

15	first missed menstrual period primitive streak	16	Stage 7 begins notochordal process	17	intra-embryonic mesoderm trilaminar embryo	18	Stage 8 begins neural plate primitive streak length: 1.5 mm	19	neural fold notochord embryonic coelom	20	Stage 9 begins brain neural groove somite Thyroid begins to develop.	21	neural groove somite Heart tubes begin to fuse.
22	Stage 10 begins Heart begins to beat Neural folds fusing.	23	rostral neuropore primordia of eye and ear present. caudal neuropore	24	Stage 11 begins heart bulge rostral neuropore closes 2 pairs of branchial arches	25	otic pit 3 pairs of branchial arches	26	Stage 12 begins arm bud indicates actual size	27	4 pairs of branchial arches, arm & leg buds present. CR = crown-rump length.	28	Stage 13 begins CR: 4.0 mm
29	CR: 5.0 mm	30	Lens pits, optic cups, nasal pits forming.	31	developing eye nasal pit primitive mouth	32	Stage 14 Hand plates (paddle-shaped) Lens pits and optic cups formed.	33	Stage 15 begins hand plate CR: 7.0 mm	34	Head much larger relative to trunk. cerebral vesicles distinct leg buds (paddle-shaped)	35	CR: 8.0 mm
36	CR: 9.0 mm	37	Stage 16 begins foot plate CR: 9.0 mm	38	Upper lip formed.	39	CR: 10.0 mm	40	Arms bent at elbow. Finger rays and auricular hillocks distinct Palate developing.	41	Stage 17 begins finger rays ventral view	42	CR: 13.0 mm

*The*  
*Developing Human* *Third Edition*  
CLINICALLY ORIENTED EMBRYOLOGY

KEITH L. MOORE, M.Sc., Ph.D., F.I.A.C., F.R.S.M.  
Professor and Chairman, Department of Anatomy,  
University of Toronto, Faculty of Medicine, Toronto, Ontario, Canada.

*With Islamic Additions*

Correralation Studies with Qur'an and Hadith

ABDUL-MAJEED A. AZZINDANI  
Director, Project of Scientific Miracle in the Qur'an and Hadith,  
Sponsored by Several Educational Institutions,  
King Abdulaziz University, Jeddah, Saudi Arabia.

Illustrated primarily by  
GLEN REID B.Sc., A.A.M.  
Medical Illustrator, Faculty of Medicine,  
University of Manitoba, Winnipeg, Manitoba, Canada.

1982 W.B. SAUNDERS COMPANY  
Philadelphia/London/Toronto/Mexico City/Rio de Janeiro/Sydney/Tokyo

This Edition was published by Dar Al-Qiblah for Islamic Literature, with special permission from W.B. Saunders Company, 1983.

W. B. Saunders Company: West Washington Square  
Philadelphia, PA 19105

1 St. Anne's Road  
Eastbourne, East Sussex BN21 3UN, England

1 Goldthorne Avenue  
Toronto, Ontario M8Z 5T9, Canada

Apartado 26370—Cedro 512  
Mexico 4, D.F., Mexico

Rua Coronel Cabrita, 8  
Sao Cristovao Caixa Postal 21176  
Rio de Janeiro, Brazil

9 Waltham Street  
Artarmon, N.S.W. 2064, Australia

Ichibancho, Central Bldg., 22-1 Ichibancho  
Chiyoda-Ku, Tokyo 102, Japan

Dar Al-Qiblah for

Islamic Literature: P.O.Box. 10932, Jeddah 21443, Saudi Arabia.

**Library of Congress Cataloging in Publication Data**

Moore, Keith L.

The developing human.

Includes bibliographies and index.

1. Embryology, Human.      2. Abnormalities, Human.  
I. Title.

QM601.M76 1982      612'.64      81-40900

ISBN 0-7216-6472-5      AACR2

Listed here is the latest translated edition of this book together with the language of the translation and the publisher.

French—Edisem, Inc., St. Hyacinthe, Quebec,  
Canada

Spanish—Nueva Editorial Interamericana,  
S.A. México, Mexico

Portuguese—Editora Interamericana do Brasil  
Ltda., Rio de Janeiro, Brazil

German—F. K. Schattauer Verlag, Stuttgart,  
Germany

Italian—Nicola Zanichelli Editore, Bologna,  
Italy

Japanese—Ishiyaku Publishers Inc., Tokyo, Japan

*Front cover:* Photograph of a 13-week-old human fetus.

The Developing Human—Clinically Oriented Embryology

ISBN 0-7216-6472-5

© 1982 by W. B. Saunders Company. Copyright 1973 and 1977 by W. B. Saunders Company. Copyright under the Uniform Copyright Convention. Simultaneously published in Canada. All rights reserved. This book is protected by copyright. No part of it may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without written permission from the publisher. Made in the United States of America. Press of W. B. Saunders Company. Library of Congress catalog number 81-40900.

Last digit is the print number: 9 8 7 6 5 4 3 2 1

In close collaboration with the author of the Islamic Additions, the English texts were prepared by the following members of the College of Medicine, King Abdulaziz University :

1. **Prof. Mohammad Yousuf Sukkar**, M.B.,B.S.,Ph.D.  
Professor of Physiology & Chairman Department of Postgraduate Studies, King Fahd Medical Research Centre.
2. **Prof. Nawab Mohammad Khan**, M.B.,B.S.,M.Phil.,Ph.D.  
Professor of Anatomy and Chairman Department of Anatomy
3. **Prof. Mohammad Tabir**, M.B.,B.S.,M.Phil.,Ph.D.  
Professor of Anatomy
4. **Dr. Mustafa Mohammad Al-Najjar**, M.B.,B.Ch.,M.Sc.,Ph.D.  
Assistant Professor, Department of Anatomy & Member, Department of Islamic Medicine, King Fahd Medical Research Centre.

Proofreading of material done by:  
Mohammad Omar Al-Farouk.  
Medics Department, English Language Centre,  
King Abdulaziz University.

## COPY RIGHTS FOR ISLAMIC ADDITIONS

For reproduction of the Islamic Addenda included in "The Developing Human, Clinically Oriented Embryology, with Islamic Additions" permission should be obtained from Sheikh Abdul Majeed Azzindani, King Abdulaziz University, Jeddah, Saudi Arabia.

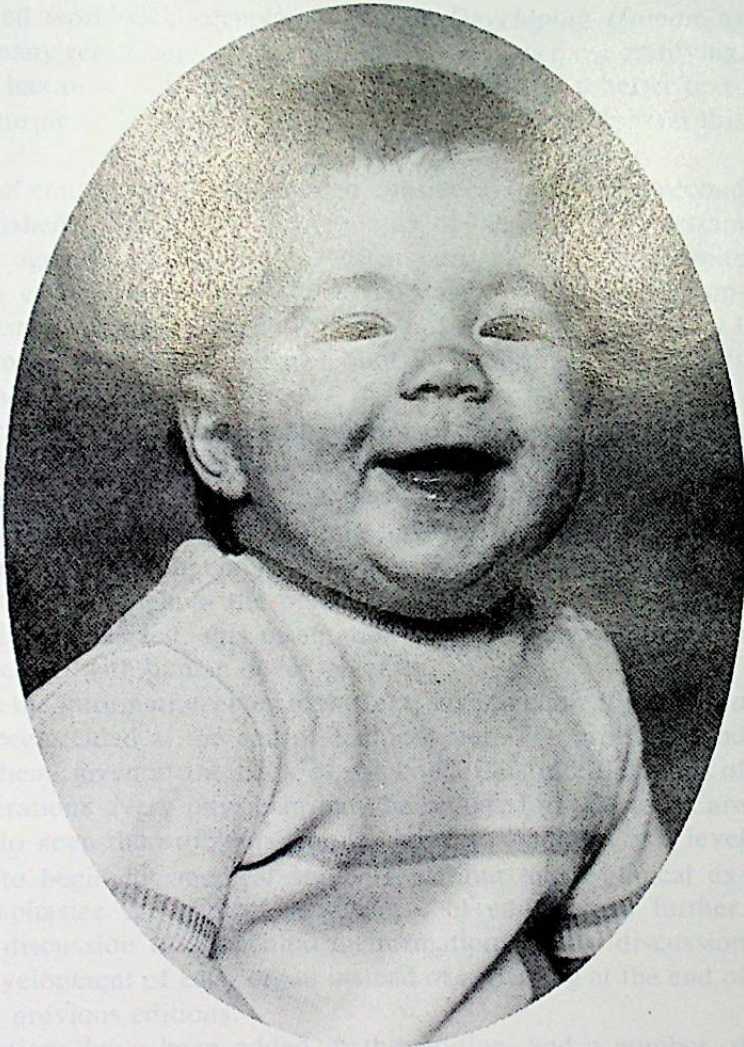
Permission for the reproduction of "Islamic Additions" will be granted free of charge for all learned bodies and for educational purposes.

# PREFACE TO THE THIRD EDITION

*To our first grandchild*

MELISSA CATHERINE MOORE

*daughter of Warren and Cathy*



# PREFACE TO THE THIRD EDITION

The continued worldwide acceptance of *The Developing Human*, as indicated by its many reprintings and foreign translations, is most gratifying. This acceptance has provided the encouragement to prepare a better textbook by restructuring it and adding new material and illustrations in this third edition.

Knowledge of embryology has expanded considerably since the second edition was published. The extreme vulnerability of the embryo to certain drugs and other agents and the practice of in vitro fertilization provide strong stimuli to embryologists studying early stages of human development. I have attempted to bring the book abreast of current literature, but I have adhered to my original aim of writing a book for undergraduate students and not a reference work for specialists.

To incorporate new information, all sections have been reviewed. In some chapters there have been extensive modifications, but in others relatively few changes were necessary. All this has entailed little increase in the number of pages because judicious pruning has been done. To improve readability and obviate possible ambiguity, many sentences and paragraphs have been rewritten. Throughout the book, the importance of embryology to the clinician is emphasized; this orientation is very likely to appeal to any person concerned with human development.

To reinforce the information given in the text, several *clinically oriented problems* have been added at the end of each chapter. The problems and the answers to them, given at the back of the book, illustrate the kinds of practical considerations every physician may be required to address. Care has been taken to keep the problems simple and the comments at a level that is suitable to beginning medical students without much clinical experience. To emphasize the clinical significance of embryology further, description and discussion of congenital malformations follow discussion of the normal development of each organ instead of appearing at the end of the chapter as in previous editions.

New illustrations have been added in this edition, and a number of figures have been redrawn or modified in light of teaching experience. *Color has also been added to several more drawings* to facilitate understanding. I owe thanks to Dorothy Irwin for this work, but I should again like to express my appreciation to Glen Reid, who is primarily responsible for the illustrations in this book.

*Italics* have been used more freely than in the past editions to indicate important terms; officially recognized synonyms or alternatives appear in parentheses, e.g., *syncytiotrophoblast* (syntrophoblast). *Italics* have also been used to emphasize important terms, concepts, and statements.

## PREFACE TO THE THIRD EDITION

The *Nomina Embryologica*, approved by the Tenth International Congress of Anatomists in Tokyo, 1975, has been followed, and, in accordance with international agreement, the terminology is anglicized, departing from strict Latin in most cases. There is also some use of eponyms (e.g., Meckel's diverticulum and Down syndrome); students will need to know such terms because they are used in specialty texts and by clinical teachers.

While working on this edition, I have had the benefit of receiving helpful criticisms from students in many parts of North America and suggestions from a number of embryologists who have kindly written me or sent reprints of their publications. To all these people I express my most sincere thanks. Several colleagues have been very helpful with this edition: Dr. J. W. A. Duckworth, Dr. D. L. McRae, and Dr. I. M. Taylor. Dr. T. V. N. Persaud, Professor and Head of Anatomy at the University of Manitoba in Winnipeg, Dr. Douglas E. Kelly, Professor and Head of Anatomy, University of Southern California, and Dr. Kunwar Bhatnagar, Associate Professor of Anatomy at the University of Louisville, have also made good suggestions for improving the book. Mrs. Jill Weinheimer and my wife, Marion, have carefully and cheerfully typed corrections and additions to the text. Roberta Kangilaski, Albert Meier, and Walter Bailey of the W. B. Saunders Company have given me much help with this edition. To all these people, I express my sincere appreciation.

KEITH L. MOORE

# CONTENTS

CHAPTER 1	
INTRODUCTION: Terms and Concepts.....	1
Developmental Periods.....	1
Timetable of Human Prenatal Development.....	2
Scope of Embryology.....	7
Significance of Embryology.....	7
Historical Gleanings.....	8
Descriptive Terms.....	10
Clinically Oriented Problems.....	12
CHAPTER 2	
THE BEGINNING OF DEVELOPMENT: The First Week.....	14
Gametogenesis.....	14
Structure of the Uterus.....	19
Reproductive Cycles.....	21
Germ Cell Transport and Viability.....	27
Fertilization.....	30
Cleavage.....	33
Blastocyst Formation.....	33
Summary of First Week.....	36
Clinically Oriented Problems.....	37
CHAPTER 3	
FORMATION OF THE BILAMINAR EMBRYO: The Second Week...	40
Implantation.....	40
Implantation Sites.....	46
Early Abortions.....	49
Summary of Implantation.....	49
Summary of Second Week.....	51
Clinically Oriented Problems.....	51
CHAPTER 4	
FORMATION OF THE TRILAMINAR EMBRYO: The Third Week...	53
Gastrulation.....	54
Neurulation.....	61
Development of Somites.....	63
Development of Intraembryonic Coelom.....	63
Primitive Cardiovascular System.....	63
Development of Chorionic Villi.....	65
Summary of Third Week.....	66
Clinically Oriented Problems.....	68
CHAPTER 5	
THE EMBRYONIC PERIOD: Fourth to Eighth Weeks.....	70
Folding of the Embryo.....	70
Germ Layer Derivatives.....	75
Control of Development.....	76



## CONTENTS

Highlights of the Embryonic Period .....	76
Disorders of Embryonic Development .....	88
Estimation of Embryonic Age .....	89
Summary of Embryonic Period .....	90
Clinically Oriented Problems .....	91
CHAPTER 6	
THE FETAL PERIOD: Ninth Week to Birth .....	93
Estimation of Fetal Age .....	94
Highlights of the Fetal Period .....	95
Factors Influencing Fetal Growth .....	104
Factors Causing Fetal Growth Retardation .....	104
Perinatology .....	105
Summary of Fetal Period .....	108
Clinically Oriented Problems .....	109
CHAPTER 7	
THE FETAL MEMBRANES AND PLACENTA .....	111
The Decidua .....	111
Placental Development and Structure .....	111
Placental Activities .....	118
Uterine Growth During Pregnancy .....	120
Parturition (Labor) .....	120
The Full-Term Placenta .....	123
The Amnion .....	126
The Yolk Sac .....	128
The Allantois .....	129
Multiple Pregnancy .....	129
Summary .....	136
Clinically Oriented Problems .....	138
CHAPTER 8	
CAUSES OF CONGENITAL MALFORMATIONS: Human Teratology .....	140
Malformations Caused by Genetic Factors .....	140
Malformations Caused by Environmental Factors .....	151
Malformations Caused by Multifactorial Inheritance .....	161
Summary .....	162
Clinically Oriented Problems .....	162
CHAPTER 9	
BODY CAVITIES, PRIMITIVE MESENTERIES, AND DIAPHRAGM .....	167
Division of the Coelom .....	170
Development of the Diaphragm .....	172
Congenital Malformations .....	174
Summary .....	176
Clinically Oriented Problems .....	177
CHAPTER 10	
THE BRANCHIAL APPARATUS AND THE HEAD AND NECK .....	179
The Branchial Arches .....	179
The Pharyngeal Pouches .....	187
The Branchial Grooves .....	188
The Branchial Membranes .....	188
Branchial Anomalies .....	188
Development of the Thyroid Gland .....	193
Development of the Tongue .....	195

Development of the Face.....	197
Development of the Nasal Cavities.....	201
Development of the Palate.....	206
Summary.....	212
Clinically Oriented Problems.....	213
CHAPTER 11	
THE RESPIRATORY SYSTEM.....	216
Development of the Larynx.....	216
Development of the Trachea.....	218
Development of the Bronchi and the Lungs.....	219
Summary.....	223
Clinically Oriented Problems.....	224
CHAPTER 12	
THE DIGESTIVE SYSTEM.....	227
The Foregut.....	227
The Midgut.....	239
The Hindgut.....	248
Summary.....	250
Clinically Oriented Problems.....	252
CHAPTER 13	
THE UROGENITAL SYSTEM: The Urinary and Genital Systems.....	255
The Urinary System.....	256
The Genital System.....	271
Summary.....	293
Clinically Oriented Problems.....	295
CHAPTER 14	
THE CIRCULATORY SYSTEM: The Cardiovascular and Lymphatic Systems.....	298
The Cardiovascular System.....	298
Partitioning of the Atrioventricular Canal, the Atria, and the Ventricles.....	306
Congenital Malformations of the Heart and Great Vessels.....	319
The Lymphatic System.....	339
Summary.....	341
Clinically Oriented Problems.....	342
CHAPTER 15	
THE ARTICULAR AND SKELETAL SYSTEMS.....	344
Development of Bone and Cartilage.....	344
Development of Joints.....	347
The Axial Skeleton.....	348
The Appendicular Skeleton.....	356
Summary.....	358
Clinically Oriented Problems.....	359
CHAPTER 16	
THE MUSCULAR SYSTEM.....	361
Striated Skeletal Muscle.....	361
Smooth Muscle.....	363
Striated Cardiac Muscle.....	363
Congenital Malformations of Muscles.....	363
Summary.....	364
Clinically Oriented Problems.....	365

## CONTENTS

CHAPTER 17	
THE LIMBS .....	366
Limb Development .....	366
Limb Malformations.....	368
Summary.....	373
Clinically Oriented Problems .....	373
CHAPTER 18	
THE NERVOUS SYSTEM .....	375
The Central Nervous System.....	375
The Spinal Cord.....	375
The Brain.....	390
The Peripheral Nervous System.....	405
The Autonomic Nervous System.....	408
Summary.....	409
Clinically Oriented Problems .....	410
CHAPTER 19	
THE EYE AND THE EAR.....	413
The Eye.....	413
Congenital Malformations of the Eye .....	420
The Ear .....	424
Congenital Malformations of the Ear.....	428
Summary.....	429
Clinically Oriented Problems .....	430
CHAPTER 20	
THE INTEGUMENTARY SYSTEM: The Skin, the Cutaneous Appendages, and the Teeth .....	432
Skin .....	432
Hair .....	434
Glands of the Skin.....	435
Nails .....	436
Mammary Glands.....	436
Teeth.....	438
Summary.....	445
Clinically Oriented Problems .....	445
ANSWERS TO CLINICALLY ORIENTED PROBLEMS.....	447
INDEX.....	459