Remoulding Plastics: Material Change at the Edge of Petrochemical Decline

Jessie French

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Conservation tour of The Metropolitan Museum of Art. Photo by Jessie French.

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The Awarding Bodies

The Fellow sincerely thanks The George Alexander Foundation for providing funding support for the ISS Institute and for this Fellowship.

The ISS Institute plays a pivotal role in creating value and opportunity, encouraging new thinking and early adoption of ideas and practice by investing in individuals. The overarching aim of the ISS Institute is to support the development of a 'Better Skilled Australia'. The Institute does this via the provision of Fellowships that allow Australians to undertake international skills development and applied research that will positively impact Australian industry and the broader community.

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Sponsor - The George Alexander Foundation

In 1972, George Alexander AM set up an independent philanthropic foundation as a way of sharing his wealth and giving back to the community. The focus of The George Alexander Foundation is supporting access to education for promising young people, particularly those from rural and remote areas. The George Alexander Foundation's aim is to help overcome barriers and make it possible for talented students to achieve their potential and go on to contribute to the Australian community.

The George Alexander Foundation (GAF) Scholarship Programs form the core of the foundation's work, operating in partnership with major tertiary institutions, while our Fellowships and other Education grants provide other enriching and challenging educational experiences.

George Alexander believed in the notion of 'planting seeds and hoping they grow into pretty big trees'. The programs supported by the Foundation endeavour to support this ideal and as GAF Fellowship recipients go on to contribute to the community, George's legacy and spirit lives on through their achievements.

The Fellow would like to extend thanks to:

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Catherine H. Stephens (MoMA) – for hosting a tour of MoMA's conservation labs and providing insights into polymer degradation and material stability in conservation.

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Bauhaus Earth – for discussions on low-carbon materials and architectural applications.

E-Werk Team (Helen Turner, Pablo Larios, and others) – for discussions on circular energy systems and material reuse in cultural institutions.

Trond Wilhelmson & Cliodhna Murphy (Hauser & Wirth) – for conversations on sustainability in exhibition practices.

Paula Camina Eiras – for discussions on biodesign education and sustainable materials, as well as facilitating the tour of Haeckels' research and production facilities in Margate.

Haeckels Team – for sharing insights into biopolymer applications in skincare packaging.

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Reference library at The David Booth Conservation Centre, Museum of Modern Art, New York. Photo by Jessie French.

02 Executive Summary

Reframing the Narrative Around Material Innovation

A prevailing assumption about novel sustainable materials is that they inherently struggle with fragility, longevity and cost barriers. However, this Fellowship revealed that these challenges are not exclusive to sustainable materials—they are common across all material categories, including those long-established in commercial and industrial applications.

This realisation highlights a deeper challenge: the difficulty is not simply in creating new materials but in designing the systems, infrastructures, and economic conditions that enable their integration.

The Fellowship examined how sustainable materials enter commercial and industrial markets, identifying key factors that determine their success or failure. A transition from a linear economy—where materials are extracted, used, and discarded—to a circular economy will not occur in a single leap but requires incremental, systemic shifts across industries.

Three key areas of focus emerged:

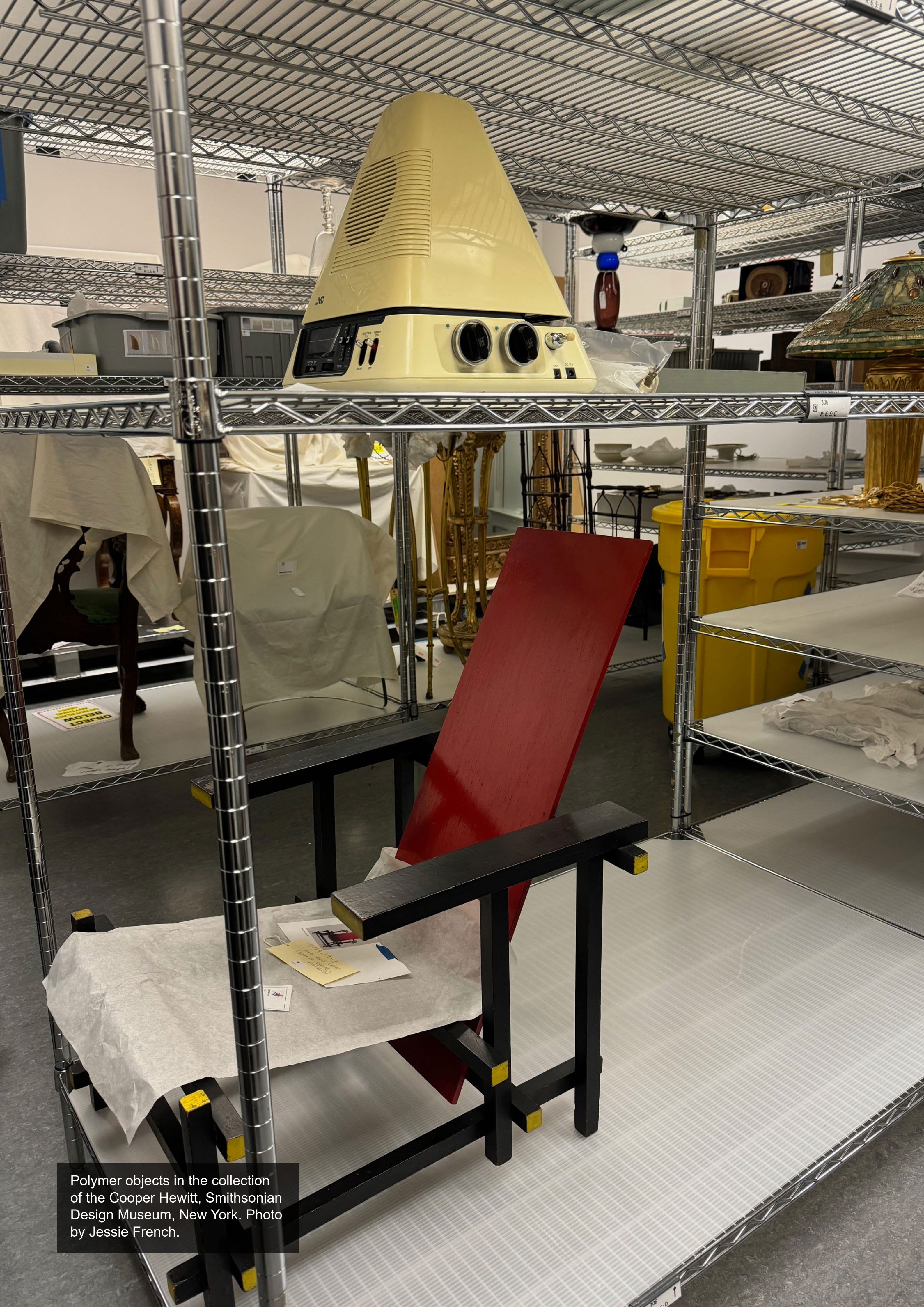
1. **Investment in R&D** – Without structured funding for early-stage material research and trials, innovative materials remain stuck in the prototype phase, unable to scale effectively.

2. **Market readiness and infrastructure** – New materials must be developed alongside manufacturing capabilities, supply chain networks, and integration strategies to ensure viability within existing industry frameworks.

3. **Policy & legislative shifts** – Current economic structures favour petrochemical plastics, which are supported by USD $7 trillion in fossil fuel subsidies (Black et al. 2023). Until policies reflect the true cost of these materials—including their environmental and health externalities—sustainable alternatives will struggle to compete.

While over 170 nations, including Australia, are currently negotiating a UN treaty to end plastic pollution (United Nations 2022), this process is slow-moving. Industry change will not happen spontaneously but must be driven through policy interventions, commercial incentives and R&D investment.

The Fellowship focused on engaging with global leaders in material innovation, conservation science, and commercial production to identify scalable, viable approaches to integrating sustainable materials into industry and design sectors in Australia. The findings presented in this report outline specific barriers, lessons, and opportunities that can inform a long-term strategy for sustainable material adoption in the built environment, conservation, and commercial applications.



Polymer objects in the collection of the Cooper Hewitt, Smithsonian Design Museum, New York. Photo by Jessie French.

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Fellowship Background

Context: The Urgency of Sustainable Material Development in Australia

Plastics are deeply embedded in modern life, found in nearly every sector, from **packaging and textiles to automotive and construction materials.** The **global petrochemical plastics market** was valued at **USD 712 billion in 2023** (Statistica 2025), highlighting the vast scale and economic impact of the industry. However, this dominance comes with significant **environmental and health costs**.

Plastics are predominantly derived from fossil fuels, an industry that received subsidies totalling USD 7 trillion in 2022 (Black et al. 2023). The widespread use of petroleum-based plastics, which gained momentum in the mid-20th century due to their low cost, versatility, and durability (including water resistance, flexibility, and thermal stability), has resulted in a material that is near-permanent in the environment. Nearly all petrochemical plastics ever produced still exist today, primarily as waste in landfills or mismanaged debris in oceans (United Nations Environment Program 2021).

Historical Perspective on Plastics and Sustainability

Historically, plastics were introduced as an environmental solution—a synthetic alternative to natural materials like ivory, tortoiseshell, and horn (Davis 2022). In the 1870s, early plastics helped reduce demand for elephant ivory by replacing it in billiard balls (Davis 2022). However, while plastics initially aimed to conserve natural resources, their mass production without end-of-life solutions has led to severe environmental consequences.

Recognising the unsustainability of petroleum-based plastics, global efforts are now accelerating the transition to non-petrochemical materials. In 2023 and 2024, 175 nations, including Australia, entered negotiations for a UN treaty to end plastic pollution (United Nations 2022)—a legally binding agreement designed to:

- Accelerate the shift toward a circular economy
- Drive global change in material production and waste management
- Redefine the role of plastics in packaging and industry

Australia's Position in Sustainable Materials Innovation

While bioplastics and alternative polymers are gaining recognition, Australia remains in the early stages of their adoption. Unlike the EU, where policy incentives and industrial infrastructure support sustainable materials, Australia's innovation efforts are fragmented. There is no coordinated national strategy to advance scalable, commercial-ready alternatives.

This Fellowship aimed to assess ways to bridge these gaps by:

- Expanding knowledge through direct engagement with leading researchers, designers, and industry professionals.
- Fostering international networks for knowledge-sharing and skill-building.
- Importing best practices from global leaders in sustainable materials research and industrial implementation.

These activities laid the foundation for:

- Advanced research and material testing.
- Industry partnerships and market integration.
- Stronger collaboration between science, conservation, and industry.

By addressing these structural challenges, Australia can position itself competitively in the global materials transition, ensuring that designers, manufacturers, and policymakers have access to the necessary expertise, resources, and networks.

Australia's Key Challenges in Sustainable Material Innovation

1. Geographic isolation from major innovation hubs

Australia's distance from key material innovation centres—such as those in the EU, UK, and US—limits access to:

- Cutting-edge material advancements and knowledge
- Specialised manufacturing expertise
- Industry research collaborations
- Investment and funding opportunities
- Supply chains and distribution

2. Limited local manufacturing infrastructure

Australia's minimal manufacturing infrastructure means:

- Most machinery must be imported, increasing costs and lead times
- There is limited local supply chain to support widespread industry adoption
- Scaling materials from prototypes to commercial products remains difficult

3. Risk-averse market & industry resistance

Australian industries prefer:

- Proven materials with proven track-record, existing certifications, or both.
- Lower-cost options that prioritise immediate economic feasibility, given the absence of regulatory mandates for sustainability or extended producer responsibility beyond voluntary corporate initiatives.
- Materials backed by comprehensive performance data and supplied by well-established industry providers.

Unlike the EU, where companies are proactively phasing out harmful materials ahead of regulatory mandates, Australian environmental regulation provides little incentive for businesses to bear costs associated with a transition to less hazardous material choices.

4. Lagging regulation & policy gaps

- The EU already has frameworks in place to support a transition away from hazardous materials and towards circular systems of reuse and recycling.
- Australia lacks equivalent policy measures, meaning industries face no pressure to transition.

Without clear regulatory direction, investment in sustainable materials remains low, as industries see it as an optional innovation rather than an inevitable transition.

Julia Bakker Arkema Associate Research Scientist, The Metropolitan Museum of Art, New York, with samples of Other Matter material for conservation testing. Photo by Jessie French.

Example installation of Other Matter's materials at Cooper Hewitt, Smithsonian Design Museum, New York, inpreparation for Scholars' Day. Photo by Jessie French.

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Fellowship methodology

The Fellowship was conducted through a series of structured engagements, including meetings, residencies, workshops, studio visits, and symposiums. This immersive approach provided a comprehensive exploration of the biopolymer research, development, and application landscape, while also enabling direct engagement with leading practitioners, researchers, and educators across multiple disciplines.

Through site visits to research institutions, design studios, conservation labs, and production facilities, the Fellowship sought to investigate:

- Current material innovation practices across various industries
- Challenges and opportunities in integrating sustainable biopolymers into existing commercial systems
- Regulatory landscapes and policy readiness for biopolymer adoption
- Cross-sector collaboration between science, design, and industry
- Public and institutional awareness of material sustainability

The Fellowship unfolded in two distinct phases:

1. A North American residency (New York) that explored material science, conservation strategies, and circular design methodologies through direct engagement with leading institutions and researchers.
2. A European research tour (Paris, Maastricht, Berlin, London) that examined industry adoption, built environment applications, and regulatory developments influencing sustainable material transitions.

Each phase targeted key research institutions, industry leaders, and design practitioners, allowing for an expansive yet focused study of sustainable material integration.

1. North American Residency at Cooper Hewitt, Smithsonian Design Museum (New York)

The first phase of the Fellowship took place in New York, centred around a residency at Cooper Hewitt, Smithsonian Design Museum. This residency was a critical component of the Fellowship, structured around:

- One-on-one meetings with curators, designers, and material scientists
- Participation in workshops focusing on material innovation
- Studio visits to leading sustainable material developers
- Attendance at a symposium-style “Scholars’ Day”, featuring collaborative deep dives into sustainable material research and applications

This phase examined biopolymers not just as materials, but as part of larger design ecosystems, investigating how materials are archived, maintained, and tested in conservation and institutional settings.

Key residency-facilitated engagements

- Meeting with Sarah Barak, Head of Conservation, Cooper Hewitt Smithsonian Design Museum – Discussed how historical material conservation informs contemporary material development.
- Meetings with the Smithsonian Exhibits Team – Investigated in-house materials testing, recycling, and sustainable exhibition practices.
- Meeting with Jessica Walthew, Conservator, Cooper Hewitt Smithsonian Design Museum – Explored historical precedents of plastics and strategies for future material adaptation.
- Meeting with Heather Davis, author of Plastic Matter and member of the Synthetic Collective – Discussed interdisciplinary collaborations between visual artists, cultural workers, and scientists in mapping plastic pollution and designing alternatives.
- Meeting with Jonsara Ruth, co-founder of the Healthy Materials Lab – Examined how design education can drive sustainable material adoption in industry.

These one-on-one meetings facilitated in-depth knowledge exchange and meaningful relationship-building, complementing lab and studio visits as well as the focused discussions of Scholar's Day. The details of these engagements are outlined below.

Scholar's Day Participants

Scholar's Day at Cooper Hewitt, Smithsonian Design Museum gathered a diverse group of experts from conservation, design, material science, architecture, sustainability, and education, offering an interdisciplinary exchange on bioplastics, material transitions, and the future of sustainable design.

Participants included:

Jessica Walthew (Cooper Hewitt) – Conservator with expertise in **plastics conservation and digital media**, co-curator of Nature by Design: Plastics.

Sarah Barack (Cooper Hewitt) – Head of Conservation and Senior Objects Conservator, with a background bridging **fine arts conservation and material culture theory**.

Catherine H. Stephens (MoMA) – Conservation Scientist specializing in **polymer degradation, synthetic materials, and preventive conservation**.

Julie Arslanoglu (The Met) – Research Scientist focused on **organic materials analysis**, with an emphasis on **biopolymers and synthetic coatings**.

Kendra Roth (The Met) – Conservator specialising in **modern and contemporary sculpture, working on the preservation of synthetic materials in museum collections**.

Karen R. Pearson, PhD (FIT) – Chemist and educator working on **material sustainability in STEAM education and cross-disciplinary research**.

Lola Ben-Alon (Columbia GSAPP, Natural Materials Lab) – Researcher specialising in **earth- and fibre-based building materials**, focusing on **bio-based alternatives in architecture.**

Alison Mears & Jonsara Ruth (Healthy Materials Lab, Parsons) – Co-founders of **HML**, advocating for **toxic-free material transitions in design and architecture**.

Cynthia Smith (Cooper Hewitt) – Curator of **Socially Responsible Design**, leading research on **design's role in global environmental and social equity**.

Kirsten McNally (Cooper Hewitt) – Museum educator working with **teen programs** to integrate **biomaterials and sustainable design into education**.

Fan Kong (Genspace NYC) – Learning scientist and teaching artist developing **bioplastic-focused curricula for climate resilience education**.

Cynthia Trope (Cooper Hewitt) – Curator specialising in **industrial and product design**, exploring the **historical and contemporary impact of plastics**.

Heather Davis (The New School) – Media theorist and writer exploring **plastics, materiality, and ecological politics through feminist and queer frameworks**.

Giuliana Moretto & Delia Müller-Wüsten (NY Art Conservation) – Specialists in **modern materials and high-gloss plastics conservation**, with a focus on **ethical challenges in preserving biopolymers**.

Kate Wight Tyler (Brooklyn Museum) – Conservator researching **mass-produced plastics and circular materials economy**.

Kate Fugett (9/11 Memorial & Museum) – Preventive conservator and **co-chair of the AIC Sustainability Committee**, focusing on **waste reduction in museum practice**.

Adriana Rizzo (The Met) – Research Scientist studying **synthetic coatings and plasticised materials**, with an interest in **circular material strategies**.

Melissa David (The Met) – Objects conservator focusing on **modern design and architecture**, exploring early conservation strategies for **bioplastics in collections**.

Laura Neill (Playwright) – Writer investigating **the cultural and economic barriers to sustainable material adoption**, currently developing a play about **seaweed-based plastics startups**.

Isabelle Held (Smithsonian NMAH) – Design historian examining **the socio-political impact of plastics and synthetic materials on postwar bodies and technologies**.

Samantha MacBride, PhD (Baruch College) – Waste and recycling expert with extensive experience in **urban environmentalism and material reuse systems**.

Yvonne Gomez Durand (Cooper Hewitt) – Head of Exhibitions, concerned with **sustainable exhibition practices and the environmental footprint of museum installations**.

Andrea Lipps (Cooper Hewitt) – Curator leading the museum's **Digital Curatorial Department, focusing on new media and contemporary design integration.**

Tina March (MoMA) – Objects conservator working at the intersection of **bioplastics, exhibition design, and preventive conservation**.

Kira Eng-Wilmot (Cooper Hewitt) – Textile Conservator, specialising in **synthetic fibres and the conservation challenges of bio-based textiles**.

Julia Bakker-Arkema (The Met) – Research scientist investigating **preventive conservation strategies for polymer-based materials in museum environments**.

This cross-disciplinary gathering provided:

- Insights into material conservation methodologies that can inform sustainable material development and validation.
- Discussions on regulatory, commercial, and scientific barriers to bioplastic adoption.
- Critical perspectives on material sustainability narratives—balancing historical precedents with future applications.

Engagements with Academic Research Labs on Sustainable Materials

a) Visit to Healthy Materials Lab at Parsons School of Design

A crucial part of the North American phase was the visit to the Healthy Materials Lab at Parsons School of Design, a research initiative dedicated to eliminating harmful chemicals from material production and advancing healthy, sustainable alternatives in design and architecture.

- Meeting with Healthy Materials Lab founders Jonsara Ruth and Alison Mears alongside lab researchers – discussing best practices for material health and toxicity assessments in product design and construction materials.
- Engagement on material certification and compliance – exploring how new materials can be integrated into architecture and interiors while meeting industry standards for health and safety.
- Strategies for scaling sustainable materials – examining how the Healthy Materials Lab collaborates with policymakers, manufacturers, and designers to shift material supply chains toward safer alternatives.

This visit reinforced the importance of not just focusing on environmental sustainability but also on material health, ensuring that biopolymers and alternative materials are non-toxic, safe for long-term use, and compatible with indoor and built environments.

b) Visit to Natural Materials Lab at Columbia University

The Fellowship also included a visit to Natural Materials Lab at Columbia University, led by Lola Ben-Alton, Assistant Professor at Columbia GSAPP and Director of the Natural Materials Lab. The lab investigates raw, earth- and fibre-based building materials, their life cycle, supply chains, fabrication techniques, and policy implications.

- Discussions with Lola Ben-Alton – exploring research into low-carbon natural materials, including cob, rammed earth, and light straw clay, and how they are evaluated for structural and environmental performance.
- Investigation of bio-based material supply chains – mapping out challenges in scaling sustainable materials for real-world construction and architectural applications.
- Exploration of fabrication techniques – looking at both manual and digital approaches to processing natural materials for potential industry adoption.

This visit provided insight into how traditional and bio-based materials are integrated into modern architectural practices, reinforcing the importance of bridging material research with applied industry solutions.

c) Visit to The Metropolitan Museum of Art (The Met) Conservation Lab

In addition to Cooper Hewitt, the Fellowship included a visit to The Met, where a guided tour of the collections and conservation lab provided deeper insight into scientific approaches to material longevity, degradation analysis, and conservation methodologies.

- Tour of The Met's collections and conservation lab with conservation scientist Julia Bakker Arkema – focusing on how conservation science evaluates materials over time, including polymer aging, environmental reactivity, and preservation techniques.
- Extended discussions with research scientist Julie Arslanoglu – exploring analytical techniques for studying synthetic and bio-based polymers, their chemical stability, and challenges in conservation science when dealing with organic materials.
- Insights into how conservation methodologies can inform the development of new sustainable materials, particularly in terms of predicting long-term material behaviour and establishing testing protocols for emerging biopolymers.

d) Visit to MoMA Conservation Lab

The New York residency phase concluded with a visit to the Museum of Modern Art (MoMA) Conservation Lab, led by Catherine H. Stephens, the Sally and Michael Gordon Conservation Scientist. This visit explored:

- Material longevity studies in contemporary art and design conservation
- Scientific testing methodologies used to assess degradation and resilience
- Implications for sustainable material adoption in permanent and temporary installations

This New York residency phase provided a foundational understanding of sustainable materials from both an historical and technical perspective, setting the stage for the next phase of the Fellowship.

2. European Engagements

The second phase of the Fellowship took place in Europe, spanning Paris, Maastricht, Berlin, and London. The timing was aligned with the end of the academic year and the peak of industry events, allowing for:

- Meetings with key educational and research institutions
- Visits to leading design studios and production facilities
- Engagement with industry leaders pioneering sustainable material applications
- Participation in symposiums focused on material sustainability and built environment integration

The European engagements focused on bridging the gap between sustainable material research and real-world industry applications.

Key engagements included:

Paris

- Meeting with Aesop's Global Design Team – resulting in the specification of algae-based biopolymers for their first commercial interior application in the Aesop Hainan retail store. This project served as a case study in material integration within high-traffic commercial spaces, requiring technical resolution of challenges related to humidity, longevity, and conservation.
- Discussions on museum and gallery adoption of sustainable materials, including research into how leading European cultural institutions are exploring material alternatives.

Maastricht

- Engagement with Future Materials Bank, an initiative mapping sustainable material innovation across art, design, and architecture.
- Discussions on new pedagogical models for integrating sustainable materials into design education.

Berlin

- Concentrated time with host and advisor, Kim Kraczon.
- Meeting with Bauhaus Earth, a research organization investigating how sustainable materials can be integrated into architecture at scale.
- Engagement with E-Werk, an experimental energy-positive cultural institution that has developed centralized material recycling hubs for architectural and exhibition materials.

London

The London engagements explored the intersection of sustainable materials, architecture, and industry adoption, with a particular focus on architectural applications, commercial sustainability strategies, and biodesign education.

Assemble and architectural material transitions

Engagements with London-based architecture studio Assemble included participation in their 'Architecture Afternoon' Symposium, as well as private meetings with Assemble's founding directors. Discussions explored:

- The role of architects in material transitions, and how experimental materials are integrated into the built environment.
- Policy and industry barriers that slow the adoption of sustainable materials, and strategies to address them.
- Real-world case studies where novel materials have been successfully implemented in architectural projects.

Additionally, concentrated time was spent with Maria Lisogorkaya, founding member of Assemble, discussing the Royal Academy of London Summer Exhibition. Fellowship insights contributed to a major material commission and installation featured in the exhibition, providing a high-profile platform for new material applications within architecture and design discourse.

Private industry meetings

A private meeting with Hauser & Wirth's head of sustainability, Cliodhna Murphy, and design director, Trond Willhelmsen, provided insights into how cultural institutions and commercial entities are integrating sustainability principles into their operations. The conversation centred on material selection in exhibition design, supply chain sustainability, and the role of galleries in shifting industry standards.

Biodesign & sustainable consumer goods

The Fellowship also included meeting with Paula Camina Eiras, a respected designer of sustainable materials and a teacher at Central Saint Martins' Biodesign course. Discussions focused on the role of biodesign education in bridging science and design, and how cross-disciplinary research is shaping the next generation of material innovators.

This meeting was followed by a tour of Haeckels' skincare laboratory and production facilities in Margate, where Eiras, in her role as Biodesign Lead, was instrumental in advancing the company's commitment to regenerative materials and circular design. Haeckels, renowned for pioneering biodegradable, compostable, and algae-based packaging, showcased how sustainable materials are integrated across product development, manufacturing, and consumer applications. The visit provided practical insights into scaling biopolymer adoption within the beauty and skincare industry, reinforcing the broader learnings around industry-specific material challenges and innovations.

The London research phase offered a multifaceted perspective on sustainable material adoption, from architectural applications and policy barriers to commercial innovation and education. These engagements reinforced key findings from the North American phase while introducing new perspectives on regulatory readiness, circular material systems, and cross-sector collaboration.

The structured approach of this Fellowship—balancing institutional research, technical analysis, and industry case studies—provided:

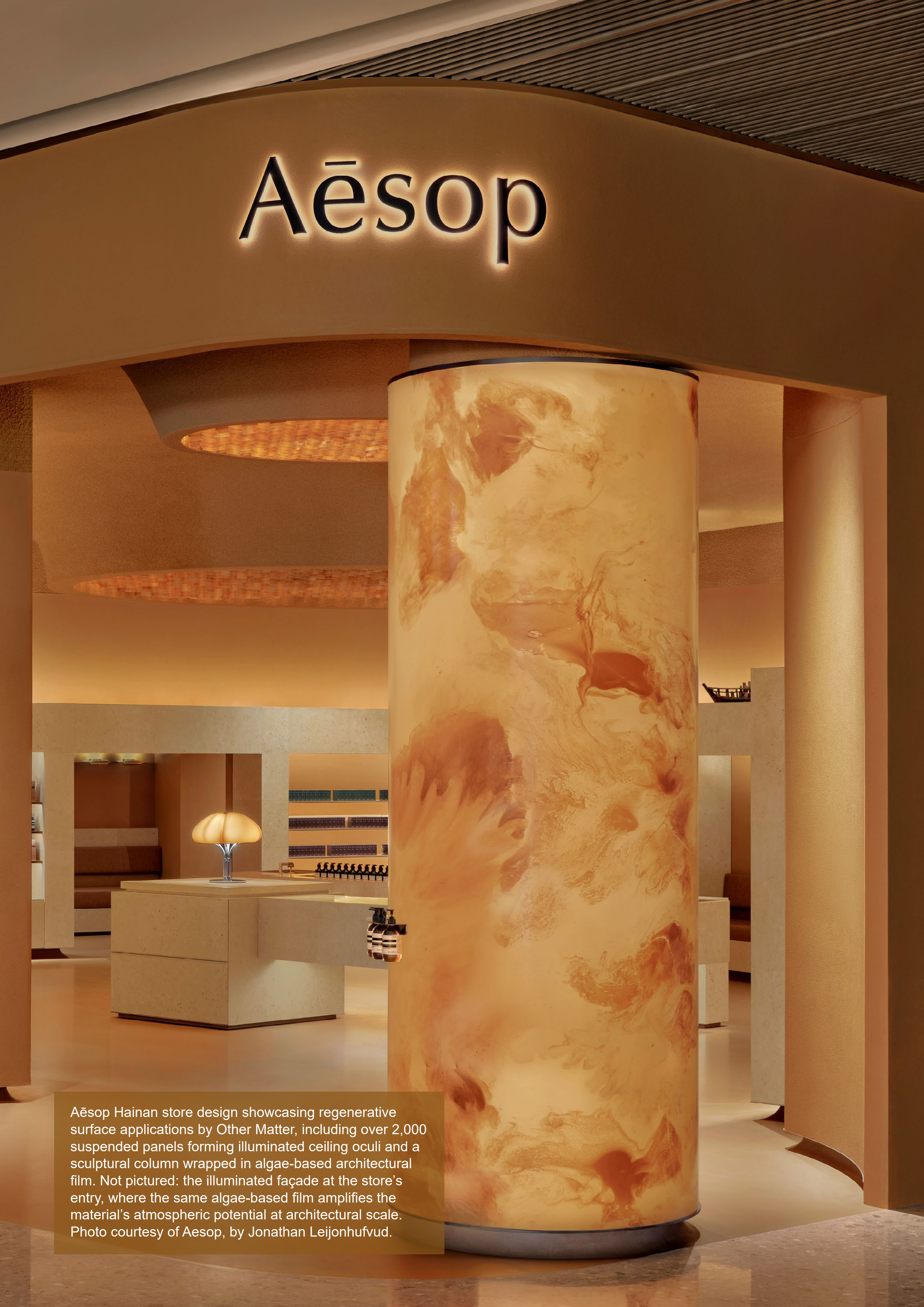
- A multi-layered understanding of biopolymer innovation, from conservation science to commercial applications
- Exposure to varied material testing methodologies across the US and EU
- First-hand insight into how policy shifts and market pressures shape material adoption
- Access to key global networks that will continue to inform the scaling of sustainable material applications in Australia

By combining academic research, commercial engagement, and direct material testing insights, the Fellowship established a robust knowledge base for advancing biopolymer innovation within Australia's design, architecture, and manufacturing sectors.

Fellowship period

The Fellowship was conducted over two distinct research trips in 2024. The first took place in April, focusing on New York, where the Fellow undertook an intensive immersion into the North American context of material innovation, conservation science, and sustainable design research. The second trip occurred in June, covering multiple European hubs—including Paris, Maastricht, Berlin, and London—to engage with industry leaders, research institutions, and material pioneers. Each phase was strategically planned to maximise opportunities for deep engagement with key contacts and to extract insights relevant to the Australian context.

Production facility in Margate of the company formerly known as Haeckels. Photo by Jessie French.



Aēsop Hainan store design showcasing regenerative surface applications by Other Matter, including over 2,000 suspended panels forming illuminated ceiling oculi and a sculptural column wrapped in algae-based architectural film. Not pictured: the illuminated façade at the store's entry, where the same algae-based film amplifies the material's atmospheric potential at architectural scale. Photo courtesy of Aesop, by Jonathan Leijonhufvud.

05
Fellow biography

Jessie French is an Australian designer and artist pioneering the development of sustainable, algae-based biopolymers. Her practice interrogates the environmental and cultural implications of materials, seeking to redefine materiality beyond petrochemical dependency. French's work bridges design, science, and environmental advocacy, positioning material innovation as a critical intervention in the global transition toward a circular economy.

Her research-led practice emerged in 2019 as a speculative inquiry into a post-petrochemical future, leading to the establishment of Other Matter in 2021. The studio is dedicated to developing, prototyping, and scaling alternative material systems through scientific experimentation, cross-disciplinary collaboration, and real-world application. Other Matter operates at the forefront of biopolymer innovation, offering new possibilities for closed-loop material ecosystems applicable across architecture, industrial design, and cultural institutions.

French's work has gained international recognition, with partnerships and exhibitions at:

- Cooper Hewitt, Smithsonian Design Museum (New York) – engaging in material research and conservation practices
- Biennale of Sydney – exploring the speculative role of new materials in contemporary practice
- Royal Academy of Arts (London) – presenting work as part of the 2024 Summer Exhibition, where her material applications were featured in the Architecture & Design rooms curated by Assemble
- Aesop Hainan Retail Store – marking her first commercial interior application of algae-based biopolymer panels, setting a precedent for sustainable materials in high-end retail design

Beyond exhibitions, French's applied material research has been sought by leading brands and institutions seeking alternatives to petrochemical materials. She is actively engaged in industry consultation and academic discourse, including participation in global forums on materials innovation, conservation science, and design for circularity.

Her practice is informed by a deep engagement with conservation research, material testing, and the realities of industrial production, ensuring that her work extends beyond speculative design into practical, scalable solutions. Through education, advocacy, and strategic collaborations, she continues to push the boundaries of what materials can be and how they can shape sustainable futures.

Material samples at Natural Materials Lab, Columbia GSAPP, New York. Photo by Jessie French.

06

Abbreviations / Acronyms / Definitions

MATERIAL SCIENCE & SUSTAINABILITY TERMS

Plastic – A synthetic or semi-synthetic material composed primarily of polymers, commonly derived from petroleum and natural gas. While plastics are valued for their durability, flexibility, and low cost, their environmental impact has led to increased demand for sustainable alternatives.

Bioplastic – A broad term for plastics derived from biological sources rather than petrochemicals. Categories include:

- **Biobased plastics** – made from renewable resources (e.g., algae, cornstarch, cellulose) but not necessarily biodegradable.
- **Biodegradable plastics** – capable of breaking down through natural biological processes, though actual decomposition rates vary depending on formulation and environmental conditions.

Polymer – A large molecule composed of repeating monomer units. Polymers can be:

- **Synthetic** (e.g., polyethylene, polypropylene, polystyrene) – made from petrochemicals.
- **Natural** (e.g., cellulose, chitin, natural rubber) – occurring in biological organisms and often serving as a basis for biopolymer development.
- **Biopolymer** – A naturally derived polymer, typically sourced from plant, algae, or microbial origins, that aims to provide an alternative to petroleum-based plastics. Examples include polylactic acid (PLA), polyhydroxyalkanoates (PHA), and algae-based polymers.

Closed-loop system – A production model where materials are continuously reused, remanufactured, or recycled, minimizing waste and reducing reliance on virgin resources.

Circular economy – An economic and industrial framework aimed at eliminating waste and keeping materials in use through reuse, repair, refurbishment, and recycling. This contrasts with the traditional linear economy (take-make-dispose) model.

Compostable – A material that biodegrades into non-toxic organic matter under specific conditions, often within industrial composting facilities. Not all biodegradable materials are compostable, as some may leave microplastic residues.

End-of-life (EOL) strategy – The planned process for disposing, recycling, or reusing a material once it has reached the end of its functional life. Effective EOL strategies are crucial for achieving true sustainability in material innovation.

Life Cycle Assessment (LCA) – A methodology for analysing the environmental impact of a material or product from its raw material extraction, production, use, and disposal. ISO 14040/14044 is the International standards used to evaluate the environmental impact of materials and manufacturing processes as part of a Life Cycle Assessment.

Microplastic – Tiny plastic particles, typically smaller than 5mm, that result from the breakdown of larger plastics or are intentionally manufactured for certain products. These persist in the environment and pose significant health and ecological risks.

INDUSTRY & POLICY TERMS

CEAP (Circular Economy Action Plan) – A policy initiative under the European Green Deal designed to regulate product design, waste reduction, and sustainable material use to transition the EU to a circular economy.

EPR (Extended Producer Responsibility) – A policy approach that holds manufacturers accountable for the entire lifecycle of their products, including post-consumer waste management and disposal.

ESG (Environmental, Social, and Governance) – A framework used by companies and investors to assess sustainability practices, including material sourcing and waste management.

Greenwashing – The misleading practice of marketing products as more environmentally friendly than they are. This often involves vague claims, selective sustainability metrics, or a lack of third-party verification.

REACH (Registration, Evaluation, Authorisation, and Restriction of Chemicals) – The EU's regulatory framework for managing chemicals, which restricts the use of hazardous substances in products and pushes industries to transition to safer materials.

UN Plastics Treaty – A legally binding global agreement currently under negotiation by 175 nations, including Australia, aimed at ending plastic pollution and transitioning towards sustainable material use.

TECHNICAL & TESTING STANDARDS

Tensile Strength – A material property that measures how much stress a material can withstand before breaking. This is critical in engineering, architecture, and commercial applications of biopolymers.

Material Degradation Testing – A set of scientific assessments that evaluate how materials age, decay, or lose function over time, often tested in museum conservation and product lifecycle studies.

VOC (Volatile Organic Compounds) – Chemical emissions from materials that contribute to indoor air pollution and environmental degradation. Many sustainable material initiatives aim to eliminate VOC emissions from products.

Fire Testing & Flammability Standards – A set of regulations governing how materials behave in fire conditions, critical for materials used in the built environment. Compliance with fire safety standards is often a major hurdle for new material adoption.

KEY ORGANISATIONS & RESEARCH INITIATIVES

The Metropolitan Museum of Art (The Met) Conservation & Scientific Research Department (New York) – One of the world's leading institutions for conservation science, The Met employs approximately one-third of all conservation scientists in the US. The museum operates a dedicated Scientific Research Department, publishing its own Metropolitan Museum Journal and conducting pioneering studies on material longevity, degradation, and preservation. Its expertise in natural and synthetic polymers, organic materials, and coatings is directly applicable to sustainable material innovation and biopolymer research.

Cooper Hewitt, Smithsonian Design Museum (New York) – Part of the Smithsonian Institution, a network of 21 museums, galleries, and research centres, Cooper Hewitt is the only museum in the US dedicated exclusively to design. The museum houses a world-renowned conservation department, specialising in historic and contemporary materials, including plastics, bioplastics, and sustainability-focused design practices. Cooper Hewitt actively collaborates with global researchers and institutions to explore the impact of materials on design history, museum collections, and conservation science.

Museum of Modern Art (MoMA) Conservation Department (New York) – A leader in the scientific study and preservation of modern and contemporary materials, particularly in industrial design, synthetic polymers, and contemporary artworks. MoMA's Conservation Science Department investigates polymer degradation, structural stability, and preventive conservation methodologies, playing a critical role in evaluating bio-based materials for museum use and broader sustainable material adoption.

Healthy Materials Lab (Parsons School of Design, New York) – A research initiative dedicated to eliminating harmful chemicals from material production and promoting healthy, non-toxic alternatives for architecture and design. The lab's work is critical in testing and validating sustainable materials, ensuring they meet health, environmental, and performance standards for real-world applications.

Natural Materials Lab (Columbia Graduate School of Architecture, Planning and Preservation, New York) – A leading research facility exploring raw, earth- and fibre-based building materials, their life cycles, fabrication techniques, and structural applications. Directed by Lola Ben-Alon, the lab integrates material science, architecture, engineering, and sustainability research, investigating the potential of bio-based and low-carbon materials for the built environment.

Aesop Global Design Team (Paris & Global) – Aesop's design team has been at the forefront of integrating sustainable materials into commercial interiors, including the first commercial interior application of algae-based biopolymers in its Hainan retail store. The brand serves as a case study for industry-driven material adoption, demonstrating how sustainable materials can transition from prototype to commercial application.

Future Materials Bank (Jan van Eyck Academie, Maastricht) – A global database of sustainable materials, mapping out innovations across design, architecture, and science. The platform serves as a research hub for artists, designers, and material scientists, cataloguing bio-based and low-impact materials for wider industry application.

Gallery Climate Coalition (GCC, Europe & Global) – An international network of galleries, museums, and cultural organisations committed to reducing the art industry's carbon footprint and transitioning towards sustainable exhibition practices. GCC provides guidance on material sustainability, shipping and logistics emissions, and climate-conscious conservation strategies, actively working with institutions to phase out petrochemical-based materials.

Bauhaus Earth (Berlin) – A research and advocacy organisation dedicated to transforming the built environment through the adoption of low-carbon, regenerative materials. Bauhaus Earth collaborates with architects, policymakers, and industry leaders to accelerate material transitions and create frameworks for sustainable building practices.

E-Werk Luckenwalde (Germany) – A cultural institution that operates as an energy-positive arts centre, repurposing a Soviet-era coal power station into a renewable energy producer. E-Werk runs on locally sourced woodchips from the timber industry, generating electricity under its own Kunststrom (Art Power) network, with proceeds funding its cultural programming. It also serves as a centralised hub for material reclamation and circular economy initiatives, particularly for architectural and exhibition materials.

Assemble (London) – A multidisciplinary architecture and design collective focused on socially engaged design and material sustainability. Assemble's projects often integrate experimental materials, adaptive reuse strategies, and circular economy principles, demonstrating real-world applications of sustainable materials in architecture, public space, and cultural institutions.

Haeckels (formerly known as Haeckels, currently undergoing a brand transition, Margate) – A pioneering sustainable skincare brand known for developing innovative biodegradable packaging and material alternatives, including algae-based biopolymers. Their Margate-based lab and production facilities serve as a hub for regenerative material experimentation in consumer goods.

Central Saint Martins (CSM) Biodesign Course (London) – A leading academic program that integrates biology, material science, and design to develop sustainable and regenerative materials. The course fosters interdisciplinary research and has been instrumental in shaping the field of biodesign through practical experimentation and industry collaborations.

Hauser & Wirth (London & Global) – A leading international gallery known for its commitment to sustainability in exhibition design and operations. Hauser & Wirth integrates circular economy principles, explores non-toxic materials, and works to reduce waste in gallery infrastructure. The gallery aligns with the Gallery Climate Coalition’s initiatives and collaborates with designers and material innovators to promote sustainable practices in the art world.

Material and packageing samples in Margate of the company formerly known as Haeckels. Photo by Jessie French.

Conservation Lab at Cooper Hewitt, Smithsonian Design Museum, New York. Photo by Jessie French.

07
Fellowship Learnings

1. Conservation & Material Science: What Museums Can Teach About Material Longevity

One of the most unexpected yet critical insights from this Fellowship came from the field of museum conservation and materials science. Museums and conservation institutions—such as The Met, Cooper Hewitt, and MoMA—operate under the unique imperative of longevity. Their expertise extends beyond preserving historical materials to understanding how new materials degrade, interact with environments, and remain viable over time.

This research has direct implications for sustainable material development:

- **Degradation patterns of biologically-originating materials** – How sustainable materials break down or persist in both controlled and uncontrolled environments.
- **Scientific testing of materials** – Evaluating humidity resistance, UV exposure, and thermal durability, crucial for architecture and commercial applications.
- **Historical precedents of natural polymers** – Learning from traditional materials like shellac, gutta-percha, and early bioplastics to inform the design of contemporary bio-based materials.

Key Engagements & Learnings

- **Cooper Hewitt, Smithsonian Design Museum** – Engaged with conservators and material scientists studying historical plastics and contemporary alternatives.
- **Meetings with Sarah Barak (Head of Conservation, Cooper Hewitt, Smithsonian Design Museum) and Jessica Walthew (Conservator, Cooper Hewitt, Smithsonian Design Museum)** – Examined strategies for material longevity, conservation challenges, and restoration techniques for new bio-based materials.
- **MoMA Conservation Lab (Catherine H. Stephens)** – Investigated the role of scientific testing in validating material composition and stability, particularly in exhibition and institutional applications.
- **Natural Materials Lab (Columbia University, Lola Ben-Alton)** – Studied natural, bio-based materials such as rammed earth, cob, and straw-clay, including their manual and digital fabrication techniques.

These engagements shifted the perspective of how new materials should be evaluated—not simply on immediate performance but on their behaviour over time, a crucial missing factor in many material trials.

New material innovation should not exist in isolation from historical conservation research. The extensive body of knowledge on material ageing, restoration, and resilience offers valuable insights that can accelerate the validation and commercial viability of sustainable materials. Moreover, experts in organic materials, polymer science, and materials engineering bring specialised expertise that can optimise production processes, refine key ingredient selection, and enhance application methods. Integrating these disciplines strengthens the foundation for material innovation.

2. New Materials in the Built Environment: Certification, Testing & Market Barriers

While biopolymers and alternative materials are often discussed in terms of sustainability and innovation, their actual adoption in commercial and industrial applications is heavily dictated by certification, safety testing, and industry standards.

A recurring challenge for new material integration is navigating the technical and regulatory landscape required for commercial application, particularly in the built environment. These include:

- **Fire Safety Testing (ASTM, EN, ISO standards)** – Many new biomaterials struggle to meet fire-retardant requirements, limiting their use in architecture and interior applications.
- **Tensile Strength & Load-Bearing Performance** – New materials must undergo engineering assessments to determine their ability to withstand mechanical stress, compression, and thermal expansion.
- **Industry Certification & Compliance** – Without adherence to building codes, environmental health regulations, and durability requirements, sustainable materials risk being classified as experimental rather than viable commercial solutions.

Key Engagements & Learnings

Bauhaus Earth (Berlin) – Investigated research into low-carbon materials for the built environment, and how they undergo industry-standard testing for regulatory approval.

Assemble (London) – Examined case studies of material integration in architecture, including how designers are navigating risk and uncertainty maintenance challenges in sustainable materials.

Aesop Hainan Retail Store Project – Provided direct experience in integrating novel non-petrochemical biopolymers into a commercial retail interior, including technical refinements based on Fellowship learnings to improve longevity and humidity resistance.

Sustainable materials will not gain mainstream adoption unless they are certified, standardised, and able to meet industry compliance requirements. The real work in this space is not just material innovation but navigating the structural barriers to industry acceptance.

3. Circular Economy in Practice: Real vs. Theoretical Models

A dominant theme across global discussions on sustainable materials is the transition from a linear economy (take-make-dispose) to a circular economy (reuse-recycle-reintegrate). However, while the concept is widely endorsed, its practical implementation is uneven and often misrepresented.

This Fellowship examined real-world circular systems, identifying:

- **What works** – Data-backed, certified and demonstrated change that is easy to implement, such as Healthy Material Lab's Material Collections (Healthy Materials Lab, n.d.) to provide resourcing to designers specifying products.
- **What fails** – Systems that rely on voluntary recycling without legislative backing.

- **Where circularity is legislated** – The EU Circular Economy Action Plan (CEAP), which enforces recyclability, repairability, and material transparency.

Key Engagements & Learnings

Smithsonian Exhibits Team (Washington, D.C. – met in New York) – Explored internal recycling and material reuse systems in museum production.

E-Werk (Berlin) – Studied how this energy-positive institution operates a centralised circular materials hub, integrating material reclamation into energy production, propelling exhibition and architectural workflows.

Future Materials Bank (Maastricht) – Mapped out global research into material circularity, particularly how bio-based materials are envisioned by post-grad students fit into circular economic models.

Despite growing interest in circular economies, the fundamental issue remains: current systems are not designed for circularity. Most materials, whether petrochemical-based or bio-based, are still produced, marketed, and consumed within a fundamentally linear economic structure.

True circularity cannot be achieved simply by developing new materials. It requires structural changes in production, supply chains, and business models.

4. Shifting Industry Perceptions: Regulation-Driven vs. Voluntary Adoption

The final major insight of the Fellowship was that industry adoption of sustainable materials is largely driven by regulation, not voluntary market shifts.

Despite growing corporate interest in sustainability, large-scale material transitions only occur when:

- **Government regulations mandate material changes** (the EU's regulatory framework for managing chemicals and hazardous substances in materials, which is impacting some petrochemical).
- **Economic incentives make sustainable alternatives commercially viable.**
- **Corporate sustainability commitments align with financial and brand objectives.**

This contrast was particularly evident in discussions with commercial players in Europe, who are already anticipating and adapting to forthcoming regulatory mandates requiring the phasing out of hazardous materials—a proactive approach not yet mirrored in Australia.

Two key regulatory frameworks shaping market attitudes in the EU towards sustainable materials are REACH (Registration, Evaluation, Authorisation, and Restriction of Chemicals) and the EU Circular Economy Action Plan (CEAP).

REACH is the EU's comprehensive chemical regulation, designed to protect human health and the environment by restricting hazardous substances in products and materials. It obliges manufacturers and importers to register chemicals, evaluate their safety, and phase out harmful substances such as toxic plasticisers, heavy metals, and persistent pollutants (European Parliament and Council of the European Union 2006). This regulation directly impacts industries reliant on PVC, plastics, and synthetic materials, pushing them towards safer, more sustainable alternatives.

The CEAP, a central initiative of the European Green Deal, aims to transform the EU's economy from a linear, waste-intensive model to a circular system. It enforces stricter regulations on product design, waste reduction, and sustainable material use, with a particular focus on plastics, packaging, textiles, and construction (European Commission 2020). By mandating recyclability, repairability, and material transparency, the CEAP promotes the adoption of bio-based, non-toxic, and reusable materials, while discouraging the continued dependence on virgin plastics and waste-heavy production methods.

These policy-driven shifts create a far more receptive environment for sustainable materials in the EU—a contrast to Australia, where the absence of equivalent regulatory pressures has resulted in slower industry uptake.

Key Engagements & Learnings

- **Hauser & Wirth (London)** – Investigated how major cultural institutions in Europe are proactively shifting toward sustainable materials in exhibition design, reflecting a broader industry trend towards environmental responsibility.
- **Kim Kraczon (Berlin)** – As an active advisor to cultural institutions worldwide and a key figure in the Gallery Climate Coalition, Kraczon has played a pivotal role in guiding museums and galleries towards sustainable material transitions. Her expertise underscores the structural and policy shifts required to embed sustainable practices within the cultural sector.

Sustainable materials will not reach scale through voluntary adoption alone. Legislative frameworks, financial incentives, and compliance mandates must play a role in accelerating their market integration. The insights gained through this Fellowship highlight that sustainable material adoption is not just a technical challenge but a systemic one, requiring intervention at multiple levels.

Future work must focus on:

- **Building industry certification pathways for new materials**, ensuring regulatory clarity and market acceptance.
- **Strengthening regulatory incentives** in Australia to encourage sustainable material uptake.
- Developing frameworks for **integrating existing material science expertise into material R&D**, drawing on expertise from conservation laboratories, scientific research, and industry specialists.
- Shifting the conversation from material novelty to viability, ensuring that **sustainable materials are positioned not just as alternatives, but as viable replacements** in mainstream industries.

These learnings will directly inform the next phase of research and material trials, driving practical applications and industry adoption strategies that prioritise scalability, performance, and compliance.

Samples displayed at the Donghia Healthier Materials Library, Parsons School of Design, New York. Photo by Jessie French.

Future Materials Library at Jan van Eyck Academie, Maastricht. A resource dedicated to regenerative, experimental, and post-industrial materials. Photo by Jessie French.

08
Personal, professional, and sectoral Impact

This section outlines the tangible and anticipated impacts of the Fellowship across personal, professional, and sectoral levels. While the Fellowship provided critical research insights, its broader significance lies in how these insights translate into real-world applications, industry influence, and long-term material transitions.

Rather than viewing the impact as an immediate transformation, it is essential to recognise that material innovation operates on extended timescales. The true impact of this Fellowship will unfold over years, as research findings are applied, industry networks strengthen, and policy shifts align with emerging material solutions.

1. Personal Impact

Deepened knowledge of material longevity, industry integration, and global certification pathways

The Fellowship provided an overarching macro-view of key industries, commercial dynamics, and regulatory landscapes that influence the development and adoption of sustainable materials. Beyond expanding knowledge in material innovation, it also reinforced a more strategic, structured approach to navigating industry barriers—from certification hurdles to market positioning.

Key learnings at the intersection of science, conservation, and industry have informed a more refined approach to material research, technical development, and commercialisation strategies. For example:

- Engagements with museum conservation experts provided critical insights into material degradation, long-term performance, and restoration methodologies—key considerations for ensuring that new biomaterials meet institutional and commercial durability expectations.
- Discussions with Future Materials Bank and Parsons Healthy Materials Lab reinforced the need to position sustainability not only as an ecological necessity but as a commercial and regulatory inevitability.
- Experience with European material regulations highlighted gaps in Australian policy and industry readiness, prompting the need for long-term advocacy and collaboration to advance policy-driven material transitions.

The Fellowship strengthened strategic thinking in material development, emphasising the importance of industry engagement, certification pathways, and long-term research partnerships to enable real adoption beyond speculative applications.

Expanded global network & direct industry opportunities

One of the most immediate personal impacts was the expansion of a global network of collaborators, researchers, and industry contacts, many of whom have already contributed to ongoing projects.

This has materially influenced the trajectory of my practice in tangible ways:

- Aesop Hainan retail store commission: The Fellowship directly led to the first commercial interior application of algae-based biopolymers. This experience provided valuable real-world insights into manufacturing constraints, durability testing, and industry expectations, which will inform future industry applications.
- Royal Academy Summer Exhibition (London): A direct outcome of connections made through the Fellowship, this commission brought algae-based material innovation into a mainstream architectural and design forum, engaging over 200,000 visitors and prompting media discourse on new material futures.
- Engagements with Bauhaus Earth and Assemble: These discussions have opened opportunities for further research and pilot collaborations, particularly in the intersection of bio-based materials and the built environment.

The relationships established through the Fellowship are not just passive contacts—they are active collaborations that are shaping future projects, material applications, and industry influence.

2. Professional Impact

Refinement of business and scaling strategies

The Fellowship directly influenced business strategy, leading to a more informed, structured approach to:

1. Scaling material innovation into industry applications

- Moving beyond research and experimental projects toward scalable, commercially viable applications
- Understanding the practical challenges of integrating new materials into architectural, design, and commercial sectors
- Developing pathways to certification, regulatory compliance, and industry adoption

2. Strategic research & development planning

- Designing targeted R&D trials informed by museum conservation insights
- Establishing data collection methodologies to validate material longevity and environmental performance
- Exploring strategic partnerships for material testing and validation

3. Building a sustainable business model for material innovation

- Developing financial sustainability models for long-term research and production
- Identifying key funding opportunities and investment pathways to support material development
- Engaging with industry partners, policymakers, and advocacy groups to align material innovation with market readiness

The Fellowship reinforced the reality that material innovation cannot succeed in isolation—it must be strategically aligned with industry demands, regulatory shifts, and commercial pathways.

3. Sectoral Impact

Influencing industry perceptions of material sustainability

A key sectoral impact of the Fellowship has been shaping discourse around sustainable materials within design, architecture, and industry circles. While the immediate material transitions may be slow, the shift in industry perception is already taking place. This is evidenced by:

- Aesop's decision to commission algae-based biopolymer panels reflects an increasing appetite for sustainable materials in high-end retail and commercial interiors. This sets a precedent for other brands to explore non-petrochemical material alternatives.
- The Royal Academy Summer Exhibition showcased sustainable material applications in its architecture rooms and a focussed architecture and design forum, reinforcing biopolymer viability in contemporary practice.

- Discussions with commercial players in Europe demonstrated that material transitions are being driven by regulatory expectations rather than voluntary sustainability commitments—an insight that informs advocacy efforts in the Australian market.

While a single Fellowship cannot shift an entire sector overnight, it contributes to incremental industry change by raising awareness of biopolymer alternatives in mainstream design and architecture contexts, creating case studies of industry adoption, which others can learn from and build upon and contributing to broader material discourse through exhibitions, publications, and industry collaborations.

Challenges and structural barriers

Despite these positive shifts, the Fellowship also reinforced the structural challenges that must be addressed for real sectoral impact:

- Regulatory lag in Australia: Unlike the EU, which is actively phasing out harmful materials, Australia lacks clear policy directives for transitioning to sustainable alternatives.
- Manufacturing constraints: Without localised production infrastructure, many sustainable materials remain financially uncompetitive against mass-produced petrochemical plastics.
- Lack of industry standardisation: Without clear testing and certification frameworks, new materials face adoption barriers, particularly in architecture and industrial design.

Future sectoral engagement

In response to these challenges, the next phase of work will focus on:

1. **Industry pilot projects** – Expanding on current early industry trial partner commissions to explore additional commercial and architectural applications.

2. **Policy engagement** – Advocating for Australian regulatory alignment with EU material restrictions and sustainability incentives.

3. **Technical Data Development** – Establishing a structured testing framework for proprietary non-petrochemical polymers, informed by conservation science and engineering methodologies.

The Fellowship has initiated a vision for sectoral shift in material awareness and industry engagement. The next challenge is in translating these insights into sustained industry adoption and regulatory progression.

The Fellowship as a catalyst for long-term impact

While the full impact of this Fellowship will unfold over years, its initial effects are already evident in expanded industry engagement and global networks, a more structured approach to material research, validation, and certification and real-world case studies demonstrating biopolymer application in commercial and design contexts.

Going forward, the focus will be on leveraging these insights into action, ensuring that sustainable materials move beyond speculative innovation and into industry-wide adoption.

The true success of sustainable materials lies not just in their creation, but in their integration. The insights from this Fellowship are now guiding the next phase of this work—turning research into reality.

Department of Scientific Research, The Metropolitan Museum of Art, New York. Photo by Jessie French.

09

Recommendations and Considerations

The Fellowship identified key opportunities, challenges, and structural gaps that influence the adoption of sustainable materials, particularly algae-based biopolymers and alternative material systems. These recommendations are designed to address these barriers and create actionable pathways for advancing sustainable material integration.

A transition to non-petrochemical materials requires strategic investment, global collaboration, regulatory alignment, and industry education. It also necessitates a clear distinction between real innovation and marketing-driven claims, ensuring that material adoption is based on verifiable environmental benefits and technical performance rather than trend-driven novelty.

These recommendations are aimed at designers, manufacturers, policymakers, investors, and industry leaders, providing a structured roadmap for ensuring that sustainable materials move beyond speculative research and into scalable industry adoption.

1. Global Networks & Strategic Travel for Industry Engagement

Travel, and particularly establishing a global network, is crucial for building industry relevance and securing opportunities in material innovation. The sustainable materials sector is highly specialised, and key insights, collaborations, and business opportunities arise from direct engagement with global leaders, material scientists, and industry pioneers.

Australia’s geographic distance from major innovation hubs creates a structural disadvantage. Without proactive international engagement, Australian designers and material developers risk operating in isolation from the critical advancements and regulatory shifts taking place in Europe, North America, and parts of Asia.

Key Actions

- Establish formal international exchange programs for sustainable material practitioners to engage with European and North American R&D hubs.
- Develop ongoing relationships with global material experts in conservation, architecture, manufacturing, and industrial design.
- Participate in international material forums and exhibitions to ensure industry alignment and visibility.
- Leverage global networks to access funding, commercial opportunities, and industry pilots.

A successful materials practice cannot operate in isolation—it must be embedded within a global discourse to ensure relevance, credibility, and access to opportunity.

2. Building Industry Knowledge & Distinguishing True Innovation from Marketing Hype

The sustainable materials industry is filled with overstated claims of innovation, many of which lack scientific rigor, real-world testing, or proven impact. The ability to 'read' through a wide range of processes, technical descriptions, and industry claims is an essential skill when navigating this space.

Before embarking on research or material development, it is crucial to understand the specific regulatory, production, and commercial challenges unique to each material application. The industry is highly fragmented, with each segment requiring distinct expertise. A material that works in packaging may be completely unsuitable for architectural applications, and vice versa.

Key Actions

- Develop technical literacy in material performance metrics (e.g., tensile strength, fire resistance, biodegradability rates, recyclability pathways).
- Critically assess industry claims to distinguish genuine innovation from rebranded conventional processes.
- Recognize the nuances between material applications—what works for industrial design may not translate into the built environment.
- Identify what is relevant for your own material development path rather than following broad industry trends.

The ability to decode complex industry language and identify real opportunities is crucial for navigating the noise in the sustainable materials sector.

3. Developing Global Industry Partnerships for Commercialisation

For new materials to succeed, they require strong commercial and industry partnerships that enable scaling, distribution, and real-world application. The right partners may include:

- Distributors (to provide access to supply chains)
- Clients & end-customers (who can champion the material in industry settings)
- Expert consultants / partners (who can navigate regulatory and production hurdles)
- Publicity links (to build market awareness and credibility)
- Funding sources (to support R&D and production costs)

Without strong industry partners, many new materials fail to reach commercialisation due to a lack of market traction or financial backing.

Key Actions

- Map out potential commercial partners in key regions and sectors.
- Establish pilot programs with industry leaders to demonstrate material viability.
- Engage in cross-disciplinary partnerships to ensure material adoption is aligned with industry needs.
- Create pathways for scaling production, including licensing agreements and localized manufacturing options.

New materials do not succeed in a vacuum—they need the right partners to enter the market, gain traction, and achieve scalability.

4. Addressing Key Challenges in Material Adoption

Key Challenges Identified in the Fellowship:

- Lack of transparency in the commercial space due to intellectual property sensitivities and proprietary production processes.
- High variability between regulatory frameworks across markets, making standardization difficult.
- Low public understanding of sustainable materials, necessitating increased education and communication efforts.

- Fragmented market applications—what works for one industry (e.g., built environment) may not apply to another (e.g., food packaging).
- High R&D and production costs—new materials are often more expensive than petrochemical counterparts, requiring strategic market positioning.

Key Actions

- Establish clearer pathways for regulatory approval to streamline industry adoption.
- Increase material education programs for industry and the public to drive informed adoption.
- Differentiate material applications to avoid a one-size-fits-all approach to sustainability.
- Develop strategic pricing models to ensure early-stage material adoption occurs in high-value markets that recognize the long-term benefits.

The challenges facing sustainable materials are structural, regulatory, and economic—addressing them requires a coordinated effort across multiple sectors.

5. Closing Gaps in Market Development & Policy Readiness

Key Market Gaps Identified

- The sustainable materials market is still in its early stages, meaning there are substantial opportunities for innovation and commercialization.
- The EU leads in regulatory maturity, providing greater opportunity for sustainable materials in those markets compared to Australia, where industry understanding, and policy incentives remain underdeveloped.

Key Actions

- Align Australian material policies with EU environmental regulations to ensure global market compatibility.
- Position sustainable materials in regions or markets that already recognise their value, rather than relying on markets that are still catching up.
- Advocate for structured industry incentives to offset the higher costs of sustainable materials in early adoption phases.

Markets that recognise the value of sustainable materials will move first—those that lag risk becoming irrelevant in global supply chains.

The findings of this Fellowship reinforce that material innovation is not just a question of technology—it is a question of systems, economics, and regulation.

Going forward, the focus must be on:

1. Building global networks to ensure industry relevance and access to opportunities.

2. Developing technical literacy to distinguish genuine material innovation from superficial sustainability claims.

3. Creating strong industry partnerships to enable scaling and commercialization.

4. Addressing regulatory and economic challenges that hinder market adoption.

5. Closing policy and market gaps to align with international leaders in sustainable material adoption.

The future of materials is not just about replacing petrochemicals—it is about redesigning industry systems to support long-term sustainability.

Material selection wall at Assemble's architecture studio in London, featuring experimental and low-impact materials. Photo by Jessie French.

10
Conclusion

The shift isn't just about materials. It's about the systems that govern them, the industries that resist them, and the economies that shape them. This Fellowship has traced the movement of sustainable materials through institutions, laboratories, exhibitions, and commercial spaces—each revealing a distinct set of constraints, pressures, and opportunities.

What emerges is a clear pattern: materials don't exist in isolation. They move through regulatory frameworks, financial structures, and design methodologies that dictate their viability. If a material fails, it is rarely because it wasn't innovative enough—it's because it didn't fit within the existing industrial logic. The challenge is not just making better materials, but making materials that industries know how to use.

In Europe, the transition is already in motion. Designers and manufacturers aren't waiting for sustainability to become an economic necessity—they are prototyping replacements, testing limits, and positioning themselves ahead of regulatory mandates. The Australian context lags, not because the materials don't exist, but because the urgency does not yet align with the infrastructure that dictates adoption. The real work ahead is in establishing the mechanisms that allow sustainable materials to integrate into production, commerce, and legislation before they are legislated into necessity.

One of the central learnings from this Fellowship is that the barriers to material adoption are rarely technical—they are systemic. New materials encounter the friction of industry habits, the inertia of existing supply chains, and the economic weight of petrochemical dominance. Without policy-driven intervention or structural incentives, sustainable alternatives remain marginal, experimental, or financially uncompetitive.

This is a problem that cannot be solved in a vacuum. Global material transitions are already being engineered in anticipation of market shifts—whether through regulatory bans, corporate ESG mandates, or the steady erosion of petrochemical cost advantages. The question is not if these materials will become necessary, but when industry will be forced to integrate them, and on whose terms.

For Australia, the opportunity is clear: engage early, build strategically, and leverage international momentum. The alternative is to remain in a passive market position, waiting for externally-imposed shifts that will leave local industries struggling to catch up. The failure to engage in material innovation is not just an environmental risk, but an economic one.

The next phase of this work is not about chasing innovation for its own sake. It is about creating the conditions where sustainable materials are not just an alternative but an inevitability. This means:

- Developing structured pathways for material testing and certification—ensuring that sustainable materials are technically validated within existing compliance systems rather than waiting for new ones to be invented.

- Aligning Australian policy with European regulatory shifts—so that local industries aren't left scrambling to adapt to external mandates when the market forces the transition.
- Positioning materials where they will gain traction first—not in speculative, high-risk applications, but in markets and industries that recognize their value now.
- Leveraging global partnerships to accelerate material trials and commercial adoption—turning knowledge networks into economic opportunities.
- Shifting material discourse from novelty to necessity—making sustainability not just a branding exercise but an industrial reality.

This Fellowship has reinforced that sustainable materials will not succeed because they are more ethical, more advanced, or more aesthetically compelling. They will succeed when they are embedded in the mechanics of industry, logistics, and economy.

The materials themselves are not the endpoint. They are vectors for economic and environmental transition, indicators of where industry is moving and how it will be forced to adapt. The real challenge is not inventing better materials, but designing a system where better materials are viable, scalable, and inevitable.

The work ahead is not just to innovate but to restructure—to create the market conditions, industrial frameworks, and economic alignments that will ensure sustainable materials move from the speculative to the systemic.

Production facility in Margate of the company formerly known as Haeckels. Photo by Jessie French.

‘I suggest looking outside the window: if you like what you see, there’s no reason for new projects. If, on the other hand, there are things that fill you with horror... then there are good reasons for your project.’

Enzo Mari

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