

Article

Lost Institutional Memory and Policy Advice: The Royal Society of Arts on the Circular Economy Through the Centuries

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Abstract: Circular economy theorists and advocates typically describe traditional market economies as linear “take, make, use and dispose” systems. Various policy interventions, from green taxes to extended producer responsibility, are therefore deemed essential to ensure the systematic (re)introduction of residuals, secondary materials and components in manufacturing activities. By contrast, many nineteenth- and early twentieth-century writers documented how the profit motive, long-distance trade and actors now largely absent from present-day circularity discussions (e.g., waste dealers and brokers) spontaneously created ever more value out of the recovery of residuals and waste. These opposite assessments and underlying perspectives are perhaps best illustrated in the nineteenth classical liberal and early twenty-first century interventionist writings on circularity of Fellows, members and collaborators of the near tricentennial British Royal Society for the Encouragement of Arts, Manufactures and Commerce. This article summarizes their respective contributions and compares their stance on market institutions, design, intermediaries, extended producer responsibility and long-distance trade. Some hypotheses as to the sources of their analytical discrepancies and current beliefs on resource recovery are then discussed in more detail. A final suggestion is made that, if the analysis offered by early contributors is more correct, then perhaps the most important step towards greater circularity is regulatory reform (or deregulation) that would facilitate the spontaneous recovery of residuals and their processing in the most suitable, if sometimes more distant, locations.



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1. Introduction

Quotations:

It has become increasingly clear that the ‘take, make and dispose’ economy that is the side effect of commercialism and specialisation needs to be transformed into a means of production that promotes better use of resources and energy. That system is the ‘circular’ economy and for the last three years the RSA has been testing the role that design can play in supporting such a transition.

- Sophie Thomas, Road to Recovery. RSA Journal 2015 [1].
- Peter Lund Simmonds, Waste Products and Undeveloped Substances: or, Hints for Enterprise in Neglected Fields. London: Robert Hardwicke, 1862 (Figure 1) [2].

TO THE
COUNCIL OF THE SOCIETY OF ARTS,
BEFORE WHOM THE SUBJECT TREATED OF IN THIS WORK
HAS BEEN FREQUENTLY DISCUSSED,
AND WHO HAVE AWARDED THE AUTHOR THE SOCIETY'S MEDAL
FOR HIS PAPER ON UNDEVELOPED PRODUCTS,
AND MORE RECENTLY ELECTED HIM AN HONORARY LIFE MEMBER

This Work

IS GRATEFULLY DEDICATED

BY THEIR OBLIGED AND OBEDIENT SERVANT,

THE AUTHOR.

Figure 1. Copy of dedication in Peter Lund Simmonds' *Waste Products and Undeveloped Substances: or, Hints for Enterprise in Neglected Fields*. 1862.

In 1754, English inventor and social reformer William Shipley (1714–1803) founded the Society for the Encouragement of Arts, Manufactures and Commerce to “encourage innovation and excellence in manufacturing, chemistry, polite arts and trade” ([1], p. 19). The organization was given the right to use the term “Royal” in 1908 and is now better known by the acronym RSA [3–5]. Among other contributions, it played a significant role in the development of modern British environmentalism, as its President from 1952 to 2011, Prince Philip Mountbatten (1921–2021), Duke of Edinburgh, and husband of Queen Elizabeth II, used its status as “as an autonomous, independent body with no sectional interest to guard” to convene otherwise isolated environmental activists, state officials and corporate actors to discuss “everything from pollution of the air and soil, to rubbish disposal, toxic waste in rivers, agriculture, and the pressures of a growing population” ([5], p. 256). (See also [6]).

In 2004, the RSA celebrated its 250th anniversary with a manifesto that promoted “mutually reinforcing policies, products, technologies, behaviours and lifestyle that reduce waste of all kinds, with zero waste as the long term ideal” ([7], p. 20). It later embraced the circular economy narrative (henceforth, CE), including its indictment of the “current linear manufacturing models of ‘take-make-dispose’” for “taking raw material out of the ground, making products for consumption and disposing of these after use in a way that loses the resource” ([8], p. 8).

Much historical evidence nevertheless suggests that past entrepreneurs, industrialists, technicians, intermediaries and agriculturalists have long strived to create economic value out of domestic refuse, production residuals, emissions and effluents of all kinds. Indeed, as suggested by London resident and Society member (after 1914, Fellows) Karl Marx (1818–1883), with “the advance of capitalist production the utilisation of the excrements of production is extended” and the “so-called waste plays an important role in almost

every industry” ([9], pp. 120–121). He even argued that industrial waste recovery was “the second great branch of economies in the conditions of production” after economies of scale ([9], p. 95).

In expressing these thoughts, Marx was echoing what other Society members had documented and promoted in previous decades. What would now be termed circularity initiatives by the organization began a few years after its creation with financial premiums offered for the development of valuable by-products out of residuals and emissions. The Society also published many articles on the topic in the various iterations of its journal (Transactions of the Society, Instituted at London, for the Encouragement of Arts, Manufactures, and Commerce (1783–1843); The Journal of the Society of Arts (1852–1908); Journal of the Royal Society of Arts (1908–1987); RSA Journal (1987–present)). As stated in an 1880 issue, its council had “always welcome[d] any communication bearing on the important subject of the utilisation of substances hitherto regarded as waste products” ([10], p. 691) The Society had by then also sponsored a significant book [2] and an exhibit on the topic [11].

Most crucial to the Society’s early circularity efforts were the chemist and statesman Lyon Playfair and the journalist and editor Peter Lund Simmonds [11]. Although their writings [12–14] and museal contributions [15,16] have been discussed by historians in recent years, the inherent incompatibility between past and present-day circularity outlooks at the RSA have not. These opposite perspectives are of more than intellectual interest because of the radically different policy implications they entail. In short, earlier contributions reflect a then dominant (classical) liberal perspective in which the profit motive triggers a constant war on waste and rewards the creation of wealth out of it. In this perspective, market forces can be relied upon to create ever greater and complex circularity, and the role of governments is essentially limited to make sure that broad and fairly enforced rules do not get in the way of innovative behaviour. Present-day contributions, by contrast, consider that the profit motive rewards the externalization of residuals because economizing on pollution treatments reduces production costs. Instead of promoting greater circularity, the profit motive is believed to reward short-sightedness and is therefore inherently incompatible with designing for longevity, disassembly, remanufacture, reuse and leasing/services. Achieving greater circularity thus requires numerous policy interventions, with some more targeted than others.

This paper documents, compares, explains and infers policy recommendations from the history of the RSA on circularity as follows. Section 2 summarizes present-day RSA Fellows and contributors’ take and initiatives on the circular economy. The otherwise incompatible evidence and stance of earlier members are then discussed in some detail in Section 3. Section 4 delves more deeply into the most meaningful differences between the two groups, i.e., the impact of the profit motive on the handling of residuals and the useful role (or not) of design, intermediaries (e.g., waste dealers and brokers) and long-distance trade in delivering greater circularity. The reflective conclusion offers hypotheses that might explain, to some degree, the RSA’s present-day stance on circularity and how it came to be, along with a suggestion that, if earlier generations of members’ take on market incentives is more correct, regulatory reform (or deregulation) might be the most promising way to facilitate the additional creation of wealth out of waste. Section 6 discusses the case selection and methodological approach used in the preparation of this article.

2. The RSA on the Circular Economy

2.1. Key Historical Narrative and Policy Outlook in Circular Economy Theorizing

The circular economy has been promoted by a wide range of prominent public and private organizations. The list of international organizations includes the Organization for

Economic Co-Operation and Development (OECD), the World Trade Organization (WTO), the World Economic Forum (WEF) and the United Nations Environment Programme (UNEP). Numerous international, national and sub-national governments, from the Chinese Communist Party and the European Commission to the author's own city of Guelph (Ontario, Canada) are also involved in such efforts, as are several large corporations. (Lists of public and private organizations supportive of the concept are available on, among other sources, the GACERE (Global Alliance on Circular Economy and Resource Efficiency) website at <https://www.unep.org/gacere> (accessed on 16 March 2025), the Ellen MacArthur Foundation Network website at <https://ellenmacarthurfoundation.org/network/who-is-in-the-network> (accessed on 16 March 2025) and the World Bank's Global Circular Economy Initiatives website at <https://www.gihub.org/infrastructure-and-the-circular-economy/circular-economy-collaboration/> (accessed on 16 March 2025)).

The CE is marketed as a necessary and lucrative paradigmatic shift away from the “take, make, waste” extractive “linear model” of traditional market economies, in which resources are extracted, processed and disposed of carelessly, resulting in the uncontrolled release of waste materials and pollution emissions in all production stages. By contrast, the goal of the CE is to maximize the utility of scarce resources by constantly re-using and regenerating them in a cyclical pattern, manufacturing more durable products and benefiting from the potential offered by the sharing and services economy.

For instance, a report from the World Economic Forum, the Ellen MacArthur Foundation and McKinsey & Company, states that the “last 150 years of industrial evolution have been dominated by a one-way or linear model of production and consumption in which goods are manufactured from raw materials, sold, used and then discarded or incinerated as waste” ([17], p. 13). Linearity creates a wide range of challenges, including “resource depletion, climate change, waste, pollution and health hazards” that “threaten long-term economic growth, jobs, security, health and environmental wellbeing” [18]. By contrast, the CE would deliver environmental improvements and economic wealth, such as up to EUR 600 billion of annual benefits in the EU manufacturing sector [19]; up to \$4.5 trillion of value by 2030 and up to \$25 trillion worldwide by 2050 [20]; 500,000 jobs in France and the reduction in energy consumption in the EU by 37% [21].

Past failure to achieve circularity is blamed on several impediments, from the profit-minded perspective of businesses to a wide range of barriers in “markets, finance, regulation and policy, technology and infrastructure, culture and research” that mandate “strong government intervention to effectively unleash industry initiatives for change” [22]. As such, an “industrial economy that is restorative or regenerative” can only be so “by intention and design” ([23], p. 14). The CE further compels us to “rethink and rebuild our society's supply and value chains” and to create a “shift in perspective from a world organised at the object level to one operating on a network level” ([24], p. 74).

2.2. The RSA and the Circular Economy

The RSA has endorsed the dominant circularity narrative in both style and substance in numerous columns, reports, events and initiatives. The CE was presented as a “paradigm shift in economic thinking” ([25], p. 9) and a move away from the “old ‘take, make, waste’ linear business model to one of ‘lease the resource, make the product, recover the resource and then remake it.’” ([26], p. 42). In 2011, *RSA Journal* readers were invited to attend a panel on “Reimagining Capitalism” featuring a discussion of how the “circular economy and cradle-to-cradle approach offer a blueprint for the future of enlightened enterprise and a long-term path to profitability” ([25], p. 9). A later contribution suggested that “in a stunning tribute to RSA founder William Shipley,” some Fellows were “firmly challenging

our current model of consumption with new, innovative ways of thinking and doing things” and “confronting old paradigms and leading us to a more sustainable future” ([27], p. 48).

The need for a CE-centred “new revolution that delivers greater equality, protects and enhances the environment while supporting economic growth” ([1], p. 19) was often accompanied by claims of significant economic benefits. In one scenario, the EU “could save at least £220bn a year if we were to design products in a way that supported resource recovery and eliminated waste streams” ([26], p. 42). In another, it would add approximately 60 million new jobs by 2030 ([28], p. 12).

The RSA’s circularity niche has been design, with a significant focus on the greater ease of reclamation of devices and their components rather than design that would deliver improved functionality or performance. The rationale is that the diversity inherent to devices such as mobile phones, refrigerators and freezers (e.g., different types and sizes of frames, screws and fittings) makes the effective recovery of valuable components and elements extremely cumbersome ([26], p. 42). The organization’s first major CE initiative, the “Great Recovery” (2012–2016) (henceforth, GR), was thus built on the premise that 80% of a product’s environmental impact was “determined at the concept design stage” ([1], p. 18) and marketed as bringing “a very distinctive design perspective” to the creation of a circular economy ([29], p. 40). Its main objective was “to redesign our ‘material to manufacturer to consumer’ system so that it makes economic—as well as social and environmental—sense to design out waste.” ([1], p. 16). Better design would provide the “creative stimuli needed to kick old business models and managers stuck in established pathways.” [30]. Various meetings and panels were arranged and participants visited textile sorting centers, packaging and car recycling plants, electronic waste recovery facilities, engine remanufacturing facilities and a disused tin mine ([1], p. 16)). “Product design for circularity” was ultimately articulated around the following four models: (1) design for longevity, (2) design for reuse, (3) design for refurbishment, and (4) design for material recovery ([1], p. 19).

According to the authors of the GR report, a key challenge in achieving their goal was that “specialisation taken to its ultimate state” left designers working on items such as TVs, disposable coffee cups, books, toothbrushes and houses little time to think about end-of-life issues ([1], p. 19). Radical change thus mandates collective action and collaboration between the private and public sectors and throughout the supply chain, including the waste industry, because most businesses are driven by “turnover and the ability to sell as much product as possible” ([1], p. 18).

Like many other circularity proponents, GR participants promoted Extended Producer Responsibility (EPR) legislation that holds manufacturers responsible for their products throughout the entire lifecycle, including at the post-consumer stage. EPR is said to incentivize leasing arrangements that encourage long-term and more cost-effective relationships. A case in point is washing machines, where the three main causes of failure are the motor, circuit board and pump. Manufacturers held responsible for repair and replacement under EPR would have much greater incentives to design for the rapid replacement of these components ([1], p. 19). A workshop ran for a “major battery producer that wanted to create an environmentally friendly battery for the African market” similarly recommended “to lease customers solar photovoltaic cells and batteries and charge on an ‘as-used’ basis” ([1], p. 19). The GR project leader argued that such models would ultimately “minimise the cost of recovery and maximise the value of the materials at the end of life, which in turn promotes new approaches to design for ease of maintenance, repair and reuse” ([1], p. 19).

Another relevant policy issue was legal and legislative barriers to circularity, from “worries over liability or prosecution” for “being anti-competitive or breaching duty of care” to international waste regulations [31]. Although in-depth discussion of the matter

was left to future initiatives, it was recommended that the “UK and EU Government must commit to supporting the move towards a circular economy by building a palette of policies, investments and design support systems that enable positive behaviour change from all actors in the circular network” ([32], p. 7).

In 2021, the RSA formally partnered with the Ellen MacArthur Foundation to spread the “idea and practice of circular design across both networks, creat[ing] an empowered community, and ultimately driv[ing] global change”, along with “advancing the circular design agenda and educating and engaging communities around the topic of circular design”. This would be achieved through the co-creation of “tools, resources, events, and projects to inspire designers, increase understanding and encourage day-to-day practice.” [33].

In their ongoing Regenerative Futures program, RSA staff took as one of their five key entry points for change that “product lifecycles, from materials extraction to consumption and disposal, are linear and drive waste, pollution and poor labour conditions”. Another is that “(t)oday, our economy is underpinned by a financial system that prioritises growth to the detriment of other forms of value on which both humans and the living world rely.” [34].

2.3. Contradictory Historical Evidence

To this writer’s knowledge, the only recent RSA writing that highlighted past circularity is a 2020 column by historian Emily Cockayne in the *RSA Journal* [14]. Building on her recently published book *Rummage. A History of the Things We Have Reused, Recycled and Refused to Let Go* [35], she observed that, before the invention of the first fully synthetic plastic in 1907, Bakelite, many plastic substances were made of recycled materials and developed in the wake of the Society of Arts’ Great Exhibition of 1851. Indeed, “many Victorian men connected with the RSA helped to develop and promote these new substances, all made in imitation of natural materials such as tortoiseshell, ivory, horn, oak and ebony” ([14], p. 50). Among these were *bois durci*, made from slaughterhouse blood and sawdust, and Parkesine, whose main input was cotton waste. Cockayne, however, does not mention that Bakelite, a combination of formaldehyde and phenol, was ultimately made up mostly of components of coal tar, a by-product of coal gasification, and wood alcohol, typically derived from sawdust and wood scraps.

I now turn to a more detailed examination of the history alluded to by Professor Cockayne.

3. The Society of Arts on Waste Products

The educational work on waste products of the Society of Arts, especially the contributions of Lyon Playfair and Peter Lund Simmonds, were once widely acknowledged [11]. For instance, a contributor to *The Chambers’s Journal of Popular Literature, Science and Arts* observed in 1869 that one “of the blessings of modern science presents itself in the form of economy, frugality, utilisation. Things which were formerly thrown away as waste are now applied to man’s purposes, to an extent far beyond our general supposition”. He added that “Dr Lyon Playfair and Mr P. L. Simmonds have frequently drawn attention to this subject, chiefly in illustration of the wonders of chemistry”. Indeed, “Mr Simmonds has recently collected a new budget of instances, which he has brought under the notice of the Society of Arts” ([36], p. 807).

In a review of the second (1873) edition of Simmonds’s book *Waste Products and Undeveloped Substances*, published in the Society’s journal, an anonymous contributor observed there were “not many subjects to which the Society has given more careful or more frequent attention than those connected with the utilisation of waste”. Practitioners had achieved much, as evidenced by many industries in which the by-products had

become almost as important as the main output. It was also “certainly true of very many of our principal manufacturing processes that they could hardly be carried on but for the commercial value of products once stigmatised as waste” ([37], p. 11).

Another reviewer commented in *Hardwicke's Science-Gossip* that “No man in Great Britain is better able to deal with [this] important question. . . than Mr. P. L. Simmonds; no other writer has devoted so much time and attention, or has for so long been regarded as an authority on these and kindred matters” ([38], p. 14). The librarian and journalist William E. A. Axon (1846–1913) similarly wrote in the [British] *Companion to the Almanac* that “while it would be impossible to name all the varied authorities who have written on the various branches” of the utilization of waste, it “would be unjust not to direct special attention to the writings of Mr. P. L. Simmonds, who has directed much attention to it, and has lived to see many of his suggestions carried into effect, to the increase of the general wealth”. He added that the “Society of Arts, by the premiums it has offered, and by the many excellent papers it has published, has done great service” ([39], p. 46).

What follows is a more detailed account of the role played by the Society of Arts in supporting these contributions.

3.1. *The Society of Arts Modus Operandi*

The Society initially promoted innovative behaviour by offering premiums, i.e., small financial or pecuniary awards, for the development of technical solutions that would not be patented. Following a major reform and democratization of the patent system in the middle of the nineteenth century, its focus shifted to the dissemination of useful information, mostly by holding weekly meetings and publishing the proceedings in its journal ([3], p. xii).

The organization's fortune improved drastically after some of its members organized and generated a substantial profit from the 1851 Great Exhibition of the Works of Industry of All Nations. Part of this sum was used to create cultural institutions and to sponsor various educational initiatives [3,40]. Most relevant here are the Museum of Manufactures, first located in central London (1852–1857), but soon relocated to and rechristened the South Kensington Museum (1857, now the Victoria and Albert or V&A Museum), and its Bethnal Green Branch (1872, now the Young V&A) [15].

3.2. *Neglected Resources and Increased Efficiency*

Many early premiums and awards to address “waste” referred to the old meaning of the word, i.e., “uninhabited or sparsely inhabited and uncultivated land” ([41], p. 39). At the prodding of some of its members, including celebrated agricultural writer Arthur Young (1741–1820) [42], the Society rewarded the conversion of wasteland into cropland or timberland. Others were meant to encourage the development of profitable uses for hitherto neglected flora and fauna, such as writing the “best treatise on the Commercial Products of the Islands of the Eastern Archipelago, and their facilities and openings for trade;” ([43], p. 96) the “introduction, commercially, of a supply of Hair, for manufacturing purposes, obtained from animals not hitherto resorted to, such as the Musk Ox, & c.,” and the “largest and best sample of Starch, produced from a non-edible substance, as cheap as any at present in use, and obtainable in large quantities.” ([2] p. 6). Journal articles further drew attention to potential resources such as artificial guano created from low-value fishes and fish processing residuals [44] or possible new fiber sources for paper production [45].

Like many of their contemporaries [46], Society members were concerned with the health problems created by industrial emissions and sewage. Among related premiums and awards, it offered, in 1791, a gold medal or 50 guineas to the future inventor of a method of condensing and collecting the smoke from steam engines, brewhouses, sugar

houses or furnaces into some form of tar that might be made useful ([47], p. 279, my modern spelling). According to its long-time Secretary (1879–1917) and historian, Sir Henry Trueman Wood (1845–1929), before the early 1870s, “numerous papers had... been read before the Society on subjects relating to sewage treatment and utilization” ([3], p. 488). (See, for instance, [48,49].) The Society’s first significant foray in sanitation, however, was a December 1874 conference on “Rivers Pollution” chaired by Lyon Playfair, in which several papers tackled both water pollution and improved methods of dealing with sewage ([3], p. 488).

Some premiums addressed waste by promoting increased efficiency. For instance, in 1805, a premium was offered for “the most satisfactory result of a series of experiments... to determine the best thickness of cotton wicks for candles” in order “to remove the unpleasant consequences and waste arising from the sparkling or guttering of the candles in common usage” ([50], p. 13). Later on, various inventors were enticed to address “New Smoke-consuming and Fuel Saving Fireplace” [51] and “Recent Improvements in the Preparation and Treatment of Flax,” [52] among other issues and problems.

3.3. *By-Product Development*

Perhaps the first Society of Arts’ premium devoted to by-products was offered in 1768 for the development of the best machine for carding waste silk ([53], p. 19, my modern spelling). Be that as it may, in 1810, the Society awarded its silver medal to B. Cook of Birmingham for some of the “early practical proposals for the utilisation of the by-products of gas-manufacture” ([3], p. 295). To give but a few later illustrations, among the premiums offered for the sessions 1858–1859 and 1859–1860 were the “best means of Utilizing Refuse Ores, Refuse Coal, and impure approximations to coal,” the “discovery of a practical means of utilizing Naphthaline,” and the “discovery of a practical process for converting the refuse Naphthaline of Gas Works into Alizarine or Madder red” ([54], p. 95).

Numerous articles discussed salvaged materials and production residuals. Contributions on papermaking tackled inputs such as used sail cloth and bags, cotton waste, sugar cane refuse and various kinds of rags [45,55]. An 1854 article by chemistry professor Frederick Crace Calvert (1819–1873) elaborated on the “manufacture and Application of various products obtained from coal (coal-gas excepted),” including various residuals obtained in coal-gas manufacture [56]. Some papers were devoted to slag (i.e., the stony residual matter separated from metals during the refining or smelting of ore) [57].

A good summary of the Society’s general takes on reuse and recovery is found in an 1884 paper on savings in the clothing industry. Chemistry professor and future Nobel laureate William Ramsay (1852–1916) put it as follows:

For just as every technical process cannot be considered to be beyond improvement, there is always scope for technical investigation; but the true residual phenomena of which I would speak to-night are waste products. There is, I imagine, no manufacture in which every substance produced meets with a market. Some products are always allowed to run to waste, yet it is evident that every effort consistent with economy should be made to prevent such waste; and it has been frequently found that an attempt in this direction, though at first unsuccessful, has finally been worked into such a form as to remunerate the manufacturer ([58], pp. 737–738).

The Society’s first sponsored exhibit that devoted much attention to by-product development was likely the Animal Products (later The Food and Animal Products) collection created for the Animal Department of the Trade Museum, itself a component of the Museum of Manufactures. Its main creator was the chemist, agronomist and antiquary Edward Solly (1819–1886). Solly joined the Society in 1838 and was a key promoter of the Great Exhibition.

He soon after served briefly as the organization's secretary (9 June 1852—4 May 1853), where he was instrumental in relaunching the journal and improving the organization's finances [59,60]. In his time, however, Solly was best known for his 1843 two volume *Rural Chemistry*, in which he had recommended, as could be expected, that "[m]anure should be carefully collected—none should be neglected or suffered to go to waste" ([61], p. 129).

The Animal Products collection was built on a selection of articles inherited from the Great Exhibition [15,62]. Solly arranged them into the following thirteen series: wool, silk, skin, horn and bone, fur, bristle, feather, horsehair, lac, wax, oil shell and refuse matter. The latter was defined as "[r]efuse animal matters derived from the previously illustrated arts, showing the uses to which they are applied. Manures; manufacture of ammonia, prussiate of potash, phosphorus, &c." ([63] p. 495). Following a formal lecture, Lyon Playfair congratulated him for the skillful manner in which he had led "from the raw material to the manufactured products, and the care which he took of the waste products, exhibiting the various shapes in which those hitherto waste products were again brought into the useful purposes of life, so that was, in fact, waste—which was the great point for science to attain" ([63], p. 494).

The Animal Products exhibit was then taken over by Playfair and Peter Lund Simmonds, although it was the latter who significantly improved it, both at the time and in later years [64]. We now turn to a more detailed examination of the contributions of both individuals.

3.4. Lyon Playfair (1818–1898)

Lyon Playfair's involvement with the Society of Arts began in the mid-1840s and remained significant throughout his life. His most important role for the Society was in the organization of the 1851 Great Exhibition, which a biographer described as the greatest of all his numerous public works [65]. Through his diplomatic role behind the scenes, involvement in redesigning the classification system, outreach efforts to manufacturers and as organizer and supervisor of the juries, he, "more than of any other man. . . turned the Great Exhibition of 1851 from failure to success" ([65], p. 542). Among other later Society-related duties, he oversaw the science component of the South Kensington Museum, a duty he relinquished in 1856, and was Secretary of the Royal Commission for the Exhibition of 1851 between 1883 and 1889 [40,66].

Playfair displayed a sustained interest in "methods of utilizing products apparently worthless, or of endowing bodies with properties which render them of increased value to industry" ([67], p. 122). The topic was certainly on his mind in the early 1840s while he was chemical manager in the Primrose calico printing works (Clitheroe, Lancashire). (As he commented a few years later, "calico printing" was then a generic term that covered "all the arts of making dresses with coloured patterns, whether they are manufactured from silk, from woollen, from linen, from cotton, or from any mixture of those materials" ([68], p. 343).) A significant water pollution problem that plagued the industry at the time was solved by profitably recovering up to one-third of the coloring matter previously discharged in local rivers ([67], p. 129). He also probably wrote a few anonymous pieces at the time, in which he originated the "industry as nature" metaphor (i.e., the waste of one species is the food of another) to describe the ubiquity of industrial recovery practices, a figure of speech he would later use on several occasions [11,69].

Playfair addressed resource recovery in more detail in an 1852 lecture "On the Chemical Principles Involved in the Manufactures of the (1851) Exhibition". He observed that chemistry had "exercised immense influence upon manufactures, having increased human power, economized human time, and communicated important values to bodies apparently the most worthless" ([67], p. 154). Among other illustrations

The horseshoe nails, dropped in the streets during the daily traffic, are carefully collected by her, and reappear in the form of swords and guns. The clippings of the traveling tinker are mixed with the parings of horses' hoofs from the smithy, or the cast-off woollen garments of the poorest inhabitants of a sister isle, and soon afterwards, in the form of dyes of brightest blue, grace the dress of courtly dames. The main ingredient of the ink with which I now write was possibly once part of a broken hoop of an old beer-barrel. The bones of dead animals yield the chief constituent of lucifer-matches. The dregs of port-wine, carefully rejected by the port-wine drinker in decanting his favourite beverage, are taken by him in the morning, in the form of Seidlitz powders, to remove the effects of his debauch. The offal of the streets and the washings of coal-gas reappear carefully preserved in the lady's smelling-bottle, or are used by her to flavour blancmanges for her friends ([67], pp. 165–166).

Playfair revisited the issue a decade later in a series of six lectures at the Royal Institution on "Some of the Chemical Arts, with Reference to their Progress between the Two Great Exhibitions of 1851 and 1862". Like its predecessor, the 1862 Exhibition was organized by the Society of Arts and Playfair served on its jury. The illustrative cases of by-product developments he discussed in this context were later summarized in a stand-alone article in Peter Lund Simmonds' magazine *The Technologist* [70], while the full lectures were printed in *Chemical News*. In the first of these, Playfair observed that one of the advantages "which science renders to industry" is the "economy of material," for there was "nothing so characteristic of chemical improvement as the uses which it makes of waste products". As a "philosopher justly defined dirt" as "merely matter in a wrong place," it was, "if put in the right place," a utility for the "substances apparently the most worthless to-day are even elegant utilities to-morrow" ([71], p. 302).

The following lecture discussed the profitable by-products created out of coal-gas residuals. At first, all efforts were devoted to gas production and the residuals were "looked upon in the light of concomitant evils, the tar and water being waste products, which were inconvenient, and to be got rid of by the most ready methods". In time, however, useful purposes were found for most of these, illustrating once again that "substances which to-day are the most useless, to-morrow become embraced within the circle of industrial utilities" ([72], p. 327).

Playfair's final lecture was devoted to matters of public health, but he once again commented that the "economy of nature and of art" are analogous in "respect to waste materials" ([73], p. 79). "Nature, he observed, "uses up her waste materials for the perpetuity of life" ([73], p. 84). He added that

Nature uses up her waste materials by beautiful processes which we try to imitate in our hygienic measures, and produces out of them substances which become of great utility in the economy of the universe. In several of my lectures I have endeavoured to bring before you the economy of chemistry. I have shown you that it takes substances apparently repulsive, and converts them into industrial utilities. We only imitate Nature in this respect. She allows nothing to be waste in the universe, but always converts the refuse materials into substances useful to man. When you see Nature thus cherishing her waste materials, and carefully using up all effete, decaying, and putrid matter for great purposes in the economy of the universe, you will not be inclined to think that the economy of chemistry in converting waste substances into industrial utilities, is either ignoble or repulsive, or that the subject itself was unworthy of being brought before you ([73], p. 84).

The Scottish chemist revisited the topic on a few occasions in later years, including in various essays republished in his 1889 book *Subjects of Social Welfare* [74]. For example, he observed in an 1884 piece that little use was made of the benzene, naphthalene and anthracene found in some fractions of Caucasian petroleum, but that similar substances were extracted profitably from coal tar to prepare synthetic dyes and other commodities. He predicted that petroleum residuals would eventually form the basis of “a very important branch of production,” perhaps even the “largest source of profit” for producers ([74], p. 269). In his 1885 inaugural address as President of the British Association for the Advancement of Science, he identified three conditions that delivered progress in the arts, the last of which was the development of “Methods of utilizing waste products, or of endowing them with properties which render them of increased value to industry” ([74], p. 250).

To this author’s knowledge, Playfair’s last essay on waste products was published in an 1892 issue of the *North American Review*. He again suggested that many “still useless” residuals would in time “be converted into a practical utility” and that the “whole history of manufactures” was a “commentary on this text,” for it had often been seen that the “refuse of the produce of to-day” had become “the chief source of profit to-morrow” ([75], pp. 565, 560).

3.5. Peter Lund Simmonds (1814–1897)

The earliest mention of Peter Lund Simmonds in the RSA archives is in a letter from 1843, in which he inquired about premium lists and the organization’s journal [76]. By the time he was elected a member in 1855 [77], he described himself as a “colonial planter in former years and a literary investigator in a later period” in the Society’s journal ([78], p. 33).

As an agricultural writer of some importance, he had long-standing interests in plants with untapped commercial potential and the potential uses of agricultural processing residuals as feed, manure or other lucrative purposes. His definition of waste products would thus always “include most products of Nature that are uncultivated, freely procurable, and can be applied to some profitable use,” such as the commercial development of beet-root sugar, and the “residues of the used raw and subsidiary substances which remain on the manufacturer’s hands after he has obtained the principal and secondary products” ([79], p. 3). Indeed, as he would reflect in a private letter in 1891, he had always experienced “difficulty. . . as to where to draw the line—between the utilisation of the residues of Manufactures, and the development of neglected products, which until used are certainly waste substances” (quoted by Christie [15]). As a rule, Simmonds investigated “what has already been done, and how much still remains to be done, to utilize and economically apply to industrial purposes the numerous substances which Nature offers in such abundance in various countries” ([79], p. 3).

Although he would acquire much knowledge as a technical writer and publisher, along with his various roles as organizer, curator, judge and consultant to trade and technological museums and international exhibitions [11,77,80,81], it was the Society of Arts that gave him the financial incentives to research and write on the topic from the 1850s to the 1880s. As alluded to earlier, after the Royal Commissioners and the Society of Arts had been “equally impressed with the importance of this object,” ([82], p. 9) they appointed Simmonds in 1856 to “catalogue and arrange, in conjunction with Dr. Lyon Playfair” the Food and Animal Collections presented to the South Kensington Museum ([77], p. 16). He would later write he “took a not inconsiderable part” in updating Solly’s collection for the Museum’s opening in 1857 ([64], p. xiv). He would also list himself as the sole author of its anonymous descriptive catalogue [77]. Simmonds’ key contributions revolved around

the expansion of the class devoted to the “application of waste matters,” including “gut and bladder,” “albumen, casein &c,” “prussiates of potash and chemical products of bone etc.,” and “animal manures, guano, coprolites, animal carcasses sic, bones, fish manures etc.” [82]. The collection was later updated and transferred to Bethnal Green in 1872 and, after years of neglect, terminated and mostly destroyed in 1928 [11,82,83].

Simmonds summarized his key contributions on waste products in the May 1895 issue of the *American Journal of Pharmacy* [84]. His first significant account went back four decades in a course of lectures on “The Utilization of Waste Products” delivered before the Society of Arts. From then on, his key lectures and articles were presented before and published in the Society’s journal. They are as follows:

- “On Some Undeveloped and Unappreciated Articles of Raw Produce from Different Parts of the World” (1854; Awarded a silver medal in 1855 by the Society of Arts) [78]
- “On the Utilization of Waste Substances” (1859) [85]
- “On the Useful Application of Waste Products and Undeveloped Substances” (1869) [86]
- “The Utilisation of Waste: A Quarter of a Century’s Progress” (1882) [87]

A Society premium enticed him to publish his book *Waste Products and Undeveloped Substances: Or, Hints for Enterprise in Neglected Fields* (1862), which he dedicated to the organization’s Council ([2], pp. iii and 6). The goal of his 430-page account was “to condense into a brief compass such desultory notes and descriptions as would lead to reflection and investigation, and probably induce many to utilize more generally products now neglected or overlooked” ([2], p. vi). Despite its length and thirty-five chapters, he acknowledged the topic was “too extensive in its scope to be discussed successfully in detail.” ([2], p. v) His work on waste and other topics, along with his work for the organization, resulted in him being elected “by a special vote of the Council of the Society of Arts, London, a Life Member, without payment,” in consideration of “being eminent in the application of Abstract Science to Arts, Manufactures, and Commerce” ([77], p. 8).

Simmonds revisited the topic in some depth when the authorities of the 1873 Vienna International Exhibition wished to create an exhibit on “Waste materials and their products” devoted to advances in this area since the 1851 International Exhibition [88]. As a result, Simmonds was appointed in 1872 by the Royal British Commission for this event to create a collection that would illustrate “some of the leading industries and utilising processes which have sprung out of waste in this country” ([89], p. iii). (See also [77].) To do so, he queried members of the Society of Arts and others for “any specimens illustrative of such processes, and communications and statistics from manufacturers and others” ([90], p. 860). (A short description of this exhibit can be found in the catalogue of the British section of the event ([91], pp. 115–117)).

Building on this work, the Science and Art Department, with financial support from the Society of Arts, appointed him in 1874 to “form a collection of waste products and their utilization, with a descriptive catalogue. . . [to be displayed] in the Bethnal Green Museum” ([84], p. 249). (See also [77].) It opened in 1875 alongside the previously relocated animal products collection, with which it sometimes overlapped, including items such as bones, animal oils, cow hair and rabbit skins ([64], pp. 147, 166, 176, 303). One could also observe minor additions. For instance, although both collections discussed the value and uses of a dead horse, the description in the Waste Product Collection contained an added invitation to “those curious to see the whole process” to “pay a visit to Green Street, Blackfriars, or Wandsworth and other localities where horse slaughterers are located” [15]. Not surprisingly, both exhibits proved difficult to maintain. Simmonds commented the following in a private letter: “Animal and Vegetable Wastes, necessarily deteriorate, and become unsightly” (quoted by Christie [15]).

Historian Ann Christie has described the waste exhibit as a “blend of a cabinet of curiosities, classroom and showcase for industry” built around three broad categories, i.e., substances “derived from vegetable and animal origins and from sewage and mineral waste.” [15]. Simmonds commented in his seventy-nine-page catalogue that many individuals were engaged in devising “means by which the rubbish may be worked up into a useful product” and that there were few “great manufactures which have not one or more of these dependent industries attached to them” ([79], p. 4). His key lesson was that scientific and technical inquiries had “transmute[d] the waste and refuse materials, elements of pollution, into sources of economy and wealth” ([79], p. 4).

Simmonds also used these opportunities to update his book *Waste Products* in both 1873 and 1876. He again observed that “one of the greatest benefits that Science can confer on man is the rendering useful those substances which being the refuse of manufactures are either got rid of at great expense, or when allowed to decompose produce disease and death” ([92], p. 10). He made ample use of Playfair’s metaphor, such as when he stated that “Nothing comes amiss to our ingenuity. We consume our smoke, write and print on the remnants of our ragged shirts, and triumph over decomposition and stench. Utilisation is the great law of Nature, and we are only following her teaching” ([92], p. 10). He concluded that “every day furnishes new instances of what has become one of the most striking features of modern industry—to let nothing be lost, and to re-work with profit and advantage the residues of former manufactures” and pointed out that while he could further expand on the subject matter, he would undoubtedly “weary the reader with too ponderous a volume” ([92], p. 477).

Simmonds simultaneously published several shorter and narrower contributions on topics such as waste coal [93] and silk [94] in the Society’s journal and elsewhere, including foreign outlets such as *Scientific American* [95], the *Popular Science Monthly* [96] and the *Revue Britannique* [97].

A thorough rearrangement and relabelling of the waste exhibit gave him the opportunity to present yet another lecture at the Society’s headquarters on 20 December 1882. He reminded his audience he had first discussed the topic in the same venue twenty-eight years earlier and might therefore be “deemed egotistical in bringing forward a hackneyed subject”. Nevertheless, in “the long lapse of years, in some of its features, it may be new to the present audience” ([87], p. 97). He added that many subjects he had “incidentally touched upon” had since been so “elaborately dealt with by specialists in papers before the members of this Society” that the ground had been taken from under him. As such, he was “but a gatherer and gleaner, summarizing, as it were, the results of their descriptions” ([87], p. 111).

Looking back, he had “reason to believe that the adoption of many of [his] suggestions [had] resulted in fortunes to some, and has utilized profitably much of the former waste in manufactures”. Science had taught his contemporaries “how to transmute the waste and refuse materials—elements of pollution—into sources of economy and wealth”. There was no doubt in his mind that future success, built on “patient experiment,” would also be achieved. The few cases he had been able to discuss within the confines of his paper thus served “to show to how great an extent civilization is daily adding to the useful products of the world, both by economizing its resources, and calling for new ones by the aid of chemistry” ([87], p. 112).

3.6. On the Society of Arts’ Popular and Professional Outreach

Playfair and Simmonds’ contributions reached large and diverse audiences [11]. An entry in the satirical magazine *Punch* highlighted Playfair’s description of the use of the drainage of urban cow stables in the perfume industry [98]. A contributor to an 1874 issue

of *The Academy* noted Simmonds' observation that some "necklaces are made of monkey's teeth" and commented it would "be interesting to know whether these are considered undeveloped substances or waste products, perhaps in the youth of the proprietor the former, in old age the latter" ([99], p. 426).

More serious reviews and discussions can be found in everything from educational pamphlets and trade magazines to economic treatises and applied science textbooks [11]. To give but one illustration, an 1859 anonymous contribution to *Farmer's Magazine* discussed the "curious details and suggestive information" found in a paper on the utilization of waste substances read before the Society of Arts by Simmonds, in which "attention was prominently drawn to the importance of this matter by the many new industries which sprung up, and the large profits which have been made by vigilant attention to small matters, and the application of some formerly waste substance to a useful purpose" ([100], p. 196).

Although Simmonds' waste exhibit was discussed in various outlets [11], its impact is more difficult to assess. Perhaps one can take the usually modest Simmonds at his word when he suggested his collection had attracted "much attention and interest" ([92], p. iii).

An interesting sidenote is the likely influence of Simmonds' and the Society of Arts' work on Karl Marx's stance on by-product development in capitalist economies, for not only was the London-based Marx a member of the Society of Arts between 1869 and 1880, but it was Simmonds who was his principal proposer for election to membership. As told by Allen and Whittick ([101], p. 260): "It seems that Simmonds either suggested Marx's name amongst others to [Society's Secretary] Peter Le Neve Foster before Le Neve Foster made his approaches or was prepared, after these had taken place, to sign Marx's" proposal form.

3.7. The RSA and Waste Recovery in the Twentieth Century

The RSA's publications on waste product recovery in the early decades of the twentieth century seem largely limited to occasional contributions, such as discussions of milling residuals [102], waste raisin seeds [103], petroleum residues [104] and breeze clinker aggregates [105]. Its journal also ran a review of *Science and Salvage* [106], a collection of essays originally published in 1938 by the National Socialist regime to extol past and future German ingenuity in creating value out of forest residues, agricultural wastes, scrap materials, municipal refuse, sewage, by-products from chemical manufacturing and coal ash [107].

Lectures and events situated within the context of the birth of the modern British environmentalist movement include a 1968 discussion of "Refuse, Scrap and Litter," [108] and various contributions to a 1986 Conference on "Industry: Caring for the Environment." In the latter, John Davidson, then Chief Executive of the Groundwork Foundation, suggested that "[a]ll companies would like to be able to turn their waste into wealth and be accepted as good neighbours in the community. What is often lacking is the management time and expertise to devise and put into action cost-effective solutions" ([109], p. 198). Yet, some succeeded. A representative for the South Caernarvon Creameries thus described how some previously unmarketable portions of the whey were turned into energy in an anaerobic digester, an "example of how environmental pollution control can be made to pay, and where something previously regarded as a waste material is now used as a resource, in this case for energy" ([109], p. 202). The Group Technical Director of Blue Circle Industries, which included Blue Circle Cement, related how "[i]n production we alleviate others' problems by utilizing domestic waste for restoration, or as a supplementary kiln fuel. As a fuel we use the biogas generated by the decomposing waste. We also burn waste tyres" ([109], p. 212). Yet, despite the occasional conference and article, it seems fair to say

that the RSA did not devote the kind of sustained attention nor play the leading role on by-product development in the modern environmentalist era as it had a century earlier.

4. Achieving Economic Circularity: Spontaneous Markets or Purposeful Design?

Nineteenth century members and more recent RSA Fellows and contributors display remarkably conflicting takes on the value or necessity of market incentives, design, intermediaries and long-distance trade in achieving greater circularity. By and large, early analysts smoothly integrated market forces with waste reuse, while recent writings deem them fundamentally at odds with the aims of sustainability and greater circularity, and therefore in need of (serious) “nudging” to achieve these goals, as will now be discussed.

4.1. Profits vs. Design

The fondness for (re)design among twenty-first century RSA Fellows and collaborators stems logically from their characterization of the price system and the profit motive as inherently short-sighted, unethical and fundamentally incompatible with designing for longevity, disassembly, remanufacture, reuse and leasing/services ([8], pp. 34–35). As argued in the Great Recovery report:

Industrialists may think they are working with the most up to date technology and fully optimised systems, and by some definitions they are. However, if the layers are peeled back they reveal real horrors: hazardous factories in developing countries producing our cheap clothes; mines that contaminate land while fuelling conflict; and unstable systems built on slave labour, accidental deaths. These now antiquated foundations do not work for the triple bottom line of people, planet and profit ([8], p. 9).

By contrast, while nineteenth century writers celebrated innovation, one looks in vain for discussions of design in their writings. One suspects they would have found nothing wrong with voluntary circular design that met with consumers’ approval, but their main emphasis was always profitability considerations. Simmonds thus commented in the third edition of his *Waste Products* that “one of the characteristic and salient points of modern enterprise” was “not only to allow nothing to be wasted, but to recover and utilise with profit the residues from former workings” ([92], p. 4). A few years later he observed that many residuals “could be made under the direction of that mighty converter, chemistry, to yield substances of use and profit” ([87], p. 112).

Profits were not only an outcome, but also a key driver of circularity. “As competition becomes sharper,” Simmonds explained in his 1875 catalogue, “manufacturers have to look more closely to those items which may make the slight difference between profit and loss, and convert useless products into those possessed of commercial value, which is the most apt illustration of Franklin’s motto that ‘a penny saved is twopence earned’” ([79], p. 4). As such, the manufacturer “who discovers a heretofore unknown use for the waste product of his work, necessarily cheapens the cost of the principal article of his production, and thus secures an advantage over competitors” ([87], p. 112).

Simmonds further insisted that the transformation of residual matter into valuable by-products should remain guided by “their success as articles of commerce,” for, if “philosophically, nothing should be lost, commercially, much may be thrown away” ([92], pp. 10–11). In other words, if, in a market economy, creative individuals were incentivized to use ever fewer materials and energy to achieve their goals, in a dynamic world, there were always situations where profitable recovery proved elusive. In this context, expanding additional inputs on money-losing endeavours entailed destroying, rather than creating, wealth, as these resources were no longer available to address other needs deemed more

important by consumers. As he put it, if “worn-out shirts could not be made into brand new paper at a profit, we should not at the present moment be chequering it with ink. So long as bones are a substitute for lime in agriculture, and it is cheaper to dissolve or grind them than to quarry limestone, crush it, and carry it to the land, so long only will they be used”. Only profitability considerations kept “shin-bones from the dust-bin and ash-heap”. Similarly, dirt was “utilized as long as it gives us a clear profit” and manure “will not pay for its carriage if the distance be great, or the available power of transit be too expensive”. Profitability considerations also helped determine the most valuable use of by-products. For instance, “[s]oap-suds and dirty water will never grow Brussel sprouts, if soap-suds and dirty water can be more profitably applied” ([92], p. 11).

Simmonds added that philanthropic views, while undoubtedly morally serviceable, had little chance of surviving when they could no longer maintain an establishment. Fortunately, in most instances, “what pays is for the general good. The opposite may be equally as likely a scenario, since we should certainly hesitate before acting on any speculation undertaken solely on the latter consideration” ([92], p. 11). It is therefore probably a fair reading of his work to assume that Simmonds would consider unprofitable recovery schemes, including both those enforced through legal mandates and the design for recovery approach now championed by the RSA, as ultimately wealth-destroying and unsustainable if they proved unprofitable or simply less profitable than other alternatives.

Marx similarly credited the search for increased profitability for widespread by-product development, as these “excrements, aside from the services which they perform as new elements of production, reduce the cost of raw material to the extent that they are saleable”. He added that a “normal loss is always calculated as a part of the cost of raw material, namely the quantity ordinarily wasted in its consumption. The reduction of the cost of this portion of constant capital increases to that extent the rate of profit” ([9], p. 96).

In short, as argued by Simmonds, Marx and some of their contemporaries, the price system, the search for increased profitability and competition between rival firms ultimately delivered both widespread circularity and lower prices over time. One suspects they would be utterly puzzled by the present-day stance that their age was characterized by a linear model of economic development.

4.2. Intermediaries vs. Extended Producer Responsibility

Extended Producer Responsibility’s (EPR) main benefits are said to be shifting the cost of end-of-life management from local institutions to producers (“polluter pays” principle), boosting the recycling and material recovery rates, and incentivizing producers “to adopt a more sustainable design for products (design for environment, DfE)” ([110], p. 4). Like most other proponents [110,111], RSA Fellows and collaborators’ case for EPR revolves around the necessity of additional policy incentives to reward the design of new products with greater and easier reuse, repair and recycle features [8].

A dissenting voice among RSA Fellows is technology entrepreneur and editor David Brunnen, who commented that the “nascent circular economy is too complex for legislation and . . . this would only kill the creativity driving it forward” [112]. (Interestingly, Brunnen attributes interest in the circular economy narrative to “newfound capabilities in complex modelling” [112].) Simmonds and many of his contemporaries would have likely endorsed this perspective, for they described rapid and widespread advances in by-product development in the absence of any legislative impetus. Unlike present-day RSA Fellows and collaborators, they pointed to an ever more complex division of labor as essential to this process. Apart from ever more knowledgeable scientists and technicians, key actors included “collectors of, and dealers in, waste substances,” ([2], p. 6) from self-employed individuals to large firms, who engaged in the gathering, sorting, grading, storing, trans-

porting, advertising and distribution of an incredibly wide array of secondary materials, used consumer goods and machine parts. Unlike current EPR systems, these actors were not limited to specific product sectors, but they instead gathered from and looked to a wide range of potential markets for recovered goods, components and materials.

The best-known and most detailed English source on the subject in the middle of the nineteenth century is journalist Henry Mayhew's 1851 *London Labour and the London Poor*. Among other observations, Mayhew divided street sellers of second-hand articles between those "who sell old metal articles," "old linen articles," "old glass and crockery," and "old miscellaneous articles," from clothes to shoes ([113], p. 3). He further described "street-buyers" such as the "purchasers of hare-skins, old clothes, old umbrellas, bottles, glass, broken metal, rags, waste paper, and dripping," and "street-finders" who picked up their living "in the public thoroughfares," be they "dogs'-dung; the cigar-end finders, or "hard-ups" ... who collect the refuse pieces of smoked cigars from the gutters, and having dried them, sell them as tobacco to the very poor; the dredgermen or coal-finders; the mud-larks, the bone-grubbers; and the sewer-hunters" ([113], pp. 3–4).

Building on Mayhew's and his own observations, Simmonds noted that, in most large cities, a class of poor persons earned their livelihood "by collecting the offal of the houses, and disposing of it for the purposes of different manufactures" ([2], p. 6). The following is his description of a typical ragman's basket:

What do we turn up first? We have pieces of cotton and linen rags,—the raw material of the paper-maker, who transforms these unsightly objects probably into the most delicately-scented note-paper. Here, again, we have pieces of paper of all kinds—what can they be for? They form materials for making paste-board, dolls' heads, and occasionally *papier mâché*. What a singular history we have here! The ball-dress of a lady drops into the rag-basket, and reappears as a *billet-doux*; disappears again, to reappear once more in the drawing room or the nursery, as a workbox or a doll. Returning to the basket again, we find pieces of wollen cloths of different colours,—what use can we put them to, as they do not make paper? The bits of scarlet cloth, which are dyed with cochineal, are boiled in soda to extract the colouring matter, which is used in dyeing chessmen, billiard-balls, and other things. Or we may sort the bits of cloth of different colours, and prepare from them materials for making flock-papers for rooms, or we might make roofing-felt of them ([2], p. 7).

Simmonds further remarked that, in conjunction with the China and glass peddlers, and the vendors of growing plants and flowers, ragmen collected worn-out garments, hats, boots and shoes, which were renovated and made "better than new" by various manufacturers. He also wrote about the wardrobe purchasers who advertised in the *Times* for garments for export and observed that "these classes furnish a considerable portion of the "apparel and slops," to the value of more than £2,000,000 sterling, annually exported, half of which goes to Australia" ([2], p. 10).

In the second edition of *Waste Products*, Simmonds observed that the 1873 London Post-Office Directory listed upwards to 2100 "Manufacturers, or Dealers, in Waste", although this number was far below the real total, because it only enumerated householders and excluded many manufacturers located in the suburbs (Table 1).

Table 1. Manufacturers, or Dealers, in Waste in London in 1873.

Bladder and sausage-skin dealers	14
Blood driers	2
Bone dealers, bone boilers and crushers	16
Chimney sweepers	180
Coal dust makers	3
Coke makers (Gas works)	18
Cork bed and cork carpet manufacturers	4
Cork cutters	50
Cotton waste merchants	17
Esparto merchants	8
Feather purifiers	12
Fellmongers	15
Felt makers	16
Fent dealer	1
Flock manufacturers	7
Fuel (patent) manufacturers	9
Gelatine makers	12
Glue and size makers	14
Glue price merchants	5
Glycerine manufacturers or agents	8
Gold beaters' skin makers	8
Grease manufacturers for coaches, carts, railways, axles, &c.	32
Guano merchants	17
Human hair merchants and manufacturers	32
Horn and bone merchants	14
Ivory-black and lamp-black makers	13
Lint manufacturers	10
Manure merchants and manufacturers	76
Marine store dealers (rags, phials, and bottles, &c.)	560
Melters and tallow chandlers	46
Mop makers	6
Naphta distillers	21
Oakum manufacturers	24
Oil refiners and seed crushers	55
Orange peel cutters	2
Plasterers' hair manufacturers	12
Rag merchants	133
Rubbish carters, and road and dust contractors	15
Sand and gravel merchants	14
Sawdust contractors	4
Scum boilers	2
Ship breakers	6
Shoddy manufacturer	1
Soot merchants	3
Tanners	54
Tripe dressers	113
Wardrobe dealers and old clothes' salesmen	337
Waste paper dealers	51
Waste ivory, bone, and tortoiseshell dealers	3
Yeast merchants	16

- Source: Simmonds ([89], pp. 29–30).

Playfair [75] and Simmonds sometimes described the careful gathering, sorting and processing of some second-hand materials and parts. The Danish-born writer thus commented that woollen rags were first “regarded as entirely waste and useless,” but then provided “a striking illustration of the adaptive ingenuity of the present day.” “In the

woollen manufacture,” he wrote, a “considerable portion of the raw material is scattered as waste; but there are a number of “waste merchants” in different parts of the country who buy up everything like wool, and send it to Leeds, Dewsbury, and Batley, to be made into shoddy or mungo. Being mixed with some new wool, it is spun into yarn, and made into broadcloth, doeskins, pilot cloths, druggets [i.e., a coarse fabric used for floor coverings], and coarse carpeting” ([85], p. 176).

He observed a few years later those woollen rags dispatched by the rag-gatherers “comprise[ed] every variety of fabric that it is possible to produce from wool, from a coarse and harsh carpet to the finest and softest product of the loom. These are piled up in huge heaps upon the warehouse floor, and women and girls attack them on all sides and “sort” them into no less than ten grades, each of which has a special use and an established value” ([92], p. 106). This was but a first step.

Rags from woollen materials undergo many peculiar metamorphoses; old clo’ criers first collect them; they are then successively converted into mungo, shoddy, and devil’s dust, and reappear as ladies’s superfine cloth; they then degenerate into druggets, and are finally used for the manufacture of flock paper. After undergoing all these transformations, they are used by the agriculturist as manure, on account of the large amount of nitrogen they contain. The presence of this element makes them of great use, also, to the chemical manufacturer; he boils them down with pearlash, horns and hoofs of cattle, old iron hoops, blood, chippings of leather, and broken horse-shoes, and produces the beautiful yellow and red salts known as prussiates of potash. From these, again, the rich and valuable pigment called Prussian blue is made, and thus do our old rags enter upon a fresh career of beauty and usefulness, to form, in their turn, other waste products, which may again be utilised through the power of man’s intelligence ([92], pp. 105–106).

While many of these substances and markets disappeared in the following decades with the rise of better substitutes (e.g., synthetic dyes and nitrogen fertilizer), intermediaries in the salvage and recovery business remained important economic actors. In a 1968 lecture at the RSA on “Refuse, Scrap and Litter,” the Assistant Director of Public Health Engineering for the Greater London Council thus observed that a “great deal of refuse” was “produced in factories, power stations and mines”. It was then the job of outsiders to “painstakingly collect. . . minute quantities of metals and textiles. . . into accumulations large enough to interest the scrap wholesalers” who, in turn, “multipl[ied] the quantity until it is large enough to supply steel mills, paper mills and factories”. He added, not surprisingly, that although some of these secondary materials came from homes, most arose “from industrial sources” ([108], pp. 750–751).

4.3. Long-Distance Trade vs. Proximity

RSA Fellows and contributors have not written much about the principle of proximity, i.e., the notion that waste should generally be managed as near as possible to its place of production because of the environmental impact of transportation. It is nevertheless both an aspirational goal in the broader circularity literature [114] and a significant obligation under European regulations regarding waste management, although it has proven difficult to implement in practice [115].

Once again, though, nineteenth-century Society of Arts’ members would have undoubtedly been puzzled by this principle, if only because they witnessed and understood the rationale for a then significant international trade in waste products, such as bones, bristles, coal tar, cotton seed, old clothes, rags, scrap steel, silk waste and shoddy, which were overabundant in one location and desirable inputs in others [92].

For instance, Simmonds commented in 1859 that “if Germany sends us abundance of rags, we send to Germany enormous quantities of shoddy in return” ([85], p. 176). Playfair observed a few years later that rags—except for woolen rags—were the main input used by paper manufacturers, and that this trade had become “very extensive”. No less than 15,000 tons of cotton and linen rags were then imported annually in the United Kingdom, representing about one-fifth of the total consumption, with the rest being derived from domestic waste. Playfair showed no qualms about these imports, for it was the “duty of an enlightened people to gather rags from barbarous nations who do not appreciate their value, and convert them into that paper which is the source through which we obtain our information and intellectual enjoyment”. Nevertheless, it was “quite true that as nations rise high in the world they appreciate the value of rags more, and are willing to give more for them in the market” ([116], p. 37).

Scrap iron was another such material. As Simmonds ([85], p. 184) pointed out, “barge-loads of old iron [were] being shipped as dunnage or ballast in vessels bound for the United States or for the continent”. Old iron in this context included “all descriptions of articles” such as “frying pans and gridirons, saucepans and candlesticks, tea-trays and boilers, shovels, and old corrugated roofing”. In 1857, the United Kingdom had exported 36,500 tons of this material, mostly to continental Europe.

Animal products are another case in point. In 1875, the United Kingdom had imported about 1,300,000 cwts. [i.e., a hundredweight or 112 pounds] of hides, 6000 tons of hoofs and horns, 74,000 cwts. of cow hair, 92,000 tons of bones and 1,250,000 cwts. of tallow [79]. Bones and the products derived from them were then used in both manufacturing and as agricultural fertilizers. Demand by turners, cutlers, sugar-refiners, assayers, potters, glue makers and farmers thus ensured that bones from both domesticated and wild animals were imported from other European countries, Africa, South America, Australia and “the great seats of the fisheries” that supplied whale bones ([92], p. 91).

The more creative or efficient use of resources in some locations was the basic rationale for long-distance trade. Describing a London bone works, Simmonds observed that the “sorting of the bones is a careful and very needful operation and that some of the “larger and more perfect bones are laid aside, and boiled by themselves; these are the best bones. When they are dry, they are cut into convenient lengths, and sold mostly to France, where brush handles and other ornaments are made from them”. He added that it was a “curious fact, that our own countrymen are unable to compete with our foreign neighbours in the purchase of, and trade generally in, bones”. There was, however, a good reason for this. While English bone workers knew “know how to make a brush handle, or any other article”, they proved “unable to utilise the chips and waste cuttings”. Their French counterparts, however, could convert these “into small toys, ornaments, & c., which are sold at large profit”. It was this “additional source of gain” that “enable[d] them to outbid our buyers for the raw bones” ([79], p. 35).

5. Reflective Conclusions

The striking differences in outlook between nineteenth- and twenty-first-century RSA contributors towards the perceived propensity (or not) of market actors to reduce and recover waste in a circular fashion is perhaps the most compelling illustration of a wider conflict of visions on the topic. Indeed, if the evidence provided by past Society members makes a compelling case that economic development in their time was not linear, one is left pondering what caused the rise of the linear narrative. Was it primarily a change in outlook, especially on the impact of the profit motive on corporate behaviour, or has industrial development indeed become more linear in more recent times, a reality that might distort present-day perception of past practices?

If one is to discuss changes in worldview, then a key factor might be a broader intellectual movement away from a once dominant techno-optimistic outlook on societal futures and its replacement by a more eco-pessimistic perspective. Another is increased skepticism as to the benefits of market competition. As suggested by a reviewer, however, many other factors and perceptions, some of them contradictory, might also be at play. For instance, there is now a strong perception that managers of publicly traded corporations are under constant pressure to report positive quarterly results. As such, they have few incentives to invest in R&D activities with uncertain and, at best, distant positive outcomes, such as is often the case in the creation of wealth out of waste. Yet, others believe that there is presently a lack of or insufficient antitrust enforcement that might result in reduced competitive pressures among large oligopolies. It might also be that, unlike in the past, when polluting waste directly affected most urbanites, industrial residuals are now often out of sight and out of the mind of most people, especially when they are shipped to distant jurisdictions. These are some of the reasons, the reviewer suggests, why government interventions that penalize waste might now be essential to create greater circularity than is presently the case.

The reviewer further suggests that low-lying fruits have already been picked up and that creating value out of the remaining present-day residuals is much more challenging. There is undoubtedly much truth to this. A case in point is the circularity rates found in documents such as the *Circularity Gap Report 2023* [117] that are typically below 10%, thus suggesting widespread market failure. These numbers are often blamed on the nature of some residual materials, the volatility of markets in secondary materials and regulatory barriers of many kinds (e.g., mandates to use “virgin” materials or to destroy hazardous waste) [118]. It is true that many sophisticated composite materials, some types of plastics, heated clay and cement cannot be profitably recycled or restored to their original condition at the present time [119]. Yet, low circularity figures are typically the result of estimates of the weight of materials, including stone, sand and clay used in construction and infrastructure work (e.g., Chinese building boom), carbon fuels (about 11% of which are petrochemical feedstock, with the remainder being combusted) and crops. While asphalt and crop residues are often profitably recycled or put to other good uses, most of these other materials are not, nor can they possibly be under present economic and technological conditions. This is not to say, however, that they will not be at a future date for, as suggested in this article, value was often created out of seemingly unpromising past residuals. In the meantime, however, whether or not infrastructures and properly landfilled synthetic materials are highly problematic from a sustainability perspective, and thus worthy of money-losing circular schemes, seems debatable.

Another consideration is that most people’s idea of waste now revolves around household garbage and, albeit perhaps less now than at the birth of the modern environmentalist movement, sewage and water pollution. The problem in this case is that, if much value was once recovered from domestic waste, night soil and sewage, the rationale for doing so from the turn of the twentieth century onward decreased significantly with the development of better substitute materials (e.g., synthetic fertilizers and plastics), new and better employment opportunities and new public health considerations that favoured burial or incineration over recovery [46,120]. There is obviously no denying that water (river and lake) pollution became more severe in later decades, primarily because of both industrial waste and municipal sewage overwhelming natural assimilative capacity [121]. In the meantime, attempts to create value out of domestic solid waste, including wartime salvage efforts, proved unsuccessful, save for a brief window of opportunity in the Chinese market at the turn of the twenty-first century [12,121,122]. Most municipal solid waste worldwide is now deposited at landfills and waste dumps (around 70%), one-fifth is officially recycled

or treated by mechanical or biological treatments and the remainder (about 11%) is incinerated [123]. Unlike domestic waste, however, industrial residuals have always and will remain consistent in their composition and produced in large volumes in a few locations, thus greatly facilitating their economic recovery.

A possible explanation that deserves further consideration in this writer's opinion is that the very success of past generations in turning polluting residuals into wealth might have played a significant role in present-day perceptions to the contrary. Probably the ultimate culprit in this respect was petroleum refining, where, at first, the most valuable output was kerosene (as a substitute for whale oil), with some of the heaviest parts of the barrel finding markets such as lubricants for steam engines and road asphalt. The lighter distillation fractions, which would later make possible a wide range of (by)products, including gasoline, were then wasted [124]. Although the first industry to provide useful feedstocks in this respect was coal gas manufacturing, some of these once wasted fractions would eventually be turned into synthetic plastics. These substances were first celebrated for having reduced pressures on the harvesting of wildlife (e.g., elephant tusks and tortoise shells) [125]. The increased availability of synthetic disposable plastics from the 1950s onward, however, gave rise to concepts such as "Throwaway Living" and "Throwaway Society" [126]. It is perhaps not a coincidence that the birth of the linear/circular dichotomy, typically traced back to economist Kenneth Boulding's (1910–1993) influential 1966 essay "The Economics of the Coming Spaceship Earth", in which he contrasted the "cow-boy" (i.e., open system/make-use-dispose) and "spaceship" (i.e., closed/cyclical/circular) economies [19,127], was contemporary with these developments. If this is the case, then current perceptions of past linearity would ultimately be attributable to both successful industrial circular development and negligent household and other disposal practices.

But what if, in the end, the analysis of nineteenth-century Society members on circularity is more broadly correct than that of present-day Fellows? If this is the case, more thought and a greater policy role should be given to the beneficial incentives created by the profit motive; the indispensable role played by intermediaries in recovering, sorting and marketing secondary materials and various components; and the crucial role of distant markets for residuals in ensuring the profitability of some recovery operations. If these past patterns of outcome can be expected to keep materializing in market-driven economies, more present-day policy making should perhaps be redirected towards factors, such as price-distorting subsidies and regulatory barriers to recovery, rather than the notion that (re)designing and leasing products is preferable to designing for improved overall economic and technological performance. And while there could be some financial and environmental benefits because of this process, one should perhaps not overpromise results arrived at through analysis based on alleged past linearity. Be that as it may, both present-day RSA Fellows and other advocates of circularity would undoubtedly benefit from recovering some of the lost institutional memory of the organization.

6. Materials and Methods

This article builds on the author's nearly three decades of occasional research on the history of by-product development from manufacturing residuals [128–130]. The selection of the RSA as a case study was motivated by both the organization's pioneering role in sponsoring inquiries and educational efforts into what is now termed circularity and more recent initiatives that not only display no knowledge of this history, but even deny its possibility.

This author has previously alluded to early RSA initiatives in an article on the two key individuals associated with these efforts, Lyon Playfair and Peter Lund Simmonds [11]. This earlier piece, however, did not delve into the Society of Arts' longer history on the

topic, broader institutional support of this line of inquiry in the nineteenth century and contributions by other Society members and collaborators at the time. While researching this article, the author came across additional information on the work and broader impact of Playfair and Simmonds, along with occasional articles and reports on resource recovery published by the RSA throughout the twentieth century.

The approach used in researching and writing this paper was straightforward. It revolved around the location of relevant primary and secondary sources, the development of a narrative exposition of key arguments, the identification and discussion of the main points of disagreement, the formulation of a hypothesis to explain the current widespread belief in past linearity and the identification of the most sensible policy recommendation based on the possibility that the nineteenth-century perspective on circularity is more correct.

The primary sources used in this article are the organization's own publications (e.g., sponsored books and exhibit catalogues; columns and articles in the organization's outlets; conference proceedings; reports) and internal archives, along with various other writings and documents produced by key members (e.g., Peter Lund Simmonds' repeated demands for support from the Royal Literary Fund towards the end of his life, in which he listed his various accomplishments) [77]. Secondary sources include various documents (e.g., books, academic and popular articles and reviews) that discuss relevant facts related to early writings and other initiatives, either contemporary of these efforts (e.g., book reviews and accounts of sponsored exhibits) or the result of later scholarly research (e.g., biographical treatments).

Recent RSA contributions on the circular economy are available on the organization's website. They were covered comprehensively to identify the organization's stance on past linearity, the purported reasons for this situation, and preferred solutions to create a more circular economy. Academic databases devoted to Victorian England (e.g., The Victorian Web, British Library Newspapers, Victoria Research Web, Curran Index of Victorian Periodicals and BRANCH (Britain, Representation, and Nineteenth-Century History)) yielded little valuable information on the Society of Arts' early waste initiative. Fortunately, most of the relevant material is now freely available through online general archives, primarily JSTOR, Google Books and the Internet Archive. Searches in these archives using specific keywords and combinations of keywords (e.g., organization, author or exhibit names in conjunction with keywords such as "waste products" or an author's name) delivered an abundance of primary and secondary sources. Close readings of these sources made it possible to document past assessments of circularity, purported reasons for this situation and the identification of other valuable resources. Additional information was located in institutional archives, such as the RSA Online Archives Catalogue, the V&A Archives and the Archives of the Royal Literary Fund. Documents not accessible online were obtained either from the organization itself (primarily the RSA and the V&A) or through interlibrary loans. Whenever the same information was available in all or a combination of freely accessible online, online gated and paper-only format, the use of the freely accessible online source as references was prioritized in this text.

Various experts on some aspects of the story discussed in this paper were contacted by the author over a period of nearly three decades. Most generous among recent communications was Anton Howes, historian-in-residence at the RSA. Experts willing to share their time and knowledge with a graduate student over two decades ago include the late Simmonds' biographers and scholars David Greysmith and Alan Davidson.

While it is possible that this search process missed some valuable historical material, it seems highly unlikely that any other document or archive would invalidate the analysis presented in this article.

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Data Availability Statement: Present-day RSA documents used in the text are freely available on the organization's website. Most historical sources used in this essay can be accessed freely through JSTOR, Google Books and the Internet Archive.

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References

1. Thomas, S. Road to Recovery. *RSA J.* **2015**, *161*, 16–19.
2. Simmonds, P.L. *Waste Products and Undeveloped Substances: Or, Hints for Enterprise in Neglected Fields*; Robert Hardwicke: London, UK, 1862.
3. Wood, H.T. *A History of the Royal Society of Arts*; J. Murray: London, UK, 1913.
4. Paskins, M. Sentimental Industry: The Society of Arts and the Encouragement of Public Useful Knowledge, 1754–1848. Ph.D. Thesis, University College London, London, UK, 2014.
5. Howes, A. *Arts and Minds: How the Royal Society of Arts Changed a Nation*; Princeton University Press: Princeton, NJ, USA, 2020.
6. RSA. 'Forward-Looking and Practical': Statement on the Death of His Royal Highness Prince Philip, The Duke of Edinburgh. RSA, 9 April 2021. Available online: <https://www.thersa.org/fellowship/news/statement-on-the-death-of-his-royal-highness-prince-philip-the-duke-of-edinburgh> (accessed on 15 July 2022).
7. Judge, P.; Smith, D.; Jones, D.; Barber, B.; Rajan, A.; Steffen, W.; Fells, I.; Foster, R.; Price, J.; Hirigoyen, J.; et al. Progress Unlocked. *RSA J.* **2003**, *150*, 18–25.
8. RSA. *Investigating the Role of Design in the Circular Economy. The Great Recovery: Redesigning the Future, Report 1*; RSA: London, UK, 2013.
9. Marx, K. *Capital, A Critique of Political Economy, Vol. 3: The Process of Capitalist Production as a Whole*; Charles H. Kerr & Company: Chicago, IL, USA, 1909.
10. Anonymous. Report to the Council. *J. Soc. Arts* **1880**, *28*, 689–700.
11. Desrochers, P. Victorian Pioneers of Corporate Sustainability. *Bus. Hist. Rev.* **2009**, *83*, 703–729.
12. Weber, H. Material Flows and Circular Thinking. In *Concepts of Urban-Environmental History*; Verlag: Bielefeld, Germany, 2020; pp. 125–144.
13. Werrett, S. *Thrifty Science: Making the Most of Materials in the History of Experiment*; University of Chicago Press: Chicago, IL, USA, 2019.
14. Cockayne, E. Rubbish: The Victorian approach to waste products could teach us a thing or two about sustainability. *RSA J.* **2020**, *166*, 50.
15. Christie, A. 'Nothing of intrinsic value': The scientific collections at the Bethnal Green Museum. *VA Online J.* **2011**, *30*. Available online: <http://www.vam.ac.uk/content/journals/research-journal/issue-03/nothing-of-intrinsic-value-the-scientific-collections-at-the-bethnal-green-museum/> (accessed on 1 October 2024).
16. Auerbach George, H. Waste and Wasted Opportunity: Utilizing Archive Collections at the Victoria and Albert Museum to Inform Contemporary Sustainability. *Fash. Stud.* **2024**, *3*, 1–29. [CrossRef]
17. World Economic Forum; Ellen MacArthur Foundation; McKinsey & Company. *Towards a Circular Economy: Accelerating the Scale-up Across Global Supply Chains*; World Economic Forum: Geneva, Switzerland, 2014.
18. World Resources Institute. Platform for Accelerating the Circular Economy (PACE). 2024. Available online: <https://www.wri.org/initiatives/platform-accelerating-circular-economy-pace> (accessed on 1 October 2024).
19. Grafström, J.; Aasma, S. Breaking circular economy barriers. *J. Clean. Prod.* **2021**, *292*, 126002.
20. Lacy, P.; Spindler, W.; Long, J. How Can Businesses Accelerate the Transition to a Circular Economy? In Proceedings of the World Economic Forum Annual Meeting, Davos, Switzerland, 21–24 January 2020.
21. WBCSD. *CEO Guide to the Circular Economy*; WBCSD: Geneva, Switzerland, 2017.
22. Cairns, S.; Cyrus Patel, S.; Jessop, A.; Mullen, M. *A Circular Agriculture and Agri-Food Economy for Canada*; Smart Prosperity Institute: Ottawa, ON, Canada, 2021.
23. Ellen MacArthur Foundation. *Towards the Circular Economy Vol. 1: An Economic and Business Rationale for an Accelerated Transition*; Ellen MacArthur Foundation: Cowes, UK, 2013.
24. Bosschaert, T. Circularity is not sustainability: How well-intentioned distract us from our true goals, and how SiD can help navigate that challenge. In *The Impossibilities of the Circular Economy. Separating Aspirations from Reality*; Routledge: London, UK, 2023; pp. 72–80.
25. Anonymous. Preview. *RSA J.* **2011**, *157*, 9.
26. Thomas, S. The Great Recovery. *RSA J.* **2012**, *158*, 42–44.
27. Shallowe, A. Sustainable Thinking. *RSA J.* **2017**, *163*, 48.

28. Nishimura, M. Energy into Action. *RSA J.* **2022**, *168*, 10–15.
29. RSA. The Great Recovery. 2016. Available online: <http://www.greatrecovery.org.uk/> (accessed on 1 October 2024).
30. Thomas, S. Hacking the Circular Economy. *RSA*, 1 April 2015. Available online: <https://www.thersa.org/blog/2015/04/hacking-the-circular-economy> (accessed on 15 July 2022).
31. Legal Barriers to Circular Economy: What are Yours? *RSA*, 15 June 2015. Available online: <http://www.greatrecovery.org.uk/legal-barriers-to-circular-economy-what-are-yours/> (accessed on 15 July 2022).
32. RSA. *Designing for a Circular Economy: Lessons from the Great Recovery 2012–2016*; RSA: London, UK, 2016.
33. Ellen MacArthur Foundation. The Foundation Welcomes the Royal Society of Arts (RSA) as a Partner. 18 March 2021. Available online: <https://ellenmacarthurfoundation.org/news/the-foundation-welcomes-the-royal-society-of-arts-rsa-as-a-partner> (accessed on 1 July 2022).
34. RSA. Join the Re-Generation. 2022. Available online: <https://www.thersa.org/regenerative-futures> (accessed on 1 July 2023).
35. Cockayne, E. *Rummage: A History of the Things We Have Reused, Recycled and Refused to Let Go*; Profile Books: London, UK, 2020.
36. Anonymous. Waste Not! *Chambers's J. Pop. Lit. Sci. Arts Fourth Ser.* **1869**, *6*, 807–809.
37. Anonymous. Review of Peter Lund Simmonds' Waste Products. *J. Soc. Arts* **1873**, *22*, 11.
38. Anonymous. [Review of Waste Products and Undeveloped Substances by P. L. Simmonds]. *Hardwicke's Sci. Gossip Illus. Medium Interchange Gossip Stud. Lovers Nat.* **1874**, *10*, 14.
39. Axon, W.E. Utilization of Waste. In *Companion to the Almanac; or, Year-Book of General Information for 1874*; The Company of Stationers: London, UK, 1874; pp. 25–46.
40. Robertson, B. The South Kensington Museum in context: An alternative history. *Mus. Soc.* **2004**, *2*, 1–14.
41. Winiwarter, V. History of Waste. In *Waste in Ecological Economics*; Edward Elgar: Cheltenham, UK, 2002; pp. 38–54.
42. Gazley, J.G. Arthur Young and the Society of Arts. *Econ. Hist. Rev.* **1941**, *1*, 129–152.
43. Anonymous. Premiums. *J. Soc. Arts* **1858**, *7*, 94–98.
44. Green, H. On Pettitt's Fisheries Guano. *J. Soc. Arts* **1853**, *2*, 87–93.
45. Collyer, R.H. On Paper Material. *J. Soc. Arts* **1860**, *8*, 400–402.
46. Goddard, N. "A mine of Wealth"? The Victorians and the agricultural value of sewage. *J. Hist. Geogr.* **1996**, *22*, 274–290.
47. More, S. Premiums Offered by the Society for the Encouragement of Arts, Manufactures, and Commerce, in the Year MDCCXCI. *Trans. Soc. Instituted Lond. Encourag. Arts Manuf. Commer.* **1791**, *9*, 221+223–328.
48. Cooke, W.F. On the Utilisation of the Sewage of Towns by the Deodorising Process Established at Leicester, and the Economical Application of It to the Metropolis. *J. Soc. Arts* **1856**, *5*, 49–56.
49. Mechi, A. On the Application of Town Sewage to a Large Agricultural Area, Comparing its Strength and Dilution with the Ordinary Farm Manurial Resources; with Considerations of its Effects on Farm Profit. *J. Soc. Arts* **1860**, *8*, 261–267.
50. Taylor, C. Premiums Offered by the Society, Instituted at London, for the Encouragement of Arts, Manufactures, and Commerce for the Year 1806. *Trans. Soc. Instituted Lond. Encourag. Arts Manuf. Commer.* **1805**, *23*, 1–19.
51. Arnott, W. On a New Smoke-consuming and Fuel Saving Fireplace. *J. Soc. Arts* **1854**, *2*, 428–432.
52. Wilson, J. Recent Improvements in the Preparation and Treatment of Flax. *J. Soc. Arts* **1853**, *1*, 229–230.
53. Society for the Encouragement of Arts, Manufactures, and Commerce. *Premiums Offered by the Society, Instituted at London, for the Encouragement of Arts, Manufactures, and Commerce*; Society by W. Adlard: London, UK, 1768.
54. Le Neve Foster, P. Subjects for Premiums During the Sessions 1858–59 and 1859–60. *J. Soc. Arts* **1858**, *7*, 93–98.
55. Stones, W. On the Materials and Machinery Employed in the Manufacture of Paper. *J. Soc. Arts* **1853**, *1*, 181–184.
56. Calvert, F.C. On the Manufacture and Application of Various Products Obtained from Coal (Coal-gas Excepted). *J. Soc. Arts* **1854**, *3*, 17–20.
57. Smith, W.H. The Utilization of the Molten Mineral Products of Smelting Furnaces. *J. Soc. Arts* **1855**, *3*, 335–339.
58. Ramsey, W. Some Economical Processes Connected with the Clothworking Industry. *J. Soc. Arts* **1884**, *32*, 737–742. [CrossRef]
59. Cole, G.A.J. Solly, Edward (1818–1886). In *Dictionary of National Biography*; Smith Elder and Co.: London, UK, 1898; p. 214.
60. Anonymous. Edward Solly, F.R.S. *J. Soc. Arts* **1886**, *34*, 579.
61. Solly, E. *Rural Chemistry: An Elementary Introduction to the Study of the Science in Its Relation to Agriculture*; Office of the Gardener's Chronicle: London, UK, 1843.
62. Scotsman. The Trade Museum of Animal Products and Manufactures—Society of Arts, London. *J. Soc. Arts* **1855**, *3*, 591–592.
63. Solly, E. On the Mutual Relations of Trade and Manufactures. *J. Soc. Arts* **1855**, *3*, 487–495.
64. Simmonds, P.L. *Animal Products. Their Preparation, Commercial Uses and Value*; Chapman and Hall on behalf of the Lords of the Committee of Council on Education: London, UK, 1877.
65. Norrish, R.G.W. Lyon Playfair and his Work for the Great Exhibition of 1851. *J. R. Soc. Arts* **1951**, *99*, 537–549.
66. Blatchford, I. Lyon Playfair, Chemist and Commissioner, 1818–1858. *Sci. Mus. Group J.* **2021**, *15*, 66. [CrossRef]

67. Playfair, L. On the Chemical Principles Involved in the Manufacture of the Exhibition as Indicating the Necessity of Industrial Instruction. In *Lectures on the Results of the Great Exhibition of 1851 Delivered Before the Society of Arts, Manufactures, and Commerce, at the Suggestion of H.R.H. Prince Albert, President of the Society*; David Bogue: London, UK, 1852; pp. 117–155.
68. Playfair, L. A Course of Six Lectures on Some of the Chemical Arts, with Reference to their Progress between the Two Great Exhibitions of 1851 and 1862. Lecture III (Thursday, May 8, 1862): Calico Printing. *Chem. News* **1862**, 5, 343–348.
69. Anonymous. Nothing is Useless. *Chambers' Edinb. J.* **1846**, 132, 19–21.
70. Playfair, L. On the Utilization of Waste. *Technologist* **1863**, 3, 403–412.
71. Playfair, L. A Course of Six Lectures on Some of the Chemical Arts, with Reference to their Progress between the Two Great Exhibitions of 1851 and 1862. Lecture I (Tuesday, May 8, 1862): Distillation of Coal. *Chem. News* **1862**, 5, 302–306.
72. Playfair, L. A Course of Six Lectures on Some of the Chemical Arts, with Reference to their Progress between the Two Great Exhibitions of 1851 and 1862. Lecture II (Thursday, May 15, 1862): Distillation of Coal.- Showing how the former Waste Products. *Chem. News* **1862**, 5, 327–332.
73. Playfair, L. A Course of Six Lectures on Some of the Chemical Arts, with Reference to their Progress between the Two Great Exhibitions of 1851 and 1862. Lecture VI (Thursday, June 12, 1862): The Chemical Arts in Relation to Public Health. *Chem. News* **1862**, 6, 79–84.
74. Playfair, L. *Subjects of Social Welfare*; Casell & Company: London, UK, 1889.
75. Playfair, L. Waste Products Made Useful. *North Am. Rev.* **1892**, 155, 560–568.
76. Royal Society of Arts. Item 184—Letter from P L Simmonds Enquiring about Premium Lists and the Transactions; Royal Society of Arts: London, UK, 1843.
77. Archives of the Royal Literary Fund. Manuscript Number 2256: Peter Lund Simmonds, n.d. Available online: <https://www.rlf.org.uk/our-archive/> (accessed on 1 October 2024).
78. Simmonds, P.L. On Some Undeveloped and Unappreciated Articles of Raw Produce from Different Parts of the World. *J. Soc. Arts* **1854**, 3, 33–42.
79. Bethnal Green Branch of the South Kensington Museum. *Descriptive Catalogue of the Collection Illustrating the Utilization of Waste Products*; George E. Eyre and William Spottiswoode for HMSO: London, UK, 1875.
80. Greysmith, D. The Empire as Infinite Resource: The Work of P. L. Simmonds (1814–1897). *J. Newsp. Period. Hist.* **1990**, 6, 3–15.
81. Cooper, T.L. Peter Lund Simmonds and the Political Ecology of Waste Utilization in Victorian Britain. *Technol. Cult.* **2011**, 52, 21–44. [CrossRef]
82. Bethnal Green Branch of the South Kensington Museum. *A Brief Guide to the Animal Products Collection*; G.E. Eyre: London, UK; W. Spottiswoode: London, UK, 1872.
83. Lesger, Y. 'Rational Recreation': Animal Products and the People of Bethnal Green. *The V&A*, 17 September 2018. Available online: <https://www.vam.ac.uk/blog/projects/rational-recreation-animal-products-and-the-people-of-bethnal-green> (accessed on 1 July 2024).
84. Simmonds, P.L. The Production and Uses of Cotton-seed Oil. *Am. J. Pharm.* **1895**, 67, 249–250.
85. Simmonds, P.L. On the Utilization of Waste Substances. *J. Soc. Arts* **1859**, 7, 175–188.
86. Simmonds, P.L. On the Useful Application of Waste Products and Undeveloped Substances. *J. Soc. Arts* **1869**, 17, 171–181.
87. Simmonds, P.L. The Utilisation of Waste: A Quarter of a Century's Progress. *J. Soc. Arts* **1882**, 31, 97–112.
88. Collier, P. *Vienna International Exhibition, 1873: Report on Commercial Fertilizers*; Government Printing Office: Washington, DC, USA, 1875.
89. Simmonds, P.L. *Waste Products and Undeveloped Substances: A Synopsis of Progress Made in Their Economic Utilisation During the Last Quarter of a Century at Home and Abroad*; R. Hardwicke: London, UK, 1873.
90. Anonymous. Vienna Exhibition—Use of Waste Materials and their Products. *J. Soc. Arts* **1872**, 20, 860–861.
91. Great Britain. *Royal Commission for the Vienna International Exhibition. The British Section at the Vienna Universal Exhibition, 1873: Fine Art Galleries, Industrial, Agricultural and Machinery Halls, and Park: Official Catalogue, with Plans and Illustrations*; J.M. Johnson & Sons: London, UK, 1873.
92. Simmonds, P.L. *Waste Products and Undeveloped Substances: A Synopsis of Progress; Made in Their Economic Utilisation During the Last Quarter of a Century at Home and Abroad*, 3rd ed.; Hardwicke and Bogue: London, UK, 1876.
93. Simmonds, P.L. Waste of Coal. *J. Soc. Arts* **1864**, 12, 463–464.
94. Simmonds, P.L. The Employment of Waste Silk. *J. Soc. Arts* **1873**, 21, 871–874.
95. Simmonds, P.L. The Utilization of Waste. *Sci. Am.* **1883**, 15, 5895–5898. [CrossRef]
96. Simmonds, P.L. The Savings of Science. *Pop. Sci. Mon.* **1883**, 23, 798–811.
97. Simmonds, P.L. Rien de perdu. Utilisation des déchets et rebuts dans l'industrie et la nature. *Rev. Br.* **1874**, 9, 329–361.
98. Angelina. The Horrors of Chemistry. *Punch Lond. Charivari* **1852**, 22, 23.
99. Editor, T. Review of P. L. Simmonds' Waste Products. *Acad.* **1874**, 5, 426.
100. Anonymous. The Utilization of Waste Substances. *Farmer's Mag.* **1859**, 196–198.

101. Allan, D.G.C.; Whittick, A. The ‘Red Doctor’ amongst the Virtuosi: Karl Marx and The Society Part (i). *J. R. Soc. Arts* **1981**, *129*, 259–261.
102. Anonymous. The Utilisation of Cereal Offals and Certain Other Products for Feeding Purposes. *J. R. Soc. Arts* **1914**, *62*, 966–968.
103. Anonymous. The Utilisation of Waste Raisin Seeds in the United States. *J. R. Soc. Arts* **1914**, *62*, 724–725.
104. Anonymous. Development of New Process for Utilising Petroleum Residues. *J. R. Soc. Arts* **1917**, *66*, 89–90.
105. Anonymous. Breeze and Clinker Aggregates. *J. R. Soc. Arts* **1936**, *85*, 25–26.
106. Ungewitter, C. *Science and Salvage*; Crosby Lockwood & Son Ltd.: London, UK, 1944.
107. Cadman, W.H. Review of Science and Salvage by Claus Ungewitter. *J. R. Soc. Arts* **1945**, *43*, 651–693.
108. Flintoff, F. Refuse, Scrap and Litter. *J. Soc. Arts* **1968**, *116*, 750–770.
109. Davidson, J.; Biddle, A.; Falkingham, B.; Quickenden, J.; Weatherilt, P.; Wilkinson, W.; Letchford, B.; Lyon, N.; Franklin, J.; Hinch, J.; et al. Industry: Caring for the Environment. *J. R. Soc. Arts* **1987**, *135*, 195–224.
110. GACERE (Global Alliance on Circular Economy and Resource Efficiency). *Circular Economy and Extended Producer Responsibility. A Webinar Report*; GACERE: Amsterdam, The Netherlands, 2023.
111. OECD. *Extended Producer Responsibility. Basic Facts and Key Principles*; OECD: Paris, France, 2024.
112. Brunnen, D. Circular Economy—Let the Market Decide. RSA, 27 September 2015. Available online: <https://www.thersa.org/blog/2015/09/circular-economy-let-the-market-decide> (accessed on 1 July 2022).
113. Mayhew, H. *London Labour and the London Poor: A Cyclopaedia of the Condition and Earnings of Those That Will Work, Those That Cannot Work, and Those That Will Not Work*; G. Newbold: London, UK, 1851.
114. Chembessi, C.; Bourdin, S.; Torre, A. Towards a territorialisation of the circular economy: The proximity of stakeholders and resources matters. *Camb. J. Reg. Econ. Soc.* **2024**, *17*, 605–622.
115. Durand, M.; Bahers, J.B. Towards A Circular Economy of Proximity? Variable-Geometry Spatiality of Urban Mining. *Issues Min. Sci. Technol.* **2020**, *2*, 122–130.
116. Playfair, L. A Course of Six Lectures on Some of the Chemical Arts, with Reference to the Great Exhibitions of 1851 and 1862. Lecture V (Thursday, June 5, 1862): Rags and Bones. *Chem. News* **1862**, *6*, 37–42.
117. Circle Economy in Collaboration with Deloitte. *Circularity Gap Report 2023*; CGRI: Amsterdam, The Netherlands, 2023.
118. Corvellec, H.; Stowell, A.F.; Johansson, N. Critiques of the circular economy. *J. Ind. Ecol.* **2022**, *26*, 421–432.
119. Michaux, S.; Butcher, A.R. Some Observations on the Current Circular Economy Model, in Particular, The Mineral-Metal-Material Stream Blind Spots. In *The Impossibilities of the Circular Economy: Separating Aspirations from Reality*; Routledge: Abingdon, VA, USA, 2023; pp. 90–102.
120. Stöger, G.; Reith, R. Western European Recycling in a Long-term Perspective. Reconsidering Caesuras and Continuities. *Jahrb. Für Wirtsch./Econ. Hist. Yearb.* **2015**, *56*, 267–290.
121. Melosi, M.V. *Garbage in the Cities: Refuse, Reform and the Environment, 1880–1980*; Dorsey Press: Chicago, IL, USA, 1981.
122. Riley, M. From Salvage to Recycling—New Agendas or Same Old Rubbish? *Area* **2008**, *40*, 79–89.
123. Gutberlet, J. Waste in the City: Challenges and Opportunities for Urban Agglomeration. In *Urban Agglomeration*; InTech Open: London, UK, 2018; pp. 191–208.
124. Larraz, R. A Brief History of Oil Refining. *Substantia* **2021**, *5*, 129–152.
125. The Age of Plastic: From Parkesine to Pollution. *Science Museum*, 11 October 2019. Available online: <https://www.sciencemuseum.org.uk/objects-and-stories/chemistry/age-plastic-parkesine-pollution> (accessed on 1 October 2023).
126. Hellmann, K.-U.; Luedicke, M.K. The Throwaway Society: A Look in the Back Mirror. *J. Consum. Policy* **2018**, *41*, 83–87.
127. Boulding, K. The Economics of the Coming Spaceship Earth. In *Environmental Quality in a Growing Economy*; Johns Hopkins Press for Resources for the Future: Baltimore, MD, USA, 1966; pp. 3–14.
128. Desrochers, P.; Szurmak, J. Long Distance Trade, Locational Dynamics and By-Product Development: Insights from the History of the American Cottonseed Industry. *Sustainability* **2017**, *9*, 579. [[CrossRef](#)]
129. Desrochers, P. Freedom Versus Coercion in Industrial Ecology: A Reply to Boons. *Econ J. Watch* **2012**, *9*, 78–99.
130. Desrochers, P. How did the Invisible Hand Handle Industrial Waste? By-product Development before the Modern Environmental Era. *Enterp. Soc.* **2007**, *8*, 348–374.

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