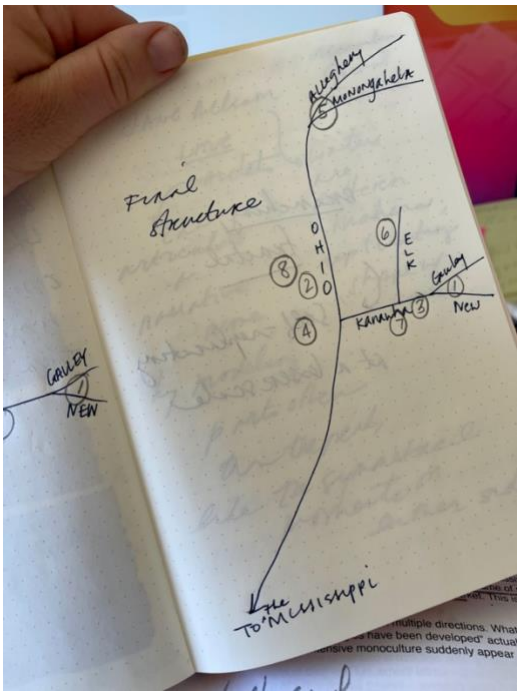
Upriver—A researcher traces the legacy of plastics
Orion Magazine | Summer 2021
Rebecca Altman (edited by Sumanth Prabhaker)

A note on structure, for those interested:



Acknowledgments:

The seeds that became this essay were first sown in Spring 2007 at Orion's Wildbranch Writing Workshop, where I studied with **Sandra Steingraber**. I am grateful for her guidance then, as now. And to my graduate mentors who supported me during my grad school years, 2002-2008, most especially while working on my dissertation, from which a portion of this essay draws: **Phil Brown**, **Rachel Morello-Frosch**, **Ann Dill** and **Julie Brody** (of the Silent Spring Institute). I'd also like to thank **Carolyn Raffensperger**, **Ted Schettler** and the entirety of **The Science and Environmental Health Network**, who have given me an intellectual home.

A special thanks to **Callie Lyons**, whose early reporting on C8/PFOA kept her community informed and educated researchers and journalists the world over about these "emerging contaminants." I would also like to thank all of the community members, leaders and scientists who spoke with me between 2005 and today.

Thanks to **Catherine Venable Moore** for her time, reflections, and her essays (listed below)—her award-winning essay, *The Book of the Dead,* helped spur West Virginia University to put Muriel Rukeyser's poems back in print, with her essay reprinted as the introduction. It is a fantastic volume and I cannot recommend it highly enough.

Thanks to **Sumanth Prabhaker**, Editor at Orion, for inviting me to curate a special series on plastics pollution, and to **The Fine Fund** for supporting it. To the entire editorial team at Orion for their assistance, including **Tara Rae Miner**, **Hans Teensma** and **Natalie Middleton** (who did an extraordinary and diligent fact-check on this bear of a piece). To **David Farrier**, **Max Liboiron**, and **Meera Subramanian**, thank you for joining me in making the series what it became. To **Madeleine Scammell**, **Rye Howard**, **Bathsheba Demuth** for reading/listening to iterations along the way.

To the **Ansel Adams Publishing Rights Trust**, who granted Orion Magazine permission to reprint some of Ansel Adams's images, which he took at two Carbide facilities as part of a Fortune Magazine commission.

To the archivists! Thank you for your dedication (and all your extra efforts at digitization) of your collections. And especially to **Emily Davis** at the Mellon Institute for Industrial Research at Carnegie Mellon, **Debra A. Basham** at the West Virginia State Archives, **Kyle Warmack** at the South Charleston Interpretative Center, and **Ashley Augustyniak** of The Science History Institute in Philadelphia. Thanks also to **Kim Johnson** of Clendenin, West Virginia.

Thanks to my family and to **Dad**, who has graciously joined me on this journey into and through plastics' history.

Additional thanks to **Mariah Blake** whose work on Teflon helped me re-think how Teflon, in some instances, is used as plastic, an a-ha moment that helped me begin connecting the dots. To **Kathy Hipple**, Professor of Finance at Bard's Sustainable MBA program, for helping me understand the riverine layout of the petrochemical industry today and of the proposed (and the current prospects for an) Appalachia petrochemical build-out. To biographer **Mary Street Alinder** for correspondence regarding Adams' work in West Virginia. (She confirmed with me that he was in WV in May and June of 1941. And that the image later published as Pipes and Gauges, which he dated as 1939, and which *seems* like it was taken at Carbide while under the *Fortune* commission (though wasn't published in *Fortune*) was very likely mis-dated, as he was "notorious for not knowing the dates of when he made his negatives."

I'd like to highlight examples of Appalachian environmental resistance, for example, see the work of the Ohio Valley Environment Coalition, Mid-Ohio Valley Climate Action, ReImagine

Appalachia, West Virginian Rivers, The Ohio River Valley Institute, Ohio Citizen Action, The Ohio Valley ReSource.

There is also a remarkable art project underway to counter the erasure of the Black men killed while working on the Hawk's Nest tunnel. Please see the work of Morgantown, WV-based photographer, Raymond Thompson, Jr., called "12 Men," "The Dust," "Tunnelitis," and "Erased. You can read his artist's statement here: http://www.raymondthompsonjr.com/artist-statement and see some of the photos on Instagram @raythompsonjrphoto.

Please consider the following essays and books:

> Jeff Young and the Ohio Valley ReSource. 2020. *Appalachian Fall: Dispatches from Coal Country on What's Ailing America*. Tiller Press.
>
> Elizabeth Catte. 2018. *What You are Getting Wrong about Appalachia.* Belt Publishing.
>
> And anything by Catherine Venable Moore, including: 2014. O BEULAH LAND. *Oxford American*. 2016. The Book of the Dead. *Oxford American*.

Also, **a note on mapping petrochemical hubs**. I mentioned only a handful of hubs built up along global river systems – please follow and contribute to the work of The Global Petrochemical Map, coordinated by a team of scholars convened under the banner, Toxic Expertise (and see the work of Dr. Alice Mah, principal investigator), who are mapping these hubs and the community mobilization within them. Read more about the mapping work here: David Brown and Lorenzo Feltrin. 2019. The Global Petrochemical Map: Drawing the Political Spatial Nexus of Petrochemical Production. Toxic News. Available at: https://toxicnews.org/2019/08/29/the-global-petrochemical-map-drawing-the-political-spatial-nexus-of-petrochemical-production/

> For more on the lower Mississippi, for example, see Thom Davies. 2017. Toxic Geographies: Chemical Plants, Plantations, and Plants that Will Not Grow. Toxic News. Available at: https://toxicnews.org/2017/11/07/toxic-plants-in-the-deep-south-chemical-plants-plantations-and-plants-that-will-not-grow/ And Richard Misraff and Kate Orff. 2014. *Petrochemical America.* Aperture. (Both a book and a traveling art exhibit). More here: https://www.scapestudio.com/projects/petrochemical-america-book/
>
> On the St. Clair and Ontario's Chemical Valley, see Reena Shadaan and Michelle Murphy. 2020. EDC's as Industrial Chemicals and Settler Colonial Structures. *Catalyst: Feminism, Theory and Technoscience.* (6)1: 1-36. Available at: https://catalystjournal.org/index.php/catalyst/article/view/32089/26034 And be sure to

visit evolving project website via the Environmental Data Justice Lab at the Technoscience Research Unit at the University of Toronto: The Land and the Refinery: Past, Present and Future, available here: https://www.landandrefinery.org/

What follows is a selection of sources used in the preparation of this work or that are recommended for further inquiry/exploration.

On Rukeyser's *The Book of the Dead:*

Muriel Rukeyser. 2018. *The Book of the Dead* reissued and with an introduction by Catherine Venable Moore. West Virginia University Press.

Tim Dayton. 2003. *Muriel Rukeyser's The Book of the Dead*. University of Missouri Press.

On the Hawk's Nest Tragedy:

David Rosner and Gerald Markowitz. (Expanded edition, 2005). *Silicosis and the On-Going Struggle to Protect Workers' Health.* University of Michigan Press.

Martin Cherniack.1986. *The Hawk's Nest Incident: America's Worst Industrial Disaster*. Yale University Press.

Catherine Venable Moore. 2016. The Book of the Dead. *Oxford American*. Available at: https://www.oxfordamerican.org/magazine/item/1049-the-book-of-the-dead

For a more expansive history of industrial petrochemicals' development, which includes but also entails other companies besides Union Carbide, for example the development of carbon black from natural gas, and derivatives work at Standard Oil, among others, see: Peter Spritz (1988) *Petrochemicals: The Rise of an Industry.* (John Wiley and Sons). And Benjamin T. Brooks. 1939 "Synthetic Organic Chemicals from Petroleum: An American Development." In *The American Way.* May 1939: 514-519.

On the history of George O. Curme, Jr., petrochemicals, ethylene derivatives and Carbide and Carbon Chemicals (later Union Carbide) – see:

Robert D. Stief. (1998). A History of Union Carbide Corporation, From the 1890s to the 1990s. Published by the Carbide Retiree Corp., Inc. Available via the Science History Institute, Philadelphia, PA.

Union Carbide and Carbon Corporation. 1934. Synthetic Organic Chemical Products. Pamphlet. Available at: https://www.lib.uchicago.edu/ead/pdf/century0612.pdf

See 3-part series published in *Fortune*, "The Corporation" (June 1941); "Alloys, Gases and Carbons" (July 1941) "Carbide and Carbon Chemicals," (September 1941). Although, note there is no by-line and specific claims require historical vetting with other sources.

August B. Kinzel. 1980. George Oliver Curme, Jr, A Biographical Memoir. National Academy of Sciences. Washington, DC.

John E. Pfeiffer. 1939. Modern Miracle: Synthetic Chemistry: Wealth from Waste. *Mechanix Illustrated*. April 1939.

Gerd Wilcke. 1972. Cleaning up Union Carbide. *The New York Times.* May 28, 1972.

Note: Additional archival sources collected through the Mellon Institute for Industrial Research at Carnegie Mellon, The Science History Institute, the West Virginia State Archives, the South Charleston Interpretative Center, and from the privately-held collections of relatives of former Carbide employees.

Carbide and Carbon Chemicals Corporation. 1936. Ethylene for Coloring Matured Fruits and Vegetables, 2nd edition.

Simon Meyer. 1924. Cracking of Paraffin Gases for Olefin Production. Carbide and Carbon Chemicals Corporation, Clendenin, WV. August 23, 1924.

Simon Meyer. 1979. *Carbide: The Recollections of the Early Years*. Courtesy of Kim Johnson.

Robert C. Hieronymus. 1997. Union Carbide Corporation History: Olefins, Early Period 1914 through 1950. September 1997.

J.N. Compton. 1945. The Beginning of the Chemicals Corporation and the Clendenin Development. Courtesy of Kim Johnson.

Carbide and Carbon Chemicals Corporation. 1939. The Carbide and Carbon Chemicals Corporation's Early Growth. *Carbide News*. June 1939. 3-13.

Carbide and Carbon Chemicals Corporation. 1940. Corporation Passes Twenty Year Mark. *Carbide News*. November 1940. 3-6.

Carbide and Carbon Chemicals Corporation. 1944. George O. Curme., Jr. Gibbs Medalist. *Carbide News*. April 1944. 3, 14.

Carbide and Carbon Chemicals Corporation. 1938. The Story of Union Carbide and Carbon Corp. Carbide News. July 1938.

Carbide and Carbon Chemicals Corporation. 1970. Union Carbide Golden Jubilee. Fifty Years of Progress. Carbide News. September 10, 1970.

Historic Plant is Coming Down. 1970. Gazette-Mail. December 20, 1970.

Union Carbide. 1990(s). The History of UCC. A 35-minute film made by Union Carbide via Westridge Production Center, Danbury, CT. Courtesy of Kim Johnson.

History of Organic Synthesis Fellowship. Mellon Institute News. September 3, 1959 Vol XXII No. 49 p. 5-9.

J.G. Davidson. 1956. Petrochemical Survey: An Anecdotal Reminiscence. Chemical Industry Medal, 1955, Medalist's address delivered before the American Section of the Society of Chemical Industry in New York, October 28, 1955). Reprinted in: *Chemistry and Industry.* May 19, 1956 edition. P. 392-398.

J.G. Davidson. 1957. Letter to Alumni Editors. Mellon Institute News. June 29, 1967. Vol XXX No. 39 p. 9-11.

From the WV State Archives: Union Carbide Corporation MS2002-064

Maxwell Sutherland 1996: the History of Vinyls and Plasticizers at Union Carbide Corp.

Chemicals from Hydrocarbon Gases.

Union Carbide Chemicals Company: Dates of First Sales of Chemicals in Lots of at Least 55 Gallons.

"Mellon Institute: Birthplace of Carbide and Carbon Chemicals Corporation," typescript copy from *Carbide News,* April 1939.

A Marketing Revolution: Early Sales Efforts of Union Carbide Chemicals Company. C. W. McConnell to R. D. Stief, October 31, 1995.

Carbide Chemistry: Union Carbide Chemicals and Plastics, How They Are Manufactured, 1975.

Ethylene and Its Derivatives: Their Chemical Engineering Genesis and Evolution at Union Carbide Corporation, by Arthur E. Marcinkowsky and George E. Keller, II, June 13, 1980.

Dates of First Sales of Chemicals in Lots of at Least 55 Gallons in the USA by Union Carbide Corp. Between 1922-1960.

Photocopy of blueprints, The Clendenin Gasoline Company, Clendenin, West Virginia. Compressor Building, Electric Power Building, Location Plan.

"A Brief and Sketchy History of the Union Carbide Corporation, and more particularly the Union Carbide Chemicals Company, a Resume of a Talk Prepared for New Technical Employees on the Above Subject," by G. J. Ratcliffe (three copies).

"The Carbides and Acetylene Commercially Considered," by T. L. Willson and J. J. Suckert, *Journal of the Franklin Institute of the State of Pennsylvania, For the Promotion of the Mechanic Arts*, May 1895.

"A Lecture Upon Acetylene," by J. M. Crafts, *Science*, March 13, 1896.

Carbide Chemistry: Union Carbide Chemicals and Plastics, How They Are Manufactured, 1975.

Ethylene and Its Derivatives: Their Chemical Engineering Genesis and Evolution at Union Carbide Corporation, by Arthur E. Marcinkowsky and George E. Keller, II, June 13, 1980.

Dates of First Sales of Chemicals in Lots of at Least 55 Gallons in the USA by Union Carbide Corp. Between 1922-1960.

"The Carbides and Acetylene Commercially Considered," by T. L. Willson and J. J. Suckert, *Journal of the Franklin Institute of the State of Pennsylvania, For the Promotion of the Mechanic Arts*, May 1895.

Memorandum of Products and Processes Pertaining to Work of Organic Synthesis Fellowship for Attention of Mr. G. C. Furness and Mr. W. F. Barret, by G. O. Curme, Jr., July 16, 1919.

On Carbide as a major 20th century US plastics manufacturer – see Howard S Bunn. Plastics. *The Analysts Journal* 9(2): 152. May 1953 – "Manufacturing seven out of the nine principal types of plastics, union carbide, also a producer of chemicals and raw materials, is nearly self-sufficient for the materials that go into plastics."

On Carbide as plastics "global center" – see Carbide ad that ran 15 August 1956 in Central NJ Home News, New Brunswick. Headline: "look like the plastics center of the world?"

On early research and development of PVC, vinyl, which wasn't exclusive to Carbide, see:

Morris Kaufman. 1968. A History of the Chemistry and Industrial Production of Polyvinyl Chloride. Dissertation. London University. May 1968.

Jeffrey Meikle (1997) *American Plastic: A Cultural History* (Rutgers University Press).

Gerald Markowitz and David Rosner. 2002. *Deceit and Denial: The Deadly Politics of Industrial Pollution*. University of California Press.

On the military interest in Teflon and fluorocarbon ancestors to PFOA, see

Note**:** PTFE (Teflon) was sold to the military beginning in 1944 (made at the company's Arlington Works in Kearny, NJ). It wasn't announced until after the war in1946 (see Malcolm Renfrew and E.E. Lewis. 1946. Polytetrafluoroethylene: Heat-resistant, chemically inert plastic. *Industrial and Engineering Chemistry* 38(9): 870-877). Intentions for new plastics plant to be built at Washington Works was announced in the March 1946 issue of *DuPont Magazine* (vol 4o .no 1: p. 14-15 "Where Washington Walked"). Then, "in 1949, DuPont authorized a 1-million pound per year plant, but because of continuing difficulty in the production and fabrication of the unusual material, the commercial growth of Teflon proceeded slowly until the mid-1950s."(from David Hounshell and John Kenly Smith. 1988. *Science and Corporate Strategy: DuPont R&D, 1902-1980.* Cambridge University Press: 483)

Harold Goldwhite. 1986. The Manhattan Project. In: *Fluorine: The First One Hundred Years.* R.E. Banks, D.W.A. Sharp and J.C. Tatlow, editors. New York: Elsevier Sequoia. P.109-132.

Special issue March 1947 (vol 39 no 3) of *Industrial Engineering Chemistry* –first published disclosure of much fluorine chemistry developed just before and during WWII. The March 1947 issue solely looks at developments in fluorine chemistry during World War II.

David Hounshell and John Kenly Smith. 1988. *Science and Corporate Strategy: DuPont R&D, 1902-1980*. Cambridge University Press.

Also see: Rebecca Altman. 2019. Time-Bombing the Future. *Aeon*. Available at: https://aeon.co/essays/how-20th-century-synthetics-altered-the-very-fabric-of-us-all

> Bibliography found here: https://static1.squarespace.com/static/5703f76762cd94e407457a23/t/5c3575a10ebbe85b8cfbbe95/1547007412910/Altman_Time+Bombing+the+Future+Final+Sources+Aeon+2019.pdf

On DuPont's introduction of Teflon into cookware (a French company did so earlier, in the 1950s, but DuPont didn't until the 1960s): https://www.nytimes.com/1986/12/21/us/teflon-maker-out-of-frying-pan-into-fame.html

On C8/PFOA contamination in the Mid-Ohio Valley

For an early look at PFOA levels in Little Hocking, see the work of Edward Emmett: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3038253/

Callie Lyons. 2007. *Stain-Resistant, Nonstick, Waterproof, and Lethal*. Praeger.

The reporting of Ken Ward Jr. archived by the *Gazette-Mail*, Charleston, WV.

Rebecca Altman. 2008. Chemical Body Burden and Place-Based Struggles for Environmental Health and Justice (A Multi-Site Ethnography of Biomonitoring Science.) Dissertation. Brown University. Department of Sociology.

Rob Billott. 2019. *Exposure: Poisoned Water, Corporate Greed, and One Lawyer's Twenty-Year Battle Against DuPont.* Atria Books.

For more coverage of PFOA and PFAS contamination beyond the Mid-Ohio Valley, see reporting of Sharon Lerner for *The Intercept*, series available here: https://theintercept.com/collections/bad-chemistry/ And watch for the forthcoming book from journalist Mariah Blake, who also wrote: Welcome to Beautiful Parkersburg, WV, for Huffington Post, available at: https://highline.huffingtonpost.com/articles/en/welcome-to-beautiful-parkersburg/

On the large-scale blood PFOA analysis of Mid-Ohio Valley residents:

Stephanie J. Frisbee et al., 2009. The C8 Health Project: Design, Methods and Participants. *Environmental Health Perspectives.* 117(12). Available at: https://ehp.niehs.nih.gov/doi/10.1289/ehp.0800379

Brookmar, Inc. 2005/2006. "Letter Accompanying Results from Blood Analyses in the C8 Health Project." Vienna, WV: Brookmar, Inc.

Rob Billott. 2019. *Exposure: Poisoned Water, Corporate Greed, and One Lawyer's Twenty-Year Battle Against DuPont.* Atria Books.

Callie Lyons. 2007. *Stain-Resistant, Nonstick, Waterproof, and Lethal*. Praeger.

Rebecca Altman. 2008. Chemical Body Burden and Place-Based Struggles for Environmental Health and Justice (A Multi-Site Ethnography of Biomonitoring Science.) Dissertation. Brown University. Department of Sociology.

On PFOA's many uses besides in the TEFLON process, see summary prepared by the United Nations Environment Programme Stockholm Convention on Persistent Organic Pollutants. This draws from a larger evaluation, which is hyperlinked at the top of the summary: http://chm.pops.int/Implementation/Alternatives/AlternativestoPOPs/ChemicalslistedinAnnexA/PFOA/tabid/8292/Default.aspx

Note: 3M phased out PFOA production in 2002, at which point DuPont took over production at its Fayetteville, NC plant.

That petrochemicals (like PFOA or ethylene derivatives) wind up used in so many different sectors and in so many different ways follows a pattern of development in which the development of chemicals precedes the development of applications or markets for them. This is discussed at length in Ken Geiser (2001) in *Materials Matter* (MIT Press). But is also made plain in this article, authored by two Union Carbide employees, which reads: "Product development can mean either of two things: developing a chemical for a contemplated market or developing a market for a special chemical." From: J.F. Bohmfalk Jr., in collaboration with R.W. McNamee and R.P Barry (Carbide and Carbon Chemicals, S. Charleston, WV). 1951. Commercial Development of Glyoxal: A Staff-Industry Collaborative Report. *Industrial and Engineering Chemistry.* April 1951. 786-794.

On PFOA levels in the US population, see: Calafat et al. 2007: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2072821

On the toxicology of PFOA, see report compiled by the ATSDR/Department of Health and Human Services. 2018. Toxicological Profile for Perfluoroalkyls. (Draft for Public Comment,

June 2018). Available at: https://www.atsdr.cdc.gov/toxprofiles/tp200.pdf (Last accessed 14 November 2018).

See also, the testimony delivered before the Senate Committee on Homeland Security and Dr. Linda Birnbaum (Director of the NIEHS and National Toxicology Program) 2018. Testimony delivered before the Governmental Affairs Subcommittee of Federal Spending Oversight and Emergency Management, September 26, 2018: https://www.hsgac.senate.gov/imo/media/doc/Birnbaum%20Testimony.pdf

Dr. Philippe Grandjean. 2017. Expert report. Given in State of Minnesota, et al., v 3M Company. Prepared on behalf of the plaintiff, 22 September 2017. Available at: https://www.documentcloud.org/documents/4383855-3M-Grandjean-Expert-Report.html (Last accessed 14 November 2018)

National Toxicology Program. 2016. Monograph: Immunotoxicity Associated with Exposure to Perfluorooctantoic Acid and Perfluorooctane Sulfonate. Available at: https://ntp.niehs.nih.gov/ntp/ohat/pfoa_pfos/pfoa_pfosmonograph_508.pdf (Last accessed 14 November 2018).

International Agency for Research on Cancer (IARC). 2016. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Perfluorooctanoic Acid. Volume 110. Available at: https://monographs.iarc.fr/wp-content/uploads/2018/06/mono110-01.pdf

EPA. 2016. "Health Effects Support Document for Perfluorooctanoic Acid (PFOA)." EPA 822-R16-003. www.epa.gov/ground-water-and-drinkingwater/supporting-documents-drinking-waterhealth-advisories-pfoa-and-pfos

U.S. Environmental Protection Agency. 2017. Technical Fact Sheet on PFOA and PFOS. November 2017. Available at: https://www.epa.gov/sites/production/files/2017-12/documents/ffrrofactsheet_contaminants_pfos_pfoa_11-20-17_508_0.pdf

Also see peer-reviewed findings from the C8 health project, list updated here: http://www.c8sciencepanel.org/publications.html

On Carbide's billionth pound in a single year milestone see *The New York Times*, 30 December 1963. Union Carbide Sets a Production Mark. p. 29 (Business and Finance section.)

On the history of chemicals production in Appalachia, see

Otis K. Rice 1993. *West Virginia: A History*. Lexington, KY: University Press of Kentucky.

Lee R. Maddex, editor. 2003. Great Kanawha Valley Chemical Heritage Symposium Proceedings. Morgantown, WV: Institute for the History of Technology and Industrial Archaeology.

Kathryn Steen. 2014. *The American Synthetic Organic Chemicals Industry: War and Politics, 1910-1930.* University of North Carolina Press.

Catherine Venable Moore. 2014. O BEULAH LAND. Oxford American. Available at: https://www.oxfordamerican.org/magazine/item/351-o-beulah-land

Selva Carter Wiley. 1956. The Industrial Geography of the Kanawha Valley. Dissertation. The Ohio State University.

On Ansel Adams' *Fortune* commission, see Ansel Adams. 1978. "Ansel Adams: Conversations with Ansel Adams." Interview by Ruth Teiser and Catherine Harroun in 1972, 1974 and 1975. Oral History Center, The Bancroft Library, University of California, Berkeley. **For more general information about Adams,** see: Mary Street Alinder.(2014). *Ansel Adams: A Biography.* United Kingdom: Bloomsbury Publishing.

On the development of plasticizers, vinyl from ethylene glycol byproduct, early trouble marketing ethylene derivatives and Vinylite, and development of a credit department w/in marketing department at Carbide:

*A note of clarification: ethylene dichloride (EDC) was technically a byproduct from Carbide's production of ethylene chlorohydrin, the precursor chemical used in making ethylene glycol (marketed as Prestone). So when I wrote EDC was a byproduct of antifreeze/ethylene glycol production, I was referring to the *whole cascading series of processes* that yielded Prestone (not specifically the step in the process that produced ethylene glycol).

Maxwell Sutherland. 1996. The History of Vinyls and Plasticizers at Union Carbide Corp. Available via the WV State Archives.

J.G. Davidson. 1957. Letter to Alumni Editors. Mellon Institute News. June 29, 1967. Vol XXX No. 39 p. 9-11.

Robert C. Hieronymus. 1997. Union Carbide Corporation History: Olefins, Early Period 1914 through 1950. September 1997.

J.N. Compton. 1945. The Beginning of the Chemicals Corporation and the Clendenin Development. Courtesy of Kim Johnson.

A Marketing Revolution: Early Sales Efforts of Union Carbide Chemicals Company
C. W. McConnell to R. D. Stief, October 31, 1995.

Ethylene and Its Derivatives: Their Chemical Engineering Genesis and Evolution at Union Carbide Corporation, by Arthur E. Marcinkowsky and George E. Keller, II, June 13, 1980.

Dates of First Sales of Chemicals in Lots of at Least 55 Gallons in the USA by Union Carbide Corp. Between 1922-1960.

Carbide and Carbon Chemicals Corporation. 1970. Union Carbide Golden Jubilee. Fifty Years of Progress. Carbide News. September 10, 1970.

Simon Meyer. 1979. *Carbide: The Recollections of the Early Years*. Courtesy of Kim Johnson. Robert D. Stief. (1998). A History of Union Carbide Corporation, From the 1890s to the 1990s. Published by the Carbide Retiree Corp., Inc. Available via the Science History Institute, Philadelphia, PA.

That **plastics' research and development was often underwritten by metals-related industries** is a point also made by Ken Geiser (2001) in *Materials Matter* (MIT Press). But in Carbide's case, this was especially true, given the unique constellation of industries and expertise assembled from the five companies that merged into Union Carbide and Carbon in 1917: acetylene welding tools, metal alloys, electric arc furnaces, carbon electrodes for the electric arc furnaces, and managing antipodal extremes in temperatures. Another interesting association that I didn't explore was how **Carbide used organometalllic compounds (based on tin and lead) in the production of vinyl**. (For more on this, see Sutherland's Carbide internal history of vinyls development).

On the Department of Energy's call for a "petrochemical renaissance" in Appalachia, see U.S. Department of Energy. 2002. The Appalachian Energy and Petrochemical Renaissance: An Examination of Economic Progress and Opportunities. Available at: https://www.energy.gov/sites/prod/files/2020/06/f76/Appalachian%20Energy%20and%20Petrochemical%20Report_063020_v3.pdf Last accessed March 8, 2021.

On the renaming of natural gas as "freedom gas," see, Department of Energy 2019. Department of Energy Authorizes Additional LNG Exports from Freeport LNG. Press release May 28, 2019, which read: "'Increasing export capacity from the Freeport LNG project is critical to spreading freedom gas throughout the world by giving America's allies a diverse and affordable source of clean energy. Further, more exports of U.S. LNG to the world means more U.S. jobs and more domestic economic growth and cleaner air here at home and around the

globe,' said U.S. Under Secretary of Energy Mark W. Menezes, who highlighted the approval at the Clean Energy Ministerial in Vancouver, Canada." Available at: https://www.energy.gov/articles/department-energy-authorizes-additional-lng-exports-freeport-lng Last accessed March 8, 2021. Or see: Grace Panetta. 2019. The Department of Energy Is Now Referring to Natural Gas as 'Freedom Gas.' Business Insider. May 29, 2019. Available at: https://www.businessinsider.com/department-of-energy-calls-natural-gas-freedom-gas-2019-5

An example of the language "shale gas revolution" can be found here: "Shell takes the lead on natural gas, welcomes the future of clean energy." Digital Energy. May edition. Available via https://www.energydigital.com/utilities/shell-takes-lead-natural-gas-welcomes-future-clean-energy Last accessed March 8, 2021.

On the demolition of the Carbide plant at Clendenin see: "Historic Plant Is Coming Down." Sunday Gazette-Mail. Charleston, WV. December 20, 1970. Courtesy of Kim Johnson.

On the Carbide/petrochemical centennial:

American Chemical Society. 2020. American Chemical Society Recognizes Clendenin With National Historical Chemical Landmark Designation. Press Released. February 25, 2020.

Mark Rosenzweig. 2019. A Petrochemical Centennial Approaches. Chemical Processing. Available at: https://www.chemicalprocessing.com/articles/2019/a-petrochemical-centennial-approaches/

On the carcinogenicity of styrene and vinyl chloride – both monomers used in plastics production—After forty years of research, a working group of 23 scientists (from 12 countries) International Agency on Research and Cancer (IARC), based on the weight of the evidence, in March 2018, upgraded the status of **styrene** from "possibly" to "probably carcinogenic," a determination which, to the casual reader, can be confusing.

Note: The designation of "possibly" or "probably" carcinogenic has strict meaning, and is a characterization of the strength of the scientific evidence NOT of the cancer-causing potential of the chemical itself. A breakdown of the IARC carcinogen classification system is available here: https://ec.europa.eu/health/scientific_committees/opinions_layman/en/electromagnetic-fields/glossary/ghi/iarc-classification.htm

IARC. 2019. Styrene, Styrene-7,8-oxide, and Quinoline. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Volume 121. Available at: https://www.ncbi.nlm.nih.gov/books/NBK551039/ See also:

See also: Mette Skovgaard Christensen, Jesper Medom Vestergaard, Francesco d'Amore, Jette Sønderskov Gørløv, Gunnar Toft, Cecilia Høst Ramlau-Hansen, Zara Ann Stokholm, Inge Brosbøl Iversen, Mette Schou Nissen, Henrik Albert Kolstad. Styrene Exposure and Risk of Lymphohematopoietic Malignancies in 73,036 Reinforced Plastics Workers. *Epidemiology*, 2018; 29 (3): 342

For vinyl chloride, IARC classifies vinyl chloride as a group 1 human carcinogen – which officially means conclusive evidence of carcinogenicity.
Available at: https://monographs.iarc.who.int/wp-content/uploads/2018/06/mono100F-31.pdf

Grosse Y, Baan R, Straif K et al. WHO International Agency for Research on Cancer Monograph Working Group (2007). Carcinogenicity of 1,3-butadiene, ethylene oxide, vinyl chloride, vinyl fluoride, and vinyl bromide. Lancet Oncol, 8: 679–680. doi:10.1016/S1470-2045(07)70235-8 PMID:17726789