

Archaeological Science

This book provides an up-to-date introduction to the exciting but complex new scientific methodologies that are increasingly used in archaeological study. Written by an international team of specialists, it provides clear and engaging overviews of a wide array of approaches, including DNA and proteomics, dating methods, materials analysis, stable isotope analysis and the scientific study of human, plant and animal remains, among other topics. Each technique is explored through the use of real archaeological examples, which both explain the methods and highlight their potential applications. The work is carefully illustrated with useful charts, graphs and other images, which complement the detail in the text and help articulate the case studies explored as well as the underlying principles of the techniques involved. Tables in many of the chapters highlight selected research on each topic, providing useful summaries of the current state and scope of the field for the reader. This volume will serve as a handy reference tool for scholars, as well as a key textbook for courses on archaeological science.

Michael P. Richards is an archaeological scientist who applies methods such as isotopic analysis to determine past human and animal diets and adaptations. He is a professor of archaeology and Canada Research Chair in archaeological science at the Department of Archaeology, Simon Fraser University in Vancouver, Canada, and is a Fellow of the Society of Antiquaries of London and a Fellow of the Royal Society of Canada. He has published over 250 research papers in journals such as *Nature*, *Science* and *PNAS*.

Kate Britton is a senior lecturer in archaeological science at the University of Aberdeen and an associate research scientist at the Max Planck Institute for Evolutionary Anthropology, Leipzig, and is a Fellow of the Society of Antiquaries of Scotland. An archaeological scientist, she studies the relationship between lifetime behaviours, diets and movements and the stable isotope chemistry of body tissues.

Archaeological Science

An Introduction

Edited by

Michael P. Richards
Simon Fraser University

Kate Britton
University of Aberdeen



CAMBRIDGE
UNIVERSITY PRESS



Shaftesbury Road, Cambridge CB2 8EA, United Kingdom
 One Liberty Plaza, 20th Floor, New York, NY 10006, USA
 477 Williamstown Road, Port Melbourne, VIC 3207, Australia
 314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India
 103 Penang Road, #05–06/07, Visioncrest Commercial, Singapore 238467

Cambridge University Press is part of Cambridge University Press & Assessment, a department of the University of Cambridge.

We share the University's mission to contribute to society through the pursuit of education, learning and research at the highest international levels of excellence.

www.cambridge.org

Information on this title: www.cambridge.org/9780521144124

DOI: 10.1017/9781139013826

© Michael P. Richards and Kate Britton 2020

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 & Assessment.

First published 2020

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

Library of Congress Cataloging-in-Publication data

NAMES: Richards, Michael P. (Michael Phillip), editor. | Britton, Kate, (Archaeological scientist), editor.

TITLE: Archaeological science : an introduction / edited by Michael Richards, Simon Fraser University, British Columbia; Kate Britton, University of Aberdeen.

DESCRIPTION: New York : Cambridge University Press, 2019. | Includes bibliographical references and index.

IDENTIFIERS: LCCN 2019035832 (print) | LCCN 2019035833 (ebook) | ISBN 9780521195225 (hardback) |

ISBN 9780521144124 (paperback) | ISBN 9781139013826 (epub)

SUBJECTS: LCSH: Archaeology—Methodology. | Archaeology—Methodology—Case studies.

CLASSIFICATION: LCC CC75 .A6543 2019 (print) | LCC CC75 (ebook) | DDC 930.1072—dc23

LC record available at <https://lccn.loc.gov/2019035832>

LC ebook record available at <https://lccn.loc.gov/2019035833>

ISBN 978-0-521-19522-5 Hardback

ISBN 978-0-521-14412-4 Paperback

Cambridge University Press & Assessment has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

CONTENTS

<i>List of Figures</i>	<i>page vii</i>
<i>List of Tables</i>	<i>ix</i>
<i>List of Contributors</i>	<i>x</i>
<i>Acknowledgements</i>	<i>xii</i>
PART I INTRODUCTION	1
1 Introducing Archaeological Science <i>Kate Britton and Michael P. Richards</i>	3
PART II BIOMOLECULAR ARCHAEOLOGY	11
2 Ancient DNA <i>Liisa Loog and Greger Larson</i>	13
3 Proteomics <i>Jessica Hendy, Nienke van Doorn, and Matthew Collins</i>	35
4 Residue Analysis <i>Oliver E. Craig, Hayley Saul, and Cynthia Spiteri</i>	70
5 Isotope Analysis for Mobility and Climate Studies <i>Kate Britton</i>	99
6 Isotope Analysis for Diet Studies <i>Michael P. Richards</i>	125
PART III BIOARCHAEOLOGY	145
7 Human Osteology <i>Darlene A. Weston</i>	147
8 Dental Histology <i>Tanya M. Smith</i>	170

vi CONTENTS

9 Geometric Morphometrics	198
<i>Philipp Gunz</i>	
PART IV ENVIRONMENTAL ARCHAEOLOGY	213
10 Vertebrate Zooarchaeology	215
<i>Beth Upex and Keith Dobney</i>	
11 Invertebrate Zooarchaeology	233
<i>Marcello A. Mannino</i>	
12 Palaeoethnobotany	276
<i>A. Catherine D'Andrea</i>	
13 Geoarchaeology	314
<i>Panagiotis Karkanas</i>	
PART V MATERIALS ANALYSIS	333
14 Ceramics	335
<i>Andrew J. Shortland and Patrick Degryse</i>	
15 Glass	347
<i>Andrew J. Shortland and Thilo Rehren</i>	
16 Metals	365
<i>Thilo Rehren</i>	
17 Lithics	387
<i>Shannon P. McPherron</i>	
PART VI ABSOLUTE DATING METHODS	405
18 Radiocarbon Dating	407
<i>Simon Blockley</i>	
19 Luminescence Dating	424
<i>Richard M. Bailey</i>	
<i>Index</i>	439

FIGURES

2.1	A typical ancient DNA laboratory setup	<i>page</i> 17
2.2	Incomplete lineage sorting between Neanderthals, Denisovans and humans	23
3.1	The structure of proteins	37
3.2	A protein mass spectrometry workflow	41
3.3	Dissociation and peptide identification in tandem mass spectrometry	44
3.4	An example of how an MS/MS spectrum generates a peptide sequence	45
3.5	Example of degradation detected in a peptide sequence	46
3.6	A simplified example of peptide mass fingerprints deriving from different animal species	47
4.1	Methodological approaches for the identification of organic residues in archaeological pottery	77
4.2	Micro- and macroscopic organic residues on archaeological pottery and lithics	80
4.3	$\delta^{13}\text{C}$ values of $\text{C}_{16:0}$ and $\text{C}_{18:0}$ fatty acids from Neolithic Grooved Ware pottery, Durrington Walls, Wiltshire, UK	82
5.1	A sequentially sampled archaeological horse tooth	108
5.2	Strontium and oxygen isotope data from modern caribou and bison	113
5.3	Strontium isotope from reindeer and bison from Jonzac, France	114
6.1	Typical bone collagen isotope values for a temperate ecosystem	138
7.1	Adult skeleton outline drawing for visual inventory	149
7.2	Numerical skeleton inventory	150
7.3	Male and female skull and pelvis	155
8.1	Polarised light images of enamel and dentine microstructure in the Scladina Neanderthal upper first molar	172
8.2	The Jebel Ihroud 3 mandible assessed with virtual phase-contrast X-ray imaging	175
8.3	Preparation of the initial thick section of the Scladina Neanderthal upper first molar	177
8.4	The Scladina Neanderthal first molar before and after sectioning	178
8.5	Stereomicroscopic imaging of dental material	180

8.6	Scanning electron micrograph of cut, etched and polished fossil ape enamel	180
8.7	Spinning-disk white light confocal images of Neanderthal enamel and dentine	181
8.8	Scladina Neanderthal dental development	186
9.1	Procrustes superimposition	199
9.2	Thin-plate spline (TPS) interpolation	202
9.3	Virtual reconstruction of a Neanderthal newborn	205
9.4	The Zeeland Ridges Neanderthal fragment	208
9.5	Landmarks and semilandmarks on the dentine crown of a tooth	209
12.1	Spectrum of plant exploitation strategies	277
12.2	Macrobotanical remains	280
12.3	Charred macrobotanical remains from Greece	282
12.4	Microbotanical remains	284
12.5	Bucket flotation of sediments from the Mezber site, northern Ethiopia	288
12.6	Machine-assisted flotation at Tel Tayinat, Turkey	289
13.1	Palaeogeographical reconstruction of the coastal area in the Bay of Palamari, Skyros Island, Greece	317
13.2	Micromorphological sample and a resin-impregnated slab of it	323
15.1	SEM micrograph showing a section through a piece of glass	351
15.2	SEM micrograph of deliberately added lead antimonate phases in a Late Bronze Age Egyptian glass	355
15.3	SEM micrograph of calcium antimonate phases that have precipitated in Late Bronze Age Egyptian glass	356
17.1	An example of edge damage on a Levallois flake from Amalda Cave	396
18.1	The tree-ring based radiocarbon calibration curve for the last 1000 years from IntCal09	410
18.2	Calibration of a radiocarbon date	413
19.1	The process of luminescence dating	427

TABLES

3.1	List of the twenty amino acids encoded by the human genome	<i>page</i> 36
3.2	Selected case studies in ancient protein research	50
4.1	Selected published reports of the occurrence of residues on archaeological artefacts	72
8.1	Methods for studying tooth growth and development	174
19.1	Luminescence dating in a nutshell	428

CONTRIBUTORS

Richard M. Bailey

University of Oxford, United Kingdom

Simon Blockley

Royal Holloway, University of London, United Kingdom

Kate Britton

University of Aberdeen, United Kingdom and Max Planck Institute for Evolutionary Anthropology, Germany

Matthew Collins

University of Cambridge, United Kingdom and Natural History Museum of Denmark, University of Copenhagen, Denmark

Oliver E. Craig

University of York, United Kingdom

A. Catherine D'Andrea

Simon Fraser University, Canada

Patrick Degryse

Katholieke Universiteit Leuven, Belgium

Keith Dobney

University of Liverpool, United Kingdom

Nienke van Doorn

University of York, United Kingdom

Philipp Gunz

Max Planck Institute for Evolutionary Anthropology, Germany

Jessica Hendy

University of York, United Kingdom

Panagiotis Karkanas

The American School of Classical Studies, Greece

Greger Larson

University of Oxford, United Kingdom

Liisa Loog

University of Oxford, United Kingdom, University of Cambridge, United Kingdom
and University of Manchester, United Kingdom

Marcello A. Mannino

Aarhus University, Denmark

Shannon P. McPherron

Max Planck Institute for Evolutionary Anthropology, Germany

Thilo Rehren

The Cyprus Institute, Cyprus

Michael P. Richards

Simon Fraser University, Canada

Hayley Saul

Western Sydney University, Australia

Andrew J. Shortland

Cranfield University, United Kingdom

Tanya M. Smith

Griffith University, Australia

Cynthianne Spiteri

Eberhard Karls Universität Tübingen, Germany

Beth Upex

Durham University, United Kingdom

Darlene A. Weston

University of British Columbia, Canada

ACKNOWLEDGEMENTS

We would first most like to thank each of our authors in this volume for their contributions, hard work and patience as we brought this volume together. Thanks also to our proof-readers and copy-editors for their valuable inputs. We are very pleased with the resulting book, and especially the high quality of all of the chapters. Our hope is that this volume will be of help to both archaeology professionals and students, to give them a starting point for the new methods of archaeological science that are increasingly being used in archaeology today.