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# Fetal and Neonatal Physiology

FOURTH EDITION

**VOLUME 1**



# Fetal and Neonatal PHYSIOLOGY

FOURTH EDITION / VOLUME 1

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#### Library of Congress Cataloging-in-Publication Data

Fetal and neonatal physiology / [edited by] Richard A. Polin, William W. Fox, Steven H. Abman. — 4th ed.

p. ; cm.

Includes bibliographical references and index.

ISBN 978-1-4160-3479-7 (hardcover, 2 v. set : alk. paper) 1. Fetus—Physiology. 2. Newborn infants—Physiology. I. Polin, Richard A. (Richard Alan), 1945- II. Fox, William W., 1940- III. Abman, Steven H.

[DNLM: 1. Fetus—physiology. 2. Infant, Newborn—physiology. 3. Maternal-Fetal Exchange—physiology. WQ 210.5]

RG610.F46 2011

612.6'47—dc23

2011025820

*Acquisitions Editor:* Judith Fletcher

*Developmental Editor:* Melissa Dudlick

*Publishing Services Manager:* Anne Altepeter

*Senior Project Manager:* Beth Hayes

*Project Manager:* Louise King

*Designer:* Louis Forgione

Printed in United States of America

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

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# **Fetal and Neonatal PHYSIOLOGY**



Dedicated to

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Our spouses -

*Helene Polin, Laurie Kilpatrick, and Carolyn Abman*

Our children -

*Allison Polin Steinbrenner, Mitchell Polin, Jessica Moseley,  
and Gregory Polin*

*Will Fox, Jon Fox, James Fox, Lauren Fox, and James Hunt  
Ryan Abman, Lauren Abman, Mark Abman,  
and Megan Abman*

And our grandchildren -

*Lindsey Steinbrenner, Eli Steinbrenner, Willa Polin,  
Jasper Polin, and Casey Moseley*

*Sarah Fox, Jane Fox, Charles Fox, Nola Fox, and Colton Fox*

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**Zinc in the Fetus and Neonate**



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**Human Milk Composition and Function in the Infant**

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**Developmental Effects on Fetal Circulation**

**Richard Harding, PhD, DSc**

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**Physiologic Mechanisms of Normal and Altered Lung Growth Before and After Birth**

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**Pathophysiology of Hypoglycemia**

**Mary Catherine Harris, MD**

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**Cytokines and Inflammatory Response in the Fetus and Neonate**

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**Regulation of Lower Airway Function**

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**Fetal Requirements and Placental Transfer of Nitrogenous Compounds**

**William C. Heird, MD**

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**Protein and Amino Acid Metabolism and Requirements**

**Emilio Herrera, PhD**

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**Maternal-Fetal Transfer of Lipid Metabolites**

**Harry R. Hill, MD**

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**Host Defense Mechanisms Against Bacteria**

**A. Craig Hillemeier, MD**

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**Fetal and Neonatal Intestinal Motility**

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**Advances in Molecular Genetics: Developmental and Clinical Implications**

**Steven B. Hoath, MD**

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**Physiologic Development of the Skin**

**Stuart B. Hooper, PhD**

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**Physiologic Mechanisms of Normal and Altered Lung Growth Before and After Birth**

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**Pathophysiology of Acute Renal Failure in the Neonatal Period**

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**Calcium, Phosphorus, and Magnesium Transport Across the Placenta**

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**Vitamin K Metabolism in the Fetus and Neonate**

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**Pathophysiology of Respiratory Distress Syndrome and Surfactant Metabolism**

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**Intraventricular Hemorrhage in the Neonate**

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**Cardiomyopathies in Infants and Children**

**Alan H. Jobe, MD, PhD**

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**Antenatal Factors That Influence Postnatal Lung Development and Injury**

**Pathophysiology of Respiratory Distress Syndrome and Surfactant Metabolism**

**Surfactant Treatment**

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**Vitamin E Metabolism in the Fetus and Newborn Infant**

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**B-Cell Development****Michael V. Johnston, MD**

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**Development of Neurotransmitters****Richard B. Johnston, Jr., MD**

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**Host-Fungi Interactions Relevant to the Newborn Infant****Deborah P. Jones, MD**

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**Developmental Aspects of Organic Acid Transport****Peter Lloyd Jones, PhD**

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**The Extracellular Matrix in Development****Rebecca L. Jones, PhD**

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**Mechanisms of Transfer Across the Human Placenta****Pedro A. Jose, MD, PhD**

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**Postnatal Maturation of Renal Blood Flow****Satish C. Kalhan, MD, MBBS, FRCP, DCh**

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**Metabolism of Glucose and Methods of Investigation in the Fetus and Newborn****Suhas G. Kallapur, MD**

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**Antenatal Factors That Influence Postnatal Lung Development and Injury****Stanley Kaplan, PhD**

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**Bile Formation and Cholestasis****Saul J. Karpen, MD, PhD**

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**Bile Formation and Cholestasis****Sudha Kashyap, MD**

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**Lipids as an Energy Source for the Premature and Full-Term Neonate Protein and Amino Acid Metabolism and Requirements****Frederick J. Kaskel, MD, PhD**

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**Role of the Kidney in Calcium and Phosphorus Homeostasis****Lorraine E. Levitt Katz, MD**

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**Growth Factor Regulation of Fetal Growth****Susan E. Keeney, MD**

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**Immunology of Human Milk and Host Immunity****Omar S. Khwaja, MD, PhD**

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**Development of the Nervous System****Laurie E. Kilpatrick, PhD**

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**Cytokines and Inflammatory Response in the Fetus and Neonate****David Winston Kimberlin, MD**

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**Host Defense Mechanisms Against Viruses****John P. Kinsella, MD**

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**Physiology of Nitric Oxide in the Developing Lung****Jay K. Kolls, MD**

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**Pathophysiology of Acute Renal Failure in the Neonatal Period**

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**Maternal Drug Abuse: Effects on the Fetus and Neonate**

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**Maternal Drug Abuse: Effects on the Fetus and Neonate**

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**Zinc in the Fetus and Neonate**

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**Physiology of Congenital Heart Disease in the Neonate**

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**Role of the Kidney in Calcium and Phosphorus Homeostasis**

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**Fetal and Maternal Responses to Intrauterine Infection**

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**Hypothalamus: Neuroendometabolic Center**

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**Host Defense Mechanisms Against Bacteria**

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**Maternal-Fetal Transfer of Lipid Metabolites**

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**B-Cell Development**

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**Testicular Development and Descent**

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**Regulation of Embryogenesis**

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**Basic Genetic Principles**

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**Pathophysiology of Gastroesophageal Reflux**

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**Concentration and Dilution of the Urine**

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**Organogenesis and Histologic Development of the Liver**

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**Structure and Development of Skin and Cutaneous Appendages**

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**Development of the Renin-Angiotensin System**

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**Fetal and Neonatal Body Water Compartment Volumes With Reference to Growth and Development**

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**Growth Hormone and Prolactin**

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**Basic Pharmacokinetic Principles**

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**Developmental Granulocytopoiesis**

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**Development of the Blood-Brain Barrier**

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**Functional Development of Respiratory Muscles**

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**Integrins and Cell Adhesion Molecules**

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**Host-Fungi Interactions Relevant to the Newborn Infant T-Cell Development**

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**Fetal and Placental Circulation During Labor**

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**Regulation of Lower Airway Function**  
**Pathophysiology of Apnea of Prematurity**

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**General Concepts of Protein Metabolism**

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**Development of the Exocrine Pancreas**

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**Oxygen Transport and Delivery**

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**Physiology of Lactation**

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**Apoptotic Cell Death**

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**Development of Taste and Smell in the Neonate**

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**Pathophysiology of Apnea of Prematurity**

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**Retinal Development and the Pathophysiology of Retinopathy of Prematurity**

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**Developmental Hemostasis**

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**Bile Acid Metabolism During Development**

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**Mechanics of Breathing**

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**Lipoprotein Metabolism and Nutritional Programming in the Fetus and Neonate**

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**Digestive-Absorption Functions in Fetuses, Infants, and Children**

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**Calcium, Phosphorus, and Magnesium Transport Across the Placenta**

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**Role of the Kidney in Calcium and Phosphorus Homeostasis**

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**Development of the Gastrointestinal Circulation in the Fetus and Newborn**

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**Regulation of Umbilical Blood Flow**

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**Developmental Aspects of Pain**

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**Neonatal Calcium, Phosphorus, and Magnesium Homeostasis**

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**Luteinizing Hormone and Follicle-Stimulating Hormone Secretion in the Fetus and Newborn**

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**Physicochemical and Structural Properties Regulating Placental Drug Transfer**

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**Brown Adipose Tissue: Development and Function**

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**Digestive-Absorption Functions in Fetuses, Infants, and Children**

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**Physiology of Lactation**

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**Homeobox Genes**

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**Developmental Basis of Congenital Limb Differences**

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**Genetics and Physiology of Surfactant Protein Deficiencies**

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**Pathophysiology of Shock in the Fetus and Neonate**

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**Functional Development of the Kidney in Utero**

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**T-Cell Development**

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**Carbohydrate Metabolism During Pregnancy**

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**Developmental Erythropoiesis**

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**Gastrointestinal Motility**

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**Developmental Pharmacology of Adrenergic Agents**

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**Luteinizing Hormone and Follicle-Stimulating Hormone Secretion in the Fetus and Newborn**

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**Metabolism of Glucose and Methods of Investigation in the Fetus and Newborn**

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**Neonatal Neutrophil Normal and Abnormal Physiology**

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**Nutritional Assessment****Jeffrey M. Perlman, MD, MB, ChB**

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**Cerebral Blood Flow in Premature Infants: Regulation, Measurement, and Pathophysiology of Intraventricular Hemorrhage****Anthony F. Philipps, MD, FAAP**

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**Oxygen Consumption and General Carbohydrate Metabolism of the Fetus****Arthur S. Pickoff, MD**

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**Developmental Electrophysiology in the Fetus and Neonate****Grisha Pirianov, PhD**

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**Apoptotic Cell Death****David Pleasure, MD**

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**Trophic Factor and Nutritional and Hormonal Regulation of Brain Development****Jeanette Pleasure, MD**

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**Trophic Factor and Nutritional and Hormonal Regulation of Brain Development****Sabine Luise Plonait, MD**

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**Physicochemical and Structural Properties Regulating Placental Drug Transfer****Daniel H. Polk, MD**

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**Development of the Nervous System****Fred Possmayer, MD**

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**Physicochemical Aspects of Pulmonary Surfactant****Martin Post, PhD**

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**Molecular Mechanisms of Lung Development and Lung Branching Morphogenesis****Brandon S. Poterjoy, DO**

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**Calcium-Regulating Hormones****Lawrence S. (Lance) Prince, MD, PhD**

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**The Extracellular Matrix in Development****Guy Putet, MD**

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**Lipids as an Energy Source for the Premature and Full-Term Neonate****Theodore J. Pysher, MD**

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**Impaired Lung Growth After Injury in Premature Lung****Marlene Rabinovitch, MD**

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**Developmental Biology of the Pulmonary Vasculature****Scott H. Randell, PhD**

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**Structure of Alveolar Epithelial Cells and the Surface Layer During Development****Timothy Robert Hume Regnault, PhD**

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**Angiogenesis****Fetal Requirements and Placental Transfer of Nitrogenous Compounds****Jann Rhodes, PhD**

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**Drug Excretion During Breast Feeding**



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**Control of Breathing in Fetal Life and Onset and Control of Breathing  
in the Neonate**

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**Pathophysiology of Neural Tube Defects**

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**Fetal and Maternal Responses to Intrauterine Infection**

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**Regulation of Surfactant-Associated Phospholipid Synthesis  
and Secretion**

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**Development of the Corticotropin-Releasing Hormone–Corticotropin  
System in the Mammalian Fetus**

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**Regulation of the Placental Circulation**

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**Organogenesis of the Gastrointestinal Tract**

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**Gastrointestinal Motility**

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**Molecular Mechanisms of Lung Development and Lung Branching  
Morphogenesis**

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**Mechanisms of Bilirubin-Induced Brain Injury**

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**Temperature Control in Newborn Infants**

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**Ontogenesis of Striated Muscle**

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**Potassium Homeostasis in the Fetus and Neonate**

**Ola Didrik Saugstad, MD, PhD**

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**Physiology of Resuscitation**

**Kurt R. Schibler, MD**

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Children's Hospital Medical Center, Cincinnati, Ohio

**Developmental Biology of the Hematopoietic Growth Factors  
Mononuclear Phagocyte System**

**Frank C. Schmalstieg, MD**

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Immunology Diagnostic Laboratory, University of Texas Medical  
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**Immunology of Human Milk and Host Immunity**

**Karl Schulze, MD**

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New York, New York, New York

**Temperature Control in Newborn Infants**

**Jeffrey Schwartz, MD**

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**Development of the Corticotropin-Releasing Hormone–Corticotropin  
System in the Mammalian Fetus**

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**Physics and Physiology of Human Neonatal Incubation**

**Jeffrey L. Segar, MD**

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Pediatrics, University of Iowa Carver College of Medicine, Iowa  
City, Iowa

**Neural Regulation of Blood Pressure During Fetal and Newborn Life**

**Istvan Seri, MD, PhD, HonD**

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of Southern California; Director, Center for Fetal and Neonatal  
Medicine, Head, USC Division of Neonatal Medicine, Children's  
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**Pathophysiology of Shock in the Fetus and Neonate**

**Regulation of Acid-Base Balance in the Fetus and Neonate**

**Thomas H. Shaffer, MD, MSE, PhD**

Director, Respiratory Physiology Section, Department of  
Physiology, Temple University School of Medicine, Philadelphia,  
Pennsylvania

**Upper Airway Structure: Function, Regulation, and Development  
Liquid Ventilation**