

Cambridge University Press

978-0-521-03537-8 - Astronomy and Mathematics in Ancient China: The Zhou Bi Suan Jing

Christopher Cullen

Frontmatter

[More information](#)

---

This is a study and translation of the *Zhou bi suan jing*, a Chinese work on astronomy and mathematics which reached its final form around the first century AD. The author provides the first easily accessible introduction to the developing mathematical and observational practices of ancient Chinese astronomers and shows how the generation and validation of knowledge about the heavens in Han dynasty China related closely to developments in statecraft and politics.

Cambridge University Press

978-0-521-03537-8 - Astronomy and Mathematics in Ancient China: The Zhou Bi Suan Jing

Christopher Cullen

Frontmatter

[More information](#)

---

NEEDHAM RESEARCH INSTITUTE STUDIES · I

Astronomy and mathematics in  
ancient China: the *Zhou bi suan jing*

Cambridge University Press

978-0-521-03537-8 - Astronomy and Mathematics in Ancient China: The Zhou Bi Suan Jing

Christopher Cullen

Frontmatter

[More information](#)

---

The Needham Research Institute Studies series will publish important and original new work on East Asian culture and science which develops or links in with the publication of the *Science and Civilisation in China* series.

The series will be under the editorial control of the Publications Board of the Needham Research Institute.

Cambridge University Press

978-0-521-03537-8 - Astronomy and Mathematics in Ancient China: The Zhou Bi Suan Jing

Christopher Cullen

Frontmatter

[More information](#)

# Astronomy and mathematics in ancient China: the *Zhou bi suan jing*

周髀算經

**Christopher Cullen**

*Senior lecturer in the History of Chinese Science  
and Medicine, School of Oriental and African Studies,  
University of London*



**CAMBRIDGE**  
UNIVERSITY PRESS

Cambridge University Press

978-0-521-03537-8 - Astronomy and Mathematics in Ancient China: The Zhou Bi Suan Jing

Christopher Cullen

Frontmatter

[More information](#)

CAMBRIDGE UNIVERSITY PRESS

Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo

Cambridge University Press

The Edinburgh Building, Cambridge CB2 2RU, UK

Published in the United States of America by Cambridge University Press, New York

[www.cambridge.org](http://www.cambridge.org)

Information on this title: [www.cambridge.org/9780521550895](http://www.cambridge.org/9780521550895)

© Cambridge University Press 1996

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

First published 1996

This digitally printed first paperback version 2006

*A catalogue record for this publication is available from the British Library*

*Library of Congress Cataloguing in Publication data*

Cullen, Christopher.

Astronomy and mathematics in ancient China : the Zhou bi suan jing /

Christopher Cullen.

p. cm.

Includes bibliographical references and index.

ISBN 0 521 55089 0 (hc)

1. Mathematics, Chinese. 2. Astronomy, Chinese. I. Chou pi suan ching. English.

II. Title.

QA27.C5C85 1996

510'.931-dc20 95-32979 CIP

ISBN-13 978-0-521-55089-5 hardback

ISBN-10 0-521-55089-0 hardback

ISBN-13 978-0-521-03537-8 paperback

ISBN-10 0-521-03537-6 paperback

# Contents

## Preface

<b>Chapter 1</b>	<b>The background of the <i>Zhou bi</i></b>	<b>1</b>
	The foundation charter	3
	The role of astronomy	4
	The problem of the calendar	7
	The structure of an astronomical system	20
	Calendrical astronomy under the Han	27
	Astronomy, cosmography and instrumentation	35
<b>Chapter 2</b>	<b>The <i>Zhou bi</i> and its contents</b>	<b>67</b>
	The text	67
	The mathematics of the <i>Zhou bi</i>	74
	The calendrical astronomy of the <i>Zhou bi</i>	92
	Instrumentation and observation in the <i>Zhou bi</i>	101
	The cosmography of the <i>Zhou bi</i>	128
<b>Chapter 3</b>	<b>The origins of the work</b>	<b>138</b>
	The sections of the <i>Zhou bi</i>	140
	Early external evidence	145
	The formation and closure of the collection	148
<b>Chapter 4</b>	<b>The later history of the <i>Zhou bi</i></b>	<b>157</b>
	The <i>Zhou bi</i> in the period of division	157
	The <i>Sui shu</i> catalogue	163
	Li Chunfeng and the ten mathematical classics	164
	The printed texts	164
	Later studies	165

<b><i>Zhou bi suan jing</i>: translation</b>	<b>171</b>
The preface of Zhao Shuang	171
A. The book of Shang Gao	172
B. The book of Chen Zi	175
C. The square and the circle	181
D. The seven <i>heng</i>	183
E. The shapes of heaven and earth; day and night	188
F. The <i>xuan ji</i> ; polar and tropical conditions	189
G. The graduated circle and north polar distance	193
H. The shadow table	196
I. Lunar lag	197
J. Rising, setting and seasons	201
K. Calendrical cycles	203
<b>Appendix 1 Zhao Shuang and Pythagoras' theorem</b>	<b>206</b>
<b>Appendix 2 Zhao Shuang and the height of the sun</b>	<b>218</b>
<b>Appendix 3 Zhao Shuang and the diagram of the seven <i>heng</i></b>	<b>221</b>
<b>Appendix 4 The old shadow table</b>	<b>224</b>
<b>References and bibliography</b>	<b>227</b>
<b>Index</b>	<b>237</b>

Cambridge University Press

978-0-521-03537-8 - Astronomy and Mathematics in Ancient China: The Zhou Bi Suan Jing

Christopher Cullen

Frontmatter

[More information](#)

---

*This book is dedicated with respect and gratitude  
to D. C. Lau, for holding up more than one corner,  
and to Ho Peng-Yoke, for bringing fuel in snowy weather.*



## Preface

---

The *Zhou bi* 周髀 is a collection of ancient Chinese texts on astronomy and mathematics. It was probably assembled under the Western Han 漢 dynasty during the first century BC, although it was traditionally reputed to have been written in Western Zhou 周 times about a thousand years earlier. Following the explanation given in the book itself, the title may be rendered 'The Gnomon of the Zhou [dynasty]'.<sup>1</sup> Much of the text consists of calculations of the dimensions of the cosmos using observations of the shadow cast by a simple vertical pole gnomon. The *Zhou bi* follows the doctrine of the *gai tian* 蓋天 cosmography, in which an umbrella-like heaven rotates about a vertical axis above an essentially plane earth.<sup>2</sup> It is therefore unique in being the only rationally based and fully mathematicised account of a flat earth cosmos.

In its present form the *Zhou bi* certainly deserves the title of 'the principal surviving document of early Chinese science' given to it by A. C. Graham in his *Later Mohist Logic, Ethics and Science*. As to its value, opinions have differed. A twentieth-century Japanese scholar well trained in modern science has called it 'a veritable golden treasury of knowledge for all ages'.<sup>3</sup> On the other hand an early seventeenth-century

<sup>1</sup> See paragraph #B15. All references to my translation take this form, in which the letter designates the sections into which I have divided the text, and the figure gives the number of the paragraph within the section. In the main translation each paragraph number is followed by a note of where the original text begins in the edition of Qian (1963). Thus 34d refers to page 34, the fourth column counted from the right. *Zhou bi* is the original title of the book, but after the work became a university set text in the seventh century AD the words *suan jing* 算經 'mathematical classic' were usually added. In Wade-Giles romanisation the title will be found as *Chou pi suan ching*, or sometimes as *Chou pei suan jing*. The reading of the second character as pinyin *bi*, Wade-Giles *pi* is supported by the earliest authority, who is Li Ji 李籍 writing in the eleventh century AD: see the details given in chapter 2.

<sup>2</sup> My use of the term 'cosmography' rather than 'cosmology' is a deliberate distinction. By the first of these terms I mean a description that (at least ostensibly) is mainly concerned with the shape and size of the heavens and the earth, and with the disposition and motions of the heavenly bodies – a cosmic equivalent of geography. By the second term I mean any theory of how the universe works in a more metaphysical sense. In China I would call discussion of Yinyang and Five Phase thinking cosmology in this sense. Of course both terms involve prefabricated 'observer categories', and we cannot guarantee that they will correspond to the 'actor categories' we hope to recover by studying the writings of ancient Chinese thinkers. In a case such as Plato's *Timaieus* the cosmographical/cosmological distinction hardly seems to be present in the author's mind at all. But in my experience this initial distinction is a helpful one, even if it may need revision at a later stage.

<sup>3</sup> Nōda (1933), 140.

Chinese scholar, also well acquainted with the Western science of his own day, dismissed much of the book as 'the greatest stupidity of all time'.<sup>4</sup> The aim of this study is to make the *Zhou bi* accessible to anybody with an interest in the history of science, or in the history of Chinese culture, so that they can judge for themselves.

There is much to be said for reading a translation with a fresh mind, without allowing one's first impression to be influenced by the introductory discussion in which (with perhaps too much proprietorial zeal) the translator tells the reader what the ancient writer really meant, and why he wrote his book. While the language of the *Zhou bi* is usually straightforward enough, I think that most readers will find that an inspection of the plain text will give them no more than a general and rough impression of the concerns of the work. To supply the sense of context and purpose needed to understand the structure and content of the work, I have therefore provided substantial discussions of relevant issues.

First of all, I have given a brief survey of as much of the history of early Chinese astronomy as is necessary to understand the *Zhou bi*. There is at present no introductory study in a Western language suitable for this purpose.<sup>5</sup> With this essential foundation laid down I have then discussed the main features of the text of the *Zhou bi*, and analysed its principal themes. Next I have looked into the question of when and how the work originated, and discussed its later history, including questions of textual transmission. After the translation itself there follow, in conclusion, translations of four important short essays written by the first commentator on the *Zhou bi* around the late third century AD.

I make no claim to have deployed any very sophisticated methodology in this book. Half the effort required was of the old-fashioned philological and text-critical variety. Otherwise I had three main guiding principles before me, which I think would be common to all serious historians of science nowadays. I have tried firstly to reconstruct the thought and practice of the ancient authors from their writings rather than taking it for granted that modern categories will apply. This is of course an aim impossible of complete attainment, as my use of such terms as 'astronomy' and 'mathematics' has already demonstrated. Secondly I have taken it as my first assumption that the various things people did in the past made sense to them as part of a more or less systematised approach to the tasks they were addressing. Naturally, in the end they may turn out to have had the usual human capacity for confusion or self-delusion. Lastly, I have tried

<sup>4</sup> Xu Guangqi 徐光啟 (baptised as Paul Xu), quoted in Dai Zhen's 戴震 introduction to the edition of the *Zhou bi* in the *Siku quanshu* collection: photographic reprint (1983) vol. 786, 2.

<sup>5</sup> The principal problem with the wide-ranging and scholarly treatment of astronomy in Needham (1959) is that it deliberately discounts the calendrical astronomy which is such an important element in the *Zhou bi*. For a general critique, see Cullen (1980).

*Preface*

xiii

as far as possible not to draw boundaries which may not have seemed at all solid at the time, or to force issues which had not yet occurred to anybody. How far I have succeeded must be left for others to judge.

I do not need to find arguments to persuade the student of the history of Chinese science to pay attention to the *Zhou bi*, nor will such scholars need to be convinced of the need for an adequate treatment of this work in a Western language.<sup>6</sup> Graham's estimation of the importance of this text is clearly correct, and in addition the *Zhou bi* has the added interest of representing the work of an unofficial group of astronomical thinkers, whose ideas may give us an alternative to the otherwise overwhelmingly official bias of Chinese astronomical literature.

But what can a historian of Western science hope to gain from the encounter? At the most trivial level, the *Zhou bi* is certainly a novelty for someone from an intellectual world where the only flat-earthers are Pre-Socratics known through a few doxographic fragments, or dogged eccentrics such as Cosmas Indicopleustes. More seriously, ancient Chinese astronomical theory and practice appears to have had no significant connections with the worlds of Hellas, Babylon or Egypt. For once, therefore, we can cite parallels and differences without being drawn into the old conflicts about who influenced whom when and to what extent. The astronomy of Han China is an independent test case. If we make proper use of the evidence it gives us we may be able to make a little progress towards deciding how far our perceptions are dictated by an objective natural world 'out there', and how far our world-view is a cultural construct. Not the smallest challenge presented by the *Zhou bi* is that we have to think away the concept of the celestial sphere that has been natural to all scientifically educated Westerners since at least the time of Eudoxus – a transition much more difficult to make than the switch from a spherical to a flat earth. Such exercise is good for the mind, and sharpens historical perception.

At some point in a preface an author has to pay his intellectual debts: as Isaac D'Israeli says, 'gratitude is not a silent virtue'. I am however in a slightly odd position in this respect. Through the peculiarities of my initially amateur interests in these matters, and through the imaginative tolerance of the Governing Body of the School of Oriental and African Studies (SOAS), I first read the *Zhou bi* at a time when I knew only classical Chinese. Modern Chinese and Japanese scholarship were initially closed to me. I was therefore in the fortunate position of forming at least a general view of the text fairly independently. Later, of course, I was able to read the work of Nōda Churyō 能田忠亮 and Qian Baocong 錢寶琮 on the *Zhou bi*, and I realised how much

<sup>6</sup> The pioneering French translation of Biot (1841) was successful in revealing many of the main features of the text, but has now been left behind by developments in scholarship. The treatment of the cosmography of the *Zhou bi* in Chatley (1938) is heavily dependent on Biot and comes to some very misleading conclusions. It is unfortunately followed by Needham (1959), 212. Chatley's views are spared criticism in the otherwise excellent short review in Nakayama (1969), 25–35.

Cambridge University Press

978-0-521-03537-8 - Astronomy and Mathematics in Ancient China: The Zhou Bi Suan Jing

Christopher Cullen

Frontmatter

[More information](#)*xiv**Preface*

more there was to many problems than I had thought. I do however feel some confidence in the basic views formed in my initial state of relative ignorance, since I found most of them confirmed in the work of these two great East Asian scholars. My debt to them is so large that it would be tedious to footnote every instance where I have been influenced by their work.

Over the years I have discussed the *Zhou bi* with many friends and colleagues. First place must go to my PhD supervisor at SOAS, D. C. Lau, who introduced me to the text and (I now realise) worked harder to teach me the rudiments of classical scholarship than I had any right to expect. In the next office to D. C. Lau was Angus Graham, who also gave generously of his time. During autumn 1991 I enjoyed the hospitality of the Institute of History at National Tsing-Hua University, Taiwan while completing the first draft of this book, and had the benefit of long conversations with Professor Huang Yi-Long and Professor Fu Daiwie. A draft of the text was read and criticised by Professor Nathan Sivin and Professor Geoffrey Lloyd, and I am most grateful to both of them for giving their time to this task. The responsibility for all remaining mistakes and omissions is of course my own. Finally, of course, only my wife Anne Farrer and my sons Peter and Robert are qualified to say how much my authorial efforts have cost those around me. To them goes my deep gratitude for their continued tolerance and support.