

Cambridge University Press
978-0-521-10519-4 - Olduvai Gorge, Volume 2: The Cranium and Maxillary Dentition of Australopithecus (Zinjanthropus) Boisei
P. V. Tobias
Frontmatter
[More information](#)

OLDUVAI GORGE
VOLUME 2

Cambridge University Press

978-0-521-10519-4 - Olduvai Gorge, Volume 2: The Cranium and Maxillary Dentition of *Australopithecus* (*Zinjanthropus*) Boisei

P. V. Tobias

Frontmatter

[More information](#)



The skull of *Australopithecus* (*Zinjanthropus*) *boisei*, reconstructed by R. J. Clarke under the author's supervision. Photograph by R. Campbell and A. R. Hughes (*see also* pls. 41 and 42).

Cambridge University Press

978-0-521-10519-4 - Olduvai Gorge, Volume 2: The Cranium and Maxillary Dentition of Australopithecus (Zinjanthropus) Boisei

P. V. Tobias

Frontmatter

[More information](#)

OLDUVAI GORGE

EDITED BY DR L. S. B. LEAKEY

VOLUME 2

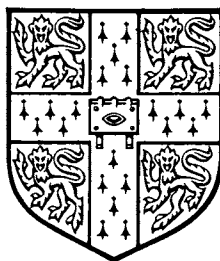
THE CRANIUM AND MAXILLARY DENTITION OF
AUSTRALOPITHECUS (ZINJANTHROPUS) BOISEI

BY

P. V. TOBIAS

WITH A FOREWORD BY

SIR W. E. LE GROS CLARK, F.R.S.



CAMBRIDGE
AT THE UNIVERSITY PRESS

1967

Cambridge University Press

978-0-521-10519-4 - Olduvai Gorge, Volume 2: The Cranium and Maxillary Dentition of Australopithecus (Zinjanthropus) Boisei

P. V. Tobias

Frontmatter

[More information](#)

CAMBRIDGE UNIVERSITY PRESS

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

Cambridge University Press

The Edinburgh Building, Cambridge CB2 8RU, UK

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

www.cambridge.org

Information on this title: www.cambridge.org/9780521105194

© Cambridge University Press 1967

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 1967

This digitally printed version (with additions) 2009

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

Library of Congress Catalogue Card Number: 66-21073

ISBN 978-0-521-06901-4 hardback

ISBN 978-0-521-10519-4 paperback

CONTENTS

<i>List of text-figures</i>	page vii	B Robusticity owing to ectocranial superstructures	page 73
<i>List of plates</i>	ix	C The thinness of the parietal bones	73
<i>List of tables</i>	xi	VIII The endocranial cast of <i>Zinjanthropus</i>	77
<i>Introductory Note</i>	xiii	A The cranial capacity of <i>Zinjanthropus</i>	77
<i>Foreword by Sir W. E. Le Gros Clark, F.R.S.</i>	xv	B The cranial capacities of the australopithecines	78
<i>Editor's Note</i>	xvii	C Australopithecine capacities compared with those of other hominoids	80
<i>Acknowledgements</i>	xviii	D Cranial capacity in relation to body size	86
I Introduction	1	E Morphological features of the endocranial cast	87
Anatomical terminology	3	F The pattern of meningeal vascular markings	93
Classificatory nomenclature	4	IX Metrical characters of the calvaria as a whole	95
Plan of the study	5	A Cranial length and the toro-occipital index	95
II Preservation and reconstruction of the cranium	6	B The position of euryon and the maximum cranial breadth	99
III The cranial vault	9	C The postero-anterior tapering of the cranial vault	100
A The curvature and components of the vault	9	D The height of the cranial vault	101
B The supra-orbital height index	16	E Some metrical features of the base of the calvaria	103
C The sagittal and nuchal crests	19	X The structure of the face	104
IV The basis cranii externa	26	A The supra-orbital torus	104
A The occipital bone	26	B The orbits and the interorbital area	106
B The temporal bone	28	C The nose	109
C The sphenoid bone and related structures	42	D The maxillary and zygomatic bones	113
V Certain critical angles and indices of the cranium	43	E Facial measurements and indices and calvariofacial indices	123
A The planum nuchale: tilt and height	43	XI The pneumatisation of the <i>Zinjanthropus</i> cranium	126
B The foramen magnum: position and plane	45	A The maxillary sinus	126
C The porion position indices	48	B The frontal sinus	127
D The position of the occipital condyles and the poise of the head	49	C Pneumatisation of the naso-orbital region	128
VI The interior of the calvaria	53	D The sphenoidal sinus	129
A The endocranial surface of the frontal bone	53	E Pneumatisation of the temporal bone	130
B The endocranial surface of the parietal bones	54	F Developmental aspects of pneumatisation	130
C The basis cranii interna	54		
D The venous sinuses of the dura mater	63		
VII The thickness of the cranial bones	72		
A Robusticity owing to pneumatisation	72		

CONTENTS

XII	The dental arcade and the palate	page 132	XVIII	Summary of cranial and dental features	page 193
A	The shape of the dental arcade, alveolar process and palate	132		of <i>Zinjanthropus</i>	
B	The front of the alveolar process	137		The cranial vault	193
C	The arrangement of teeth in the arcade: evidence of dental crowding	138		The basis cranii externa	195
XIII	The pattern of dental attrition and occlusion, with comments on enamel hypoplasia	139		Certain critical angles and indices of the cranium	198
A	Attrition of individual teeth	139		The interior of the calvaria	200
B	The pattern of attrition and occlusion	140		The thickness of the cranial bones	203
C	The state of the enamel	141		The endocranial cast of <i>Zinjanthropus</i>	204
XIV	The size of individual teeth, absolute and relative	144		Metrical characters of the calvaria as a whole	206
A	Notes on methodology and terminology	144		The structure of the face	207
B	Dimensions of the incisors	147		The pneumatization of the cranium	212
C	Dimensions of the canines	152		The shape of the dental arcade and the palate	213
D	Canine-premolar ratios	155		The pattern of attrition and occlusion	213
E	Ratios of premolar dimensions to premolar-molar chords	157		The state of the enamel	214
F	Dimensions of the premolars	158		The size of individual teeth	214
G	Dimensions of the molars	162		Shape indices of the teeth	216
H	Ratios of molar dimensions to premolar-molar chords	165		Morphology of the teeth	217
I	Relative molar size	166	XIX	The taxonomic status of <i>Zinjanthropus</i> and of the australopithecines in general	219
XV	The size of the dentition as a whole	170	A	General considerations	219
A	Flower's Dental Index	170	B	<i>Zinjanthropus</i> a hominid and an australopithecine	223
B	'Tooth material'	170	C	The generic and specific status of <i>Zinjanthropus</i>	224
XVI	The crown shape index of the teeth	172	D	Formal definitions of <i>Australopithecus</i> and its species	233
XVII	The morphology of the teeth	175	XX	The cultural and phylogenetic status of <i>Australopithecus boisei</i> and of the australopithecines in general	236
A	The maxillary incisors	175	A	Cultural status	236
B	The maxillary canines	177	B	The place of <i>Australopithecus boisei</i> and the other australopithecines in hominid phylogeny	240
C	The maxillary premolars	179			
D	The maxillary molars	182			
				<i>References</i>	245
				<i>Index of persons</i>	253
				<i>Index of subjects</i>	255

LIST OF TEXT-FIGURES

1	Craniograms of norma lateralis of <i>Paranthropus</i> , <i>Zinjanthropus</i> and <i>Australopithecus</i>	page 9	16	Outline of norma dorsalis of endocranial cast of <i>Zinjanthropus</i> superimposed on that of <i>Australopithecus</i> —Sts II	page 90
2	Craniograms of norma verticalis of <i>Paranthropus</i> , <i>Zinjanthropus</i> and <i>Australopithecus</i>	10	17	Outline of norma dorsalis of endocranial cast of <i>Zinjanthropus</i> superimposed on that of <i>Australopithecus</i> —Sts 5	90
3	Lateral craniograms of gorilla and <i>Zinjanthropus</i> , to show the landmarks from which are derived three cranial indices, CD/CE, AG/AB and FB/AB	17	18	Outline of norma dorsalis of endocranial cast of <i>Zinjanthropus</i> superimposed on that of <i>Australopithecus</i> juvenile from Taung	91
4	Diagrammatic representation of the values of three cranial indices in a variety of hominoid crania	18	19	Dioptrographic tracings of norma lateralis of endocranial casts of <i>Zinjanthropus</i> superimposed respectively on those of Sts II, the Taung juvenile and Sts 5	91
5	Dioptrographic tracings of norma occipitalis of crania of chimpanzee, <i>Zinjanthropus</i> and gorilla	20	20	Dioptrographic tracing of norma lateralis of endocranial cast of <i>Zinjanthropus</i> , to show the pattern of meningeal vessels on the right side of the brain	93
6	Variations in the lateral margin of the tympanic plate in <i>Zinjanthropus</i> , <i>Australopithecus</i> (MLD 37/38), <i>Paranthropus</i> (SK 46, SK 48, SK 52 and SK 848) and <i>Homo erectus pekinensis</i> (107, 109 and 101)	31	21	Craniograms of norma facialis of <i>Paranthropus</i> , <i>Zinjanthropus</i> and <i>Australopithecus</i>	112
7	Diagrams to show the relationships of structures on the basis cranii, in <i>Zinjanthropus</i> and a variety of other hominoids	39	22	The shape of the dental arcade in <i>Paranthropus</i> , <i>Zinjanthropus</i> and <i>Australopithecus</i>	137
8	Median sagittal craniograms of <i>Australopithecus</i> (Sts 5), <i>Zinjanthropus</i> and a female gorilla, showing the basicranial axis	46	23	Mesiodistal diameters of maxillary teeth of <i>Zinjanthropus</i> compared with the ranges in <i>Paranthropus</i> and <i>Australopithecus</i>	151
9	The interior of the occipital bone, to show the pattern of venous sinus grooves	64	24	Buccolingual diameters of maxillary teeth of <i>Zinjanthropus</i> compared with the ranges in <i>Paranthropus</i> and <i>Australopithecus</i>	151
10	Scheme of venous sinus grooves in the posterior cranial fossa of <i>Zinjanthropus</i> , <i>Paranthropus</i> (SK 859) and three modern Bantu crania	69	25	Modules of maxillary teeth of <i>Zinjanthropus</i> compared with the ranges in <i>Paranthropus</i> and <i>Australopithecus</i>	154
11	Cranial capacities of hominoids	82	26	Crown areas of maxillary teeth of <i>Zinjanthropus</i> compared with the ranges in <i>Paranthropus</i> and <i>Australopithecus</i>	155
12	Range of estimates of 'extra' cortical neurones of hominoids	88	27	Mesiodistal diameters of maxillary teeth of <i>Zinjanthropus</i> , compared with means for <i>Paranthropus</i> , <i>Australopithecus</i> , <i>Homo erectus pekinensis</i> , and the absolute values for <i>H. e. erectus</i> IV	160
13	Dioptrographic tracings of norma ventralis (basalis) of endocranial casts of adult chimpanzee, adult gorilla and <i>Zinjanthropus</i>	89	28	Buccolingual diameters of maxillary teeth of <i>Zinjanthropus</i> , compared with means for <i>Paranthropus</i> , <i>Australopithecus</i> , <i>Homo erectus pekinensis</i> , and the absolute values for <i>H. e. erectus</i> IV	160
14	Dioptrographic tracings of norma lateralis of endocranial casts of adult chimpanzee, adult gorilla and <i>Zinjanthropus</i>	89	29	Mesiodistal diameters of maxillary teeth of <i>Zinjanthropus</i> compared with means for male and female Pongidae	161
15	Dioptrographic tracings of norma ventralis (basalis) of endocranial casts of juvenile chimpanzee, juvenile gorilla and <i>Zinjanthropus</i>	90			

LIST OF TEXT-FIGURES

30	Buccolingual diameters of maxillary teeth of <i>Zinjanthropus</i> compared with means for male and female Pongidae	page 161	35	Crown shape indices of maxillary teeth of <i>Zinjanthropus</i> compared with the sample range of shape indices for <i>Paranthropus</i>	page 173
31	Modules of maxillary teeth of <i>Zinjanthropus</i> , compared with means for <i>Paranthropus</i> , <i>Australopithecus</i> , <i>Homo erectus pekinensis</i> , and with absolute values for <i>H. e. erectus</i> IV	164	36	Crown shape indices of maxillary teeth of <i>Zinjanthropus</i> compared with the sample range of shape indices for <i>Australopithecus</i>	174
32	Crown areas of maxillary teeth of <i>Zinjanthropus</i> , compared with means for <i>Paranthropus</i> , <i>Australopithecus</i> , <i>Homo erectus pekinensis</i> , and with absolute values for <i>H. e. erectus</i> IV	165	37	Three earlier interpretations of the relationship between the Lower Pleistocene <i>Australopithecus africanus</i> and the Middle Pleistocene <i>A. robustus</i>	241
33	Modules of maxillary teeth of <i>Zinjanthropus</i> compared with mean modules in male and female Pongidae	168	38	Schema of Lower and Middle Pleistocene hominids, showing the position in space and time of the most important specimens discovered to date	242
34	Crown areas of maxillary teeth of <i>Zinjanthropus</i> , compared with means for male and female Pongidae	169	39	Provisional schema of hominid phylogeny from Upper Pliocene times to the Upper Pleistocene	243

LIST OF PLATES

Frontispiece: Zinjanthropus with mandible (reconstructed by R. J. Clarke under the author's direction)

Between pp. 252 and 253

- | | |
|---|---|
| 1 Norma facialis of the cranium of <i>Zinjanthropus</i> | 20 Occlusal view of teeth and palate of <i>Zinjanthropus</i> |
| 2 Right norma lateralis of the cranium of <i>Zinjanthropus</i> | 21 The parietal bones of <i>Zinjanthropus</i> , (A) from above and somewhat behind; (B) from above and to the left |
| 3 Left norma lateralis of the cranium of <i>Zinjanthropus</i> | 22 The parietal bones seen from below and behind |
| 4 Norma occipitalis of the cranium of <i>Zinjanthropus</i> | 23 The right temporal bone from the lateral (A) and medial (B) aspects |
| 5 Norma verticalis of the cranium of <i>Zinjanthropus</i> | 24 The left temporal bone seen (A) from above and (B) from below |
| 6 Norma basalis of the cranium of <i>Zinjanthropus</i> | 25 Lateral view of the left temporal bone |
| 7 The dental arcade and palate of <i>Zinjanthropus</i> compared with those of (A) two modern men (Bantu Negroids) and (B) a gorilla and chimpanzee | 26 The occipital bone seen from below and behind |
| 8 Norma basalis of the cranium of <i>Zinjanthropus</i> compared with that of the recently discovered cranium of the Makapansgat <i>Australopithecus</i> (MLD 37/38) | 27 The occipital bone from within |
| 9 Norma occipitalis of the cranium of <i>Zinjanthropus</i> compared with that of MLD 37/38 | 28 The endocranial cast of <i>Zinjanthropus</i> as seen in norma ventralis (basalis) |
| 10 The posterior part of the vault of the cranium as seen from above | 29 The dental arcade and palate of <i>Zinjanthropus</i> |
| 11 The posterior part of the vault of the cranium as seen from the rear | 30 The interior of the occipital bone of the juvenile <i>Paranthropus</i> from Swartkrans (SK 859) |
| 12 The posterior part of the vault of the cranium as seen from (A) the left, (B) the right | 31 The interior of the occipital bones of three Bantu crania with anomalous patterns of the venous sinuses |
| 13 The posterior part of the vault of the cranium seen from below, behind and to the right, to show the formation of the compound (temporal/nuchal) crest and the lateral divergence of the simple temporal and nuchal crests from it | 32 Labial, occlusal and lingual views of the front maxillary teeth |
| 14 The posterior part of the basis cranii externa (A) and interna (B) | 33 The tooth-row from lateral incisors to first molars |
| 15 The upper calvariofacial fragment, (A) from in front and (B) from above | 34 The maxillary canines and first premolars of <i>Zinjanthropus</i> |
| 16 Anterior view of the lower facial fragment, comprising most of the maxillae as well as the right zygomatic bone | 35 (A) Labial aspect of right canine and P ³ ; (B) labial aspect of right premolars and M ¹ ; and (C) labial aspect of the left P ³ and P ⁴ |
| 17 The right maxilla seen from the right side | 36 The lingual aspect of the premolars and the first molar |
| 18 The maxilla of <i>Zinjanthropus</i> , (A) as seen from the left side, (B) as seen from behind, looking into the exposed antra | 37 Occlusal surfaces of the first and second molars |
| 19 Left lateral view of the lower facial fragment: a straw has been passed through the bony canal for the inferior orbital nerve | 38 The lingual aspect of the molar teeth (M ² and M ³ on right, and M ¹ , M ² and M ³ on left) |
| | 39 Buccal views of the maxillary molars of <i>Zinjanthropus</i> |
| | 40 Maxillary third molars of <i>Zinjanthropus</i> , in occlusal and distal views |
| | 41 Norma facialis of reconstructed skull of <i>Zinjanthropus</i> |
| | 42 Norma lateralis dextralis of reconstructed skull of <i>Zinjanthropus</i> |

LIST OF TABLES

1	Measurements and indices of the parietal bone in <i>Zinjanthropus</i> and other hominids	page 11	20	Indices of the calvariae of <i>Zinjanthropus</i> and other hominids	page 101
2	Ranges of measurements of the parietal bone in australopithecines (including <i>Zinjanthropus</i>), <i>Homo erectus</i> and modern man	12	21	Facial measurements of <i>Zinjanthropus</i> and other hominids	107
3	Ranges of indices of the parietal bone margins in australopithecines (including <i>Zinjanthropus</i>), <i>Homo erectus</i> and modern man	13	22	Indices of the face of <i>Zinjanthropus</i> and other hominids	107
4	Measurements and indices of the occipital bone in <i>Zinjanthropus</i> and other hominids	13	23	Nasal measurements of <i>Zinjanthropus</i> and other hominids	110
5	The occipital index of <i>Zinjanthropus</i> and other hominids	16	24	Nasal indices of <i>Zinjanthropus</i> and other hominids	111
6	Differences between the supra-orbital height index of <i>Zinjanthropus</i> and other hominoids: (A) including the sagittal crest of <i>Zinjanthropus</i> ; (B) excluding the sagittal crest of <i>Zinjanthropus</i>	17	25	Calvariofacial indices of <i>Zinjanthropus</i> and other hominoids	125
7	The petro-median angle in hominoid crania. (The angle between the axis of the petrous portion and the median sagittal plane, measured on the basis cranii externa)	34	26	Palatal and arcadal dimensions and indices of <i>Zinjanthropus</i>	134
8	Dimensions and indices of the mandibular fossa in <i>Zinjanthropus</i> and other hominoids	35	27	Maxillo-alveolar index of <i>Zinjanthropus</i> and other hominoids	135
9	Differences between the nuchal area height index (AG/AB) of <i>Zinjanthropus</i> and other hominoids	44	28	Ranges of maxillo-alveolar indices in hominoid groups	136
10	Differences between the condylar position index (CD/CE) of <i>Zinjanthropus</i> and other hominoids	51	29	Crown dimensions and indices of individual teeth of <i>Zinjanthropus</i>	144
11	Dimensions and indices of the foramen magnum in <i>Zinjanthropus</i> and other hominoids	61	30	Metrical characters of maxillary permanent teeth of <i>Australopithecus</i> (<i>A. africanus</i>) and <i>Paranthropus</i> (<i>A. robustus</i>)	147
12	Cranial capacity of <i>Zinjanthropus</i> and other australopithecines	79	31	Metrical characters of maxillary permanent teeth of <i>H. erectus</i>	148
13	Ranges and means of cranial capacities of hominoids	81	32	Standard deviations of hominid teeth as computed by two different methods (s.d. 1—estimate by the method of deviations; s.d. 2—estimate from the sample range)	149
14	Cranial capacity of <i>H. erectus</i>	81	33	Metrical characters of <i>Zinjanthropus</i> teeth as compared with those of <i>Paranthropus</i> (= <i>A. robustus</i>)	150
15	The variability of hominoid cranial capacities	85	34	Modules and crown areas of incisors and I ² /I ¹ ratios in <i>Zinjanthropus</i> and other hominoids	152
16	Estimates of 'extra neurones' in hominoids	87	35	Crown dimensions, modules and crown areas of canines of <i>Zinjanthropus</i> and other hominoids	154
17	Encephalic measurements and indices of <i>Zinjanthropus</i> and other australopithecines	92	36	Comparison of maxillary canine and premolar dimensions in Australopithecinae: (A) mesiodistal crown diameter, (B) buccolingual crown diameter, (C) module, (D) crown area	156
18	Measurements of the calvariae of <i>Zinjanthropus</i> and other hominids	96	37	Maxillary canine-premolar percentage ratios in <i>Zinjanthropus</i> , <i>Paranthropus</i> and <i>Australopithecus</i>	157
19	Toro-cristal length and index in hominids	98			

LIST OF TABLES

38	Percentage ratios of premolar dimensions to P ³ -M ³ chord	page 157	44	Maxillary 'tooth material' (sum of mesio-distal crown diameters of left and right I ¹ -M ¹) of <i>Zinjanthropus</i> and other hominids	page 171
39	Percentage ratios of premolar dimensions to P ⁴ -M ³ chord	158	45	Shape indices (M.D./B.L.) of maxillary permanent teeth of <i>Zinjanthropus</i> and other hominoids	172
40	Crown dimensions, modules and crown areas of premolars of <i>Zinjanthropus</i> and other hominoids	158	46	The frequency of Carabelli structures and protoconal cingulum in Australopithecinae	191
41	Crown dimensions, modules and crown areas of molars of <i>Zinjanthropus</i> and other hominoids	163	47	Coefficients of variation for buccolingual diameters of mandibular teeth	221
42	Percentage ratios of molar dimensions to P ³ -M ³ chord	166	48	Coefficients of variation for M.D. and B.L. diameters of mandibular teeth	221
43	Percentage ratios of molar dimensions to P ⁴ -M ³ chord	166	49	Mandibular canine-premolar ratios in <i>Paranthropus</i> and <i>Australopithecus</i>	227

Introductory Note to the 50th Anniversary of the Discovery of 'Zinjanthropus'

The Olduvai Gorge in the Republic of Tanzania came to the attention of the world shortly after my mother Mary discovered the 'Zinjanthropus boisei' skull on July 17th 1959. The field of African prehistory, and in particular the study of human evolution, has changed and developed dramatically over the past 50 years. I am particularly pleased that Cambridge University Press have decided to republish the 5 monographs that comprehensively cover the many scientific studies that have been undertaken on the Olduvai material collected by my parents, Louis and Mary, working with a number of colleagues. As the Golden Anniversary of the discovery approaches, it is timely to reflect on the importance of that find.

I was lucky to arrive at Olduvai two days after the discovery and I well recall the excitement of the occasion. My parents were operating on a very tight budget and the field season was short. Fortunately, on hand was world-renowned photographer Des Bartlett who, aided by his wife Jen, fully recorded on film the first few days of excavations and reassembly of bone fragments back in camp. As pieces were glued back together, and the shape of the skull and its morphology became clear, my parents showed uncharacteristic and unrestrained emotion! At the time, ages for fossils were wild guesses and radiometric dating had not been done anywhere in Africa. The best, guessed age for Zinj was a little more than 500,000 years. Some months later, a real Potassium/Argon date was obtained by Jack Evenden and Garniss Curtis, and the 1,750,000 age was announced. This ignited huge excitement worldwide and for the first time my father was able to raise financial support for extended field work at Olduvai. Everything changed. The unqualified enthusiasm and support of the National Geographic Society from 1960 onwards had a major impact on the later work at Olduvai, and indeed on the growing international interest of Africa as the cradle of humanity.

Since those first exciting years at Olduvai, the investigation of human origins has gone forward and extended to many other sites in Africa. The age of hominins has been taken back to beyond five million years and the collected fossils and lithic records are now numerous. International multi-disciplinary teams are working in many parts of the world and, with the exception of a few fundamentalist 'flat earth' types, the acceptance of the fossil record of our past is widely accepted. Much of this has come about because of the initial Olduvai finds.

The pioneering work at Olduvai was the launch of this fantastic 50-year period when we as a species have come to realize and appreciate our common evolutionary past. Olduvai, conserved and protected by the Republic of Tanzania, remains as a landmark in the epic story of humanity, and these monographs are a wonderful testimony to that landmark.

Richard Leakey, FRS

FOREWORD

By SIR W. E. LE GROS CLARK, F.R.S.

The discovery by Dr and Mrs Leakey of an australopithecine skull in Bed I of the deposits of the Olduvai Gorge is of major importance for two reasons. First, the skull was found at a stratigraphical level that has been dated with reasonable assurance by the potassium-argon method to well over a million years, indeed probably as much as one and three-quarters of a million. Second, the skull, though fragmented, was found to be practically complete except for the lower jaw; it was possible to piece together the broken fragments with fair accuracy and to demonstrate that it was almost free of distortion and deformation in spite of its prolonged period of fossilisation. In fact, apart from one specimen discovered by the late Dr Robert Broom at Sterkfontein in South Africa in 1947, no australopithecine skull is yet known that approaches in completeness the Olduvai skull.

It is particularly fortunate that the responsibility for the detailed study of this skull should have been given to Professor P. V. Tobias, for he has had many years of experience in dealing with fossil hominid material as well as a wide acquaintance with the skeletal structures of the higher Primates and their degree of variability. I do not suppose that any such meticulous and exhaustive description of a fossil hominid skull as is to be found in this monograph has ever before been made, even if account is taken of Boule's description of the Chapelle-aux-Saints skull, or of Weidenreich's account of the crania of Chinese representatives of *Homo erectus*. Not only does Professor Tobias describe and define with great clarity the various anatomical features of all parts of the skull, including its endocranial characters, he makes numerous statistical comparisons based on his extensive studies of large collections of skulls of modern apes and modern man, as well as com-

parisons with a number of fossil human skulls of which he himself has examined the original specimens.

When the Olduvai skull was discovered, Dr Leakey at first thought it to be generically distinct from any of the known South African australopithecines, and he gave it the name *Zinjanthropus boisei*. The careful studies of Professor Tobias have now convincingly shown that it is an East African representative of the genus *Australopithecus* and that even the use of *Zinjanthropus* as a sub-generic term is no longer justifiable. Following the recognition that the australopithecines should properly be included in one genus only, *Australopithecus*, possibly comprising not more than one or two species, several of the generic and specific terms that were coined during the early days of the australopithecine discoveries in South Africa, and which were the source of some misunderstanding in the initial controversies about these fossils, may now be discarded. Professor Tobias discusses at some length the details of the dental morphology in the African australopithecines (so far as these are at present known) and sees no reason on the basis of their variability to make any generic distinctions. The variability in the size and cusp pattern of the teeth is remarkable, to such an extent that some of the specimens of the dentition, for example those of smaller dimensions found at Sterkfontein, are not easy to distinguish from the more megadont individuals of the fossil species *Homo erectus*. It seems, indeed, that the dental characters by themselves do not have a high taxonomic relevance for making such a distinction; the latter must depend rather on contrasts in cranial characters, brain size and limb structure. Thus even the generic distinction of 'Telanthropus' may be open to question. This type has more recently been taken by some authorities to be a

FOREWORD

South African representative of *Homo erectus*, but to the present writer the dental evidence seems equivocal, and the very fragmentary remains may with greater probability be assigned to small-sized individuals of the australopithecine group.

The cranial capacity of the Olduvai skull is small (530 c.c.) and thus comes within the existing australopithecine sample range. But it perhaps needs to be emphasised that this sample is still very limited, so that we do not yet know what the general population range may have been. If it was anything like that of the modern gorilla it may be assumed that the upper limits of the population range would have reached well over 600 c.c., perhaps nearer 700 c.c. In spite of its small cranial capacity, it is remarkable that in detail after detail described by Professor Tobias the Olduvai skull displays hominid and not pongid characters. It is thus no longer possible to controvert the allocation of the australopithecines to the family Hominidae rather than the Pongidae. The evidence for such a classification is now so complete that we can afford to forget the controversies that were aroused by the earlier discoveries in South Africa. For example, there is now no question of a sagittal crest (when it is present) being continuous with a high nuchal crest as it consistently is in the large apes. On the contrary, the nuchal area of the occipital bone is very restricted, and the external occipital protuberance is actually situated below the level of the Frankfurt plane. Other distinctively hominid characters include a large pyramidal mastoid process of typical hominid form even in an immature individual, a parabolic dental arcade with no diastema, spatulate canine teeth wearing down flat from the tip only, the degree of flexion of the cranial base, the anterior position of the occipital condyles and the nearly horizontal plane of the foramen magnum, the detailed construction of the mandibular fossa of the temporal bone, the moderate subnasal prognathism, and so forth. Of course, these hominid features of the australopithecine skull were already known from the South African fossil material but, as much of the latter consisted of fragmentary specimens, it is highly satisfactory

to find such an emphatic confirmation of them in the almost complete and undistorted Olduvai skull.

No doubt one of the most important implications of the Leakeys' discovery is the apparently long time gap between the estimated date of the Olduvai skull and that of the almost identically similar skulls of the robust variety of *Australopithecus* in South Africa, a gap of a million years or more. Clearly the genus *Australopithecus* was long-lived (though not more so than some fossil genera in other mammalian groups). With such a wide temporal and geographical dispersion it would be surprising if the East African populations of *Australopithecus* did not show some degree of morphological difference from the South African populations, though some may doubt whether such differences are adequate to postulate generic, or even specific, distinctions—it may even be that they warrant no more than sub-specific distinctions.

Remains of australopithecines have been reported from other parts of the world outside Africa, but such reports are based on very friable evidence. It may be, therefore, that *Australopithecus* evolved somewhere in Central Africa, and that in the course of many centuries members of the group trekked down to South Africa where they persisted unchanged into the Middle Pleistocene long after the genus *Homo* had arisen elsewhere. Since the discovery of the 'Zinjanthropus' skull was announced, further relics of fossil hominids have come to light in the deposits of the Olduvai Gorge as the result of the energetic field-work of Dr and Mrs Leakey. The interpretation of these later finds is still obscure because full reports on them have not yet been completed and published. The correct assessment of their real significance will doubtless depend on a recognition of the wide range of variability in the different groups of the genus *Australopithecus* already known, with due attention to the differential taxonomic relevance of various characters of the skull, dentition and limb structure. In this monograph, Professor Tobias has shown that he is well aware of the need to take such factors into account.

EDITOR'S NOTE

This is the second volume of the new series of publications dealing with the discoveries made at Olduvai Gorge since 1951. The title of the first volume included the dates '1951–1961'. These have been dropped from the present volume, and will also not occur in the remainder of the series, since, inevitably, data obtained since 1961 will need to be included. The next two volumes in this series will deal with the cultural sequence and excavations of the 'living floors' in Beds I and II, at Olduvai, by Mary D. Leakey, and the detailed geology of the deposits exposed in the Gorge by Richard L. Hay. It is not yet certain which of the two will be ready for publication first.

A fifth volume is in preparation by Phillip Tobias, the author of this volume on '*Zinjanthropus*'. In it he will describe, in detail, the fossil hominid remains from Olduvai that are attributed to *Homo habilis*, and to *Homo erectus*, as well as the new mandible of an australopithecine of '*Zinjanthropus*' type from Peninj, north of Olduvai. The fifth volume will also include chapters dealing with the post-cranial hominid material from Olduvai by Dr John Napier, Dr Peter Davis and Dr Michael Day.

In the present volume, my friend and colleague, Phillip Tobias, has produced a truly magnificent

piece of research—a major contribution to the study of the anatomy of the australopithecines, or 'near men' as I call them. This volume is without doubt the most detailed study of any one single fossil hominid skull that has ever been made, and the facts that have emerged from his studies are presented with admirable clarity. I need not enlarge upon this, since Professor Sir Wilfrid Le Gros Clark has done so in his Foreword.

Naturally, Tobias concludes his study of the facts about *Zinjanthropus* with an expression of his views as to the taxonomic status of the members of the sub-family Australopithecinae. He believes that the ancestral stock which gave rise to both *Homo habilis* and to *A. africanus* was an Australopithecine. I would prefer to refrain from suggesting that the common ancestor was closer in morphology to one or the other. We do not yet know. Similarly, it would seem better to leave open for the present the question of whether *Homo erectus* was a derivative of *Homo habilis*.

Finally, it remains only for me to congratulate Phillip Tobias upon a magnificent piece of anatomical study. This book will stand as a model for a very long time as to how a study of a fossil skull should be conducted.

L. S. B. LEAKEY

ACKNOWLEDGEMENTS

Various parts of this study have been generously assisted by the British Council, the Wenner-Gren Foundation for Anthropological Research, the South African Council for Scientific and Industrial Research, the Boise Fund, the National Geographic Society and the University of the Witwatersrand, Johannesburg.

I am grateful to both Professor R. A. Dart, who guided me into physical anthropology, and Dr J. T. Robinson, for allowing me freely to study specimens in their collections and for helpful discussions. Doctor Robinson also kindly assisted me with the loan of an unpublished median sagittal craniogram of *Australopithecus* (Sterkfontein 5). Professor Sir W. E. Le Gros Clark, F.R.S., kindly contributed the Foreword and made available a median sagittal craniogram of a female gorilla. In addition, I wish to thank the Keeper of Palaeontology and the Keeper of Zoology at the British Museum (Natural History), Dr K. P. Oakley, Dr J. C. Trevor, Dr D. R. Hughes, Mr D. Brothwell, Miss Rosemary Powers, Professor H. V. Vallois, Dr C. Arambourg, Professor S. Sergi, Dr D. Hooijer, Professor G. H. R. von Koenigswald, Dr V. FitzSimons, Professor L. H. Wells and the Uganda Gorilla Research Unit of the University of the Witwatersrand.

The extremely difficult and laborious task of casting each of the delicate and frequently undercut fragments of the cranium was successfully undertaken by Mr T. W. Kaufman; the casts have been skilfully painted to simulate the originals by Mrs C. R. Esson. The reconstruction of the cranium and the plaster and endocranial cast have been made by Mr A. R. Hughes in conjunction with the author, and it is a pleasure to acknowledge my indebtedness to him for freely imparting the fruits of his long experience at handling, preparing and reconstructing fossil material, as well as in the accurate preparation of dioptographic tracings and drawings. The X-rays were made by Miss J.

Dreyer and Mrs D. Coetzee, through the co-operation of Professor J. Kaye, Head of the Department of Radiology at the Johannesburg General Hospital. Miss C. Orkin and Miss J. Soussi sacrificed their personal vacation arrangements to execute painstakingly many of the drawings, graphs, diagrams and dioptographic tracings, while Miss Soussi was largely responsible for the punctilious tabulation and statistical reduction of data, the tests for significance of differences, and for the careful checking and collation of the manuscript. Miss A. Wright helped with such tedious details as the cutting out and mounting of the photographs. Mr T. E. Badenhuizen assisted with the calculation of indices, as well as with the statistical reduction of comparative data in the literature. Miss C. Orkin and Mr D. Gillmer helped me check the proofs. The entire task of photographing the skull—its several components, individual teeth and the assembled reconstruction—was undertaken with finesse, artistry and devotion by Mr R. Klomfass. In all some 200 photographs were taken. A proportion of these is included in this work and eloquently testifies to his skill. Mrs L. V. Hitchings, as well as Mrs R. W. Kaplan and Mrs B. E. Wilson, graciously lavished many weeks of their time on the meticulous and thoughtful typing of the manuscript, the tables and the legends. To all of this fine team, I express my warmest gratitude.

The advice, inspiration and encouragement of Dr and Mrs Leakey have been forthcoming at all times: I am deeply in their debt for giving me the privilege of working on so important and anatomically ideal a specimen.

Finally, I sincerely appreciate the patient, helpful and friendly co-operation of those many people at the Cambridge University Press—in the Pitt Building, at the Printing House, and in Bentley House, London—who have participated in producing this book. It has been a joy to work with them.

P.V.T.