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The Seville synthesis: Unifying disciplines to tackle global challenges

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The recent Science Across Boundaries Symposium highlighted the idea that science's future lies in crossing disciplinary boundaries. Complex challenges such as sustainability, AI, and health demand integrated, systems-level approaches rather than isolated specialization. Success requires resilient collaboration, human-AI co-intelligence, and boundary-crossing leadership to navigate increasing complexity.

Seville is a city that understands mixture. Its beauty is not the beauty of purity, but of layered inheritance: Roman foundations, Islamic geometry, Catholic stone, Mediterranean light. It was, in that sense, an almost unnervingly apt place to think about the future of science.

Over three days in March 2026, beneath the formalities of panels and plenaries and with an auspicious ambition to honor the scholarly impact and global

Figure 1. Participants in the International Symposium in front of the Royal Tobacco Factory building of the University of Seville

leadership of Prof. Subra Suresh,[1] a larger idea came into focus (Figure 1). The next era of discovery will not be decided inside disciplines. It will be decided by how well we navigate across the seams, in any direction, as needed.

The problems now commanding scientific ambition—climate, sustainable materials, human health, artificial intelligence (AI), energy, and resilience—refuse to stay in departmental boxes. They are not chemistry problems or biology problems or mechanics problems. They are systems problems: entangled, multi-scale, and indifferent to the borders that academic communities draw around knowledge.

For centuries, the model of science was specialization. Focus deeper, master the niche, purify the question. That model produced astonishing results. It also produced an institutional architecture that mistakes disciplinary thinking for reality. Climate is tangled with materials, materials with mining, mining with politics, politics with behavior, behavior with culture, culture with technology. The physical world does not respect our disciplines. It transcends them.

Nowhere was this clearer than in the conversation about sustainability. For generations, materials science pursued purity: cleaner alloys, perfect crystals, and ideal structures. But sustainability arrives with radically different demands. Recycled feedstocks are heavily contaminated. Supply chains are complex and fragile. Waste does not vanish because our models prefer elegance. The question now is how to build high-performance systems from feedstocks that are mixed, scarred, and reused—irreversibly altered by history. Even recycling cannot close the loop.

The shift is from circularity to spirality—materials designed for graded repurposing across multiple lives. This is more than a technical challenge. It is a philosophical shift. Resilience, not refinement, becomes the goal. Performance under real-world conditions, not perfection under ideal ones, becomes the measure.

AI, too, appeared in a new light: not as a machine for replacing scientists, but as co-intelligence—humans and machines thinking together. AI is moving from pattern recognition to hypothesis generation, from passive prediction to active collaboration. In quantum optics, AI has proposed experimental configurations that experts had never considered. In materials science, AI systems orchestrate teams of AI agents to discover new structures from remarkably small datasets.

The most compelling vision is the opposite of black-box mysticism: it is AI tethered to physics, constrained by real-world principles, extending human intuition rather than replacing it, and complementing human thinking with scalability. Yet even here, boundaries press back. The energy demands of large-scale AI—measured in megawatts, while the human brain runs on roughly twenty watts—pose their own sustainability questions. Co-intelligence must reckon with its own costs. Efficiency can be learned from one another.

And then there was human health, revealing perhaps the most consequential frontier of all. Biology is increasingly understood as a system shaped by forces, environments, and constraints that extend far beyond genetics. Cells do not exist in isolation; they are embedded in tissues that stiffen, age, and reorganize. Tumors are not merely genetic anomalies; they are systems evolving under mechanical pressure. Even fertility reflects changes in the physical environment of the body itself.

To understand health, one must move across scales—from molecules to cells to tissues to organisms—and across disciplines, from engineering to medicine to data science. The body is the quintessential coupled system. And like all systems, it cannot be understood in fragments.

We have intelligence. We have tools. We have intention. So why does progress stall? The bottleneck is coordination. Our institutions—universities, funding systems, regulatory regimes, and even our professional identities—remain built for a world in which problems could be carved apart and solved in parallel. The next generation of scientists will need to be trained differently: not merely deep in a discipline, but fluent across several— comfortable with ambiguity, equipped to work at the boundaries that the hardest problems span, yet able to delve deep into one discipline when needed.

What is required now is a different kind of leadership: less territorial, less possessive, more architectural. Leadership that builds conditions in which ideas move, disciplines mix, and true collaboration, which is greater than the sum of its parts, becomes ordinary rather than heroic. It is no accident that the symposium honored Prof. Suresh,[1] whose career moved across materials, biology, medicine, AI, and the leadership of institutions themselves.

What came into view in Seville was the emergence of a new scientific ideal: rigor and expertise without insulation, ambition large enough to cross scales and fields, and enough humility to collaborate. The age of isolated brilliance is not over, but it is no longer sufficient. The frontier has moved outward, into the turbulent space between fields, where translation is hard, ownership is blurred, and the most consequential work often looks, at first, like trespassing.

E.O. Wilson's consilience was a philosopher's dream: unity through shared foundations. The Seville synthesis was a scientist-engineer's answer: integration through shared work. Science is moving from the study of isolated things to the design of connected systems: from theory to integration, from disciplinary sovereignty to intellectual traffic.

And crossing boundaries, it became clear, is not a matter of occasional visits to neighboring fields.[2] It means entering the flows—the continuous circulation of ideas, methods, data, and people moving between disciplines. The boundary-crosser does not simply step across a line but enters a current.

Seville's truest tribute to Subra Suresh was not ceremonial but diagnostic. The boundary-crosser is no longer a romantic outlier. They are the prototype for science's future.

AUTHOR CONTRIBUTIONS

All authors contributed to discussions at the symposium and to shaping the ideas presented in this Matter of Opinion article. C.E.A. led the writing of the manuscript.

DECLARATION OF INTERESTS

The authors declare no competing interests.

REFERENCES

1. Wikipedia contributors. Subra Suresh. https://en.wikipedia.org/wiki/Subra_Suresh
2. Zierler, D. (ed.), Crossing Boundaries: Subra Suresh's Life Journey.