Chapter: Wearable Ecologies, Fashion, Technology, and Intelligent Matter

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Chapter Abstract

This chapter examines the future of fashion through the emergence of intelligent matter: responsive textiles, adaptive colour, programmable form, biofabricated materials, artificial intelligence, digital product passports and regenerative systems. It argues that fashion's most significant transformation will not occur only at the level of silhouette, image or seasonal novelty, but at the level of material behaviour. Colour, material and finish are shifting from passive aesthetic attributes into active systems that can sense, respond, disclose, repair, biodegrade, regulate, authenticate and communicate across bodies, environments, data infrastructures and waste streams. Drawing on posthuman theory, new materialism and fashion studies, the chapter reframes the garment as a situated interface between skin, atmosphere, information and ecology. Rather than celebrating technological innovation as inherently progressive, it asks what responsibilities emerge when matter becomes intelligent. Through discussions of sensory textiles, structural colour, symbiotic skins, pollution-derived materials, AI-assisted design and the ethics of endings, the chapter proposes "wearable ecology" as an alternative to conventional wearable technology. In this model, garments are judged not by novelty or responsiveness alone, but by the relations they make visible, the harms they reduce and the forms of care they enable. Ultimately, the chapter argues that the future of fashion is not simply smart, seamless or technologically enhanced, but materially accountable, socially situated and ecologically responsible.

Keywords:

fashion futures; intelligent matter; wearable ecology; adaptive CMF; responsive textiles; artificial intelligence; posthuman fashion; new materialism; regenerative design; biofabrication; digital product passports; circular fashion; Karen Barad; Rosi Braidotti; Donna Haraway; Anneke Smelik; Jean Baudrillard; Juhani Pallasmaa; Sara Ahmed.

Prelude: The Matter of Forgetting

> The island is stirred up after a disappearance. People gather in little groups out in the street to talk about their memories of the thing that's been lost. There are regrets and a certain sadness, and we try to comfort one another. If it's a physical object that has been disappeared, we gather the remnants up to burn, or bury, or toss into the river. But no one makes much of a fuss, and it's over in a few days. Soon enough, things are back to normal, as though nothing has happened, and no one can even recall what it was that disappeared. (7)
>
> Yōko Ogawa *The Memory Police* (2019)

In Yōko Ogawa's *The Memory Police*, disappearance is not an event but a system. On an unnamed island, things vanish one by one: flowers, birds, photographs, calendars, ribbons, perfumes, maps. Their disappearance is not only material, though, once an object has been removed from the world, the memory of it also begins to fade. People wake to the strange knowledge that something has gone, gather what remains, and surrender it to destruction. They do not simply lose access to things; they lose the capacity to remember what those things meant, how they were used, what they touched, what sensations they carried, what forms of life they sustained. The Memory Police (who enforce this vanishing) search homes, confiscate remnants, and pursue those rare figures who continue to remember what the island has been made to forget (Ogawa 2019). Ogawa's novel offers a haunting way to think about fashion because, it too, depends on orchestrated disappearance. The industry is built not only on the production of newness, but on the repeated fading of attachment. Colours disappear from desirability, silhouettes quickly lose their cultural charge, and fabrics fall out of fashion. Garments that once carried intimacy, aspiration, identity or promise become tired, embarrassing, excessive or obsolete. The back of the wardrobe becomes a (sad) private archive of these small disappearances. Fashion does not need a formal police force to make objects disappear from memory…instead it has seasons, trends and eventual discard.

Fashion has always been a technology of the future, long, long before Silicon Valley discovered the language of the interface. A garment is a threshold: between self and public, fantasy and memory and projection. The history of fashion, then, is not only a

history of styles. It is also a history of materials communicating. The forthcoming decades of fashion will not only be defined by new silhouettes, colour stories, or the predictable rehashing of a previous decade's styles. The most significant transformation will be happening at the level of matter itself. Colour, material and finish: (what the design industries call CMF,) are moving from static attributes to remarkably adaptive behaviours. As a result, the future fashion surface will not simply soften, stiffen, stretch, shimmer or drape across the body as a passive skin of appearance. It will increasingly exhibit autonomous behaviours. It may sense the warmth of the wearer, the pressure of movement, the humidity of a room, the toxicity of air, or the changing conditions of light. It may respond through colour, texture, permeability, tension or touch, shifting its chromatic state like a living signal rather than a fixed seasonal shade; store information about fibre content, chemical treatments, provenance, repair history and end-of-life pathways, allowing the garment to speak not only of style but of origin, labour and consequence; or even regulate heat, cool the body, support recovery, assist healing, biodegrade under carefully designed conditions, or disclose when it has been damaged, contaminated, exhausted or ready for repair. In its most ambitious form, the fashion surface may even move beyond protection and expression to participate in environmental repair: absorbing pollutants, supporting microbial life, returning nutrients, or making visible the atmospheric and material harms that fashion has too often kept elsewhere. The surface, then, is no longer merely the place where fashion is seen, it becomes the place where fashion performs itself.

This does not mean that every garment should become technological, nor that intelligence should be confused with novelty. A textile that senses the body while extracting intimate data is not inherently progressive. A biodegradable fibre that only decomposes under unavailable industrial conditions is not meaningfully ecological. A colour-changing finish that contaminates recycling streams is not intelligent simply because it responds. The promise of adaptive fashion depends on whether these material behaviours reduce harm, extend use, support care and make the garment's relations more visible. As Anneke Smelik argues, clothing is never inert matter; it is already a material assemblage entangling bodies, labour, technologies, planetary resources and waste (Smelik 2026). Future fashion should therefore not ask only what matter can do, but what responsibilities its actions create.

This chapter begins from the opposite premise to the epigraph: that the future of fashion must be understood not through forgetting, but through material memory. If the coming decades of fashion are to be shaped by intelligent matter, responsive textiles, adaptive colour, biofabricated materials, digital product passports, artificial intelligence and regenerative design, then the central question is not only what these systems can do, but also what they will allow fashion to remember. The capacities of future garments will matter only if they interrupt fashion's culture of disappearance. Intelligent matter must not become another way of making extraction disappear behind technological wonder. It must become a way of making relations legible.

The Future Will Be Worn (Out): Fashion, Technology, and Intelligent Matter

This marks a pretty radical shift from 'surface as appearance' towards 'surface as behaviour'. Colour, material and finish are no longer only aesthetic decisions made at the end of the design process; they are becoming active systems through which garments communicate with bodies, climates, data infrastructures and waste streams. Responsive pigments may register heat, light, pollution or bodily change. Smart textiles may monitor movement, temperature or pressure. Bioactive membranes may support comfort, recovery or protection. Digital product passports may allow a garment to disclose its fibre content, chemical treatments, repair history and end-of-life pathway (European Commission 2022). In this sense, the garment becomes less like a passive commodity and more like a situated interface: a material threshold between skin, atmosphere, information and ecology.

In this new model, a jacket might warm through light-absorbing particles rather than bulky insulation. A dress might shift colour in response to heat or air quality, pigments might be cultivated by bacteria rather than mined from the earth, or a shoe upper might be sprayed robotically in one seamless act rather than cut, stitched and glued. This is why fashion futures must pay close attention to CMF.

This also marks a decisive shift from fashion as image to fashion as intelligent matter which reflects a broader cross-industry movement from passive surfaces towards intelligent, responsive and regenerative systems (Palmer and Smith 2025). This is not a minor technical adjustment. It asks fashion to reconsider its deepest cultural habits. The modern fashion system has largely been built on acceleration: more seasons and product drops, more synthetic novelty, logistics, extraction, more returns…ultimately more waste.

The language of sustainability has tried, often heroically (but realistically inadequately,) to slow that machine down. Yet slowing alone is no longer enough. The Organisation for Economic Co-operation and Development projects that global material use could more than double from 79 gigatonnes in 2011 to 167 gigatonnes by 2060, even with expected gains in efficiency and relative decoupling (OECD 2019). Meanwhile, the circular economy's promise remains under-realised. Circle Economy reported that the share of secondary materials consumed by the global economy fell from 9.1 percent in 2018 to 7.2 percent in 2023, and its 2025 update placed global circularity even lower, at 6.9 percent (Circle Economy Foundation 2024; Circle Economy Foundation 2025). Recycling, by itself, is not saving us from the appetite of the system.

Fashion futures therefore require a more radical positioning: what if the garment were designed not as an object to be consumed, but as a living participant in a material ecology? This question moves away from the exhausted binaries between natural and synthetic, and craft and technology. Moving instead towards a more complex field in which biotechnology, structural colour, 4D printing, regenerative design, soft robotics, responsive textiles, compostable polymers, pollution-derived pigments and digital product passports will all become part of the same dialogue.

That conversation is not simply about making fashion less harmful. It is about making fashion behave differently. For me, it introduces the concept of a 'Wearable ecology' which offers a way to make fashion's intelligent future more accountable by shifting attention from what a garment can do to the relations it produces. It is not enough for a textile to sense, respond, change colour, store data, biodegrade or authenticate itself. A wearable ecology evaluates whether such capacities contribute to more responsible material, social and ecological relations. It asks fashion technologies to reduce extraction and total material throughput rather than adding another layer of material novelty to an already excessive system. It requires garments to protect bodily privacy and autonomy rather than turning the wearer into a site of continuous data capture. It values repair, adaptation, modularity, changing fit and emotional durability as ways of extending use, rather than allowing responsiveness itself to become another accelerated trend.

This is where posthumanist and new materialist thinking become relevant to the analysis. If matter is not passive, then fashion cannot continue to treat fibres, dyes, coatings, microbes, minerals, animals, plastics and atmospheres as silent resources awaiting conversion into style (Barad 2007; Braidotti 2013; Haraway 2016). The future garment will be judged by its relations: what it extracts, what it emits, what it stores, what it reveals, what it repairs and how it ends. Wearable technology has often imagined the body as a site of data capture; wearable ecology asks a larger question. How might clothing participate in more careful relations between bodies and worlds? In that sense, the future of fashion is not only wearable technology. It is wearable ecology: a form of dress that recognises the garment as an active participant in biological, social, climatic and material systems. A wearable ecology is a garment-system evaluated according to material throughput, bodily autonomy, labour visibility, data restraint, repairability, end-of-life viability, and more-than-human care.

A wearable ecology also demands that garments disclose their provenance, labour conditions, chemistry and afterlife, making their histories and futures legible rather than hidden. It supports recycling, composting and reuse systems only when technical complexity does not contaminate the circular infrastructures such systems claim to serve. Most importantly, it extends care beyond the individual consumer to workers, non-human life, atmospheric systems, waste streams and future ecologies. Understood in this way, wearable ecology is not simply another name for wearable technology. It is an ethical method for judging whether fashion's future materials reduce harm, support sufficiency and participate in more responsible forms of living with matter.

From Surface to Behaviour

The emerging CMF paradigm alters previous theoretical frameworks in fashion studies. Fashion critical theory investigates image, identity and representation, while fashion sustainability research is more likely to focus on fibre, labour and waste. All are essential explorations; however, CMF is where these categories begin to fuse. It is the zone where sensory experience, cultural meaning, environmental impact and technical performance are all materially negotiated. The future garment will need to readily answer three questions at once. What does it do for the body? What does it do to the world? What does it reveal about the system that made it? These questions are aesthetic, ethical and infrastructural. Make no mistake though, they are also *commercial*. Consumers may not use the phrase 'adaptive CMF,' but they are already being primed to desire its effects. They encounter the material future through tactility, transparency, wellness, repair, resale, personalisation, climate anxiety and digital verification. They may not ask for a thermochromic textile, but they understand the appeal of a garment that responds to heat. They may not describe a surface as bioactive, but they recognise the promise of clothing that feels healthier, calmer or more protective against the stresses of daily life. They may not speak of circular material systems, but they increasingly expect products to be traceable, repairable, resellable and less obviously destructive. This is where fashion's material future becomes economically powerful. Innovation encounters desire not through technical vocabulary, but through *feeling*. A consumer touches a fabric and senses comfort, quality or care. They scan a digital product passport and feel reassured by provenance. They buy second-hand not only because it is cheaper, but because resale now carries cultural capital. Repair is chosen not only from necessity, but because visible mending can signal ethics and individuality. They may respond to wellness because fashion has always mediated bodily anxiety but now does so through a clear language of regulation, protection, restoration and self-optimisation.

Sensory Connections: The Garment That Feels You Back

Fashion has always been intimate because it touches us before anything (or anyone) else does. Cloth is the first architecture of the body, it mediates warmth, modesty, eroticism, comfort and social recognition. Yet the sensory language of fashion has

often been reduced to softness, stretch, weight and luxury hand-feel. The next stage is more complicated: materials that do not merely touch the body but register it. For fashion, this opens a field beyond the hard, device-centred history of wearable technology. The first wave of wearables often made the body feel like a data site strapped to electronics. The next wave must be softer, more textile-native and more emotionally literate. The question is not whether a garment can collect biometric data, a better question is whether it can translate bodily signals into forms of care, comfort, attention and self-knowledge without turning the wearer into a heavily surveilled subject. A haptic textile that records temperature, heart rate or motion can become a tool of mindfulness, rehabilitation, sports performance or adaptive comfort. Unfortunately, it can also become a mechanism of control if the data belongs to employers, insurers, platforms or brands rather than wearers. Fashion futures must therefore treat sensory materials as political materials. The intelligent surface is never neutral. It will decide what counts as relevant data, and who receives it.

At its most humane, sensory fashion may help us redesign clothing for neurodiversity, ageing, disability, anxiety and recovery. Imagine a garment that calms through pressure and temperature modulation; a sleeve that vibrates gently to guide breathing; a textile that shifts tone when the wearer is overheating. These are not simply gadgets; they are new forms of haptic culture. This is where fashion can learn from biophilic design, responsive interiors and therapeutic objects. Biophilic design begins from the premise that human beings are not separate from ecological systems, but psychologically, sensorially and physiologically shaped by contact with them (Wilson 1984; Kellert, Heerwagen, and Mador 2008). In architecture and interiors, this has meant designing spaces that use light, air, plants, natural materials, tactility, acoustic softness and environmental variation to support wellbeing rather than merely house activity. Fashion could apply this logic at the scale of the body. A garment might not simply cover, decorate or brand the wearer, but create a portable micro-environment: calming through pressure, cooling through ventilation, regulating through texture, comforting through weight, or restoring attention through material softness.

It also connects to responsive interiors and interactive architecture, in which environments are designed to sense human presence and adapt through light, sound, movement, temperature or surface behaviour (Fox and Kemp 2009). The research on therapeutic environments, where sensory qualities such as natural views, touch, light and atmosphere can influence stress, recovery and emotional regulation (Ulrich 1984; Pallasmaa 2012). Pallasmaa's critique of ocularcentrism is important for fashion futures because it reminds us that design is never only visual. In The Eyes of the Skin, he argues that modern architecture has too often privileged the eye at the expense of the body, producing spaces that may be visually striking but sensorially thin (Pallasmaa 2005). Fashion risks the same mistake, especially as AI-generated imagery, digital fashion, virtual try-on and spectacular smart surfaces increasingly dominate how garments are imagined and circulated. A garment, however, is not only an image to be seen; it is a physical atmosphere to be inhabited. Pallasmaa's emphasis on touch, shadow, sound, and embodied perception allows us to understand clothing as a small architecture worn directly against the skin: a haptic environment that mediates between body and world. In an age of digital overstimulation, the most intelligent garment may not be the one that dazzles the eye, but the one that restores the body to itself.

The important shift for fashion is from garment as object to garment as responsive milieu. Clothing can become a small therapeutic interior worn against the skin: an intimate architecture of care. Yet this must not collapse into wellness branding or biometric surveillance. The best future garments will not simply monitor the body as data; they will support the body as lived experience. They will understand touch, pressure, rhythm, softness, warmth and protection as forms of material care, not merely as features to be optimised.

However, intimate experience need not become data, and not every garment needs to 'sense,' the future ethics of sensory fashion must also depend on restraint. A genuinely sophisticated fashion future will know when matter should become intelligent and when it should remain beautifully inert. Silence and privacy, too, are fabulous luxuries.

The Future Is Already Here: Material Evidence

The future of fashion is often narrated as though it belongs elsewhere: to the laboratory, the speculative runway, the design fiction, the patent, the pitch deck, the beautiful but unreachable prototype. Yet many of the material behaviours that define fashion's next phase are already present, even if unevenly distributed, inconsistently scaled, and often trapped between demonstration, luxury capsule, research platform and supply-chain pilot. The point, then, is not that fashion must wait for intelligent matter to arrive. It has already arrived. The more important question is whether these emerging material systems will be absorbed into fashion's existing habits of novelty, acceleration and spectacle, or whether they will be used to redesign the relations among body, surface, data, waste and care.

Responsive pigments offer one of the clearest examples of this shift. Photochromic and thermochromic colourants are not speculative technologies; they are established chromic systems that change in response to light, heat, pH, pressure, electricity or other stimuli, and they have already been explored in textile and fashion applications (Chowdhury, Joshi, and Butola 2014). Their

limitations are equally important. Many chromic systems face problems of cost, wash fastness, light fastness, durability, fibre compatibility and binder performance, which means that their existence does not automatically translate into responsible fashion futures (Chowdhury, Joshi, and Butola 2014). However, as fashion artefacts, they already demonstrate the movement from colour as applied surface to colour as event. Lauren Bowker's material studio The Unseen has used responsive inks to make garments and objects that change according to pressure, heat and bodily conditions, including a jacket whose colour shifted according to pollution levels and fabrics designed to visualise otherwise invisible environmental forces (Wired 2015). More commercially, Stone Island's heat-reactive pieces, popularised through social media spectacle, used thermosensitive coatings that shifted colour in response to touch and heat (Wheeler 2022). These examples reveal both promise and danger. Responsive colour can make atmospheric or bodily change visible, but it can also become an algorithmically perfect gimmick: a surface designed less for care than for virality. Although, I have to say for me as an active yoga practitioner, the *last* thing I want is for my clothes to respond to where I happen to be heating up at any given time.

Bioactive membranes move the argument further because they do not simply change colour; they behave through living or biologically derived processes. MIT's bioLogic project, developed through the Tangible Media Group and collaborators, used live microbial cells in a moisture-responsive workout suit whose ventilating flaps opened and closed in response to sweat and body heat (Wang et al. 2017; Chu 2017). In this case, the garment does not depend on a conventional electronic sensor to detect the body. The cells themselves shrink and expand in response to humidity, acting as both sensor and actuator. The result is not merely a smart textile, but a biohybrid interface between skin, sweat, air and movement. This matters because it reframes intelligence as distributed material responsiveness rather than device-based computation. The garment does not simply monitor the athlete; it participates in thermoregulation. Yet bioactive membranes also demand caution. Once living cells, biofilms or bioengineered interfaces enter clothing, fashion moves closer to medicine, hygiene, biotechnology and microbial governance. The ethical question is not only whether the membrane works, but what kinds of bodies, climates and behaviours it is designed to support, correct or optimise.

Intelligent Pigments: Colour After Extraction

Colour is one of fashion's oldest seductions, but it is also one of its most complicated material histories. It has never been merely an aesthetic effect applied to cloth; it has always been tied to power, extraction, labour, chemistry, class, empire and desire. Purple, for instance, once belonged to molluscs and monarchy: Tyrian purple derived its value from the labour-intensive extraction of dye from sea snails and became associated with imperial authority, sacred power and sumptuary distinction (Finlay 2002; Pastoureau 2001). Cochineal red, produced from insects cultivated on prickly pear cactus, became one of the most valuable colonial commodities of the early modern Atlantic world, binding colour to conquest, Indigenous knowledge, Spanish imperial trade and European luxury consumption (Phipps 2010). Indigo, too, cannot be separated from plantation economies, colonial botany, enslaved and coerced labour, and the violent transformation of plant matter into global commodity (Balfour-Paul 1998). Even the apparently modern freedom of synthetic colour carries its own industrial history. William Henry Perkin's accidental discovery of mauveine in 1856 helped launch the synthetic dye industry, linking fashion colour to coal tar chemistry, mass production and the expansion of modern consumer desire (Garfield 2000). Alison Matthews David's *Fashion Victims* (2015) reveals colour as a toxic material danger rather than a merely visual pleasure. Her research on nineteenth-century arsenic green reveals how fashion's seductions have repeatedly depended on toxic chemistry, hidden labour and the willingness of consumers to separate beauty from consequence (Matthews David 2015). The tantalizing greens associated with Scheele's green, emerald green, and 'Paris' green offered precisely the kind of reliable artificial-natural colour that modern urban consumers desired: a vegetal intensity that suggested freshness, nature and luxury in the middle of industrial modernity. However, this chromatic fantasy was produced through arsenic compounds. Green became desirable because it looked alive, but its liveliness was chemically lethal. As the *British Medical Journal* warned in February of 1862, "Well may the fascinating wearer of it be called a killing creature. She actually carries in her skirts poison enough to slay the whole of the admirers she may meet with in half a dozen ball-rooms" (Little 2016, n.p.) Women and girls who made artificial flowers handled powdered green pigment directly, often in poorly ventilated conditions and with little protection. The death of the young London flower maker Matilda Scheurer (and the frankly revolting circumstances of her demise in 1861) became one of the most notorious examples of fashion's poisonous underside. Her labour produced the illusion of botanical delicacy for fashionable consumers, but the material cost of that illusion was horribly evidenced by her illness and death (Matthews David 2015; McMahon and Matthews David 2019). The artificial flower, worn as an ornament of femininity and nature, was therefore also an object of industrial toxicity. It staged a pastoral fantasy while administering poison through the hands, lungs and epidermis of the workers. It is a danger that persists to the present day in designed objects from this era[1]. Thus, arsenic green warrants inclusion into any discussion of intelligent

[1] The afterlife of arsenic green is still managed materially in archives, libraries and museums. Because copper arsenite and copper acetoarsenite pigments can remain hazardous long after their fashionable moment has passed, bright green Victorian artefacts are not simply historical curiosities; they are conservation risks. The recent concern over nineteenth-century green bookcloth makes this clear. Researchers associated with the Poison Book Project at Winterthur Museum, Garden & Library and the University of Delaware have shown that some Victorian-era cloth bindings were coloured with emerald green, a copper acetoarsenite pigment capable of offsetting arsenic onto hands and surrounding surfaces (Tedone and Grayburn 2020; Tedone and Grayburn 2022). As CBC reporting on bright green nineteenth-century books also notes, the beauty of these objects can conceal a toxic material history that requires specialist handling rather than ordinary archival contact (CBC Radio 2022). Contemporary conservation protocols therefore often involve visual identification, X-ray fluorescence testing, protective storage, handwashing, restricted handling and the use of nitrile gloves when suspected arsenical green objects must be consulted (Poison Book Project n.d.; Tedone and Grayburn 2020). Arsenic green therefore belongs not only to fashion history, but to the history of conservation, occupational safety and the long afterlife of toxic beauty. Pigment persists, and toxicity survives style. A shade once desired for its vivid modernity can later reappear as a curatorial hazard, requiring institutions to protect researchers, staff and collections from the material residue of nineteenth-century chromatic desire.

pigments, bio-inks and future colour systems, as it is an early warning about the toxicity that can be hidden inside beauty.

Later fluorescent colours, plasticised coatings and high-performance finishes further tied fashion's chromatic imagination to petroleum, petrochemistry, industrial spectacle and synthetic novelty. Metallic finishes, meanwhile, often carry the hidden histories of mining, mineral extraction, coatings, foils, pigments and complex composites. If nineteenth-century synthetic dyes had already connected colour to coal-tar chemistry and the modern laboratory, twentieth-century colour intensified that relationship through plastics, petrochemical fibres, fluorescent pigments, vinyl surfaces, polyurethane coatings, acrylic finishes and performance treatments (Garfield 2000; Blaszczyk 2012). Colour no longer simply entered cloth through dye; it increasingly appeared as coating, iridescence or waterproofing. Fluorescent colour, in particular, transformed fashion's palette into a spectacle of artificial brightness, producing colours that seemed to exceed nature itself: acidic pinks, safety oranges, electric greens and ultraviolet yellows that belonged as much to advertising, nightlife, sport, plastics and screen culture as to dress (Blaszczyk 2012). These shades announced modernity through intensity. They made the synthetic visible. This synthetic brilliance, however, was not immaterial. It depended entirely on industrial chemistry, fossil-fuel infrastructures and the wider expansion of plastics into everyday life. Plasticised finishes and coated textiles offered fashion new forms of shine, protection and futuristic appearance; however, they also embedded garments in petrochemical systems that are very difficult to separate from pollution, toxicity, microplastic shedding and end-of-life failure (Meikle 1995; Fletcher 2014). The very qualities that make these surfaces desirable can also make them ecologically problematic, they may resist weathering, but they may also resist repair, recycling and eventual decomposition.

Responsive pigments offer an alternative pathway. Thermochromic and photochromic materials can shift with heat or light, allowing a garment to carry multiple visual states rather than one fixed seasonal identity. The more radical development, however, is structural and biological colour. Structural colour produces visual effects through microscopic architectures rather than conventional pigment chemistry. In nature, this is the brilliance of beetle shells, butterfly wings and peacock feathers. In design, it offers the possibility of shimmer without metallic particles, mined minerals or microplastic glitter. The implications for luxury are considerable. Luxury has long depended on rare materials: gold, silk, cashmere, exotic skins, gemstones, high-gloss leathers, metallic embroidery. A regenerative future asks whether rarity can be redefined. Could the future precious object be the one that deliberately avoids extraction, or a pigment's ethical intelligence become part of its aura? Offering an elusive shimmer that becomes more desirable because it is grown rather than mined?

It needs to be noted here that intelligent colour also risks becoming another novelty trap. Colour is one of the fastest ways the industry actively produces anticipatory desire and then rapid obsolescence in turn. A seasonal shade can make last year's garment feel socially dead. If fashion is to escape this chromatic churn, colour must be redesigned as durability, adaptability and meaning rather than mere novelty. A dress that changes colour but cannot be recycled is not progress in the right direction. A bio-ink that requires industrial conditions unavailable at scale may remain a beautiful but ultimately elusive prototype. Just as a responsive pigment that contaminates the environment later may undermine circularity. There is also a semiotic shift. Colour may become informational, as when a textile might reveal contamination, washing damage or repair history through chromatic change; colour as truth-telling surface. The challenge for fashion is to avoid confusing responsiveness with responsibility. The future of colour needs to be evaluated for its life cycle as well as its magic.

Programmable Forms: 4D Fashion and the End of the Fixed Garment

Fashion has always shaped bodies, but it has usually done so through fixed forms: seams, darts, boning, tailoring; fundamentally through stretch and compression. The body adapts to the style; as the garment adapts only within the limits of fibre, cut and wear. Programmable materials disturb this sequence. They suggest garments that continue to form after production, adapting to movement, heat, impact, moisture or time. This aligns with fashion futures wherein materials move from 3D to 4D, exhibiting behavioural intelligence through adaptive polymers, shape-memory alloys, tunable structures, self-healing systems and additive manufacturing (Palmer and Smith 2025). For fashion, this is not just about 3D-printed spectacle. The early public imagination of 3D-printed fashion was often brittle, sculptural and runway-centric; also, plastic and uncomfortable evoking for me the skeleton models from kits I used to build as a kid.

Soft robotics offers another already-existing challenge to the fixed garment. Wearable robotics is often imagined as hard exoskeletons, but some of the most interesting work is textile-native. Zhu, Do, Hawkes and Visell's fluidic fabric muscle sheets use fabric structures and integrated fluidic transmissions to produce actuators that can bend, squeeze, strain and conform to the human body (Zhu et al. 2020). These are not decorative textile effects; they are fabric-based mechanical systems. Rice University's logic-enabled textiles push this even further by embedding pneumatic digital logic into fabric itself, allowing garments to perform basic control functions without conventional electronics (Rajappan et al. 2022). In one demonstration, a fabric system could raise

and lower a hood through air-based logic, suggesting a future in which clothing can compute mechanically rather than electronically (Rajappan et al. 2022). Harvard's Biodesign Lab has also developed soft exosuits that use textiles to provide a more conformal and less rigid interface with the body than traditional exoskeletons, with applications in mobility assistance and rehabilitation (Harvard Biodesign Lab n.d.). These examples shift fashion away from the garment as static form and toward garment as soft machine. But again, the future is not automatically emancipatory. A soft robotic garment may support disability, ageing, labour and recovery, or it may produce a new market for bodily optimisation and productivity. Its ethical value depends on the relations it enables.

A more desirable future may well be the one that is quieter: flexible printed textiles, zoned support, auxetic structures, repairable components, material efficiency, localised production and made-to-fit systems that reduce inventory waste.

Auxetic structures are especially interesting for fashion because they *expand* laterally when stretched. This gives them potential in sportswear, footwear, protective gear and adaptive clothing. Rather than adding padding, foam and multi-material complexity, designers can engineer geometry itself to absorb impact, ventilate, flex or support. In this sense, form becomes material behaviour. The cut is no longer only a pattern; it is a computation. This opens a post-size future. Standard sizing is one of fashion's most ordinary cruelties. It asks diverse bodies to conform to industrial averages and then sells the resulting discomfort as personal failure. Programmable and additive manufacturing could help garments adapt to bodies rather than bodies adapting to garments. A shoe upper can be printed with variable density. A bra could alter support zones. A jacket could stiffen at the shoulder while remaining soft at the elbow (or elongate for people with extra-long arms like myself!) A medical compression garment could be tuned to the individual rather than approximated through generic sizing.

In any discussion of fashion, it is necessary to return to the body, because (as explored earlier) every technological future of fashion eventually meets the problem of fit. Fashion's most persistent fantasy has been the measurable body: the body translated into proportion, symmetry, size, pattern, block, chart, standard and market category. This fantasy has a long genealogy. Vitruvius's account of bodily symmetry, Leonardo da Vinci's Vitruvian Man, nineteenth-century anthropometric studies, tailoring manuals and modern sizing surveys all participate in the belief that the body can be rationalised into a knowable system (Vitruvius 1960; Da Vinci 1490; Wampen 1864; Poulin 1952; Wilson 1948; Size North America 2017). Yet the dressed body repeatedly refuses this fantasy. It shifts, ages, leans, resists and exceeds standard measurements. Fashion's technical systems may require the body to become legible, but embodied life remains stubbornly irregular. This is why fit is never merely technical. It is phenomenological, social, emotional and political. Sara Ahmed's *Queer Phenomenology* is useful here because it posits orientation as a relation between bodies, objects, spaces and worlds (Ahmed 2006). Bodies are not simply located in garments; they are directed, corrected, disciplined and made comfortable or uncomfortable through them. A suit, a bra, a uniform, a size chart, a fitting room mirror or a body scan does not merely accommodate the body. It orients the body toward particular norms of gender, class, labour, professionalism, respectability, beauty and ability. The garment is therefore not only a covering, but an apparatus of orientation. It tells bodies how to stand, how to move, how to appear, and sometimes where it has failed.

Fashion theory has long communicated that clothing operates as a system of signs, but the future of fashion requires us to ask what happens when those signs are also produced through machines, scans, databases, algorithms and adaptive materials. Barthes reminds us that fashion is linguistic and semiotic, structured by systems of meaning that exceed the garment itself (Barthes 2017). Derrida's concept of *différance* further complicates any stable relation between object and meaning, showing how meaning is always deferred, relational and produced through difference (Derrida 1982). Fashion, in this sense, is always in deconstruction: cut, displaced, reassembled, quoted, repeated and undone (Loscialpo 2011). This is evident in the radical pattern systems of Julian Roberts's subtraction cutting, in the in-between forms of Rei Kawakubo, and in the deconstructive oeuvre of Martin Margiela, where the garment repeatedly exposes its seams, absences, structures and ghosts (Roberts 2008; Bolton 2017; Samson and Saillard 2018). These practices challenge the assumption that fashion's future must be smoother, more seamless and more efficient. The language of fashion technology often promises a perfect fit: body scanning, AI sizing, parametric patternmaking, 3D prototyping, mass customisation and adaptive garments. These tools may be powerful, especially if they reduce waste, improve comfort and make garments more responsive to actual bodies. But they can also intensify fashion's old obsession with correction. The suit offers one of the clearest historical examples of how fit becomes ideology. As Christopher Breward argues, the suit is not simply a garment but a structure of modern masculinity, professionalism, discipline, class aspiration and social order (Breward 2016). Sloan Wilson's *The Man in the Gray Flannel Suit* captured this mid-century image of conformity, where clothing becomes a uniform of corporate life, emotional containment and social legibility (Wilson 1955). Yet fashion's history is also full of bodies that exceed such containment: the tallest and shortest bodies recorded by Guinness World Records, the Queer body, the disabled body, the aging body, the non-standard body, the body that tailoring manuals could not imagine or would not serve (Guinness World Records 2019a; Guinness World Records 2019b). These bodies are not exceptions to fashion's system; they reveal the violence of the system's normative claim to universality.

This is where programmable form becomes more than a technological possibility; it becomes a critique of fashion's inherited

systems of measurement. Adaptive garments suggest a future in which support, fit, compression and structure are no longer imposed through standardised size categories but negotiated in relation to the particularities of the body. The question is not simply how a garment might change shape, but how fashion itself might change when the body is no longer treated as a problem to be corrected or averaged.

Missed Fit

Figure 1: Author participating in Philip Sparks "Missed Fit" Seneca Fashion Studies FST 101 performance at Seneca Newnham Campus, Nov. 25th 2022. Photograph: Rose de Paulsen. https://fashionresourcecentre.com/?p=3958

This concern connects directly to Philip Sparks's *Missed Fit* (Sparks 2020, 2019) research, which challenges the conformist logic of conventional sizing, patternmaking and manufacture by foregrounding the body as variable, performative and resistant to industrial standardisation. His practice-led garments-as-art-as-investigation are part of a larger corpus of research by professor Sparks that includes performative engagements, body measurements, and creation of prototypes and models that deliberately disrupt the conformist structures imposed by traditional fashion, design, and manufacture.

Sparks uses practice-based fashion research to explore both individual as well as larger issues around form and function within the designed fashion object. For example, as he notes of his work:

> *200%* is a shirt with its pattern enlarged to two hundred per cent of my own shirt size to create more of a long gown than a shirt. Despite its outsized form, I did not want *200%* to become too comfortable for the wearer, so I made it from a very fragile cloth with very little cohesiveness. This meant that one had to be very careful trying on and wearing the piece as a finger could easily puncture the cloth. Many visitors told me that this piece reminded them of trying on their parents clothing as a child. […] Some of the pieces looked at restricting movement as an issue with fit. *Abduction*, meaning "moving away" (Marieb 2011, 214), is a shirt made with the arms attached too low. *Abduction* is designed to prevent the wearer from lifting their arm away from the body. As guests tried on this piece, new ways of wearing it were proposed, as a cape, for example, instead of buttoned closed as a shirt. This reinforcing that everyone's experience of fit is different, and my intended meanings are not always interpreted as I had planned Abdomen and Neck are both shirts where one part of the shirt was enlarged. In *Abdomen*, a front section of the shirt was enlarged by two hundred per cent and gathered back into an otherwise regular white shirt. This was a play on enlarging a part of the body that I am usually conscious of minimizing. *Abdomen* presented several ways of being worn. Many people suggested that it could be worn when carrying a child. *Neck* was made with a neck opening too big, exposing most of the chest abdomen and navel. It was meant to question the concept of appropriateness in clothing, but most guests simply thought of the shirt as a new type of jacket instead. (Sparks 2020, n.p.)

Sparks elaborates on this concept of the individual vs. the conforming mediation of anthropometric data:

> One individual with a jacket that cannot be buttoned closed may complain that it is too loose, and tell their tailor that it needs to be taken in. Another individual may complain that a very boxy jacket is too tight, and needs to be let out. As a tailor and clothing designer for almost two decades, I have made the crafting of garments that fit perfectly my primary goal, studying anthropometric data in a desperate search for a good standard and working tirelessly to flawlessly clothe individual bodies. I have witnessed first-hand the positive effects this can have on a person. Through my craft, I have had the opportunity to help clients heal from the pain of a physical injury or health issue. (Sparks 2020, n.p.)

Regarding his research process, Sparks notes that:

> I looked to historical tailoring texts from Canada, the United Kingdom, Italy, and France for insights into our past ideas on finding fit and, in them, I found historical records and theses on anthropometry, or the geometry of the human form. Anthropometry is defined in the Gage Canadian Dictionary (Avis 1983) as "the branch of anthropology that deals with measurements of the human body" (48). Anthropometric data is often published for use in various design fields including tailoring, industrial design, and architecture. This is a practice-based and qualitative research project that challenges the use of quantitative data on the human body, as it is applied in fields where this body is considered. (Sparks 2020, n.p.)

Sparks states of his research:

> In Western culture, there has been a trend towards a more sedentary workplace and home life, but has that affected the shape and proportions of the human form and how Western culture perceives the concept of fit? I thought that the issues I faced as a custom tailor in finding the resources I needed to fit individuals reflected a need to update quantitative data on the human body. I found early in my research that it was my reliance on this quantitative data that caused the problem in the first place. (Sparks 2020, n.p.)

And relates this to his work as an educator:

> [I]t is my hope to continue this research and publish a text that can be used by teachers and students who rely on applying anthropometric data in order to help them open up their methodology. In fashion education, the traditional way of teaching patternmaking is to have students start with an existing developed pattern in what is called a sample size, usually suited to a tall, thin model. But I believe that the experience of fitting a variety of bodies is essential to making them better designers, cutters, patternmakers, and fashion professionals. (Sparks 2020, n.p.)

This research engaged with larger issues Sparks addresses in his work:

> This exploration hinted at new and exciting ways to explore fit, but still did not answer my question of how to best draft for an individual. This brings me back to the anthropometric data that I was so interested in when I started this research. Has our anthropometric data changed across time? Surely our lifestyles and occupations have changed, but have our bodies changed too? […] My personal experience of working with pattern drafts (both historic and contemporary) have led me to the conclusion that they don't accommodate individual bodies. For example, if I am tasked with drafting the pattern for a jacket and the client has a waist circumference that is larger than their chest, this is a challenge as most drafts published assume a smaller waist to chest ratio. As a tailor, I am more often than not faced with a body that doesn't conform to published standards. […] In my practice, I have not yet measured an individual whose measurements conform to any of the many charts I have gathered. Mechanical fit is specific and inherently provides for the right amount of looseness. The amount of ease or looseness required in the fit of a garment, however, is always up for debate. (Sparks 2020, n.p.)

As Sparks notes: "the wearer imparts meaning to clothing" (Sparks 2020, n.p.), and this groundbreaking body of research expands on this by examining meanings and messages that are communicated through both design and manufacture.

This shift from wearer as passive consumer to wearer as co-producer of meaning is relevant for thinking about programmable fashion. If clothing gains meaning through use, embodiment and interpretation, then future technologies must not simply generate more adaptive objects; they must also create more accountable relationships between bodies, garments and systems of production. Sparks's work helps clarify that fit is never only technical. It is cultural, social, emotional and political. The promise of programmable form, then, lies not merely in its capacity to alter shape, support or compression, but in its ability to challenge the industrial assumption that bodies should conform to fashion's existing categories. Yet this is precisely where the promise of technological innovation must be held open to critique.

The scanned body may become more measurable without becoming more free.

Also, we should be cautious about technological salvation narratives. Additive manufacturing is not automatically sustainable. It can produce waste, energy demand and difficult-to-recycle composites. It can also become another tool for overproduction if brands use personalisation to stimulate endless novelty. The value of programmable fashion will depend on whether it reduces material throughput, extends use, enables repair and supports circular design. A 4D garment that changes shape but enters landfill as an unreadable hybrid is simply a more theatrical example of waste.

Agential Realism and the Fashion Surface

The aesthetic question is also compelling. If a garment can change over time, when is it finished? Fashion has long valued the pristine new object, but programmable materials may make change the definition of beauty in fashion. A garment that folds,

opens, tightens, softens or repairs itself asks us to value process over fixity. This is closer to performance than product, and it returns fashion to time, and this temporal question is by turns an ontological one as well. If the garment is no longer fixed, then it can no longer be understood as a stable object to which meaning is added after production. Its meaning continues to emerge through behaviour: the fold, the repair and the response to body. Programmable fashion therefore unsettles the old hierarchy in which the designer creates form, matter shapes that form, and the wearer eventually interprets that form. The garment becomes a progressive series of relations rather than a finished thing.

Karen Barad's *Meeting the Universe Halfway* (2007) refutes the idea that matter is passive. For Barad, matter and meaning are not separate domains, with material on one side and interpretation on the other. They emerge together through specific practices, instruments, bodies, histories, technologies and relations. Her concept of "agential realism" (Barad 2007, 26) challenges the assumption that the world is composed of pre-existing objects that are later represented, measured or given meaning by human subjects. As she states:

> [A]gential realism [is] an epistemological-ontological-ethical framework that provides an understanding of the role of human and nonhuman, material and discursive, and natural and cultural factors in scientific and other social-material practices, thereby moving such considerations beyond the well-worn debates that pit constructivism against realism, agency against structure, and idealism against materialism. Indeed, the new philosophical framework that I propose entails a rethinking of fundamental concepts that support such binary thinking, including the notions of matter, discourse, causality, agency, power, identity, embodiment, objectivity, space, and time. (Barad 2007, 26)

Instead, entities become determinate through what Barad calls "intra-action": not the meeting of separate things, but the process through which boundaries, identities and properties come into being (Barad 2007).

> The notion of intra-action is a key element of my agential realist framework. The neologism "intra-action" signifies the mutual constitution of entangled agencies. That is, in contrast to the usual "interaction, " which assumes that there are separate individual agencies that precede their interaction, the notion of intra-action recognizes that distinct agencies do not precede, but rather emerge through, their intra-action. It is important to note that the "distinct" agencies are only distinct in a relational, not an absolute, sense, that is, agencies are only distinct in relation to their mutual entanglement; they don't exist as individual elements. (Barad 2007, 33)

This has profound implications for fashion. A garment is not simply an object made from inert matter and then worn by a human subject. It is a material-discursive phenomenon produced through fibre, dye, cut, labour, body, data, and climate. Fashion does not merely place meaning onto matter; it participates in mattering.

In relation to intelligent textiles, adaptive CMF, biofabricated materials, AI-assisted design and digital product passports, these technologies are too often described as neutral tools that reveal, improve or optimise fashion. Barad's work suggests otherwise. A body scanner does not simply record the body; it helps produce the body as measurable, comparable, sortable and commercially legible. A digital product passport does not merely disclose a garment's truth; it creates an apparatus through which fibre content, provenance, repair, resale and end-of-life pathways become visible, governable and valuable. In Barad's terms, these are apparatuses: material-discursive arrangements that enact boundaries, categories and exclusions (Barad 2007). They do not stand outside fashion, they help *make* fashion.

This is why the future fashion surface cannot be understood only as a technical innovation. A responsive pigment, a sensor-embedded textile or a bioactive membrane is not simply a clever material. It is part of a wider apparatus that decides what counts as intelligence, sustainability, provenance or risk. A textile that senses heat or pressure may appear to make the garment more responsive, but the ethical question is what kind of response is being produced: who receives the data, what bodily norms are encoded into the system, and what labour is hidden behind the interface?

Barad's argument helps move fashion beyond the language of features and toward the politics of materialisation. The question is not only what a material can do, but what world it helps bring into being. Barad's concept of the "agential cut" is particularly useful here as it:

> [E]nacts a resolution within the phenomenon of the inherent ontological (and semantic) indeterminacy. In other words, relata do not preexist relations; rather, relata-within-phenomena emerge through specific intra-actions. Importantly, then, intra-actions enact agential separability—the condition of exteriority-within-phenomena. (339)

Barad's agential realism refuses the idea that material phenomena are simply produced by human intention, design authorship or technological control. Phenomena, for Barad, are not merely the outcomes of laboratory exercises engineered by human subjects; they are "differential patterns of mattering" (Barad 2007, 140–41), or diffraction patterns, produced through complex

agential intra-actions among material-discursive apparatuses). Garments are too often treated either as designed objects or as cultural signs: things made by designers and then interpreted by wearers, consumers, critics or markets. Barad allows us to think otherwise. A garment is not simply designed first and given meaning later. It becomes what it is through the intra-actions of fibre, dye, body, labour, law, waste stream and image. Fashion is not only representation, but also a form of imbricated matter. This shifts the fashion surface from passive exterior to active phenomenon. A textile surface then is not merely the place where colour, print, texture or finish appear, it is also a boundary-making practice that decides what touches the body and what is kept away.

Symbiotic Skins

The phrase "second skin" has been overused in fashion, often to describe tightness, seamlessness or sensual proximity; usually in running kits or Yoga wear. However, the next generation of symbiotic materials gives the phrase new force. A second skin may become breathable, sensing, antibacterial, biodegradable, energy-harvesting or bioactive.

Here, fashion moves closer to medicine, wellness, cosmetics and prosthetics. Biocompatible innovations that merge biotechnology, sensing and performance, especially in soft e-textiles, gels, membranes, spray-on fabrics, bioactive wound dressings and skin-healing pigments (Palmer and Smith 2025). For fashion, this is a profound opportunity because clothing already lives at the boundary between self-presentation and bodily maintenance. We dress not only to be seen, but to be protected from cold, heat, injury, and exposure.

The next generation of bioresponsive and health-oriented materials gives the phrase 'second skin' new urgency, as it may no longer be simply a metaphor for intimacy or fit. Instead, it may become a breathable, sensing, biodegradable, healing or energy-harvesting interface between the body and its environment. In this context, fashion extends one of its oldest protective functions into the realm of health. Clothing has always sheltered the body from cold, heat, abrasion, exposure and shame; symbiotic skins ask whether garments might also support hydration, recovery, thermoregulation, skin repair, injury prevention or clinical monitoring. The garment becomes less like a surface placed upon the body and more like a soft infrastructure of wellness.

This future is already visible in experimental sportswear, biomedical textiles and transient electronics. MIT's bioLogic project remains one of the clearest examples of a textile that behaves with the body rather than merely recording it. Developed by researchers in the Tangible Media Group and collaborators, the project used moisture-responsive microbial cells to open and close ventilating flaps in a workout suit and shoe structure. The cells acted simultaneously as sensor and actuator, shrinking and expanding in response to humidity so that the garment could ventilate when the body became hot and sweaty, then close again when moisture levels dropped (Wang et al. 2017). This is a significant conceptual shift. The garment does not simply display biological inspiration as pattern, print or biomorphic styling; it incorporates biological behaviour into the material logic of the textile itself. Sweat, usually treated by fashion as a problem to be hidden, deodorised or disciplined, becomes a signal through which the garment participates in bodily regulation. Recent work in biodegradable e-textiles extends this logic into health monitoring. Researchers at the University of Sussex have developed seaweed-based health sensors using rock salt, water, seaweed and graphene, positioning them as biodegradable alternatives to the rubber- and plastic-based components often found in wearable monitoring devices (Luckett 2023). Similarly, the SWEET project, or Smart, Wearable, and Eco-friendly Electronic Textiles, led by researchers at the University of Southampton and UWE Bristol with collaborators at Exeter, Cambridge, Leeds and Bath, uses inkjet-printed graphene-based conductive materials on a Tencel substrate to create e-textile swatches capable of monitoring heart rate and temperature while also addressing biodegradation and life-cycle impacts (Dulal et al. 2025). These examples matter because they challenge the assumption that health-oriented wearables must be hard, device-like, extractive and materially persistent. The symbiotic skin, at its best, does not add a gadget to the body; it redistributes sensing into softness, flexibility and eventual disappearance.

Other research pushes this further through edible, transient and bio-based sensor systems. Capacitive pressure sensors made from cellulose and pectin suggest that wearable sensing can be produced from renewable and biodegradable biomaterials rather than conventional electronic substrates (Basarir et al. 2024). Eco-friendly wearable strain sensor arrays and bacterial-cellulose-based conductive macrofibres point toward smart textiles that can register movement, pressure or deformation while reducing dependence on persistent plastics and metal-heavy electronic assemblies (Wu et al. 2023; Yuan et al. 2025). These developments are especially important for rehabilitation, ageing, sports medicine and disability design, where the ability to track strain, pressure, posture or movement could support comfort and recovery. Spray-on fibres offer another route into symbiotic skins. Fabrican, developed by Manel Torres through research associated with Imperial College London, demonstrated that fibres suspended in a liquid medium could be sprayed directly onto skin or other surfaces to form a non-woven textile. The fashion world encountered this technology spectacularly when Coperni used Fabrican to spray a dress onto Bella Hadid during its Spring/Summer 2023 runway presentation, but the more consequential implications may lie beyond spectacle. Fabrican has also been discussed in relation to medicine patches, bandages, hygiene products and spray-on dressings for wounds or burns (Imperial College London 2010; Fabrican n.d.). In this context, the sprayed garment becomes less a fantasy of instant fashion and more a

temporary textile intervention: a material that can conform to the body's irregularities, cover without pressure, deliver active substances, and perhaps dissolve or be reconstituted after use. The cultural danger, of course, is that the same technology can move quickly from care to spectacle. A sprayed bandage and a sprayed runway dress belong to the same material family, but they do very different ethical work.

Microalgae and algae-based pigments also suggest how fashion's health-oriented future may draw from living systems. Research on microalgae has identified bioactive compounds with antioxidant, antimicrobial and anti-inflammatory potential, including compounds relevant to inflammatory skin conditions (Choo et al. 2020). More recent reviews have positioned microalgae as promising ingredients for skin repair, cosmetics and regenerative skincare because of their production of polysaccharides, carotenoids, fatty acids, vitamins and other biologically active compounds (Chinjoo et al. 2025). In textile research, algae-based coatings have also been explored as fully bio-based colourants for cotton, showing how algal matter can function as pigment as well as biological resource (Blanckart et al. 2025). The bridge between these fields remains experimental: a microalgae-dyed textile is not automatically anti-inflammatory, and a bioactive skincare ingredient does not automatically become a responsible garment. Still, the convergence is revealing. Colour may no longer be only chromatic; it may become biochemical, therapeutic, protective or microbial. The surface of fashion begins to approach the surface of skin. Energy-harvesting films add another dimension to the symbiotic skin because they suggest garments that may one day power their own low-energy sensing systems. Hydrovoltaic technologies generate electricity from moisture, evaporation or humidity, and recent research has explored film-based generators, microbial films and biodegradable moisture-electric devices as possible routes toward low-power electronics (Ren et al. 2022; Jiao et al. 2024). A 2026 gelatin-and-salt moisture-electric generator developed by researchers at Queen Mary University of London and collaborators demonstrates how ordinary, food-grade or biodegradable materials might be used to draw energy from ambient humidity rather than from conventional batteries (Dong et al. 2026). For fashion, the implications are significant but should be treated cautiously. A humidity-powered garment is not yet a commercial everyday object. However, the material principle is important: the body and atmosphere already contain moisture gradients, heat, movement and friction. The symbiotic skin asks whether clothing can work with these conditions rather than impose rigid devices upon them.

The beauty and skincare industries have already begun to move toward textiles that act on the skin. Cosmetotextiles use microencapsulation, coatings or fibre treatments to transfer active substances from fabric to body through contact, friction, heat or moisture. Recent studies have explored sportswear treated with microencapsulated natural extracts intended to improve skin hydration and reduce the appearance of cellulite, while broader reviews of functional clothing and therapeutic textiles discuss fabrics designed to support skin comfort, reduce irritation, manage moisture or assist conditions such as atopic dermatitis (Kurtoğlu Necef et al. 2024; Broadhead et al. 2021). These examples reveal both the promise and the danger of symbiotic fashion. On the one hand, clothing that supports the skin barrier, reduces itching, manages sweat, improves comfort or assists healing could be genuinely valuable. On the other hand, fashion and beauty have a long history of converting bodily vulnerability into commercial opportunity. The garment that promises "repair" can easily become the garment that shames the wearer into viewing their ordinary skin as insufficient.

They also raise a key question: does the garment sense in order to care for the wearer, or in order to make the wearer more measurable?

The ethical stakes are therefore high. Symbiotic fashion could deepen the surveillance and correction of the body. A genuinely symbiotic skin would therefore need to be judged by more than responsiveness. It would need to protect bodily autonomy, minimise data extraction, avoid pathologising ordinary embodiment, and be designed for safe endings as carefully as for intimate contact. Its task would not be to perfect the body, correct the body or turn the body into a dashboard. Its task would be to support the body as lived, changing, vulnerable and relational. The most meaningful future health garment may not be the one that promises optimisation, youth or flawless performance. It may be the one that reduces pain, prevents injury, restores dignity, protects sensitive skin, supports recovery, keeps a wearer cool, dry or calm, and then knows how to disappear without leaving another toxic trace behind. In that sense, the symbiotic skin is not simply a smart textile. It is a test of whether fashion can learn to care without capturing, soothe without correcting, and touch the body without turning it into a market.

A regenerative fashion future must also resist wellness elitism. If bioactive and adaptive garments become luxury-only products, they will reproduce the inequalities already embedded in healthcare and fashion. The true promise of symbiotic skins lies in accessibility: burn care, elder care, disability design, occupational safety, climate protection, sensory comfort, and inclusive sportswear. The most beautiful future garment may not be the one photographed on a runway, but the one that prevents injury, restores dignity or allows someone to move more freely.

There is also a material caution. Bio-integrated textiles must be designed for end-of-life from the beginning. Combining electronics, polymers, coatings, fibres and biological agents can create products that are impossible to recycle or compost. The

future 'smart' garment must not become a soft landfill problem. This is where design for disassembly, mono-material thinking, compostable circuitry and digital product passports become important. The garment must be intelligent enough to die properly.

Not to mention the elephant in the room: what happens when any of these intimate technologies goes horribly wrong. The incorrect chemical salve is secreted at the wrong time, a miscalibrated compression squeezes too tight, or the heat gets turned up far too high? Given the unreliability and snake oil promises of unscrupulous actors already abounding within the wellness sphere, the inherent potential for disaster is huge within all of these technologies…a corrupted (or counterfeit) symbiotic exosuit could end up poaching you alive.

Pollution as Value: The Aesthetics of Accountability

One of the most provocative material futures is the transformation of pollution into value. Smog, soot, contaminated soil, wastewater residue, vacuum dust and industrial by-products can be converted into pigments, glazes, composites and building materials (Palmer and Smith 2025). Pollution-derived pigments show how future colour systems can become forms of material testimony. Graviky Labs' AIR-INK transforms captured carbon emissions and particulate matter into ink, and PANGAIA's 2021 AIR-INK capsule printed garments with a pigment made from transformed carbon emissions (Phelps 2021; Graviky Labs n.d.). Fashion for Good's Black Pigment Project has similarly worked to validate black pigments derived from waste feedstocks such as industrial carbon, algae and wood waste as alternatives to conventional fossil-derived carbon black in dope dyeing applications (Fashion for Good n.d.). Nike's collaboration with Billie Eilish and Living Ink used algae-derived black pigment in the Alpha Force Low sneaker, while broader industry pilots have explored wood-waste and algae-waste colourants as alternatives to petroleum-based black (Cernansky 2023). These examples are important because black is one of fashion's most basic colours and one of design's most overlooked material problems. If a ubiquitous pigment can shift from fossil-derived carbon black toward waste-derived or bio-based alternatives, colour itself becomes a site of decarbonisation, toxicity reduction and material literacy. However, pollution-derived pigment remains ethically unstable. Capturing pollution and turning it into ink does not absolve the systems that produced the pollution. A soot-derived print cannot become a moral alibi for continued emissions. Its strongest value lies not in making pollution beautiful, but in making pollution accountable.

This strategy, which Palmer and Smith identify as 'Pollution as Value,' materialises the invisible by giving form, colour and texture to substances that usually circulate outside aesthetic attention: airborne particulates, toxic deposits, industrial runoff, domestic dust and the sedimented remains of extractive production. In doing so, it shifts pollution from background condition to material witness. What was once dispersed through air, water, soil or infrastructure is gathered into objects that can be seen, touched, exhibited, worn or built with. For fashion and design, this proposition is both seductive and ethically unstable. It is seductive because fashion has long aestheticised damage: distressing, staining, fading, corrosion, patina, ruin and decay have all been transformed into signs of style, authenticity or luxury. Pollution-derived materials extend this logic by turning environmental harm into aesthetic intensity. Yet this transformation risks converting ecological violence into spectacle. Turning smog into ink, soot into pigment or toxic residue into surface effect does not absolve the industries, infrastructures or consumption systems that produced those pollutants in the first place. As Nixon argues, environmental harm often operates as "slow violence": gradual, dispersed, unequally distributed and frequently invisible to those who benefit from the systems that cause it (Nixon 2011). Pollution as Value is therefore meaningful only if it resists that invisibility rather than beautifying it for consumption. The ethical force of pollution-derived design depends on accountability. Such materials must not merely aestheticise contamination; they must expose its origins, document its processing and avoid transferring toxic burden from one body, worker, community or ecosystem to another. A pigment made from exhaust particulates, for example, should not be celebrated as circular unless its collection, stabilization, use and afterlife are safe and transparent. A composite made from contaminated soil cannot be understood outside the political and colonial histories that made certain lands available for extraction, dumping or neglect. In this sense, Pollution as Value must be read not simply as a material innovation but as a material-discursive practice: an apparatus that can either reveal or conceal the relations among matter, harm, labour, evidence and responsibility (Barad 2007).

This 'Pollution as Value,' design strategy materialises the invisible and turns environmental harm into a catalyst for awareness and repair. For fashion, this is both seductive and dangerous. It is seductive because fashion has always known how to aestheticise the abject (O'Connell 2021): through rips, stains, decay, distress, and ruin. It is dangerous because pollution-derived design can easily become moral spectacle. Turning smog into ink does not absolve the systems that produced the smog in the first place. I am the first one to admire the iridescence in a oil slick on the asphalt, but come on, making beauty from contamination does not erase contamination's impacts…or *victims*. The task is not to romanticise pollution, but to expose and redirect it. This is the important caveat here, turning pollution into a product does not absolve the systems that produced the pollution. A carbon-based pigment made from exhaust does not excuse fossil-fuel dependence. A material made from wastewater residue does not eliminate the need to stop contaminating water. A composite made from toxic soil does not erase the political histories that made particular lands available for poisoning. Nixon's concept of "slow violence" is useful here because pollution often harms gradually, unevenly and out of sight, accumulating in bodies, landscapes and communities over time (Nixon 2011). Pollution as value is only meaningful if it resists the invisibility of slow violence rather than aestheticising it for consumption. This is why safety

and accountability are central. Pollution-derived materials must not transfer toxic burden from one context to another in the name of innovation. Designers cannot simply capture residue, make it beautiful and declare it circular. These materials require rigorous testing, transparent processing, appropriate containment and clear communication across the lifecycle. They must be safe for workers, wearers, repairers, recyclers and ecosystems. Without this, pollution as value becomes another form of greenwashing: a surface that speaks the language of repair while redistributing risk to those who handle, produce or dispose of it. The stronger possibility lies in combining pollution-derived design with bioremediation and material repair. Microbial-induced calcite precipitation, algae-based systems and bacteria capable of metabolising contaminants suggest futures in which materials do not merely symbolise environmental repair but participate in it. In such cases, the material object becomes both evidence and intervention: it reveals the existence of harm while helping to bind, filter, neutralise or transform it. Haraway's concept of response-ability is useful here because it asks not simply whether humans can respond to damaged worlds, but whether multispecies and technological arrangements can render each other capable of more careful forms of living and dying (Haraway 2016). Pollution as value becomes powerful when it creates response-able systems rather than symbolic absolution.

Fashion has a particular role to play because it is intimate and public at the same time. A pollution-derived pigment on a garment touches the body while also circulating socially. It makes environmental harm wearable, visible and discussable. This does not mean that every garment should become a billboard of ecological damage, but it does suggest that fashion can help train perception. It can make consumers see what has been kept distant. It can bring the atmosphere, river, soil and landfill back into the aesthetic field. Smelik's posthuman ethics of care is useful here because she insists that fashion must account for the non-human worlds entangled in clothing: water, fibres, chemicals, synthetic materials, waste, planetary resources and polluted environments (Smelik 2026). Pollution as value becomes one possible practice of such care, but only if care changes systems rather than merely changing appearances. The stronger possibility lies in connecting pollution-derived aesthetics to repair, remediation and public knowledge. If these materials make environmental damage perceptible while also supporting safer processing, reduced extraction, bioremediation or circular reuse, they can become more than symbolic gestures. They can function as pedagogical matter: objects that teach where pollution comes from, who lives with it, who profits from it and what forms of repair remain possible. For fashion, this means that Pollution as Value should not be treated as a trend in colour, material and finish alone, it should be understood as an ethics of visibility. The polluted material becomes powerful only when it refuses the fantasy of clean innovation and instead insists that design remain accountable to the damaged worlds from which its materials are drawn.

Aesthetically, this may alter the future surface of fashion. The luxury surface of tomorrow may not be flawless, pristine or immaculately detached from the world. It may be speckled, darkened, flecked, uneven, reclaimed or visibly processed. Imperfection may become evidence, and trace may be transformed into beauty. This would mark a significant shift from the twentieth-century fantasy of clean modernity, with its polished synthetics, sealed surfaces and pristine hygienic aura, toward an aesthetic that admits consequence. The future fashion object may need to carry its own material history on its surface.

Yet, this future must remain critical. Pollution as value should not become an excuse for continued pollution, nor a luxury aesthetic of damage sold back to privileged consumers. The question cannot be, "Can pollution be made beautiful?" Fashion already knows how to make almost anything beautiful. The harder question is, "Can beauty interrupt the systems that produce pollution?" Can a pigment made from soot reduce new extraction? Can a surface made from residue teach material literacy? Can a garment carry evidence without commodifying suffering? Can design transform waste without making waste feel acceptable? These are the questions that separate regenerative practice from ecological theatre. Pollution as value is therefore one of the most important and unstable strategies in the future of CMF. It forces fashion to confront the fact that every surface has an elsewhere. The mine, the refinery, the dye bath, the exhaust pipe, the wastewater stream, the landfill and the contaminated field are already inside the garment, whether or not the garment admits it. By materialising the invisible, pollution-derived design can make fashion's hidden atmospheres visible. However, its ethical force depends on what happens next. The residue must not simply become a new palette; it must become a demand. The stronger possibility lies in combining pollution-derived materials with bioremediation. Microbial-induced calcite precipitation, algae-based systems and bacteria that metabolise contaminants suggest futures where materials do not merely symbolise repair but participate in it. A garment, product or built surface might help filter, bind, neutralise or reveal environmental harm. Even if fashion's direct capacity here is limited, its symbolic power is large. Fashion can make environmental processes visible, desirable and culturally legible.

Used carefully, pollution-derived colour can become a form of material testimony. A pigment made from captured carbon, a glaze made from urban particulates, a textile dyed with reclaimed industrial residue: these objects carry evidence of the atmosphere we have made. They refuse the fantasy of clean surfaces detached from dirty systems. They remind us that every product has an elsewhere: be it the mine, the refinery, the dye house…or the lungs of workers.

Exit Strategy: The Ethics of Endings

Fashion is notoriously bad at endings. It knows how to launch, seduce, trend, discount and replace, however, it knows far less

about how products should terminate. Landfill, incineration, export, downcycling and wardrobe accumulation have become the shadow archive of modern fashion. A regenerative future must design the death of the garment as carefully as its birth. The notion of a fashionable 'exit strategy' focuses on compostable, traceable systems, biodegradable synthetics, degradable inks, waste-derived feedstocks, mycelium packaging and smart markers that support transparency. This is an important shift in fashion futuring because it reframes disappearance not as loss, but as a form of renewal. Fashion has historically been great at beginnings: the launch, the drop, the collection, the campaign, the first wear, the new season. It has been far less willing to think seriously about endings. Yet every garment has an afterlife. It is worn, washed, and eventually it becomes tiresome. Depending on the quality (and the cachet) it can then be resold or donated, or it can be dumped and shredded, downcycled, incinerated, landfilled or just abandoned. The future of fashion therefore depends not only on how products enter the world, but on how they leave it. Designed disappearance challenges the fantasy that durability always means permanence. A product that safely returns to soil may be more sophisticated than one that persists for centuries. This is especially important in relation to petroleum-based synthetics, coatings, trims, elastics, adhesives and blended fibres, many of which complicate recycling and extend fashion's material life far beyond its cultural desirability. Fashion's problem is not only that garments are discarded too quickly, but that many discarded garments do not know how to end. They remain materially present long after they have become socially obsolete. A fast fashion dress may be aesthetically temporary but materially persistent. Designed disappearance asks whether fashion can build intelligence into endings: compostability, disassembly, material identification, fibre separation, safe degradation and return.

This does not mean that all fashion should quickly biodegrade. The point is not to replace one universal model with another. Some garments should last for decades: coats, tailoring, workwear, footwear, heirlooms, uniforms, archival garments and emotionally significant objects. Others, however, especially packaging, short-use components, labels, tags, protective films and certain trims, may be better designed for safe disappearance. The more precise question is: what kind of afterlife does this product require? Circular design must therefore distinguish between products that should endure, products that should circulate, and products that should return harmlessly to biological systems (McDonough and Braungart 2002; Ellen MacArthur Foundation 2017). The risk is that biodegradability becomes another vague promise. "Biodegradable" is often used as if it means automatic ecological innocence, but materials degrade under specific conditions: temperature, moisture, microbial activity, oxygen, time and industrial composting infrastructure all matter. A compostable material that requires facilities unavailable to most users is not truly designed to disappear in everyday practice. A biodegradable synthetic that fragments into residues or disrupts recycling streams may not represent ecological progress. A degradable ink or coating that releases toxic compounds merely transfers harm from one form to another. Disappearance must therefore be designed materially, infrastructurally and ethically. The product must not simply vanish from the consumer's conscience; it must return without creating new forms of damage.

Traceability is key; digital product passports, smart markers, fibre tags and chemical identifiers all allow garments and packaging to disclose what they are, how they should be used, how they can be repaired, and what should happen at the end of life. The European Union's strategy for sustainable and circular textiles identifies digital product passports, durability, repairability, recyclability, producer responsibility and better consumer information as key components of a more accountable textile system (European Commission 2022). In this context, disappearance is not an excuse for forgetting. It requires documentation. The future garment may need to carry instructions for its own ending: not only wash me, but repair me, return me, recycle me, or do not combine me with these other materials.

Digital verification will become especially important in this commercial landscape. As sustainability claims multiply, trust becomes a material value. Provenance may no longer refer only to rarity, craftsmanship or brand heritage, but to environmental accountability, labour visibility, repair history and circular potential. The material future is therefore not hidden in a laboratory; it is already entering consumerist appetites. The consumer may not ask for intelligent matter directly, but they are increasingly asking for the sensations, assurances and identities that intelligent matter can provide. Climate anxiety only intensifies this shift. The consumer increasingly knows, even if only vaguely, that fashion is implicated in extraction, emissions, microplastics, water use, waste and labour exploitation. This knowledge does not automatically produce ethical behaviour, but it changes the emotional atmosphere in which consumption takes place. Consumerism is increasingly shadowed by doubt (guilt), scrutiny and the need for justification. In this context, material innovation becomes a form of reassurance. The material future can genuinely help transform fashion's systems, but it can also become the aesthetic management of consumer unease. Smart markers and digital identities make another part of the future visible: the garment as evidence. These systems include physical markers embedded into fibres, forensic tracers, QR codes, NFC labels, RFID systems, blockchain-linked records and digital product passports. FibreTrace, for example, uses luminescent pigment markers embedded into fibres at the raw material stage so that material origin and movement can be scanned and verified throughout production, use and even recycling (Textile Exchange 2025). Haelixa uses DNA-based traceability markers to verify material origins and product authenticity, including in textile supply chains where certification alone may not provide sufficient proof (Haelixa n.d.). Avery Dennison's atma.io assigns unique digital IDs to products and tracks events associated with them from source to consumer and beyond, while Eon's CircularID model has been used by brands such as Gabriela Hearst to link garments to digital profiles containing material, origin, production, carbon and circularity information (Avery Dennison n.d.; McDowell 2020). These markers matter because circular fashion cannot function

on good intentions alone. Recyclers need to know fibre content. Resellers need authenticity. Repair systems need material information. Regulators need evidence. Consumers need more than symbolic transparency. A smart marker can allow a garment to carry part of its own biography. However, smart markers also clarify the politics of disclosure. A digital product passport is not neutral. It decides what counts as relevant data, who controls that data, who can access it, and which forms of labour, chemistry, transport, waste or harm remain outside the frame. The garment that "speaks" through a QR code may reveal fibre composition while concealing subcontracted labour. It may disclose carbon data while obscuring water toxicity. It may authenticate luxury while leaving repair unaffordable. In this sense, smart markers are not simply transparency tools; they are apparatuses of fashion truth-making. They can support circularity, but they can also become another smart surface.

Mycelium packaging is a useful example because it rethinks protective material as temporary biological infrastructure rather than permanent waste. Instead of using petroleum-based foams or plastics to cushion a product during transport, mycelium-based materials can be grown into form and, under appropriate conditions, composted after use. Mycelium packaging demonstrates that the future of fashion materials is not limited to garments. Packaging is one of fashion's most mundane material infrastructures, and precisely for that reason it matters. Ecovative's Mushroom Packaging uses mycelium and agricultural feedstock to grow protective packaging as an alternative to petroleum-based foams (Ellen MacArthur Foundation 2021; Mushroom Packaging n.d.). The process treats mycelium as a binding network: a living growth system that can be shaped, dried and stabilised into protective forms. Mushroom Packaging describes its products as home compostable, plastic-free and made from hemp hurd and mycelium, with forms such as corners, coolers and custom protective structures (Mushroom Packaging n.d.). This is not fashion spectacle in the conventional sense. It is more modest and potentially more important: a redesign of the material interval between production, distribution and disposal. A mycelium package is not meant to become an heirloom. Its intelligence lies in appropriate temporality. It protects briefly, then returns. Such materials suggest that fashion's future does not depend only on making garments live longer, but on knowing which components should endure, which should circulate, and which should safely disappear. Such systems suggest a shift from packaging as disposable residue to packaging as designed biological interval: something that protects briefly and then returns. Waste-derived feedstocks similarly challenge the assumption that newness must begin with virgin extraction. If agricultural residues, food waste, textile waste or industrial by-products can become substrates for new materials, then fashion's future may depend less on extraction and more on transformation. However, the exit strategy must also be read through fashion's colonial and global waste geographies. Disappearance has too often meant disappearance from the wardrobe, the boutique, the brand ledger or the consumer's field of vision, while unwanted clothing reappears elsewhere: in landfill, in incinerators, in second-hand export markets, on beaches, in deserts, in drainage systems and in communities forced to absorb the waste of wealthier nations. Smelik's posthuman ethics of care is useful here because she insists that fashion waste is not the end of meaning, but the beginning of another set of obligations to materials, labourers, ecosystems and non-human worlds (Smelik 2026). To design disappearance ethically is not to make waste invisible. It is to take responsibility for where matter goes.

This is also where Haraway's concept of "response-ability" becomes important. A disappearing material is not ethical simply because it decomposes. It must participate in a more careful relation between humans, non-humans, infrastructures and damaged environments (Haraway 2016). Compostability, in this sense, is not just a technical property. It is a relationship. It requires soil, microbes, systems of collection, user knowledge, regulation and trust. If those relations are absent, the claim collapses. A compostable garment sent to landfill, where conditions may not support meaningful decomposition, is not an ecological solution; it is a failed relation. Designed disappearance, therefore, requires fashion to think like a systems discipline. Designers must consider fibre blends, threads, labels, buttons, zippers, coatings, prints, dyes, adhesives, interlinings and finishes as part of the same end-of-life problem. A garment cannot meaningfully disappear if one component biodegrades while another contaminates the process. Mono-material strategies, removable trims, non-toxic dyes, dissolvable stitching, compostable packaging and legible labelling all become design decisions with ethical consequences. The end of the garment must be designed from the beginning.

The circular economy has become a dominant framework for fashion sustainability, and rightly so. The Ellen MacArthur Foundation's vision for a new textiles economy argues that clothes, textiles and fibres should remain at their highest value during use and re-enter the economy afterwards rather than becoming waste (Ellen MacArthur Foundation 2017). This has helped shift fashion discourse away from linear take-make-waste models. But circularity, if reduced to recycling, will not be enough. The problem is *scale*, if total material consumption continues to rise, circularity rates can decline even while recycling improves. With widespread dumping of cheap goods on the global resale market (O'Connell 2021). This is why sufficiency must re-enter the conversation. Fashion does not only need better materials; it needs fewer unnecessary products, longer use, repair cultures, rental and resale where appropriate as in the Eileen Fisher ReSewn project that takes back used product and recuts and resews it into fresh fashion (O'Connell 2019). Regeneration is not compatible with infinite novelty. This is a hard pill to swallow for fashion because the industry's economic model depends on desire renewal. Regenerative fashion is also not a purely technological future. It requires cultural change. Consumers must learn to value maintenance, and brands measure their profits from services, not only units.

The fashion future I am interested in then, is not one where garments become gadgets and nature becomes a branding asset, it is one where fashion regains seriousness as material culture. The best future garments will not merely arrive looking new; they will age with dignity.

There is also an aesthetic shift at stake. Fashion has long equated value with preservation: the pristine object, the archive garment, the untouched luxury surface, the collectible piece protected from wear. Designed disappearance proposes another form of value: the beauty of appropriate return. A material that ages, breaks down, nourishes soil or leaves no toxic trace may ask us to value transformation rather than possession. This does not diminish fashion's emotional power. It may deepen it. The garment becomes part of a cycle rather than a monument to consumption. Barad's agential realism is useful here, because it reminds us that matter and meaning are entangled; materials are not passive substances waiting to be discarded, but participants in the worlds they help make (Barad 2007). A biodegradable textile, a degradable ink or a smart marker does not merely solve a technical problem. It reconfigures what fashion thinks a product is. Is a garment a possession, a service, a temporary relation, a biological participant, a data-bearing object, a future nutrient, or a potential contaminant? Designed disappearance forces these questions into the design process.

The deeper promise of this trajectory is that it changes fashion's temporality. The industry has been governed by seasonal time: novelty, obsolescence, replacement. Contrary to this, designed disappearance introduces ecological time: decomposition, regeneration, return, soil, microbial action, repair, reuse and afterlife. It asks fashion to stop treating endings as failure and begin treating them as design responsibilities. The most advanced future product may not be the one that lasts forever, but the one that knows how long it should last, what it should become next, and how to leave without harm. A suitable exit strategy also challenges fashion's emotional economy. Fashion has often equated value with possession and permanence: the heirloom coat, the archival dress, the investment bag. A regenerative system does not abolish permanence; it differentiates between what should last and what should return to the earth. A fine tailored wool suit (like my prized Rick Owens garments) deserve decades of repair and preservation; or in the case of Marie Antoinette's gown (O'Connell 2025) museum preservation. A festival wristband or cosmetic sample package do not. The future fashion system must develop a more nuanced ethics of duration. Some things should endure, others circulate, with others left to dissolve; the wisdom lies in knowing the difference.

Posthuman Care: When Fashion Stops Treating Matter as Dead

If the future of fashion is to be intelligent, it must first learn how to care. This may sound sentimental, beside the harder languages of AI, biotechnology, circular systems, and programmable materials, however, care is not weakness. Anneke Smelik's "Posthuman Ethics of Care for Fashion" offers a necessary corrective to any future-facing fashion discourse that becomes too dazzled by novelty. Her argument begins with the apparently banal object of a basic cotton T-shirt, but this ordinariness is precisely the point. The T-shirt is not simple at all. It carries within it earth, water, air, sun, agricultural labour, industrial processing, dye chemistry, logistics, washing, wearing, affect, social media performance and eventual waste (Smelik 2026, 2). The garment is therefore not an inert commodity. It is a material assemblage: a knot of human and non-human relations. The coming decade's design language will revolve around "smart" matter: adaptive textiles, living pigments, bio-integrated membranes, AI-assisted design and traceable circular systems. But Smelik's posthuman framework asks us to pause before celebrating intelligence as a technical achievement. Matter already acts. Clothes already participate in planetary systems. Cotton drinks water. Polyester sheds microplastics. Dyes enter rivers. Container ships burn fuel. Waste travels. The garment touches the body, but it also touches the world. The question, then, is not simply how to make materials more responsive, but how to become more response-able to the materials we already wear.

Smelik's posthumanism is useful here because it refuses the old hierarchy in which the human sits at the centre and everything else exists as resource, backdrop or tool. She defines the posthuman as the interaction between human and non-human forces in the Anthropocene, especially at the intersection of technology, environment and economy (Smelik 2026, 3). For fashion, this means the garment cannot be understood only as identity, style or commodity. It must be understood as a relation between bodies, fibres, fossil fuels, plants, labour, machines, water systems, waste streams and desire. This is where fashion futures must move from ego-logical to eco-logical thinking. The old fashion system is ego-indexed: my look, my feed, my newness, my haul, my seasonal relevance, my self-expression. Posthuman care does not abolish self-expression, but it places the self back inside a wider ecology. The wearer is not a sovereign consumer standing outside the system. The wearer is implicated in it. To dress is to enter a web of dependency.

That web is affective. We do not relate to clothes rationally alone. We love them, neglect them, hoard them, and sometimes use them to become versions of ourselves we cannot otherwise reach. Smelik insists that affect is central to fashion's power: emotional attachments can sustain overconsumption, but they can also become catalysts for change (Smelik 2026, 8). Fashion sustainability will fail if it only gives consumers information. The wardrobe is not a spreadsheet; it is an emotional archive. The task, then, is not to remove affect from fashion, but to redirect it. The industry has trained us to attach feeling to acquisition: the

thrill of the new purchase, the dopamine of the package, the fantasy of transformation. A posthuman ethics of care asks us to attach feeling to maintenance, longevity, and end-of-life responsibility. The pleasure of fashion need not disappear, but it does need to mature.

This is where Smelik's use of "revolutionary routines" becomes especially powerful. Sustainable fashion cannot depend only on spectacular gestures, capsule collections or guilt-driven campaigns. It must become habitual. Care has to enter the everyday: washing less, repairing more, buying differently, refusing unnecessary novelty, learning what fibres are, asking where garments go, valuing the worn and the mended, and building political pressure for better systems (Smelik 2026, 13–14). These routines are revolutionary precisely because they are ordinary. They challenge fashion at the level where fashion reproduces itself: repetition.

Waste is the brutal test of this ethics. A garment we once loved becomes, in Smelik's terms, a "thing" when "we change our relation to [it]" (Smelik 2026, 10). The moment of disposal exposes the violence of carelessness. The dress is outdated, the jeans are too tight, the colour is wrong, the object has lost its affective charge. It is no longer 'mine' in the same way. And so, it moves elsewhere: charity bin, resale platform, recycling stream, landfill, incinerator or dumped "in the rivers and on the shore near Accra or in the Atacama Desert in Chile" (2026, 11). Fashion's waste problem is therefore not merely technical. It is relational. Waste begins when care ends. Smelik's discussion of discarded clothing in the Global South is particularly important for any article about fashion futures, because it punctures the fantasy that circularity is automatically virtuous. Second-hand trade, recycling and reuse may appear sustainable from the viewpoint of the Global North, while still producing dumping grounds elsewhere. Smelik draws attention to textile waste as part of a neo-colonial system in which unwanted garments are displaced onto other people, other landscapes and other ecosystems. This is the "slow violence" of fashion waste: damage that happens gradually, out of sight through "leaking toxic microplastics or chemicals from discarded garments into water, bodies or the environment" (2026, 11). Posthuman care therefore demands material literacy. Smelik argues that consumers and wearers need to understand not only what things are made of, but also how to become responsible for production, consumption, disposal and afterlife (Smelik 2026, 12). This is where the advanced CMF future becomes ethical rather than merely aesthetic. Intelligent pigments, bio-fabricated skins, atmospheric materials and programmable forms must teach us more about matter, not less. They should make relations visible. They should disclose origin, use, repair, degradation and consequence.

A genuinely intelligent fashion system would therefore not only sense the wearer's body. It would sense its own obligations. It would know where its fibres came from. It would be designed for repair or safe return. It would refuse toxic glamour. It would treat labour as part of material value. It would understand that a garment's afterlife is not an externality, but part of its design. It would not ask care to sit politely at the margins of innovation. It would make care the condition of innovation. This is the moral centre of fashion futures. The question is not whether materials will become more alive, more adaptive or more responsive. The question is whether fashion will become worthy of those materials. If matter is vibrant, as new materialist thought insists, then fashion's responsibility expands. The garment is not dead stock, dead matter or dead waste. It is a living relation, even when it is synthetic, discarded or broken. To care for fashion is not to preserve the industry as it is, it is instead, to transform the habits, values and infrastructures through which fashion comes into being.

Zoe, Zoa and the Biotechnological Wardrobe

Rosi Braidotti's posthumanism is a useful framework for fashion futuring because it refuses the fantasy that the human body is the stable centre of design (or the universe). Fashion has always staged the human as its privileged subject: the dressed body, the desiring consumer, the styled self, the sovereign wearer. But posthumanism asks us to move the human out of that comfortable centre and to recognise that bodies are always already entangled with animals, plants, bacteria, machines, atmospheres, minerals, infrastructures and waste. In Braidotti's work, the posthuman is not a glamorous cyborg fantasy or a Silicon Valley dream of human enhancement. It is a critical condition: the recognition that the human has never been pure, bounded or autonomous, and that contemporary life is now structured through dense relations between biology, technology, ecology and capital (Braidotti 2013; Braidotti 2022). This has huge implications for fashion futures.

The future garment may not simply be worn by a human. It will be grown with bacteria, coloured through structural bio-pigments, tracked by digital passports, altered by heat, informed by AI, repaired by data, metabolised by composting systems, and judged through its ecological afterlife. Fashion's coming materials are not only textiles. They are biological, computational and planetary assemblages. Braidotti's concept of zoe is central here. Where bios traditionally names the politically recognised life of the human subject, zoe refers to non-human, generative life: animals, plants, bacteria, cells and the dynamic vitality of matter itself (Braidotti 2016). This shift from bios to zoe is not a decorative theoretical move. It asks fashion to stop treating non-human life as raw material. Cotton is not just fibre. Leather is not just hide. Silk is not just luxury. Bacteria are not just production tools. Yeast is not just a platform. Algae, fungi, collagen, mycelium, cellulose and microbes are not simply the new ingredients of sustainable branding. They are living or once-living participants in the fashion system. This is where Modern Meadow's Zoa becomes a perfect case study. Zoa was presented in 2017 as a biofabricated leather material, developed through biotechnology rather than conventional animal hide. Its debut at MoMA under the title *Zoa: A New Animal Is Born* was more than a material

innovation; it was a conceptual provocation (Museum of Modern Art 2018). Zoa did not simply offer "leather without cows." It asked what leather becomes when the animal is displaced by engineered biology, fermentation, collagen production and the laboratory. It also asked what fashion becomes when the material is no longer cut from an animal body but grown through a designed biological process.

The wordplay is almost too precise: Braidotti's zoe and Modern Meadow's Zoa meet at the threshold of life, matter and fashion. However, they should not be collapsed. Braidotti's zoe is a philosophical challenge to human exceptionalism; Zoa is a branded biotechnological material operating within advanced capitalism. The first asks us to decentre the human. The second risks turning decentered life into a new commodity.

This tension is key, as Braidotti warns that contemporary capitalism increasingly commodifies life itself, extracting value not only from labour or raw matter but from the informational and generative power of living systems (Braidotti 2013). Biotechnology intensifies this problem. In fashion, biofabrication can reduce dependence on animal slaughter, petrochemical synthetics and toxic tanning systems. It can also create new forms of enclosure: patented organisms, proprietary processes, energy-intensive fermentation, laboratory infrastructures, venture-backed material platforms and luxury scarcity dressed as ecological salvation. So, the ethical question is not only: is biofabricated leather better than animal leather? The more posthuman question is: what relations does this material produce? What does it demand from microbes, energy grids, feedstocks, workers, designers, investors and ecosystems? What forms of life does it spare, and what new forms of extraction does it require? What kinds of responsibility become visible, and what kinds disappear behind the smoothness of innovation?

Zoa is therefore not interesting because it solves leather. It is interesting because it reveals leather as a posthuman problem. Traditional leather already entangles animal life, land use, water, methane, slaughter, tanning chemistry, craft, luxury, waste and desire. Synthetic leather entangles fossil fuels, plastic coatings, performance limitations and microplastic futures. Biofabricated leather introduces yet another assemblage: engineered biology, fermentation, collagen, design laboratories, intellectual property and the aesthetic memory of animal skin. None of these options is innocent. The task is not to find purity. The task is to become materially literate enough to judge consequences. This is where Braidotti's posthumanism is more useful than simple techno-futurism. The fashion industry loves the language of innovation because it allows the future to be sold long before it will be held accountable. Biofabrication can easily become another luxury myth: clean, white, laboratory-born, animal-free, future-facing. But a posthuman fashion politics must ask harder questions. Who owns the biology? Who controls the process? What energy powers the fermentation? What happens at scale? Is the material repairable, recyclable, compostable, or merely less visibly violent than what it replaces? Does the new material reduce consumption, or does it simply make consumers feel less guilty about consuming?

The implications for design are nevertheless radical. If fashion takes Braidotti seriously, the designer is no longer only a stylist of surfaces or author of silhouettes. The designer becomes a negotiator of life processes. The fashion studio becomes part laboratory, part ethics chamber, part ecological interface. Material development is no longer a back-end technical issue; it becomes the conceptual centre of the work. To design with biotechnology is to design with non-human agencies, and this, in turn, changes fashion aesthetics. Biofabricated materials need not imitate the animal materials they are designed to replace. In fact, the most conservative thing Zoa could do would be to become indistinguishable from traditional leather. The more interesting possibility is that biofabrication produces new material languages: stitchless seams, liquid applications, grown surfaces, translucent skins, irregular textures, responsive finishes and hybrid forms that no animal hide could ever offer. A posthuman fashion future should not merely reproduce the past without the cow. It should ask what else skin, surface and second skin might become.

There is also a deeper species politics here. Leather has long been one of fashion's most charged materials because it carries the (questionable) glamour of death. It is animal skin transformed into a luxury surface. Vegan leather, meanwhile, often hides major petrochemical dependency behind ethical language. Biofabricated leather complicates both positions, it suggests a material future beyond the binary of animal cruelty versus plastic substitution. However, it also forces us to confront the fact that animal absence is not the same as non-human justice. Yeast, bacteria, collagen, plants, sugars, water and energy do not vanish from the ethical field just because the cow does.

Braidotti's zoe-centred thinking allows me to articulate (and understand) this more clearly. A regenerative fashion system cannot simply replace one input with another and call itself ethical. It must recompose the relations between human and non-human life. This means designing not only for performance and beauty, but for interdependence. It means acknowledging that biotechnology is not outside nature; conversely, it is one of the main contemporary forms of capitalism through which nature and culture are now inseparably entangled. The future of fashion may therefore be less about the 'next leather' than about the end of leather as a stable category. Zoa points towards a world in which materials are no longer defined by origin alone, animal, plant, synthetic, but by process, relation, consequence and afterlife. This will unsettle luxury, sustainability, and the whole romance of the 'natural' versus the omnipotence of the 'artificial.'

Good, fashion needs unsettling. The biotechnological wardrobe is coming. It will be grown, brewed, printed, programmed, composted and perhaps even healed. But if it is to be more than another market hallucination, it must be guided by a posthuman ethics of care. Braidotti gives us the philosophical language for that shift: away from Man as the measure of all things; towards zoe, towards the generative life of human and non-human worlds; towards a fashion system that understands matter not as dead resource but as active relation.

The Hegemony of the Smart Surface: Baudrillard, Fashion and the Masquerade of Sustainability

> The high point of the struggle against domination was the historic movement of liberation, be it political, sexual or otherwise-a continuous movement, with guiding ideas and visible actors.
>
> But liberation also occurred with exchanges and markets, which brings us to this terrifying paradox: all of the liberation fights against domination only paved the way for hegemony, the reign of general exchange-against which there is no possible revolution, since everything is already liberated.
>
> Total revolt responds to total order, not just dialectical conflict. At this point, it is double or nothing: the system shatters and drags the universal away in its disintegration. (76)
>
> Jean Baudrillard *The Agony of Power* (2010)

There is, however, another (more ominous) way to read fashion's intelligent future. One can't help look at responsive pigments, AI design systems, digital product passports, biofabricated skins, and regenerative materials…and not see a new ethics of matter emerging. Jean Baudrillard, would probably pose an uncomfortable question: what if the future of fashion is not liberation from the old system, but its more perfect simulation? In *The Agony of Power* (2010), Jean Baudrillard distinguishes domination from hegemony. Domination still belongs to a recognisable structure of conflict: master and slave, oppressor and oppressed, dominator and dominated. It is violent, but it is also legible. Hegemony, by contrast, begins when domination becomes internalised, networked and operational. It no longer appears as an external force imposed upon us; it becomes the environment we participate in, the code through which we work, shop, speak, desire and imagine ourselves (Baudrillard 2010, 33–35). The dominated subject does not simply obey power. They help circulate it. Where the old fashion system dominated through scarcity, class hierarchy, gender discipline, labour exploitation, colonial extraction and the visible regimens of 'taste,' the new system is more ambient. It does not merely command us to consume. It invites us to co-produce consumption as identity, self-care, activism, creativity and personal choice. We are not only sold garments. We are sold the sensation of agency. As we are asked to curate, personalise, resell, rent, recycle, repair, upload, tag, authenticate, influence and optimize, fashion becomes less a wardrobe than a networked condition.

Baudrillard's hegemony is especially relevant because fashion's future is increasingly organised through the very systems he associates with calculation, exchange, simulation and the virtual. AI forecasting, algorithmic merchandising, digital product passports, virtual try-on, traceability platforms and automated design promise transparency and intelligence. But they also risk converting ethics into interface. The more fashion becomes measurable, scannable and optimised, the more it may appear accountable while remaining structurally unchanged. A QR code can disclose a supply chain; it can also aestheticise responsibility. A digital passport can support circularity; it can also become a sustainability prop. The sign of transparency is not the same as transparency. This is where Baudrillard's language of masquerade aligns with hegemony. With signs that proliferate even as substance disappears. In this scenario, power does not need to hide; it parodies itself through the excessive display of its own values (Baudrillard 2010, 35). Fashion knows this mode intimately. It is, after all, the great cultural machine of surface, sign, styling and symbolic exchange. A brand can claim "care," "circularity," "regeneration," "craft," "community" and "planetary responsibility" as aesthetic codes while leaving the fundamental rhythm of overproduction wholly untouched.

This is not an argument against circularity, biotechnology or intelligent materials, it is an argument against their simulation. The sign of the solution can become part of the problem. Baudrillard therefore helps us read the danger of 'smart fashion' as a hegemonic fantasy. In domination, fashion tells us what to wear. In hegemony, fashion persuades us that every act of wearing is our own choice, our own expression, our own ethical positioning, our own data point. We become not victims to fashion in the old cliché, but hostages and accomplices of its global exchange system. Baudrillard differentiates between domination and hegemony, defining the former as "a dual relationship with the possibility of explosion, revolution, alienation and disalienation." contrasted with the latter where "Everyone is an accomplice" (Baudrillard 2020, 116) as he states:

> We must distinguish between domination and hegemony. Until now, we were dealing with domination, a master/slave relationship, a symbolic one if you like, a dual relationship with the possibility of explosion, revolution, alienation and disalienation. This domination has made way for hegemony, which is something else altogether. There is no longer a dual relationship. Everyone is an accomplice.

> And hegemony uses this complicity to lower individuals even more, playing on everyone's desire to lower themselves in this way. Hegemony works by devaluing everyone. There are no longer dominants and dominated, but a kind of total annexation (nexus = networks). Everyone is caught up in the (116-117) network and submits to this hegemony. who benefits? We can no longer calculate in terms of benefits for one power or another. §le can no longer go back in history to find out who is responsible for the domination. We are both victims and accomplices, guilty and not responsible. Hegemony is within us. It is the next phase of domination. I think it is worse, because hegemony brings domination, and therefore alienation, to an end. We are no longer alienated; alienation is no longer the problem. And yet we suffer. We have fallen into an irreversible vertigo; we are drawn to the black hole. We can sense the strategy but there is no one behind it. The black hole is what I call integral reality. And this integral reality, the signature of this new hegemony, is frightening because we cannot resist it. If we want to resist hegemony and escape it using the means we once used against domination (revolt, critical thought, negative thought, etc.), there is no hope. (Baudrillard 2010, 116-117)

We participate willingly because fashion gives us something back: identity, pleasure, novelty, belonging, status, even the feeling of being good. This is the scandal of voluntary servitude in fashion. Baudrillard returns to La Boétie's question from *Discourse of Voluntary Servitude* (1548)*,* of why people participate in their own subjection and emphasises that servitude is not simply passive. It is something willed, desired, and rewarded (Baudrillard 2010, 22). As he states:

> Boetie suggested, a "misfortune" [*malencontre*] made people willing, even eager, to embrace their tyrant. Suddenly domination caught on, affecting everyone, eventually wearing the face of the sovereign or the form of the State. (Baudrillard 2010, 23)

Fashion's version of this is not mysterious, we all know fast fashion exploits labour and damages ecosystems. Still, the package arrives; platforms accelerate desire; we scroll on with the knowledge that the system is broken, asking it to make us feel *new*.

The future-facing language of CMF only intensifies this paradox. Intelligent pigments, symbiotic skins, programmable forms and designed disappearance all promise a more ethical material culture. Yet they also risk giving fashion a new symbolic alibi: the garment becomes advanced enough that we stop asking whether it was necessary. The smart surface dazzles us into forgetting the old question of sufficiency. It is not enough for matter to become intelligent if desire remains stupid.

Baudrillard's most useful provocation is that resistance to power cannot simply mean refusing to be dominated. It must also mean refusing to dominate (Baudrillard 2010, 29). We are complicit in the process. As he states:

> Consensus, be it voluntary or involuntary, replaces traditional servitude, which still belongs to the symbolic register of domination. "HEGEMON" means the one who commands, orders, leads and governs (and not the one who dominates and exploits). This brings us back to the literal meaning of the word "cybernetic" (*Kubernetikè*, the art of governing). Contrary to domination, a hegemony of world power is no longer a dual, personal or real form of domination, but the domination of networks, of calculation and integral exchange. (Baudrillard 2010, 34)

For fashion, this is devastatingly precise. The industry must refuse not only the domination of workers, animals, ecosystems and consumers, but also its own desire to dominate time, trend, body, image, nature and novelty. It must stop treating the world as material waiting to be styled. The future of fashion will therefore be judged by whether it can escape the hegemony of its own signs. If circularity is just a logo, or biotechnology just another luxurious myth, or if AI becomes another accelerant of desire, they have *all* failed.

Baudrillard leaves fashion with a difficult instruction: do not trust the surface simply because it has learned to speak. The most dangerous surface is the one that says all the right things…

Conclusion: Fashion Symbiogenesis

Symbiogenesis

> Sympoiesis is a simple word; it means "making-with." Nothing makes itself; nothing is really autopoietic or self-organizing. In the words of the Inupiat computer "world game," earthlings are never alone.1 That is the radical implication of sympoiesis. Sympoiesis is a word proper to complex, dynamic, responsive, situated, historical systems. It is a word for worlding-with, in company. Sympoiesis enfolds autopoiesis and generatively unfurls and extends it. (Haraway 2016, 1)

Donna Haraway *Staying with the Trouble: Making Kin in the Chthulucene*

Make no mistake, the future will be worn. the question is whether it will be worn as another layer of planetary exhaustion or as a second skin for a more careful world. Haraway's concept of "staying with the trouble" (Haraway 2016, 1) is relevant for

fashion futuring because it refuses both techno-salvation and ecological despair. In *Staying with the Trouble*, she argues that the task is not to escape into fantasies of a clean technological future, nor to surrender to apocalyptic resignation, but to remain present within damaged worlds and cultivate forms of "response-ability" with human and non-human others (Haraway 2016, 5). This is especially important for fashion, an industry that repeatedly presents innovation as absolution: the smart textile, the biofabricated leather, the AI-designed collection, the compostable package, the regenerative fibre. Haraway's work asks us to slow that narrative down. As she states:

> Staying with the trouble does not require such a relationship to times called the future. In fact, staying with the trouble requires learning to be truly present, not as a vanishing pivot between awful or edenic pasts and apocalyptic or salvific futures, but as mortal critters entwined in myriad unfinished configurations of places, times, matters, meanings. (Haraway 2016, 1)

A garment is never only an object worn by a human subject; it is a knot of relations involving plants, animals, microbes, minerals, dyes, water, labour, logistics, atmospheres, waste streams and data systems.

To think fashion through Haraway is therefore to move from wearable technology to wearable kinship. Responsive materials are not enough; fashion must become response-able. A textile that senses the body but ignores extraction, toxicity, labour or disposal remains trapped in the old logic of innovation without accountability. Haraway's language of sympoiesis, or "making-with," is useful here because it reminds us that no material system makes itself alone (Haraway 2016, 5). Biofabricated skins, microbial dyes, mycelium composites and algae-based pigments should not be treated as new resources waiting for fashion's command, but as forms of multispecies making that create obligations. The future garment, then, must not simply perform intelligence; it must learn how to stay with the trouble of its own making.

The future of fashion will not be decided by the next hemline, the next platform, the next viral object, or the next artificial intelligence tool promising to accelerate design beyond the limits of human imagination. It will be decided by a deeper and more difficult question: what kind of relationship does fashion want to have with matter?

This is why the future of fashion cannot be judged by intelligence alone. A textile that senses the body but ignores extraction, toxicity, labour or disposal remains trapped in the old logic of innovation without accountability. A pigment that changes colour is not necessarily ethical. A biofabricated leather is not automatically regenerative. A digital product passport is not transparent if the data behind it is partial, inaccessible or used primarily as branding. A compostable package is not responsible if the conditions required for its disappearance do not exist. A smart garment is not smart if it produces stupid waste. The central question is not only what matter can do, but what forms of relation its actions produce.

The real future then is not the smart garment, but the system intelligent enough to need fewer garments; and a refusal of the 'sign' of regeneration, offering instead a regeneration that can survive without spectacularization. Baudrillard's claim that intelligence consists in a "double refusal" (Baudrillard 2020, 48) is especially important for fashion because it unsettles the easy language of 'smartness.' Intelligence, here, is not mastery. It is not the ability to calculate faster, sense more intimately, predict desire more accurately, optimise production more efficiently, or render the body more legible to platforms, brands and supply chains. Intelligence begins where power is refused in both directions: in the refusal to be dominated, but also in the refusal to dominate. As he states:

> Power itself must be abolished-and not solely the refusal to be dominated, which is at the heart of all traditional struggles-but also, just as violently, in the refusal to dominate (if the refusal to dominate had the same violence and same energy as the refusal to be dominated, (47-48) the dream of revolution would have disappeared long ago). Intelligence cannot, can never be in power because intelligence consists of this double refusal. "If I could think that there were a few people without any Power in the world, then I would know that all is not lost" (Elias Canetti). (Baudrillard 2010, 48)

This is a devastating proposition for fashion because the industry has historically imagined intelligence as *control*: control over trend, body, season, silhouette, image, labour, material, waste and desire. Even its future-facing technologies risk continuing this logic. AI may dominate taste through prediction. Smart textiles may dominate the body through biometric capture. Digital product passports may dominate matter through total informational management. Biofabrication may dominate life by turning living systems into proprietary material platforms. Responsive pigments may dominate attention by converting environmental change into spectacle. In each case, intelligence risks becoming merely another form of power. Intelligence in all of these scenarios is fundamentally lacking in wisdom.

For wearable ecology, then, the question is not simply whether matter can become intelligent, but whether fashion can become wise enough to relinquish domination. A genuinely intelligent garment would not only resist the domination of the wearer by discomfort, surveillance, exclusion or standardised sizing; it would also refuse to dominate workers, animals, microbes,

rivers, atmospheres, waste landscapes and future bodies. It would not treat the world as material awaiting conversion into style. Baudrillard's double refusal therefore gives wearable ecology its political edge. The garment must not only disclose power; it must interrupt the desire to exercise power over matter. This is where his argument meets posthuman care. To refuse domination is not to retreat from design, but to design with limits. It is to understand restraint, sufficiency, repair, privacy, biodegradation, opacity, slowness and non-extraction as forms of intelligence. In this sense, the most intelligent fashion system may not be the one that knows the wearer most completely, but the one that knows when not to know, not to extract, not to accelerate, not to optimise, and not to produce. Intelligence cannot be in power because intelligence begins where power gives up its claim to own the world.

This is where wearable ecology becomes necessary. Wearable ecology is not simply another name for wearable technology; it is a critical method for judging fashion's intelligent matter according to the relations it produces, the harms it reduces and the forms of care it makes possible. It asks fashion to move beyond the excitement of responsiveness and to consider whether a garment genuinely reduces extraction and total material throughput, rather than introducing another layer of material novelty into an already excessive system. It insists that bodily privacy and autonomy matter as much as sensory innovation, refusing forms of smart clothing that transform the wearer into a site of continuous data capture. It values repair, adaptation, emotional durability and changing fit as ways of extending use, while remaining alert to the danger that responsiveness itself may become another trend cycle and another mechanism of obsolescence. It requires garments to disclose provenance, labour, chemistry and afterlife so that their histories and futures become legible rather than hidden. It demands that recycling, composting and reuse be materially supported rather than rhetorically promised, since technical complexity can easily contaminate the very circular systems it claims to serve. Most importantly, wearable ecology understands intelligent fashion as a practice of care across human and non-human worlds, resisting any future in which life, matter, data and ecology are translated into yet another resource waiting to be styled

The answer cannot lie in substitution alone. Fashion cannot simply replace animal with cell, petrochemical with plant, hand with robot, landfill with compost bin, or one miracle feedstock with another and declare the future solved. These substitutions may reduce slaughter, toxicity, fossil-fuel dependence, water use, waste, land pressure, chemical exposure or certain forms of labour exploitation. They may interrupt specific harms and open genuinely important pathways toward less extractive material cultures. Substitution, however, is not the same as transformation. A new fibre, a new pigment, a new biofabricated surface, cannot, on its own, redeem an industry still organised around acceleration, disposable excess, and the relentless conversion of novelty into value.

A lab-grown leather may still depend on proprietary biology, energy-intensive infrastructure, venture capital and luxury scarcity. A plant-based plastic may still compete with food systems, require industrial chemical composting conditions or persist in environments where its promised afterlife cannot take place. Compostability may sound like an ending, but without collection systems, non-toxic chemistry, user knowledge and living soil, it remains only a beautiful promise. A robotic factory may reduce some forms of physical labour while intensifying Orwellian surveillance regimes and causing deskilling or displacement elsewhere in the supply chain. A regenerative fashion system therefore requires more than cleaner inputs or more seductive alternatives. It requires a deeper change in the relations through which garments are designed, distributed, worn, and valued.

This is the danger of the miracle material narrative. Fashion is remarkably skilled at turning every apparent solution into another sign of progress, yet each can also be absorbed into the same machinery of desire that produced the crisis in the first place. The problem is not only what fashion is made from, but how often it is made, how quickly it is made obsolete, and how easily its material consequences are hidden behind the next seductive surface.

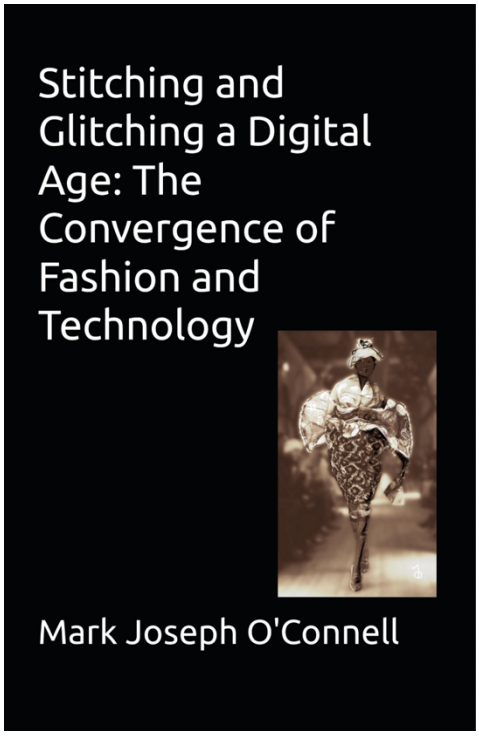
This does not mean the end of fashion's pleasures. It means the end of fashion's ignorance. Fashion should remain seductive, strange, sensuous and playful, it should aid in the invention of new forms of selfhood, but its pleasures can no longer depend on an end user amnesiac. The future luxury object may not be the rarest, newest or most seamless thing, it may be the object whose relations are legible. It will be decoded by a more difficult question: what kind of relationship does fashion want to have with matter? If matter is active, then fashion is accountable to what it activates.

Ogawa's island from the epigraph is terrifying because forgetting is so quotidian. The more things disappear, the more the inhabitants adapt to the absences. Fashion's danger is similar and the industry has become extraordinarily skilled at manufacturing 'disappearance' as pleasure. The future fashion surface, then, is not simply a more advanced composite of materiality and data. It is also a site of memory, evidence and accountability. At its best, it may help fashion move from a system of seasonal amnesia to one of wearable ecology: a material culture in which garments are judged not by novelty alone, but by the relations they preserve, disclose, repair and responsibly release.

The future of fashion must not simply be 'smart'. It must be held accountable or it counts for nothing.

Chapter: Wearable Ecologies

Stitching and Glitching a Digital Age: The Convergence of Fashion and Technology (2026)



This chapter is from the forthcoming monograph*: Stitching and Glitching a Digital Age: The Convergence of Fashion and Technology* (Fall 2026, Toronto: Markoconnellstudio; ISBN: 9798182169332; 2026) which rethinks fashion as one of the most powerful technological systems of modern life. Moving from the needle, loom and sewing machine to artificial intelligence, smart textiles, digital fashion, avatars, biofabrication and platform retail, dr. Mark Joseph O'Connell argues that fashion has never been merely decorative. It has always mediated bodies, identities, labour, desire, data, environments and power. Bringing together fashion studies, media theory, political economy, posthuman philosophy and design ethics, this book examines how garments have become interfaces and how fashion now circulates through screens, algorithms, biometric systems, virtual wardrobes and global supply chains. Through case studies of luxury retail, digital avatars, gamified consumption, surveillance, abject marketing and intelligent materials, O'Connell reveals both the promises and the dangers of fashion's technological future. Against techno-utopian claims that innovation alone will solve fashion's crises, *Stitching and Glitching a Digital Age* proposes a critical ethics of fashion technology grounded in labour justice, material accountability, data restraint, inclusive embodiment, repair and more-than-human care. Fashion, this book argues, is not simply becoming technological; it has always been stitched through technology. Its glitches show us what still needs to be repaired.

BIO

Dr. Mark Joseph O'Connell is a professor of fashion studies at Seneca Polytechnic, Toronto, Canada. His research focuses on visual culture and political economy within the history of fashion. His monograph Canadian Fashion Economies: A Select History of Fashion Culture, Commerce, and Colonization was published by Bloomsbury UK in September 2025. He is the author of Lilac Time at the Rodeo, Stories of Identity AIDS & Fashion (2021) and Lilac Time at the Rodeo 2, Marie Debris, David Wojnarowicz, Martin Wong (2024). His articles have been published in Fashion Theory; Textile: The Journal of Cloth and Culture; Fashion, Style & Popular Culture; and Queer Studies in Media & Popular Culture. In addition to his academic research Mark is also an artist and writer of fiction, and prior to teaching worked as a designer both in-house at M.A.C Cosmetics and for his clothing line Modular Menswear. Current work: markoconnellstudio.com.