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From Albums to Streams: How Modularity Changes Systems

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Scientific publishing is under growing strain. Researchers are producing more outputs, across more formats, at a pace the traditional publishing model was not designed to support. The question is not whether scientific communication will evolve, but how that evolution will be shaped, and by whom.

We use streaming and Spotify as a familiar example, not because it got everything right, but because it made a structural shift visible. Music did not change because audiences suddenly wanted playlists. Playlists existed long before streaming. Music changed because digital infrastructure made it possible to break apart bundled products, reconnect them in new ways, and move value through *use* rather than control.

> **What if access was never the hard part, but structure was?**
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> Structure is what emerges when research is broken into components, given shared attributes, and connected through explicit relationships. By structure, we don't mean control or centralization. We mean taking standardized ways of defining, describing, and relating parts of research across time and systems.

For years, efforts to modernize scientific publishing have focused on reducing friction. Faster access. Fewer paywalls. Smoother discovery. These changes mattered, and still do. But they stop short of the deeper constraint: in a system still organized around bundled documents, improved access does not automatically lead to reuse, attribution, or recombination. Knowledge can be open and still remain locked inside containers.

The real shift begins when research is treated not only as documents or a collection of documents to be accessed, but as components that can move, connect, and *compound* across systems.

1. The Album Problem

Before streaming, you bought albums. Even if you wanted one song, you bought twelve. The bundle was the product. Record labels controlled distribution, shelf space, and exposure. Scarcity shaped access and revenue alike. The album was not just a format, it was the business model.

Scientific publishing follows a similar pattern. Researchers bundle methods, data, figures, code, and conclusions into a single artifact, most often a narrative paper. Journals play an essential role in validation, synthesis, and stewardship of the scholarly record. At the same time, they control what is formally published, what gains visibility, and what carries career-defining prestige. Peer review, editorial coordination, and reputational signaling are costly to manage. Prestige remains scarce and powerful.

What if the paper has never been the scientific equivalent of a song at all?

The paper, like the album, functions as a wrapper for content, concentrating value, recognition, and authority.

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2. The Bundle Is Not Always the Starting Point

The tension is not that bundles are bad. The bundled paper remains essential. The tension is that bundling remains the default entry point.

Music listeners rarely want an entire album as their first interaction. They want a track that fits a moment, a mood, or a task. In research, the pattern is similar. Full papers are essential for interpretation and synthesis, but researchers often engage first with specific components, like a figure or method.

In a physical world of vinyl records and printed journals, bundling made sense. In a digital world, we are increasingly constrained by boundaries that no longer exist. In a world of artificial intelligence, what does the bundle *prevent* us from seeing?

3. "Spotify for Science"

The Spotify metaphor has appeared repeatedly in scientific publishing, with the analogies focusing on user experience, universal access, and instant delivery. A decade ago, Kopernio branded itself the "Spotify of research papers,"[1] emphasizing frictionless access. Other proposals imagined unified subscriptions or centralized discovery layers[2]. These efforts correctly identified frustration with access, discoverability, and experience.

But **access, on its own, only removes the lock**. It does not create the conditions for reuse, attribution, or recombination.

What most "Spotify for Science" visions miss is the deeper structural shift that allowed streaming to reshape music in the first place. Streaming did not simply make *albums* easier to access. It changed *what* moved through the system. Songs became the primary unit of circulation, while albums became one way—among many—to assemble, contextualize, and package them.

The paper is *not* the song. The paper is the album.

In scientific publishing, this distinction is often blurred. Many analogies implicitly assume that improving science means streaming *papers* more efficiently, rather than reconsidering what the fundamental units of exchange actually are. Looking back we forget an important intermediate step: Apple introduced per-song purchases at $0.99 with iTunes in 2003, years before streaming became dominant[3]. Streaming later **normalized unbundling so completely** that we now forget the intermediate step ever felt radical.

The shift towards streaming did not succeed simply because it unbundled albums. It succeeded because tracks became well-defined, interoperable objects. A song carries consistent attributes: tempo, artist, collaborators, licensing, identifiers, relationships. Those shared descriptions make it possible for countless tools and experiences to be built on top: playlists, recommendations, radios, analytics, remixes. Standardized attributes enable songs to become referencable, replayable entities, with their value now coming from **use, reuse, and recombination**.

Unbundling without shared standards produces fragments, not ecosystems.

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[1] Kopernio's vision was to provide one-click access to millions of journal articles, inspired by Spotify. The startup was acquired by Clarivate in 2018.

[2] At a 2025 CSF workshop [1], one of the prototypes that was built produced a Spotify for Science focused on access and centralization of trust-signals.

[3] In iTunes songs could be purchased individually, but they were still downloaded, stored locally, and organized manually, largely siloed within Apple's ecosystem, especially in its early years. Recomposition existed, but it was limited: playlists you curated yourself, on a single device, inside a single platform. Spotify launched in Europe in 2008 and reached the United States in 2011, nearly a decade after iTunes normalized per-song purchases. By then, unbundling had become the default.

To support modularity, standards must exist. Standards also serve a second, equally important role. To avoid centralization. This is essential for science. We do not want a single platform to define how knowledge circulates. Open standards are what make interoperability possible without central control.

4. Preprints Opened the Door. Standards Open the Ecosystem.

Preprint servers did for science what SoundCloud did for music. They removed the gate at the front door. Researchers could share work before permission was granted. Discovery could happen earlier. This was a necessary step.

Preprints accelerated sharing by removing permission from the point of release, while largely preserving bundled narrative documents. Machines can index papers and infer structure after the fact, but that structure is not native or dependable. Search, evaluation, and reuse remain anchored to static containers. Components are present, but implicit. Relationships remain loosely unknown and not portable.

Preprint servers feel decentralized relative to journals, but they are still a form of centralization. SoundCloud was enabling, but not enduring. The point of access changed, it removed gatekeeping at the point of sharing. Utility did not fully follow. The change in distribution is making a big difference. But we *also* need to move on.

A song is the same song no matter where it is played. Its identity, rights, and relationships persist across platforms, allowing new experiences to emerge.

Science has not yet crossed that line. Preprints open the door, but without shared exchange formats, research components cannot move together across tools with context and integrity.

Access creates visibility. Standards create mobility.

5. From Modularity to Standards to Composability

The transition underway in science depends on three connected steps.

First, **unbundling**. Research must find ways to distribute the modular components *alongside existing research*, like for example preprints.

Second, **standardization**. Those components must carry agreed-upon attributes so they can be interpreted and surfaced consistently across systems. If a figure supports a claim, that relationship must be explicit. If a method has dependencies, they must be describable. If a dataset is reviewed, versioned, or licensed, that information must travel with it.

Third, **explicit relationships**. Components must be able to reference one another in ways machines and humans can understand. This is what allows recomposition.

Composability is not the starting point. It is the outcome.

When components are modular, described consistently, and linked through shared standards, interoperability becomes possible. And when interoperability exists, an ecosystem can emerge where many tools compete on experience and utility, not on incompatible formats and access.

6. Why This Matters Now

Three forces make this shift difficult to avoid.

AI is forcing the issue. Models trained on bundled papers struggle with verification and provenance. When claims, data, methods, and code are collapsed into a single narrative

artifact, machines can extract text but cannot reliably or explicitly trace evidence, credit, attribution, or reuse. Hallucinations are not a substitute for the scientific record.

Computational research cannot wait. Many fields already operate through continuous sharing of data, code, and methods. Publishing infrastructure should amplify that reality, not lag behind it.

The future of science is not about destroying the paper. It is about *decentering* it.

The album still exists. It is simply no longer the only way music creates value. What needs to change is the assumption that the paper is the only or best unit for discovery, reuse, or credit. Especially in the age of AI.

7. What This Enables for Science

With unbundling and standardization new possibilities emerge:

Claim-level discovery Search for a specific research question and surface the figures, datasets, and analyses that support it, even when buried inside unrelated papers.

Method reuse Find a protocol, see how others have used or modified it, and import it directly into a workflow with attribution flowing automatically.

Living research Update a dataset or method, and every dependent work can reference the new version transparently.

Distributed credit & trust Attach credit, review, licensing, and provenance at the component level, not only to final articles.

Composed knowledge Build curated collections of methods, figures, and findings organized around problems, not venues.

Modularity creates the parts. Standards give those parts shared meaning. Explicit relationships make new compositions possible.

This is the vision Continuous Science Foundation holds.

We are focused on building standards in the open, making modular research interoperable, and coordinating across diverse groups to unlock a new future.

References

[1] R. Cockett and T. Teal, “From Tools to Adoption: A Path to Modular and Interactive Scientific Publishing,” 2025, doi: 10.62329/kcep6732.