeasible to set up color experiments that do not themselves influence the outcome. These problems are inherent to even the most ambitious studies of the division of color perception, such as the World Color Survey. The surveys and experiments themselves tend to have a normative effect by creating color divisions and conveying these to the subjects being studied.[42]

Efforts of linguists, cognitive psychologists, and anthropologists have yielded fascinating data with their studies of perception of color division in texts and in people around the world. None could be more interesting than the living experiments on color perception done by Neil Harbisson, who gave a lecture in 2013 at the Linda Hall Library for

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[41] Saunders, "The Normativity of Colour," 94.

[42] Levinson, "Yélî Dnye and the Theory of Basic Color Terms," 20. Levinson found that when speakers of Yélî Dnye were asked to identify colors on a chart of Berlin and Kay's focal colors, they, unlike English-speakers, tended to identify blackish color chips as "green." Levinson wrote, "Outside the context of the chart, the literal reference of the simile to rain forest tree foliage seems to bring the foci down to much darker canonical exemplars that we would think of as good greens. This phenomenon does raise serious questions about how the chart may bias responses toward light exemplars, away from the boundary of other hues."

the exhibit "Wheels, Pyramids, and Spinning Tops: The Scientific Approach to Color."[43] Colorologist Harbisson was born with achromatopsia, a condition that permits him to see in only black and white. At the age of twenty, he and a colleague invented an electronic eye, an "eyeborg," which he had installed in his head that allowed him to "listen" to colors. The eyeborg allows the wearer to hear light waves. Harbisson explained, "Color is basically hue, saturation, and light.…The eyeborg detects the light's hue and converts it into a sound frequency that I can hear as a note. It also translates the saturation of the color into volume."[44] Harbisson said that the technology had created a new sense in his brain, and that, because rods and cones for the perception of the spectrum visible to most humans do not limit him, he can see beyond the normal range. He stated that he can perceive near infrared and colors that are invisible to the human eye, and near ultraviolet, which allows him to detect harmfully sunny days and to perceive motion detectors. The condition that the eyeborg has engendered in his brain, Harbisson called sonochromotopsia because it is an extra sense, not achromatopia nor synesthesia. Sonochromatopia relates color to sound objectively and equally to everyone. Harbisson has used his new sense for his profession. He explained,

> Thanks to the eyeborg, I've made a career by combining music and art. I do concerts where I plug myself into a set of speakers and play the colors of the audience back to them. The good thing is that if it sounds bad, it's their fault!

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[43] My research on color charts began in the rare books room of the Linda Hall Library in 2009. My calls for the rare books on color charts and nomenclature from the archives brought to light the many works that the Linda Hall Library has on this topic. These works on color were displayed for the special exhibit, in coordination with a series of lectures, from October 10, 2013 – March 14, 2014.

[44]Neil Harbisson, *Hedgehog*, 53 (Fall 2013): 1, http://www.lindahall.org/wp-content/uploads/sites/5/2014/08/Hedgehog_Number_53_Fall_2013.pdf.

> I also do portraits live by pointing at the different hues on the different parts of the face, so I can create a chord of a face. Prince Charles sounds surprisingly like Nicole Kidman. This is how I found out that there are no black or white skins. We are all different shades of orange.[45]

The case of Harbisson and others who have anomalies of color perception have provided fascinating insight into brain function and the nature of category and division. In Harbisson's case, the perception of color is directly translated into sound without the semantic aspect. In his case, the sound is the color. He does not have terms to divide the spectrum, but instead stable tones.

The division of color is dependent upon time, location, and cultural influence on the eye of the perceiver, and research into color perception has undergone a shift in underlying assumptions about the divisions of color being real, subjective, or created. Despite thorough literary analysis, it is unclear how the ancients may have perceived color. Despite the great lengths that have been taken to test if people living in pre- and post-industrial cultures divide colors in the same way, only flawed and rudimentary outcomes have been achieved. Even with fascinating systems, which substitute sound to make up for color blindness, the division of color remains dependent on sensory perception. The perception of color division has proven to be highly subjective, but what has become clear through these studies and experiments is that, among other factors, color names influence color perception. Having a name for a color may well even cause the color to be noticed, or divided out, in a way that was formerly unperceived. The power of naming a color is remarkable. The dualistic interplay of word to world and world to word affects our very perception of color. The name not only can make the color distinguishable, the name also carries within it linguistic

[45] Neil Harbisson, *Hedgehog*, 53 (Fall 2013): 3, http://www.lindahall.org/wp-content/uploads/sites/5/2014/08/Hedgehog_Number_53_Fall_2013.pdf.

information that reveals much about the language, history, culture, and attitude of the speaker. Color naming systems and their taxonomic nomenclature are especially rich in information. The color taxonomies I next examine not only serve to create divisions out of a continuous colors spectrum, they reveal cultural and historical information, and they reveal the systematic approaches and assumptions of the taxonomists.

CHAPTER 5

NAMING COLORS

Color names evolved as the faculty of language evolved, and the words employed to name colors were relative to time, place, and the culture of the speaker. Having more terms for color may help us to distinguish finer divisions, and undoubtedly, knowing multiple languages allows one to view one's surroundings from a slightly different perspective. An individual with a large number of words for color, or any other topic, has a rich history of associations that sensory discernment alone cannot match. General color terminology is adequately accounted for by the theories of language evolution and linguistic relativism, which I have discussed. What is of is of special interest to me here is the systematic division, organization, and nomenclature of color, or color taxonomy. This systematic approach to the naming of colors is better understood through the lens of speech act theory.

A taxonomist of color purposely chooses a name in order that a color become recognized and standardized. As Searle wrote, language does not just describe but instead the words create, and partly constitute, what they both describe and create.[1] Taxonomy uses language in a conscious and purposeful manner that is artificial by comparison to naturally evolving language. In taxonomy, especially, there is a volition in the use of language with special consideration to the connotative and denotative aspects of a name. Yet, I argue that we must be aware that naming something is an act of creation, as Towner describes, of singling something out from unknown formlessness. He describes that unknown reality can

[1] John R. Searle, *Making the Social World: The Structure of Human Civilization* (Oxford: Oxford University Press, 2010), 85.

be chunked in various ways into discrete objects of known reality.[2] In naming colors or species, we are creating structures that reflect both the exterior and interior, and this structure, artificial though it may be, serves as a bridge and a scaffolding for higher cognition. In addition, I argue that a taxonomy comprised of words, rather than a simply being a numeric catalogue convenient as a computational tool, serves to build knowledge.

Comparative studies of languages proliferated in the nineteenth century, and in many of these studies, special attention was paid to the color terms in ancient cultures and in exotic languages. These language studies brought to the fore that people of different cultures called natural objects by wildly different color names. From these color studies by classicists and anthropologists, a sense of the instability and relativism of words, and especially color names, arose. Yet, this is the same era that saw a swell of color naming systems. Botanists, art historians, mineralogists, philologists, and biologists produced what they hoped would serve as a stable and scientific color naming system. Tension arose between the desire to organize color into a world of discrete, named objects, and the recognition that the task was hampered by the fact that the perception of color is peculiar to individuals and cultures and that color exists on a continuum. Despite the debates over color perception and color names, dozens of color naming systems were produced. They ranged from slim field guides with beautiful hand-colored swatches, to multi-volume sets with screen-printed swatches. As with other forms of taxonomy, in which exemplar is paired with word, many authors of chromotaxonomies paired color swatches with names in an attempt to link object with word in a fixed relation. But where exactly does the purple

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[2] George Towner, *The Reality of Knowledge: The Ways in Which Life Constructs Reality so It Can Be Known* (Lanham, MD: University Press of America, 2011): 22.

called “thistle bloom” become “clover” or the green named “lizard” becomes “hummingbird”?[3] In their efforts to make a stable organization of color, color-naming systems radically expanded the number of named colors. The naming of colors in a systematic way was an endeavor undertaken by scientists and artists alike, each one with the hope of providing a standard of color names for universal employ. For the naming of colors, I examine taxonomic systems for science, art, and industry, and the identification of color through spectrographic data.

A History of Chromotaxonomies

The flourishing of books on color nomenclature began with Patrick Syme’s *Werner’s Nomenclature of Colours* (1814) and ended with Albert Henry Munsell’s *Atlas of the Munsell Color System* (1915). There have been, of course, many such books before and after these dates, but this time span saw a heyday of interest in the topic. The names for color taxonomies were generally taken from their similitude to things in nature, the source of pigments, etymology, and trade. The multiplicity of chromotaxonomies caused the same shade of green to be variously named by the authors of color taxonomies depending on the purpose of their systems. Patrick Syme named a certain shade of green triply as “leaves of a leek in winter,” “the egg of a thrush,” and “flint.”[4] George Fields named the same color

[3] Aloys Maerz and M. Rea Paul, *A Dictionary of Color* (New York: McGraw Hill Book Company, 1930), 28, 51.

[4] Patrick Syme, *Werner’s Nomenclature of Colour* (Edinburgh: James Ballantyne and Company, 1814), Colors 47, 50 and 10.

"mineral green."[5] Pier Andrea Saccardo provided the same color the name, *melleus* and gives its synonym in six additional languages.[6]

Most authors of chromotaxonomies were naturalists or artists. Naturalists intended their guides for fieldwork in botany (mycologists were especially prolific), zoology, or mineralogy. Naturalists generally intended their guides to be taken along into the field, and to be used to describe and identify species. A copy of Syme's 1821 *Werner's Nomenclature of Colour,* for instance, was taken aboard the HMS Beagle by Charles Darwin. Syme's work is one of the earliest classical color charts for use by naturalists. Syme provided 108 hand-colored swatches. The colors were grouped by whites, greys, blacks, blues, purples, greens, yellows, oranges, reds, and browns. Each color was given a number, an English term, and then three names, which corresponded to colors for animal, vegetable, and mineral. As can be seen in Figure 5.1, Syme called color 24 "throat of a blue titmouse," "stamine of a single purple anemone," and "blue copper ore."

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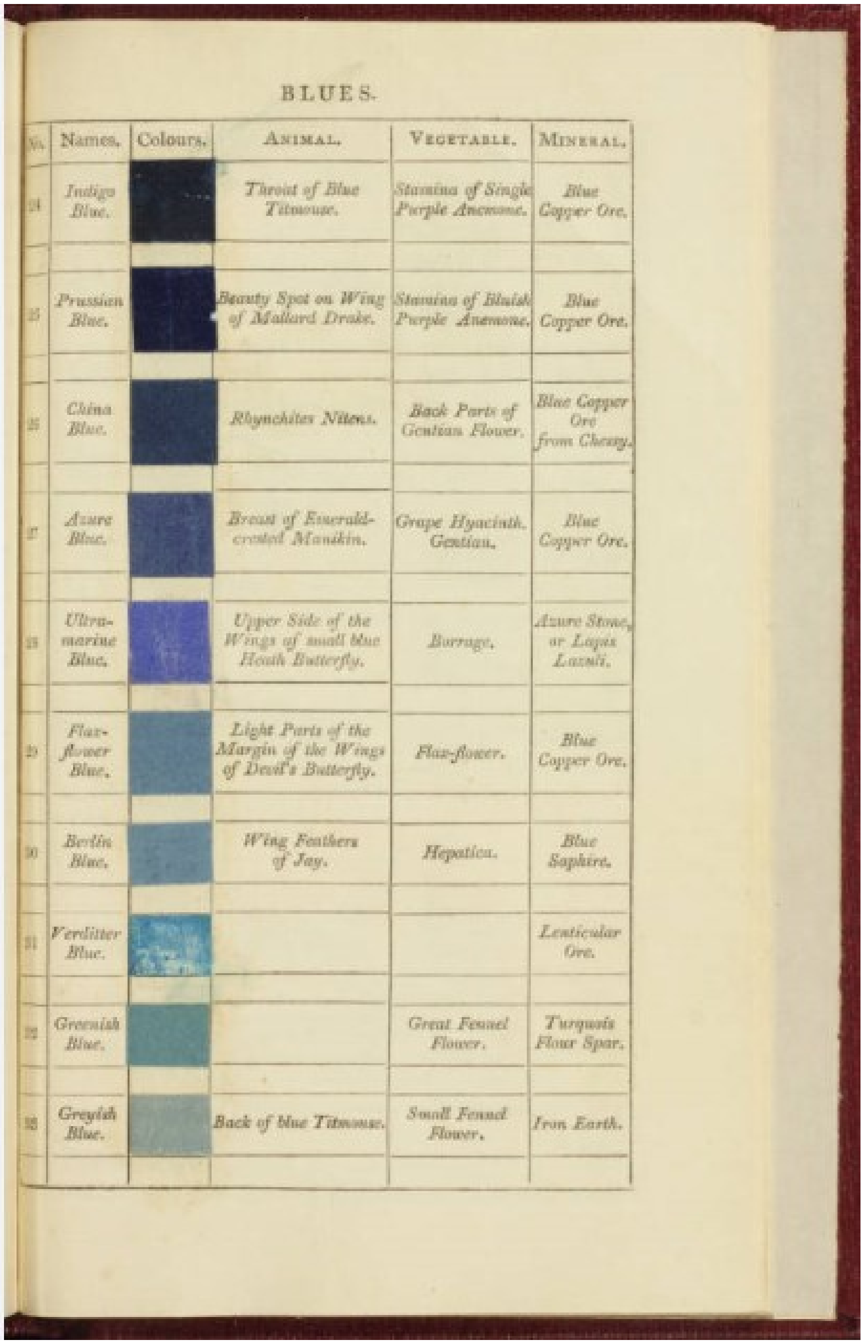
[5] George Field, *Chromatography; or, A Treatise on Colours and Pigments, and of Their Powers in Painting* (London: Tilt and Bogue, 1841), 203.

[6] Pier Andrea Saccardo, *Chomotaxia seu nomenclator colorum* (Patavii: Typis Seminarii, 1894).



BLUES.

No.	Names.	Colours.	Animal.	Vegetable.	Mineral.
24	*Indigo Blue.*		*Throat of Blue Titmouse.*	*Stamina of Single Purple Anemone.*	*Blue Copper Ore.*
25	*Prussian Blue.*		*Beauty Spot on Wing of Mallard Drake.*	*Stamina of Bluish Purple Anemone.*	*Blue Copper Ore.*
26	*China Blue.*		*Rhynchites Nitens.*	*Back Parts of Gentian Flower.*	*Blue Copper Ore from Chessy.*
27	*Azure Blue.*		*Breast of Emerald-crested Manakin.*	*Grape Hyacinth. Gentian.*	*Blue Copper Ore.*
28	*Ultra-marine Blue.*		*Upper Side of the Wings of small blue Heath Butterfly.*	*Borrage.*	*Azure Stone, or Lapis Lazuli.*
29	*Flax-flower Blue.*		*Light Parts of the Margin of the Wings of Devil's Butterfly.*	*Flax-flower.*	*Blue Copper Ore.*
30	*Berlin Blue.*		*Wing Feathers of Jay.*	*Hepatica.*	*Blue Saphire.*
31	*Verditter Blue.*				*Lenticular Ore.*
32	*Greenish Blue.*			*Great Fennel Flower.*	*Turquois Flour Spar.*
33	*Greyish Blue.*		*Back of blue Titmouse.*	*Small Fennel Flower.*	*Iron Earth.*

Figure 5.1. From Patrick Syme's *Werner's Nomenclature of Colours*[7]

[7] Patrick Syme's *Werner's Nomenclature of Colours. Source:* http://lhldigital.lindahall.org/cdm/ref/collection/color/id/12017

In one of his outings into the woods with his father, Elias Magnus Fries, the founder of modern systematic mycology, might have consulted his copy of *Synopsis methodica fungorum*, or some other handbook of mushrooms, in trying to determine what possibly delectable morsel might be there by the toe of his boot. Perhaps it was *Russula foetens* or *Boletus edulis* [8] After reading their descriptions, Fries might well have decided to also consult Hayne's *De coloribus corporum naturalium*, as seen in Figure 5.2, in order to define more closely the colors used to describe these to mushrooms.[9]

Figure 5.2. Haynes' *De coloribus*[10]

[8] Christiaan Henrik Persoon, *Synopsis methodica fungorum*, 1801. A *Russula foetens*, magnus foetidus, sordide pallidus, pileo depresso: margine fornicato tuberculato-sulcato, lamellis nonullis dimidiatis, basi venis conuexis, (443). *Boletus eduli,* pileo puluinato latissimo fuscescente- vaccine: carne inmutabili: poris primo farctis albidis dein dilute flauis, stipite tuberoso stubuentricoso reticulato subrufescnte - cinéreo, (510).

[9] Fridericus Gottlob Hayne, *De coloribus corporum naturalium* (Berolini: Impensis J. E. Hitzig), 1814.

[10] Fridericus Gottlob Hayne, *De coloribus corporum naturalium* (Berolini: Impensis J. E. Hitzig, 1814), unpaginated. *Source:* https://de.pinterest.com/pin/305541155945301869/.

To identify these mushrooms by color is a dubious proposition. *Russula foetens* is described as having the color of "pale dirt," whereas *Boletus edulis,* is described as having the color "medium brown." A mistake could easily occur, since the names and swatches vary from color guide to color guide; "pale dirt" is paler in some than in others. The misidentification of *Russula foetens* for *Boletus edulis* is a matter of no small consequence. In the introduction to *The Edible and Poisonous Fungi of Sweden,* Fries wrote, "During my visits to Stockholm during autumn, I frequently examined the mushrooms offered on the market at Munkbron. Certainly, the most were of the better kind, but sometimes I found baskets of poisonous mushrooms as well, such as *Russula foetens*. Pointing this out, I was told, 'oh, mister, mind your own business.'"[11]

Fries was concerned with producing accurate color names for mycological descriptions and depictions, as can be seen in Figure 5.3. In addition to arming shoppers at Swedish markets against unscrupulous mushroom vendors, he intended his work to aid in the identification and description of colors in botany, zoology, or mineralogy. Although authors of color guides used diverse sources for names, Fries was a traditionalist and, like his countryman Linnaeus, wrote most of his work in Latin.

[11] Elias Magnus Fries, *Sveriges ätliga och giftiga svampar* (Stockholm: A.J. Salmson, 1860), 9. My translation.

Figure 5.3. Page from Elias Magnus Fries *Sveriges ätliga och giftiga svampar*[12]

Fries' prolific use of Latin color terminology sparked a rash of interest in Latin as a source for naming colors. Henry Thornton Wharton,[13] translator of classical Latin texts such as *Sappho*, and Benjamin Daydon Jackson,[14] British botanist and taxonomer, each wrote an extensive analysis of Fries' use of Latin color names with the intent of bringing order to Latin color nomenclature.

[12] Page from Elias Magnus Fries, *Sveriges ätliga och giftiga svampar. Source:* http://www.eliasfries.org/

[13] H. T. Wharton, "On Fries' Nomenclature of Colours," *Grevillea* 13, no. 66 (1884): 25-31.

[14] B. Daydon Jackson, "A Review of the Latin Terms Used in Botany to Denote Colour," *Journal of Botany* 37 (1899): 97-106.

Due to his work in the translation of classical texts, Wharton had developed a highly refined sense of nuance regarding color terminology in Latin. In his article "On Fries' Nomenclature of Colours," in *Grevillea*, Wharton addressed one by one several dozen colors and refined their meanings according to their use by authors of classical Latinity. For example, while *albus* is often used by naturalists to mean pure white, it ought to be specified that *albus* was so named because it was of a dead white. Cicero employed *candidus* to describe glistening white, whereas *argillaceus* indicated the white of clay and connoted a texture or surface to the whiteness.[15] For variations of white alone, Wharton provided a dozen more such etymologies and lamented that Fries probably never thought of these classical Latin differences.[16] Wharton was concerned with the lack of rigor and authority in the field of color nomenclature not only in Latin but also in modern languages:

> Much of the difficulty that surrounds the nomenclature of colours is also due to there being no authoritative code. In each branch of art or knowledge at the present day different names are used for the same colours. The "purple" of the cardinal is crimson; the "pink" of the huntsman is scarlet.[17]

Despite his regrets about Fries' lack of consideration with etymological, Wharton suggested that Fries should be the "law-giver" in current usage of Latin color terms. Wharton was ultimately more concerned with the stability of the system than with accuracy according to historical color meanings.

Benjamin Daydon Jackson is likewise troubled by the loose employment of color terms in Latin. He blames part of the mess on Homer and his coarse ilk. "The love of

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[15] Wharton, "On Fries' Nomenclature of Colours," 25-26.

[16] Wharton, "On Fries' Nomenclature of Colours," 25.

[17] Wharton, "On Fries' Nomenclature of Colours," 26.

landscape, with its varying subtle effects of delicate light and shade and colour, was very little felt, only the more obvious and striking effects of tempest, sunrise or sunset would attract attention; hence no terms would be needed to express what was unfelt."[18] Jackson was concerned that the etymological roots of Latin color names were hidden in obscurity due to the lack of rigorous definition at the time of their use by classical authors. Jackson expressed his admiration for the excellent lecture on color, which he heard the late Mr. Wharton give at the Woolhope Club *Transactions,* yet he wrote that he had "been forced to the conviction that great confusion actually exists as to the meaning of many of the words employed to connote colours."[19] Whereas Wharton deferred to the authority of Fries on current usage of Latin color terms, Jackson instead interjected his own refinements and etymologies. The apparent stability of using a "dead" language for a standard universal color nomenclature was encumbered with as many difficulties as the other methods employed to name colors.

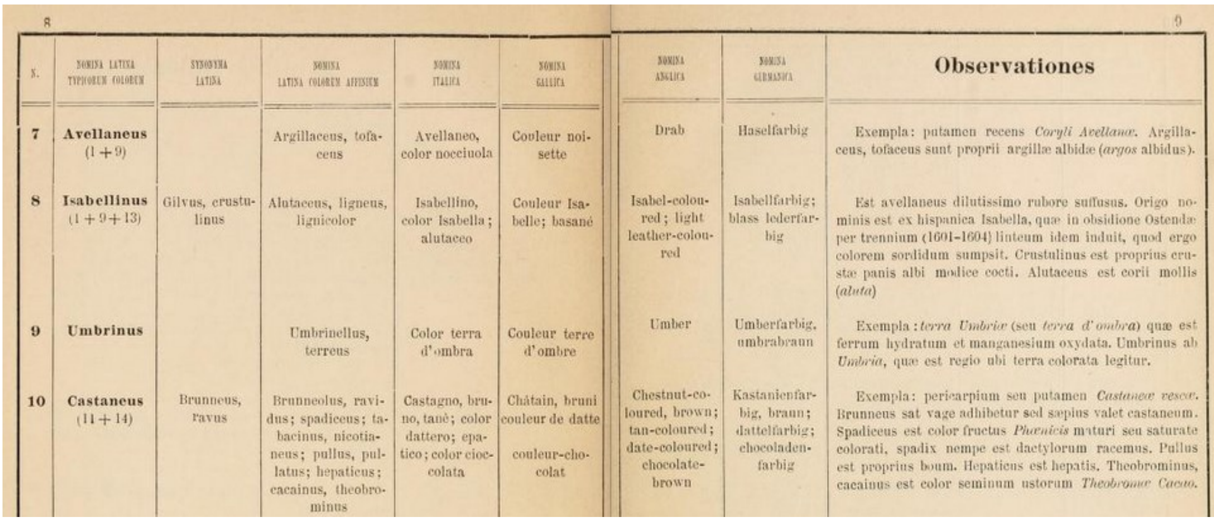
All three editions of Pier Andrea Saccardo's *Chromotaxia*[20] contain fifty hand-colored swatches painted directly on the pages. Although the colors are generally fast, there is substantial variation in color among exemplars and editions of the work. Saccardo provides each color with seven names, and then observations: *Nomina latina typicorum colorum, Synonima latina, Nomina latina Colorum affinium, Nomina italic, Nomina gallica, Nomina anglica, Nomina germanica*, as can be seen in Figure 5.4 for the color white.

[18] Jackson, "A Review of Latin Colour Terms," 97.

[19] Jackson, "A Review of Latin Colour Terms," 98.

[20] Pier Andrea Saccardo, *Chomotaxia Seu Nomenclator Colorum* (Patavii: Typis Seminarii, 1891, 1894 and 1912 (editions 1-3).

Saccardo chose his Latin color names from contemporary usage of Latin in botany and zoology. By providing a point of reference, his work became useful to other chromotaxonomists, and, among naturalists of the nineteenth century who still wrote in Latin, Saccardo's nomenclature became a standard.



N.	Nomina latina typicorum colorum	Synonyma latina	Nomina latina colorum affinium	Nomina italica	Nomina gallica	Nomina anglica	Nomina germanica	Observationes
7	**Avellaneus** (1 + 9)		Argillaceus, tofaceus	Avellaneo, color nocciuola	Couleur noisette	Drab	Haselfarbig	Exempla: putamen recens *Coryli Avellanæ*. Argillaceus, tofaceus sunt proprii argillæ albidæ (*argos* albidus).
8	**Isabellinus** (1 + 9 + 13)	Gilvus, crustulinus	Alutaceus, ligneus, lignicolor	Isabellino, color Isabella; alutaceo	Couleur Isabelle; basané	Isabel-coloured; light leather-coloured	Isabellfarbig; blass lederfarbig	Est avellaneus dilutissimo rubore suffusus. Origo nominis est ex hispanica Isabella, quæ in obsidione Ostendæ per trennium (1601-1604) linteum idem induit, quod ergo colorem sordidum sumpsit. Crustulinus est proprius crustæ panis albi modice cocti. Alutaceus est corii mollis (*aluta*)
9	**Umbrinus**		Umbrinellus, terreus	Color terra d'ombra	Couleur terre d'ombre	Umber	Umberfarbig, umbrabraun	Exempla: *terra Umbriæ* (seu *terra d'ombra*) quæ est ferrum hydratum et manganesium oxydata. Umbrinus ab *Umbria*, quæ est regio ubi terra colorata legitur.
10	**Castaneus** (11 + 14)	Brunneus, ravus	Brunneolus, ravidus; spadiceus; tabacinus, nicotianeus; pullus, pullatus; hepaticus; cacainus, theobrominus	Castagno, bruno, tanè; color dattero; epatico; color cioccolata	Châtain, bruni couleur de datte couleur-chocolat	Chestnut-coloured, brown; tan-coloured; date-coloured; chocolate-brown	Kastanienfarbig, braun; dattelfarbig; chocoladenfarbig	Exempla: pericarpium seu putamen *Castaneæ vescæ*. Brunneus sat vage adhibetur sed sæpius valet castaneum. Spadiceus est color fructus *Phœnicis* maturi seu saturate colorati, spadix nempe est dactylorum racemus. Pullus est proprius boum. Hepaticus est hepatis. Theobrominus, cacainus est color seminum ustorum *Theobromæ Cacao*.

Figure 5.4. Part of a page from Saccardo's *Chromotaxia seu nomenclator colorum*[21]

In 1886, the first edition of *Ridgeway's Nomenclature of Colors* provided 200 colors and gave their names in seven languages. In 1912, in the second edition of his work *Color Standards and Color Nomenclature*, Ridgeway expanded the number of colors to 1,115, three pages of which can be seen in Figure 5.5. There are significant variations in spectral characteristics of colors with the same names from the first to second edition, indicating changes in fabrication of inks, or fading and changing over time. His color taxonomy is intended for use as a color chart for naturalists, especially ornithologists.

[21] Saccardo, *Chomotaxia seu nomenclator colorum. Source:* https://archive.org/stream/chromotaxiaseuno00sacc#page/8/mode/2up

Figure 5.5. Three color plates from Robert Ridgway's 1912 book, *Color Standards and Color Nomenclature*.[22]

Ridgway rejected trade names and complained, "since the introduction of aniline dyes and pigments, [nomenclature has] become involved in almost chaotic confusion through the coinage of a multitude of new names."[23]

Less concerned with Latin color etymology than with providing a comprehensive color guide, in 1905 the Société française des chrysanthémistes with René Oberthür and Henry Dauthanay produced *Répertoire de Couleurs*, a two-volume set of 365 loose-leaf plates,

[22] Three color plates from Robert Ridgway's 1912 book, *Color Standards and Color Nomenclature. Source:* http://lindahall.tumblr.com/post/31543582175/three-color-plates-from-robert-ridgways-1912.

[23] Robert Ridgway, *ANomenclature of Colors for Naturalists, and Compendium of Useful Knowledge for Ornithologists* (Boston, MA: Little, Brown and Company, 1886), 19.

each with four printed color tones.[24] Due to the high quality of the printing, these plates have also retained their original colors. Oberthür and Dauthanay often used objects in nature as their guide for color names, as seen in Figure 5.6. Their work was intended for use by horticulturalists and naturalists; thus the names were frequently matched to plants. The color name is given in French and is translated into English, German, Italian, and Spanish. In addition, Oberthür and Dauthanay provided brief explanatory comments on the origin and remarks to the tones on each loose-leaf plate.

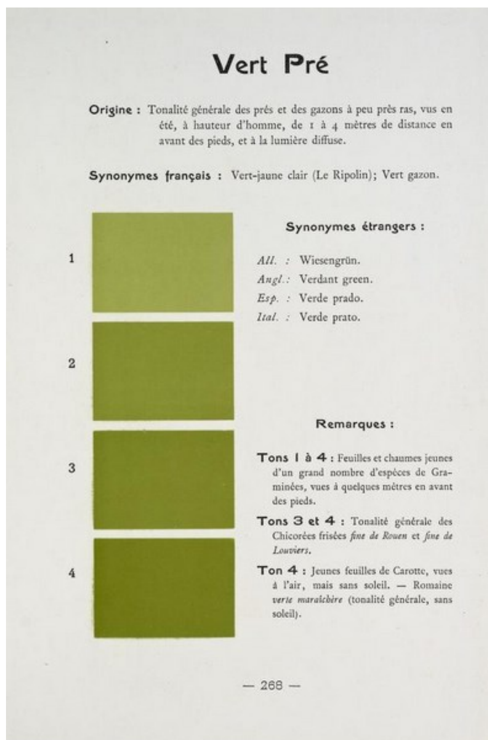


Figure 5.6. *Vert Pré* from René Oberthür and Henri Dauthenay[25]

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[24] René Oberthür, and Henri Dauthenay, *Répertoire de couleurs pour aider á la détermination des couleurs des fleurs, des feuillages et des fruits* (Société française des chrysanthémistes, 1905).

[25] René *Vert Pré* from Oberthür, and Henri Dauthenay. *Source:* http://www.biodiversitylibrary.org/item/124245#page/92/mode/1up

As can be seen in Figure 5.6, in Oberthür and Dauthanay's system, the color *Vert Pré,* or "verdant green," they specify that the green of grass they intend to identify is "the general tone of meadows or lawns, closely trimmed, observed in summer, from the height of a man, at one to four meters from the feet, and in diffuse light."[26]

No work on color systems should overlook the enormous contribution made by Michele Eugené Chevreul.[27] Chevreul was raised during the French Revolution and trained as a chemist. His approach to color systematics was quite broad. He used diverse sources for color names, but perhaps due to his training as a chemist, often referred to the composition of a pigment. Yet Chevreul drew heavily upon objects in nature, word etymology, and trade color names for his nomenclature as well.

Chevreul made scales with distinct breaks between the colors. As can be seen by the visual organization of their color arrangement in Figures 5.7 and 5.8, color systematists Chevreul and Charles Henry took different approaches.

Henry visualized color on a continuum and made a circular spectrum by a process that tested the printer's skill and required six plates. Henry at last produced a print of a continuous

[26] René Oberthür, and Henri Dauthenay, *Répertoire de couleurs,* 268, my translation.

[27] Michel Eugène Chevreul, *The Laws of Contrast of Colour and Their Application to the Arts* (London: Routledge, Warne, and Routledge, 1861); and Michel Eugène Chevreul, *Exposé d'un moyen de définir et de nommer les couleurs: d'après une méthode précise et expérimentale avec l'application de ce moyen a la définition et a la dénomination des couleurs d'un grand nombre de corps naturels et de produits artificiels: atla.* (Paris: Typographie de Firmin Didot frères et fils, 1861).

color circle based on the spectrum with white at its center and black at the periphery. The most intense colors are located between the center and periphery.[28]

Figure 5.7. Michel Eugène Chevreul's color wheel, 1861[29]

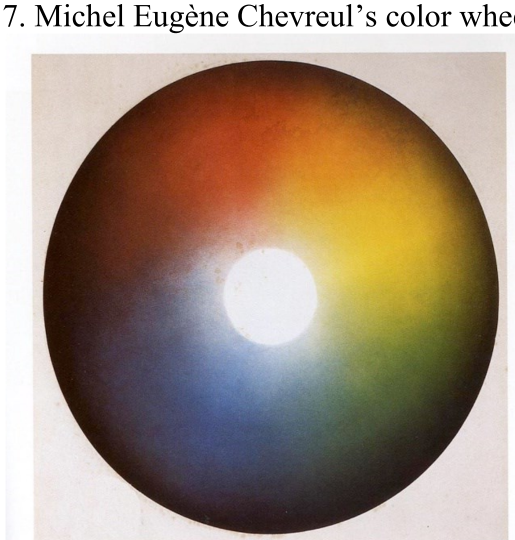

Figure 5.8. Charles Henry *Cercle Chromatique,* 1889[30]

[28] Charles Henry, *Cercle Chromatique présentent tout les compléments et toutes les hamonies de couleurs, avec une introduction sur la théorie général du contraste, du rythme et de la mesure* (Paris: Verdin, 1888).

[29] Michel Eugène Chevreul's color wheel in William Ashworth's Scientist of the Day - Michel Chevreul, August 31, 2016. *Source:* http://www.lindahall.org/michel-chevreul/

In Henry's continuous spectrum, colors would be difficult to single out. In order to make his system more useful, Henry invented a *rapporteur esthétique* to complement his *cercle chromatique.* His color circle and aesthetic protractor were adopted by artists such as Paul Signac and Georges-Pierre Seurat to develop ways of gauging length, rhythm, hue, and harmony.[31] The problem with Chevreul's color wheel is that it made breaks which are merely arbitrary; however, just as with other systems, such divisions are needed if one is to provide taxonomic groupings.

Natural objects have proven a rich source of color terminology. Even so, variation of specimens present but one difficulty with this method of naming colors, such as indicated by Oberthür and Dauthany's "verdant green," which required a precise view of a particular lawn. An added difficulty is that color has no objective existence. It is but a momentary impression on the retina that can be completely altered by a change in the light. Because of these difficulties, other chromotaxonomists preferred to name colors according to the ingredients used to produce them. The color nomenclatures they produced were generally intended for use by artists and manufacturers.

George Field, in his works of color names, *Rudiments of the Painter's Arts; or a Grammar of Colouring, Chromatography,* and *Chromotography for Artists,* used pigment ingredients as the primary source for nomenclature. Since he was concerned with the source of the pigment, Field forwent color swatches altogether. Instead he gave a color name,

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[30] Charles Henry *Cercle Chromatique,* Paris 1889. *Source:* Chris Mullen's Collection of Books on Colour. http://www.fulltable.com/VTS/c/02.jpg.

[31] Rolf Kuehni and Andreas Schwarz, *Color Ordered: A Survey of Color Order Systems from Antiquity to the Present* (Oxford: Oxford University Press, 2008), 86-87.

synonyms, the qualities of the ingredients, and a description of the color. For example, "Cappagh Brown," or "Euchrome," is produced from bog-earth from the estate of Lord Audley at Cappagh, near Cork. It is deep and rich in color and dries promptly in oil. "Hypocastanum" is a brown produced from the horse-chestnut. It is a warm brown and is very durable in both water and oil.[32] Field may have been inclined to use color names derived from ingredients for pigments because of his understanding of the causes of colors: "We may therefore regard the transient colours of refracted light, and also light itself, as oxides of hydrogen, produced by a species of combustion, attended by heat or caloric, as observed in a sunbeam and prismatic spectrum."[33] For Field, the phenomenon of color was primarily chemical in nature, so his preference for color names based on composition of pigments is logical.

Like Field, David Ramsay Hay was concerned with color primarily in its application. His *Nomenclature of Colours* contains forty plates each with six hand-colored swatches affixed to the pages, many of which have darkened or become mottled. While Hay drew from a variety of sources for names, his preference was for color names based on pigment ingredients. He credited Field for some of the color terms he adopted, such as "citrine" and "russet."[34] While Hay was disinclined to use color names based on similitude to objects

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[32] George Field, *Rudiments of the Painter's Arts; or a Grammar of Colouring* (London: John Weale, 1858), 279, 286.

[33] Field, *Rudiments of the Painter's Arts*, 69.

[34] David Ramsay Hay, *A Nomenclature of Colours, Applicable to the Arts and Natural Sciences, to Manufactures, and Other Purposes of General Utility,* 2nd ed. (Edinburgh, London: W. Blackwood & Sons, 1846), 33.

found in nature, he found word pedigrees nearly as important a source and arbiter of suitable color names as pigment composition:

> At a more recent period, two other colours were introduced into heraldry, called *tenney* and *sanguine*. These correspond to orange[35] and russet; the first being composed of red and yellow, and the other being described as a darkish red. But the use of these colours in heraldry has been almost exclusively confined to the Dutch and Germans, and they are of course little known in English blazonry.[36]

His choice of sources for color names can be traced, in part, to his profession. Early in his career, he was named Decorator to the Queen. Hay preferred names that conjured the image of precious ingredients or noble descent.

The works of chromotaxonomy geared toward application in the arts have a high proportion of color names that stem from the ingredients utilized to make pigments. While color names based on their resemblance to natural objects had the difficulty of specimen variation, the use of pigment composition as a basis for color naming also had its limitations and difficulties. A revolution in color manufacturing through the use of synthetic substances made many pigment names obsolete. Colors produced with coal tar products, for instance, replaced natural siennas and umbers. The old and new colors had the same appearance, but with a synthetic color, the name "burnt umber" no longer represented anything more than the color.

Every author, however, found that he was short some color words when adhering to the basis he followed, and so borrowed color names from other systems. For example,

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[35] Hay accepts "orange" as a color name, even though it is derived from a natural object, because of his admiration for Goethe, who also wrote that he preferred "Orange" in *Zur Farbenlehre.*

[36] Hay, *A Nomenclature of Colours*, 36.

British naturalist Henry Thornton Wharton, who based his color names predominantly on the colors of mushrooms, found that he could not help but include *Isabellinus* as his name for a light brownish yellow. The Infanta of Spain, Isabella, made a vow not to wash her linens until her husband had taken Ostend. This took three years. Another such example of such borrowing may be found in David Ramsey Hay's *Nomenclature of Colours* (1846). He generally used color words for which he could find the oldest etymological root. Unlike Werner's nomenclature, which was based on colors of animals, vegetables, and minerals, Hay disregarded names from natural objects because the specimens are too variously colored. Yet he borrowed "orange" to replace "red-yellow" because he found the word had more descriptive power. Although chromotaxonomists relied on one main source for their systems based on nature, pigments, or etymology, there was some degree of overlap in color terminology among the systems.

There are some color names that appear in the chromotaxonomy that do not have as their source any of the common derivations. What is the provenance of these color names? In large part due to correspondence with Sarah Lowengard, author of *The Creation of Color in the Eighteenth Century* (2008), I began to look at trade color names as a source. Trade color names, then as today, are often more whimsical than descriptive, such as a shade of dark gray named by a Parisian textile dyer, "burnt opera house." While this trade name was not a candidate for inclusion into works of chromotaxonomy, I found that other trade names were. For instance, *Scabieuse*, a silk textile color name, was adopted in 1861 by Chevreul in his *Exposé d'un moyen de définir et de nommer les couleurs*. Despite the complaints by Ridgeway and other authors of works of serious color nomenclatures about the chaos caused by the caprice of trade names for colors, such as in Figures 5.9 and 5.10, some trade names were integrated into their systems.

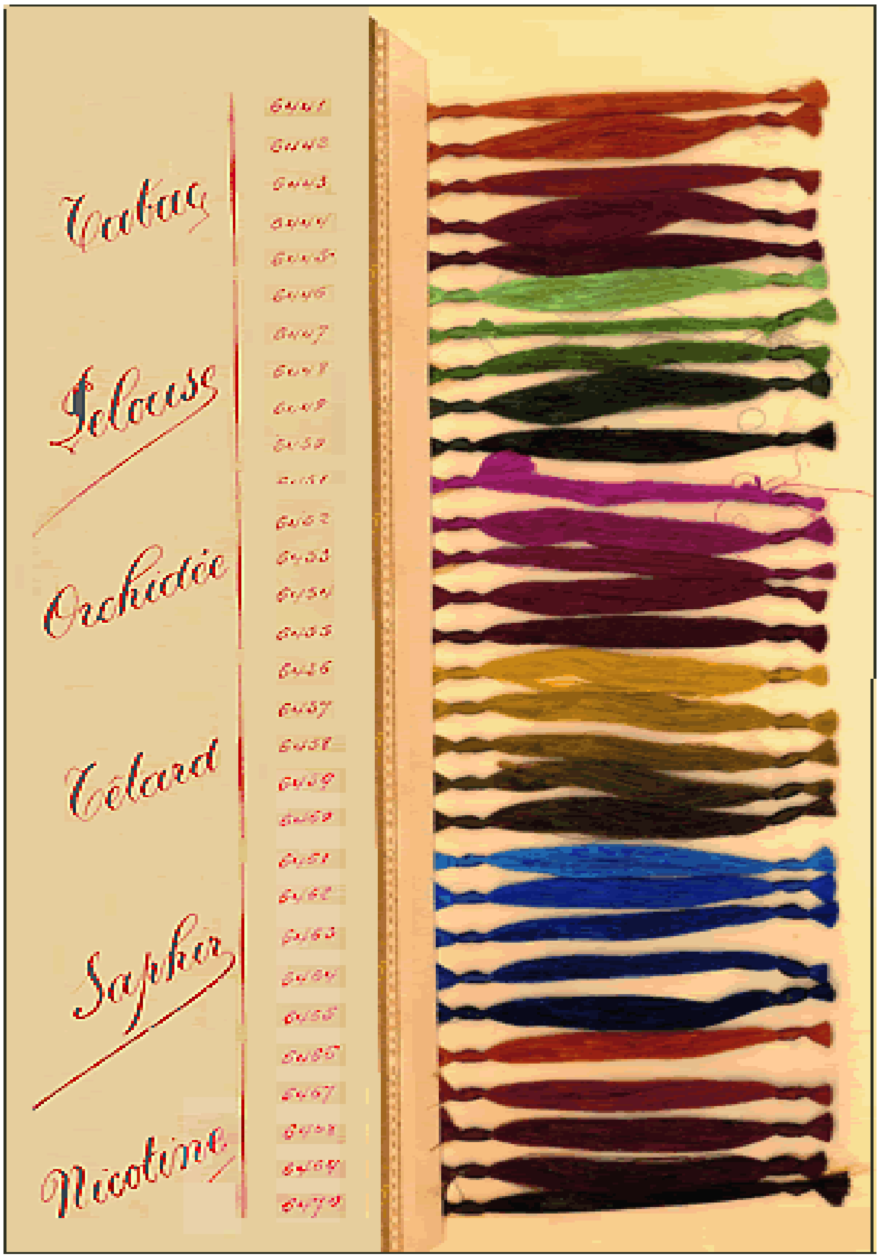

Figure 5.9. Trade names for colors from a Fall 1891 color card from the Paris house of Renard, Villet & Bunanol.[37]

[37] Trade names for colors from a Fall 1891 color card from the Paris house of Renard, Villet & Bunanol. *Source:* Hagley Museum & Library.

Figure 5.10 BASF Chemical Company Musterbuch 1900[38]

[38] BASF Chemical Company Musterbuch 0003. *Source:* http://www.kettererkunst.de/kunst/kd/details.php?obnr=411101833&anummer=405

In their struggle to find enough words to label colors, authors borrowed terms from one another, from other languages, and from the trades to complete their taxonomic nomenclature.

There were hopes among those who devised sophisticated nomenclatures that they would be as widely used as the Linnaean plant and animal nomenclature. While binominal nomenclature still serves as the basis for naming species, today Syme's *Werner's Nomenclature of Colours* (1814) and Saccardo's *Chromotaxia Seu Nomenclator Colorum* (1891) are little more than curiosities, Ridgeway's Color *Standards and Color Nomenclature* (1886) is most loved for its a charming hand-colored swatches paired with poetic color names, and Chevreul's *Exposé d'un moyen de définir et de nommer les couleurs* (1861) is an impressive monument to obsolescence.

Color Identification through Technology

Albert Munsell, whose system of color identification is still widely in use today, was already dissatisfied with the use of language to describe color divisions. His intent was to design a way of identifying color in a rational way. He felt that color names were foolish and misleading, and he preferred a decimal notation instead. The use of numerical designation of color has evolved and expanded since Munsell's color system, but the move from color terms to color codes is now standard practice.

To introduce his decimal notation of colors, in 1905 Munsell published *A Color Notation.* Improvements were made to it in 1915, and especially in the 1929 *Munsell Book of Color.* Munsell's system provided a color chart with newly proposed color notation based for the first time on exact photometric measurements of some 400 different colors. Color samples were recorded by a notation only. The decadal color-order system accounted for hue, value, and chroma. Munsell's atlas of color was arranged into removable pages of color hue swatches with varied value and chroma for each. It includes the following hues: red (R), yellow-red (YR), yellow (Y), green-yellow (GY), green (G), blue-green (BG), blue (B), purple-blue (PB), purple (P), and red-purple (RP) with numeric notation for hue and value. For example, a medium purple was designated 5P 5/10 with 5P indicating the middle of the purple color band, 5/ indicating medium value, or lightness, and 10 indicating the chroma, or purity of the color, as can be seen in Figure 5.11.

Figure 5.11. Munsell Books of Color[39]

In the division and quantification of color, Munsell laid important groundwork that continues to serve in color-space designations today. The Munsell system of color identification is still the official method used in agriculture to describe soil colors, in forensic pathology to identify skin and hair color, in dentistry to match for dental

[39] Munsell Books of Color. *Source:* https://commons.wikimedia.org/wiki/File:Munsell_Books.jpg

restorations, and as can be seen in Figure 5.12., in the frozen food industry to match French fry colors.

Figure 5.12. Munsell colors for French fries[40]

Although the Munsell system is still in use, several additional systems have been developed: the Optical Society of America's Uniform Color Scales, the International Commission on Illumination's CIELAB, also known as L*a*b*, the L*C*h*, and CIECAM02 color models. These systems rely on spectrographic readings from spectroradiometers, spectrophotometers, and spectrocolorimeters. Spectroradiometers measure the radiance of light. Spectrophotometers measure the reflectance of a color sample. A spectrocolorimeter is a spectrophotometer that can calculate the tristimulus

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[40] Munsell colors for French fries. *Source:* http://www.pantone.com/munsell-usda-frozen-french-fry-standard.

values, which are the three primary color receptors of the human eye and quantified into coordinate values of X,Y, and Z.

These technologies are used to identify color, and many color space systems, such as X-Y, L*a*b* and L*C*h*, use graphs, spheres and cylinders to define and mathematically express the color attributes. Altogether, the science and technology used in quantifying and describing human color perception through the use of coordinates in color spaces is colorimetry.

Notation systems employed in colorimetry are used to communicate in internationally accepted languages about color divisions and designations. Colorimetric measurement eliminates subjectivity in color perception by using color space coordinates with numeric correlates. Yet, there is not one universal colorimetry system for all fields. Depending on their fields, physicists, botanists, manufacturers, filmmakers, and dentists still use different color space systems to designate colors numerically.

Among the most commonly employed color spaces for dividing and mathematically naming colors are the CIE X-Y diagram color spaces, the CIELAB's L*a*b*, the L*C*h* color space, CIELUV, Hunter Lab, and the CIECAM02 color space. It will not be necessary to discuss the details of each color space system used for notation of colors, but three examples will serve.

One of the earlier color spaces was the 1931 X-Y chromaticity diagram as shown in Figure 5.13.

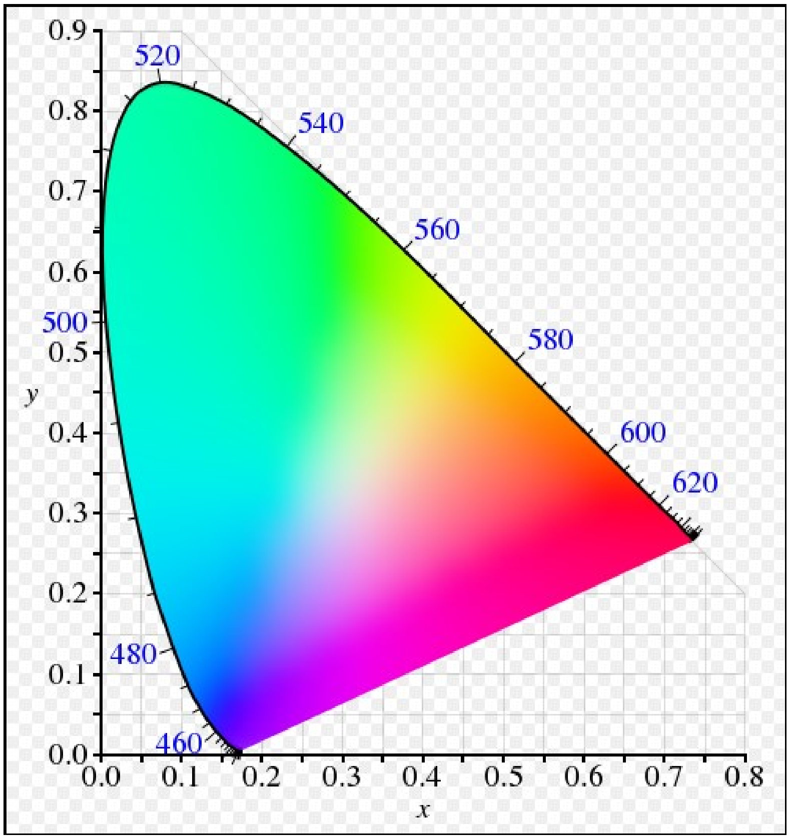

Figure 5.13. 1931 X-Y chromaticity diagram[41]

This diagram is used for two-dimensional graphing of color, independent of lightness. X and Y are the chromaticity indicators calculated from the tristimulus. The achromatic colors are central, with chromaticity increasing toward the outside. A colorimetrically measured red apple whose chromaticity coordinates are X = 0.4832 and Y = 0.3045 would be located in the color space above at the intersecting coordinates.

In 1976, the CIELAB L*a*b* color space improved upon the X-Y diagram system to adjust for perceived color differences of lightness, using a circular diagram, as in Figure 5.14.

[41] 1931 X-Y chromaticity diagram. *Source:* Wikimedia Commons.

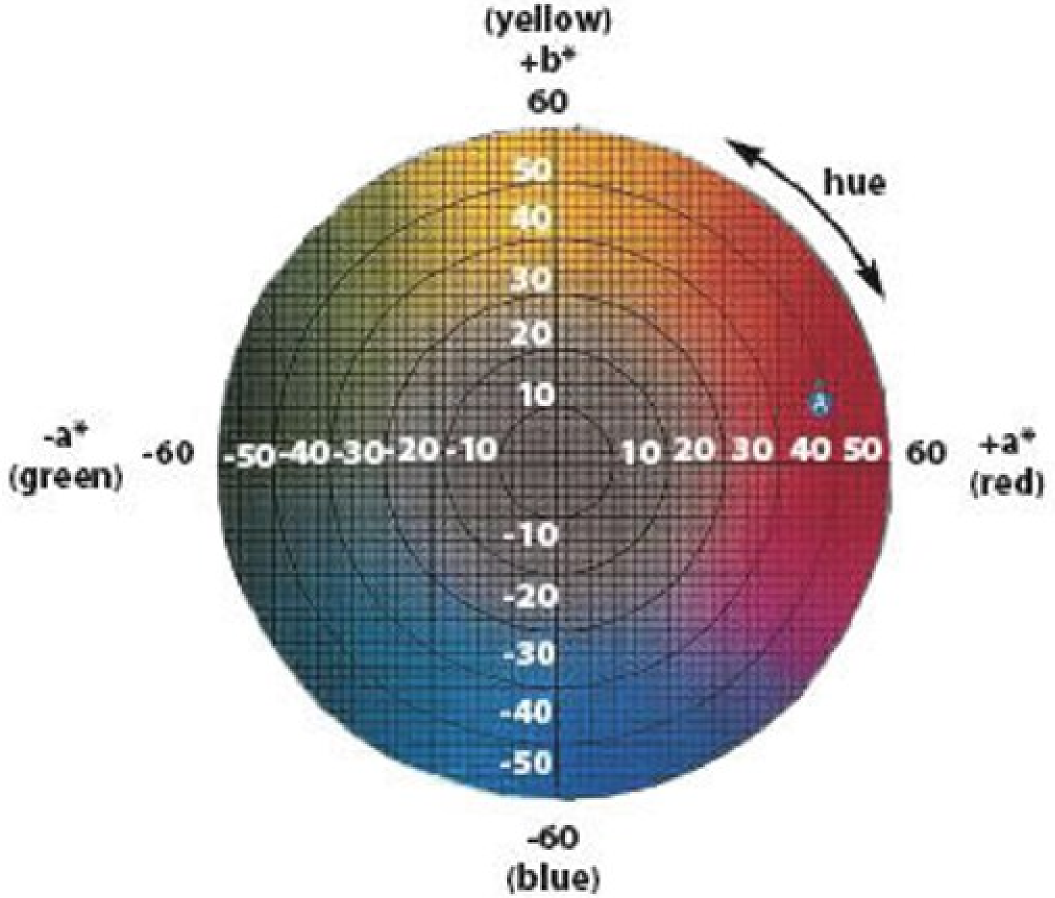

Figure 5.14. 1976 the CIELAB L*a*b* color space[42]

In a further evolution, L*C*h* color space uses cylindrical rather than rectangular coordinates. With the configuration of L*C*h* color designations, the "L" is the same coordinate as in the L*a*b* system, but the "C" accounts for chroma and the "h" accounts for hue, as can be seen in Figure 5.15.

[42] 1976 the CIELAB L*a*b* color space. *Source:* http://www.qualitydigest.com/inside/metrology-news/how-measure-color-differences.html#.

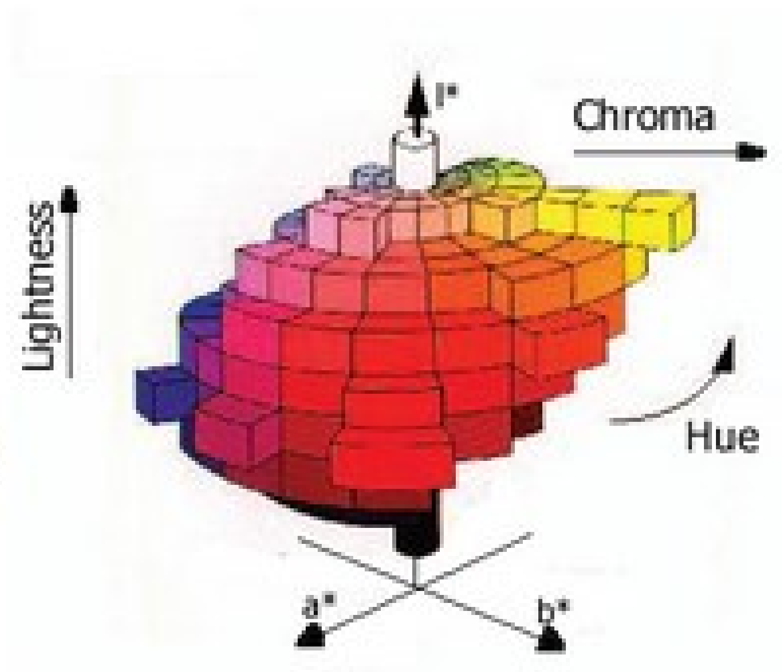

Figure 5.15. L*C*h* color space[43]

There are multiple color space systems in use today, such as the Munsell, L*a*b*, and L*C*h* color spaces, which allow for accurate reproduction and identification of color in industry, art, and science, yet there is not one universal color space system for designating these numeric color identification codes. The taxonomy of color is still varied but now with numeric systems rather than naming systems.

Despite the intention of chromotaxonomists in the nineteenth century and scientists of colorimetry today, no unanimous system of color notation prevails. Systems such as Robert Ridgway's employed the color of a referent to name the color. More technological systems establish a direct numerical (or tonal, in the case of the eyeborg), correspondence

[43] L*C*h* color space. *Source:* http://www.coatsindustrial.com/en/information-hub/apparel-expertise/colour-by-numbers.

between color spectrographic readings. Even with advances in identifying colors through the use of spectographic data, the organizing and structuring of color perception is still one of the most important tasks of the color systematists. The artificial systematization of nomenclature for color is a speech act that serves to create divisions where formerly there were none. As had Chevreul, Ridgway, Munsell, Oberthür, and Dauthenay and others, taxonomists of color purposely chose a name in order that a color become recognized and standardized. Despite the fact that language is used volitionally and in an artificial manner in taxonomic nomenclature, the words serve two purposes. The names single something out from unknown formlessness, and the names serve to build scaffolding for higher cognition through the interplay of word to world and world to word perception by revealing the underlying structures. Rather than numeric identification through spectography, which is a convenient computational tool and a means by which to match paint at a hardware store, a taxonomy comprised of words serves to relate a history, to reveal interior and exterior systems, and to build knowledge.

CHAPTER 6

SPECIES DIVIDED

After the theory chapters about division and naming, I addressed the division and naming of colors, and now I will do the same for the division and naming of species. In this chapter, I am concerned with studies of species perception. Although species perception is almost inextricably linked to their names, I address systematic and artificial taxonomic species nomenclatures as an independent topic. I take this methodical approach in order ultimately to build the case for retaining taxonomic nomenclature.

Here I will show how created divisions are imprinted by human consciousness, by subjective experience, and by cultural tradition on our perceptions of species. Folk taxonomies reveal much about the people who use them, and systematic scientific taxonomy likewise allows us to discern underlying perceptions of the taxonomist's hypotheses about how species are, or should be, divided. By showing how species have been divided, and by then examining the approaches taxonomists have taken to devise artificial languages and nomenclatures to systematize species names, I build toward my case that the nomenclature for species is not only a taxonomic treasure, but also a rich source of cultural information that is much impoverished by switching to a method of identification through genomic barcoding.

The Argentinian poet Jose Luis Borges (1899-1986), in *El idioma analítico de John Wilkins* recounts the Chinese taxonomic divisions of a "Celestial Empire of Benevolent Knowledge." "In its remote pages it is written that animals are divided into (a) those that belong to the emperor; (b) embalmed ones; (c) those that are trained; (d) suckling pigs; (e) mermaids; (f) fabulous ones; (g) stray dogs; (h) those that are included in this classification; (i) those that tremble as if they were mad; (j) innumerable ones; (k) those drawn with a very fine camel's-hair brush; (l) etcetera; (m) those that have just broken the flower vase; (n) those that at a distance resemble flies."[1] Ethnobiologists and folk taxonomists traveling to gather specimens and speak with native people to learn more about the plants and animals they were studying often came away as bewildered by the classification systems of these people as did readers of Borges' taxonomic divisions.

Why do people divide up their surroundings in the ways that they do? Why are these categories sometimes wildly divergent depending on the culture? As in the "Celestial Empire of Benevolent Knowledge," the groupings made by the American Papago Indians might leave one bemused. Their categories include "those which think," "those which are afraid of people," "those which fly," and "those which are thorny."[2] Likewise, it may seem equally strange to the Papago that Europeans lump together whales and lemurs. Upon inspection, however, one can begin to see that the Papago groupings have a logic as valid as the familiar logic of grouping animals by warm and cold-bloodedness, or flowers by their numbers of pistils and stamens. Depending on the purpose of a species category, one can put species together in an endless variety of ways because groupings are made for purposes

[1] Jorge Luis Borges. *Otras Inquisiciones* (Madrid: Alianza, 1976), 62. My translation of the passage, "Franz Kuhn atribuye a cierta enciclopedia china que se titula *Emporio celestial de conocimientos benévolos*. En sus remotas páginas está escrito que los animales se dividen en (a) pertenecientes al Emperador, (b) embalsamados, (e) amaestrados, (d) le-chones, (e) sirenas, (f) fabulosos, (g) perros sueltos, (h) incluidos en esta clasificación, (i) que se agitan como locos, (j) innumerables, (k) dibujados con un pincel finísimo de pelo de camello, (l) etcétera, (m) que acaban de romper el jarrón, (n) que de lejos parecen moscas."

[2] William W. Pilcher, "Some Comments on the Folk Taxonomy of the Papago," *American Anthropologist* 69 (1967): 205-9.

that vary greatly from place to place. American anthropologist Cecil Brown (1948-) pointed out that categories can depend on function. He cited the case of the vegetable:

> Some biological categories are not so directly underlaid by discontinuities in nature. For example, the class *vegetable* is not directly linked to a distinct biological discontinuity. In other words, there is no set of clustering features that pertains to all things called vegetables. Rather, *vegetable* exist by virtue of the fact that some botanical organisms are eaten while others are not. Mere observation of a sample of plants called *vegetables* cannot lead to a conception of "vegetableness" since these plants have little in common other than their edibleness.[3]

The case of the vegetable indicates a grouping of diverse plants, all lumped together, because we happen to be able to eat them. *Weed* is another example of a category in which diverse and unrelated plants are lumped together, such as thistles and Asian honeysuckle, because they are considered to be nuisance plants. If one calls to mind inanimate objects, such as books, here again one can categorize them according to numerous criteria. One could group all books with red bindings together, all books on bee-keeping, or, as it is rumored to have been in some English Victorian libraries, all books by women were kept in a group, so as not to comingle on the shelves in an unseemly way with the books authored by men.[4] The way of dividing and ordering our surroundings can vary according to region, to purpose, and many other factors. I will examine species division by the folk, division by descent, and division by the molecule.

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[3] Cecil H. Brown, *Language and Living Things: Uniformities in Folk Classification and Naming* (New Brunswick, NJ: Rutgers University Press, 1984): 10.

[4] A running source of amusement in my family is the idiosyncratic organization of the family address book. Instead of the usual standard of entering people alphabetically by last name, the Dillys and the Ellingsons are listed under "H" because they are "horse people." Clyde Sommerset is under "C" because he is part of "coffee group." We tease my father, the main divisor of this impenetrable system, that we children should all be under "O" because we are "offspring."

Division by the Folk

In folk taxonomies, plants and animals are often grouped together for their usefulness to people. In modern western botany, wildly unrelated plants are lumped together under the general descriptors "herb" and "weed." Folk taxonomies identify and group plants and animals in ways that sometimes require a profound understanding of the cultural context. In organizational plans for plants, it has been proposed that the first taxonomies organized plants as being either harmless or noxious to people.

This proposal makes sense, since it is of the most vital of information to pass on. Probably every child who grew up in and around the woods has a clear image in mind of the plant that corresponds to the saying "leaflets three, let it be," and by that manages to avoid exasperating bouts of poison ivy. How much more important is this means of grouping plants to those who gather them for sustenance and must teach their children not to put foxglove into their mouths. Organizing plants according to their use for human consumption, whether for medicinal purposes, social virtues, or symbolic importance, has been a common way of grouping plants across folk taxonomies. Herbalists from around the world, from ancient China, the Middle East, Mesoamerica, and Medieval Europe, have produced pragmatic taxonomies of plant groupings. Yet the American anthropologist Scott Atran, in his important work *Cognitive Foundations of Natural History,* disagrees with the assumption that folk taxonomy began with the groupings of plants into categories of harmful and edible.

Atran stated that the works of the early herbalists were not based solely on a plant's relation to people, but instead that these early taxonomies took into account many other aspects, including affinity to other plants. "The systematists, in other words, presupposed *all* that the herbalists intuitively knew with respect to local patterns of natural affinity. Such prior knowledge was necessary, but not sufficient, for an attempt at systematic generalization on a world-wide scale." [5] While it does seem likely that the initial ways of passing on information about the environment to one's offspring first focused on the most vital information, it is also likely, as Atran pointed out, that the categories soon became much more complex as culture developed. Perhaps this is because they often lived in greater proximity to nature and depended more directly on knowledge of nature for survival. One can imagine that children were early taught to distinguish plants and animals in their surroundings rather than being taught to distinguish finely among colors, since the former provided more essential information in these contexts. This is revealed in folk taxonomic categories, such as those of the Papago Indians who grouped living organisms in ways far more complex than just harmless or noxious. In the grouping "those which are thorny," the elemental grouping of plants that should be avoided is apparent. However even in the so-called primitive taxonomy of the Papago, the grouping "those which think" takes into account a feature of a living organism that is independent of its harmful or helpful relation to people.

The considerations that make up ancient and primitive taxonomies are indeed complex and not as simple as grouping things by their usefulness. Early folk taxonomies also took into account a plant's appearance, or morphology, and a plant's kinship to other plants, or affinity. Folk taxonomies tend to have such a diverse set of criteria for categories, that they are oftentimes not easily accessible to the uninitiated. In ancient herbal

[5] Scott Atran, *Cognitive Foundations of Natural History* (Cambridge, MA: Cambridge University Press, 1990), 23.

taxonomies, for instance, there frequently "appear to be 'unnatural' groupings of plants, that is, groupings based not on any readily perceived morphological similarity, but on the basis of some acknowledged virtue," noted Atran. He continued with these examples of such "unnatural" groupings:

> In European herbals since Pliny, for instance, various species of Euphorbiaceae are often grouped with plants of other families because of a similarity in the texture and color of the sap which was valued as a medicinal purgative. Similarly, in the sixteenth-century Aztec herbal known as the Badianus Manuscript, two illustrated plants appear: the *tohmioxihuitl* ("hairy plant") belonging to the tribe Chichorirae of the Compositae, and the *memeyaxiuhtontli* ("little milk plant"), a species of *Euphorbia.* These are also linked together on the basis of their milky juice – a juice thought to increase lactation in women.[6]

While the singularities of folk taxonomies revealed much about the way of life of a people, these differences also fueled the movement called cultural relativism. There are stunning and interesting differences in perception, as with the color perception. The differences in cultural perceptions are intriguing, but it is equally interesting to ask why there is so much similarity in the way people from regions as distinct as the tropics and the arctic, when exposed to the same surroundings, end by making virtually the same demarcations between things, whether plants, animals, or colors.

Ethnobiologists found that there is generally a consensus in the perception of discontinuities in nature. Brown wrote that this is because "discontinuities in nature are underlain by feature or attribute or clustering… For example, if a creature possesses

[6] Atran, *Cognitive Foundations of Natural History,* 20-21.

feathers, it will invariably also have wings, a bill or a beak, and characteristic legs."[7] More often than not, folk taxonomy makes the same groupings as modern taxonomy:

> Within any local community the layman readily perceives "gaps" between groups of organisms. For the most part, these apparent discontinuities in the local flora and fauna correspond to species differences. Among the Tzeltal Maya, for example...nearly all (95%) animal generics correspond to recognized scientific taxa, three-fourths (75%) to scientific species and more than half (57%) to "isolated species" having no congeners in the local area. So, in the majority of cases species and genus are extensionally equivalent and hence cannot be distinguished perceptually.[8]

There is little doubt that over time and across boundaries, people more often than not see the same discontinuities in their surroundings. This is not surprising, since we are all of a species, and have basically the same sensory organs and neurological make-up. Similarities in taxonomic divisions are fairly uniform when people across boundaries are confronted with specific exemplars, but it is when higher level groupings are formed and when greater levels of abstraction are applied, that wider ranging differences of category formation occur. It is easy enough to say this is a fish and that is a cat, but once one begins to articulate why, in some taxonomies, a whale is more similar to a cat than a fish that one begins to weight certain features over others. In this case, spending a lifetime in the water is less important than the means of reproduction. While the simple perception of discontinuities is fairly consistent, it is when taxonomists form groupings by features – such as usefulness to our own species, mode of locomotion, morphological similarity, and mode of reproduction – to establish criteria for categories that the groupings tend to diverge. Here again it is useful to examine our assumptions.

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[7] Cecil Brown, *Language and Living Things,* 9.

[8] Atran, *Cognitive Foundations of Natural History,* 28.

Most principles of taxonomy that have come to us in Western European culture can be traced to Aristotle. Many of the categories set forth by Aristotle have come to be viewed as natural, as somehow beyond question. Because they are supported by common sense and because they have a long heritage, these groupings seem to us inevitable, and Aristotle's categories have formed the foundations of the works of most subsequent European naturalists. First among these is that groups must be identified by their substantial and not their accidental characteristics. First and foremost, it is the substance of the species – the thing that determines the purpose of its being – that distinguishes it. Second, there are the characteristics that define groups, the *differentiae.* Third is the rule to divide genus by their plurality of *differentiae.* In *Metaphysics* Aristotle wrote,

> It is also necessary that the division be by differentia *of the differentia*; e.g. "endowed with feet" is a differentia of "animal"; again the differentia of "animal endowed with feet" must be of it qua endowed with feet. Therefore we must not say, if we are to speak rightly, that of which is endowed with feet one part has feathers and one part is featherless (if we do this we do it through incapacity); we must divide it only into cloven-footed and non-cloven; for these are differentiae in the foot; cloven-footedness is a form of footedness.[9]

It is important in Aristotle's scheme to make divisions successively but to base them first on substance and not on accidents. For example, the substantial quality, such as footedness, comprises the essential or substantial quality of the species, and is not an accidental quality. Under Aristotle's scheme, it would not make sense to make divisions by mixing the accidental with the substantial qualities. Instead, divisions are made according to the

[9] Aristotle, *Metaphysics,* trans. W. D. Ross. http://classics.mit.edu//Aristotle/metaphysics.html

substance, which is the main *differentia*, and the remaining *differentiae* would be used to create groupings:

> For instance, if we had divided, at a high level, into *feathered* and *featherless*, and then divided *feathered* successively into *tame* and *wild*, a member of the group "featherless" might well also be wild (or tame). This is not possible with successive division: if we divided the differentia *feather* into different conditions of feathers, no member of the group "featherless" can possess the differentia. ... Without successive division, as many differentia are needed as there are divisions; but with successive division, only one differentia, the last one, is needed, because it implies all others....The last differentia will be the substance of the thing and its definition.[10]

Aristotle's hierarchical method, which sought to identify the main substantial or essential quality of a being, was passed on and appears implicitly in subsequent taxonomic systems.

Atran noted that, although there were already common notions in place about how the world was organized, the movement to systematically study the living world was begun by Aristotle, and naturalists who followed, assumed, to a large measure, the precepts he set forth. "Such a movement was possible at all, however, only because access was assured by a common-sense appreciation of the living world shared not only by Aristotle and Linnaeus, but by ordinary folk everywhere."[11] Systematic taxonomy has, of course, a large dose of common sense, but groupings were ordered also according to ideals and abstractions:

> The principle task of Aristotelian philosophy and science, or metaphysics, is to determine the essential nature of common sense ontology so as to reveal these different pieces of the world as instances of, or more justly as teleological tendencies *to*, order and beauty. As a result, Aristotelian speculation goes beyond simple common sense; that is to say, those

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[10] Mark Ridley, *Evolution and Classification: The Reformation of Cladism* (London: Longman, 1986), 101.

[11] Atran, *Cognitive Foundations of Natural History*, 85.

> intuitively obvious aspects of common sense that are visibly manifest and iterated in ordinary language constitute necessary, but not sufficient, conditions for the determination of how the world is structured. Speculation aims to connect intuitively separate and dissimilar features of the everyday world (distinct relations, qualities and substances) into a harmoniously integrated universe. In it, each thing will be shown to have its proper place relative to every other in the economy of nature. Accordingly, the determination of essences involves a mixture of commonsensical and aesthetic criteria.[12]

Seeking to organize the world in an orderly and beautiful way so as to fulfill an aesthetic plan necessitates that one sometimes gloss over the facts. This became especially apparent as the known world became much wider and more diverse than it was during Aristotle's time. Atran commented, "Initially, for Aristotle, it is a question of analyzing the already well-formed ranks of lay taxonomy so as to systematically unify their constituent taxa. Second, only later, with Europe's Age of Discovery, does the problem of 'enormous proportions' arise with the consequent attempt to reform the traditional taxonomic ranks so as to extend their scope beyond the limits of the local flora and fauna to the living world at large."[13] With Europe's Age of Discovery, the work of Aristotle, Theophrastus (371-287 B. C.), Pliny, and the medieval herbalists and naturalists, while still useful and influential, became insufficient. The mere 500 different animals that Aristotle dealt with in his scientific works, and the 550 plants Theophrastus discussed, were dwarfed in number by the time Linnaeus began his work, and specimens were still pouring in.

The ambition of the great organizer Carolus Linnaeus was to create a system in which all things could be accounted for in an orderly fashion. Part of the reason for the

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[12] Atran, *Cognitive Foundations of Natural History,* 85.

[13] Atran, *Cognitive Foundations of Natural History,* 289.

success of the Linnaean system is that it was rooted in the familiar concepts set forth by Aristotle, which were the tacit foundations for European taxonomy. As with Aristotle's reliance on identifying the substance of a species, Linnaeus likewise based his system on identifying essential characteristics. In botany, Linnaeus classified with the reproductive system because of its essential importance to the defining of the plant. Using this essential or substantial quality, then also allowed Linnaeus to make successive further divisions according to *differentiae*, which was the third rule set forth in the Aristotelian system.

The Linnaean system itself was both derivative and original. His botanical system may be described as an artificial system that included many ingenious and practical inventions. His animal taxonomy, however, more or less expanded on existing "natural" systems of classification and had fewer organizational novelties. His masterpiece, *Systema Naturae,* used many existing taxonomic strategies, but its rules were, "an elegant package which so surpassed other existing schemes in their all-encompassing nature, their clarity, and their simple good sense – seeming so inexplicably right to so many – that they and he would take the world by storm."[14]

From his mentor and family physician Johan Rothman and his predecessors, Linnaeus adopted the sexual system of plant classification. "Rothman demonstrated to Linnaeus how to examine a plant according to Tournefort's system. When one finds an unknown plant, Rothman explains, the first thing is to see if the flower bears petals or not. If there are petals, one then examines whether the flower is single or double or notes

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[14] Carol Kaesuk Yoon, *Naming Nature: The Clash between Instinct and Science* (New York: W.W. Norton, 2009), 26.

whether it is formed like a bell, or has some other shape."[15] Linnaeus went on to refine and defend the sexual system of plant identification, which was at that time still under attack.

He maintained that the relationship between the stamens and the pistils may take one of three forms: they may be united in the same flower, as is most usually the case; they may be separated but found on the same individual plant; or they may be found on separate individuals. Linnaeus devised a simple hierarchy that arranged plants into twenty-four classes according to the number and position of their stamens (male parts). From there he divided the classes into sixty-five orders, mainly in accord with the number and positions of their pistils (female parts). In addition, Linnaeus attempted to base his refinements on empirical evidence:

> He amasses seven items of empirical evidence for his sexual theory: that there exist flowers whose long pistils bend down when they bloom to receive pollen and then straighten up again; that rain is harmful to the setting of fruit if it falls when cereals are shedding pollen or when fruit trees are in bloom, so that the pollen is beaten to the ground instead of finding the pistils; that plants with their sexual organs located apart generally have the male flowers above the female flowers so that pollen can easily fall onto the latter; that catkin-bearing trees bloom before the leaves come out, enabling the pollen to reach its target unimpeded; that the stamens and the styles of stigmas of the pistils come out simultaneously (the many exceptions had apparently escaped his notice) because their functions have to be coordinated; that the ancients had pointed out that in the nutmeg and in the palm the males had long been regarded as absolutely essential to the fertility of the female trees. Finally – and unusually – Linnaeus refers to an experiment: …if the anthers are removed from a hermaphrodite flower, it may sometimes bear seed notwithstanding, but these seeds will not prove germinative.[16]

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[15] Gunnar Eriksson, "Linnaeus the Botanist," in *Linnaeus: The Man and His Work*, ed. Tore Frängsmyr (Canton, MA: Science and History Publications, 1994), 64.

[16] Gunnar Eriksson, "Linnaeus the Botanist," 70-1.

This artificial system was much simpler than other methods of botanizing at the time, and was meant only as a tool to later organize the diversity of plant species according to the reality of divine order. Although this artificial method of plant classification was effective and useful to many professional and amateur botanists, Linnaeus had hoped it was only a stage in his methods of classification. Linnaeus examined various artificial systems and compared them with that which he had devised and concluded in *Philosophia botanica* Chapter II of Botany, Section LXXVII that:

> besides all the above-mentioned systems or methods of distributing the plants… there is a natural system, which we ought diligently to endeavor to find out… And that this system of nature is no *chimera*, as one may imagine, will appear, as from other considerations, so in particular from hence, that all plants, of what order soever, show an affinity to some others to which they are nearly allied. In the meantime, till the whole of nature's method is completely discovered (which is much to be wished), we must be content to make use of the best artificial systems now in use.[17]

He never gave up the idea of discovering God's order in the organization of plants.

"Acknowledging that his method did not reflect any 'real' order in nature, Linnaeus believed that naturalists nevertheless could use his 'artificial' system until he developed one that actually conveyed God's plan in nature. He worked the rest of his life at constructing such a 'natural' system but was, in the end, unable to formulate one satisfactorily."[18] The simplicity of his botanical system allowed for the rapid collection and classification of thousands of plant species from around the world, and the world was, at just that time, receptive to a system of organizing nature.

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[17] Carl Linnaeus, *Philosophia botanica,* trans. Stephen Freer (Oxford: Oxford University Press, 2003), 51.

[18] Paul Lawrence Farber, *Finding Order in Nature: The Naturalist Tradition from Linnaeus to E.O. Wilson* (Baltimore, MD: The John Hopkins University Press, 2000), 9.

Linnaeus lived in an era in which people had a particular love for the living world. It was common for families to display collections of butterflies, to plant theme gardens with new and exotic plants, to press and label flowers:

> The living world was considered so delightfully entertaining that inns and taverns were luring customers with their advertised collections. The Museum Coffee House, a London public house, kept such an extensive display that Benjamin Franklin thought it worthy of a visit. There you could drink your pint while surrounded by such rarities as two South Carolinian garter snakes, barnacles, a frog over a foot long, a whale's penis, and even, somewhat more in the vein of Ripley's Believe It or Not, a starved cat discovered in the walls of Westminster Abbey.[19]

The esteem held for collections from nature and cabinets of curiosities were further beneficial to Linnaeus because he was a gifted teacher. Hundreds of students were attracted to his lectures. Students and those who just wished to tag along and help classify according to his simple sexual system, accompanied him on 40-kilometer long hikes. Lynda Payne, who wrote a commemoration of Linnaeus for the tercentenary of his birth in Uppsala, Sweden in 2007, described his popularity as a botanizing teacher with this anecdote: "In 1748 the rector of the University finally put an end to these noisy and somewhat drunken events with the famous words: 'We Swedes are a serious and slow-witted people, we cannot, like others, unite successfully the pleasurable and the fun."[20] The popularity of collections from nature and botanical classification among Western gentlefolk was a pastime in keeping with an orderly creation.

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[19] Carol Yoon, *Naming Nature,* 34.

[20] Lynda Payne, "'Mr. Flower Power': Celebrating Linnaeus in 2007," *Language and the Scientific Imagination: Proceedings of the 11th Conference of the International Society for the Study of European Ideas (ISSEI),* Helsinki, Finland (July 28-August 2, 2008): 2, http://hdl.handle.net/10138/15274.

In *Systema naturae,* Linnaeus makes clear that in his system of organizing the natural world, he was following the structure of God's order.[21] Whereas Aristotle pointed to essences as the underlying purpose of all organisms, Linnaeus pointed to a divine order. His system was practicable for professional and amateur botanists alike, and although his botanical system was artificial instead of natural, he defended it because it was serviceable for all the work at hand.

The predecessors of Linnaeus, such as Otto Brunfels (1448-1534) with *Herbarum vivae eicones,* Andreas Cesalpino (1519-1603) with *De plantis*, and John Ray with *Historia plantarum*, had already done much to systematize botany. Their systems relied on varied principles of organization but had in common the assumption that species were stable through space and time. Linnaeus shared this assumption. He wrote in *Fundamenta botanica* (1736), "We count today as many species as were created in the beginning."[22] Linnaeus imagined that the world began as an Eden or paradise containing all species and that it was just a matter of time until enough discoveries were made to complete the taxonomic record. As the son of a Lutheran minister, Linnaeus believed that God, in all his perfection, would not have left any gaps. He wrote in *Philosophia botanica* (1751), "The absence of things not yet discovered has acted as a cause of the deficiencies of the natural method; but the acquisition of knowledge of more things will make it perfect; for nature

[21] Linnaeus believed that animals and plants existed in his day as the creator had made them. Later, though, he conceded that through hybridization some new species had come about since the day of creation.

[22] Gunnar Brober in "Broken Circle," in *The Quantifying Spirit in the 18^{t}h Century,* ed. Tore Frängsmyr, J. L. Heilbron and Robin E. Rider (Berkeley, CA: University of California Press, 1990), 54. Brober quotes Linnaeus.

does not make leaps."[23] It therefore seemed to him that the world could be fully comprehended taxonomically. Because of the underlying assumption that species were discrete and stable, Linnaeus persisted in classifying all of the new specimens being sent to him by his pupils and other botanists. Linnaeus believed that he, or future botanists, would one day classify the entire plant kingdom.

The general public and the many of the scientific community were primed for an ambitious and comprehensive method of ordering the natural world. It was common for the followers of Linnaeus – his apostles, as they were known – to accompany him devotedly into the fields to gather specimens. Some of his pupils sailed to exotic locations in South America and in the Indies just to report back with new and exciting species to classify:

> Such were the men whom Linnaeus sent out to distant and dangerous lands in order that man's knowledge of the world's flora and fauna might be extended. When he learned of the perils to which they had been exposed, and the hardships that they had endured, when he remembered those who had died or had returned with broken health, he may well have recalled what he had written in 1737 in his *Critica Botanica* while reviewing the lives of earlier botanical travellers: 'Good God! When I observe the fate of botanists, upon my word, I doubt whether to call them sane or mad in their devotion to plants.'[24]

Those who were mad in their devotion to plants helped to establish Linnaean taxonomy as the blueprint for taxonomic practices even today. Despite the revolutionary ideas and scientific advances that have occurred since the time of Linnaeus, his system still holds sway in taxonomic circles, and devoted traditional evolutionary taxonomists still struggle to adapt

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[23] Carl Linnaeus, *Philosophia botanica,* 49.

[24] Wilfrid Blunt, *Linnaeus: The Compleat Naturalist* (Princeton, NJ: Princeton University Press, 2001), 197.

his system to the times. The methods of taxonomy founded by Aristotle and ingeniously refined by Linnaeus focused chiefly on external characteristics. Comparing morphological features to form groupings, or the phenetic method, would rally in the mid-twentieth century; yet taxonomy is in the midst of a monumental shift.

Just as in the case of color perception, taxonomists' perception of species, although admittedly much more complex, began to undergo a confounding kaleidoscope effect depending on the point of view that the taxonomist took. While the difficulties increased in color taxonomy as researchers found cultural differences in color perception and became ever more aware of the problems presented by the continuity of the spectrum, in the biological sciences, the complexities presented by cultural and regional variation was further complicated once it became established that species were not, as had been assumed, fixed and stable.

It is useful here to recall the chapter on the nature of discontinuities and division, and to thereby tie the color and species dilemma together. Until nearly the eighteenth century, species and color were considered by most to be objective entities. An interest in the reality of colors arose in the nineteenth century, which led to a flurry of studies of ancient literature and of color perception among primitive people. This had influence on the future of color nomenclature. With the acceptance of the theory of evolution, the existence of species as an objective category was called into question, much as had the objective existence of colors. Were there real divisions in nature, were they subjective, as some folk taxonomists contended, or were species simply created categories for human convenience, pulled out of an amorphous evolving continuum?

Division by Descent

As had Aristotle, Linnaeus believed that objective categories existed in nature. For Linnaeus, everything in nature could fit into five hierarchic categories: Kingdom, class, order, genus, and species. Nature was seen by Linnaeus as a cupboard full of compartments containing smaller and smaller boxes within. He saw nature as ordered according to a uniform hierarchy. Although this hierarchical view was challenged even before the publication of Charles Darwin's *Origin of Species*, taxonomy was already moving away from classical formalism.[25] Yet it was with the theory of evolution that the nature of species had to be reconsidered.

The Aristotelian and Linnaean search for the essence of a species, or a natural divine order, and the resultant ordering of species into hierarchic ranks, usually with *Homo sapiens* at the pinnacle, was by and by being called into question.[26] If one does not believe in some external logic that gives order to species – or for that matter, colors – then one is free to devise a system according to other criteria. With the general acceptance of evolutionary theory, not only were the assumptions underlying taxonomy shifting; the entire edifice being organized was transformed from solid to liquid, so to speak.

Mounting evidence for the evolution of species put the paradigm founding the shape of the classificatory system at stake. The accepted underlying theory of taxonomy came

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[25] For instance, Lamarck described a natural distribution of species, or continuous scala, which he contrasted with the artificial division by means of a classification intended to produce a hierarchy.

[26] "Part of the history of taxonomy between Linnaeus and Darwin could be regarded as the rejection, but not total abolition, of the concept of natural order as a scala," wrote Alec L. Panchen, *Classification, Evolution, and the Nature of Biology* (Cambridge, MA: Cambridge University Press, 1992), 118.

from the observational method and the comparison of specimens. Linnaeus, for example, had a sense of his surroundings that came from countless hours of fieldwork with his apostles. He came to his system of classification, in part, by viewing plants within their natural settings and comparing their forms, or morphological features, in order to establish taxonomic ranks. Such a method, based as it is on the external characteristics, or morphology, of a species, is still favored by some taxonomists.[27] The growing importance of derivation of species caused a shift in approach in taxonomy. Instead of focusing on the comparison of external characteristics, taxonomists began to pay more attention to the ancestry of a species. Between the method of taxonomy which relied on the comparison of external characteristics, to the method of taxonomy that relied on the tracing of ancestry, there are several intermediate methods.

The practice of taxonomy with *a priori* weighting of characteristics was giving way to the practice of taxonomy in which organisms were ordered into intuitively natural groups and characteristics were weighted *a posteriori.* One can view the practice of organizing either on the horizontal (phenetic) plane or on the vertical (phylogenetic) plane. Another way of viewing this dichotomy (although there are certainly more than two ways of

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[27] In traditional taxonomy the external characteristics of a species are carefully compared to those similar to themselves in order to note differences in appearance. Comparing the number of petals, or mammaries, for example, is a method employed in traditional taxonomy. The external characteristics are known as morphological features. The comparison of morphological features is the basis of phenetic taxonomy as well as numerical taxonomy. The practice of defining species primarily by means of their descent gained favor after evolutionary theory. Defining species by descent has several branches in taxonomy. Traditional evolutionary taxonomy takes into account phylogyny (over phenology), and more recently, the division of species by clade, the nearest branching of the family tree, gained sway. Phylogenic and cladistic methods continue to expand as more advances are made with identification through DNA sequences.

organizing) is to think of them as either classifications or systemizations. In classification, organisms are defined by a characteristic shared by the members. Systemization describes the way in which elements are related and attempts to reconstruct the whole.

Darwin was more interested in gaining a view of the whole. While he did important work in classification, his greatest contribution to the field of taxonomy was in systematics. The astounding insight that one species can evolve into another new species changed taxonomy from a straightforward (if complex) system of classification to one in which species must be viewed over the course of time. Metaphorically speaking, a more accurate taxonomy must reflect both the horizontal and vertical levels of species. The dilemma is plain: if species are variable, how can they also be real? By way of comparison, it is useful to consider things thought by most to be invariable. The element whose atoms have 79 protons in each nucleus was from the origin of the universe until this day gold. It has not changed or evolved in any fashion, so its identity is certain. Laws of nature likewise are considered by most to be invariable; thus that they may be called laws. As previously discussed, mathematics is also thought by many to hold an invariable transcendence. Such was the view of species. Species were thought to have essences or to have fitted into a divine order. Species were believed to be fixed and constant. However, with the increased certitude that in the distant past our world was filled with beings quite unlike those which now exist, not only was the idea of the fixity of species thrown into doubt, but also the very idea of species at all. As he came to see the implications of evolutionary theory, Darwin grappled with doubts about the nature of species.

The species debate, as the problem brought about because of evolutionary theory has come to be known, concerns taxonomic practice, language, and philosophy. In *On the*

Origin of Species by Means of Natural Selection, Or the Preservation of Favoured Races in the Struggle for Life, Darwin repeatedly defined species, both in individual cases and as a category as existing only in name, or nominalistically, and therefore as arbitrary groupings not existing outside the mind, but argued also for the objective existence of species as defined by interbreeding populations:

> From these remarks it will be seen that I look at the term species, as one arbitrarily given for the sake of convenience to a set of individuals closely resembling each other, and that it does not essentially differ from the term variety, which is given to less distinct and more fluctuating forms. The term variety, again, in comparison with mere individual differences, is also applied arbitrarily, and for mere convenience sake.
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> In short, we shall have to treat species in the same manner as those naturalists treat genera, who admit that genera are merely artificial combinations made for convenience. This may not be a cheering prospect; but we shall at least be freed from the vain search for the undiscovered and undiscoverable essence of the term species. [28]

Although it is possible to attribute to Darwin the opinion of species nominalists, it would be odd if Darwin entitled his book *Origin of Species* if he came to say that species are only convenient mental constructs which do not exist out in the world. In his struggles to define species, Darwin was responding to his own research but also to debates about species that surrounded him. Evolution and species nominalism were in his time commonly equated. In 1809, the preeminent French naturalist Jean-Baptiste Lamarck had written:

> it was no doubt indispensable to break up the productions of nature into groups, and to establish different kinds of divisions among them, such as classes, orders, families, and genera. It was, moreover, necessary to fix what are called *species*, and to assign special names to these various sorts of objects. This is required on account of the limitations of our faculties, some such means are necessary for helping us to fix the knowledge which we gain

[28] Charles Darwin, *The Origin of Species by Means of Natural Selection,* 39, 304, http://charles-darwin.classic-literature.co.uk/the-origin-of-species-by-means-of-natural-selection/.

> from that prodigious multitude of natural bodies which we can observe in their infinite diversity.
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> But these groupings, of which several have been happily drawn up by naturalists, are altogether artificial, as also are the divisions and sub-divisions which they present. … We may, therefore, rest assured that among her productions nature has not really formed classes, orders, families, genera or constant species, but only individuals who succeed one another and resemble those from which they sprung.[29]

Lamarck proposed here that all units of nature exist as individuals and that the groupings applied to them are for our convenience but are not real. The essentialism of Aristotle and the received interpretation of creation story in Genesis had informed generations of naturalists and perpetuated a static view of nature. Ray himself believed that in a single act of creation all species were designed in their perfect states. In 1686 in *Historia plantarum,* Ray wrote, "the number of species in nature is certain and determined: *God rested on the sixth day, interrupting his great work* – that is the creation of new species."[30] Ray believed that species were fixed and had essences but that individuals of a species varied in their outward manifestations. These outward manifestations were all naturalists had at their disposal in making classificatory systems.

The notion that organisms were created and then replicated copies of themselves – like nested Russian dolls – was quickly losing currency as the eighteenth century progressed. Three major discoveries called fixity of species into question: the fossil record, an increasing awareness of hybridization, and European voyages of discovery. First, naturalists had at hand a growing number of fossils, some of which did not seem to represent any living species. The fossil record indicated that species change over time and even

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[29] Jean-Baptiste Lamarck, *Zoological Philosophy*, trans. Hugh Elliot (New York: Hafner Publishing Company, 1963), 20-1.

[30] Atran, *Cognitive Foundations of Natural History*, 162. Atran quotes Ray.

become extinct. Second, naturalists were becoming more and more aware of fertile hybrids; new species could emerge through experiments and in the wild through interbreeding between species. Third, previously unknown species were being discovered by Europeans in the Americas, Asia, and in the Indies. These new specimens stretched the limits of Enlightenment systems. All new theories had to address the historical aspect of change, the stability and the diversity of species; in other words, new theories of natural order had to account for the temporality and morphology of organisms. Thus began the questioning of the strictly analytical systems of the Enlightenment and the formulation of the more synthetic systems typical of the Romantic era. Yet this view of nature as unchanging was giving way to a more dynamic view even late in the life of Linnaeus. By Darwin's time, the nature of species was a fiercely contended topic and remains so to this day.

As a result of the Darwinian revolution, the focus of taxonomy had shifted from one in which external characteristics were foremost in determining the ordering of the natural world, into one in which the line of descent became primary. Although there would be a brief revival of the phenetic method under the guise of numerical taxonomy, which I shall describe below, the current methods rely on data which can indicate lines of descent. Evolutionary biologists group animals according to clades, or relative recency of common ancestry, and genomic sequencing.

The Austrian American biologist Robert Sokal (1926-2012) and the American physician and microbiologist Peter Sneath (1923-2011), working continents apart and on different species, came to this method at around the same time. Sokal worked in Lawrence, Kansas with the American entomologist and famed bee taxonomist C. D. Michener (1918-2015). Michener practiced traditional evolutionary methods of taxonomy, in which he studied the details of form, color, and markings of his bees, but also closely observed their habits and relationships. Although Michener and Sokal worked in the same department, they were not of the same mind. Sokal had spent much time in the company of fellow graduate student Clyde Stroud, who was passionate about the application of mathematics and statistics to the field of biology. Having come to be a convert to this method himself, Sokal was at odds with the traditional evolutionary taxonomists in the department.

This resulted in a wager. Sokal boasted that by using mathematical formulas and statistics he could come up with a system more accurate than Michener's traditional taxonomic system of ordering the Hoplitus complex bees. Sokal coded 122 characters of physical feature and gave the characters a numeric code. He formed a data base to account for the variance of character. In many ways, this method was like the methods employed by a classical Linnaean taxonomist. The difference lay in the fact that Sokal did not use knowledge of the bees' environments and habits in order to weight the characters. For Sokal, each physical feature of the bees carried equal weight. A traditional evolutionary taxonomist used knowledge gained through long observation to weight the various physical characters according to their preponderance through generations. Carol Yoon, contemporary science writer for the *New Yorker* magazine and author of *Naming Nature,* recounts the process of weighting as follows:

> The evolutionary taxonomist might have noticed, for example, that three groups of the bees shared a certain curious shape to their antennal segments and also a cloudy, pigmented patch in one area of their wing, as well as strangely small mouth parts. If he, in his lifetime of experience with studying bees, had found each of these characteristics to be extremely rare, then he might feel that it was most likely that these three groups shared their rare characteristics because they were close relatives. Because if each were a very rare characteristic, it would be unlikely that all three different types of bees would have evolved all three characteristics independently. Much more

> likely, they shared the three characteristics because they inherited them from some ancestor, some original small/mandibled, cloudy winged, funny antennae/bearing bee species that gave rise to them. On the other hand, if the evolutionary taxonomist had reason to believe that it was quite an easy thing to evolve, or that these were a suite of adaptive traits that worked well together and so would likely evolve as a group again and again, he might ignore the three characteristics altogether in his ordering because they were likely to be poor indicators of close evolutionary relationship. And so he would proceed, clustering and reclustering species, imagining and reimagining the evolutionary scenarios that each new ordering system demanded, trying to judge each scenario's likelihood, trying to get a feel for which species seems most closely related, which characteristics most important in determining relationships and which downright misleading.[31]

Whereas the traditional evolutionary taxonomist made judgments along the way as to the importance of different features, a numerical taxonomist weighted all features equally. At the conclusion of the wager, when the Hoplitus complex bee evolutionary trees were compared, the results Sokal achieved with his strictly computational method were nearly the same, and sometimes more accurate than those used by Michener.

Across the Atlantic, the young physician Sneath had taken a research post at the National Institute for Medical Research in England to study bacteria. Sneath was working on thirty-eight strains of exotic Malaysian *Chromobacterium*. As a first step, Sneath decided to situate the bacteria in the taxonomic tree, but this proved to be quite difficult. Not only do bacteria have very few defining characteristics, they are also capable of quick physical change. One of the few features bacteriologists had to go by was the whiplike tail with which bacteria propel themselves. These tails are either located at the pole or side, and bacteriologists used the location of the flagella, or tails, to place bacteria in one genus or another. Sneath noticed on his *Chromobacterium* that the flagellum could quickly change from the polar to lateral position, thus making this physical characteristic useless as a feature

[31] Carol Yoon, *Naming Nature,* 201.

with which to determine a taxonomic grouping. Sneath began examining the criteria other bacteriologists used for making their decisions of taxonomic groupings and found that there were many methods, all ill-defined and with little consensus among the practitioners. Sneath published his findings about the flagella and the state of confusion in bacteriological taxonomy. He started to think that there must be some objective way to order bacteria and was casting about for ideas when by chance in 1959 he went to Kansas and met Sokal. Not long after, Sokal went to visit Sneath in London, where the two initiated collaboration on making a broad-based numerical taxonomic system that could be used not only for bees, but for bacteria and every other species that needed to be classified.

The result of Sokal and Sneath's collaboration yielded the seminal work on numerical taxonomy called *Principles of Numerical Taxonomy,* which Sneath described as the greatest advance since Linnaeus. Sokal and Sneath called for a revision in the way taxonomy was practiced. He explained, "As our knowledge of the organic world increases there are continuing stresses and strains in the frame of the taxonomic system to accommodate those new discoveries, and the inadequacies of the present system become ever more apparent."[32] They also found that "the present system of taxonomy tries to fulfill too many functions at once and as a consequence does none of them well. It attempts (1) to classify, (2) to name, (3) to indicate degrees of resemblance (affinity), and (4) to show relationship by descent – all at the same time."[33] The main fault that Sokal and Sneath found

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[32] Robert Sokal and Peter Sneath, *Principles of Numerical Taxonomy* (San Francisco, CA: W. H. Freeman and Company, 1963), 48-50.

[33] Sokal and Sneath, *Principles of Numerical Taxonomy,* 6. The scope of their book does not address extensive revisions to the nomenclature system, although the authors indicate that the nomenclature system also needs to be thoroughly revised.

with the present system was that it is derived from a natural system of taxonomy. Sokal and Sneath argued that natural taxonomy is based on Aristotelian logic, which they found unsuited for biological classification:

> This was the method used by early systematists such as Cesalpino and even largely by Linnaeus. The Aristotelian system as applied to taxonomy consisted in the attempt to discover and define the *essence* of a taxonomic group (what we may somewhat loosely think of as its "real nature" or "what makes the thing what it is"). In logic this essence gives rise to properties which are inevitable consequences: for example, the essence of a triangle on a plane surface is expressed by its definition as a figure bounded by three straight sides, and an inevitable consequence is that any two sides are together longer than the third. ... Aristotelian logic does not, however, lend itself to biological taxonomy, which is a system of *unanalyzed entities,* whose properties cannot be inferred from the definitions – at least not if the taxonomy is to be a natural one.[34]

Instead of adhering to a natural system, as they argue all systems until then had, Sokal and Sneath advocated a system based on objectivity. The tenets of numerical taxonomy are objectivity, repeatability, quantification, and explicit and explicable methods.[35] No features could be singled out or weighted as more significant.

Luckily for Sokal and Sneath and others who were joining the movement, the widespread use of computers coincided with the rise of numerical taxonomy. All the numerical data could easily be stored, retrieved, and computed electronically. Yoon described the practitioners of numeric taxonomy in the 1960s as men working in sterile labs, wearing white coats, and always having a ruler at hand. This image she contrasted with that of Linnaeus and his followers, who walked in their gardens and in the woods luxuriating in

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[34] Sokal and Sneath, *Principles of Numerical Taxonomy,* 12.

[35] Sokal and Sneath, *Principles of Numerical Taxonomy,* 5.

the sensuousness of life while at once practicing their craft.[36] It is indeed a contrast to see Sokal and Sneath's book filled with chapters of complex formulas and graphs beside a friendly illustrated guide to the identification of flora from a century ago.

Division by the Molecule

While traditional taxonomists, with their glass boxes full of beetle and butterfly specimens, and perhaps a curio cabinet filled with dusty bottles of snakes floating in formaldehyde, were dismayed at the cool analytics of numerical taxonomists, they would come to feel all the more estranged from their observational methods once chemists intruded into their field. Numerical taxonomists at least still looked at specimens, but the chemists entering the field of taxonomy had no need for anything but a little chunk of the species they were investigating. A few cells of a kangaroo, an orchid, or a fruit fly, pureed into a slurry, centrifuged a dozen times, poured onto a slab of gel and electrocuted, yields all the information a chemical taxonomist needs.

At the forefront of these chemical taxonomists was the Nobel Prize-winning American chemist and biochemist Linus Pauling (1901-1994). Pauling began his research of mutation and natural selection because of his concerns with the burgeoning nuclear industry of the mid-twentieth century. Unlike proponents of nuclear science, who announced that radiation might even be advantageous to the evolutionary process, Pauling was convinced that mutation is nearly always detrimental. Teamed with the Austrian scientist Emile Zuckerkandl, Pauling focused his study of mutation on the molecules of hemoglobin. They began with a survey of comparative studies of the hemoglobin of primates. It did not take long for them to realize that this was no idle comparative survey.

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[36] Yoon, *Naming Nature*, 205.

As Pauling and Zuckerkandl expanded from the study of primate hemoglobin into that of other species, their results replicated many of the relationships indicated by traditional taxonomists; however, they were sometimes surprised at how their results also indicated new and shocking kinships. Suddenly, humans were just a few hairs short of being gorillas.

They soon realized that "they were helping to found an entirely new field. They had begun using the power of chemistry to see deep into the evolutionary past as no one had done before, creating the field of molecular taxonomy, or 'molecular systematics.'"[37] More scientists began exploiting other DNA strands for taxonomic purposes, and likewise, achieving unassailable, but nevertheless disputed, results. New kinships among animals were being discovered, but also "as more molecular biologists tinkered with such animals, more and more species were divvied up into multiple cryptic species, until it seemed that on every hill and under every tree there was a new organism to be named."[38] Just as with the influx of new specimens brought on through the voyages of discovery, the molecular method discovered new species that stretched the limits of established methods of taxonomic hierarchies. Another crisis was brewing in the field of taxonomy. Biologists had developed so many approaches and molecular scientists had developed so many new ways to identify organisms, that taxonomists found themselves confronting a task as seemingly difficult as sorting grains of sand. The debates over how to conduct taxonomy followed three or four main lines of thought.

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[37] Yoon, *Naming Nature,* 219.

[38] Yoon, *Naming Nature,* 226.

The philosopher of science, David N. Stamos has written extensively on what is termed “the species problem.” He wrote that the main approaches to taxonomy can today be summarized as follows:

> Numerical or phenetic taxonomy involves overall similarity, but it takes similarity as reducible to properties, and hence as not real. Traditional evolutionary taxonomy involves both similarity and descent, in some ways giving priority to descent, but it has never provided clear criteria for how to fully incorporate these two. Cladistic or phylogenetic taxonomy involves only descent, namely branching points, and eschews similarity altogether… Pattern cladism, an apparent hybrid between cladism and pheniticism, uses the methods of cladism to produce nested similarity classes, but in doing so explicitly eschews historical reconstruction.[39]

Sorting out organisms was becoming far removed from folk taxonomy, traditional taxonomy, and even numerical taxonomy. Joshua Rest maintained that relying on molecules to reveal evolutionary histories and kinships freed taxonomists from depending on their senses to order the world:

> As magical as this data revolution may seem, however, evolutionary biology will be ill-served by merely increasing the amount of data collected. Let us not forget that Linnaeus and Lamarck had gathered copious observations on natural history, but only Darwin actually derived a sound scientific explanation for the data. Even in the jungle of molecular genomics data, careful thinking, good hypotheses, and broad knowledge of organisms will remain central to actual discovery. Data collection and analytical details are only important to the extent that they complement these skills. In this way, how evolutionary biologists *ask* questions will remain fundamentally the same.[40]

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[39] David N. Stamos, *The Species Problem: Biological Species, Ontology, and the Metaphysics of Biology* (Lanham: Lexington Books, 2003), 29.

[40] Joshua S. Rest, “The Expansion of Molecular Data in Evolutionary Biology,” in *Evolution since Darwin: The First 150 Years*,” eds. Michael A. Bell, Douglas J. Futuyama, Walter F. Eanes, and Jeffrey S. Levinton (Sunderland, MA: Sinauer Association, 2010), 665.

Although it is technologically possible to identify each individual by means of quantifying a single, or very limited, number of characteristics, this serves only as a means of identification of divisions, much as spectography does for color identification. Genomic data banks do not provide the "careful thinking, good hypotheses, and broad knowledge of organisms [that] will remain central to actual discovery," that Rest described as crucial to systematic taxonomic science. Charles Jeffrey, in *An Introduction to Plant Taxonomy*, asked the reader to imagine being faced with a heap of coals and rocks to sort out. The result would probably consist of two piles, one of coal and one of rocks. But then, the reader is to imagine being told to sort out a heap of coals alone. Most likely, the result would be a progression of the biggest chunks down to the finest coal dust. Conceivable, each pile could even consist of one piece of coal.[41] Species groupings are giving way to a method in which a division is made for each individual through genomic sequencing. Even with advances in tracing evolution through the use of molecular data, the organizing and structuring of the connective narrative is still one of the most important tasks of the evolutionary biologist.

I have shown that divisions of species may be real, as was presumed by Aristotle, Linnaeus, and many others; division of species may be subjective, as is exemplified in folk taxonomies; or division of species may be created, as is epitomized by the sometimes political interest in dividing plants and creatures in strategically significant ways. As I move now to the naming of these divisions, I will show how the names reveal much about the underlying structure of the system of species division and language theory. I will also show

[41] Charles Jeffrey, *An Introduction to Plant Taxonomy* (Cambridge, MA: Cambridge University Press, 1982), 8.

that taxonomic nomenclature is superior to numeric identification, because, as Searle noted, “the key to understanding nature is that it’s a series of causal relations and the notion of computation is not a causal notion, it’s an abstract syntactical or symbolic or formal notion.”[42] While numeric systems list individuals according to one or few characteristics, thus providing ease of computation, taxonomy is the science of systematizing, organizing, and showing relationships according to multiple characteristics. Instead of a catalog of individuals, taxonomy should provide a holistic overview of a system. Language is therefore the better tool for designation of groupings and relationships in taxonomy because a numeric catalog conveys less category information. Writing the story of evolution requires first and foremost, a functioning way in which to refer to the organisms at hand. While there is much to be gleaned from becoming familiar with species folk taxonomic names, I will focus next on scientific taxonomy, in which names are used in a volitional and artificial manner to create taxonomic nomenclature. By showing how the divisions to species are systematized and how the words we use designate these divisions, I will show the value in retaining taxonomic nomenclature.

[42] Julian Moore, “Interview with John Searle,” *Philosophy Now* 25 (1999): 39.

CHAPTER 7

NAMING SPECIES

While taxonomic nomenclature may seem dry, the naming of organisms is a contentious topic that stirs the fervor of biologists, historians of science, and anthropologists alike. In "Stability or Stasis in the Names of Organisms: The Evolving Codes of Nomenclature," the authors report on the meetings of Botanical, Zoological, and Bacteriological Code conferences which occur at intervals every five or more years. Despite the advent of molecular data, which can be stored in sophisticated databases, it has been found at these conferences that rather than nomenclature systems being simplified, they are becoming ever more debated and complex. "The rapidly emerging field of genomics has thrown into stark relief the need for names and has highlighted the chaos that can result when no rules exist. Interestingly, nomenclature also seems to arouse passions in both the long-established and the newer communities [of scientists]...Rather than becoming less relevant, nomenclature is emerging into the spotlight."[1] William Ashworth, in "Halley's Discovery of NGC 6231 and the Hazards of Early Star Nomenclature," describes a similar problem in the history of naming stars. Of modern star nomenclature, he wrote, "Of course we should not feel too smug about modern nomenclature,"[2] since the same star has been renamed multiple times and there is no assurance that even the latest name is the permanent one. Such is also the state of nomenclature for species. As is attested by current debates

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[1] Sandra Knapp, Gerardo Lamas, Eimer Nie Lughadha, and Gianfranco Novarino, "Stability or Stasis in the Naming of Organisms: The Evolving Codes of Nomenclature," *Philosophical Transactions of the Royal Society London* B, (2004): 614-5.

[2] William Ashworth, "Halley's Discovery of NGC 6231 and the Hazards of Early Star Nomenclature," *Journal for the History of Astronomy*, 12 (1981): 8.

over taxonomic nomenclature at the meetings of Botanical, Zoological, and Bacteriological Code conferences, language as a tool for scientific identification, is inherently problematic.

The objective of taxonomists has been to establish universal and enduring systems to name the divisions in our environments. When the divisions themselves are debated, naming them becomes a very complex endeavor indeed.

Those who seek to devise a structure and a naming system for living organisms are confronted with many of the same problems as those who tried to divide and systematize color names. It is easy to understand the appeal of identification through genomic sequencing and the assignment of a code. While numeric or code systems of identification are still called “taxonomy” by some of their proponents, and spectography is used to identify color, this is a misnomer. Numeric systems list individuals, thus facilitating computation, but taxonomy is the science of systematizing, organizing, and showing relationships. Revealing and creating a system is better achieved with the tool of language. Words create divisions, and as Searle described, also create and comprise the things named. Names identify the thing out in the world, but the name also reveals the structure of the system into which it is fitted. The information about the world is linked to the word in a manner that allows for the building of a holistic and rich system. By naming a species, the species is created, and the word for the species is created. Taxonomy uses language in a conscious and purposeful manner that is artificial by comparison to naturally evolving language. In taxonomy, language is used volitionally with special attention paid to the connotative and denotative aspects of a name. Once a taxonomist has devised a method by which to make divisions, a topic I discussed in the previous chapter, his or her next undertaking is to represent these groupings by some method of coding. For the naming of species, I will examine taxonomic systems based on Greek and Latin, artificial or intentional languages, PhyloCode names, and identification through genomic sequencing.

A History of Species Taxonomy

In ancient times, as well as in so-called primitive cultures, there exist fairly uniform "common sense" groupings of what are now identified as species. The human mind either has been conditioned or is preconfigured to group things in certain ways. For example, through exposure to different kinds of birds, an expectation that feathers, wings, and so on, go together to form a grouping in the minds' of people that can be given a name. Folk taxonomy employs a linguistic strategy for ordering experiences of our surroundings in a hierarchical arrangement. Scientific taxonomy is an inclusive strategy for the purpose of analysis. Often these two approaches result in fundamentally different vocabularies. Although the vocabularies of folk taxonomy and that of scientific taxonomy have some cross-pollination, one may nevertheless safely generalize by saying that scientific taxonomy tends more toward arbitrary association of word and object than does folk taxonomy. The practice of naming plants, for example, after the Europeans who first classified them illustrates clearly the arbitrary association between word and object. There is the trivial epithet *tournefortia* after the French naturalist Joseph Pitton de Tournefort (1656-1708). Contrariwise, the names used in folk taxonomy frequently describe some aspect of a plant or animal, such as the animal named for its slow movements, which is in commonly known as the sloth. An additional, and obvious, difference in folk taxonomy and scientific taxonomy is the intention toward universal applicability. Folk taxonomies are, naturally enough, in the local language, and in the main, with specific reference to local specimens and experience. Scientific taxonomies attempt to structure universal languages intended for use around the world, and not confined to local specimens and experience. The nomenclature of folk-taxonomies is too varied and idiosyncratic for consideration in this brief history of species taxonomy, so instead I will begin with the first taxonomic system that was produced with the intention of being methodical.

Aristotle is credited as being among the first of men to apply reason to theretofore intuitive systems of categorization, so scholars of natural history often begin by examining the contributions of Aristotle. To better understand the importance of Aristotle's contribution to the science of classification, and the degree to which it set the tone for subsequent generations of philosophers and naturalists, it is useful to examine how his system resembled and differed from previous folk taxonomy.

While it is true that many of the groupings Aristotle forms are common, what distinguished his system are the philosophical underpinnings of his method of classification. Aristotle begins *Categories* by describing the function of words in classification:

> Things are said to be named "equivocally" when, though they have a common name, the definition corresponding with the name differs for each. On the other hand, things are said to be named "univocally" which have both the name and the definition answering to the name in common. Things are said to be named "derivatively," which derive their name from some other name, but differ from it in termination. [3]

Aristotle's system has been critiqued as being full of "empty verbiage and barren scholasticism," in which word meanings no longer reflect reality.[4] The problem of verisimilitude in Aristotle's classifications is not a new debate; "these questions were taken

[3] Aristotle, *Categories,* trans. E. M. Edghill http://www.gutenberg.org/files/2412/2412-h/2412-h.htm.

[4] Scott Atran, *Cognitive Foundations of Natural History* (Cambridge, MA: Cambridge University Press, 1990), 83.

up by the Scholastic philosophers in the form of realist-nominalist debates."[5] The realists believed that there existed a parallel between nature and the way in which we describe nature; signs are connected to the things they signify. The nominalists believed, "there is nothing common to a class of particulars called by the same name other than that they *are* called by the same name."[6] Because of the emphasis of naming and definition in his system, Slaughter traced the linkage of philosophical language and science to these debates sparked by Aristotle's classifications:

> We may sum up Aristotle's philosophy of science as a program for the explanation of nature in three parts: the first is the essences and their classification and the things which manifest them, i.e. the primary substances which are found naturally grouped in genera, the particulars which both participate in the common nature and are individuated from it. The second part is the names of essences, and the third part the statements of essences, or definitions.[7]

Aristotle's classification opened the debate on the nature of things and the way in which the words we use to define that nature are related. So influential were Aristotle's contributions to systems of classification that, "in subsequent generations taxonomy was carried out in accordance with Aristotelian rules, and this method of analyzing nature carried with it at the same time an implicit theory of nature."[8] Atran agrees with the high assessment of Aristotle's importance: "Solidly rooted in common sense but wholly novel in

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[5] Mary M. Slaughter, *Universal Languages and Scientific Taxonomy in the Seventeenth Century* (Cambridge, MA: Cambridge University Press, 1982), 10.

[6] Slaughter, *Universal Languages and Scientific Taxonomy,* 21.

[7] Slaughter, *Universal Languages and Scientific Taxonomy,* 25.

[8] Slaughter, *Universal Languages and Scientific Taxonomy,* 15.

design, Aristotle's classificatory program appears a true successor to no other and a predecessor for all to come.[9]"

Groupings had relied on outward appearances and readily visible habits or traits, but Aristotle endeavored to group plants and animals by their essences. Matter and form are for Aristotle the two hylomorphic attributes of substances; matter constitutes raw material and when it takes on a form, it contains an essence. These essences are distinguished as having qualitative differences which make them divisible by natural kind; "sometimes 'natural kind' is taken to denote all natural things commonly judged to possess underlying essences."[10] What distinguishes Aristotle from prior folk taxonomers is the sophistication of his partitions and divisions. Although critics point out that his limited knowledge of only about 600 species abridged the usefulness of his system for taxonomists, and that his categories based on essentialism exaggerated the clarity of taxa delineation, Aristotle nevertheless provides a pliant system, which could be applied to multiple levels of classification. Instead of the simplistic folk taxonomy, he "opts for a division along many dimensions simultaneously, by all differentia exhibited by the *deiniendum*, then a *unique* classification may be both logically possible and empirically possible."[11] Thus, for instance animals are not grouped only by their readily visible parts, but also by their parentage, their environments, and by analogy. The crudest grouping would divide animals by their means

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[9] Atran, *Cognitive Foundations of Natural History,* 104.

[10] Atran, *Cognitive Foundations of Natural History,* 72.

[11] Atran, *Cognitive Foundations of Natural History,* 108.

of nutrition, locomotion, and reproduction; then follow divisions by constituent organs; and so forth.

Aristotle's philosophic premises of classification developed into a hierarchal ranking of nature, later known as "the great chain of being," and can be traced through generations of naturalists. According to Slaughter, "The Great Chain of Being is not a taxonomy in the scientific sense of the word; rather it can be seen as a highly elaborated folk taxonomy, and as such a predecessor of scientific taxonomy."[12] The development of rank in systems of classification come from Aristotle's idea that "all individual things may be graded according to the degree with which they are infected with mere potentiality."[13] Although the following centuries would erode the intricacies of his classificatory system – by pragmatic "how to" handbooks on herbal remedies and other folk taxonomic manuals – what remained was the sense of gradation. Aristotle had subjected the world to an evaluation, which resulted in the systematic ordering of all creation in hierarchical terms.

Botanical works by Theophrastrus (c. 371-c. 287 BC), Pliny (23-77 AD), and Dioscorides (40-90 AD) tended to disregard first-hand examination of the natural world and rely instead on received authority. Although this served to disseminate information, it also started the process of stagnation of Aristotle's method. Several centuries later, two of the most common medieval botanical treatises that built upon the earlier versions were *Pseudo-Disocorides ex herbis femininis* and *Pseudo-Apuleius Herbarius*. These had shriveled to descriptions of only seventy-one and one-hundred-thirty plants, respectively. After

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[12] Slaughter, *Universal Languages and Scientific Taxonomy,* 36.

[13] Slaughter, *Universal Languages and Scientific Taxonomy,* 26.

centuries of practical herbal guides based primarily on the use of plants for human purposes, in the thirteenth century, Roger Bacon and Albert Magnus resurrected ideas from Aristotle via a forgery of his *De Plantis* by Nicolaus of Damascus. The influence of Aristotle in botany continues, but folk taxonomies also expanded.

The tendency in folk taxonomy is to cobble together words for local things to classify exotic species. The German language is notorious for this: "Nilpferd" is "horse of the Nile" and, like the Greek, it describes a "horse of the river": hippopotamus. The three German fathers of botany, Otto Brunfels, Jerome Bock, and Leonhart Fuchs, strove to incorporate new species into the language. Instead of using the indigenous name of a new species, they would frequently match the name of the foreign species to local types:

> Take the Latin edition of Brunfel's *Herbaum vivae eicones* (1530-36). Here the author refers to the mallow of the ancients as simply *Malva*, but labels a second species found in Germany *Malva equina*, or "horse mallow." Yet, in the German edition it appears that *Malva equina* is no longer simply a variety of *Malva* because both species are now labeled with binomials: "horsemallow" is called *Rosshappeln* and the original *Malva* is termed *Gänshappeln*, or "goose mallow." The local generic-specimen has apparently achieved conceptual equality with the ancient type.[14]

Many of the contributions in taxonomy and manipulations of language to include new species developed in central Europe. Gesner's *Thierbuch* and Andreas Cesalpino's *De medicamentorium facultatibus* did much to further the movement towards systematically classifying nature. Classification of animals and plants had relied in large measure on readily visible forms: quadrupeds were categorized with other quadrupeds; fish with fish; birds with birds, et cetera. Still grasping to marshal the existing vocabulary for the task in 1583, Cesalpino held to the notion that naming exotic species could be accommodated with

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[14] Atran, *Cognitive Foundations of Natural History,* 131.

the present system if "they can be arranged in some order, like a great army in a camp…distributed in companies."[15] The time for reform was imminent.

Naturalists employed Latin and local language to classify the flood of new information, but these languages were not satisfactory. "In the face of that explosion [of information] came strategies for coping, for bringing the pieces under control. If the first half of the seventeenth century has a prevalence of an episteme of order, it is not by chance that it occurs at this time; the development of a science of order on a scale never before witnessed was simply imperative."[16] There was a mounting sense of urgency felt by many scholars that the classification systems were being overwhelmed:

> All of these developments, though, are embedded in the profound shift from common-sense understanding of local, everyday experience, from evermore reflective events to cope with worldwide novelty; from the layman's spontaneous treatment of what is rare and strange in the world in terms of readily visible and familiar patterns of the phenomenal order of things, to the naturalist's progressive effort to deal with unceasing discovery by means of nonphenomenal processes of biology.[17]

Naturalists faced the task of sorting and naming this worldwide novelty with which they were confronted either by trying to adapt traditional systems of nomenclature or revise them.

About natural languages, M. M. Slaughter wrote, "In the seventeenth century, however, it was generally felt that natural language was not isomorphic with nature or reality – that words and things did not properly match – an attitude which is not surprising in

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[15] Atran, *Cognitive Foundations of Natural History,* 86.

[16] Slaughter, *Universal Languages and Scientific Taxonomy,* 148.

[17] Atran, *Cognitive Foundations of Natural History,* 85.

the multi-cultural, multi-lingual context of Renaissance humanism."[18] Most works of taxonomy were written in Latin throughout the middle ages and well into the eighteenth century. Although some of the most renowned taxonomists used Latin for their systems even in the eighteenth century, currents of dissatisfaction were circulating. One concern was that Latin nomenclature and its translation differed from region to region and over time.[19]

John Ray, originally Wray (1627-1705), one of the most eminent naturalists of his time, is esteemed as "the only describer who conveys some precise idea in every term or word."[20] Ray was born in Black Notley and educated at Trinity College in Cambridge, where he was appointed as a lecturer of Greek, Mathematics and Humanities. He excelled in his studies, earned an MA, and was appointed Junior Dean. At Cambridge, he spent his time in Cambridge, London, Black Notley, and in travels to the continent. Everywhere he went, he observed nature, but he was repelled by the upheavals taking place politically and philosophically. With the discovery of the microscope, telescope, and the increasing voyages being made, the world was becoming unfamiliar. "Those like Ray who hated controversy and were not deeply interested in history found a wonderland of almost limitless attraction in natural philosophy."[21] From his studies in natural philosophy, Ray gained unparalleled expertise; the first volume of *Historia plantarum*, which is considered his great

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[18] Slaughter, *Universal Languages and Scientific Taxonomy,* 10.

[19] Latin color terms continued to be refined and changed through efforts such as those of B. Daydon Jackson, "A Review of Latin Colour Terms Used in Botany to Denote Colour," *Journal of Botany* (1899): 97-106.

[20] Charles Earle Raven, *John Ray, Naturalist: His Life and Work* (Cambridge, MA: Cambridge University Press, 1950), 31.

[21] Raven, *John Ray, Naturalist*, 44.

work, was published in 1686. This was just one of approximately forty works he published in his lifetime, ranging from religious tracts, works on ornithology, fish, quadrupeds, fossils and language.

Among traditionalists, such as Ray, there was an effort to continue to use Latin to manage the task of classifying, but Ray was also involved with efforts toward language reform in the development of a universal scientific language. Ray's efforts to regularize the nomenclature of classification ranged from reform to reinvention.

Ray lived in a time of transition; even though the Roman liturgy and the Latin Bible were no longer used in churches and the use of Latin was declining among the elite, Latin was still the language of many scholars. Most of Ray's books were written in Latin, which gave him the advantage of having readers outside of Britain; he gained fame among German and French naturalists and was read by Tournefort, Hermann, Cuvier, and Haller. Nevertheless, the use of Latin, even among scholars, was in decline. Ray once complained, "that there was only one printer in London, Benjamin Mott, who could be trusted to set up a Latin book."[22] Not only was the quality of Ray's use of Latin superb – the precision and economy of his descriptions were widely praised – Ray was adept at several other languages. He was known to be fluent in Greek and Hebrew, and to do well enough in both French and Italian. Ray had a general fascination with languages; he wrote books on the English language as well: *A Collection of Words Not Generally Used* (1674) and *Collection of English Proverbs* (1670). Although his works on language and theology were respected and influential, it is for his work in botany that Ray is most famed.

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[22] Raven, *John Ray, Naturalist*, 31.

Of especial interest is Ray's *Dictionariolum trilingue*. It is a slender volume of terms, divided by topic – of Heaven, of Elements and Meteors, of Stones and Metals, of Herbs, of some Accidents of the Body – under which are listed the same words in English, Latin and Greek. In his preface, Ray gives his reasons for publishing the dictionary:

> Having lately had occasion to review some of the last Published English and Latin Nomenclatures, I observed in them some inveterate Errors, especially in the names of the Animals and Plants still continued, which I thought it might not be amiss to correct; notwithstanding that for their Antiquity, they may plead Prescription, and for their Universality in our Schools, general Approbation.[23]

Ray's efforts to set the record straight regarding the misuse of name translations points to his concern with getting the nomenclature of classification right. It also distinguishes him among his peers as one who still has faith in the ability of existing languages to rise to the occasion of naming all the exotic species in an orderly manner. Tellingly, much like Aristotle, he believed in nominal essences and in a ranked hierarchy of species. In *De variis plantarum methedos dissertatio brevis* Ray explained his point of view:

> I would not deny that universals have a foundation in things truly agreeing or similar in special parts or properties. This agreement is so great, especially in living things, that individuals of the same species are seen as having been made according to the same exemplar or idea in the Divine Mind….From this it follows that species are distinguished essentially from one another and are not transmutable, and the forms and essence of these are either certain specific principles, that is, certain very small particles of matter, distinct from all others, and naturally indivisible, or certain specific seminal reasons enclosed by means of an appropriate vehicle.[24]

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[23] Ray John, *Dictionarolum trilingue* (London: The Ray Society, 1981), unpaginated preface.

[24] Atran, *Cognitive Foundations of Natural History,* 164.

Ray believed in nominal essences and in other works, such as *The Wisdom of God Manifested in the Works of the Creation*, he explained the order of things through his belief in natural theology. Despite his conservative approach to hierarchy and the use of Latin in nomenclature, Ray nonetheless collaborated with his contemporaries on a radical project for language reform.

The idea for creating an artificial language to contend with colossal demands for new taxonomical nomenclature did not originate in England – it had been proposed in France initially – but it gained a serious following there.[25] At least three universal language schemes developed. One involved Johann Amos Comenius (1592-1670), a second John Wilkins (1614-1672) and the Royal Society, and a third Thomas Urquhart (1611-1660).

Comenius was a linguist and an education reformer. His reforms to language emphasized the importance of linking things to words and avoiding excessive abstraction. Comenius' efforts have been linked to reformatory Puritanism. Comenius in *The Way of Light* works towards formulating a universal language to promote a greater understanding among the nations and make his ideals of pansophy general to all. Although Comenius wrote much about the benefits of a universal language, he did not invent one.

John Wilkins and members of the Royal Society were interested in a project of language reform for primarily scientific purposes, and they worked toward a system that would facilitate international scientific dialog. Despite Ray's devotion to religion, he worked with Wilkins in composing tables for *Essay toward a Real Character and a*

[25] Gottfried Leibniz (1646-1716) conceived of a *characteristica universalis*, an algebraic language capable of expressing all conceptual thought. His system will not be described here, but it bears note since, current taxonomic nomenclature, for flora, fauna, and color, now has numeric expression.

Philosophical Language, Wilkins' book on universal languages undertaken at the request of the Royal Society in 1668. The interest in developing universal languages directly influenced the artificial or intentional use of language in scientific taxonomy, such as Linnaean binomial nomenclature and several of the color taxonomies.

John Wilkins held university positions early in his life; he was Warden of Wadham College and Master of Trinity College at Cambridge. After the Restoration, he was deprived of the Mastership at Trinity and devoted himself to the church, where he became Bishop at Ripon. As a Bishop within an increasingly intolerant Church, Wilkins exercised a moderating influence. But his true calling was his role as a champion and popularizer of the experimental science who explained how new techniques might improve life. Wilkins expounded the discoveries and theories of Copernicus, Galileo, and Kepler, promoted further experiment and observation, and extolled the virtues of cooperative scholarly and scientific inquiries. Wilkins, like Ray, wrote on a wide range of subjects. His works include *Mathematicall Magick, Mercury or The Secret and Swift Mesenger: Shewing How Man may with Privacy and Speed communicate His Thoughts to a Friend at Any Distance, Of the Principles and Duties of Natural Religion.* It is, however, Wilkins' *Essay toward a Real Character and a Philosophical Language* that has been quoted by generations of philologists and linguists.

Wilkins wrote that a new language "would very much promote and facilitate the knowledge of Nature, which is one great end of our Institution."[26] In "Book I: The First

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[26] John Wilkins, *An Essay Towards a Real Character, and a Philosophical Language,* 1668 (Menston England: The Scolar Press Limited, 1968), unpaginated Dedicatory Epistle.

Principle of Communication," Wilkins explains the theoretical underpinnings of his linguistic method:

> As men generally agree in the Principle of Reason, so do they likewise agree in the same Internal Notion or Apprehension of things. The External Expression of these Mental notions, whereby men communicate their thoughts to one another, is either to the Ear, or to the Eye. To the Ear by sounds, and more particularly by Articulate Voice and Words. To the Eye by any thing which is visible, Motion Light, Colour, Figure; and more particularly by Writing. That conceit which men have in their minds concerning a Horse, or a Tree, is the Notion or mental Image of that Beast, or natural thing, of such nature, shape or use. The names given to these in several Languages, are arbitrary sounds or words, as nations of men have agreed upon, either casually or designedly, to express their Mental notions of them. The Written word is the figure or picture of that Sound. So that if men should generally consent upon the same way or manner of Expression, as they do agree in the same Notion, we should then be freed from that Curse in the Confusion of Tongues, with all the unhappy consequences of it.[27]

Not only do the philosophical observations Wilkins makes hearken back to the questions raised by Plato about the relation of shadows and realities, they address the nature of the relation between objects and the things they name. Wilkins states that names are arbitrary sounds given casually or designedly, to express mental notions. Wilkins, in many ways, sets the stage for debates in modern linguistics; Ferdinand de Saussure, in his *Course in General Linguistics* (1959), addressed the problem of the relation between signifier and signified and the arbitrary nature of the connection between the two.

In Wilkins' new universal language, an example of which can be seen in Figure 7.1, all the concepts in the world were divided into forty primary Genera, each of which is represented by a two-letter syllable. Each Genus is then divided into Differences, adding another letter to the word. Differences are then divided into Species, adding a fourth

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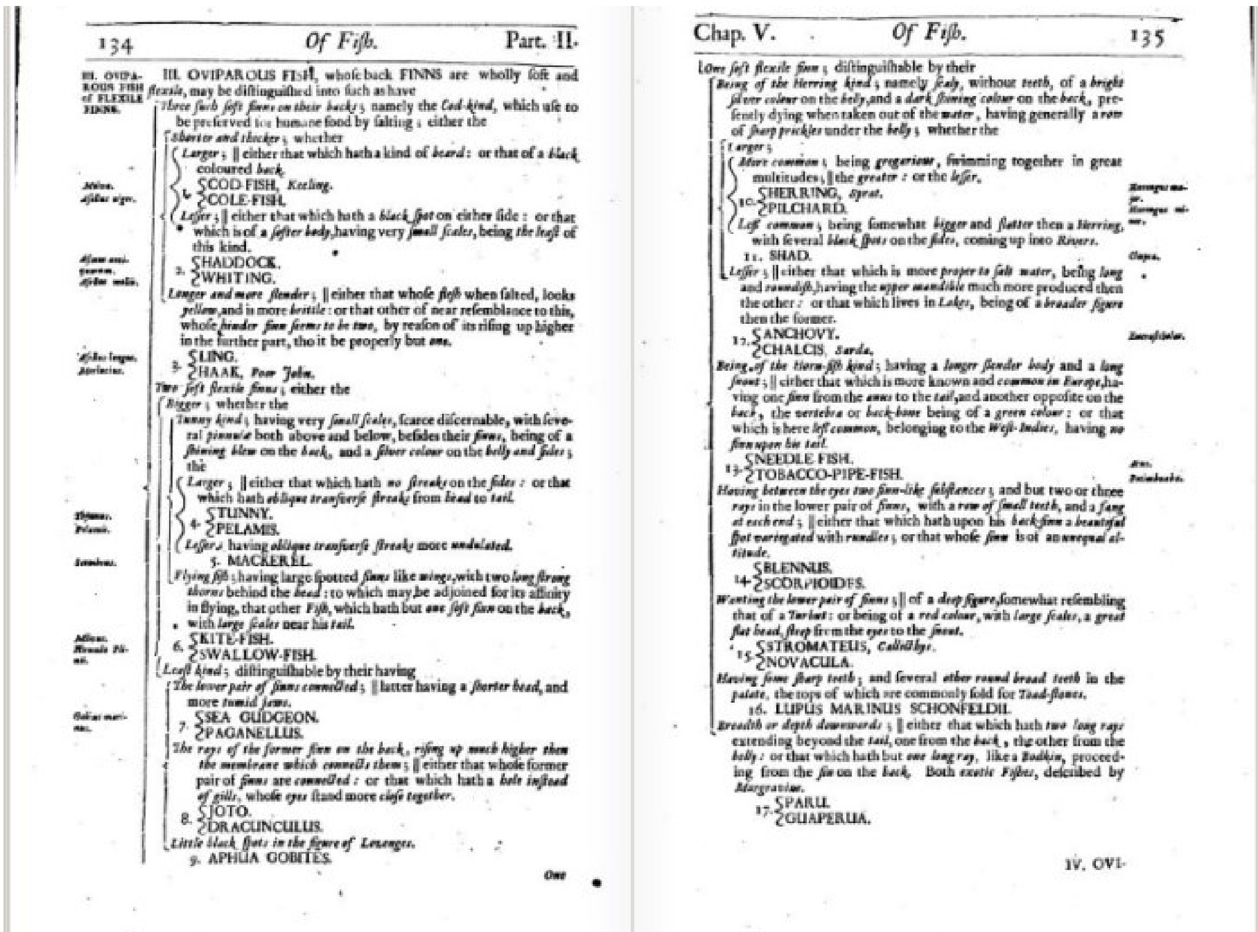
[27] Wilkins, *An Essay Towards a Real Character, and a Philosophical Language*, 20.

letter to the word. For instance, Zi identifies the Genus of "beasts" (mammals); Zit gives the Difference of "rapacious beasts of the dog kind"; Zitα gives the Species of dogs.[28]


134 *Of Fiſh.* Part. II.

III. OVIPAROUS FISH, whoſe back FINNS are wholly ſoft and *flexile*, may be diſtinguiſhed into ſuch as have

Three ſuch ſoft finns on their backs; namely the *Cod-kind*, which uſe to be preſerved for humane food by ſalting; either the

Shorter and thicker; whether

Larger; ‖ either that which hath a kind of *beard*: or that of a *black* coloured *back*.

1. COD-FISH, *Keeling*. / COLE-FISH.

Leſſer; ‖ either that which hath a *black ſpot* on either ſide: or that which is of a *ſofter body*, having very *ſmall ſcales*, being *the leaſt* of this kind.

2. HADDOCK. / WHITING.

Longer and more ſlender; ‖ either that whoſe *fleſh* when ſalted, looks *yellow*, and is more *brittle*: or that other of near reſemblance to this, whoſe *hinder finn ſeems to be two*, by reaſon of its riſing up higher in the further part, tho it be properly but *one*.

3. LING. / HAAK, *Poor John*.

Two ſoft flexile finns; either the

Bigger; whether the

Tunny kind; having very *ſmall ſcales*, ſcarce diſcernable, with ſeveral *pinnulæ* both above and below, beſides their *finns*, being of a *ſhining blew* on the *back*, and a *ſilver colour* on the *belly and ſides*; the

Larger; ‖ either that which hath *no ſtreaks* on the *ſides*: or that which hath *oblique tranſverſe ſtreaks* from *head* to *tail*.

4. TUNNY. / PELAMIS.

Leſſer; having *oblique tranſverſe ſtreaks* more *undulated*.

5. MACKEREL.

Flying fiſh; having large ſpotted *finns* like *wings*, with two *long ſtrong thorns* behind the *head*: to which may be adjoined for its affinity in flying, that other *Fiſh*, which hath but *one ſoft finn* on the *back*, with *large ſcales* near his *tail*.

6. KITE-FISH. / SWALLOW-FISH.

Leaſt kind; diſtinguiſhable by their having

The lower pair of finns connected; ‖ latter having a *ſhorter head*, and more *tumid jaws*.

7. SEA GUDGEON. / PAGANELLUS.

The rays of the former finn on the back, riſing up much higher then the membrane which connects them; ‖ either that whoſe former pair of *finns* are *connected*: or that which hath a *hole inſtead of gills*, whoſe *eyes* ſtand more *cloſe together*.

8. JOTO. / DRACUNCULUS.

Little black ſpots in the figure of Lozenges.

9. APHUA GOBITES.

One

Chap. V. *Of Fiſh.* 135

One ſoft flexile finn; diſtinguiſhable by their

Being of the Herring kind; namely *ſcaly*, without *teeth*, of a *bright ſilver colour* on the *belly*, and a *dark ſhining colour* on the *back*, preſently dying when taken out of the *water*, having generally *a row of ſharp prickles* under the *belly*; whether the

Larger;

More common; being *gregarious*, ſwimming together in great multitudes; ‖ the *greater*: or the *leſſer*.

10. HERRING, *Sprat*. / PILCHARD.

Leſs common; being ſomewhat *bigger* and *flatter* then a *Herring*, with ſeveral *black ſpots* on the *ſides*, coming up into *Rivers*.

11. SHAD.

Leſſer; ‖ either that which is more *proper to ſalt water*, being *long* and *roundiſh*, having the *upper mandible* much more produced then the other: or that which lives in *Lakes*, being of a *broader figure* then the former.

12. ANCHOVY. / CHALCIS, *Sarda*.

Being of the Horn-fiſh kind; having a *longer ſlender body* and a *long ſnout*; ‖ either that which is more known and *common in Europe*, having one *finn* from the *anus* to the *tail*, and another oppoſite on the *back*, the *vertebra* or *back-bone* being of a *green colour*: or that which is here *leſs common*, belonging to the *Weſt-Indies*, having *no finn upon his tail*.

13. NEEDLE FISH. / TOBACCO-PIPE-FISH.

Having between the eyes two finn-like ſubſtances; and but two or three *rays* in the lower pair of *finns*, with a *row of ſmall teeth*, and a *fang at each end*; ‖ either that which hath upon his *back-finn a beautiful ſpot variegated with roundles*; or that whoſe *finn* is of an *unequal altitude*.

14. BLENNUS. / SCORPIOIDES.

Wanting the lower pair of finns; ‖ of a *deep figure*, ſomewhat reſembling that of a *Turbot*: or being of a *red colour*, with *large ſcales*, a *great flat head*, *ſteep* from the *eyes* to the *ſnout*.

15. STROMATEUS, *Callichys*. / NOVACULA.

Having ſome ſharp teeth; and ſeveral *other round broad teeth* in the *palate*, the tops of which are commonly ſold for *Toad-ſtones*.

16. LUPUS MARINUS SCHONFELDII.

Breadth or depth downwards; ‖ either that which hath *two long rays* extending beyond the *tail*, one from the *back*, the other from the *belly*: or that which hath but *one long ray*, like a *Bodkin*, proceeding from the *fin* on the *back*. Both *exotic Fiſhes*, deſcribed by *Margravius*.

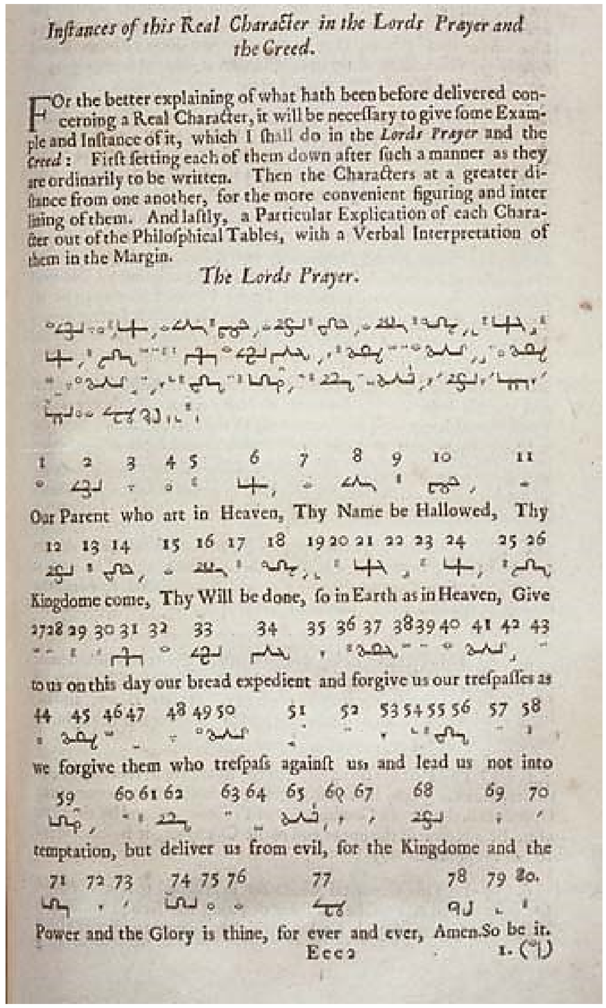
17. PARU. / GUAPERUA.

IV. OVI-

Figure 7.1. John Wilkins' universal language for "fish"[29]

[28] Umberto Eco, *The Search for the Perfect Language* (Oxford, UK: Blackwell, 1995), 97. On page 249, Eco points out that Wilkins himself made this kind of mistake on page 415 of *Real Character*, using *Gαde* (barley) instead of *Gαpe* (tulip).

[29] John Wilkins' universal language for "fish." *Source:* https://katherinemcdonald.net/2016/06/22/ancient-languages-and-john-wilkins-real-character/



Inſtances of this Real Character in the Lords Prayer and the Creed.

FOr the better explaining of what hath been before delivered concerning a Real Character, it will be neceſſary to give ſome Example and Inſtance of it, which I ſhall do in the *Lords Prayer* and the *Creed*: Firſt ſetting each of them down after ſuch a manner as they are ordinarily to be written. Then the Characters at a greater diſtance from one another, for the more convenient figuring and interlining of them. And laſtly, a Particular Explication of each Character out of the Philoſphical Tables, with a Verbal Interpretation of them in the Margin.

The Lords Prayer.

1 2 3 4 5 6 7 8 9 10 11
Our Parent who art in Heaven, Thy Name be Hallowed, Thy
12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Kingdome come, Thy Will be done, ſo in Earth as in Heaven, Give
27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43
to us on this day our bread expedient and forgive us our treſpaſſes as
44 45 46 47 48 49 50 51 52 53 54 55 56 57 58
we forgive them who treſpaſs againſt us, and lead us not into
59 60 61 62 63 64 65 66 67 68 69 70
temptation, but deliver us from evil, for the Kingdome and the
71 72 73 74 75 76 77 78 79 80.
Power and the Glory is thine, for ever and ever, Amen. So be it.
Eee 2

Figure 7.2. John Wilkins' universal language as applied to the Lord's Prayer[30]

Given the turbulence of the times, Wilkins shows amazing optimism not only in his effort to devise a system to better categorize the world, but also in thinking that men might indeed generally consent to using an artificially devised language, as his coding of the Lord's Prayer in Figure 7.2 indicates. As much as Ray worked for the use of Latin in

[30] John Wilkins' universal language as applied to the Lord's Prayer. *Source:* https://www.mhs.ox.ac.uk/gatt/catalog.php?num=43

science, especially for botany, he supported the efforts of Wilkins toward a universal language for use in nomenclature.

Thomas Urquhart, who is perhaps best known for his translation of François Rabelais' *Gargantua and Pantagruel,* in which life at an ideal monastery is described where residents are entrusted to do as they see fit every day. Urquhart was politically involved as a staunch royalist, and he was, for some time, even imprisoned. In his book devoted to universal languages, *Logopandecteision,* he occasionally made room to lament his lot – "These grievous pressures with many others, and as many more I have sustained from the ministry of the Land"[31] – but the majority of the book was devoted to declaring the need for a universal language. Urquhart speculated that language arose from necessity to describe common objects, and gradually, as the human capacity for abstraction increased, "Philosophical quiddities" required that language be refined and its scope enlarged. He used the analogy of a house to describe the evolution of language. "I have known some to have built houses for necessity, having no other aime before their eyes, but barely to dwell in them; who nevertheless in a very short space were so enriched, that after they had taken pleasure to polish and adorn, what formerly they had but rudely squared, their moveables so multiplied upon them, that they would have wished they would have made them of a larger extent."[32] With the desire to categorize more things and to describe their essences, language had to cobble together new means of expression. Urquhart mused that these additions to language are like "striking forth new lights and doors, outjettings of Crennels, erecting of

[31] Thomas Urquhart, *Logopandecteision*, 1653, reprint (Menston, England: The Solar Press Limited, 1970), 10-11.

[32] Urquhart, *Logopandecteision*, 7.

prickets, barbicans, and such like various structures upon one and the same foundation" of an inadequate house.[33] Like others who proposed universal language schemes, Urquhart found existing language inadequate. He did not go so far as to devise a language, but contented himself with the philosophical questions. Like Wilkins, though, Urquhart was prepared to radically revise language; he also placed more value on the ability of the signal to clearly signify something, than on maintaining tradition:

> For it boots not so much, by what kind of tokens any matter be brought into our minde, as that the things made known unto us, by such representatives, be of some considerable value: not much unlike the Ines-a-court gentlemen at London, who usually repairing to the commons at the blowing of a horn, are better pleased with such a sign (so the fare be good) then if they were warned to courser cates, by the sound of a Bell or Trumpet.[34]

Although Urquhart was perhaps more of a dilettante in taxonomy and universal language schemes, he was caught up in the general tumult and excitement of the age. He and his contemporaries were some of the last to enjoy the lives of the Renaissance scholars before specialization became routine. The variety of approaches to addressing the problems of the perceived inadequacies of language to give order to the burgeoning repository of information can be seen in Ray, Wilkins and Urquhart. To varying degrees, Aristotle's ideas were still informing theirs, but a new forward-looking age had begun. Language reform and artificial languages invented for the purpose of creating a nomenclature for universal application in science did not gain a foothold but instead, just as John Ray would have preferred, Latin continued as the language of scientific nomenclature.

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[33] Urquhart, *Logopandecteision*, 7.

[34] Urquhart, *Logopandecteision*, 7.

Had Latin not still been in use as the language of learned correspondence when Carolus Linnaeus (1707-1778) applied his organizational genius to the formalization of botanical and animal names, the system of binominal nomenclature might not be as robust as it is today. William T. Stearn, (1911-2001) in *Botanical Latin: History, Grammar, Syntax, Terminology and Vocabulary,* claimed that it is because Linnaeus resurrected the nomenclature of Pliny the elder that botanical Latin is today a living and developing language.

In the Linnaean system, the name of an animal or plant is two words, of which the first is the name of the genus, or generic name, and the second is the name of the species, or the trivial name. Together the binomial is called the specific name. Binominal nomenclature has aided in the ability to organize and communicate about species. The name of a species is a binary combination consisting of the name of the genus and a specific epithet that can be in the form of an adjective, a noun, or many other sources. There are, of course, rules governing all aspects of how a Latin binomial name can be formed. For example, below is a small section from the rules of Linnaean taxonomy, “Chapter III. Nomenclature of taxa according to their rank, Section 4. Names of species”:

Article 23

- *23.1.* The name of a species is a binary combination consisting of the name of the genus followed by a single specific epithet in the form of an adjective, a noun in the genitive, or a word in apposition, or several words, but not a phrase name of one or more descriptive nouns and associated adjectives in the ablative (see Art. 23.6(a)), nor any of certain other irregularly formed designations (see Art. 23.6(b–d)). If an epithet consists of two or more words, these are to be united or hyphenated. An epithet not so joined when originally published is not to be rejected but, when used, is to be united or hyphenated, as specified in Art. 60.9.

- *23.2.* The epithet in the name of a species may be taken from any source whatever, and may even be composed arbitrarily (but see Art. 60.1).
  - *Ex.1. Adiantum capillus-veneris, Atropa bella-donna, Cornus sanguinea, Dianthus monspessulanus, Embelia sarasiniorum, Fumaria gussonei, Geranium robertianum, Impatiens noli-tangere, Papaver rhoeas, Spondias mombin* (an indeclinable epithet)*, Uromyces fabae*.[35]

The rules of Linnaean binomial nomenclature are thorough, and the names produced under these rules often have stories associated with them. Many Linnaean binomial names carry the name of the person who first classified the species. While most of these names commemorate the name of a zoologist or botanist who first classified the organism, there are instances in which those who have naming rights use the opportunity to take a jab at a rival. *Dinohyus hollandi* is a dinosaur named to insult W. J. Holland, a director at the Carnegie Museum who stole credit from his students, and is now immortalized as "Holland, the terrible pig." There is a rare predatory beetle *Anophthalmus hitleri,* discovered in the caves of Slovenia, whose name means "the eyeless one of Hitler." Many such colorful binomial name histories exist, as well as those that give reference to classical literature. The names of the spiders and her kin echo the name of the Lydian princess Arachne, the weaver of whom Athena was so jealous that she turned her into a spider. Historical names have value because of the associations the names conjure.

The system of Linnaean nomenclature was assumed to provide sufficient words to name the real divisions in a world that was unevolving. After the acceptance of evolutionary theory, Linnaean nomenclature continued as the means of naming new species, but as new kinships were discovered, renaming species became problematic. The annals of taxonomy

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[35] International Association of Plant Taxonomy, *International Code of Nomenclature for algae, fungi, and plants (Melbourne Code),* Chapter III, Section 4, http://www.iapt-taxon.org/nomen/main.php?page=art23.

are littered with debates over what a new species should be named, or how a reclassified species should be renamed. These debates have grown to be so numerous, and, as technological means of identifying species increases, some scientists doubt that Linnaean binomial nomenclature can effectively provide names for taxonomists.

The problem for Linnaean nomenclature became obvious to Charles Darwin. Darwin was at times confounded by where to make the divisions by which to assign names. "I was much struck by how entirely vague and arbitrary is the distinction between species and varieties."[36] Darwin referred to the example of the primrose and the cowslip. These two plants grow in different habitats, flower at different times, are difficult to hybridize, yet, Darwin argued, should be considered varieties of the same species due to their common ancestry. Common ancestry, shared habitat, and inter-breeding populations are factors that serve in defining species, but sometimes, making the scheme even more capricious, the difference between species and variety is simply a matter of national pride. "Several most experienced ornithologists consider our British red grouse as only a strongly marked race of a Norwegian species," he quibbles, "whereas a greater number rank it as an undoubted species peculiar to Great Britain."[37] Such protean and doubtful species identification continues to fuel the debate among biologists as to whether species are in fact real or just convenient nominal groupings.[38] Since the Linnaean nomenclature depends upon hierarchic

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[36] Charles Darwin, *On the Origin of Species*, 1859, 48.

[37] Charles Darwin, *On the Origin of Species*, 1859, 50.

[38] Today, we still have a wealth of species concepts. Many of those concepts fall into two groups: interbreeding concepts (see Mayr, 1970; Patterson, 1985) and phylogenetic concepts (see Mishler and Brandon, 1987; and Ridley, 1989).

ranking of species, the nomenclature also has been subject to proposed revisions and even replacement.

Species Identification through Technology

The Linnaean system of binomial nomenclature is the prevailing system today for naming or renaming species, yet some scientists find it inadequate to the task. With new species being discovered every day, and with unexpected relations found through new technologies that allow us to trace lines of kinship, the established system of Latin binomial naming is found by many to be insufficient.

Proposals for revising or replacing taxonomic nomenclature have proliferated alongside technologies such as carbon dating and genome sequencing, as well as the easy availability of databanks of information. Here I consider two of these proposals for revising or replacing Linnaean nomenclature: the PhyloCode and the barcoding method.

Biologists of phylogenetics focus on lines of descent of an organism and evolutionary relationships. In this field, Kevin de Queiroz and Jacques Gauthier published a paper in 1990 in which they first proposed revising the Linnaean binomial nomenclature better to reflect phylogenetic definitions of taxon names.[39] The traditional system clusters organisms according to their resemblance into types situated into a hierarchy of inclusive categories; however, a system based on phylogeny groups organisms according evolutionary relationships into clades of common ancestry. Organisms are grouped into clades and no reference to family, order, class, or genera would be reflected in the name. Although not

[39] Kevin De Queiroz and Gauthier Jacques, "Phylogeny as a Central Principle in Taxonomy: Phylogenetic Definitions of Taxon Names," *Systematic Zoology* 39, no. 4 (1990): 307-22, http://www.jstor.org/stable/2992353.

fully developed, the naming system under phylogenetic principles proposes to do away with genus names and use only species names. For example, the Linnaean binomial *Homo sapiens* would be shortened under the PhyloCode to sapiens. The family Hominidae only has one living species, so the PhyloCode name sapiens is clear. However, the species is *vulgaris* in many Linnaean names. If the genus name were to be omitted under the PhyloCode naming system, we would be faced with hundreds of species named vulgaris. One suggestion under the PhyloCode is to add a number after "vulgaris" to add clarity. Another suggestion is to maintain the genus name, but to hyphenate it to the species name and strip the genus portion of the name of any hierarchic significance. Although the science of cladistics, the study of phylogenetic clades, is highly developed, the system of naming organisms according to their clades is still a project in a formative stage. The intention of de Queiroz and Gauthier is that the nomenclature of the PhyloCode provide information about the descent of an organism and simplify or adapt the existing species name when possible. The following articles are taken from the PhyloCode website[40] from the section Division II Rules:

> 9.3. In order to be established, a clade name must be provided with a phylogenetic definition, written in English or Latin, linking it explicitly with a particular clade. The name applies to whatever clade fits the definition.
>
> 21.2. The name of a species under the rank-based codes (except the ICVCN) is a binomen (two part name), the first part of which is a generic name (i.e., a name that is tied to the rank of genus) and the second part of which is a specific name (ICZN) or epithet (ICNB, ICBN) (i.e., a name that is tied to the rank of species). Because this code is independent of categorical ranks (Art. 3.1), the first part of a species binomen is not interpreted as a genus name but instead as simply the first part of the species name (a prenomen; see Art. 21.4), and the second part of a species binomen is associated with the species as a kind of biological entity, not as a rank (Note 3.1.1).

[40] The PhyloCode, https://www.ohio.edu/phylocode/index.html.

Two examples of new PhyloCode names are given:

> Example 1. ©Hypotheticus could indicate that the prenomen Hypotheticus is an established clade name, while Hypotheticus (with no symbol) could indicate that this prenomen has not been established as a clade name under this code. If so, the meaning of the symbol © should be clearly indicated.
>
> Example 2. Hypotheticus (with no symbol) could indicate that this prenomen has been established as a clade name under this code, while [R]Hypotheticus could indicate that the prenomen Hypotheticus is not an established clade name ("R" meaning governed by a rank-based code). If so, the meaning of the symbol [R] should be clearly indicated.

One proposal is that the PhyloCode copyright established clade names and use the copyright symbols as part of the species name, whereas a bracketed letter *R* would indicate that the clade name is not established. Whether the PhyloCode adds symbols, hyphens, or numbers to a species name, it is clear that much renaming would take place if the PhyloCode were fully adopted. To destabilize the Linnaean system is not the objective of PhyloCoders.

The purpose of a PhyloCode name is to provide stability when new kinships are discovered:

> PhyloCoders say that once a name has been redefined in PhyloCode terms, it should be more stable than it has been under Linnaean rules. For example, the addition of the herb Ajuga to Teucrioidae would not have forced that name to be changed. Unlike in the Linnaean system, they say, the new names will allow for organisms to move in and out of clades without disturbing the clade's names or the other organisms.[41]

Since PhyloCode names are intended to provide more flexibility when organisms have to be reclassified, it is argued that the nomenclature will be more stable than Linnaean nomenclature, wherein organisms must often be renamed when they are reclassified.

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[41] Elizabeth Pennissi, "Linnaeus's Last Stand? (Introducing PhyloCode)," in *The Application and Limitations of Taxonomy (in Classification of Organisms),* ed. Jeri Freedman (New York: Rosen Publishing Group, 2006), 34.

Detractors, however, argue that the stability and flexibility of PhyloCode names are not all that is claimed. In the article "Taxonomic Stability is Ignorance," Eduardo Dominguez and Quentin D. Wheeler argue that PhyloCode names are not as stable and flexible as Linnaean names. In contrast to the example above of the change required in the Linnaean system by the addition of the herb Ajuga to Teucrioidae, they cite a counter example. "What used to be a family (Chamaeleonidae) becomes a part of another family without changing its Latin ending (i.e., spelling), since de Queiroz and Gaulthier's system is rankless."[42] A second critique of the PhyloCode nomenclature is the very importance that is given to descent in classification. Max C. Langer in "Linnaeus and the 'PhyloCode': What Are the Differences?" questions the assumption that the genealogy of a species should be the primary criterion of its classification. He wrote, "Even under an evolutionary framework, the validity of non-genealogy-based classification is supported by their utilitarian nature and by the definition of taxa as abstract human constructs."[43] Critics of the PhyloCode nomenclature object to all the needless initial renaming according to clades, but also object to the loss of the hierarchical information in the new names. Detractors also find fault with the lack of continuity a new system represents and the disruption of one with a long established history.

De Queiroz and Gauthier are aware that the categories formed by the application of phylogenetics are developed to a level not commensurate with the PhyloCode nomenclature

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[42] Eduardo Dominguez and Quentin D. Wheeler, "Forum: Taxanomic Stability is Ignorance," *Cladistics*, 13, no. 4 (December 1997): 367-72, doi:10.1006/clad.1997.0050.

[43] Max C. Langer, "Linnaeus and the 'PhyloCode': What Are the Differences?" *Taxon*, 50, no. 4 (Nov. 2001): 1094, http://www.jstor.org/stable/1224724.

and they anticipated the objections they would encounter to changing traditional methods of nomenclature:

> The use of phylogenetic definitions liberates biological taxonomy from a 2000-year-old tradition of basing definitions of taxon names on characters. Because of the antiquity of this tradition and the importance of definitions in taxonomy,…one might expect the adoption of phylogenetic definitions to have far-reaching consequences for other taxonomic principles, practices, and conventions.[44]

Many of the objections to changing the definitions and the names of species, whether to names developed under the PhyloCode or other systems, have to do with the lack of continuity that a long tradition of defining and naming provides.

Kevin Nixon, plant systematist at Cornell University, found it valuable to retain Linnaean ranks, even if they lacked biological meaning. "They are extremely important to our ability to communicate information about biodiversity that we see and study."[45] To Nixon and others in his field, the ability to communicate about the natural world involved not only current day systematics, but the history of systems as well. In revising or replacing a naming system with a long tradition, part of what is lost is the historical lineage of the classification. "Almost two centuries ago, the dipterist C. R. W. Wiedemann said, 'names carry values like coins, the sound of the name, not its contents, to remind us of the named.'"[46] Wiedemann finds value in the connotations and stability of a name. There have

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[44] Kevin de Queiroz, and Gauthier Jacques. "Phylogeny as a Central Principle in Taxonomy," 307-22.

[45] Elizabeth Pennissi, "Linnaeus's Last Stand?" 37.

[46] Sandra Knapp, Gerardo Lamas, Eimear Nic Lughadha, and Gianfranco Novarino, "Stability or Stasis in the Names of Organisms," 619.

long been calls to reform the Linnaean system, and almost as long there have been advocates for maintaining it. In 1867 A. P. de Candolle wrote in *Lois de la nomenclature botanique*:

> Meanwhile, let us perfect the system introduced by Linnaeus. Let us try to adapt it to the continual and necessary changes in our science…; let us attack abuses and negligence; and let us reach an understanding on contentious points, if possible. So we shall have paved the way for the practices of science for many years to come.[47]

Those who find use, comfort, and beauty in taxonomic nomenclature, whether Linnaean, or PhyloCode, will find none in barcoding nomenclature systems. These taxonomic nomenclatures would have no names at all, but instead species would be represented by number sequences. Much as spectrographic readings made the identification of color a numeric formula, species identification under the systems of barcoding would be digital or numeric. As with color nomenclature, in which no chromotaxonomy could adequately name all the shades, nor designate the continuity of the spectrum, demarcations between species are not as distinct as once believed. Unlike the case of color naming systems, which spectrographic codes swiftly replaced, the replacement of traditional biological classification with genome sequencing codes will not happen as readily. The PhyloCode nomenclature has many opponents, perhaps precisely because it tinkers with an established naming system, but because of the lack of names, barcoding methods are readily adopted.

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[47] A. P. de Candolle, *Lois de la nomenclature botanique* (Paris: V Masson et fils, 1867): 12. My translation. "En attendant perfectionnons le système de la nomenclature binominale introduit par Linné. Tàchons qu'il s'adapte mieux aux changements continuels et nécessaires de la science, et pour cela répandons, le plus posible les príncipes de la méthode, attaquons les petits abus, les petites négligences, et mettons-nous d'accord, s'il est posible, sur les points controversés. Nous préparerons ainsi, pour quelques années, une meilleure marche dans les travaux de classification des botanistes."

Paul Herbert and his colleagues at the University of Guelph in Canada proposed a DNA barcoding system at the proceeding of the Royal Society B in 2003.[48] The project has taken further form under a systematic barcoding effort called The Barcode of Life.[49] Under this system, mitochondrial DNA, especially from cytochrome c oxidase, would be used to determine the quartet of chemical bases, adenine, cytosine, guanine, and thymine in a code referred to by the letters A, C, G, T, that can be millions of letters long. Product barcodes consist of a string of 11 digits, each digit being a numeral from 0-9. For products, such an 11-digit barcode provides 100 billion unique combinations. For categorizing organisms, this is not enough, so Herbert proposed a sequence of a 45-letter signature for the encoding of DNA.

Another such proposed system would forego the determination of taxonomic names through the examination of phenotypic and phylogenetic analysis altogether in favor of codes of genome sequencing. Haitham Marakeby, Eman Badr, Hanaa Torkey, Yuhyun Song, Scotland Leman, Caroline L. Monteil, Lenwood S. Heath, and Boris A. Vinatzer have developed a system to automatically classify and name any individual genome-sequenced

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[48] Paul D. N. Hebert, Cywinska Alina, Ball Shelley L., and DeWaard Jeremy R. "Biological Identifications through DNA Barcodes," *Proceedings: Biological Sciences* 270, no. 1512 (2003): 313-21, http://www.jstor.org/stable/3558697.
Also published by the *Philosophical Transactions of the Royal Society B* in 2005 is the article, "Defining operational taxonomic units using DNA barcoding data," by Mark Blaxter et. al., in which it is argued that treating the taxa defined by barcodes facilitates access to taxon groups that are not accessible to other methods of enumeration and classification.

[49] Barcode of Life: Identifying Species with DNA Barcoding, 2017, http://www.barcodeoflife.org/

organism independently of current biological classification and nomenclature.[50] In biology, the need for a system with more individuation has increased as scientists discover genetic diversity within species nearly every day. "The revolution in DNA sequencing technology is now allowing us to sequence genomes of any size at low cost and it is revealing a level of genetic diversity that cannot be classified and named appropriately within the current biological classification system."[51]

The merits of a classification system based on genome sequences are multiple. Unlike the Linnaean and PhyloCode systems, once a DNA sequence is established, the designation is immediate and does not require protracted description of phenotypes or phylogenetics and the establishment of a specific name that falls into the complex regulations of binomial nomenclature. The codes would never need to be revised as more and more biodiversity is sequenced, since the codes are individual. Instead of groupings made according to the broader categories of a species name, the numeric codes have digits that indicate the level of similarity or divergence by individually genome-sequenced organism. Another benefit to a genome coding system is that it applies to all life forms. Those working in all of the life sciences would have the same system of classification and naming, and it would be universal.

The key principle behind genome codes as proposed in 2014 by Marakeby and colleagues would be as follows. Each individual organism's chromosomal or mitochondrial DNA would be assigned a unique code that expresses how its genome is related to that of

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[50] Haitham Marakeby et al., "A System to Automatically Classify and Name Any Individual Genome-Sequenced Organism Independently of Current Biological Classification and Nomenclature," *PLoS ONE,* 9, no. 2 (2014), doi:10.1371/journal.pone.0089142.

[51] Haitham Marakeby et al., "A System to Automatically Classify," 2.

other organisms. Codes consist of 24 positions, each consisting of one or more digits, to which additional positions could be added. Each individual position of the code reflects a different level of similarity between organisms. Furthest to the left, the first position reflects the lowest level of similarity, and furthest to the right, the last position reflects the highest level of similarity. The digits in the positions of a genome code for an organism will be the same as those of similar organisms toward the left until, moving toward the right, the final position indicates its individuality. As an example, Marakeby and colleagues applied the coding system to bacteria, viruses, and humans to test. To see an example of how species nomenclature under this proposed system, their table in Figure 7.3 shows the results of assigning provisions codes.

Class/order/family, Species	Common name	Code
Amphibia/Anura/Ranidae		
Pelophylax nigromaculatus	Dark-spotted frog	$1_A 1_B 76_C 0_D 0_E 0_F 0_G 0_H$
Mammalia/Rodentia/Muridae		
Mus musculus	House mouse	$1_A 0_B 28_C 0_D 0_E 0_F 0_G 0_H$
Rattus norvegicus	Brown rat	$1_A 0_B 28_C 1_D 0_E 0_F 0_G 0_H$
Mammalia/Primates/Hominidae		
Gorilla gorilla	Gorilla	$1_A 0_B 18_C 0_D 0_E 0_F 0_G 0_H$
Homo sapiens	Human	$1_A 0_B 18_C 0_D 1_E 0_F 0_G 0_H$
Pan paniscus	Bonobo	$1_A 0_B 18_C 0_D 1_E 1_F 0_G 0_H$
Pan troglodytes	Common Chimpanzee	$1_A 0_B 18_C 0_D 1_E 1_F 1_G 0_H$
Pongo abelii	Sumatran Orangutan	$1_A 0_B 18_C 0_D 2_E 0_F 0_G 0_H$
Pongo pygmaeus	Bornean orangutan	$1_A 0_B 18_C 0_D 2_E 1_F 0_G 0_H$
Mammalia/Primates/Hylobatidae		
Hylobates lar	Lar gibbon	$1_A 0_B 18_C 1_D 0_E 0_F 0_G 0_H$

Code positions from A (60% ANI) to H (99% ANI) are shown. See Table S3 in File S1 for codes, ANIb values, and percentage of fragments that aligned with the genomes used for code assignment for 466 mitochondria.
doi:10.1371/journal.pone.0089142.t004

Figure 7.3. Marakeby provisional DNA codes[52]

These genomic codes could be adapted to all life forms, and because positions could be added for information to reflect variables such as maternal and paternal lineage, the coding

[52] Marakeby provisional DNA codes. *Source:* http://dx.doi.org/10.1371/journal.pone.0089142.t004

system is flexible and permanent. Marakeby and colleagues proposed that their system work to complement, but not replace, existing biological classification, a wisely proffered olive branch that savors somewhat of a mollifying gesture such as hosting an exhibit of antiquated velocipedes at the Grand Prix.

Despite the intention of botanists and biologists of previous centuries and geneticists today to create a universal and permanent taxonomic nomenclature, taxonomies and systems of encoding species continue to be proposed and debated. The successful Linnaean system examines multiple characteristics of a species to devise nomenclature, which employs strict rules of naming to designate new species or reorganize them within an existing system. Genomic sequencing systems catalog a direct numerical or coded correspondence by quantifying one or few characteristics. The quantification and coding of limited characteristics makes computation of species easier, but taxonomy is a science of creating a holistic system of naming and organizing. Part of the value of taxonomic species names is that they expose perception during a historical era, as well as relating information about a species itself.

The organizing and structuring of species is still one of the most important tasks of the biologists and botanists. As Joshua Rest said, "Even in the jungle of molecular genomics data, careful thinking, good hypotheses, and broad knowledge of organisms will remain central to actual discovery. Data collection and analytical details are only important to the extent that they complement these skills."[53] The artificial systematization of nomenclature for species, is a speech act that serves to create divisions where formerly there

[53] Joshua S. Rest, "The Expansion of Molecular Data in Evolutionary Biology," in *Evolution since Darwin: The First 150 Years*," eds. Michael A. Bell, Douglas J. Futuyama, Walter F. Eanes, and Jeffrey S. Levinton (Sunderland, MA: Sinauer Association, 2010), 665.

were none. As had Linnaeus and others, taxonomists of species choose a name in order that the species become recognized and standardized. Since language is used volitionally and in an artificial manner in taxonomic nomenclature, the names serve two purposes. They delineate something from an evolving continuum, and, through the interplay of word to world and world to word perception, they serve to build scaffolding for higher cognition by exposing underlying structures. The taxonomic nomenclature can help to lead to actual discovery. Rather than numeric identification through genomic sequencing, which is a convenient computational tool and a means by which to sort characteristics in databases, a taxonomy comprised of words serves to relate a history, to reveal interior and exterior systems, and to build knowledge.

CHAPTER 8

CONCLUSIONS

To begin this dissertation of taxonomic nomenclature, I discussed the perception of divisions in our environment as real, subjective, or created, and I showed how the language we use to represent and communicate about these divisions also limits and determines them. I showed how early theories of language evolution were informed by the notion that divisions to the environment are real in that they often cited the influence of categorizing our surroundings as the basis for language. I showed how theories of relativity then introduced the idea that divisions to the environment were influenced by language, culture, time, and location. Finally, I showed how speech became credited as being an instrumental force in the creation of these divisions to the environment. I applied the theories of the perception of division and of naming these divisions to the two case studies of color and species. Even though they are very different cases, the main difference being that species are subject to evolution over time, dividing and naming colors and species have compelling points of intersection. Both can be viewed as existing on a continuum, and both have undergone a change from taxonomic nomenclature to numeric coding. Since the goal of good taxonomic nomenclature should be to describe and systematize the world and the most sophisticated means we have of representing reality is with language, I have made the case that words should serve as the basis of taxonomic nomenclature. Language can communicate the real divisions of our environment, and, more tellingly, it conveys the subjective and created divisions our mind necessarily imprints on the systems we devise. Language reflects these structures and logic that our minds impose on our perception of the world. It is because of this duality, the combining of word to world, and world to word directions, that language should remain the basis for taxonomic science.

Even so, the ease of computation has eroded the use of words in taxonomy in favor of systems of identification that quantify one or few characteristics of a color or species. As computation becomes easier, it is especially tempting to switch to a numeric system. In addition, the scope of colors and species makes numeric identification appealing. The primary argument for using numeric identification is the facilitation of computation. But understanding nature is a matter of understanding relations, and computation is a tool that does not result in an explanation of relations. Thus, while numeric systems of identification are still called “taxonomy” by some of their proponents, this is not an accurate portrayal. Numeric systems list individuals encoded according to few characteristics, and this provides ease of computation. However, taxonomy is the science of systematizing, organizing, and showing relationships, not of creating a catalogue. Because language can provide a basis for a more revealing and holistic system, it is therefore the better tool for explaining and communicating about categories and relationships.

Applying these theories specifically in my case studies of color and species, I have shown that, although none became as prevalent as Linnaean binomial nomenclature, nomenclature systems devised for color quickly became obsolete for the sciences and industry as our ability to identify and encode colors with the use of spectrographic readings arose. Likewise, since methods of identifying plants, animals, bacteria, viruses, and humans through the reading of genetic materials is now commonplace, some biological scientists and taxonomists propose replacing the Linnaean nomenclature and the PhyloCode with a system of genomic sequences. Because the taxonomic naming system in the biological sciences is more established than any single color taxonomy, the resistance to a taxonomic system based on genomic sequences faces detractors. Nevertheless, and regardless of opposition, classification and naming of organisms by genome sequencing is developing quickly as data accumulate.

Taxonomists who advocate for continuing the use of words to designate taxonomic divisions argue that having a name for something instead of an opaque label, such as a series of numbers or symbols, has the merit of having a tradition, having been in use for almost three hundred years. This established tradition facilitates communication. Having a word for a species also has the advantage of being easier to remember, as linguist Martin Haspelmath pointed out. Cognitive studies indicate that having a word for an object makes us more like to, if not perceive, at least notice it, as cognitive psychologist Jules Davidoff determined.

Detractors for the use of names in nomenclature point to the instability of a system that tries to group things that are continuous, and ever shifting into categories denoted by words. What use is the word if the referent is not exactly discrete or if it evolves out from under the label? As the efforts of theologian Johann Amos Comenius and reformer John Wilkins attest, there have long been attempts to make a scientific language based on symbols or codes that accurately, stably, and universally represent taxonomic divisions. Genome sequencing would go as far as labeling individuals instead of grouping things into categories by taxonomic names. Promoters of this system say that it provides a more flexible and workable system of taxonomy than ones that rely on artificial categories designated by names.

The yellowish brown color *Isabellinus*, which Henry Thornton Wharton's color nomenclature included due to the name's picturesque provenance, and Ridgeway's "Throat of a blue titmouse," have faded into obscurity and are no longer used for taxonomic purposes. Spectrographic data made color taxonomy by name almost instantly archaic. Yet, designating a color, however precise it may be, by X = 0.4832 by Y = 0.3045 is simply not as colorful or memorable as "Cappagh Brown," the brown produced from the bog-earth from the estate of Lord Audley at Cappagh, near Cork.

As the changes in species nomenclature are taking place today, and as the arguments for and against the continuing use of Linnaean binomial nomenclature are made, it is worth considering the loss that will occur when words for species are replaced by genome sequences. The story behind the Latin binomials, such as *Dinohyus hollandi* will go the way of names from color taxonomies. *Homo sapiens* would become something such as $1_{A}O_{8}18_{c}O_{p}1_{E}O_{F}O_{G}O_{H}$.

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VITA

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For the governmental department Eduaragón, Ms. Kelley developed the elementary and middle school English curriculum for a region of Aragón, Spain. She continues this work on a free-lance basis on location in Anzánigo, Aragón.

Ms. Kelley has spoken at conferences in the United States, Spain, and Germany. Her topics have included neuroplasticity, humor, language acquisition, art, and literature. She has written articles and book reviews for scholarly journals. Ms. Kelley has translated works and edited translated works.

In the fine arts, Tanya Kelley paints abstracts, landscapes from Wernigerode and Worpswede and Paleolithic art from the Pyrenees. Her work has been featured in solo and group shows in New York City, Bar Harbor Maine, Kansas City and Excelsior Springs Missouri. She has worked on historical art restoration of medieval wall painting at the Burg zu Hagen im Bremeischen and the restoration of a galleon figure in the Schiffahrtsmuseum in Bremen.