Tube morphogenesis

Mark A. Krasnow and W. James Nelson

Epithelial and endothelial tubes are the fundamental structural unit of organ design: most internal organs, including the vascular system, lungs, kidneys, gastro-intestinal tract and urinary-genital tract, are composed of single, or networks of, tubes that transport gases or liquids. In many cases, these tubes provide a barrier that separates different biological compartments (often the 'outside' from 'inside' of the organism) and regulate ionic homeostasis by vectorial transport of ions and solutes across the barrier from one compartment to the other. In addition, the sizes and shapes of tubes are precisely specified during development and modulated by physiology to generate tubular networks with the desired flow properties.

While there has been much progress in the past decade on many aspects of epithelial and endothelial cell biology, we still understand very little about how these tubes form, how their sizes and shapes are regulated and how, once formed, these tubular structures are maintained.

The medical importance of answering these questions is highlighted by diseases such as polycystic kidney disease, aneurysms and vaso-inclusive diseases and congenital blood malformation syndromes, where tube formation and maintenance go awry.

Recently, there has been progress in addressing some of these questions in a number of systems using a variety of experimental approaches. These approaches range from: basic cell-biological studies of tubulogenesis *in vitro* with cultured cells to *in vivo* imaging of organ development using microscopy. Genetic analyses of tube formation and maintenance in model organisms such as *Caenorhabditis elegans*, *Drosophila*, zebrafish and mouse has also been important, as has identification of genes that, when mutated, cause human tubulogenesis disorders and understanding their mechanism of action.

Because progress is coming from different directions, there is a need to bring together experts in each of these areas to foster interactions and cross-fertilization of ideas, and to see whether any general principles of tubulogenesis are emerging.

Over the coming months, *Trends in Cell Biology* will be featuring a series of reviews on different topics of tubulogenesis (Box 1), with the goal of highlighting different ideas, model systems and experimental approaches to the regulation of epithelial and endothelial tubulogenesis. We hope that the compilation of these articles will convey to a broader audience the synergy between different approaches and experimental systems, and emerging concepts of how biological tubes form, organize and function.

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Box 1. Forthcoming 'Tube morphogenesis' series in *TCB*

The tubulogenesis series begins on p. 390 with a review from Greg Dressler on tubulogenesis in the developing mammalian kidney. Other reviews planned for the series:

***In vitro* studies of epithelial polarity and tubulogenesis**
Keith Mostov

Tubulogenesis in *Drosophila* and mammalian kidney development
Helen Skaer

Constructing an organ: the *Drosophila* salivary gland as a basic model for tube formation
Elliott Abrams, Melissa Vining and Deborah Andrews

Branching morphogenesis in the lung
Andy McMahon and Pao-Tien Chuang

Control of pathfinding and tube growth in the developing *Drosophila* airways
Christos Samakovlis

Imaging blood vessel formation in the developing zebrafish
Brant Weinstein

Tubes and the *C. elegans* excretory cell
Matthew Buechner

Epithelial patterning and function in the zebrafish pronephric kidney
Iain Drummond

Role of polycystic kidney disease protein in establishing and maintaining tubular structure
Alessandra Boletta and Greg Germino

Vascular development and disease
Dean Li

Epimorphin and mammary gland tubulogenesis
Derek Radisky and Mina Bissell

Induction of vascular networks in adult organs
Yuval Dor, Rinnat Porat and Eli Keshet

How to make tubes: signaling by the c-Met receptor tyrosine kinase
Walter Birchmeier and Marta Rosario

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