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THE ENDURING IMPACT OF THE FIRST WORLD WAR

A collection of perspectives

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Wool, Paper, Dye: 1917 and the Roots of the Synthetic Fibre Revolution

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Abstract

In the Great War, wool was as essential to success as steel and gunpowder. All combatant nations tried to ensure continuing supplies of this vital resource, but none so successfully as Britain, whose Australian and New Zealand dominions were key sources of the apparel wools sought after for military uniforms and blankets. Wool was a lynchpin in Allied planning in 1917 and the subject of negotiation, intrigue, and anxiety: how could the United States possibly send its troops—suitably attired for Europe's trenches—as soon as they were needed, in the face of raw materials shortages, including wool?

This article first addresses the complexities of British control of the Australasian wool clip during the First World War. It then looks at how this led the American and German textile industries to seek substitutes—shoddy (recycled wool), Peruvian cotton, paper yarns, regenerated cellulose, silk, and jute—and eventually, synthesised fibres. Next examined is why and how research and development in fibre technology was rooted in the field of dye chemistry, then largely controlled by Germany. Deprived of German dyes for a wide range of products, United States' companies, notably the DuPont Corporation, entered the field in 1917, setting the stage for later breakthroughs in synthetic fibre technology. It took several decades for wool to lose its primacy in war and peace, but the First World War hastened that end. 1917 was a pivotal year: its challenges, opportunities, and actions affected global textiles in ways that still resonate today.

Keywords

DuPont; First World War; strategic military resources; synthetic fibres; textiles; wool

WOOL AS AN INTERNATIONAL STRATEGIC RESOURCE IN THE FIRST WORLD WAR

When the First World War erupted in August 1914, the realisation of how important supplies of raw wool would be to victory was still in the future. Ultimately, success in the Great War would depend as much on wool as on steel and gunpowder. Certainly, for many centuries, wool was the pre-eminent fibre for cold weather clothing, and for military uniforms and blankets (Fig. 1). But not until the production of wool textiles was mechanised in the 19th century, and paired with radical sheep husbandry that engineered sheep whose wool could easily feed the factory machines, was the stage set for mass cold climate war. It was in 1917 that wool's pivotal role as a strategic resource would become glaringly apparent.

The Germans and British entered the conflict with substantial stockpiles, and as both nations had important

woollen textile industries, with significant export trade, they could turn that capacity to the domestic needs of both civilians and the military. While in 1914 optimists held that the war would be over by Christmas, the British government did act quickly, imposing a naval blockade of German ports to prevent wool, among other raw materials vital to the war effort, from reaching the Central Powers.¹

Also disturbed by the possibility that the neutral United States, which had a sizable population of German descent, including a number of well-known woollen manufacturers, might supply Germany, Britain imposed an embargo in late 1914 on shipments of Dominion wool to the United States. In response, in early 1915 a group of American manufacturers formed The Textile Alliance, to oversee imports of wool to the United States, and reassure the British that buyers would not trans-ship either raw wool or finished products to Britain's enemies, for wartime use or post-war stockpiling. Contracts to

1 Pierre Chancerel, 'Raw Materials', in *International Encyclopedia of the First World War*, eds Ute Daniel, Peter Gatrell, Oliver Janz, Heather Jones, Jennifer Keene, Alan Kramer, and Bill Nasson (Berlin: Freie Universität Berlin), accessed 18 May 2019, https://encyclopedia.1914-1918-online.net/article/raw_materials.



Figure 1. Washing day for a New Zealand soldier, woollen socks and undergarments, near Ypres, Belgium, 1918. Photographer unknown. [Sanders, H.A.B. (1917)]. Auckland War Memorial Museum Tāmaki Paenga Hira. PH-ALB-419-H357.

supply blankets and uniform cloth to the Allied armies and in 1917 to meet America's own preparedness needs, boosted American production but also magnified the supply chain weaknesses inherent in the major sources of raw wool being an ocean or two away.²

On the other side of the globe, war also disrupted Australian and New Zealand sheep pastoralism and the countries' secondary and tertiary wool industries. Beginning in the 1880s, Australia's steady increase in sheep numbers prompted wool buyers from around the world to live and work there. By 1914 Australia had overtaken London as the most important centre for wool auctions.³ The toll that naval warfare would

take on this trade, and wool's importance as a strategic commodity, earned attention in October 1914 when the British cargo ship *Troilus*—heading to England laden with West Australian wool—was sunk by the German ship *Emden* in the Indian Ocean.⁴ In 1915 woollen mills in Australia and New Zealand were brought under their respective governments' control to meet local defence requirements.⁵ The Australian Commonwealth Government complained to London in September 1916 that restrictions on shipping wool from Australia to the United States were 'greatly embarrassing Government and causing pastoralists heavy losses'.⁶ The British government became more aware that the unprecedented

- 2 See, for example, S. Banks Rollings, 'The Wool and Woollen Trade as Administered in Wartime', *Bulletin of the National Association of Wool Manufacturers*, XLV111 (October 1918): 343–345. US textile industry trade journals document minutely the difficulties of the woollen business during the war, in getting purchase approvals for wool from abroad, finding shipping, price hikes, labour unrest and shortages, trade disruption, etc. *The Boston Globe*, a daily newspaper in the seat of the American woollen industry, also featured articles on the challenges of wartime production, and statistics on imports and exports of raw wool and finished products.
- 3 See Simon Ville, 'The relocation of the international market for Australian wool', *Australian Economic History Review* 45, no. 1 (2005): 73–95; and David Merrett and Simon Ville, 'Institution Building and Variation in the Formation of the Australian Wool Market', *Australian Economic History Review*, 53, no. 2 (July 2013).
- 4 Christopher Fyfe, *Gentlemen's Agreements: Australian Wartime Wool Appraisements* (Dalkeith, W.A.: Lana Press, 1996), xxiii.
- 5 Mills in Tasmania were turned over to blanket manufacturing for the Defence Department in late 1914. Julian Burgess, *The Outcome of Enterprise: Launceston's Waverley Woollen Mills* (Launceston: Friends of the Library, Local History Series No 3, 2009), 69; S.R.H. Jones, *Doing Well and Doing Good – Ross and Glendinning – Scottish Enterprise in New Zealand* (Dunedin, New Zealand: Otago University Press, 2010), 244.
- 6 Secretary, Attorney General's Dept., to Official Secretary to the Governor-General, 11 Sept 1916. Suggested text for cable to the Secretary of State for the Colonies, London. National Archives Australia. W29/2/99 A456/3.

size of the fighting force, the realities of trench warfare, and the severe Australian drought of 1914/15 had made wool a critical resource.⁷ In late November 1916, having already instituted compulsory purchase of the United Kingdom's entire clip, the government finalised contracts to 'commandeer' the entire clip from Australia and New Zealand. The complex and often contentious negotiations encompassed purchase and appraisal prices, details of sorting, packing, storing, and shipping, and distribution of profits. The agreement applied to both crossbred wools preferred for many military uses, and the finer merinos used primarily for civilian products. It also meant the public wool auctions in Australia's port cities, that had been a mecca for wool buyers from all over the world, were shut down 'for the duration'.⁸ Meanwhile, India agreed to send its clip of blanket quality wools to the United Kingdom.⁹ Thus, as the year 1917 dawned, Britain controlled the majority of the world's supply of raw apparel wool.

WOOL, DYES, AND WAR IN THE UNITED STATES

Meanwhile, from early 1915 American industry began to worry in earnest about the economic effects of the war in Europe—particularly concerning materials and products not produced in sufficient quantity, or at all, in the United States. The first serious shortage Americans faced was a dearth of dyestuffs, with Britain's blockade of Germany, the world's pre-eminent producer of dyes and dye chemicals since the 1870s, reducing the flow to a trickle.¹⁰ Franklin Hobbs of The National Association of Wool Manufacturers, exclaimed in January 1916: 'The situation was serious, not only in textiles, but in every business where colors were needed—ink, leather, paper, and even the ornamental cherry at the bottom of a famous American drink was threatened! It looked like an era of black and white.'¹¹

In response to the dye shortage, the industry fell back on natural dyes and instituted new research efforts. The fashion industries made a virtue of necessity, touting 'black and white' as the height of chic (as opposed to mourning).¹² As anti-German hysteria grew, dye companies that had been founded by German immigrants found it expedient to change their names: Schoelkopf Aniline and Chemical, Beckers Aniline and Chemical, and the Benzol Products Company, for example, merged in 1917 to form National Aniline & Chemical Co. After the United States entered the war on the Allied side in April 1917, the dye sector—which also produced pharmaceuticals and other chemicals—benefited somewhat from 'compulsory licensing' of German-owned dye patents with the passage a few months later of the Trading with the Enemy Act of 1917 (40 Stat.411). But the chemistry of synthetic dyes is very complex, and since patent data is often deliberately incomplete to protect trade secrets, the American chemical industry did not immediately have the capacity to replicate German know-how.¹³ The DuPont Company, whose main product, 'smokeless' gunpowder, required a chemical compound also used in dyes, responded the same year by building a laboratory to develop synthetic dyes. This relatively new focus on basic chemistry research and long-term research and development was supported by the huge profits made from selling gunpowder in the war. From this start, DuPont developed a broader chemical industry footprint, including dye making not only for textiles but also for paints and plastics. After the war, with German patent rights restored, DuPont's dye-works employed German chemists and took over companies whose laboratories had dye chemistry expertise. Lessons learned in this undertaking would support DuPont's shift between the world wars into synthetic fibre development.¹⁴

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- 7 Fyfe, *Gentleman's Agreement*, xxiii; Dorothy Zimmern, 'The Wool Trade in Wartime', *The Economic Journal* (Mar 1918): 13.
 - 8 Kosmas Tsokhas, *Markets Money and Empire: The Political Economy of the Australian Wool Industry* (Melbourne: Melbourne University Press, 1990), 18–28; Fyfe, *Gentleman's Agreements*, 8.
 - 9 South Africa's clip was left on the open market. South America also had substantial wool-growing capacity. Both regions were relative newcomers to the wool trade, but rapidly developed their markets under the shortages manipulated by the UK government. See for example, 'South African Letter', *American Sheep Breeder* 32, no. 2, (Feb 1912): 116–117; 'A Wool Trade Anomaly', *Financial Times* (London) Edition 8, no. 175 (Monday 14 Nov 1914): 2, *The Financial Times Historical Archive, 1888–2010*. Gale Document #: HS23000338783.
 - 10 The UK government allowed two shipments of German dyes to the US via Rotterdam in 1915. 'An Import Company Organized', *Posselt's Textile Journal* XVII, no. 6 (December 1915): xv. See also: Edwin J. Clapp, Chapter XIII, 'The Import Situation (Continued)', in *Economic Aspects of the War: Neutral Rights, Belligerent Claims, and American Commerce in the Years 1914–1915* (New Haven: Yale University Press, 1915).
 - 11 Franklin W. Hobbs, 'Textiles—The Backbone of New England. An Address Before the Boston Art Club'. *Bulletin of the National Association of Woolen Manufacturers*, LXVII, no. 1 (Jan 1917): 83.
 - 12 'Germany's Dyestuff Industry', *Posselt's Textile Journal* XVI, no. 2 (Feb 1915): xv–xvi; 'The Dyestuff Situation'; 'Natural Dyestuffs'; and 'Swiss Dyestuffs for American Use', *Posselt's Textile Journal* XVII, no. 2 (August 1915): 39–41, 44, xv.
 - 13 Peter J. T. Morris and Anthony S. Travis, 'A History of the International Dyestuff Industry', *American Dyestuff Reporter* 81, no. 11 (November 1992): 46–50.
 - 14 'History', DuPont, accessed 16 May 2019, <http://www.dupont.com/corporate-functions/our-company/dupont-history.html>. Even so, it would take DuPont from 1927 until 1939 to develop nylon as the first fully synthetic textile, that would then be almost immediately pressed into service for use in the Second World War.

Even before the dye situation was resolved, the United States' textile industry fretted over supplies of, and substitutes for, wool.¹⁵ American growers had never raised enough wool to meet even the domestic requirements of the nation's textile manufacturers in peacetime. The industry was therefore both heavily reliant on imports, and adept at eking out supplies of new wool by blending it with other fibres. Manufacturers worried about satisfying their domestic civilian customers, and also about their ability to meet foreign demand—not only the combatant nations, but countries which had purchased from those nations before the war and needed alternative sources of supply. American buyers snapped up the wool clips of South Africa, Argentina, and Uruguay—the only market sources the British did not control. After the United States entered the war, civilian shortages became critical. Government public relations encouraged the public to patriotic efforts to increase the wool supply. Small growers formed sheep clubs; President Woodrow Wilson even installed a small flock on the White House lawn (Fig. 2).¹⁶

In the United States, as in the other combatant nations, conserving wool was presented as a civic duty. Civilians were expected to substitute other materials or choose clothing that was slimmer, shorter, and plainer.¹⁷ The armed forces contributed by repairing and re-issuing damaged and worn uniforms. Those beyond fixing were reclaimed as 'shoddy'—the textile industry term since the early 1800s for recycled wool fibre. In the United States, the use of shoddy was coloured by the national memory of the Civil War's 'shoddy scandals', when northern textile manufacturers, trying to outfit an army that had ballooned from 20,000 to 500,000 in a few months, mixed shoddy with virgin wool in such quantity that the yarn quality, and therefore the durability of the uniforms and blankets made from those yarns, was seriously compromised. The term shoddy became 'a

synonym for miserable pretence in patriotism' and by extension, a metaphor for poor quality of any kind.¹⁸ Even though for certain uses, such as blankets and overcoats, shoddy was perfectly acceptable, the aura of Civil War profiteering clung to it, and some feared that through the use of shoddy the recycled uniforms of dead soldiers would be given to those who followed.¹⁹

From an international perspective, fear of the wool uniforms of dead soldiers being reused to clothe a new 'batch' of soldiers, with or without being minced up and reformed into 'shoddy', was by no means fanciful. American journalist Isaac Marcossan observed that once the war was in 'full swing' and the value of wool obvious, the British government set up a Paris Ordnance Depot, with some 4,000 women employed by the 'Agency of Reconstruction'. Huge piles of battlefield salvage,—'eloquent, if odorous evidence of the life and death struggle in which they have figured'—were sorted into clothing reusable by new recruits after washing and mending, and rags and fragments only fit for conversion into shoddy. A third category, primarily overcoats, when 'beyond repair for a soldier ... [were] ... stained grey or black and served out to the Chinese, East Indian or Egyptian Labour Battalions, or to prisoners of war. Marcossan estimated that this saved US\$12 million a year, and that without it shoddy wool prices would have risen even higher than they did during the war.²⁰ A similar depot was set up in Britain, in Dewsbury, Yorkshire, near the British woollen industry cities of Bradford and Leeds. Even the American army recovered wool in salvage operations at St.-Pierre-des-Corps, selling nearly one-and-a-half million pounds at 20 cents per pound to Britain.²¹

Although post-Civil War sensibilities limited American use of reclaimed wool for its military, United States manufacturers were adept at adulterating new wool for civilian uses, and actively sought new ways to

- 15 'Twenty Sheep Needed for Every Soldier: How the Government is Mobilizing the Wool Industry...', *Boston Daily Globe* (1872–1922), 27 January 1918; ProQuest Historical Newspapers: *The Boston Globe*, SM9.
- 16 They were shorn annually from 1918 to 1920, with the wool sold to benefit the Red Cross. 'Wilson to Sell 48 Prize Sheep', *The Washington Post* (1877–1922), 1 August 1920. <https://search.proquest.com/docview/145791499?accountid=46638>.
- 17 See, for example, 'Government Wool Policy', and 'Army Cloth Shortage', *Textile World Journal*, (6 April 1918): 56–57. (Bound volume page numbers 4558, 4559)
- 18 Henry Morland, *The Days of Shoddy: A Novel of the Great Rebellion in 1861* (Philadelphia: T.B. Peterson & Brothers, 1863), 174. For a discussion of shoddy see Madelyn Shaw and Lynne Bassett, *Homefront & Battlefield: Quilts & Contexts in the Civil War* (Lowell, MA: American Textile History Museum, 2012), 117–118.
- 19 Shoddy was an important part of the UK's control of wool textile production. 'By means of a careful salvage system, old uniforms, hosiery articles, etc., are collected from all the theatres of war and sent to the Government Rag Depot at Dewsbury, where they are torn up into shoddy and issued to contractors for making army cloths, for which it is particularly suitable'. Dorothy Zimmern, 'The Wool Trade in Wartime', *The Economic Journal* (March 1918): 28. See also Consul Percival Gasset, 'Demand for Heavy Woolens, March 8', United Kingdom – Leeds. *Commerce Reports* No. 19c, (May 9 1918): 4–5; 'Substitutes Strong', *Textile World Journal* (6 April 1918): 146.
- 20 Isaac Marcossan, *The Business of War*. (New York: John Lane Co., 1918), 180, 183, 186. See also: Henry G. Sharpe, *The Quartermaster Corps in the Year 1917 in the World War* (New York: The Century Co., 1921), 171–189; 'The Dewsbury Army Clothing Depot' Consul Percival Gasset, March 8. 'Demand for Heavy Woolens'. United Kingdom – Leeds. *Commerce Reports* No. 19c, Washington, DC: Government Printing Office (9 May 1918): 5.
- 21 'Salvage Service', *United States Army in the World War, 1917–1919*. Reports by the Commander-in-Chief, Staff Sections, and Services 15. (Reprint) (Center of Military History, United States Army, Washington, DC, 1991): 97.



Figure 2. 'More Sheep, More Wool' movement: Flock of sheep on the White House Lawn, 1918. Library of Congress; Prints and Photographs Division. 10788a.

do that. The American industry had long been (mis)using the word 'merino' to mean a yarn spun from a mix of wool fibres—possibly from merino sheep—and particular strains of coarse, long staple cotton obtained from China or Peru. With cotton also at a premium, other fibres, such as ramie (a bast, or stem fibre, also called China Grass), were tested.²² The American silk industry—by production volume the largest in the world—jumped at the chance to wrest civilian market share from cotton and wool, and developed new ranges of weave structures and finishes to make silk fabrics suitable for active sports and daytime activities, usable in place of wool and cotton.²³ Textile fibre shortages were largely a civilian issue. The *National Association of Wool Manufacturers Bulletin* reported in April 1918: 'The soldiers are now sufficiently supplied with clothing to be kept warm and comfortable. No shoddy or wool substitutes are used in the 16-ounce Melton cloth from which the uniforms—the coats and breeches—are made, this cloth being a worsted made

from all wool. The heavy, 30-ounce Melton used for soldiers' overcoats and the blankets contain about 35 per cent of shoddy mixed with 65 per cent of virgin wool.'²⁴ Normalising the use of substitutes in certain military textiles would have future ramifications for the later widespread adoption of synthetic fibres (Fig. 3).

In Germany and Austria, meanwhile, wool was increasingly scarce. From early in the war French wool textile factories in German-occupied areas were lost to Allied use.²⁵ Their stockpiles of wool were loaded onto railway cars and taken to Germany; some factories were stripped of equipment; others were turned to wool textile production for Germany.²⁶ A post-Armistice intelligence summary from the United States Third Army dated 20 November 1918 reported on the condition of the French in the regions occupied by Germany: 'The forced contributions of money on the towns drained most of the remaining wealth. Recent orders also required the taking of blankets, wool from the mattresses, and even

22 One 1915 example was the Superior Thread and Yarn Company's 'Stycos Wool Substitute' ramie fibre, according to the manufacturer, 'Suitable for mixing with the best 3/8 blood stock', meaning a cross-bred wool with 3/8 merino genes. Donation records for Superior Thread and Yarn Co., 1915. Accession 57996, catalogue number T2367. Textiles Department, National Museum of American History, Smithsonian Institution, Washington, DC.

23 See, for example, Madelyn Shaw, 'American Silk from a Marketing Magician: H.R. Mallinson & Co'. *Textile Society of America Symposium Proceedings*, (2002): 245. <http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1545&context=tsaconf> and, <https://americanhistory.si.edu/blog/keeping-khaki-kool-during-world-war-i>.

24 *National Association of Wool Manufacturers Bulletin*, (April 1918): 85.

25 Jacqueline Dwyer, *Flanders in Australia: A Personal History of Wool and War* (East Roseville, NSW: Kangaroo Press, 1998), 60.

26 'Silk looms in France now making woolen goods', *Posselt's Textile Journal* (Jan 1916): xxi.



Figure 3. Romanians in Craiova, packing wool to deliver to Germany, August 1917. *Official German WWI Photo*. US National Archives. From: Series: German Military Activities and Personnel, 1917–1918; Record Group 165: Records of the War Department General and Special Staffs, 1860–1952. 17390988.

shoddy cloth'.²⁷ Other occupied regions of Europe suffered similarly. A photograph of Serbian villagers with a stockpile of wool they had hidden from the German army suggests this was one form of resistance in occupied territories.²⁸

Confiscated wool, whether taken from storehouses or mattresses, was sent to Germany to be processed into yarn. Germany also pressed into service many substitute fibres, some in development before the war: artificial silk (regenerated cellulose); cattail or Typha fibre; stinging nettle (a bast or stem fibre like ramie); Posidonia (a regenerated fibre made from seaweed), and Solidonia (a treated ramie fibre used in blends with wool). Tough and scratchy jute fibres too were treated with caustic soda in a process dubbed 'woollenising' to eke out wool supplies—mixtures with as much as 60% jute were said to have been used.²⁹

An unlikely but extremely common substitute in Germany and Austria was yarn spun from paper strips, called xylolin or textilose. German inventor Emil Claviez had patented his machinery to spin these yarns for weaving in Europe and the United States, many years before the war. The original product was used for table covers, wall coverings, rugs, and for sacking for substances which would pick up an offensive odor from jute bags. But when textiles ran seriously short in 1916, paper yarns were deployed for household furnishings and civilian clothing.³⁰ German efforts to improve the deficiencies of paper yarns led them to incorporate wool waste fibres—those too short to spin—into the slurry from which the paper was made, hoping to give it more body. Yarns were 'sized' to make them more water resistant and durable. This was important, because it was not only civilians who used spun paper textiles. During

27 Quoted in *United States Army in the World War, 1917–1919. Reports by the Commander-in-Chief, Staff Sections, and Services*. Volume 11. (Reprint) Center of Military History, United States Army (Washington, DC: 1991), 16.

28 U.S. Library of Congress Photograph. LC-A6195- 6207 [P&P] American National Red Cross photograph collection (Library of Congress), <http://hdl.loc.gov/loc.pnp/anrc.03686>.

29 See Pierre Grezac, 'Some War Substitutes in Germany', *The New France* 3, No 3 (May 1919) 507–508; 'Textile and Paper From Pine Needles; and The Land of the Ersatz', *Scientific American* 119 (2 November 1918) 368; 'German Substitutes', *Los Angeles Times* (1886–1922), 13 May 1917.

30 Chauncey Depew Snow and J.J. Kral. *German Trade and the War: Commercial and Industrial Conditions in War Time and the Future Outlook*. Bureau of Foreign and Domestic Commerce; B.S. Cutler, chief. Miscellaneous series- no. 61. Washington DC: Government Printing Office, 1918, 50–52.



Figure 4. Handwritten inscription reads: 'Germany's shortage of wool. Hun undercloths [sic] worn by prisoners captured by New Zealanders was made of material resembling sack cloth'. 15/4/17. Photographer unknown. [Sanders, H.A.B. (1917)] Auckland War Memorial Museum Tāmaki Paenga Hira. PH-ALB-419-H509.

the war, New Zealanders expressed pride in having wool for their soldiers' underwear, especially in comparison to the standard issue German underwear, which they compared to sacking, and which may indeed have been woven of paper yarn (see Figs. 4, 5). A group of about 40 German army wagon covers, tool covers, slings, buckets, horse trappings, and other utilitarian objects, all of them woven, braided, or knotted from paper yarns, and salvaged by the United States Army at the end of the war, were acquired by the Smithsonian National Museum in 1923. Textile curator Frederick L. Lewton was likely alert to the fact that American anxiety over sourcing wool in wartime inspired a concomitant interest in alternatives.³¹ Indeed, by the end of the war the British too had encouraged efforts at paper yarn and textile



Figure 5. New Zealand soldiers proudly show the undershirts and long johns that demonstrate what being a soldier from a nation with plentiful supplies of wool means at the front. Photograph April 1918. Photographer unknown. [Sanders, H.A.B. (1918)]. Auckland War Memorial Museum Tāmaki Paenga Hira. PH-ALB-419-H510.

making. The Textilite Engineering Company exhibited its spinning machine and products at the August 1918 British Scientific Products Exhibition in London.³²

FIRST WORLD WAR LEGACY

British control of so much of the world's wool supply during the Great War, the problems of dependence on foreign sources of textile fibres, and the resultant privations for soldiers and civilians pushed many manufacturing nations between the wars to continue the search for substitutes for the wool that another war would again put out of reach. In the 1930s Italy developed Lanital, a casein or milk-protein-based regenerated fibre. The American version of this, called Aralac, was tested by a number of companies and produced during the 1940s by a division of the National Dairy Products Corporation. Other substances—such as milkweed fibre, peanuts, soybeans, and chicken feathers—were tested, even less successfully.³³ Aralac itself had no lasting impact, as European nations did not make use of casein fibre during the Second World War, finding that milk was far more important as food.³⁴

31 National Museum of American History, Smithsonian (NMAH), Division of Work & Industry, Accession No. 70063; Catalog No. AG23FP03.01-.20.

32 NMAH Accession No. 20253. Three photographs illustrating British paper yarn machinery and products, dated August 1918, from the British Scientific Products Exhibition, King's College, London; and Vice Consul Hamilton C. Claiborne, 'English Production of Paper Textiles', *Commerce Reports, Bureau of Foreign and Domestic Commerce* 3 (3 July 1917): 20.

33 The Textiles Dept, NMAH, Smithsonian Institution, holds many examples of experimental fibres from the interwar period and World War II. A suit made from a chicken feather fabric, formerly in the collection of the now-defunct American Textile History Museum, was transferred to the Henry Ford Museum, Dearborn, Michigan. The Henry Ford Museum also holds a 1941 photograph of Henry Ford in a soybean fibre suit (P.188.29414).

34 'New Fibers and their Applications in Germany During the War Period', *Field Information Agency, Technical. Final Report No. 44*. (United States Group Control Council, Germany, 14 September 1945) (Unclassified). Held in the Textile Dept. Library, NMAH/SI. T-863. Related reports also in the NMAH departmental library are: No. 50, 'General Developments in the German Staple Fiber Industry' (18 September 1945) T-864; and No. 154 'The German Woolen Industry' (1 October 1945) T-868.

As the search for natural fibre substitutes failed to produce fibres in quantities and qualities to insure against future shortages, attention turned instead and alongside the search for substitutes to chemically created synthetics. Wool's physical properties of flame resistance, durability, and warmth—even when wet—made it exceptionally difficult to imitate, but the manipulated shortages of wool in the First World War encouraged a long view. An early focus of synthetic textile chemistry was the further development of rayon, a man-made alternative to natural fibres based on chemically reworking cellulose wood fibres, first developed in the nineteenth century but little used until the 1910s. The filament extruded from liquid cellulose (there were four different processes) was called artificial silk until 1924, when the industry adopted rayon as a generic name, in part because the filament was shiny, like the sun. Even at their most desperate, no nation during 1914–18 sent soldiers to war in glossy, slick rayon, which lost strength when wet. But in 1927 a delustreing process was unveiled, and a year later staple fibre rayon—meaning short, spinnable fibres like cotton or wool—was introduced. World rayon production grew rapidly, from 33 million pounds in 1920 to 457 million pounds in 1930, to 1,818 million pounds in 1937. Rayon did not initially replace wool, but blended fabrics gradually increased market share.³⁵ In the 1939–45 war, rayon linings and part-rayon outer garments such as raincoats were used by the United States military, eking out supplies of cotton or wool.³⁶ Germany and Japan also used rayon for military purposes.

In the 1920s the DuPont Corporation's chemists turned from dyes and a cotton-based artificial leather known as Fabrikoid, developed in 1915, to fibre chemistry more generally.³⁷ Having made massive profits in the 1914–18 war, primarily from selling gunpowder to combatants on both sides of the conflict, DuPont had the capital and industrial capacity to invest in long-term research and development, and worked assiduously from around 1927 to develop the fibre that would become known as nylon. Nylon, an alternative to

silk, was launched in 1939, used in hosiery immediately, and almost wholly replaced silk for parachutes in the Second World War, but was in no way a substitute for wool or cotton (Fig. 6).

Inspired by the huge success of nylon however, DuPont chemists early in the Second World War developed a new chemical synthetic based on carbon petrochemicals, known initially as Fibre A. The staple version of this fibre was developed in the late 1940s and trumpeted in a DuPont News Release as 'the most wool-like we know'.³⁸ In the 1950s this would be marketed as Orlon, but it was not ready for use in either the Second World War or the Korean War of 1950–53.³⁹ Eventually, the brand name slipped away and it became simply known as acrylic, a major source of current pollution in oceans and elsewhere.⁴⁰ The United States law called the Berry Amendment, first introduced in 1941 and still a permanent part of military procurement regulations, prohibits acquiring textiles or textile materials from foreign sources. In emergencies this is skirted by means of special licenses. The Korean War was one such exception, and a huge economic fillip for the wool producing nations of Australia and New Zealand. But the genie was out of the bottle, and synthetics were poised to make inroads into military markets, looking to bypass the supply chains that had caused so much anxiety back in 1917.

CONCLUSION

The soldiers and sailors of the First World War were, for the most part, clothed in wool or wool-blend fabrics. But this was a war on a scale almost impossible to imagine, with eventually nearly 70 million soldiers needing warmth and covering, along with their civilian populations, at a time when access to raw materials, and in some places such as occupied France and Belgium, textile production, was seriously compromised. In the course of this project we have wondered whether, without the industrialisation of wool production in the preceding

- 35 U.S. Dept. of Agriculture, *Report on Development and Use of Rayon and Other Synthetic Fibers* (October 1938). Held in the Textile Dept. Library, NMAH/SI. T-825.
- 36 Erna Risch, 'United States Army in World War II. The Quartermaster Corps: Organization, Supply, and Services'. Volume I (Reprint). Center of Military History, United States Army. (Washington, DC:1995). Chapter III, 'The Development of Army Clothing'.
- 37 Ebenezer Kotei, 'Fabrikoid – A Game Changer', Hagley Museum & Library, accessed 12 December 2019, <https://www.hagley.org/about-us/news/museum-fabrikoid-game-changer>.
- 38 Joseph Quig, of DuPont's Rayon Department's Technical Division in 'News Release to Morning Papers of Thursday Dec 2, 1948', Orlon boxes, Hagley Library and Archive, Wilmington, Delaware.
- 39 An industry evaluation of the glories of man-made fibres can be found in: A. Frank Tesi, C.W. Bendigo, and Arthur Spiro. 'The New and Old in Synthetic Fibers', *The Analysts Journal* 8, no.1, Proceedings, Eastern Regional Conference, New York Society of Security Analysts, 8 November 1951 (January, 1952), 58–69. <https://www.jstor.org/stable/40796933>. Documents internal to the Du Pont Corporation about Orlon reveal a less glowing assessment, noting that DuPont was having trouble selling the fibre, due to market confusion about its continual chemical reformulation and problems with dye take-up 'coloration was not adequate'. The internal report concluded that the gap between these problems and its marketing as a 'miracle fibre' had made Orlon a 'barbed joke in the trade' from 'Report of "Orlon" Product Committee Study of "Orlon" Acrylic Staple – July 1953', Textile Fibers Department, 30 July 1953, Orlon Archive, Hagley Library, Wilmington Delaware.
- 40 Marc Bain, 'Deadly Spin Cycle: Our synthetic clothes are quietly polluting the oceans', *Quartz*, (28 September 2016), accessed 20 June 2019, <https://qz.com/793760/synthetic-clothes-are-polluting-oceans/>.

century, mass trench warfare on this scale could ever have arisen? A concomitant hypothetical is to ask if the use of paper and other substitutes allowed Germany and other Axis powers to continue fighting beyond the point when the lack of wool might otherwise have forced them to surrender? But the actual and perceived shortages of wool fibre in that war, and in particular the shortages in

the United States and Germany that were biting deeply by 1917, precipitated a search for substitutes that lasted for decades and led directly to our contemporary reliance on petrochemical fibres, and the issues of pollution and sustainability that face all of us, civilian and military, in our use of textiles today.

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Du Pont Announces for the World of Tomorrow...

a new word and a new material

NYLON

NO BETTER EXAMPLE of the fruits of research could be found than nylon—so new a material that a name had to be coined by Du Pont for it—as vast in the number of its possible uses that no list, however farreaching at present, can include them all—so promising in its first uses that Du Pont will spend \$8,000,000 on a plant employing approximately 1,000 people.

Nylon is the generic name for all materials defined scientifically as synthetic fiber-forming polymeric amides having a protein-like chemical structure, derivable from coal, air and water, or other substances, and characterized by extreme toughness and strength and the peculiar ability to be formed into fibers and into various shapes, such as bristles, sheets, etc.

This is the newest of the synthetic materials. In its development a group of Du Pont chemists have been occupied for years. Nylon, though it springs from common raw materials that exist in abundance, can be fashioned into filaments possessing a beautiful luster, strong as steel, delicate as the fiber of a spider's web, yet more elastic than any of the natural fibers.

Toothbrushes with "Eaton" bristles made from nylon are now available. Soon other forms of this new product will reach the public as a result of experimental work in progress.

Out of continued research in synthetic chemistry has come this development, as will others, to aid in the building of the World of Tomorrow.

Jobs... Jobs...

Still another important result comes from this contribution—as from other chemical developments. From these fruits of chemical research spring jobs for the men who build plants and machinery—jobs for the men who make the raw material—jobs for the men who convert it into numerous articles for everyday service. This science doubtly aids man in his search for better living.

The Past Gives a Clue to the Future

During the past ten years, Du Pont developments have included (among many other uniquely useful products) such contributions as these:

Moistureproof "Cellaphan" cellulose film to protect food—

...night from dirt and germs, and to preserve freshness and flavor.

"Cordura" rayon yarn, the super-tough fiber for truck and auto tires.

Nitrogen compounds made from the air, to return vital elements to the soil.

Neoprene chloroprene rubber with the resilience, strength and toughness of natural rubber, yet superior in its resistance to gasoline, oils, sunlight, heat and aging.

Improved fire retardants to reduce fire hazards in home and industry.

"Zerom" anti-ice anti-freeze to protect automobile radiators from freezing in winter... from rusting and corroding in summer.

"Dulux" enamels, the tough, long-lasting finishes now used on automobiles, trucks, streamlined trains, ships, bridges, home appliances, interior walls, refrigerators.

Higher Wages... Lower Prices

Since 1929, Du Pont has developed scores of new products. Today Du Pont employs more people than in 1929, pays higher wages, and sells its goods in greater quantities and at lower prices. Last year, forty percent of Du Pont's entire sales was on twelve lines of products developed or improved since 1929.

Scientists believe this record of accomplishment, these contributions to better living, are a promise of things to come—a promise for the World of Tomorrow and for those who will inherit it.

Your Preview of a Better World

At the New York World's Fair, Du Pont's "Wonder World of Chemistry" exhibit will present some of the more spectacular chemical achievements. Here will be shown, for the first time, many of the intricate processes used in the development and manufacture of Du Pont products. Here those who look hopefully in the future will find proof of what orderly research has done to contribute to better living and more continuous employment for everyone.

Where to Tomorrow, Mr. Chemist?

And the chemist answers: "To a thousand untouched shores. To a land of tomorrow where rain won't wet your clothes, where everyone gets his vitamins, where fire won't burn your home, where insects won't steal your wealth, where life is easier, happier, and more complete in ways that can't even be dreamed of today."

How soon, Mr. Chemist? And the chemist answers: "Just as soon as I can make it come true. I build for the tomorrow that will be yours, and your children's and your grandchildren's. And when each of these tomorrows becomes a 'today'—there will still be tomorrows to work for!"

Such is the spirit and the meaning of the Du Pont pledge: "Better Things for Better Living . . . through Chemistry."



When you visit New York's World Fair in 1939, you will find nothing more fascinating than a tour through this building—The Wonder World of Chemistry, presented by Du Pont to give you a glimpse of the world of tomorrow.



E. I. du Pont de Nemours & Company, Inc., Wilmington, Delaware

BETTER THINGS FOR BETTER LIVING...THROUGH CHEMISTRY

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Reprinted from
The Women's Forum, Sunday, October 30th, 1939
New York Herald Tribune

Figure 6. DuPont company advertisement: Public introduction of Nylon at the 'Wonder World of Chemistry' exhibit, 1939 New York World's Fair. Printed in the *New York Herald Tribune*, Sunday, October 30th, 'The Women's Forum' section. Courtesy of Science History Institute.

Madelyn Shaw is a curator and historian whose work explores history and culture through textiles and dress. Recent projects have ranged from the history of exoticism in fashion, to an examination of slave cloth and clothing in the pre-Civil War American South. Publications include an award-winning Civil War sesquicentennial book, *Homefront & Battlefield: Quilts & Context in the Civil War* (American Textile History Museum, 2012); *Clothing through American History: The British Colonial Era* (Greenwood Press, 2013); and the case study 'H. R. Mallinson & Company' in *American Silk: Entrepreneurs & Artifacts, 1830-1930* (Texas Tech University Press, 2007), winner of the Millia Davenport Award. She is currently Curator of Textiles at the National Museum of American History, Smithsonian Institution. This paper is part of a larger project, *Fabric of War*, which she shares with Trish FitzSimons. ShawM@si.edu

Trish FitzSimons is a documentary filmmaker and social historian. She is professor and Deputy Head of the Griffith Film School, Griffith University, in Brisbane, Australia. Interdisciplinarity is a hallmark of her work, which has encompassed documentary production, history and theory, as well as social and environmental history. She was an author of *Australian Documentary: History, Practices, Genres* (Cambridge University Press, 2011). Her early documentary production was for broadcast, including *Snakes and Ladders: A Film about Women, Education and History* (1987) and *Another Way?* (1996). Latterly, her work has been for social history exhibitions – *Channels of History* (2002-05) and *Navigating Norman Creek* (2015). Trish and Madelyn share a Fabric of War, a creative research project which enhances conventional historical research including archival documents, with filmmaking and other screen media techniques and material culture approaches to produce a rich social history. t.fitzsimons@griffith.edu.au