Mending the Interconnected Web of Life: Endocrine disruption and global plastic pollution

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> *"It is not my contention that chemical insecticides never be used. I do contend that we have put poisonous and biologically potent chemicals indiscriminately into the hands of persons wholly ignorant of the potential for harm."* Rachel Carson *Silent Spring***.** P.12

As we advance into the twenty-first century, it is more and more evident that Rachel Carson's message of precaution and care for preserving the natural world holds the heart of our way forward. We see all around us the evidence of our failure to protect the living systems that support life on Earth. Now it is time to reverse the trajectory that has precipitated the triple existential threats of accelerated climate change, global pollution and global biodiversity loss. Our policies and personal behaviors must shift from a culture that depends on extracting fossil resources to one that regenerates and preserves resources. Without a healthy environment, we will not have healthy people.

The proliferation of endocrine disrupting chemicals in the environment is among the more insidious effects of the surge in use of synthetic substances following World War II. "Better Living through Chemistry" brought single use plastic dishes, cutlery, and food storage and packaging materials. Synthetic fibers from nylon and polyester to the sophisticated polymers of today's high-performance sportswear shed small fibers with each washing. Particles of plastics and synthetic materials are now ubiquitous in oceans, rivers, streams and even tap water.

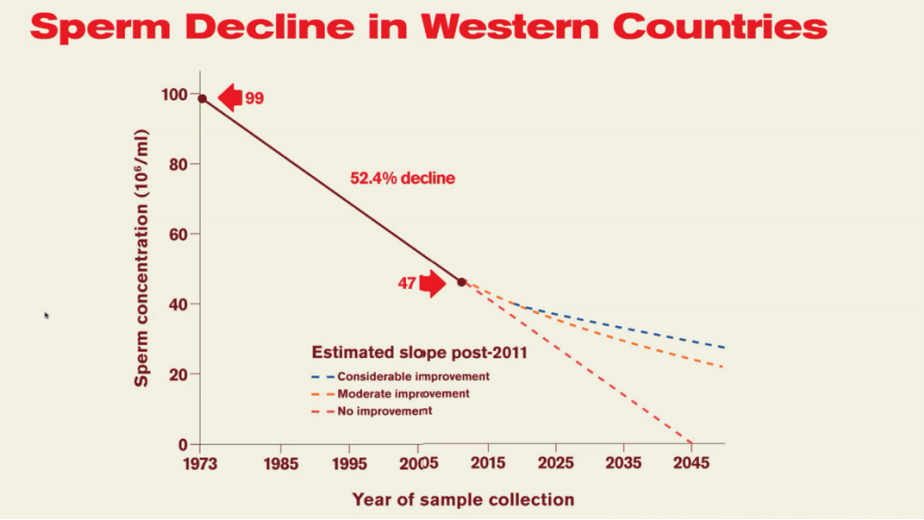
Arlene Blum of the Green Science Policy Institute at University of California has documented six classes of chemicals that have potentially harmful effects on living systems: [1]

1. **Highly Fluorinated chemicals**- forever chemicals used for oil-, stain-, and water-repellant as well as non-stick surfaces in cooking. They are extremely difficult to break down.
2**. Antimicrobials**- included in many products intended to kill bacteria, but often have properties that disrupt hormone function and may cause developmental or reproductive effects.
3.**Flame Retardants** – intended to reduce fire risk in furniture, electronics, children's products and building materials. Some are associated with increased risk of cancer, developmental and reproductive harm and hormone disruption.
4. **Bisphenols and phthalates** – incorporated into many plastics, personal care products, adhesives and building materials, these compounds are often toxic and harmful to humans and ecosystems even at very low exposure concentrations because they mimic or block normal hormone functions.
5**. Organic Solvents** –used in oil paints, dry cleaning, sealants, household cleaners, nail polish, aerosols are persistent in the environment and can remain for decades as contaminants to water supplies. They are mobile and can be distributed for long periods of time as plumes through air or water currents. They can cause breathing problems or rashes, nervous system symptoms and cancer risk, especially for occupational exposures.

6. **Certain metals**- like mercury, arsenic, cadmium and lead can cause impediments to brain development in children, cancer risk and adverse effects on the nervous and cardiovascular systems.

These materials, derived for the most part from fossil petroleum and natural gas, are now ubiquitous in the environment, and even in people. Exposure is unavoidable as we use plastic synthetic materials in consumer products, inhale volatile organic compounds through air pollution and ingest plastic microparticles through water pollution and contaminated food chains. The Centers for Disease Control and Prevention conducts a biomonitoring program evaluating the presence of more than 400 chemicals in human blood and urine samples taken from a random representative sample of Americans. Widespread exposure in over 90% of sampled individuals include PBDE polybrominated diphenyl ether (a fire retardant), BPA Bisphenol-A (common in plastic packaging and thermosensitive printed material such as receipts) and PFOA perfluorooctanoic acid used in the manufacture of non-stick coatings in cookware.[2]

The widespread exposure to endocrine disrupting chemicals has serious health consequences. Many endocrine-related diseases and disorders such as diabetes and obesity are on the rise, and developmental and reproductive system disruption is becoming more and more prevalent. "Worldwide, sperm counts have declined 50 percent in males the past 50 years. Other key aspects of human fertility – miscarriages, testosterone levels, premature egg depletion, difficulty conceiving – are all changing at a similar rate," according to Shanna H. Swan, Mount Sinai Medical Center award winning researcher.[3]



Source: https://www.ehn.org/fertility-crisis-2650749642/phthalates-the-everywhere-chemical

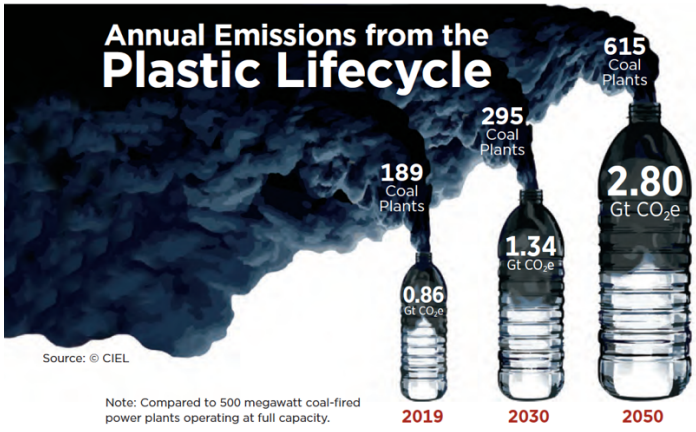
Evidence of widespread endocrine disruption is also evident in many life forms besides humans. Research from the United Nations Environment Programme shows widespread threats to biodiversity as well as to humans. Wildlife populations have been affected by endocrine disruption, with negative impacts on growth and reproduction. These effects are widespread and have been due primarily to Persistent Organic Polymers and other endocrine disrupting chemicals in the environment.[4] The plastics industry and the U.S. government officially dispute any connection between synthetics and health problems and reject restrictions on chemicals like phthalates in food containers. The burden of proof of harm in a regulatory system dominated by industry influence continues to rest with consumers, advocacy groups and concerned researchers in public health and epidemiology.

Because many of the chemicals of concern persist in the environment for long periods of time and travel through food chains, it is important to understand the policies and international industry changes that can curtail or reverse the production and use of these materials.

Plastics are part of the extractive fossil industry that contributes to climate change. Only twenty oil and gas companies are responsible for 55% of the world's single use plastics, all also major emitters and producers of greenhouse gases responsible for climate change.[5] U.S. Companies ExxonMobil and Dow Chemicals top the list of 100 international corporations responsible for 90% of global single-use plastic production.[6]

Single-use plastic beverage containers, food packaging and bags are the predominant form of plastic materials that end up in oceans, landfills or incinerators. Major oil and gas companies see their financial future in production of even more plastic disposable products to fill the gap from policies focused on reducing the use of gas and oil for fuels.[7] Currently, petrochemicals comprise only a fraction of total oil and gas production and use, but the petrochemical and gas energy companies plan to double plastic production in the next 15 years. The industry predicts petrochemicals will grow from 16% of oil demand in 2020 to 20% by 2040 largely to supply feedstocks for making plastics.[8] The advance of hydraulic fracturing for deep shale gas extraction has made the precursor chemicals for making plastics very cheap, compared to alternative methods of making non-fossil- based materials, or of recycling and reclaiming plastics in the post-consumer market.[9]

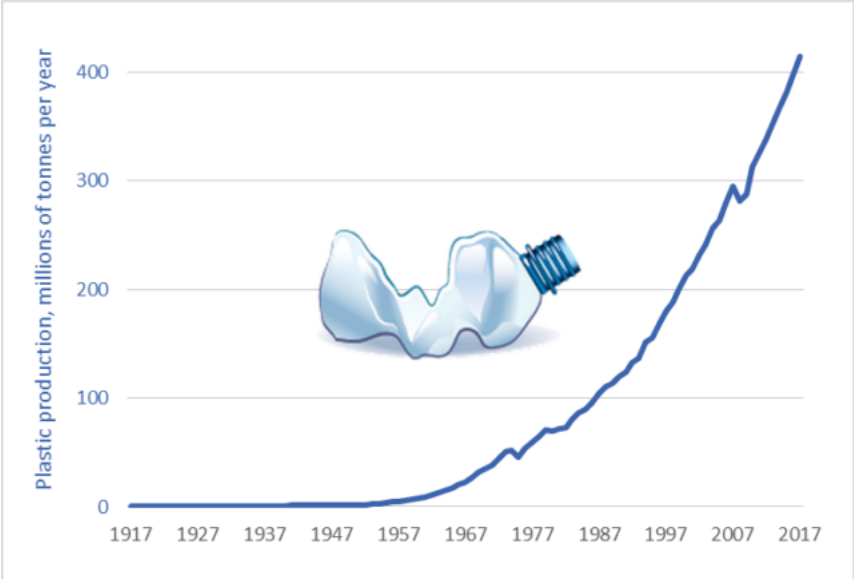
FIGURE 1
Emissions from the Plastic Lifecycle



Source: https://www.ciel.org/wp-content/uploads/2019/05/Plastic-and-Climate-FINAL-2019.pdf
Expanding the production of plastics from oil and gas sources will increase greenhouse gas emissions from the production and transportation of plastic and from sending the post-consumer plastics to landfills or incineration.[10] The increase in plastic production is expected to triple CO2 emissions from plastics to 309 million metric tonnes by 2050. That is the equivalent to emissions from 615 five- hundred -megawatt coal plants.[11] "The petrochemical sector is one of the blind spots of the global energy debate and there is no question that it will be the key driver of oil demand growth for many years to come," International Energy Administration Executive Director Fatih Birol told Reuters.[12] Most of the increase in demand will come from the Middle East and China where large petrochemical plants are being built.

Plastic proliferation is an industry push not a consumer demand.

Early plastics were made from plant-based cellulose and were designed to replace expensive and increasingly scarce natural materials such as ivory and tortoise shell for making consumer products. Advances in the 1930s and '40s led to bakelite, a thermoset plastic made from coal tar and later, thermoplastic materials such as nylon, polystyrene and polyethylene.[13] These relatively inexpensive materials allowed the proliferation of consumer products once limited to luxury consumers. During World War II, the production of synthetic materials proliferated rapidly to make mortar fuses, parachutes, aircraft components, antenna housing, bazooka barrels, enclosures for gun turrets, helmet liners, and countless other applications. Plastics were even essential to the building of the atomic bomb: Manhattan Project scientists relied on Teflon's supreme resistance to corrosion to make containers for the volatile gases they used.



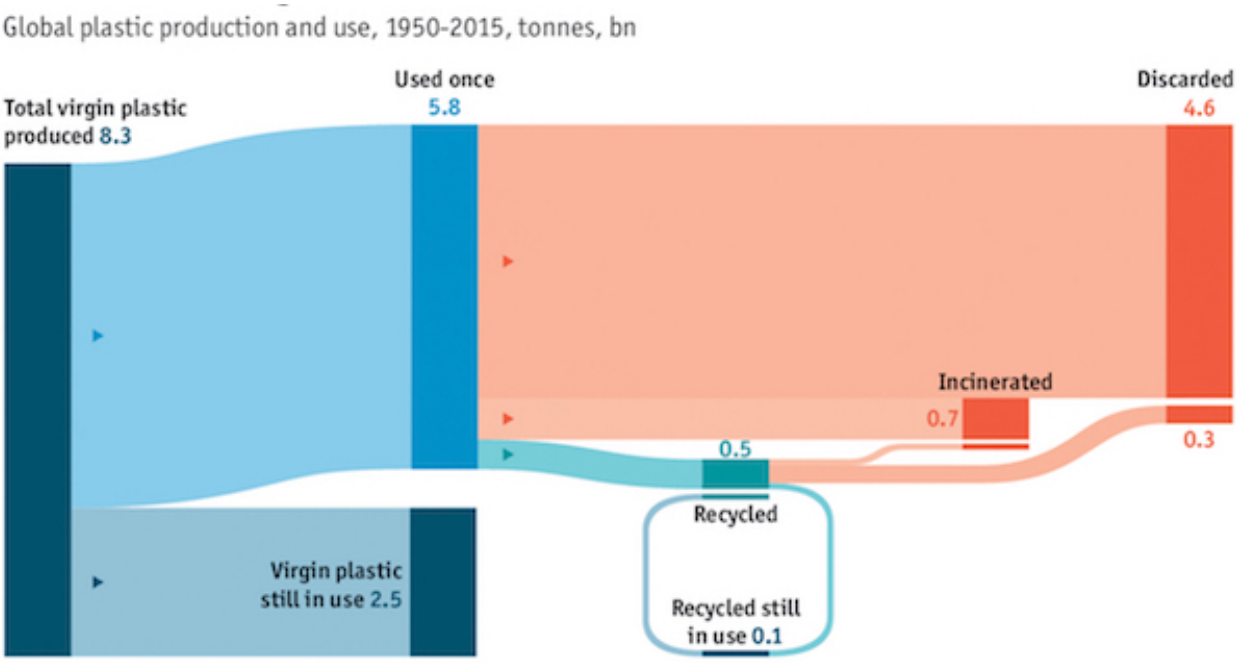
Source: https://www.darrinqualman.com/global-plastics-production/

Production of plastics leaped during the war, nearly quadrupling from 213 million pounds in 1939 to 818 million pounds in 1945.[14] When the war ended, all of that scaled up production capacity turned to making consumer products. Everything from radios to appliances to structural materials like siding and window frames was being made of plastic. Cheap, light, strong, malleable and adaptable to multiple forms, plastic found its way into everything from suitcases to fishing line. Since synthetics had never before been part of the average American's daily routine, there was little existing demand for the stuff. Also, because plastic couldn't be

repaired when it broke, it melted when heated, and it smelled strange, consumers weren't always compelled to purchase the mysterious substance. Based on this, SPI concluded that synthetics had to be aggressively marketed through sophisticated advertising and "education" campaigns.[15] The plastics industry teamed up with mainstream media and magazines such as McColl's, House Beautiful and Good Housekeeping to target promotional narratives for plastic products. Tupperware Parties became a fashionable way to share the benefits of plastic storage containers, compared to the heavier and breakable traditional glass jars. The strategic marketing campaign paid off for the plastics industry. The critical years after WWII brought a growth rate of more than 15 percent to plastics, almost quadruple that of steel. By 1960, plastics surpassed aluminum, and became one of the largest industries in the country.[16]

Recycling is not the answer- consumers cannot solve the plastic inundation.

Even as the plastics industry was ramping up demand for products and touted recycling as a way to keep the plastic waste out of landfills, they knew that recycling would never achieve an economic solution. Yet Exxon, Dow, DuPont Chevron and their lobbyists in Washington spent tens of millions on advertising promoting recycling as a customer option while making billions selling new products. "The bottle may look empty, yet it's anything but trash," says one advertisement from 1990 showing a plastic bottle bouncing out of a garbage truck. "It's full of potential. ... We've pioneered the country's largest, most comprehensive plastic recycling program to help plastic fill valuable uses and roles."[17]



However, less than 10% of all plastic produced since 1960 has been recycled or re-used to make another product.[18] An industry report written in April 1973 by their top scientists noted that recycling plastic on a broad scale is unlikely to happen because plastic degrades with each turnover and the process of recovering and reprocessing plastic materials is costly and

infeasible.[19] The cost of separating and sorting plastics post-consumer use is prohibitively high and inefficient. The cost of materials for producing virgin plastics from oil or natural gas is so low, the recycling and reclamation process can not be justified economically. However, the public was expressing concern about the mounting problem of plastic trash as early as 1974. NPR reports that the industry responded with massive advertising about the benefits of plastics while funding high visibility recycling projects for the publicity value. "NPR tracked down almost a dozen projects the industry publicized starting in 1989. All of them shuttered or failed by the mid-1990s. Mobil's Massachusetts recycling facility lasted three years, for example. Amoco's project to recycle plastic in New York schools lasted two. Dow and Huntsman's highly publicized plan to recycle plastic in national parks made it to seven out of 419 parks before the companies cut funding."[20]

Source: https://www.acmeplastics.com/content/your-guide-to-plastic-recycling-symbols/

The recycling problem compounds with the familiar triangle of arrows indicating recycling with a number in the center. Although only a few products have markets for recycling, when consumers see the symbol, they put all plastic materials into the recycling container, creating a huge contamination of the mixed plastic waste. Until 2018, most of American recycled plastic trash went to China for processing, often by incineration. In 2018 China adopted a policy prohibiting the import of plastic waste with less than 5% contamination across sorted types.[21] Now, most "recycled plastic" trash collected in the US ends up in landfills because there is no structured market for the material. People practice "hopeful recycling" putting all plastic materials into their recycling bins, but the mixed plastics are not marketable.

Sophisticated technology for separating recycled plastics is emerging, but not in wide use yet.[22] From simple magnetics to new near-infrared-based spectroscopic waste-sorting systems, a computer is able to determine the color, type, shape and position of each item. Air jets then push particular items from one conveyor belt to another, or into a bin. Numerous types of paper and plastic can be sorted with up to 98% accuracy – better than human workers manage.[23] For recycling plastics to function efficiently, the regulatory infrastructure must be put in place to address these underlying disfunctions. We cannot consume our way out of this problem.

Plastic manufacturers must be held accountable for the disposal of their products – circular materials management.

While industry advertising has placed the plastic trash problem squarely on the consumer, in reality, consumers have little influence on the actual recycling or reclamation of plastic materials designed for single use. The plastic trash problem is a classic case where the profits from exploiting an under-valued natural resource (oil and natural gas) falls to private corporations

while the costs to public health, environment and planetary stability fall to the public and society as a whole. Some people refuse to buy or use plastic disposable items, but even attempts to ban single use plastics have met organized industry opposition, for example the Pennsylvania law that prohibits municipalities from adopting single use plastic bans.

The concept of holding manufacturers responsible for their product is gaining attention. Senators Tom Udall of New Mexico and Representative Alan Lowenthal of California are introducing legislation "Break Free from Plastic Pollution Act" which includes a national "Bottle Bill" that would provide a 10- cent refund for each bottle returned.[24] In states that have such bottle refund programs, recycling beverage containers achieves about 85% recovery of bottles. The bill also calls for a halt to new plastic production facilities and standardizing labeling to improve ease of separating plastics by type. A recent report from Penn Environment finds that producer responsibility is a proven approach to reducing waste and improving recycling.[25] Under producer responsibility programs, the manufacturers bear responsibility for the waste their products create, and bear responsibility for the collection and proper recycling of their products at the end of their useful lives. This mandate creates incentives for producers to create products that last longer (as opposed to single use) and to be more amenable with recovery and re-use.[26]

The United Nations Sustainable Development Goal 12 Responsible Consumption and Production defines a move towards more sustainable consumption and production patterns as the essential condition for reducing environmental damage, protecting ecosystems and biodiversity and tackling climate change. This report examines the economic and environmental impacts of a core global policy scenario (a *material fiscal reform)* to promote the transition to a resource efficient and circular economy. The material fiscal reform implements taxes on primary mineral resources and uses the revenue of these taxes to finance subsidies to recycled goods and to secondary metal production. [27] In practice applied to the plastics production industry, this approach would impose a tax on producers, ranked according to the level of hazard or pollution created by the product, and the proceeds would be applied to subsidize recycling and re-use infrastructure and processes through municipalities waste management programs.

Another fundamental change would address the underlying problem of the difference in economic value between virgin material and recycled or reclaimed material. To shift the economic equation, remove taxpayer subsidies to the fossil extractive industries to eliminate the subsidized low price of natural gas and oil.[28] Absent the annual $20.5 Billion in taxpayer support, 50% of the oil extraction operations and 98% of natural gas operations would not be economically viable.[29] Actual subsidies derived from regulatory treatment and indirect industry support amounts to $62 Billion per year, on the average.[30] Removing these subsidies will require changes in legislation because some of the subsidy provisions are enacted in laws dating back fifty years or more. Fossil fuel subsidies represent a government failure. They are a form of spending paid for by the American taxpayer to businesses in an industry that has long been profitable with a negligible impact on production or employment.[31] Federal legislation to remove these subsidies is under consideration in "End Polluter Welfare Act" introduced by Senator Sanders.

Protect the health of people and living systems, not manufacturers unrestrained right to product marketing.

Industrial chemicals are regulated under the Toxic Substances Control Act first enacted in 1976. Unlike pharmaceuticals, industrial and commercial chemicals are rarely tested for safety before they reach the U.S. market. The Toxic Substances Control Act of 1976 governed chemicals in commerce in the United States, but it is widely known to be weak and ineffective and did not require manufacturers to test or provide data about the health impact of chemicals before they accessed the lucrative U.S. market. Health and safety testing was available for just 200 chemicals –less than 2% of the total manufactured chemicals– and under the 1976 TSCA law, the U.S. Environmental Protection Agency could not effectively regulate chemicals with documented adverse health effects, like asbestos and methylene chloride, for example.[32]

The 2016 Frank Lautenberg amendments to TSCA gave the EPA new requirements and authorities. Passed with bipartisan support, the legislation provided EPA with authority to require reporting, safety testing, and restrictions relating to harmful chemical substances and/or mixtures. This reform law was designed to modernize U.S. industrial chemical policy to promote health. However, the Trump Administration did not act to enforce the law through the EPA regulatory process, stalling and deferring action on critical requirements, including the science review. EPA's process for assessing and controlling toxic substances was among the High Risk areas of government operations identified by the U.S. Government Accountability Office in March 2021.[33] Addressing the significant hazards entailed in the production, use and disposal of plastic materials requires a higher priority on protecting public health and the health of the environment including wildlife and ecosystems. Reducing the regulatory system to economic parameters alone will not protect the public from advancing harms caused by pollution. The approach to regulation has been to limit the amount of toxic materials allowed in the environment, one specific substance at a time. This approach ignores the fact that people and other living systems are actually exposed to great mixtures of chemical contaminants, some of which have additive effects, as discussed by Arlene Blum in her work on classes of chemicals.

$$\text{Risk} = \{\text{Toxicity} \times \text{Exposure}\}$$

The regulatory framework should be changed to focus on reducing or eliminating the inherent risk of materials released into the environment or embedded in consumer products. The focus should be on preventing toxicity through green chemistry design principles. Incentives should be in place for materials and their byproducts to be benign by design to prevent harm, rather than try to limit exposures to "acceptable levels."[34] This shifts the focus of regulation from titrating limits of emissions of known toxic substances toward preventing health and environmental damage by preventing pollution instead. The Pollution Prevention Act of 1990, amended in 1992 begins to address this approach, but has not effectively reversed the industry trends.[35]

Combining mandates for industry accountability for wastes with mandates for pollution prevention in the design and production of all new materials would make a beginning to reverse the disasters of our plastics industry. The petrochemicals industry has the ability to reduce greenhouse gas emissions. From 1990 to 2016, the European chemicals industry cut its GHG emissions by 60.5% while increasing its production by 85%. Chemical sector emissions of CO2 are set to decline by 45% by 2050 under a 'clean technology scenario', while demand for basic chemicals is anticipated to grow by 40%.[36] We can begin by stopping the production and use of single-use plastics and move toward zero waste strategies for materials management at all levels.

The endless installation of infrastructure to perpetuate dependence on fossil gas and oil traps us into another generation of climate disaster. We must pivot our tax subsidies, policies and investments into renewable and sustainable options for energy, and for materials. We can DO this! We do not have a technology problem. We have an ethics problem. The Laws of Nature are NOT negotiable. We must live in harmony with the resources of the living Earth if we are to survive and if our children are to thrive on this Earth.

Sources and Citations

[1] (https://greensciencepolicy.org/harmful-chemicals/certain-metals/)

[2] (https://www.cdc.gov/exposurereport/pdf/FourthReport_ExecutiveSummary.pdf and https://www.cdc.gov/exposurereport/pdf/FourthReport_UpdatedTables_Volume2_Mar2021-508.pdf)

[3] Shanna H. Swan. Countdown: how our modern world is threatening sperm counts, altering male and female reproductive development, and imperiling the future of the human race. Simon and Schuster, New York, NY. 2020. Page 13.

[4] https://wedocs.unep.org/bitstream/handle/20.500.11822/12223/State%20of%20the%20Science%20of%20EDCs%20Summary%20Report%202012.pdf?sequence=1&isAllowed=y p.2-5.

[5] https://www.cnbc.com/2021/05/18/20-companies-responsible-for-55percent-of-single-use-plastic-waste-study.html

[6] https://www.minderoo.org/plastic-waste-makers-index/data/indices/producers/

[7] https://e360.yale.edu/features/the-plastics-pipeline-a-surge-of-new-production-is-on-the-way

[8] https://theconversation.com/fossil-fuel-industry-sees-the-future-in-hard-to-recycle-plastic-123631

[9] https://www.ciel.org/plasticandclimate/

[10] https://www.reuters.com/article/us-petrochemicals-iea/rising-use-of-plastics-to-drive-oil-demand-to-2050-iea-idUSKCN1ME2QD

[11] https://theconversation.com/fossil-fuel-industry-sees-the-future-in-hard-to-recycle-plastic-123631

[12] https://www.reuters.com/article/us-petrochemicals-iea/rising-use-of-plastics-to-drive-oil-demand-to-2050-iea-idUSKCN1ME2QD

[13] Define thermoset and thermoplastic characteristics

[14] https://www.scientificamerican.com/article/a-brief-history-of-plastic-world-conquest/

[15] https://brooklynrail.org/2005/05/express/a-brief-history-of-plastic

[16] Ibid.
[17] https://www.npr.org/2020/09/11/897692090/how-big-oil-misled-the-public-into-believing-plastic-would-be-recycled
[18] https://www.forbes.com/sites/danielcassady/2020/09/11/plastic-industry-pushed-recycling-on-america-knowing-it-would-fall-short-according-to-report/?sh=1e9f10b41a68
[19] https://www.npr.org/2020/09/11/897692090/how-big-oil-misled-the-public-into-believing-plastic-would-be-recycled
[20] ibid

[21] https://www.forbes.com/sites/jamesconca/2017/11/16/china-will-no-longer-take-our-recycled-junk/?sh=35e3ec272122
[22] https://www.economist.com/technology-quarterly/2007/06/09/the-truth-about-recycling
[23] https://www.tomra.com/en/sorting/recycling/tomra-solutions
[24] https://www.nytimes.com/2020/02/10/business/recycling-law.html
[25] https://pennenvironment.org/sites/environment/files/reports/PA_PIRG_EA_Break%20the%20Waste%20Cycle%3Dscrn.pdf

[26] OECD, *Extended Producer Sustainability*, accessed July 5, 2021, archived at https://web.archive.org/web/20200121201934/http://www.oecd.org/environment/ waste/extended-producer-responsibility.htm.

[27] Bibas, R., J. Chateau and E. Lanzi (2021), "Policy scenarios for a transition to a more resource efficient and circular economy", *OECD Environment Working Papers*, No. 169, OECD Publishing, Paris,https://doi.org/10.1787/c1f3c8d0-en.

[28] https://www.ciel.org/wp-content/uploads/2018/04/Fueling-Plastics-Untested-Assumptions-and-Unanswered-Questions-in-the-Plastics-Boom.pdf

[29] https://www.vox.com/energy-and-environment/2017/10/6/16428458/us-energy-coal-oil-subsidies
[30] https://www.pnas.org/content/118/14/e2011969118
[31] https://www.govinfo.gov/content/pkg/CHRG-117hhrg44383/html/CHRG-117hhrg44383.htm
[32] https://sph.umich.edu/news/2021posts/toxic-substances-control-act-chemical-regulation.html
[33] https://www.gao.gov/assets/gao-21-119sp.pdf
[34] https://pubs.acs.org/doi/pdf/10.1021/bk-1994-0577.ch001
[35] https://www.epa.gov/p2/pollution-prevention-act-1990
[36] https://www.weforum.org/agenda/2021/03/future-plastics-industry-green/

Additional resources:
Theo Colborn. Our Stolen Future