…in search of the internal logic of complex systems—from fast-evolving viruses to exploiting quantum effects for physical sensing and time-keeping…

My name is Jim Gimlett. As a kid, I loved math and physics, things that had a clear internal logic to them. I wound up going to Caltech, back in the days when Richard Feynman was a towering figure on campus. I loved the way Feynman looked at the world, trying to see to the heart of something, the internal logic.

As a DARPA program manager, I now have programs in quantum optical clocks and sensors, transductional materials, chronobiology, and a new approach to combatting fast-evolving viruses. If it seems like I don't stay in any one swim lane, it's true. However, there is a common theme that runs through all of these programs. They're all examples of high-dimensional, complex dynamic systems that are multiscale in both space and time. While we may know the physics in one scale, our models can't span across scales to predict behavior at another. I'm searching for the internal logic beneath all the complexity.

One thing I've been thinking about recently is whether we are leaving anything on the table regarding learning from data, letting the data tell their own story. Deep learning has shown remarkable results in finding patterns from data. However, these approaches have been disappointing in generating predictive models. I haven't seen a rigorous attempt at fusing both model-driven and data-driven approaches to get the best of both worlds. Are we missing something important, a better understanding, a better learning methodology, to take full advantage of everything we know about the system?

Feynman always asked questions at multiple levels, starting with the meta-meta question, "Are we asking the right question?" He'd say you were more than halfway to the answer if you could ask the right question. In the case of complex systems, I think we're not asking bad questions but are there other questions we might also be asking? Here are some examples of questions I never hear: For example, "What's the complexity or the sparsity of the system?"; "How much data is sufficient to fully characterize it?"; "Can we quantify how stable the system is, how close are we to a tipping point?"; "Can I rebalance the system even if I don't have a predictive model?"

Like all DARPA PMs (program managers), I'm looking for new, out-of-the-box ideas with transformative impact. Why can't I stay within a single domain? I can't really tell you, except perhaps I'm still looking for a general purpose key that can unlock the internal logic for many classes of complex systems. That key could come from anywhere. The key to unlocking engineered materials might come from biology, for example, or the key to unlocking biology may come from physics or topological math. The more domains I engage in, the more the hidden connections may become apparent. At least, that's my hope. Thanks for listening. Perhaps within your own domains you'll find the skeleton key that unlocks many of these doors!

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