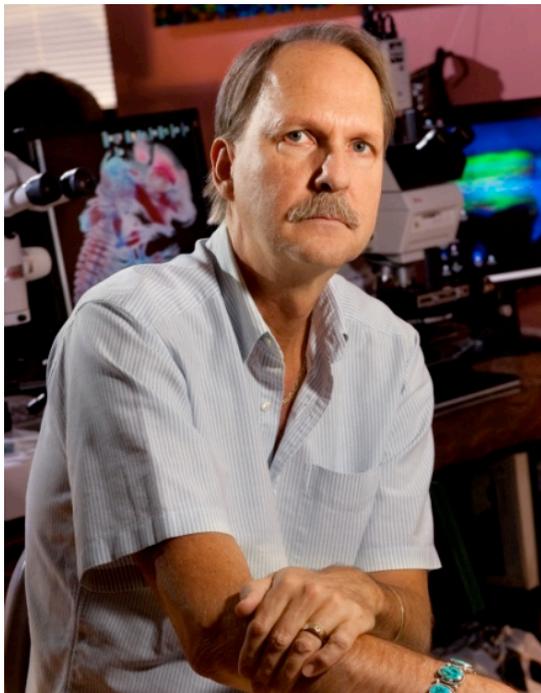

Evolutionary History of Human Craniofacial Development: Integrating Functional Matrix Theory with Hard Tissue Biology

The functional matrix hypothesis was introduced by Melvin L. Moss in the 1960's, and has been an enduring concept for explaining the compensatory growth and development of the craniofacial complex in general, and the facial skeleton in particular. It remains true in concept, but it is incomplete and it stopped short of integrating hard tissue biology and complexity science into its rubric.

Functional matrices are of two types: periosteal matrices comprise muscle/tendon attachments to skeletal units, and capsular matrices enclose a tissue mass or volume within a functional space. However, expansion of orofacial capsular matrices were said to be intrinsically-derived spaces, not functionally-mediated, that satisfy the metabolic demands of the body.

Support is offered for the idea that these capsular matrices have contents that furnish the pressures required to form these spaces. The oropharyngeal capsule is mechanically challenged by chewing a hard and tough diet, and in so being challenged grows sufficiently to render a normal occlusion. The functional matrix of the oral cavity is hard and tough food.

The nasopharyngeal capsule is mechanically challenged by air pressures elicited by vigorous nasal breathing. While chewing forces likely also play a role in development of the nasopharyngeal passage, nasal breathing is suggested to be primary. The functional matrix of the nasal cavity is air. With a more complete understanding of functional matrices, an evolutionary history of the human craniofacial complex concept makes sense. This research is supported exclusively by the arts: <https://www.essentialortho.com/store1/Artwork-c115649774>.



CURRICULUM VITAE

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EDUCATION:

<u>Dates</u>	<u>Degree Conferred</u>	<u>Field of Study~ Institution</u>
1980-86	1986/Ph.D.	Biological Anthropology University of Toronto
1978-80	1980/M.A.	Biological Anthropology University of Toronto
1972-1978	1978/B.A.*	Anthropology-Biology-Geology California State University, Sonoma* California State University, Fullerton University of Dundee

ACADEMIC POSITIONS

2010-	Honorary Professor La Salle University Madrid, Spain
2010-	Honorary Research Fellow Senckenberg Research Institute & University of Frankfurt Frankfurt, Germany
2020-	Tenured Full Professor (F/T) Department of Molecular Pathobiology New York University College of Dentistry Adjunct Professor, NYU Institute for the Study of the Ancient World
2010-20	Tenured Full Professor (F/T) Department of Biomaterials & Biomimetics New York University College of Dentistry
2004-10	Education Coordinator II (F/T) Department of Biomaterials & Biomimetics New York University College of Dentistry
2004-	Adjunct Professor (P/T) Department of Basic Science and Craniofacial Biology New York University College of Dentistry
2004-	Adjunct Professor (P/T) Ph.D. Program in Anthropology New York University and C.U.N.Y. Graduate School.
1998-04	Professor (F/T) Department of Anthropology and the Thomas Hunter Honors Program, Hunter College, CUNY
1998-04	Tenured Full Professor (F/T) Ph.D. Programs in each of Anthropology, Biology, and Earth and Environmental Sciences, C.U.N.Y. Graduate School.
1994-98	Associate Professor (F/T) Department of Anthropology, Hunter College, C.U.N.Y., and Ph.D. Program in Anthropology, C.U.N.Y. Graduate School

1989-94	Assistant Professor (F/T) Department of Anthropology, Hunter College, C.U.N.Y., and Ph.D. Program in Anthropology, C.U.N.Y. Graduate School
1986-03	Honorary Research Fellow (F/T) Department of Anatomy & Developmental Biology, University College University of London, UK
1987-88	Postdoctoral Research Fellow (F/T) Department of Child Dental Health, London Hospital Medical College, University of London, UK
1986-87	NATO Postdoctoral Fellow (F/T) Department of Anatomy & Developmental Biology, University College London University of London, UK

HONORS/AWARDS

<u>Date</u>	<u>Institution/Organization</u>
2020	Elected Full Member, Sigma Xi, The Scientific Research Honor Society
2020	Federation of American Societies For Experimental Biology BioArt winner
2015	Elected Fellow, American Association for the Advancement of Science
2013	Phi Beta Kappa Visiting Scholar
2011	Omicron Kappa Upsilon inductee, National Dental Honor Society
2010	Max Planck Prize (Life Science), Max Planck Society and the Alexander von Humboldt Foundation
1989-02	PSC-CUNY Research Award, CUNY
1999	Eugene Lang Student Faculty Research Fellowship, CUNY
1998	New Research and Teaching Initiative Award, CUNY
1997	Presidential Faculty Incentive & Teaching Grant Award, CUNY
1996	Presidential Award for Excellence in Scholarship, CUNY
1996	Spring Invitation Lecturer, Barts & the London School of Medicine & Dentistry, University of London
1996	George N. Shuster Award, CUNY
1995	Hunter College Pluralism and Diversity Fund Award, CUNY
1993	Division of Dentistry and Medicine Visiting Lecturer, Dept. of Anatomy and Human Biology, University of Western Australia
1992	Distinguished Alumni Award, California State University, Sonoma
1991	NASA Cosmos Biosatellite Group Achievement Award
1990, 89	Eastern European Research Award, Int'l Research and Exchange Board
1990	Eugene Lang Junior Faculty Development Award, CUNY
1986	NATO Postdoctoral Fellowship in Science, NATO
1984, 83	Ontario Graduate Scholarship, University of Toronto
1982, 80, 79	University of Toronto Open, Doctoral, and Graduate Fellowships, University of Toronto
1981	Charles Gordon Heyd Fellowship, University of Toronto
1980	University of Toronto School of Graduate Studies Student Visa Award, University of Toronto

MEMBERSHIP IN PROFESSIONAL SOCIETIES

American Association for the Advancement of Science
American Association for Dental Research
American Association of Physical Anthropologists
American Society for Bone and Mineral Research
American Society for Mass Spectrometry
Anatomical Society
Association of Biomolecular Resource Facilities
European Calcified Tissue Society
European Microscopy Society
Friends of the Alexander von Humboldt Foundation
International Bone and Mineral Society
Royal Microscopy Society
Senckenberg Society
Sigma Xi, The Scientific Research Honor Society Sigma Xi

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Bromage TG, Denys C, De Jesus CL, Erdjument-Bromage H, Kullmer O, Schrenk F, McKee MD, Reznikov N, Sandrock O, Poudel SB, Yakar S, Kubat J, Hu B, Rabieh S, Neubert TA. Fossil mammalian paleometabolomes yield metabolic and ecologic profiles. *Nature*, *in revision*.

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- 2/23/19 Craniofacial Complexity, Culture, and Plain Human Laziness Conspire to Make Our Lives Miserable: Can a Knowledge of Growth Rescue Us From Ourselves? Medical Dental Building, Winter Garden Conference Room, Seattle, WA.
- 3/20/19 Hard Tissue Biology Contributions to A Metabolic Theory of Everything. Queen Mary, University of London, Dental Biophysics Section, Institute of Dentistry, London, UK.
- 4/9/19 Hard Tissue Biology Contributions to A Metabolic Theory of Everything. Graduate Center of the City University of New York, New York, NY. 4/27/19 New Perspectives on Human Cranio-Mandibular Remodeling. Symposium on Integrative Dental Health, San Antonio, TX.
- 10/7/19 Why I make more sense on Tuesdays: multidien biological timing in human health and disease. Evolutionary Medicine: The Biocultural Perspective, Senckenberg Research Institute, Frankfurt, Germany.
- 10/19/19 The Biology of Facial Growth. Inside Dentistry, Inc., Melbourne, Australia.
- 11/13/19 How we came to know what we didn't know we didn't know: Life history lessons learned by leaving reductionist research to dweebs. Bioengineering Society of The College of New Jersey, Ewing Township, NJ.

BRIEF BIOGRAPHY

Following an undergraduate degree at the California State University at Sonoma in Anthropology, Biology, and Geology, Timothy G. Bromage obtained his MA and then in 1986 his PhD in Biological Anthropology from the University of Toronto with Prof. Becky Sigmon. The later years of his PhD program were completed in the Department of Anatomy and Embryology, University College London with Prof. Alan Boyde. Tim was awarded a NATO Postdoctoral Fellowship in 1987 and in 1988 appointed as a Postdoctoral Research Fellow in the Department of Child Dental Health, London Hospital Medical College, University of London with Prof. Jim Elliott. In 1989 he took a position in the Department of Anthropology, Hunter College, City University of New York, where he remained for 15 years. There he developed the first fully digital light and electron microscopy facility in the United States, and together with his preparation laboratory, created the Hard Tissue Research Unit (HTRU). In 2004 Tim moved the HTRU to the NYU College of Dentistry and further introduced an isotope laboratory within the laboratory.

Primary foci of research in the HTRU relate to bone and tooth biology with emphases on organismal development and life history, as well as for what “signals” exist in these tissues of variability in the external environment. His research has been reported in >200 papers and cited more than 6,500 times. He holds two patents from NYU, for a portable confocal microscope and for a method for simultaneously determining the absolute concentrations of 71 elements in seconds from aqueous solutions. His funding has largely come from the NIH, NSF, the Max Planck Society and the Alexander von Humboldt Foundation, and the United Nations Development Program. Tim’s contributions to science have been recognized by awards including: the Max Planck Prize (Life Science), Omicron Kappa Upsilon inductee of the National Dental Honor Society, Phi Beta Kappa Visiting Scholar, elected Full Member of Sigma XI, and elected to Fellow of the American Association for the Advancement of Science.