Additional praise for

A Scheme of Heaven

"Educated in both the humanities and the sciences, Boxer is uniquely qualified to guide his readers into a fascinating story of mathematical complexity. The overarching theme of our human destiny is inspirational."

—**Norman Austin**, emeritus professor of classics, University of Arizona

"Astrologers as the first and most ambitious quants and data scientists? Alexander Boxer's remarkable book reveals astrology's mathematical, scientific, historical, philosophical, and literary roots. He shows that astrology is not only an indispensable part of science history but also springs from the same mixture of motives: the desire to control the world and to wonder about it."

—**Robert P. Crease**, author of *The Workshop and the World*

"Through multidisciplinary lenses, Alexander Boxer frames astrology as one of the most ambitious and daring of all human intellectual endeavors. This stellar book is a probe launched into the mysteries of the cosmos, venturing out to rekindle our timeless capacity to marvel at the universe."

—**Ferdinando Buscema**, magic experience designer and magician in residence, Institute for the Future

A SCHEME OF HEAVEN

ASTROLOGY and THE BIRTH of SCIENCE

ALEXANDER BOXER

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A HOROSCOPE

Upon Opening This Book for the Very First Time

♓ ♒ ♑ ♐ ♏ ♎

Today you find yourself presented with a mysterious opportunity. Take it, even if you're not sure it was really meant for you. The focus you apply at this moment has the potential to reveal a number of unexpected connections, each of which can give you new insights into how things stand around you. Go ahead, trust your instincts. Your intuition has always been a faithful guide whenever you've been true to yourself. Yes, mischievous Mercury has been in and out of retrograde more than once this past year, and this hasn't made justifying yourself to others any easier. But Jupiter, ruler of the sky, is there to reassure you that, right now, it's your opinion which matters most. And the Moon? Don't mind her. That scary aspect of hers will look completely different by the time she glides into a new sign in just a few days. Besides, if all of this year's transitions have amounted to anything, it's that you've emerged from them even more resilient and receptive. Your whole being is now perfectly tuned to appreciate the new perspectives that come with a challenging new endeavor. But remember: even if it was the stars which brought you here, only you can decide how much further you'll go.

♈ ♉ ♊ ♋ ♌ ♍

INTRODUCTION

Do the stars and planets really have something to tell us about the cycles of history, the secrets of love, the reasons your last job was no longer right for you, and why everyone born in May is so incredibly amazing? Astrology's unflinching reply is: yes, yes, yes, and definitely yes. That the configurations of the heavens above can influence our lives here on Earth below is, of course, the basic idea of astrology. Modern science has flatly rejected astrology's claims but this hasn't hobbled astrology's charms, certainly not if the continued popularity of online and magazine horoscopes is anything to go by. Let's leave to one side for a moment all the arguments about whether astrology is wrong, or right, or still wrong even when it's sometimes right. I'm here to make the case that astrology is fascinating and still tremendously relevant as a challenge to what we think we know and why we think we know it.

For starters, the questions astrology asks—questions about the patterns of the universe and our place within them—are about as deep and as captivating as they come. If there really is a way to tap into the hidden rhythms of the cosmos, wouldn't you want to know about it? But even more intriguing, at least from where I stand, is how astrology uses mathematics and data to investigate these questions. Over two thousand years ago, astrologers became the first to stumble upon the powerful storytelling possibilities inherent in numerical data, possibilities that become all the more persuasive when pre-

sented graphically in a chart or figure. Although it took a while for the rest of the world to catch on, the art of weaving a story out of numbers and figures, often to encourage a specific course of action, is used everywhere today, from financial forecasts to dieting advice to weather models.

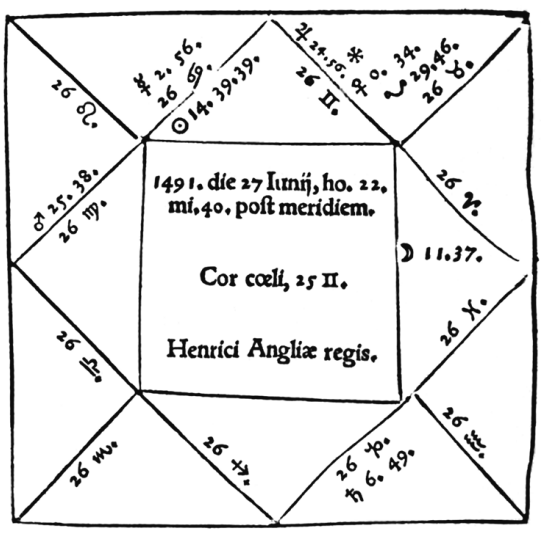
And yet numbers still mislead, figures still deceive, and predictions still fail—sometimes spectacularly so—even those that rely on exceptionally sophisticated mathematics. So, are the techniques being used today to parse and package quantitative information any more effective than what was devised by astrologers millennia ago?

In order to make that assessment, it's first necessary to have a basic understanding of what astrology is and how it works. But that sort of understanding—one that's at least adequate to resolve some seemingly straightforward technical questions—is surprisingly hard to come by for such a long-lived and influential craft. Being frustrated in my own search for a simple yet competent overview of astrology, I decided I might just as well write one myself. This, curious reader, is the book you now hold in your hands.

My own interests in astrology stem from several directions, but mainly it's my enchantment with any sufficiently musty book from the history of science that nudged me to investigate astrology in a more detailed way. Astrology was the ancient world's most ambitious applied mathematics problem, a grand data-analysis enterprise sustained for centuries by some of history's most brilliant minds, from Ptolemy to al-Kindi to Kepler. Just consider that for much of the last two thousand years, the word "mathematician" (*mathematicus*) simply meant an astrologer; there was no distinction.

Throughout its history, astrology's aim has been nothing short of a systematic account linking the nature of the heavens to our own human nature. And from the computations of Copernicus to the sonnets of Shakespeare, even to the sculptures in Rockefeller Center, there are, quite simply, recesses of our culture that can't be accessed without astrology's key. This is especially true in fields such as math and astronomy, where so many of the principal innovators were themselves practicing astrologers. Take, for instance, the Renaissance physician and mathematician Girolamo Cardano, who, when he

wasn't busy laying the foundations of algebra and probability theory, compiled one of the first collections of celebrity horoscopes. Here, for example, is his horoscope for King Henry VIII of England.



Birth horoscope of King Henry VIII. Girolamo Cardano, *Libelli Quinque* (Nuremberg: Johannes Petreius, 1547), Geniture 46.

Diagrams like this appear seemingly everywhere in books and pamphlets from the Renaissance and scientific revolution. For the longest time, I would skip over them, unable to make heads or tails of what seemed to me like graphical gibberish. But to an expert interpreter like Cardano, these inscrutable hieroglyphs evidently had the capacity to brew a bottomless pot of juicy gossip. Were you taken aback by Henry's break with the Catholic Church? Well, now, who's being naive? According to Cardano, Venus in the Ninth House in a sextile aspect to Mercury is just screaming a major change to the laws. His six wives? They really ought to have known better than to get involved with someone whose Moon was in the Seventh House in square with the Sun, while Saturn was in aspect with Venus at the same time Mars was in aspect with Jupiter, the very lord of the Seventh House! Talk about asking for marriage troubles!

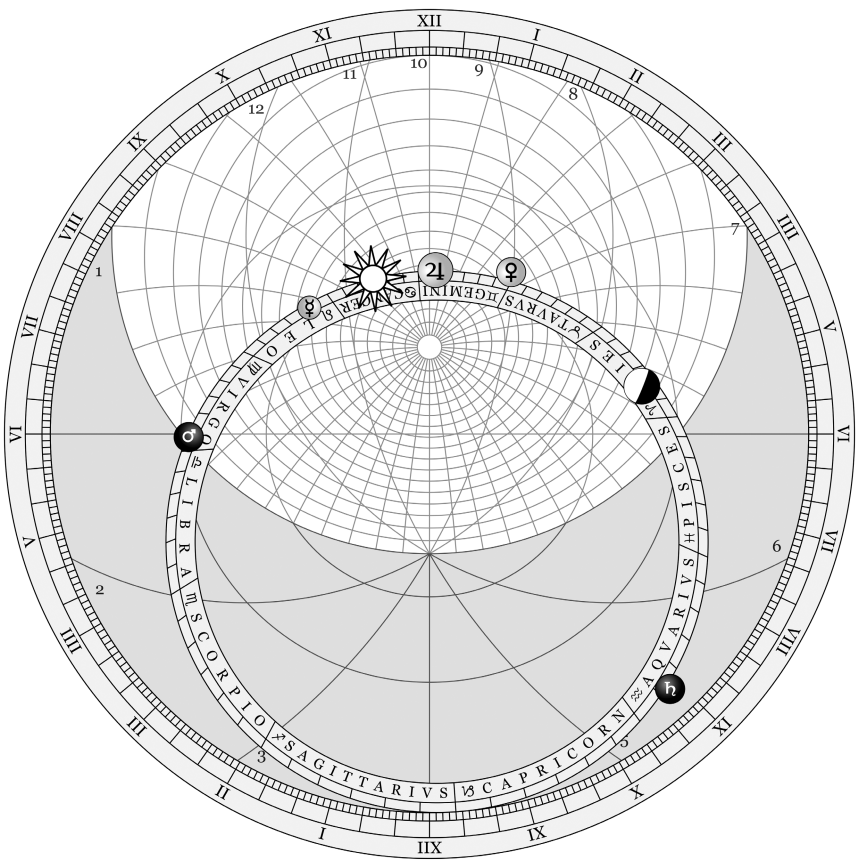
I find horoscopes such as Henry's exciting on several levels. First, there's the exquisitely complex astronomical calculations needed to generate a horoscope, which is really a map of the sky as seen from a particular spot on Earth at a particular moment in time. The millennia-long project to refine these calculations led directly to Copernicus's revolution and, from there, to modern science as we know it today.

Then there was the problem of how to condense and arrange all of this information. Typically this was done visually. The graphical depiction of the positions of the Sun, Moon, and planets constituted what William Lilly—by far the most notorious astrologer in England during the 1600s—referred to colorfully as a "scheme of heaven." As an homage to this art, I've included a number of these heavenly schemes throughout this book as a way to show how the solar system was configured at key moments in astrology's history. The graphical style I've adopted, which is a bit different from Cardano's, takes the outputs of the most modern astronomical computations and displays them according to the design of a very ancient and very beautiful astronomical instrument called an astrolabe (plate 1). Presented in this format, King Henry's horoscope now looks like the diagram on the opposite page.

No doubt about it, there's a tremendous amount of information here. But astrology's particular genius is that it can encode all of the complex astronomical data needed for its operations so perfectly within a single, abstract image. To a remarkable degree, then, the exercise of understanding astrology is really the exercise of learning how to "read" one of these figures. As this book unfolds, I'll describe how to do this piece by piece so that, by the end, you'll be able to visualize the sky in these charts as intuitively as you can see your house in its floor plan, or navigate your way through a city with a street map.

To sketch out a scheme of heaven like this was, however, only the beginning of the astrologer's art. It was still necessary to interpret the data once it had been reduced to graphical form, and this is where things really got interesting. As Cardano's reading of Henry VIII's horoscope shows, these sparse diagrams somehow contain within themselves a wild multitude of possible plotlines. But which ones are expressed and which ones suppressed? To borrow a term from biology, horoscopes are like the "pluripotent cells" of

An Astrolabe-Style "Scheme of Heaven" for Tuesday, June 28, 1491
The Birth of England's King Henry VIII



The Palace of Placentia, Greenwich, England: 51°29'01"N, 0°00'21"W
JD: 2265823.94722
10:44 UT
ΔT: 311s
Local Time: 10:40 AM
Local Apparent Sidereal Time: 5:44

	λ	β	RA J2000	Dec J2000	Az	El	House
♄ Saturn	♒ 6°42'↓	0°44'	21h 05m 59s	-17°25'	297°04'	-43°22'	⑤ 13°17'
♃ Jupiter	♊ 24°24'	0°17'	6h 06m 34s	23°12'	184°00'	61°34'	⑨ 27°49'
♂ Mars	♍ 26°16'	0°21'	12h 12m 54s	-1°00'	88°17'	0°58'	⑫ 29°01'
☉ Sun	♋ 14°39'	0°00'	7h 34m 02s	21°44'	144°22'	57°21'	⑩ 20°27'
♀ Venus	♊ 0°50'	-2°41'	4h 26m 26s	19°01'	222°00'	50°11'	⑨ 0°50'
☿ Mercury	♌ 6°45'	1°17'	9h 06m 54s	17°56'	116°26'	43°41'	⑪ 13°08'
☽ Moon	♈ 10°59'	3°30'	1h 01m 13s	10°21'	264°46'	13°50'	⑦ 13°53'

storytelling, capable of producing many, but still not quite every possible outcome. Considered this way, horoscopes offer up neatly wrapped little packages for examining the mischief that can arise when words are translated into numbers and numbers are translated back into words, even if the numbers themselves are handled with the utmost precision and care. The various ways the borders get blurred between numbers and words, whether innocently or otherwise, can be thought of as a second type of scheme, one that astrologers were the first, but by no means the last, to grapple with.

As someone who analyzes data for a living, my curiosity about these schemes of heaven—"schemes" in their double sense of both a graphical blueprint and an interpretive sleight-of-hand—ultimately became too much to resist. I wanted to understand them, to know how they work, to take them apart and put them back together again. And so, perhaps not fully aware of what I was getting myself into or where it all would lead, I took a deep breath, I set aside my preconceptions, and I began in all seriousness to examine astrology.

I can't say that calculating planetary aspects to high precision was something I ever pictured myself doing but, then again, maybe it all makes perfect sense. I love opportunities to mash up ancient and modern technology, and when it comes to archaic high-tech, astrology is the most formidable and therefore the most tantalizing challenge of them all. Also, with astrology, it helps to have a somewhat eclectic knowledge of both math and dead languages which, by an odd quirk of my upbringing (unless Fate insists on taking credit), I happen to possess. This combination isn't terribly rare, but it's uncommon enough that it seems to have left astrology surprisingly underexplored.

Of course, in a book of this scope, it's not possible to focus on more than just a few of astrology's many facets. Certain topics, such as the astrology of India and China, I've avoided altogether on account of the fact that I know very little about them. But the traditions of Greek, Roman, and Renaissance astronomy and the modern-day arts of statistical analysis are subjects which I know quite well, the latter through my profession, the former through a lifetime's fascination. Does this give me license to write about astrology—a topic for which the whole idea of expertise seems thoroughly up for grabs? That's a judgment you'll have to make for yourself. For my own part, I make

no pretense to astrological mastery. My hope, instead, is simply to offer a different perspective on a subject for which it's all too easily said that there's nothing new to be said about it.

At a minimum, I want to give astrology a treatment that's open and fair. Unlike many others who have a scientific background, I've never felt any particular animus toward astrology. On the contrary, its taboo status as the arch-pseudoscience makes it all the more delicious to think about. Why, for example, is astrology considered unscientific while economics—which also uses complex mathematical formulas to predict the future with results that are, let's say, mixed—is regarded as a perfectly respectable field of study? Being able to articulate the distinctions, yes, but also the commonalities between astrology and other modes of asking questions about the world helps to clarify which approaches are fruitful, which aren't, and why.

Astrologers were the quants and data scientists of their day, and those of us who are enthusiastic about the promise of numerical data to unlock the secrets of ourselves and our world would do well simply to acknowledge that others have come this way before. What profession would I, or anyone who delights in numbers, have been drawn to had we lived five hundred years ago? A thousand years ago? Two thousand years ago? Astrologers were the originators, and for most of history the sole cultivators of a tradition that transmuted numbers into stories. And like any story that's been retold for generations, astrology's account of the cosmos has been refined to just its most captivating themes. Regardless of whether astrology has distilled any truth or not, what seems clear to me is that it has bottled up a certain type of magic, one that has proven time and again its ability to get us to stop and think about our connections to the wider universe. Against a backdrop of indifference, this is some magic indeed. So who's to say we can't use a little of astrology's charms for our own ends? Whether you're intrigued by astrology, repelled by it, or anywhere in between, we can interpret astrology's bold claims as an open invitation to explore some of the deepest mysteries of who we are and where we are. This book is my elaborate way of saying yes to that invitation, and now it's my turn to invite you to come explore these mysteries with me.

1

TO EVERYTHING THERE IS A SEASON

When I behold Thy heavens, the work of Thy fingers,
the moon and the stars, which Thou hast established;
What is man, that Thou art mindful of him?
and the son of man, that Thou thinkest of him?

Psalm 8:4–5

It's possible that in ages past, there was a common intimacy with the night, even if this has long since been lost to us in modern times. I'm not so sure. To be outside, alone, on a clear and moonless night, far from any lights, far from any trees, and looking up at the sky is not an ordinary thing. I'm skeptical that it ever was. No, I don't believe that we ever really notice the stars except in those rare moments when their possibility of being seen coincides with our openness to seeing them. But if you catch them in their splendor, glimmering across the brisk night air like icy drops of cosmic fire, then you have no choice except to stop and notice them. They engulf your vision fully. They enfold your thoughts up whole. And there you stand beneath them feeling suddenly, utterly exposed. Because if you can see the stars that clearly, might not they, then, see you too? Thus, when David sang his psalm, gazing up at the sky in wonder, it wasn't the contents of the night which moved him;

it was his astonishment that just as he was contemplating the universe, so too the universe, or rather its creator, was contemplating him right back.

This perception of a mutual regard between man and the cosmos has, from our earliest beginnings, animated humanity's efforts to understand the world and our place within it. Modern science began from studying the heavens, and in this sense we can say that, yes, the stars really have communicated to us many profound truths about the nature of things. The bigger question isn't whether the universe is speaking but, instead, how far we can ever hope to comprehend what it might be saying. Because for all the progress that's been made in deciphering the Book of Nature, what expectation can there be that humankind will ever manage more than a thin and incomplete translation? The language of the cosmos is simply not our native tongue. And if ever we wanted a reminder of the mismatch between the world as it is and the world as it is processed through the filters of our minds, all we need to do is look up at the stars.

THE STRANGENESS OF SEEING

Quick: On a clear, dark night, how many stars can be seen in the sky? A thousand? A million? A *billion*? If you're like me, you might think a million sounds high but it's probably at least in the ballpark. Actually, in the modern, high-precision *Hipparcos* star catalog there are only a paltry 5,044 stars that have a visual magnitude of 6.00 or less—that's the value generally considered to be the limit of what's visible with the naked eye. Since at any given moment roughly half of these are hidden below the horizon, seeing a couple thousand stars in the sky at any one time is as good as it gets—ever—even on a perfectly pristine night. Does this seem like a surprisingly low number to you? It did to me. So consider this our first hint, courtesy of the stars, that our natural ability to gauge large numbers is not necessarily to be trusted without question.

Now, a few thousand may sound like a small number, especially when talking about stars, but it would still be very difficult, if not impossible, to create a mental picture of the heavens that consisted of these several thousand stars regarded individually. Yet this bewildering chaos of darkness and

light is immediately converted into a more intelligible map of the sky simply by grouping the stars into constellations. The specific shapes of the constellations may be arbitrary, but the tendency to cluster the stars this way can be found across the various stargazing cultures. The stars that make up the constellation Ursa Major, for example, have been seen as a bear, a dipper, a wagon, a plough, and an ox's leg, to list just a few of its varied personae.

Quite clearly, our brains have become exquisitely tuned to recognize the shapes of people, animals, and other objects meaningful to our daily lives. And when what occupies our field of view defies any discernible pattern, we tend to foist these same shapes onto otherwise amorphous scenes such as cloudscapes, rock formations, or the stars in the sky. Does the stone outcrop in figure 1.1(a) look like a human head to you? If so, then your mind has performed a remarkable act of association, one which emphasized the object's loose outlines while completely discounting other information, such as size, texture, color and situational context. Rock formations like this one, just like the constellations above, are good indicators that we rarely perceive the world in a perfectly straightforward way.

Interestingly, a very similar phenomenon occurs in computer vision applications. It's an impressive technological feat to coax a computer to recognize a class of visual objects—say, for example, dogs—within a larger collection of images. But once you succeed in doing this, it's just as hard, if not harder, to restrain the algorithm from falsely seeing dogs everywhere. Figure 1.1(b), for instance, uses an algorithm called DeepDream—originally developed by Google in 2015—to show what a computer-vision application trained to recognize dogs "sees" when looking at a photograph of clouds. The composite images generated by DeepDream are sometimes illuminating, occasionally beautiful, but mostly just delightfully bizarre. Yet what these images do reveal is that a computer that has been taught to see faces and animals like we do—namely, by emphasizing outlines above everything else—will tend to see faces and animals in the clouds just like we do, too. This suggests, not surprisingly, that our peculiarly human way of seeing the world is probably inseparable from our peculiarly human ways of misconstruing what we see.

Of course, the fact that the constellations have traditionally taken on

Figure 1.1: What Do You See?

(a) The Grey Man of the Merrick, Galloway Hills, Scotland. GARY COOK / AGEFOTOSTOCK.

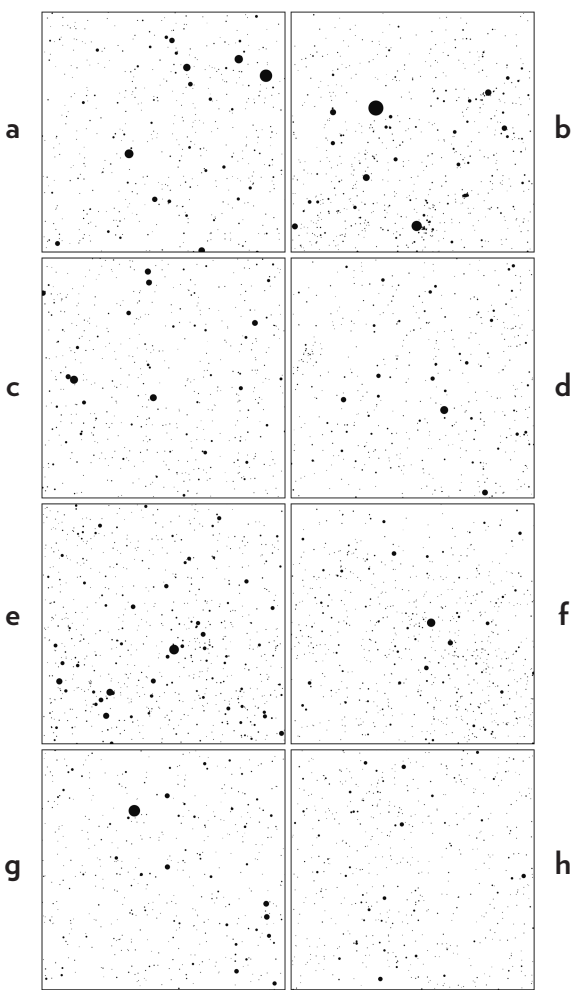
(b) Doglike features in the clouds over Washington, DC, enhanced by Google's DeepDream algorithm.

the rowdy shapes of beasts and demigods doesn't mean that anyone has ever suggested that the sky is infested with lumbering space-bears or interstellar scorpions. But the constellations do illustrate nicely that there is a limit to the number of objects the human mind can handle individually before it tends to impose an additional layer of abstraction. For most people it's simply more convenient—one might even say more human—to view the night sky not as the disposition of several thousand stars but instead as the disposition of just several dozen constellations.

In general, when the number of distinct objects in a system is reduced from thousands to dozens, our minds can begin to develop a basic familiarity, identify structures, and examine how parts relate to the whole. We can even

take those parts and craft that higher and most human layer of abstraction: a narrative story. As an extreme case, consider that nearly 10 percent of the night sky (plate 2) can be accounted for by retelling just one single legend, that of a hero (the constellation Perseus) who slays a monster feared for her demon eye (the star Algol) which could turn any living creature to stone. This hero then returns to rescue a beautiful princess (the constellation Andromeda)

Figure 1.2: Real and Random Star Maps



Four of these maps depict famous constellations, and four show random dots. Can you tell which are which?

chained to a rock by her parents (the constellations Cepheus and Cassiopeia) as a sacrifice to a giant sea monster (the constellation Cetus).

All the same, our propensity to group stars into constellations and constellations into stories can hardly be said to derive from the actual arrangement of the stars themselves. In fact, to a remarkable degree, the distribution of stars in the sky is completely random. Figure 1.2, for example, shows eight star maps, each depicting a roughly equal area of sky. Four snippets contain famous constellations and the other four show an alternate night where all the brightest stars of our sky have been repositioned entirely at random. Can you tell which four are real and which four are random? I'll reveal the correct answers in the next section.

KEEPING COUNT

For millennia, the stars have been our teachers in how to extract information from vast, unruly clumps of seemingly incoherent data. And if, as the stars have shown us, there are peculiarities in how our minds process quantities that are very large, or that exhibit randomness, this doesn't mean that we're unable to learn anything about systems that are large, or random, or both. Fortunately, our brains are capable of a trick or two that allows us to compensate, at least somewhat, for our occasionally skewed first impressions of things. For the most part, these tricks rely on nothing more than our innate ability to count.

As an example of what can be learned simply through careful counting, take another look at figure 1.2. The four images depicting a genuine representation of the night sky are b: Taurus and Auriga, d: Leo, e: Scorpius, and f: Cygnus. If you were brave enough to attempt to sort them, then your score, which is the number of star maps you correctly identified as being genuine, will be either 0, 1, 2, 3, or 4. For all but the most seasoned stargazers, however, it should be pretty tough to pick out all four legitimate maps. How tough? Well, your chances getting any given score just by guessing are presented in table 1.1.