In a different vein

Old explanations accumulate their own inertia. It's easy to keep tweaking a familiar and trusted theory, seeking the elusive technical trick that will wrap up its loose ends, rather than making the painful and disorienting break for some really new idea. This is roughly the essence of Thomas Kuhn's rightly celebrated view of the nature of scientific revolutions.

But revolutions needn't only concern fundamental matters with earth-shaking repercussions. Kuhn could have illustrated his point with almost anything: for example, the science of plant leaves and their structure.

The networks of veins in leaves share universal features that demand explanation. All leaves have a hierarchy in their vein structure, with veins branching in a regular way down to smaller scales. Venation networks in all leaves also have a preponderance of vein channels that form complete circuits, and divide a leaf into a patchwork of larger and smaller polygons. Only the tiniest veins have exposed ends.

No theory has ever explained both of these facts successfully. The most widely accepted current 'explanation' of vein structure focuses on the role of the growth hormone, auxin, which is synthesized in growing leaves. Studies find a net flow of auxin towards the base of the leaf, from where it flows out to the rest of the plant. Genetic mutations that influence auxin production also strongly influence the vein pattern, suggesting that auxin transport really is at the heart of the story.

Still, models based on this transport picture — of the co-evolution of auxin flow and network structure, with new veins growing where flow is high — don't give a complete explanation. The resulting networks look fairly realistic, yet conspicuously lack any closed loops.

Hence the suspicion of some researchers that auxin isn't the whole story. In this regard, Yves Couder and colleagues pointed several years ago to a seemingly bizarre similarity between the vein patterns in leaves and the patterns of cracks left over when a slurry dries on a substrate. These patterns occur when one surface shrinks on top of another, leading to a characteristic pattern of stresses that produce the cracks.

This idea enters vein network science from left field, but may in fact be highly relevant. Other researchers

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now point out (M. F. Laguna *et al.* http://arxiv.org/abs/0705.0902) that a growing leaf has two epidermal layers separated by a softer tissue called mesophyll. In general, the mesophyll tends to grow faster than the epidermis, creating stresses. Cursory evidence from biological samples suggests that the cell differentiation leading to veins within leaves gets initiated at points of high stress between surfaces. A simplified model of the process shows that it reproduces the statistics of the leaf patterns quite accurately.

This model, too, is incomplete, but may go together with the traditional auxin-based story to produce something much closer to a real explanation, the result of an almost accidental observation of similar patterns in two totally different settings.

A friend of mine once puzzled me by saying that he found a certain research paper uninteresting because "we already have an explanation for that". But science isn't only about explaining what hasn't yet been explained; it's also about exposing old and largely accepted explanations, or partial explanations, to invigorating new challenges.

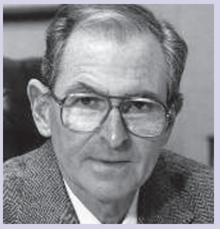
Mark Buchanan

Fair trial by one's peers?

The time has come for us to take a serious look at the institution of peer review. It is not a good way to catch misconduct or outright fraud in science, because the reviewer quite naturally accepts the account of how and why the research was done. But detecting fraud is not the purpose of peer review.

Peer review is instead a good way to identify valid science. Of course, a referee may occasionally fail to appreciate a truly visionary or revolutionary idea, but, by and large, peer review works pretty well as long as scientific validity is the issue at stake. However, it is not at all suited to arbitrating an intense competition for research funds or for editorial space in prestigious journals. There are many reasons for this, not the least being the fact that the referees have an obvious conflict of interest: they are themselves competitors for the same resources.

This point seems to be another of those relativistic anomalies, obvious to any outside observer but invisible to those of us who are falling into the black hole. It would take impossibly high ethical standards for referees to avoid taking advantage of their privileged anonymity to advance their own interests. As time goes on, more and more referees risk having their standards eroded because they themselves, as authors, have been victimized by unfair reviews.



The problem is how to replace peer review and with what.

Peer review is thus one example among many of practices that were well suited to the period, lasting until the early 1970s, when science was undergoing exponential expansion. But that time is gone forever, and the system of peer review will become increasingly dysfunctional in the difficult future we face.

The problem is how to replace peer review and with what. As long as journal editors and contract monitors find it a convenient way of making hard choices, I fear that peer review will continue to hold its exalted place in our system of science.

David Goodstein