The Mammalian Jaw

The structure of mammalian skulls is notably diverse; however, at a fundamental level the jaw mechanism is remarkably similar, if not essentially the same, in the majority of mammals.

Using simple models that are compared with real animals at every step, this book examines the basic structural features of the mammalian jaw mechanism from a mechanical point of view. It explores how the mechanical constraints placed on the jaw have contributed to the evolution of an efficient underlying structure, used by many mammals, which precludes mechanical difficulties and uses a minimum amount of bone tissue. Throughout the book the emphasis is on conceptual understanding, with explanations linked together to form a complete story that can be applied to both fossil and extant mammals.

Walter Stalker Greaves is a retired member of the Department of Oral Biology, University of Illinois at Chicago. He spent his career teaching anatomy at Indiana University of Pennsylvania and human gross anatomy in the College of Dentistry, UIC. His research concentrated on the mammalian jaw mechanism, using very simple mechanical models to explain how the jaw works and why the jaw mechanism has evolved to essentially the same basic structure.

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A Mechanical Analysis

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CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town,
Singapore, São Paulo, Delhi, Mexico City

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/9781107016224

First published 2012

Printed in the United Kingdom at the University Press, Cambridge

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

Library of Congress Cataloguing in Publication data
Greaves, Walter Stalker, 1937–
The mammalian jaw : a mechanical analysis / Walter Stalker Greaves.
pages cm
Includes bibliographical references and index.
ISBN 978-1-107-01622-4
1. Mammals–Anatomy. 2. Jaws–Mechanical properties. I. Title.
QL739.G74 2012
599.14′4–dc23
2012013670

ISBN 978-1-107-01622-4 Hardback

For
Marsha Lee and Jacqueline Sinclair

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Preface

I initially studied the jaw mechanism in fossil selenodont artiodactyls (antelope and their kin) and augmented the study with an examination of modern forms. One could argue that this was not the best approach, because the jaw mechanism of artiodactyls, while basically similar to other mammals, is in some ways slightly atypical. At the same time, however, some features appear to be somewhat less complicated in the artiodactyls. So it is just as reasonable to imagine that even though these animals were in some ways not the best animals to choose for an *initial* study of the mammalian jaw mechanism, the simplicity of some features made some early progress possible in a reasonable amount of time.

Later studies naturally concentrated on problems that presented themselves at the time. While this is a perfectly reasonable approach, the difficulty is that a clear, logical, and sequential presentation of how the mammalian jaw mechanism works would not necessarily be evident from an examination of a series of papers prepared in this way. The reader, in effect, would be asked to integrate a large amount of unordered information to produce a logical, linear sequence. My view of how the jaw mechanism functions evolved over time as more information came to light, as my early errors were corrected, and as erroneous ideas from the literature were rectified. In short, someone with an interest in the mammalian jaw mechanism might not have an easy time deciphering my views if they simply read my various papers in their order of appearance.

Thus, the purpose here is to present in a clear, logical, and linear sequence, my view of the basic structure of the mammalian jaw mechanism from a geometric point of view. The emphasis is on what this basic structure is and, just as importantly, why, in a mechanical sense, the masticatory apparatus has evolved to the same basic structure. This presentation begins at a very elementary level and, while maintaining as much simplicity as possible, moves along step by step in a linear fashion. For example, the first analysis described below treats the jaw as a line with a joint on one end, the teeth at the other, and a muscle vector somewhere in between. Two reasonable questions could be asked of such a model: where, along the line representing the jaw, is the muscle vector located and how long is the tooth row? Naturally, simpler models must give way to those that are more complicated. The hope is to provide a clear explanation that accounts for the present structure (or natural design) of the mammalian jaw mechanism. Some workers approach studies of this kind by studying the basic physics, say, and then by applying the

appropriate equations to apparent problems. Here I find it more satisfying to start with the problem and then try to find an "equation."

In the following account references are largely omitted with the hope of producing a smoother presentation. Readers who prefer a slightly more formal discussion, of course, can consult my original published papers as well as the other papers in the References section. However, they then must integrate the material into a smooth linear sequence for themselves.

Acknowledgments

Over the last 40 years, many students and colleagues have contributed, in both large and small ways, to my ideas about the jaw mechanism. At the beginning, my thesis advisor Len Radinsky and my committee members Jim Hopson, Ralph Johnson, Leigh Van Valen, and especially Charles Oxnard, had a great influence.

For all her efforts I especially want to thank Sue Herring, who was both a fellow student at the University of Chicago and later a colleague at the University of Illinois at Chicago. Very little escaped Sue's sharp mind. Her efforts to teach me to spell, however, were less successful, especially after spell-checkers became common. My other colleagues at Illinois are fondly remembered. Many hours were spent with Herb Barghusen, who challenged me at every turn. While he found errors in my thinking, I remember the look on his face one day after a long discussion that suggested to me that he thought there might (finally) be something to what I was telling him; but he never quite said so. Bob Scapino also constantly challenged me, but I think his greatest contribution to my career was to ensure that I was able to pursue the research I wanted to, while he was head of the Department of Oral Anatomy and later Oral Biology. Karen Hiiemae helped me to crystallize in my mind the different approaches to research. Writing a paper with Ray Costa gave me a better appreciation of other fields of study. Tom Lakars was constantly encouraging and questioned me in a calm and friendly manner. Lloyd DuBrul hired me and made possible these relationships with the functional anatomists in his department.

Graduate and post-doctoral students probably don't realize what a strong effect they have on one's ideas. Discussing things with students certainly clarifies your thinking. I well remember some of my discussions with Fred Anapol, Keith Condon, Doreen Covey, Dean Dessem, Don Dunbar, Bob Druzinsky, Ken Gordon, Bruce Manion, Bob Mucci, Ginny Naples, Al Obrez, Bob Schmitz, Kenshu Shimada, and Larry Wineski. Audrone Biknevicius and Mark Spencer were graduate students from other schools who influenced me and whose research I have since followed carefully.

There is another component of an effort like this. Repeated enhancement of my ideas took place when preparing lectures in gross anatomy that touched on the topics discussed here.

My wife Marsha has illustrated, and questioned me about, every paper that led up to this book. She also greatly improved this manuscript. Of course, any errors or bad ideas are mine.

Finally, I should thank Daryl Domning who, every time he saw me, pressed me to write this book.