

NEW stars for old

STORIES FROM THE HISTORY OF ASTRONOMY

Marc Read

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*Dedicated to my family, friends, and students
(past and present)*

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Introduction

Science is done by people. That might seem a staggeringly obvious thing to say, but it's all too easy to forget. We're very used to the idea that when we think about art, music, literature, or architecture, we should learn a bit about the person who created the work, and about the society he or she lived in. Why not science, too?

Partly it's because we learn science in school with very little (if any) history involved. We're taught current theories, because what's the point in learning about things that turned out to be wrong? There's a lot to be said for that argument; after all, school science is confusing enough without throwing in a bunch of old ideas and names as well.

On the other hand, we can get the impression that scientific theories are somehow revealed by a booming voice from Heaven, and are set in stone once they've been established. Nothing could be further from the truth!

Science is an intensely human activity. Any theory that you've encountered was produced by someone who had a personality and a life outside the lab, who was worried about paying the bills, who listened to music and read books; someone who was very much part of society. Scientists aren't disembodied brains, but people who can take all of those cultural influences and add their own insights and creativity, all while working within a logical and mathematical framework.

The other point about science is that it changes as time goes by. Old theories are constantly being replaced by new ones, and the

reasons for this are many and complicated. It's not always as simple as "theory A explains things better than theory B," especially if theory B had a few hundred years of tradition behind it, or the support of some powerful people.

Both of these points are especially clear in the history of astronomy. Many of the characters involved were much larger than life, with extraordinary stories to be told about them. Their debates burned slowly, with ideas sometimes disappearing for centuries before re-surfacing – astronomers generally feel themselves to be part of a very long tradition, with time on their side.

New Stars for Old is an exploration of the way in which these human influences have shaped science. Over the course of the book, you'll meet many of the people who changed the way that we think about the universe. Some of them are famous, but others will almost certainly be new to you. I've stuck pretty closely to the facts and to what we know of the characters' personalities. If you're interested in which bits are my own invention, there are some historical notes at the end of each chapter, but these aren't crucial to understanding any of the stories.

Not all of the figures I've selected were scientists as such, but those who weren't played important parts in changing the way that science was seen by people around them. I've always had a soft spot for people who seem fated to end up in the footnotes of more famous figures' biographies.

Another big theme of the book is the way that science (or more particularly astronomy) relates to other areas of life. Two of these areas which appear in many of the individual stories are astrology and religion.

Astrology and astronomy often got lumped together in previous ages, and the words were used pretty much interchangeably as it tended to be the same people who studied them. Although nowadays there is a clear separation between

them, it's clear that one of the main reasons for studying the movements of the stars and planets (astronomy) in the first place was to help make predictions about what will happen on Earth (astrology). Individual astronomers throughout history held widely differing views about how this link should work, or whether astrology was at all valuable.

The historical links between religion and science are also more complicated than many people believe. Over the past couple of hundred years, a particular fight between one sort of Biblical literalism and one sort of atheism held by prominent scientific figures has dominated any discussion of this topic.

However, 'religion' and 'science' are huge labels, and you'll see through these stories that even within the Roman Catholic Church (for example) there was a very wide range of opinions. Not only that, but the overall consensus changed from one generation to the next (and there have always been mavericks). In times when religion made up a much larger part of people's lives and thoughts, it's hardly surprising that it tended to dominate a lot of discussion and surface in places that seem surprising to us.

The influence of personality and culture on our lives and our work; the urge to progress, to improve on previous ages; the uneasy relationships between various different ways of thinking – we might think that these are very modern concerns. In fact, they're all essential parts of what makes us human. We have more in common with past ages than we realise.

1

Composition

327 BC

In which we meet Aristotle, the greatest thinker of ancient Athens and former student at Plato's Academy, discover his somewhat unusual household arrangements, and consider whether his theory of the Celestial Spheres has any connection with art, religion or love.

Herpyllis stood back to consider her Master's new haircut critically. In her opinion, it was too short for such a distinguished man, and would have been more suited to one of the yobs who haunted the Agora, hanging around the marketplace to see and be seen; but she hadn't been asked her opinion. She turned her head, and simply raised an eyebrow. Lydias, her own young maid, cocked her head to one side and pursed her thin lips. Herpyllis nodded agreement, then placed the scissors down and stepped forward to slip her pale hands through Master's silver-grey locks, such of them as were left, and tousle them artistically.

Aristotle reached up to touch her on the wrist.

"That's enough, honey. Has Pyrrhaeus laid out my jewellery?"

She had selected the particular combination of sparkling rings to match Master's new sky-blue robes herself, and doubtless he knew it. However, she helped to maintain the fiction that his elderly valet still had his uses, rather than spending his time with his feet up in the kitchen flirting with the scullery girls.

"Yes, my lord."

She nodded to young Lydias, who carried the tray over to him. Her hands slipped lower to caress his shoulders as he slipped on the rings. She couldn't disapprove of this: displays of wealth were never unfashionable, and he was one of the wealthiest men in Athens, perhaps in all of Greece.

"Are you sure that the children won't disturb us, angel?"

"I'm sure, my lord. Pythias is safely with her tutor, and I think that little Nicomachus is on a trip to a farm with his nurse. You know how he adores animals."

She smiled happily. Little Nicomachus was getting so big, talking excitedly about his tiny world. How did he get to be four so quickly, their little boy? The days are very long, as a friend had said, but the years are very short. She wondered if she should share that thought with Master sometime. That was normally a bad idea, as he'd only turn it into some sort of meditation on the nature of time. She leant forward and kissed the top of his head instead. Nico was now the same age that his big sister Pythias had been when Mistress died, she reflected, and instinctively murmured a prayer to Hera.

"What was that, dear?"

Luckily, before she had to explain, or lie – Master was at best ambivalent about the whole idea of prayer – there was a cough from the doorway. Olympios the steward was there; how did he move so silently for such a giant of a man? Years of practice, she supposed.

"Excuse me, my lord, girls, but your visitor is here. I've put him in the library, my lord."

Aristotle glanced helplessly at the scrolls spread out before him. He'd been reading one even during his haircut, and Herpyllis had had to stop suddenly several times as he nodded violently.

"He wasn't supposed to be here until after lunch! But Lysippos never was good at keeping appointments. Ah well, this will have

to wait.”

He gestured to his half-finished lecture notes.

“Pyly, honey, you come with me to greet our honoured, and very early, guest. Olympios, fetch some light refreshments. Goat’s milk for me.”

Herpyllis looked at the visitor with interest. Lysippos had aged a lot more than Master since she’d last seen him at the Court in Macedon, what, seven years ago? Although they were roughly the same age, the sculptor was balding, his remaining hair a dull grey in contrast to Master’s elegant silver – and she noticed a walking-stick leaning near to his chair. She smiled a greeting, sliding silently away from Aristotle’s side to sit on a low stool, her appointed place for this room.

The artist nodded, his expression as serious as ever. He wore a perpetually worried look, and Herpyllis wondered whether he was happy with his fame and the riches that had accompanied it. She had spent her life as a slave to powerful and wealthy families, and the idea that money couldn’t buy happiness was a puzzling one. She cast her eyes down as she, in turn, became the object of scrutiny.

“It’s good to see you again, my old friend. You’ll excuse me if I don’t get up, your chair is far too comfortable for an old man. Speaking as an artistic professional, I see that your Herpyllis has grown into a stunning young woman – you always did have very good taste in girls, and in boys come to that. I understand that belated congratulations on the birth of a son to the two of you are in order? You must be very pleased.”

Herpyllis had never known how to read Lysippos. He was saying pretty things, as always, but his heart never seemed to be in it. Perhaps he only expressed his true emotions through his art, not through his voice. Another thought not to share with Master!

Aristotle smiled. He had waited until his Pyllly, his slavegirl, maid, and lover, had settled before striding into the room to clasp Lysippos around the shoulders.

"Thank you, on all counts. Yes, I have two children now. Little Pythias is ten already, and I can't quite believe that. Time does odd things. I trust that you had a pleasant journey? Are your quarters satisfactory?"

"I came straight here – I'm sure they'll be fine. I'm impressed by your set-up here, a fine complex of buildings for a college, my compliments to the architect. But I'm impatient to start while there's good daylight. We can talk while I sketch, so long as you don't get too animated."

"Do I have time for a glass of milk, or do you need to start drawing before my features change?"

Now, Master was so incredibly easy to read, the good humour never far from his eyes, his heart, his voice. Olympios, who was wearing his best concerned stewardly expression, stepped forward and handed his owner some fresh milk, almost colliding with young Lydias. The slender young girl stepped back, and easily knelt beside the stool, bearing the embroidery that they were working on.

"And I hope you don't mind if I have Herpyllis, and her own maid, here. If I'm going to be sat still for hours, I'd like to look at something pretty."

Lysippos had brought a young man with him. This curly-haired youth, hovering behind the chair, handed a board, a lead-tipped stylus, and papyrus to the sculptor. Herpyllis scanned him from behind her lashes, careful to avoid his gaze. She set herself the challenge of working out their relationship. Was he apprentice, servant, slave, lover or a combination of these roles?

Aristotle sat down on the high stool near his desk. The steward had, in his satchel, the scrolls that Master had been reading from

the bedroom and now he laid them carefully on the cluttered surface. The philosopher glanced down at them, then questioningly up at Lysippos.

“No, my friend. If you start reading, I’ll only see the top of your head.”

He had already started to sketch. Herpyllis craned her neck, but couldn’t see the dull lines left by the metal pen on the crisp sheet. Art always seemed a very special sort of magic, almost like the way Master could take the dulllest of lecture notes and breath life and passion into them when standing before his élite students. He cared so deeply about getting everything just right, surely the sign of a genius.

“Turn your head to the left, if you please. You’re obviously in the middle of something – why don’t you tell me? I miss our conversations from the Court.”

What a glittering affair the Court had been! Old Philip and young Alexander, godlike in their arrogance and finery, with the greatest talents of the world gathered around them. Mistress had bought new clothes every week, as befitted a princess, and it had been Herpyllis’ job to keep them in perfect condition. Sometimes she regretted the move to Athens, but Master was doing so well here, and their mansion really was a dream house. She was so proud when she went to the marketplace and heard the stallholders and the nobles alike talking of the latest news from the Lyceum. Everyone agreed that it was an even finer college than the old Academy! She glanced across at Lysippos’ young man, wondering whether he would be studying here or staying with his master. He did have such beautiful eyes.

She bent her head down to her work again. An intricate decorated border would make this old blanket look a hundred times better. She could almost hear Master’s amused query, *Have you changed its essence or merely its appearance?*

Aristotle sighed. "Where should I put my hands? In my lap, like this? Oh, it's astronomy. You know that maths isn't my thing."

"Then get one of your staff to handle it."

The old artist was working very slowly and carefully, thickening and defining the lines with long, slow methodical sweeps.

"I normally do, but Kallipos is away on one of his observation tours, and I've left it too late to ask anyone else. It's fine, I remember the basics, there are just some oddities I can't quite reconcile. I don't want to say anything *wrong* now, do I?"

"Still the same perfectionist. How many of your students do you think would notice?" Was he teasing, or serious? It was hard to tell, with that flat voice and dry delivery; but the curly-haired youth smiled broadly from behind Lysippos. Herpyllis suddenly decided that he must be an apprentice. His stance was confident, not servile. There was none of that odd chemistry that she observed between, say, Master and the young men of the Lyceum who had crushes (or more) on him.

"Maybe you're right. It's more a matter of principle. I define the course of instruction here, and how can I do that if I don't understand it all myself? Kallipos has left me his notes, here, and it's all coming back to me. We were both taught astronomy by Eudoxos, you know."

"Not sure I've heard of him – did he write anything popular?"

"Not really. He studied under Plato, ran the Academy whenever the Old Man was away. Chipped away for years at one of those impossible challenges that the Old Man used to throw out to drive us all crazy. The thing is, he got somewhere."

Herpyllis smiled softly as she switched the colour of the thread. "The Old Man" – Aristotle had loved his teacher dearly, and often recounted anecdotes over dinner of life with him. Nevertheless, he realised his predecessor's limitations, and had no time for his

mysticism. When he had returned to Athens, there had been much discussion about teaching at the Academy – but Master had found the syllabus there far too narrow for educating society’s future leaders. She raised her eyes to gaze at Aristotle, wondering how different things could have been if she’d never been selected by Mistress, if the family hadn’t moved, if... if... She murmured her thanks to the Fates.

“The Old Man wondered aloud – could the motion of the planets, looping madly in the sky, going back on themselves, be explained by some combination of simple, regular movements? Probably just a bit of rhetoric, but Eudoxos was a brilliant mathematician. It took him years, but he did it. If you imagine that each planet – including for the moment the Sun and the Moon – is a light, stuck to a sphere, and that sphere rolls around, but it’s inside some *other* spheres all rolling in different directions, you can build up almost any motion, d’you see?”

Lysippos nodded.

“In my art, the most complex shape can be reduced to arcs of regular curves combined in unexpected ways.”

“Precisely! Eudoxos worked it all out. Twenty-seven spheres, all told.”

Twenty-seven, thought Herpyllis. When I’m twenty-seven, he’ll be... sixty. An auspicious age. And little Nico will be seven and starting lessons with a tutor. She turned her head to share the thought with her maid, and couldn’t help noticing that Lysippos’ apprentice hurriedly averted his gaze. So many complex movements, all reduced to the basics. Oh yes, Master should speak to me about that sometime.

Lysippos’ eyes flicked constantly between his subject and his sketch. She could see his concentration clearly in his furrowed brow. There was a long silence, not an uncomfortable one. It seemed that the artist was processing what Aristotle had said,

while still working. Master sipped his milk, Lydias was humming quietly next to her, the apprentice was still hiding his glances at her. Presumably, twenty-seven distinct spheres were turning around different axes. Everything proceeded according to the dictates of the gods.

Aristotle finished his drink, and placed it down on the desk.

"A perfect solution to an impossible problem. Except that Kallipos, bless him, has been taking precise measurements of planetary movements for the last few years, from different places, and has found that it is far from perfect. He's added another seven spheres to make the planets loop around in just the right way."

Lysippos nodded. He seemed to be shading now, filling a space with short, precise, cross-hatchings.

"Another perfectionist. Are you *sure* you gentlemen don't believe in Plato's ideal forms?"

Aristotle chuckled.

"I'll explain both systems in my lecture, of course. I have two concerns, though."

The apprentice had stepped behind his master, to lean over and view the sketch. His look of rapt admiration thrilled Herpyllis. She knew what it was to devote her life to a person, a cause, a skill. She saw it in Master's face when he was lecturing, and she watched quietly from her seat by the door. Lysippos turned his head, sensing the presence of the young man. He smiled, the first genuine smile she had seen on his face that day. Maybe more than an apprentice after all?

"Maybe things are even more complicated than we currently think. Who knows what might be needed if Kallipos' latest observations don't tally? If so, then where will it end? Do we add more spheres every few years? Thirty-four could become forty."

Lysippos rested his stylus on the board, and looked straight at the philosopher.

"In my experience, my friend, things are always more complicated than they first appear. If you'll pardon my bluntness, that's why I could never be a system-builder, like you and Plato. I think that I have captured the very essence of my sitter – there, I thought you'd like that – on my papyrus, in my bronze. Then when everyone is admiring it and lauding it to the heavens, those perfectly spherical crystalline heavens of yours, I see the subject standing there with an expression on his face which is completely alien to my statue, and I know that once again, I have the wrong combination of basic elements. It's close enough to fool most observers, but that's not what you want, is it?"

Aristotle met his gaze.

"You speak well, my friend. While you're here, could I persuade you to give a lecture to my students on Truth in Art?"

"No, no. I've said my piece now, and spinning it to an hour's length would serve no purpose. But I'd willingly engage any students in discussion, if that would suit you. Now, could you turn your head a little to the right? Look just past your maid to the younger girl, if you please."

"Certainly. Like this?"

There was another long silence, broken only by Lydias' tuneless humming.

"All you can do is to teach the truth as you know it. Or does that sound too Socratic for your liking, my friend? Who knows? Perhaps this Kallipos will return and be able to confirm that thirty-four is exactly the right number of simple spheres to define and encircle the gods."

Aristotle rolled his eyes.

"Let's leave the gods out of this, hmm? It's the other concern of mine that's making this so difficult."

"Go on."

Herpyllis finished filling a particularly ornate key pattern, and

snapped the thread. She always marvelled at the intricate designs that humans could produce, and saw no reason that the gods couldn't be equally complicated in their workings. That was an unfair jibe from the artist, who should know better.

"I'm caught in a dilemma, Lysippos. Maybe these spheres are just... mathematical tricks. They allow us to predict the planetary motions, but by accident and connivance rather than because they truly describe the structure of the world. In which case, I couldn't possibly lend them my authority – and yes, that does count, even beyond Athens. It's not enough to be right, your arguments have to be valid as well."

She had heard this many times. How could that apply to us mortals here below the unchanging heavens? Surely we're creatures of error and imperfection. What if my reasons for loving Master aren't what he would call valid ones? What matters is that I do love him. A sigh escaped her as she started the next interlocking part of the pattern, but nobody seemed to notice. Apart from the apprentice. Who, she supposed, had *valid arguments* to suppose that a slavegirl in his host's house was a proper object for his attentions, but who happened to be wrong. It cut both ways.

"And what's the other horn of your dilemma?"

"If the spheres are real, aethereal spheres – then why don't the spheres governing Mercury get muddled up with the spheres governing Venus? It won't do. The space between each pair of planets must be filled with counter-rotating spheres to make sure that each one starts from scratch, with no motion from the inner planets, d'you see? So now we'd need fifty-five spheres."

Lysippos had returned to sketching.

"Fifty-five is better or worse than thirty-four or twenty-seven, in your opinion? Surely you don't believe in lucky numbers. If it's fifty-five, then it's fifty-five."

The apprentice had produced another, smaller, board and

stylus and was also sketching. He grinned as Herpyllis noticed him, then raised an eyebrow. She nodded, flattered. Would she ever be cast in bronze for the lobby of the Lyceum, she wondered? She who had kept Master going through the despair following Mistress' sudden death? If things had been different... but they weren't, they couldn't be. Life is just as complicated as it needs to be. If it's fifty-five, then it's fifty-five. She decided that she liked Lysippos, after all.

Aristotle stretched.

"I can't sit here much longer, I'm too used to walking. Let me show you around – we can resume the sketch later. You're right, my friend, the truth is the important thing, no matter what. Fifty-five has a certain ring to it. I just wish I had the chance to talk it over with Kallipos before the lecture. Well, we seldom get everything we want."

He grinned and rose, then turned to his steward.

"Olympios, lunch will be at the fifth hour, in the blue room. Pylly, why don't you show Lysippos' assistant to his quarters?"

And as the young man offered his arm to help Herpyllis up, she wondered just how complicated it was to keep spheres safely separated.

Notes on Chapter One

Aristotle

Fictional characters:

Lydias (although we know that Herpyllis had her own maid)

Aristotle's household arrangements were as described. Herpyllis, his deceased wife's young slavegirl, became his constant companion. In his will, he freed her and left her money, slaves and property, commenting on how good she had been to him. The other slaves mentioned are named in his will. The philosopher was known for his fashionable appearance.

Lysippus was the most famous sculptor of the day, and a beautiful bust of Aristotle is attributed to him. (I have generally used the Greek "-os" ending for names, rather than the Latin "-us" except when the characters are very well-known and this would prove confusing. However, the Latin spelling is normally the more common one.) They worked together at the Macedonian Court at Pella, where Aristotle was the tutor of Alexander the Great.

Aristotle's astronomical writings were a tiny part of his work. He was a universal genius, commenting on every aspect of the natural and human world. If his books seem dry to us today (compared to those of his teacher, Plato) it is almost certainly because what have survived were his lecture-notes rather than anything more complete. He had a reputation for being an energetic and engaging teacher.

2

Evidence

AD 153

In which we jump across the Mediterranean to Egypt, visit Alexandria (founded by Greeks but now a part of the Roman Empire) and find that a mixture of religious piety, mathematical brilliance and crafty business sense lay behind the extraordinarily complicated planetary system of Claudius — Klaudios Ptolemy — Ptolemaeus — Ptolemaios.

“**S**hut up! I can hear you, I’m coming! Just keep quiet, for Bacchus’ sake!”

Bacchus was to blame for all this, thought Klaudios as he rolled out of bed and into an old, threadbare, robe. His greying hair was dishevelled, his beard a little on the wild side, but what did such an eminent scholar care for such things? No, his attention was fully occupied with his thumping head and dry throat. He was getting too old for this sort of thing. He really should have known that a civilised dinner party to honour the new Director of the Library, the greatest collection of texts in the known world, would last into the small hours and involve wine, women and furious academic debate. Oh Athena, what had he said to the Head of Research at the Museum? It might be, in theory, a Temple of the Muses; but in practice, Klaudios knew that his standing there relied as much on who his friends were as on either intelligence or piety.

There was another hammering at his bedroom door. A quick glance through the window – the sun was over the palm-trees

outside Hermes' temple already, it must be nearly noon. Damn, damn, he had arranged a mid-day meeting with Marcus Flavius the astrologer, newly arrived from Rome, hadn't he? Why hadn't his slaves woken him earlier? Useless, the lot of them.

He flung open the door, trying to get his thoughts together as his butler cowered before him.

"Is he here yet? He is? Damn, damn... show him to the study, get me clothes, and cold water. Lots of water. He can wait, he was the one who wanted to see me."

Some fifteen minutes later, he presented a slightly neater figure as the butler opened the study door for him, although his hair was still noticeably damp. His headache had subsided to a dull thudding, thank the gods, and he felt ready for anything that a mere commercial astrologer, even one with offices in the Temple district, could throw at him. This Marcus had only appeared a month or so ago, but was apparently poaching clients from the more established businesses left, right and centre. He'd probably just come to point out an error in the *Handy Tables*, some impossible conjunction or other, or Mercury getting too far away from the Sun. Then Klaudios could show him the master copy, and explain that it was a simple copying error – it always was. You just couldn't get the scribes these days, not for complicated pages of numerals. At least he'd be back in bed in, what, half an hour?

His visitor was surprisingly young – maybe mid-twenties – and very well-polished, even unctuous. He wore expensive silks, of midnight blue with vaguely astrological symbols tastelessly embroidered around the hem. Either business genuinely was booming, or he wanted to project that image. Klaudios sized him up quickly; probably he had a client base of well-to-do women of a certain age. Marcus put down the scroll he had been perusing, standing from the low stool, and smiled a very false smile.

"It's an honour to meet you, Claudius Ptolemaeus," he murmured in Latin.

Klaudios had precisely no time for that. Alexandria might be a melting-pot, and his taxes might end up with the Emperor, but his loyalties were firmly with the previous wave of conquerors and he felt Greek to the core. He shambled behind his desk, making a sweeping wave that could mean almost anything.

"What do you want, lad? I'm busy."

Was that a smirk on Marcus' clean-shaven face? Had he drawn his own conclusions already? Astrologers were good at that sort of thing, and Klaudios should know – he'd been one for years before taking up technical mathematics, and they were still his biggest audience. Lazy, oily, types who couldn't do the maths, who just wanted the results. No wonder his *Handy Tables* were outselling the *Syntaxis* by about twenty copies to one. Nobody these days seemed to be buying his handbook on astrological theory, either. Strange how the market shifted, he thought to himself, as he gathered up the voluminous folds of his clothing and reclined in as much comfort as he could manage. He vaguely wondered how he had acquired so many bruises on his legs last night.

Marcus spread his hands, a conciliatory gesture, head slightly bowed in deference, switching effortlessly to fluent if accented Greek.

"Well, sir, I'm puzzled. There's a discrepancy..."

"Hah! I knew it! You just can't get the scribes these days, you know? When I was a lad, they had values, training, even in long strings of numbers. How do you think we learned?"

"Indeed, sir. I don't think it's scribal error, as I've already compared my copies with those of several colleagues, and with the text in the Library."

Klaudios' eyes widened. This whippersnapper had connections

at the Library? Either he was a scholar, which made him potentially a colleague but more likely a rival, or... perhaps he'd caught the eye of one of the Library hierarchs. Or both?

"That's interesting, then. I'm sorry if I seemed a little short. It's just..."

He trailed off, waving vaguely, trying to will the demons in his head to stop their antics with a whispered prayer to Asklepios to heal him quickly. Marcus' easy smile was infuriating.

"Of course, sir, I understand completely. Well. Recently I've been trying to work through your theory of the Moon, sir, and I can't quite get things to work out right."

Klaudios swung himself upright, quicker than his body was expecting judging by the sharp pains that lanced across his forehead. He scowled them away, and kept the scowl on his face as he rested his elbows on the desk. He had been dreading this day, but he had always thought that when the blow came, it would have been from one of his colleagues, or someone new at Athens.

"The Moon. What's wrong with the Moon?"

"Well, sir, first of all let me say how wonderful your books are. We couldn't do our jobs without them, and you're obviously –"

"Yes, divinely inspired or a genius and you count yourself lucky to be alive in the same time as me and I've reformed the subject beyond all recognition. I know. Stick to the Moon."

"It's probably nothing. Your *Tables* tell us exactly where it will be, when it will rise, every day with miraculous accuracy. I should be happy with that, that's what my friends told me when I said I was coming to see you. But I've always been curious, sir, and I wanted to follow the theory for myself, so I've been working my way through the *Syntaxis*. It's eye-wateringly hard, and my maths isn't quite up to it, but some of the scholars up at the Museum have been helping me. I've had them check my working, but they can't find anything, so I've turned to you. You see –"

Klaudios couldn't stand it any more. If it all had to fall apart, let him be the one to pull out the key-stone.

"I know. The distances are all wrong. My explanation gets the positions right, but they predict that the Moon –"

His head slumped into his hand. After all, he couldn't say it. Let this rising star have his moment of glory, even if the blaze was from burning the *Syntaxis*.

Marcus was nodding along, and picked up the thought.

"The Moon, as seen from the Earth, should double in size every month as it approaches the Earth. Except that... well..."

He shrugged and raised an eyebrow, hands spread, the comic actor's stance to indicate surprise and disbelief.

"The mistake isn't in your mathematics, young man. The thing is, I can't see where I went wrong, either. As you so generously observed, the mechanism gets the position right every time. Sit down, lad. I've had this speech prepared for quite some time, so you might as well be the one to hear it."

Klaudios felt very old, very suddenly. Was it time to hand on the torch? A torch that continued to give light although its core was rotten? He'd intermittently rehearsed his excuses on behalf of the Moon ever since he had put together the original theory, but hadn't done so recently. He'd certainly never expected to be hungover when it came to the crunch.

"The Moon's different from the other planets, you see. I spent years working out just how everything up there moves – circles, circles, everywhere. I was eating, drinking, dreaming circles. I was consumed with circles – of course, it has to be circles, doesn't it? The heavens are unchanging and perfect, we all know that, and a circle is the only perfect shape, yes? If you've worked through the *Syntaxis*, you'll know that it's not just Earth-centred circles, that doesn't get it right. The Ancients were wrong. You've got to have circles on circles, but that isn't enough – the circles speed up, they

slow down, their centres are all different, it's crazy up there but it works. You wouldn't expect the gods to be simple, would you? The priests will tell you that only the initiates get to know the true stories, and what's astronomy but the priesthood of the heavens?"

Marcus frowned. He'd heard that old Ptolemy was a little bit off-balance; to borrow a word from the *Syntaxis*, "eccentric". He'd certainly not been warned about this religious slant. Astrology was just a job to him, a good job, paying well and with decent social status, and he was good at it. Wasn't the mathematical side of things just the same?

Klaudios leaned forward.

"That's why if you've any sense you'll get out of your current game, my boy. Why sell trinkets to the temple-goers when you could be a priest instead?"

Was a reply required? The young man shrugged mentally, and tried to prod this increasingly unstable prodigy back into the right orbit.

"But the Moon, sir, you were talking about the Moon!"

"So I was. The gods know that I struggled long and hard with the other planets. Mercury and Venus, now, they're the real trouble. You'd think that they would wander away from the Sun, but they don't, and it took me three whole years just to fix their cycles, their epicycles, their eccentrics and their equant points... but I did it, with Athena's help. So I thought that the Moon would be easy. Everyone knows how the Moon moves, don't they? We've seen it from childhood, before we even know about the other planets. Except it doesn't work. I couldn't get the mechanism to work.

"I was in despair, I didn't eat or sleep, I could barely get through the days. Until I had a vision of one final circle, the missing piece! You stare, lad, but I really mean a vision, sent from the gods. What if the epicentre itself cycled around the Earth? Crazy, I know,

but the Moon is the Triple Goddess, the realm of magic and mystery, so why shouldn't it have a magical, mysterious, motion, an extra wheel in the machinery?"

He lifted his head, eyes shining, the headache completely forgotten.

"And it worked! It worked! I was the first person, with the gods' help, to crack it – the position of the Moon, perfectly predictable after all."

Marcus coughed softly. He felt rather brutal interrupting the old man, but this conversation was going precisely nowhere.

"Except, sir, it didn't. Work, that is. The distances. The Moon doesn't change its size, does it? It waxes and wanes, but the disk is always about the size of a sestertius piece held at arm's length."

"Except it didn't. The distances. Yes, yes. Can you even begin to imagine how I felt?"

Perhaps, after all, he could. Even though he hadn't seen as much, done as much, as this latter-day Aristotle, Marcus had known the weight of crushing disappointment enough times in his life to get just an inkling of the emotions that Claudius – no, Klaudios – must have experienced. He lowered his head, folded his hands in his lap, carefully adopted his most calming, conciliatory voice. He hadn't come to needle the old chap, he had genuinely thought that he had misunderstood the text, had miscalculated. Everyone knew that *Ptolemy* didn't get things wrong! He was a household name, not just in Alexandria, but even in Athens, in Rome itself.

"So, sir, what did you do? And what can we do?"

He was implicated, too. Had nobody else noticed this before, could he really have been the first to spot the inconsistency? Was that a matter for pride, or for regret?

"Do? A good, practical question, from a good practical businessman."

Klaudios poured two cups of cold water from the jug his butler had thoughtfully provided, sipping one and gesturing for his visitor to take the other.

"I'm not proud of what I did. I didn't lie – it would be blasphemous to lie in such a holy task."

His conscience pricked him – or was that the sudden shock of the cold water? – and he promised himself that one of these days, he would silently edit his astrology manual to remove all that nonsense about finding his ideas in previously-undiscovered Babylonian scrolls. But that was what the market wanted to hear! Back to the matter at hand.

"I didn't exactly draw attention to the problem, either. I knew that people who read the *Syntaxis* would either be mathematicians who didn't know the astronomy, or astronomers who didn't understand the maths."

He looked up from his cup, pleadingly. "Was that so wrong?"

Marcus shook his head slowly. He was glad he had the cup as a prop to play with now, and busied himself in sipping the water. It saved him from having to say anything else.

"As for what we can do now, I've been thinking of playing the same trick. Did you know that I'm writing another book, explaining how all the systems in the *Syntaxis* fit together? You didn't? Here, have a look at my *Hypotheses*, such as they are."

He pushed a loose sheet of papyrus, covered with his latest work, across the desk.

Marcus scanned the page quickly.

"Oh. I see."

As chance would have it, Klaudios had been working on the average distances of the planets. Or was it chance? Perhaps they were both being swept along in some elaborate joke being played by the gods on those who would penetrate their heavenly realm. He shook his head briskly. Some of this religious mania was

beginning to rub off on him, and he didn't like how it felt.

"I'm going to leave it at the average distances, I'm not going to show my workings. My old teachers would have a fit! Because..."

"Because if you showed the workings, sir, it would be obvious to every fool who can read the *Handy Tables* that the Moon isn't doing what it should. I see."

Klaudios put down his cup. He started to speak, but visibly halted to consider before resuming.

"Marcus, you're the first person to have spotted this. I hope you'll be the last, at least until after I'm long gone. Can I have your oath that you'll not mention it to any of your friends, to anyone else at all? When they ask about our meeting, tell them that the great Ptolemy showed you the error in your maths. If my reputation for accuracy goes, then so does everything else. Can I have your oath?"

Marcus felt a surge of pride at this confirmation of his own abilities, his insight. He sipped slowly, turning the matter over. He had nothing to gain from the destruction of this fellow's reputation, nothing whatever, and Ptolemy would be the best possible ally in getting his business up and running. A personal endorsement from the Prince of Astronomy above the door to his offices. Appearances together at public events... it was easy enough to decide.

"You have my oath. Shall I swear it formally before a priest?"

"No, man, the gods will witness it here well enough. I think you'd better go, now. I have a lot to think about."

Marcus placed the cup down delicately next to the jug, pushed the papyrus back across the desk, and stood. He turned to leave, without interrupting Klaudios any further; the latter was sunk deep in thought.

As his foot crossed the threshold, it came to him.

"Sir! I have it! I have the answer!"

Klaudios' face was a picture, thought Marcus. At least three

competing emotions took it in turns to govern his features, in very rapid succession.

“What do you mean? You barely understand the mathematics!”

Marcus felt his confidence welling. Human weakness and frailty, the limits of reason; these were his professional meat and drink. Admittedly, not on such a universal scale.

“What if it displeases the gods for us mortals to know their secrets? No, hear me out. We know that our reasoning is correct, but our eyesight, our senses, our poor, feeble, human senses... how easy it is to mislead them, to judge things wrongly. Can you, Klaudios, judge accurately how far away a horseman near the horizon might be? Are our mariners never led astray in their navigation? Not from reason, but from the weakness of our senses when looking at objects far away. Indeed, the further away the object is, the less likely we are to perceive its size and distance correctly...”

He paused, as understanding dawned on the astronomer’s face.

“And our senses cannot therefore be relied upon to judge sizes when the distances involved are so huge, such as...”

“That between the Earth and the Moon.”

The philosophers stared at each other. Could that be it? The universe was governed by reason, but here on this corruptible and corrupted Earth, we cannot see properly?

Klaudios grabbed papyrus and ink, knocking over the jar in his hurry. The cold, clear water trickled across the desk, pooling on a long-abandoned scroll containing scores of detailed planetary observations from Thebes. It started to blotch and fade, unnoticed, as the two men, the two colleagues, set to work, finding the right phrase to sell their new, improved, truth to the world. The breeze in the palm-trees laughed gently.

Notes on Chapter Two

Ptolemy

Fictional characters:

Marcus Flavius

Ptolemy was the greatest astronomer of the Classical world. We know very little about his personal life, other than that he started his career as what we would call an astrologer. We have to be cautious, as until the eighteenth century or so the words “astronomer,” “astrologer” and “mathematician” were used completely interchangeably. I have used them in their modern senses throughout. He certainly saw astronomy as a religious calling.

He was no relation to the Ptolemy Dynasty who ruled Egypt (being surnamed Windsor today doesn’t make someone a member of the Royal Family). This confused historians in the Middle Ages, who often depicted our Ptolemy as an astronomer-king.

His astronomical system was incredibly complicated, as described in the chapter. The diagrams in history books with the planets moving in simple circles are a huge simplification. The Ptolemaic System could predict the positions of the planets with pin-point accuracy. However, it did predict that the moon should move in impossible ways. The compromise solution of skipping over this with a mention of the difficulty of judging distances was, indeed, the one that he adopted although there is no evidence that anyone else was involved. It is extraordinary that he got away with this cover-up until the Renaissance (when, for the first time, astronomers appeared who were even better mathematicians).