istry of these reactive forms of oxygen and their roles in signaling before placing them into signaling networks by describing their interactions with plant hormone signaling pathways. The chapter stands out for its logical organization and the general clarity of the exposition.

Plants play host to a number of welcome and most definitely unwelcome visitors, and the signaling processes governing these biotic interactions are reviewed in the final chapters. The symbiotic interactions of plants with rhizobia and ectomycorrhizal fungi are covered in two very readable sections from Mirabella et al. and Martin et al.

As for unwanted pathogenic relationships, Whitham and Dinesh-Kumar give a good account of the sort of bare-faced cunning with which viruses cheat their way through life, including the hijacking of the plant's DNA replication machinery and suppression of host defense mechanisms such as posttranscriptional gene silencing. Their coverage of R gene-mediated defense inevitably overlaps with that found in Ham and Bent's thorough review of defense signaling in plant/bacterial and fungal interactions. The final chapter on plant-insect interactions complements an earlier section on wound and mechanical signaling.

Throughout the book, the opportunity and almost inevitability of crosstalk becomes increasingly apparent in the number of signaling agents common to the signal transduction pathways described. Among a (nonexhaustive) list of the usual suspects including abscisic acid, ethylene, auxin, jasmonic acid, salicylic acid, reactive oxygen, and MAP kinase cascades, the second messenger calcium is preeminent. This single, simple ion is implicated in the diverse signaling events resulting from heat, cold, drought, and salt stress, wounding and pathogen defense, and nodulation. One is left wondering how the integrity of the signals is maintained. Where is the specificity? This, of course, is the major question of contemporary calcium biology. There are several possible answers involving specific differences in the source and subcellular "sink" for the Ca^{2+} signal, spatial and temporal differences in the occurrence of Ca^{2+} binding proteins and the output signals they propagate, and the concept of specific Ca^{2+} oscillations, conveying their message like a monotonous birdsong, in changing iteration (for a full discussion, see Sanders et al., Plant Cell, *14*, supplement S401-S417, 2002). Although some of these issues are touched upon in the chapters and it would not particularly fit the structure of the book, I would nevertheless have welcomed a section devoted to calcium signaling to help soothe away the angst relating to the specificity question.

The swift and relentless progress of research means that books such as this can age rapidly. To maintain their value against a barrage of up-to-date reviews appearing in periodical journals, such books must focus on the organization of the material and the clarity with which the fundamental principles are discussed. Here, as with many edited collections, the style and depth of coverage varies, although most of the chapters are indeed well written. As a whole, the text seems to be slightly underillustrated and, to keep costs down no doubt, there are only a few color figures, which are buried together on four pages in the center of the book. This reduces its accessibility somewhat but then this is clearly not a volume aimed at undergraduates but rather at graduate and professional scientists in or around the subject area. As such, it stands as a solid reference in a quite specific field of research that is otherwise unaddressed by current texts.

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Blood Vessels under Construction

Assembly of the Vasculature and Its Regulation
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Our understanding of how blood vessels form and what regulates this has undergone exciting growth in recent years—what was a relatively sleepy corner of the scientific world ten or fifteen years ago is now a major academic and biotech research priority. A major impetus for this remarkable transformation has been a new appreciation for the clinical importance of controlling blood vessel growth. The seemingly farfetched idea that tumors might be held in check or even eliminated by pharmacologic treatments aimed at inhibiting the blood vessels that supply them now stands as one of the most attractive potential approaches for the treatment of cancer, while therapies for stimulating new blood vessel growth show promise as effective treatments for limb or cardiac ischemia. If clinical applications have been the engine driving recent advances in vascular biology, it could be argued that in vivo studies of developing blood vessels have provided much of the fuel.

Interest in the vasculature is certainly not new, with recorded descriptions of human vascular anatomy dating back at least to the Greek anatomists Praxagoras and Herophilus in the third century BC. William Harvey established the modern functional definition of the circulatory system in the 17th century, describing how arteries and veins carry blood away from and towards the heart in a continuous circulation. In the early 20th century, pioneering vascular embryologists such as Florence Sabin used careful examination of developing blood vessels to prepare detailed anatomical descriptions of formation of the earliest blood vessels in a variety of different mammalian and nonmammalian species. These mainly descriptive studies by classical and more recent authors established important basic concepts regarding the morphology, origins, and growth of blood vessels. Blood vessels are composed of an inner epithelial endothelium (tunica intima) lining the vessel lumen, surrounded by an internal elastic tissue layer, a smooth muscle cellular layer (tunica media), an external elastic tissue layer, and fibrous connective tissue layer (tunica adventitia). Vascular endothelial cells (VEC) and most vascular smooth muscle cells (VSMC) are mesodermal derivatives, although their precise origins are still in many cases unclear. VEC assemble first, then recruit supporting periendothelial (pericyte) or VSMC. Pericytes and VSMC help to stabilize and "mature" nascent vessels. Although blood vessels form in a variety of different ways during development, a useful distinction has been made between vessels that form by vasculogenesis (the de novo aggregation of migratory angioblasts [endothelial progenitor cells] to form cellular cords and then tubes) and angiogenesis, the emergence of new vessels by sprouting and elongation from or remodeling of preexisting vessels. Vasculogenesis predominates early in development and is responsible for initial assembly of vessels in the mammalian and avian yolk sac and for formation of major intraembryonic blood vessels such as the dorsal aorta and cardinal veins. In most species, these early vasculogenic vessels undergo further angiogenic remodeling, and many additional vessels form throughout the animal as development proceeds, mostly by developmental angiogenesis. Blood vessel growth continues throughout postnatal life in both normal contexts (postnatal growth and development, diet- or exercise-related increases in fat and muscle mass, uterine cycling) and pathological contexts (wound healing, cancer).

Recently, interest in factors that might positively or negatively influence blood vessel growth and the application of molecular methods to vascular biology have led to the discovery of many new genes involved in blood vessel growth and assembly. Key players include the vascular endothelial growth factor (vegf)-vegf receptor (vegfR) and angiopoietin (ang)-Tie receptor families of extracellular ligands and their corresponding endothelial receptor tyrosine kinases. Vegf signaling is critical for survival, proliferation, migration, and arterial differentiation of endothelial cells, while angiopoietin signaling through the Tie2 receptor is important for endothelial-smooth muscle interactions and vessel remodeling, maturation, and stability. Developmental studies have played a central role in helping uncover the functions of these and other genes essential for proper blood vessel formation. Targeted disruption and overexpression experiments in mice have provided definitive assays for the in vivo functions of vascular genes during development. In most cases, these genes have been shown to play analogous functional roles in pathologic or nonpathologic neoangiogenesis in adults. Studies in developing avians, *Xenopus,* and zebrafish have also provided important new insights into vessel specification, differentiation, and assembly during early development. What we have learned has reinforced the idea that blood vessels in vivo are highly heterogeneous and that their formation and stability is highly dependent on proper cell-cell and cell-matrix interactions, factors that can be difficult to reproduce in vitro.

Given the importance of developmental studies for our emerging understanding of blood vessel formation and its regulation, it might be surprising to learn that there that there are very few books devoted to this subject, particularly recent books that incorporate the latest molecular insights. *Assembly of the Vasculature and Its Regulation*, the newest contribution to the series *Cardiovascular Molecular Morphogenesis,* attempts to fill this gap. The book consists of 11 chapters, each written by a different set of authors, in many cases leaders in their subject matter. Although it has many of the deficiencies found in other multiauthor edited texts, including lack of strong organizing focus, partial redundancy, and inconsistency in chapter format, scope, and readability, the book does provide a reasonably broad survey of our current understanding of vascular development. Aficionados of the vasculature will find this book useful as a fairly inclusive compendium of the recent literature in vascular development. Others, however, may find this book a difficult read. A large amount of very descriptive detail is provided regarding vessel formation in general and in specific vascular beds, but this detail is not always presented concisely or with sufficient critical synthesis. More liberal use of illustrations and diagrams illuminating salient points in the text might have helped in bringing additional clarity to all of this detail. In contrast to the extensive descriptive detail, there is much less discussion of clearly delineated molecular pathways or well-defined molecular interactions and their functional consequences for blood vessel assembly. There are also some noteworthy omissions from this book, including lymphatic vessel formation, retinal vascular development, arterial-venous fate determination, and studies of vascular development in amphibians and fish.

The first six chapters provide a reasonably up-to-date overview of genes and mechanisms underlying vessel formation, with more detailed discussion appropriately reserved for those genes of greatest interest and about which the most is now known. This half of the book is the most accessible and useful to the average reader. Chapter One, "The development of blood vessels: cellular and molecular mechanisms," surveys genes implicated in vascular development, mainly those for which targeted disruption experiments have been performed in mice, briefly indicating the known or suspected functional roles of each. The extensive breadth of this chapter makes it most useful as an introduction and a jumping-off point for further detailed exploration of the scientific literature. Chapters Two and Three provide more in-depth discussion of the roles of vegf/vegfR and angiopoietin/Tie signaling, respectively. Both chapters are clearly written and provide useful introductions to these key players, although they are not especially critical in their analysis of the literature, and Chapter Three digresses somewhat into discussion of the role of angiopoietins during tumor angiogenesis (a topic covered well elsewhere). Chapter Two lacks exciting new information that has only very recently emerged regarding the role of vegf signaling in arterial fate determination and arterial patterning. Chapters Four, Five, and Six survey the roles of extracellular matrix and adhesion receptors in blood vessels and the development and differentiation of vascular smooth muscle. Chapter Four, "Extracellular matrix in the regulation of angiogenesis," is comprehensive in scope but somewhat unsatisfying in providing a clear picture of ECM-vascular functional interaction. This reflects, at least in part, the relatively ubiquitous interactions between ECM and all cells and the difficulty in uncovering vascular-specific functions in vivo. Chapter Five, "The role of cell adhesion receptors in vascular development," is succinctly written and walks the reader through the major players, VE-cadherin, N-cadherin, PECAM, and integrins, providing a useful literature overview and critical discussion for each. Chapter Six, "Development and differentiation of vascular smooth muscle," is another well-organized and clearly written chapter with useful critical syntheses of the literature on the origins of VSMC (still relatively obscure), VEC-

VSMC signaling, tunica media formation, and VSMC differentiation. The remaining five chapters of the book provide details on the formation of blood vessels in selected vascular beds, including the heart, nervous system, kidney, lung, and placenta. This half of the book will be of interest primarily to specialists in the formation of blood vessels in these particular organs. The chapters include extensive descriptions of the anatomy, cellular origins, and assembly of the blood vessels of each organ. Most of the chapters also discuss factors that might regulate formation of these vessels, although delineation of clear functional pathways and mechanisms is generally lacking. There is also substantial redundancy between information on molecular mechanisms provided in this portion of the book and the first half of the book.

Despite its flaws, this book is probably the best option available for those interested in an up-to-date reference on vascular development. Furthermore, the descriptive emphasis of this book and dearth of well-developed molecular mechanisms largely reflects our current ignorance. Although hundreds of new genes with important functions in the vasculature have been identified, our understanding of how these genes work together to orchestrate the assembly of the vertebrate vasculature is still fairly superficial. *Assembly of the Vasculature and Its Regulation* sets the stage for advances yet to come, giving us a lengthy molecular cast of characters and a broad sampling of anatomical settings. With the continued rapid progress in this field, it is to be expected that five or ten years from now we will be reading about a book that finally unravels and synthesizes the complex molecular mechanisms regulating vascular assembly and patterning during development.

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A Mutable Tribe

Molecular Biology of Fungal Development
Edited by Heinz D. Osiewacz
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608 pp. $195.00

Biologists have studied the fungi for hundreds of years, but a coherent view of the field has been achieved only recently. In earlier days, pockets of mycological interest could be found in herbaria, departments of botany, microbiology, biochemistry, plant pathology, and a host of industries that enriched our diets and kept us well. This implies a huge diversity of biological interests and of the fungi themselves. Unity began to prevail in the field in the early days of biochemical genetics, when Dodge, Beadle, Tatum, Pontecorvo, Lindegren, Winge, Roman, and Ephrussi demonstrated the benefits of these simple organisms as model systems for the study of the transmission, structure, and function of genes.

An early ambition of geneticists using filamentous fungi lay in using them, with the visible morphology of their mycelium, asexual dispersal systems, and fruiting bodies, for studies of development. J.T. Bonner and his students used the slime mold *Dictyostelium dicoideum* to explore the aggregation of free-living amoebal cells into multicellular slugs and fruiting structures. A good deal was learned of extracellular signaling among the amoebae and the differentiation of cells within the slug, the stalk, and the sporangium that later formed. But the system was not amenable to facile genetic analysis, and the organism has even been cast out of the company of true fungi. But Beadle and Tatum, in their work on *Neurospora*, demonstrated how biochemical pathways of simple organisms could be dissected genetically. Others, including Tatum himself, hoped to demonstrate that developmental sequences were only slightly more complicated. They were frustrated by the old difficulty of tracing causal links between gene and phenotype. Most of the early workers disentangled themselves from the web of cause and effect and went on to simpler and more productive lives.

In the 1970s, the genetic analysis of the cell cycle and mating system of *S. cerevisiae* became new inspirations and models for students of development, regulation, and cell recognition in filamentous fungi. They have found, to their chagrin, that the unicellular budding yeast has continued to reveal more about the molecular biology of fungal development than frontal attacks on the filamentous fungi themselves. *Molecular Biology of Fungal Development* demonstrates this by showcasing *S. cerevisiae* as a model for (pseudo)hyphal growth. Nevertheless, recent progress in the understanding of fungal development, summarized in this volume, demonstrates the coalescence of mycological traditions, the impact of the techniques and language of molecular biology, and the use of model organisms in the analysis of complex problems.

This collection of reviews begins with 11 general biological chapters, each dealing for the most part with a major developmental problem studied in one or a few organisms. The chapters include analyses of pseudohyphal growth in *Saccharomyces cerevisiae*, conidiation in *Aspergillus nidulans*, senescence in *Podospora anserina*, vegetative development in *Coprinus cenereus*, and separate chapters on blue light responses and circadian rhythms in *Neurospora crassa*. Chapters discussing more than one key species include those on sexual development in Ascomycetes, sexual development in Basidiomycetes, vegetative incompatibility, models of hyphal growth, and spore-killers. These chapters are almost without exception excellent reviews of the developmental features of fungi, most of which have model-system status suitable for generalizations to less well-known species.

Two chapters of this first set illustrate the different traditions by which hyphal growth has been and continues to be analyzed. The chapter by H.-U. Mösch on pseudohyphal growth of budding yeast (in which chains of cells remain fully septate, as opposed to true, cytoplasmically connected hyphal cells) reviews the sensors and the signaling cascades required for this life-style. Many of these elements had turned up in other genetic studies, and it had become clear that small and heterotrimeric G proteins, the several MAP kinase cascades, and the cAMP-protein kinase A system were used in