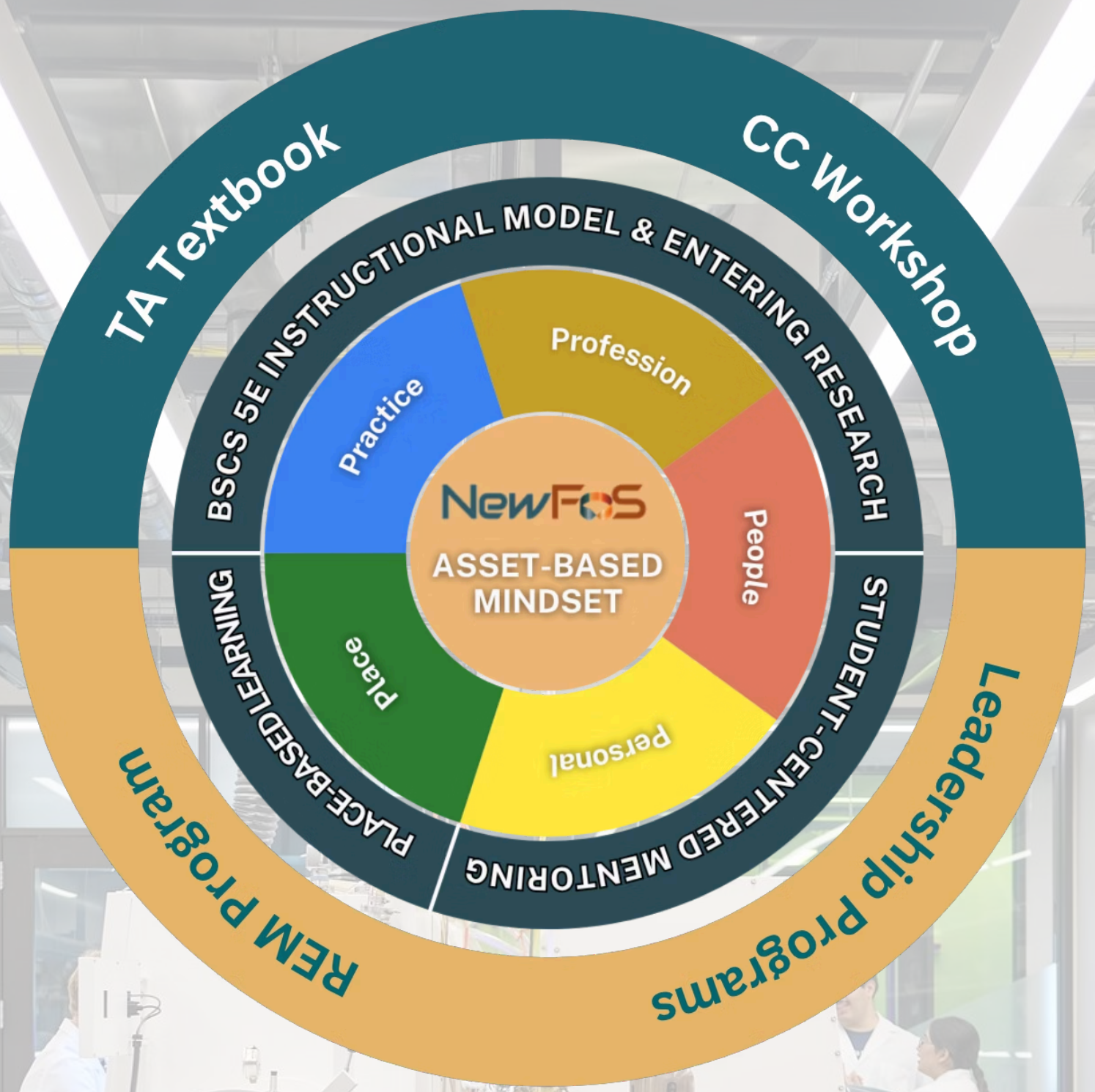


The NewFoS Education Framework

Integrating an Asset-Based mindset with the LINCSS 5P domains and four complementary instructional approaches, enabling aligned implementation and evaluation across diverse New Frontiers of Sound (NewFoS) Science and Technology Center programs.

Figure 1: The NewFoS Education Framework connects Asset-Based thinking, the LINCSS 5P domains, and four instructional approaches into a unified, evaluable system for all Center education programs.

From Independent Programs to a Unified Framework

After the first years of implementing the Community College Workshop, Student-Centered Leadership modules, and the REM program, assessment data and program experience revealed clear and consistent threads across these initiatives, despite their independent development and structural complexity.

In response, the Education and Broadening Participation team convened in late summer and early fall to synthesize these insights into a unified framework that intentionally connects and guides all Center education programs.

Community College Workshop

Foundational Topological Acoustics engagement for community college learners

Student-Centered Leadership

Modules supporting identity and professional development

REM Program

Research Experience and Mentoring for undergraduate students

Topological Acoustics Textbook

A modular, inquiry-driven curricular ecosystem that supports flexible and scaffolded pathways into topological acoustics, connecting foundational knowledge, conceptual understanding, and research participation through customizable learning experiences

University of Arizona Grand Challenges Research Building 6th Floor, home of NewFoS

The Asset-Based Mindset: Our Organizing Principle

We began with what is central to all programs and what we seek to cultivate: **students**. Research on student development indicates that adopting an Asset-Based mindset grounded in established educational theory is critical to building effective STEM learning environments that support student success, identity development, and persistence (Ladson-Billings, 1995; Yosso, 2005; Carlone & Johnson, 2007; Espinoza, 2011; National Academies of Sciences, Engineering, and Medicine, 2017).

The Asset-Based mindset serves as the organizing principle of this framework, shaping how all approaches are selected, integrated, and enacted across programs. Using this framework, we recognize the strengths, experiences, and cultural wealth that all individuals connected to the Center bring, fostering confidence, belonging (Strayhorn, 2012), and innovation (Page, 2007).

No single member or student shares the same background or experiences; rather, there exists a diversity of academic, cultural, and experiential knowledge that creates a robust foundation for innovation, creativity, and growth.

What Asset-Based Thinking Cultivates

- Recognition of individual strengths and cultural wealth
- Confidence and sense of belonging in STEM spaces
- Innovation through diverse perspectives
- Inclusive learning environments for all learners

Left to Right: Yousif Kandelchy, undergraduate student at Wayne State University; Dr. Pierre Lucas, Professor of Materials Science and Engineering at the University of Arizona

Undergraduate REM Students on Mt Lemmon from Left to Right: Ture Gustafson from University of Arizona; Yousif Kandelchy from Wayne State University; Anwar Gatto from University of Arizona; and Kevin Kraseman from University of Arizona

Looking Beyond the Artifact

How an archaeological perspective became a framework for understanding people.

The framework used throughout NewFoS emerged through the collaborative work of **Sara Chavarria** and **Cory Knox**. While working with STEM programs, Chavarria observed that professionals often focused on explaining their work without considering the broader experiences of the students they were trying to mentor. She sought a way to help students understand not only the science around them, but also the people, relationships, and experiences shaping their development.

> Drawing on her background as a professional archaeologist and lithic specialist, Chavarria approached this challenge through a familiar lens. Archaeologists rarely reconstruct the past through written records alone. Instead, they interpret communities by examining the traces people leave behind. A projectile point, for example, is more than a stone tool—it is evidence of the people who created it, the environment in which they lived, the needs they sought to meet, the practices they developed, and the expertise they cultivated.

As she reflected on this process, Chavarria found herself returning to the same fundamental questions:

- **Who were the people?**
- **Where did they live?**
- **What needs shaped their decisions?**
- **What practices did they develop?**
- **What expertise made those practices possible?**

These questions revealed that artifacts tell stories far larger than the objects themselves. They reveal the relationships between people, place, human needs, practice, and expertise that define a community.

> **"Technology is not technology for technology's sake. It exists to serve people, places, and communities." Chavarria to REM students, 2026**

The same perspective extends beyond archaeology. Just as archaeologists look beyond artifacts to understand ancient communities, educators can look beyond grades, research projects, and technical skills to better understand the students developing behind them. The questions that reveal the story of a community can also illuminate the development of a scientist, engineer, or future professional.

The LINCSS 5P Framework

This mindset informs how we design and support learners' STEM and NewFoS identity development. We frame this process using the **LINCSS 5P framework** (Chavarria & Knox, 2023): People, Personal, Place, Practice, and Profession. While many STEM programs primarily emphasize technical practice, our model expands beyond this narrower focus.

1

People

How research impacts individuals and communities; who benefits or is affected; and who influences the scientist, the research process, and areas of inquiry.

2

Personal

How individual experiences, beliefs, and values shape and inform research questions, approaches, and interests.

3

Place

The contextual environment in which research occurs, including geographic, institutional, and sociopolitical factors, as well as the historical context of the space.

4

Practice

The methods, tools, instruments, and processes used in research, and how these shape knowledge production; including whether practices are traditional, innovative, or evidence-based.

5

Profession

The culture of the field or discipline, including norms, collaboration, dissemination practices, career pathways, and the development of professional identity.

Making Identity Development Visible and Measurable

We posit that intentional engagement across these domains strengthens learners' sense of belonging and supports their recognition as STEM practitioners. By explicitly integrating and labeling programs and workshops with these domains, we make identity development **visible, structured, measurable, and adaptable** for ongoing evaluation for both learners and program developers.

All Center learning experiences are further structured through four complementary approaches. Each approach contributes distinct, research-grounded elements that, when integrated, support holistic STEM identity development across the LINCSS 5P domains.

Student-Centered Mentoring

Developmental relationships supporting academic and personal growth

Place-Based Learning

Situating STEM education within real-world, community contexts

Entering Research Curriculum

Structured scaffolding for undergraduate research experiences

BSCS 5E Instructional Model

Inquiry-based learning through five structured phases

These four approaches function as **translation mechanisms**, operationalizing the Asset-Based mindset into structured, actionable learning experiences across diverse program contexts.

Undergraduate REM Students on Mt Lemmon from Left to Right: Nestor Rojas-Badillo from University of Arizona; John Keleman from University of Arizona; and Luke Thoresen from University of Arizona

Undergraduate REM Students at CUNY from Left to Right: Diego Ferrer from University of Colorado Boulder; Sophie Do from University of Arizona; Patrice Akayi from University of Arizona; and Tyi Jones from Spelman College

Student-Centered Mentoring & Place-Based Learning

Student-Centered Mentoring

Drawing on mentoring theories that highlight psychosocial and career development functions (Kram, 1985; Higgins & Kram, 2001; Brueggeman, 2022), this approach positions mentors not only as technical guides but as **facilitators of identity formation, belonging, and professional navigation**.

Within our framework, mentoring is intentionally aligned across all 5P domains, supporting learners in connecting their experiences (Personal), relationships (People), and future pathways (Profession) to their work.

Place-Based Learning

This approach situates STEM education within real-world contexts, emphasizing the importance of environment, community, and lived experience in shaping learning (Gruenewald, 2003). It reinforces that research is not abstract or isolated but **embedded within geographic, institutional, and sociopolitical contexts**.

Within the wheel, Place-Based learning directly activates the Place domain while also strengthening connections to People and Personal by grounding learning in meaningful and relevant contexts.

Left to Right: Howard Yawit, PhD Student in Material Science at University of Arizona; Dr. Derrick Hylton, Associate Professor for Physics at Spelman College; Grant Batchelder, Administrator for Academic Programs at NewFoS; and Dr. Kasi Kiehlbaugh, Director of Health Sciences Design at University of Arizona

Entering Research & the BSCS 5E Model

Entering Research Curriculum

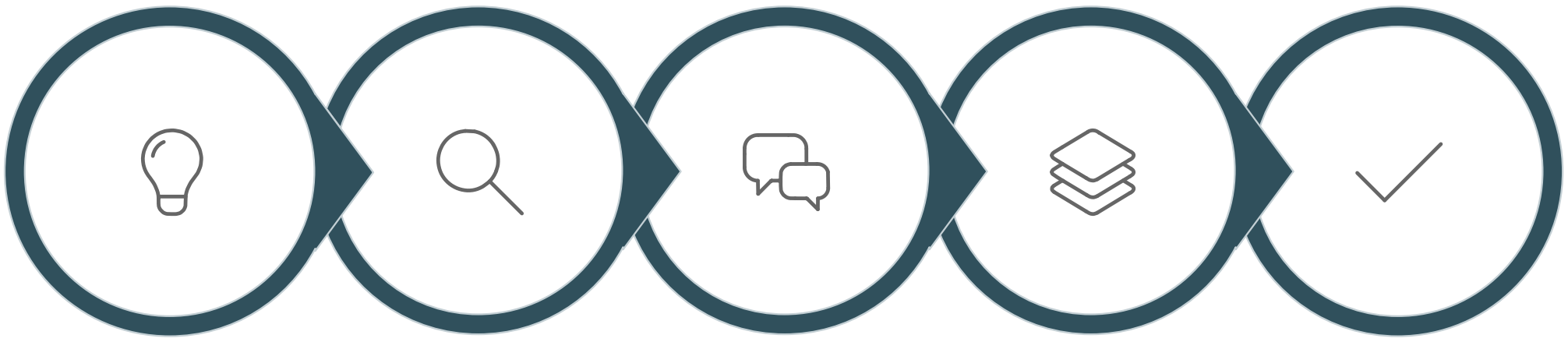
This curriculum provides structured scaffolding for undergraduate research experiences, focusing on research communication, ethics, project ownership, resilience, mentoring relationships, and disciplinary thinking (Branchaw, Pfund, & Rediske, 2010).

Rather than treating research as a set of discrete tasks, Entering Research emphasizes **participation in research communities** and supports learners in developing as emerging scholars. It strongly supports the Practice and Profession domains while reinforcing People and Personal through mentoring, collaboration, confidence-building, and reflection.

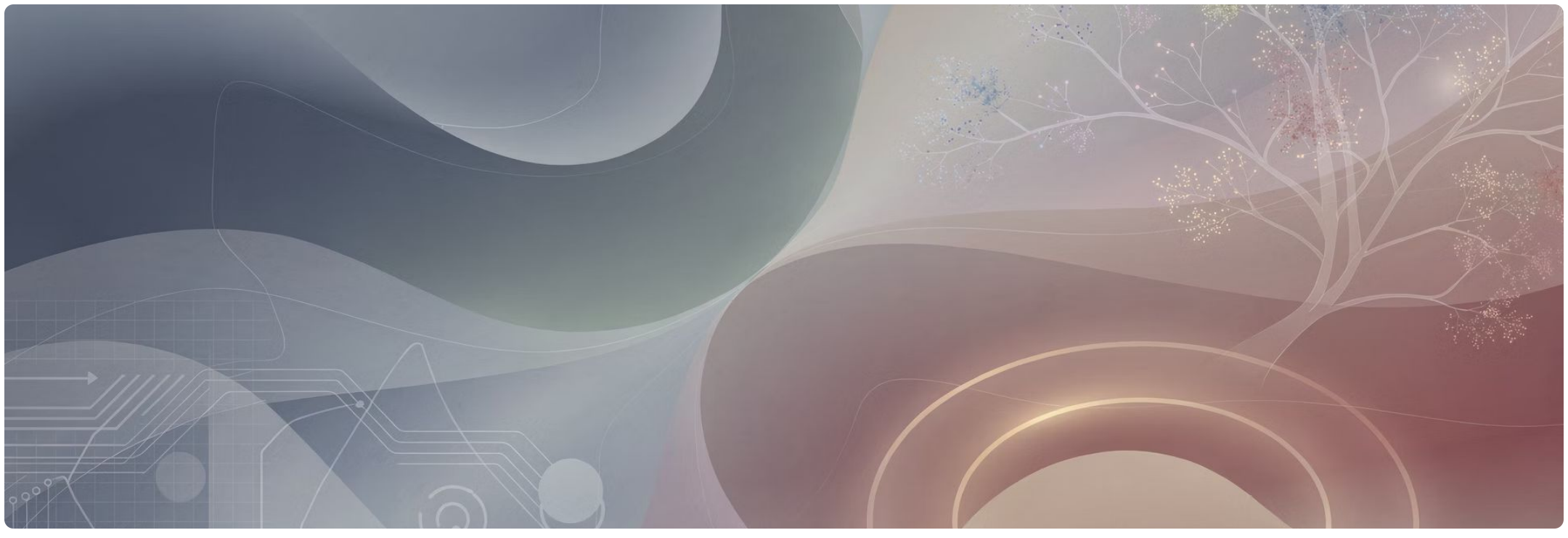
BSCS 5E Instructional Model

The BSCS 5E model (Bybee et al., 2006) offers a structured, inquiry-based approach through five phases: **Engage, Explore, Explain, Elaborate, and Evaluate**. This model supports deep conceptual understanding and iterative learning, ensuring that students actively construct knowledge rather than passively receive it.

Within our framework, the 5E model primarily strengthens the Practice domain while enabling integration across all domains by structuring inquiry, active meaning-making, and how learners engage with People, Place, and Personal experiences throughout the learning process.



The 5E model ensures students actively construct knowledge at each phase, supporting iterative and inquiry-driven STEM learning experiences.



An Integrated, Counterbalancing System

As illustrated in the framework wheel, these approaches are not implemented in isolation. Instead, they are **intentionally layered and integrated**, allowing each approach to activate multiple 5P domains simultaneously. This design ensures that no single aspect of STEM identity development is privileged at the expense of others.

> Learning experiences are co-constructed as interconnected systems, where mentoring relationships, contextualized learning, structured research experiences, and inquiry-based instruction collectively support the development of well-rounded STEM practitioners.

This integrated structure intentionally counterbalances the tendency of STEM education to prioritize technical practice, ensuring equal attention to relational, contextual, and identity-based dimensions of learning. This ensures that learners engage not only in *what they do* as scientists, but in *who they are*, *where they are situated*, and *how they relate* to the broader impacts of their work.

- The outer layer of the framework represents **Center programs as implementation environments**, where these approaches and domains are enacted in distinct programmatic contexts while maintaining alignment through the shared framework.

What They Do

Technical practice, research methods, and disciplinary skills

Who They Are

Identity, belonging, values, and personal connection to science

Where They Are

Contextual, geographic, and sociopolitical situatedness

How They Relate

Broader impacts, community connections, and professional networks

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