

Crutchfield, Ditto & Sinha (2010): “Intrinsic and Designed Computation: Information Processing in Dynamical Systems—Beyond the Digital Hegemony.” ([pubs.aip.org](https://pubs.aip.org))

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## 1. Motivation & Scope

The paper asks: how do **dynamical (nonlinear, often analog) systems** store and compute information—particularly as Moore's Law slows and we explore alternatives to digital CMOS? This intersects with foundational ideas in dynamical systems, probability, logic, communications, and computing.

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## 2. Defining Two Computational Modes

- **Intrinsic computation:** How a system naturally processes and stores information through its own dynamics—without external control.
- **Designed computation:** Engineered information processing, where computation is imposed via external inputs or configuration.

The distinction emphasizes that natural systems compute in their own, often unexpected ways.

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## 3. Focus Issue Contributions

The paper introduces a curated collection of studies exploring:

- **Reservoir and dynamical computing** in systems like optical or spin networks.
  - **Synchronization and control**—how observers can tune into the hidden states of complex processes (via information-theoretic approaches).
  - **Chaos computing**—utilizing nonlinear circuits (e.g. Chua's circuit) to implement logic gates and reconfigurable logic through a system's chaotic behavior.  
([cambridge.org](https://www.cambridge.org), [pubmed.ncbi.nlm.nih.gov](https://pubmed.ncbi.nlm.nih.gov), [csc.ucdavis.edu](https://csc.ucdavis.edu), [arxiv.org](https://arxiv.org), [frontiersin.org](https://frontiersin.org))
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## 4. Core Themes & Insights

- **Computational mechanics:** Provides tools (e.g.  $\epsilon$ -machines) to quantify intrinsic information processing by a system.
- **Emergence:** Simple interacting components can produce complex, unpredictable behavior—offering computation beyond conventional logic.

- **Analog as fundamental:** Emphasizes that computation isn't exclusive to bit-based systems; analog, stochastic, and natural systems contribute rich computational capacity.
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## **5. Why It Matters**

- **Designing new computing architectures:** As CMOS scaling stalls, leveraging dynamical and analog systems offers a path forward.
  - **Engaging fundamental theory:** Ties into deep questions: What *is* computation? How does it emerge in nature?
  - **Bridging disciplines:** Connects physics, computer science, and complex systems theory.
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## **TL;DR**

Crutchfield et al. broaden the idea of computation beyond engineered digital systems, revealing that computation can be intrinsic: emerging from natural dynamics, noise, chaos, and oscillation. The focus issue they introduce dives into both **observation** (how to uncover computation where it already exists) and **design** (how to harness it for new computing paradigms).

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