JOHN C. BARENTINE

THE LOST CONSTELLATIONS

A HISTORY OF OBSOLETE, EXTINCT, OR FORGOTTEN STAR LORE

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To my grandparents,
Gerald and Verne Anne Danley

Preface

I grew up at the edge of Phoenix, Arizona, just before the start of the vast, sprawling suburbs that completely surround the city. In the late 1980s, beneath a sky already so light polluted that fourth-magnitude stars had essentially vanished, I came of age as an amateur astronomer. With a small backyard telescope, my views were largely limited to the Moon, bright planets, interesting double stars, and a handful of the very brightest nebulae, galaxies, and star clusters. In high school, I upgraded to a simple but sturdily constructed 8-in. Newtonian telescope that brought some of those distant objects closer; in the very middle of the night, when the city light was at a relative minimum, I could just begin to glimpse a few of the brighter galaxies in the NGC catalog. But the bright stars, those needing no telescope for a fine view, were first and foremost among my companions on many long nights, and to this day their seasonal comings and goings take them away and bring them back regularly like old friends.

When I was in college, I met the famed amateur comet-hunter David Levy, fresh off the spectacular impact of his co-discovery with Carolyn and Gene Shoemaker, Comet Shoemaker-Levy 9, with Jupiter in the summer of 1994. David was an inspiration ever since I first read about him 10 years earlier, as a kid. I asked who inspired him in the same phase of life, and he pointed me to a very under-appreciated book by an unfamiliar author: Lesile Peltier (1900–1980). The book was *Starlight Nights*[1] (1965), in which Peltier recounts his life as, in Harlow Shapley's words, "the world's greatest nonprofessional astronomer." As a boy growing up in rural western Ohio during the earliest years of the twentieth century, he first set out to learn the names of the stars; along the way, they became as familiar as the earth beneath his feet. Peltier wrote that it took him

> about a year to become acquainted with the stars. This may have been a longer apprenticeship than some would care to serve but I have found it well worthwhile for in the end I had much more than just a mere assortment of names and places in

[1] David arranged for a reprinting of the book Sky Publishing in 2007, along with an excellent new foreword he wrote.

> the sky. Each star had cost an effort. For each there had been planning, watching, and anticipation. Each one recalled to me a place, a time, a season. Each one was now a personality. The stars, in short, had now become *my* stars.

I, too, set about to learn the names of the stars—at least a few bright ones visible from my part of the world—and in time I began to assemble them into asterisms and constellations. The Big Dipper was familiar from childhood; the fainter stars comprising the rest of the Great Bear remained a challenge. Orion rose in the fall and ruled the winter sky, while an appearance by the bright orange star Arcturus, low on the northeastern horizon in late February, was an annual reminder those long winter nights were drawing to a close. Sagittarius took its place low in the southeast by midnight in May, but I could only imagine the steam issuing forth from its famous "Teapot" because the sky was far too bright to show any trace of the Milky Way. By the time the Summer Triangle marched overhead at sunset in September, the long days of school vacations were already over. These were the cycles I came to expect every year, without exception. While I knew fainter stars existed from occasional overnight trips out of town to darker locations, they were otherwise always minor players in the nightly spectacle, watching from behind the folds of dark velvet curtains in the wings.

Various books and how-to guides on astronomy also made me aware that, from our latitude, about one-third of the entire night sky was rendered permanently invisible. There were other bright stars marking exotic constellations, but they never rose above our southern horizon. For several years in my early teens, I had a pen pal in Australia with whom I exchanged letters every few weeks; I wrote asking for descriptions of his night sky and marveled at his recollection of seeing Supernova 1987A from his home in the Sydney suburbs, a bright star visible to the naked eye despite the light pollution problems of the big city. I was left to imagine what southern skies looked like.

One winter night when I was about 14 years old I ventured out into the front yard of our house to set up my telescope, a 60 mm refractor received as a gift the previous Christmas. Although it had little light-gathering power or angular resolution, it was "good enough" given the bright skies of Phoenix. My quarry that night was a very young crescent Moon that would appear in the gap between the tall trees on either side of our street as it gently curved toward the southwest. The front of our house faced south, and as I wrangled the telescope tripod through the open front door, I looked up and spotted something grazing the top of the peaked roof of the house on the other side of the street. It was a bright, steely blue-white star, twinkling fiercely in the murk only a few degrees off the southern horizon. And it wasn't supposed to be there.

I stopped and set the tripod down, leaned against one of the brick support structures holding up the roof above the front porch, and waited. *Surely it must be an airplane*, I thought as I waited for the subtle tell-tale motion, parallel to the roof line, of planes on approach from the west into Sky Harbor International Airport. I waited for the steady *blink-blink-blink* of the warning lights that would betray the interloper as a commercial airliner. I waited several minutes, noting only a slow, constant march westward at the sidereal rate. It didn't change the shape, brightness, or color. It was a star, all right, and a quick examination of my how-to books showed it had a name: *Canopus*.

Canopus is the brightest star in the constellation Carina. It is a virtual twin, in apparent brightness and color, to the star Sirius in Canis Major, the brightest star in the entire sky. From the southern hemisphere, on summer nights, the two lights follow each other, passing nearly overhead. From my location at 32° north latitude, its southerly location ensured that it never rose nearly so high. The effect of atmospheric extinction on Canopus was clear, rendering it noticeably fainter than Sirius. The experience felt like noticing an intriguing and altogether new detail in a painting hanging on the same wall for all one's life, hiding in plain sight the entire time.

Carina, I learned, represents "the Keel," as in a part of a ship's functional anatomy. Then I read something astonishing: at Carina's southerly declinations, there were also Sails (Vela), a mariner's Compass (Pyxis), and a Poop Deck (Puppis). There was an entire *ship* down there, one long hacked into bits that are now recognized as entirely separate constellation. But at one time, centuries ago, that vessel—the ship *Argo*—had ruled the starry waves. Considered a single constellation, it dwarfed every other figure in the sky from antiquity until around 1900.

Why did Argo suffer the fate of being broken up into its constituent parts, like a real boat dashed on coastal rocks? The seeds of its disassembly were sewn in the mid-eighteenth century when the French astronomer Nicolas Louis de Lacaille decided it was too unwieldy to easily yield to the designs he had on mapping the stars of the southern sky. By popular acclamation, his suggestion was gradually adopted over the next 150 years and finally formalized when the International Astronomical Union (IAU) promoted the changes as authoritative in its 1928 declaration of the modern constellation boundaries. Only in the past several decades have professional astronomers decided among themselves what (and which) constellations properly *are*, but for centuries the nomenclature of the sky was subject to a kind of Wild West mentality. The story that emerges is one of technologies, the diffusion of knowledge, voyages of discovery, the egotism of astronomers and cartographers, and nationalistic pride.

While we were at college, my friend Marci Winter gave me a book she had mistakenly bought in hopes it would be useful for her introductory astronomy course. That book, Richard Hinckley Allen's *Star Names: Their Lore And Meaning* (1899), is the other key to understanding why I wrote *this* book. Although written over a century ago, Allen's book remains the definitive written work on the history of the constellations. Allen was a gifted polymath with an encyclopedic knowledge of history. As a young man, in an era when astronomical research was driven by visual telescopic observations, his hopes to pursue professional astronomy as a career were dashed by his poor eyesight. While he later experienced reasonable success as a businessman, he never lost his passion for the night sky, and *Star Names* is the love letter expressing his devotion to understanding how the lore of the sky came to be. Structured as a series of section headings, one per constellation, Allen dug deeply into history, literature, art, and science to collect essentially everything then-known about the constellations into a single volume, now attractively priced as an inexpensive reprint. While he wrote extensively about references to the constellations in classical antiquity, he also collected the myths and legends of Medieval, Arab, Indian, Babylonian, and Chinese traditions.

Thumbing through *Star Names* for the first time, I made a second astounding discovery: Argo Navis wasn't the only "former" constellation lurking in the night sky. There were many others consigned to an even worse fate. They had vanished entirely leaving behind as the only vague indicator of their former status at the top of the astronomical food chain some quirky irregularities in the boundaries of the modern constellations. Allen is a detailed, carefully researched source whose name appears repeatedly here, even as some modern critics have dismissed some of his sources as obsolete and his star names as unreliable. Most importantly, his research included constellations already disappeared from the then-current maps in the interest of completeness.

One winter long ago, I made a new friend among the stars, one that would lead me on a journey more than a quarter-century in the making. That journey now culminates in this book. For years I kept notes on scraps of paper and photocopies of the odd article now and then on obsolete constellations from popular astronomy magazines. But I was always dismayed that no proper history of these celestial also-rans had ever been written other than the few tantalizing glimpses in Allen and a handful of other sources, such as Ian Ridpath's excellent *Star Tales* (1989). After finishing my Ph.D., I suddenly found myself with free time for the first time in several years, and writing this book helped fill that void. What has emerged is a very human story that transcends astronomy itself, somewhere at the confluence of history, mythology, folklore, exploration, and psychology.

Like many "Generation X" kids who later went into science I was profoundly influenced by Carl Sagan's 1980 television series *Cosmos*, in which Sagan described the constellations as a "set of human hopes and fears placed among the stars." The same hopes and fears informed the process by which the divisions of the night sky eventually became canonical. How the constellations won (and lost) the astronomical popularity contest, resulting in historical immortality or obsolescence, contains all the essential elements of entertainment, featuring moments of comedy, tragedy, and whimsy. This book tells how we got to where we are, and what we cast off along the way.

Many people contributed indirectly to this book through many years of unfailing support, and I am fortunate that my friends, family, and teachers number too many individuals to name them all here. A few people stand out and are worthy of special recognition for their roles in the realization of this work. I am forever indebted to the love of my mother, Delsia, and of my father, John (1952–2010) who, sadly, did not live to see it published. Their support of my hobby-turned-career set me on the path I continue to walk today. To my friend of more than two decades, Gilbert Esquerdo (Smithsonian Astrophysical Observatory/Planetary Science Institute), I owe thanks for many useful conversations in the early stages of its planning. My former research supervisor Dr. Roger Culver (Colorado State University), the best mentor a student could ask for, heard one of the earliest pitches for this story. Dr. Joel Cruz (Elmhurst College, Illinois), historian and gentleman, encouraged me to see this work to publication and shared with me his

knowledge of the academic publishing world. And finally, I am grateful to Marci Winter Lister for gifting me her unneeded copy of Allen's *Star Names* and launching me on a fascinating and rewarding journey.

Lastly, it is a pleasure to acknowledge the influence of two authors whose works loomed large over the writing of this book: Richard Hinckley Allen's *Star Tales* and *Burnham's Celestial Handbook* by Robert Burnham, Jr. Both writers brought the rigor of scholarship to understanding the history of the heavens, and I have tried to emulate their respective styles—thorough but not exhaustive—in telling the story of parts of the night sky hidden in plain view.

Tucson, AZ
June 2015

JOHN C. BARENTINE

Technical Note

SOURCES

The goal of this book is to be comprehensive without being exhaustive. Original sources of the works referenced herein were preferred in every possible situation. Where the primary works were unavailable, secondary citations were used; I have endeavored to make this distinction clear.

ILLUSTRATIONS

In addition to consulting original written works, I have preferred first printed editions of various charts and atlases as the source of most illustrations in this book. This approach is taken is to show as many interesting depictions of lost constellations as practicable without reproducing every known instance. Depictions from certain seminal works, such as Johannes Hevelius' *Prodromus Astronomiae* (1690) and Johan Elert Bode's *Uranographia* (1801b), are included in every appropriate case; otherwise, the choice of illustrations is made to adequately trace the origin and evolution of constellations in as straightforward as possible a manner.

I have employed a limited amount of manipulation of images from historical atlases strictly for the purpose of improving the clarity and legibility of those images while never altering the figures therein contained. Mild enhancements, such as those undertaken to increase contrast and reduce the background "noise" of discolored or damaged paper, are not generally noted. Any instances of significant image processing that fundamentally alters the source material, such as digitally joining globe gores to produce a seamless composite map, have been noted in the text.

Photographs of non-printed works such as paintings and other illustrations have been reproduced with image density adjustments for clarity only. I have made an effort in every case to try to include in image captions information about the dimensions of the original,

the medium, and current location and/or catalogue information where obtainable. For works not in the public domain, credit is given to the creator along with usage information such as Creative Commons licenses.

TRANSLATIONS

As a result of preferring original sources, I have often confronted passages in original Latin, German, and French. I render these in English as best as I can, being fluent in none of those languages; wherever possible, I have checked with native speakers or those with extensive formal training in Latin. Sometimes the renderings are imprecise, but I have tried to retain some of the flavor of the original and always the essence. In every instance I have quoted passages in their original (non-English) languages as footnotes throughout the text such that the reader can decide if my translations are good. Any deficiency in the essence of the translations will be corrected in a future edition. Otherwise, when using others' translations, I have indicated the translator's name and corresponding bibliographic information when known.

NOMENCLATURE

Since by definition the constellations described in this book had fallen into complete disuse by the time of the first General Assembly of the International Astronomical Union (IAU), where the canon of modern constellations was decided by the international governing body of professional astronomers, they were never subjected to the process by which the IAU formalized a set of genitive cases and three-letter abbreviations (see Chap. 2). There is also the issue of the names of the constellations themselves; as they passed in and out of fashion and were rendered by authors writing in, variously, Latin, English, French, German, and other languages, a variety of spellings often ensued. I describe here how I settled on a means of standardizing names, cases, and abbreviations across the chapters corresponding to individual constellations.

Constellation Names

The names of constellations adopted by the IAU are a mix of Latin and Greek words; the latter generally derive from the names in circulation at the time Ptolemy wrote the *Almagest* in the second century AD Others were Roman inventions, but the names of all constellations in the Ptolemaic canon were Latinized. Some of the first new constellations added since the time of Ptolemy referred to discoveries made by explorers to southern hemisphere destinations and the New World. Latin had no native word for the toucan, for example, so when the native name "tukana" came from the Tupi language of Brazil via Portuguese, it was appropriately Latinized as "Tucana." Petrus Plancius suggested a

constellation representing the toucan in 1598, labeling according to the borrowed Latin. Constellations created in the eighteenth century to celebrate the apparatus of the arts and sciences often required contrived Latin names for concepts unknown to the ancients (e.g., "Globus Aerostaticus" for the Hot Air Balloon and "Machina Electrica" for the Electrical Generator). Sometimes they repurposed ancient words for similar devices such as "Antlia Pneumatica" (later shortened to "Antlia") to describe a mechanical air pump, whereas the word "antlia" referred to a water pump in ancient sources.[1]

I have retained the preference for Latin names in this book in all practical cases; fortunately, many of the extinct constellations here discussed were introduced by their creators with native Latin (or Latinized) names. In isolated cases, constellation names were never Latinized by their creators or involve words that have no obvious Latin equivalent. An example is the Battery of Volta, described in Volume 2. Since an electrical battery has no conceptual expression in Classical or Medieval Latin, I borrowed the Latin word "pila," meaning a pillar or column, as of stone, to indicate the original sense of a battery as a "Voltaic pile." Thus, while I use "Battery of Volta" as the formal name of the constellation, I render its genitive as "Pila Voltae" and its three-letter abbreviation as "PiV."

Genitives

The genitive grammatical case is used to indicate possession, in the sense that a particular star "belongs" to the constellation inside whose boundaries it falls. The widespread use of this convention originated in Johann Bayer's *Uranometria* (1603). Bayer devised a system of cataloging the stars in a particular constellation visible to the unaided eye by the use of Greek letters. According to this scheme, the brightest star in a constellation was labeled "α," the next brightest "β," and so forth through the 24 letters of the Greek alphabet. However, most constellations had more than 24 visible stars; when he ran out of Greek letters in a particular constellation, Bayer ran through the lowercase Roman alphabet starting at "a," among which he omitted the lowercase letters "j" and "v." That brought the total number of available letters to 48. Bayer never exceeded this number in any constellation, but later astronomers sought to extend the series using uppercase Roman letters beginning with "A" following "z" and finishing at "Q," inclusive of "J." Within any given constellation, Bayer proceeded from one whole magnitude to the next in half-magnitude intervals; for example, a "third-magntitude star" is any having a visual magnitude between +3.5 and +2.4. He further proceeded in an overall north-to-south pattern, then repeated the process for the next-faintest magnitude bin. In other cases, Bayer changed the order of the letters for historical or other reasons.

To complete the designation, Bayer added the classical constellation name in the genitive case; for example, the brightest star in the constellation Canis Major became α Canis Majoris ("alpha of Canis Major"). This convention followed the rules of Latin noun declension, which in some cases required the Latinization of constellation names

[1]For example, Martial, *Epigrammata* 9, 14, 3; C. Suetonius Tranquillus, *Tiberius* 51.

Table 1 Modern constellations whose names consist of two words: nominative case, genitive case, and meaning

Nominative	*Genitive*	*Meaning*
Canes Venatici	Canum Venaticorum	The Hunting Dogs
Canis Major	Canis Majoris	The Greater Dog
Canis Minor	Canis Minoris	The Lesser Dog
Coma Berenices	Comae Berenices	Berenice's Hair
Corona Australis	Coronae Australis	The Southern Crown
Corona Borealis	Coronae Borealis	The Northern Crown
Leo Minor	Leonis Minoris	The Lesser Lion
Piscis Austrinus	Piscis Austrini	The Southern Fish
Triangulum Australe	Trianguli Australis	The Southern Triangle
Ursa Major	Ursae Majoris	The Greater Bear
Ursa Minor	Ursae Minoris	The Lesser Bear

originally derived from ancient Greek. For instance, Orion became "Orionis" in the genitive case and the star Betelguese, which appeared to Bayer as the brightest in that constellation, became α Orionis.

Among extinct constellations, a variety of names occur in more than one language. For the purposes of standardizing their genitives as closely as possible to the convention implicitly adopted by the IAU, I constructed genitives based on Latinized forms of the constellation names as described above. Naturally, there are some special cases. Modern constellations whose names contain a noun and a modifier, like Ursa Major and Corona Borealis, appear in Table 1. In the "Name/Modifier" paradigm, both words take the genitive case, so the above examples become Ursae Majoris and Coronae Borealis, respectively. Often the modifier is itself already rendered in the genitive, such as in the case of Caput Medusae (see Volume 2). In these situations, the modifier remains unchanged in the genitive, while the name changes case, so "Capitis Medusae" ("*of* the Head *of* Medusa"). There are a few instances of unusual Latin declensions, such as Argo Navis, which becomes Argūs Navis in the genitive. In that singular example I have kept the macron over the "u" in order to specify the genitive as completely as possible.

Abbreviations

At the first IAU General Assembly at Rome in 1922, the Union approved a list of 88 constellations which remain with us today as a modern canon used by professional and amateur astronomers alike. To simplify written references to the constellations, a three-letter abbreviation was devised for each after delegates expressed dislike of a proposed four-letter scheme. The convention determining how a three-letter abbreviation is rendered depends on whether the approved constellation name consists of one or two words. For one-word constellations (e.g., Orion, Taurus, Sagittarius), the word is contracted so as to

make each distinct from any other with a similar spelling. So Orion becomes "Ori" and Taurus becomes "Tau," but Sagittarius becomes "Sgr" rather than "Sag," as the latter was reserved for the constellation Sagitta. Therefore, the preferred rendering is the first three letters of the Latinized name unless some other constellation exists for which those initial three letters are the same. In all cases, the first letter only of the three is capitalized.

If a constellation consists of two words, the format for the three-letter abbreviation is capital-lowercase-capital, where the first capital and lowercase letters refer to the first word in the name (typically Name in the "Name Modifier" paradigm), and the final capital letter refers to the second word. So Corona Borealis becomes "CrB" and Piscis Austrinus becomes "PsA." However, there are irregularities. In some cases, the abbreviation is formulated capital-capital-lowercase, as "CVn" for Canes Venatici and "UMa" for Ursa Major. Then there is the completely inexplicable "Com" for Coma Berenices, ignoring entirely the second word. Rather than explicitly naming a formula for making these determinations, the IAU simply published the abbreviations as a list.

I have imposed the following set of rules in creating abbreviations for extinct constellations:

- For three-letter abbreviations of constellations containing two words, I followed the predominant IAU convention of capital-lowercase-capital. When "Major" or "Minor" is the modifier, I follow the form capital-capital-lowercase *except* if the result is identical to an existing IAU abbreviation. So, e.g., Cancer Minor cannot be shortened as "CMi" because Canis Minor already holds that abbreviation. So, Cancer Minor becomes CnM.
- In a few situations there are totally unique combinations such as "Cerberus et Ramus Pomifer." This I rendered as "CeR" ("Cerberus et Ramus").
- For names consisting of three words, each word receives one capital letter. So, e.g., Gladii Electorales Saxonici becomes GES.
- There are two names consisting of three words where the last word is a modifier and the names differ *only* by that modifier: Telescopium Herschelii Major and Telescopium Herschelii Minor. Since there is no proper way to reduce these names to three-letter abbreviations without losing essential elements, I opted for four letters: THMa and THMi.

Contents

Part I
Toward the Modern Night Sky

1

What Is a Constellation?

> [A]ncient customs are difficult to overcome, and it is very probable, that, except the recently-named groups, which we may now suppress, the venerable constellations will always reign.
>
> – Camille Flammarion, *Astronomie Populaire* (1880)

From a dark location on Earth, far from sources of artificial light pollution, a few thousand stars are sufficiently bright to be seen by the unaided human eye. They are spread across the night sky in a seemingly random way, although the keen observer will note a few structural consistencies. The sky is bisected by the path of the Milky Way, the faint band of light that represents the plane of the galaxy in which we live, its innumerable faint stars blurred together into softly glowing clouds as seen by the human eye. There are generally more visible stars in the direction of the Milky Way's center, in the constellation Sagittarius, than its "anticenter" (the point opposite the center on the sky) in the constellation Auriga. Otherwise, the distribution of stars visible to the naked eye does not yield many clues as to the Earth's position in the universe.

One popular misconception about the stars is that brightness indicates distance, fainter stars being located further away from Earth than the bright ones; were it the case that all stars had identical *intrinsic* brightnesses, this would be true. But by the twentieth century, astronomers realized that the luminosities of stars spanned an enormous range of values, from those many thousands of times intrinsically brighter than the Sun to those just a fraction of a percent of our own star's luminosity. The brightness of stars, then, does not tell us much about the immediate volume of space we inhabit. That some stars are brighter and others are fainter is also only part of the story by which certain ones come to form recognizable patterns to humans.

The main influence on the distribution of stars in the night sky has to do with our location in (and the structure of) the Milky Way. Our home galaxy is a common type known a "disk spiral," consisting of a relatively flat "Disk" embedded in an extended,

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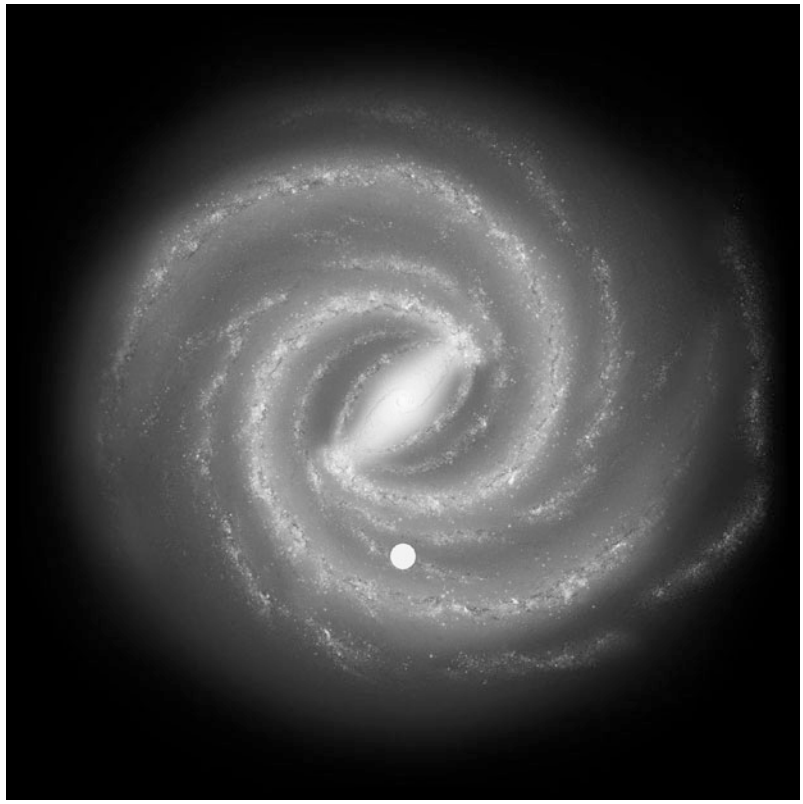
more or less spherical "Halo".[1] A set of spiral arms, regions dense with stars and the materials from which they form, unwind from the center to the edge; the arms are not readily apparent in our night sky by virtue of the fact that the Solar System lies in their common plane. The central region of the Milky Way is characterized by a "bar," a transient kinematic feature kicked up by resonant interactions between stars in their orbits and the gravitational potential of the entire galaxy. From our perspective, we see the bar oriented at an angle of about 45° to the line of sight toward the Galactic center, one end of the bar pitched toward to us and the other directed away.

Since we live inside the Disk, our understanding of the geometry of the Galaxy comes from the structures we can infer from our vantage point, supplemented by studies of other galaxies seen from the outside that we think resemble the Milky Way. Combining information from both sources, we can make an educated guess as to both the shape of our galaxy and the location of our solar system within it. An artist's conception of the Milky Way is shown in Fig. 1.1, illustrating what a viewer situated high above the plane of the Disk might see looking down at it. The Sun, whose position is marked by a yellow circle, makes a leisurely orbit around the Galactic center once every 225–250 million years. Our motion through the Galaxy ensures that the Earth's night sky is never static, and that the stars of tonight's sky differ from those of the distant past and future.

Early astronomers presumed the Solar System was located at the center of this system given two pieces of evidence. First, when we look out into the night sky we see stars in every direction, but they tend to be concentrated into a fairly narrow band dividing the sky into two halves. This suggests a largely flattened system, and that we must be situated nearly in its middle. Second, this band of stars is fairly uniform in density around the sky in an azimuthal sense, so we must be near or at the center of the flat disk. Studies carried out in the twentieth century showed that we are not at the center of the Galaxy, but rather at some considerable radius. In fact, the Sun's place in the Milky Way is on a spur projecting from one of the spiral arms, a relatively quiet backwater compared to the swift streams of the main spiral arms and the crowded environment of the Galactic center.

Humanity's first view of the Milky Way as a single stellar system emerged in the eighteenth century. While the Galaxy has been known since time immemorial, an understanding of its composition awaited the invention of the telescope. In 1610 Galileo Galilei turned one to the Milky Way for the first time, resolving its luminous clouds into innumerable faint stars. A century later philosophers and scientists began to devise ideas about what the Galaxy physically represents. The English astronomer Thomas Wright published *An original theory or new hypothesis of the Universe* in 1750, in which he posited that the Milky Way was a large, rotating body composed of individual stars held together by gravity. He deduced it was a scaled-up version of the solar system, by then describable with relatively simple physics under Isaac Newton's universal theory of gravitation. In 1755, the German philosopher Immanuel Kant elaborated on Wright's

[1] By convention in astronomy, capitalized versions of "Disk", "Halo", and "Galaxy" refer specifically to the Milky Way and its constituent parts; lowercase versions of these same words refer generically to any external galaxy other than our own.



1.1 An artist's rendering of the Milky Way as it might appear viewed face-on from several hundred thousand light years above the midplane. The *solid white circle* indicates the location of the Sun (Credit: NASA/JPL-Caltech/R. Hurt)

hypothesis, suggesting that the Milky Way might have begun as a spinning cloud of gas that somehow condensed into stars. He further speculated that other similar systems might exist and that the faint and featureless nebulae seen in contemporary telescopes could be such "island universes" unto themselves.

Based on his careful telescopic counts of stars toward various directions in the night sky, the Anglo-German astronomer William Herschel made probably the first attempt at a structural model of the Milky Way (Fig. 1.2), correctly concluding that the solar system was embedded inside it. From this vantage point, Herschel wrote,

> the heavens will not only be richly scattered over with brilliant constellations, but a shining zone or milky way will be perceived to surround the whole sphere of the heavens, owing to the combined light of those stars which are too small, that is, too

1.2 William Herschel's model of the Milky Way based on his star counts. The model is essentially a longitudinal slice through the Galaxy, reflecting the Solar System's position within its Disk. Figure 4 from "On the Construction of the Heavens," *Philosophical Transactions of the Royal Society of London*, Vol. 75, pp. 213–266 (1785)

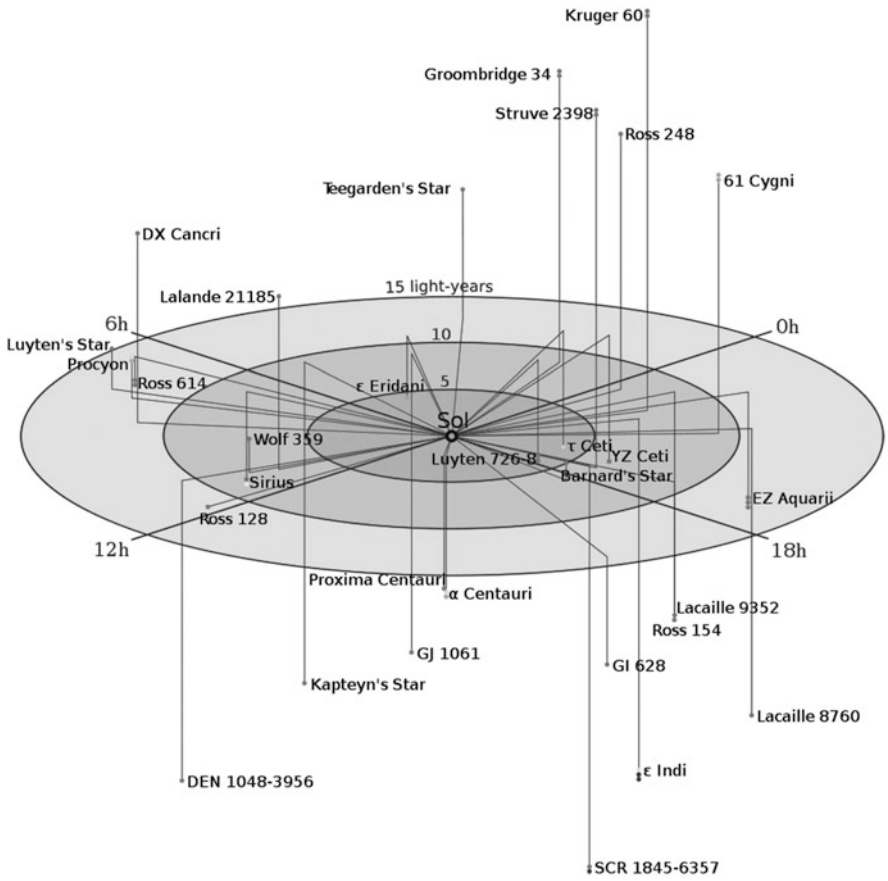
> remote to be seen. Our observer's sight will be so confined, that he will imagine this single collection of stars, of which he does not even perceive the thousandth part, to be the whole contents of the heavens.

Historical interest in the makeup of the Galaxy recounted here is not about appreciating Galactic structure as a subject in its own right; rather, it is in understanding how the stars are scattered about our night skies. The bright stars that mark the familiar constellations tend to be remarkably close to Earth, and many are intrinsically faint given the rapid drop-off of observed brightness with distance, it is clear that most of the stars visible to the naked eye are within a relatively short distance of Earth. This is illustrated in Fig. 1.3, a representation of all known stars within 15 light years of the Sun in space that shows the random nature of the distribution of stars in the space near us. In order to see such low-luminosity stars, they cannot be very far away from us.

Considering the faint, integrated light of the entire Galaxy across our skies as a separate phenomenon, the *individual* stars we see sample a relatively small volume of the Milky Way. We do not live in a part of the Galaxy particularly close to where stars are actively forming; this point is important because such clustered environments are the only places where the distribution of stars in such small volumes of space is relatively uniform. Once stars leave their natal clusters, they drift away in random directions until their orbits around the Galactic center are no longer distinguishable from those of myriad other stars.

For all intents and purposes, the bright stars in Earth's night skies are distributed (semi-)randomly, and do not lend themselves to any *apparent* positional hierarchy imposed by the laws of nature. The constellations, therefore, are a distinctly human invention dictated by culture an imagination rather than being the result of any physical process. How and why we ended up with a sky full of mythical heroes and fantastical beasts says much more about the human condition than it tells us anything useful about how the heavens are constructed.

The tendency of the human brain to detect regular patterns has served our species very well in the realms of science and technology; the assembly of taxonomies is



1.3 A schematic representation of all 32 known stars within 15 light years of the Sun ("Sol") in space. If a star is multiple, the components are shown stacked vertically with the actual position being that of the star closest to the center plane. The coordinate system is right ascension (RA) and vertical distance; hours of RA are marked, as well as distance in three concentric circles with radii of 5, 10 and 15 light years

often the first instinct of scientists when confronted with new and unfamiliar data. We look for similarities and bin them together in a form of intellectual stamp collecting (hopefully) before speculating on the underlying natural laws and principles that make for different categories of phenomena. This approach has been fantastically successful, yielding everything from the hierarchical, so-called "tree of life" arrangement of living organisms to the "tuning fork diagram" of galaxy classification and its early insights into the formation and evolution of galaxies. Under the assumption that, as in biology, "form follows function," a great deal can be learned about the nature of complex systems by searching for the order of repetitive structures or characteristics.

But not every regular pattern in nature indicates some sort of meaningful significance. Identifications of figures in the skies, composed by drawing imaginary lines between the bright stars, seems to be a natural result of the phenomenon of *pareidolia*, a predilection on the part of humans to sense significance in otherwise random stimuli. Pareidolia manifests itself most familiarly in the tendency to see shapes in clouds passing overhead on a summer day; it is involved in specific cases, among the most famous of which is the so-called "face" on Mars. What the constellations represented changed through history even as the figures remained the same and the civilizations that first named them disappeared.

Part of our overwhelming success as a species involves the superior capacity of the human brain for pattern recognition, of sensing a signal buried within the noise and applying that capacity to problem solving. This is useful, for example, to a hunter-gatherer society when it realizes that the population of its favorite game animals waxes and wanes cyclically with the seasons, or among agriculturalists when it becomes clear, as the anonymous author of the Biblical Book of Ecclesiastes reminds us there is both "a time to plant, and a time to pluck up that which is planted."[2] Understanding calendric cues in both the day and night sky was crucial to the survival of our nomadic ancestors and the transition to settled cities after the emergence of agriculture some 12,000 years ago.

Constellations are among the oldest human cultural inventions, certainly predating writing and, in all likelihood, civilization itself. The presumably oldest figures still in existence, such as the Hunter and the Bull, refer to a time in human history before the emergence of settled agricultural communities. It is probably no coincidence that Orion and Taurus reflect themes in the oldest extant works of art: the human form and game animals. Furthermore, it is likely that well-developed oral traditions about these figures long predate the emergence of written proto-language in the early Neolithic period, perhaps as long ago as the seventh millennium BC. Drawing such a conclusion about pre-literate humans is not a huge intellectual leap, considering what early modern humans had to do at night: long before the Internet, television, radio, or even books, before we gathered in insular communities behind the walls of shelters, we lived at night under the sky. Even though early lifeways may have been dictated by the rising and setting of the Sun, some fraction of life must have been lived at night. As the light of campfires died down, those still awake would have been confronted by night skies absolutely untouched by the modern scourge of light pollution. Those people had each other, their folklore and the stars; in such circumstances the constellations were born and later adapted to other uses. Perhaps 10,000 years ago, humanity began a journey in folklore associated with a religious tradition, developed it for practical purposes, and ultimately refined it in the empirical interest of science.

The oldest accounts of constellations and individual stars date to the earliest phases of Old Babylonian culture in the Middle Bronze Age, although the number and variety of Sumerian names found in extant catalogues suggests (but does not prove) the existence of an earlier, pre-literate tradition from which they were drawn. These earliest figures fall into either of two broad categories: gods and their symbols, and depictions of rustic activities

[2]Ecclesiastes 3:2 (King James Version).

associated with the practice of agriculture (Rogers, 1998). The motivation for identifying and naming them may have served a very practical purpose: already in the prehistoric period, humans discovered that the positions and movements of celestial bodies served a calendric function—rather important to societies dependent on correctly predicting the regular cycles of planting and harvesting. The creators of the constellations therefore may well have been the astronomer-priests of the Mesopotamian tradition who viewed the placement of mythological figures in the heavens as a fundamentally pragmatic act.

The earliest surviving written record referencing the Mesopotamian constellations is found in a text called "Prayer to the Gods of the Night" (Cooley, 2011), dating from about 1700 BC, which references the Arrow (the star Sirius), the Yoke Star (the star Arcturus), the "Stars" (the Pleiades star cluster), the True Shepherd of Anu (Orion), the Dragon (possibly the constellation Hydra), the Wagon (the "Dipper" stars of Ursa Major), the Goat Star (Vega) and the Bison (the composite figure depicted in the constellations Ophiuchus and Serpens).

A more thoroughly detailed account, consisting of lists and observations of nearly all the Mesopotamian constellations was carefully recorded in cuneiform script in the so-called "MUL.APIN" tablets (Watson and Horowitz, 2011) whose oldest dated version was written in the eighth century BC but is based on observations from before 1000 BC. The figures of the classical zodiac were established in the Old Babylonian period of the Near East, cast in their final form during the Neo-Babylonian era around the sixth century BC. The folklore that originated in the earliest societies of the Fertile Crescent was transmitted widely across the region, adapted to fit into local cultures; for instance, by around 1000 BC nearly every Near Eastern people adopted its own version of the Mesopotamian flood myth as though it were an original story.

Around the time of the rise of classical Greek culture, the author of the Biblical Book of Job referred[3] to several asterisms, including Ursa Major (the Great Bear), Orion (the Hunter) and the Pleiades. Expanding on earlier work by Hunger and Pingree (1999) on the MUL.APIN tablets, Schaefer (2006) recently concluded, somewhat controversially, that "most of the Mesopotamian constellations and observational data were made from near a latitude of 33–36° between 1300 and 1000 BC, by people we would call Assyrians." Adding additional constraints in the fourth century BC works of the Greek astronomer Eudoxus of Cnidus (408–355 BC), Schaefer further narrowed the time and place of the classical constellations' origin to 1130 BC and 36° north latitude.

This work suggests that the figures in the Western tradition that occupy the night skies of the northern hemisphere were essentially in place as we now know them around 3000 years ago and originated in or near the northern half of Mesopotamia. Textual evidence indicates that the Greeks came into possession of these constellations in the century or so preceding Eudoxus, and that their cultural influence spread the ideas into Europe by the Roman era. In the second century AD, Claudius Ptolemy (*c.* AD 90–*c.* 168),

[3] Job 9:9, 38:31–32.

a Greco-Egyptian writer in Alexandria, codified 48 constellations from the Middle Eastern canon in his *Almagest*, a work that set the Western standard of astronomy for nearly 1500 years.

We will likely never know for certain the ultimate origin of the oldest constellations in our night sky since they long predate written history. Humans showed an affinity for regular spatial structure in some of the earliest works of art dating to some half a million years ago; the recognition of constellations could well be as old, perhaps contemporaneous with the emergence of religious belief and the notion of mythical figures. However old the constellations, it is safe to conclude that they have long journeyed with us on our path to becoming fully human.

With belief comes dogma, and each world culture came to regard its vision of the night sky as authoritative. In the past century a version of the constellations regarded by professional astronomers as canonical emerged, guiding the nomenclature encountered in the scholarly literature. This version was informed distinctly by the cultural preferences of the West, and, whether fair or not, has become the recognized global standard. In the Western vision are preserved echoes of distant human history and extinct peoples, making the modern recension of ancient skies representative of the history of civilization itself. But the census of figures in the Western night sky through history is surprisingly dynamic, reflecting a variety of changing tastes and biases. The adoption of mythology as scientific convenience, and what was lost along the way, is what this book is about.

Even as Ptolemy's constellations held sway for some 1500 years, the figures believed to be represented by stars in the night sky were not entirely static. As Europe emerged from its intellectual dark ages and embarked upon audacious new voyages of exploration, it opened a new "discovery space" in the southern hemisphere. Upon encountering previously unknown stars, sailors drew their own patterns on the night sky as much for of the practical needs of navigation as the expression of imagination. They brought their culture and history to newly-conquered lands, spreading European sky lore across the globe. Their maps of Earth and sky present the world as a knowable place, with each continent and each constellation in its respective place. Finally, science emerged with its emphasis on structure and function. While human knowledge of the universe expanded, the familiar night sky remained the user interface to the cosmos. Inevitably it called for some standardization among the people trying to understand it.

With a sense of what a constellation is in hand, the question remains: who decides? From a literal world of interpretations of the patterns of the night sky emerged a set of 88 figures to be found on every star map today used by amateur and professional astronomers alike. That some constellations are considered "official" by astronomers implies that others are—or were—not, and that a history of night sky folklore existed that is now lost. Its story is fully told here for the first time.