STS 181-01
MW 1:30-3, EDUC 210
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Office hrs: Weds 3-4:15

TECHNO-METABOLISM

Technology, Society, and the Anthropocene

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Most current syllabus always available at this link — check version date

The technosphere transforms energy, materials, and information. In the course of producing and consuming food, goods, and services, it metabolizes not only fossil and nuclear fuels, but also solar energy, through processes including photosynthesis (agriculture), wind, and hydro. The technosphere also metabolizes information, ingesting some kinds of data as inputs and producing other data as outputs, often in complex cycles of feedback and control.

The waste products of this metabolism are, in turn, transforming both the biosphere and the geosphere. Microplastics, artificial chemicals, and human-made radioactive materials can be detected in the cells of organisms all over the planet, including in the deep oceans. Greenhouse gases and particulate aerosols are transforming the atmosphere and the climate. Radioactive wastes from uranium mining, weapons testing, and power plants will persist for tens of thousands of years. So will microplastics.

Scientists, historians, and other analysts have proposed new ways to conceptualize and model technometabolism that directly account for these materials. Meanwhile, some practitioners are seeking ways to close or de-intensify metabolic loops to reduce energy requirements and material waste. "Data exhaust" — the data generated by individual activity, from web searches to Facebook to online shopping — is one significant "waste" product of the technosphere, now increasingly "recycled" to detect patterns, trends, and individual preferences.

In this project-centered course, students will seek creative ways to visualize, understand, and change the interplay of energy, materials, and information in the technosphere.

Prerequisites: none

Requirements and assignments

Summary

- Attendance (miss no more than 2 sessions after intro)
- Participation (20 pct)
- Reading logs (20 pct, must be turned in before class, minimum 7 logs required)
- Project reports (20 pct, one report per group, all group members get same grade)
- Term project (10 pct for project presentation, 30 pct for finalized project, all group members get same grade)

Details

- ***Attendance is required.*** Discussions are part of the work in this class. Missing more than 2 class sessions during the quarter will negatively affect your final grade, since you can't participate if you're not there. No employer would keep you on if you didn't show up to work 20 percent of the time — and 2 sessions is 20 percent of this course.

- ***Class participation*** **(20 percent of grade)**. This class involves discussions and project work with your peers. Its success depends on the commitment and involvement of *all* participants. You will be graded on both the regularity and the quality of your participation.

- ***Reading logs*** **(20 percent of grade).** A short reading log is due **before** each class session in which readings and/or videos are assigned. These cannot be turned in after the session. You must complete at least 7 of the 10 possible log entries in order to pass the course.

- ***Project reports*** **(20 percent of grade).** A short (½-1 page) project report is due at the end of each project session: what you read, what you're working on, next steps. Your group should divide responsibility for composing each report. Everyone in the group gets the same grade.

- ***Term project*** **(40 percent of grade).** In groups of 3 or 4, research and create a visualization, a map, an infographic, an art work, an interactive website, a performance, or another way of grasping and analyzing some particular techno-metabolic process. We will try to form groups whose participants have different skill sets (qualitative analysis, data analysis, drawing, painting, computer graphics, theater, etc.) Five class sessions are dedicated entirely to work on your project, in close collaboration with the instructor. See the end of this syllabus for ideas, examples, and data sources.

    1. Research phase. A 400-500 word research plan, clearly describing your topic, your approach, and some of the sources you plan to use, is due April 30.

    2. Group meeting with the instructor to discuss your idea (April 30-May 4).

    3. Project reports are due within 24 hours after the end of each project session (see above).

    4. Our final week of classes will be devoted to project presentations (10 pct of grade). This is an opportunity for feedback from the group before you finalize the project.

    5. A final version (30 pct of grade), including a complete list of your sources, is due by midnight on June 13. NO LATE PROJECTS.

Required books

Bonneuil, Christophe and Jean-Baptiste Fressoz. *The Shock of the Anthropocene: The Earth, History and Us*. New York: Verso Books, 2016.

Hawken, Paul, ed. *Drawdown: The Most Comprehensive Plan Ever Proposed to Roll Back Global Warming*. Penguin, 2017.

Course Schedule

April 2 — Introduction

April 4 — The technosphere and the Anthropocene

Haff, Peter K. "Technology as a Geological Phenomenon: Implications for Human Well-Being." Geological Society, London, Special Publications 395, no. 1 (2014): 301–9. This article is fundamental to our course. *If you missed this session, please read it carefully.*

The Shock of the Anthropocene, Chapter 1. If you have not yet been able to buy this book, you can read the first chapter online at Amazon by clicking "look inside." The whole chapter is there - but not the rest of the book, so please buy it ASAP. You'll need it before next Weds, April 11.

Recommended:

Edwards, P.N. "How to Read a Book"

April 9 — Scales of space and time

The Shock of the Anthropocene, Chapter 2

Agard-Jones, Vanessa. "Spray," *Somatosphere* (2014)

Sayre, Nathan F. "Climate Change, Scale, and Devaluation: The Challenge of Our Built Environment." *Washington and Lee Journal of Energy, Climate, and the Environment* 1 (2010): 83-94

Haff, Peter K. "Humans and Technology in the Anthropocene: Six Rules." *The Anthropocene Review* (2014): 1–11

April 11 — Carbon and consumption

The Shock of the Anthropocene, Chapter 5: Thermocene, Chapter 7: Phagocene

Fey, Willard R and Ann CW Lam. "The Ecocosm Paradox." *Encyclopedia of Life Support Systems* (2009)

Edwards, Paul N., "Control Earth," *Places Journal* (2016)

April 16 — Metabolism at scale

The Shock of the Anthropocene, Chapter 9: Agnotocene

Cunfer, Geoff, and Fridolin Krausmann: "Old and New World Agriculture," in Singh et al., eds., *Long Term Socio-Ecological Research: Studies in Society-Nature Interactions Across Spatial and Temporal Scales*, Dordrecht 2013, 269-296

Gierlinger, Sylvia and Fridolin Krausmann. "The Physical Economy of the United States of America." *Journal of Industrial Ecology* 16, no. 3 (2012): 365–77

April 18 — Measuring techno-metabolism

Boyden, Stephen and Stephen Dovers. "Natural-Resource Consumption and Its Environmental Impacts in the Western World: Impacts of Increasing Per Capita Consumption." *Ambio* (1992): 63–69.

- This article is 26 years old, so many of the statistics it cites are outdated. We're reading it for the concepts it defines. Pay special attention to the concept of "human energy equivalent (HEE)," and to the authors' version of "techno-metabolism."

Haberl, Helmut et al.: "Socioeconomic Metabolism and the Human Appropriation of Net Primary Production: What Promise Do They Hold for LTSER?", in Singh et al.: *Long Term Socio-Ecological Research: Studies in Society-Nature Interactions Across Spatial and Temporal Scales*, Dordrecht 2013, 29-52.

Krausmann, Fridolin: "A City and its Hinterland: Vienna's Energy Metabolism,", in Singh et al., eds., *Long Term Socio-Ecological Research: Studies in Society-Nature Interactions Across Spatial and Temporal Scales*, Dordrecht 2013, 247-268

April 23 — Ways forward: energy and information

Asafu-Adjaye et al., "An Ecomodernist Manifesto." (2015)

Jacobson, Mark Z. and Mark A. Delucchi. "A Path to Sustainable Energy By 2030." *Scientific American* 301, no. 5 (2009): 58–65.

Edwards, Paul N. "Knowledge Infrastructures for the Anthropocene." *The Anthropocene Review* 4, no. 1 (2017): 34–43

Lovins, Amory, "A 40-year plan for energy," 2012 (video, 27 minutes)

Recommended (as a companion to the Jacobson & Delucchi reading):

Shaner, Matthew R., Steven J. Davis, Nathan S. Lewis, and Ken Caldeira. "Geophysical Constraints on the Reliability of Solar and Wind Power in the United States." *Energy & Environmental Science* (2018).

April 25 — More ways forward, and start of term projects

Hawken, Paul. *Drawdown: The Most Comprehensive Plan Ever Proposed to Roll Back Global Warming*. Penguin, 2017. Guided by your own interests, please read at least 20 of the 100 brief sections.

- This book will serve as your guide as we move into the "Projects" phase of the course. It gives very brief (2-3 page) overviews of 100 strategies to combat climate change as well as environmental degradation of all sorts, along with related social problems. The Project Drawdown website contains references, assumptions used in modeling, and technical discussion for all 100 strategies. Keep reading in this book as you begin project work.

IMPORTANT: Carefully review the project ideas and examples at the end of the syllabus, and think about what you'd like to do for a term project. Brainstorming project ideas will be a principal activity in this session.

April 30 — Whose Anthropocene?

Hecht, Gabrielle, "The African Anthropocene," *Aeon* (2018)

Wong, Edward, "Life in a Toxic Country," *New York Times,* 3 August 2013

Spangenberg, Joachim. "China in the Anthropocene: Culprit, Victim or Last Best Hope for a Global Ecological Civilisation?" *BioRisk* 9 (2014): 1–37. This article has some dense parts; read selectively to get the main ideas. Focus on pages 8-37, since the material in pp. 1-8 should be familiar by now. What do the section headings mean — China the culprit, China the victim, China the last best hope?

"What Is Equity in the Context of Climate Negotiations?," World Resources Institute (2012)

— Due: project proposal —

May 2 — Project session

May 7 — Project session with guest instructor Gabrielle Hecht (see reading for April 30)

May 9 — Closing loops: energy, materials, and information

United Parcel Service, "2016 Corporate Sustainability Report" — in the top menu bar, click "Environmental Responsibility" and read the two sections "Management Approach" and "Energy & Emissions" (and anything else that interests you). Also read: "ORION: The algorithm proving that left isn't right"

Ellen MacArthur Foundation, "What is a Circular Economy?" This website contains numerous short articles and case studies. Please read at least 10 of these, guided by your own interests. Most of them can be read in 3-5 minutes.

Bové, Anne-Titia, and Steven Swartz, "Starting at the source: Sustainability in supply chains," McKinsey & Company (2016)

Hauschild, Michael Z., Christoph Herrmann, and Sami Kara. "An Integrated Framework for Life Cycle Engineering." *Procedia CIRP* 61 (2017): 2–9

Recommended:

European Commission, "Implementation of the Circular Economy Action Plan." Contains numerous fact sheets and brochures as well as policy documents. Browse — much of this material is dry and lacking in concrete details, but it shows considerable forward movement by the European Union, one of the world's largest economic powers.

May 14 — Carbon, policy, and economics

The Shock of the Anthropocene, Chapter 10: Capitalocene

"A Reader's Guide to the Paris Agreement," *The Atlantic*, 16 December 2015

America's Pledge. "America's Pledge Phase 1 Report: States, Cities, and Businesses in the United States Are Stepping Up on Climate Action" (2017)

"Only India can save the Paris climate agreement," *Hindustan Times*, 15 June 2017

For reference: UNFCCC, full text of the Paris Agreement

May 16 — Project session

May 21 — Big data and ICT for sustainability

Google, "Environment: Projects." Read all the project articles on this page - they're not long.

Our World in Data, "III. Correlates, Determinants & Consequences [of CO2 emissions]"— one section of a long article about CO2. Focus especially on III.4 and III.5. Read the rest if you're interested. This whole site is an excellent project resource.

Catulli, Maurizio and Emma Fryer. "Information and Communication Technology-Enabled Low Carbon Technologies." *Journal of Industrial Ecology* 16, no. 3 (2012): 296–301.

May 23 — Project session

May 28 — NO CLASS (Memorial Day holiday)

May 30 — Plastic

Parker, Laura, "A Whopping 91% of Plastic Isn't Recycled," *National Geographic* (2017)

Arnold, Carrie, "This Bug Can Eat Plastic. But Can It Clean Up Our Mess?" *National Geographic* (2017)

Stone, Maddie, "The Crazy Plan to Clean Up a Giant Island of Trash Might Actually Happen," Gizmodo (2016)

Schiller, Ben, "Boy Genius Boyan Slat's Giant Ocean Cleanup Machine Is Real," FastCompany (2017)

June 4 — Project presentations

June 6 — Project presentations and wrap-up

— Final version of project due by midnight June 13 — NO LATE PROJECTS —

PROJECT IDEAS

Evaluate information/energy tradeoffs in cloud computing

If cloud computing were a country, it would be the world's 6th largest consumer of electricity — more than Germany, France, or Canada — according to Greenpeace (2014). Yet a recent study by Lawrence Berkeley National Laboratory (2013) claimed that if all U.S. business users shifted their email and other business software to the cloud, they might reduce energy consumption by up to 87% — saving enough electricity to power the City of Los Angeles. Who's right? How do we know?

Map the travels of raw materials and wastes for a single product, e.g. an iPhone

Coltan from the Congo; manufacturing in Malaysia; discard and recycling in China or Ghana: iPhone materials circumnavigate the globe at an especially rapid pace. What might we learn from different ways of accounting for (and representing) these travels? What's at stake politically, financially, socially? You can pick any product; we're not paid by Apple or its rivals.

Energy metabolisms. Map raw materials and wastes for a single energy source. Or depict the evolution of energy metabolism in a specific place over some long period of time.

Techno-metabolism requires energy. Where does it come from? Don't just think about fuel — also think about the materials and systems that turn fuel into energy. Concrete. Silicon. Steel. Where do these come from? Where do they end up? Also think about change over time. And differences between places. You get the picture. Now picture it.

Geographies, topographies, and histories of dumps and dumping

Despite our best efforts to pretend otherwise, waste never goes away. When we throw something out, we're really just rearranging the earth's materials. That's a key insight of thinking through metabolism. So what does that mean for how we treat landfills and other sites of waste accumulation? Ponder and picture dumps (of whatever sort) in horizontal, vertical, temporal, and/or geopolitical perspective.

Inequalities of consumption and waste

We all shit. But we don't all shit the same things: some of us shit arugula, others manioc (few people shit both; it's worth saying that). Also, different things happen to our shit. Some of us never have to think about it after flushing it down our state-of-the-art Japanese toilets. Others can never get away from its smell. Lots of people have no place to do it. And of course the same thing applies to all sorts of other consumption and waste cycles. Pick a process of consumption or metabolism to compare in different countries. Find a way to get a grip on it.

Machines that count or measure

Prototype a device, process, service (etc…) that measures or quantifies something that hasn't been quantified yet. Set the focus on the process of raw data aggregation and recycling. For example, how

might a portable personal measuring instrument be designed so it would collect true random numbers that are used to simulate a certain risk condition?

New units of measure

Propose, justify, and illustrate one or more new units of measure which express a hidden or not-well-known technometabolic relationship. Examples from our readings are Human Appropriation of Net Primary Production (HANPP, in Haberl et al.) or Human Energy Equivalent (Boyden & Dover). Miles per dinosaur? (That is, how far your vehicle travels on the calories contained in one dinosaur, now become oil.)

New uses for "data exhaust" or novel data-collection techniques

Propose a novel use for "data exhaust" that might (a) improve the efficiency of an existing metabolic process, or (b) create a new understanding of some important relationship among raw materials, energy, and waste. (In addition to passively generated "data exhaust," you could also consider innovations in active data collection such as crowdsourcing, micro-narratives, sensors embedded in cellphones, or participatory statistics.) Here are some examples from United Parcel Service "sustainable logistics." Also see the many ideas in "Mobile Phones as Ubiquitous Social and Environmental Geo-Sensors."

INSPIRATION, SOFTWARE, DATA

Examples of infographics, art, maps, films (documentary, art…), speculative designs, and other visualizations or performances of technometabolism:

Trash | Track - MIT project to tag and track the movement of waste

The recent extreme drought in Southern California produced infographics showing the amount of water represented by various foods. Similar graphics are available for the energy required to produce particular food types.

How much land is required to power the world from solar energy alone?

Energy consumption over a lifetime

Blueprints for the Unknown: The Phosphate Standard

Welcome to the Anthropocene: a storymap

Views of the World

Software tools

https://www.mapbox.com/ - Mapping platform

http://materialflows.net/materialflowsnet/home/ — national-level database of material flows, with visualization and mapping tools
https://d3js.org/ - JavaScript-based visualization tool
https://cartodb.com/ - Self-service mapping and analysis tool
http://unfoldingmaps.org/ - Library to create interactive maps and geo-visualizations in Processing and Java
http://www.communitywalk.com/ - Simple tool to put markers and data on a map
https://storify.com/ - Create social media streams
https://datawrapper.de/ - Create basic charts & maps
http://circos.ca/ - Visualize data in a circular layout
http://colorbrewer2.org/ - Colors for cartography
http://www.cytoscape.org/ - Open source software platform for visualizing complex networks
http://geojson.io/ - Editor for JSON based geo data
http://www.datavizcatalogue.com/ - Data visualizations overview
http://raw.densitydesign.org/ - Create charts based on google spreadsheets
https://plot.ly/ - Create and share charts, datasets, and dashboards online
https://googlemaps.github.io/js-samples/styledmaps/wizard/index.html - Use custom style in google maps

Data resources

https://ourworldindata.org - Oxford University-run, data-driven articles about population, health, energy, environment, technology, etc. An excellent resource.
http://materialflows.net/materialflowsnet/home/ — national-level database of material flows, with visualization and mapping tools
http://blog.safecast.org/data/ - Citizen science for the environment
http://www.radicalcartography.net - Many interesting maps and mapping styles. Click the menu on the left to access them - otherwise nothing appears.
http://sailwx.info/ - Ship tracker
http://www.globalsoilmap.net/ - Digital soil map of the world
http://www.seabirdtracking.org/ - Seabird tracking database
https://library.stanford.edu/research/stanford-geospatial-center/data - Set of base and thematic spatial data as well as a large collection of static maps
http://www.geofabrik.de/en/data/download.html - openStreetMap datasets
https://data.nasa.gov/data - NASA'S data portal
http://data.gov - US government data portal
http://berkeleyearth.org/data/ — Berkeley Earth Surface Temperature project - largest database of land and ocean surface temperatures from instruments
https://www.consumerbarometer.com/en/ - Tool to help you understand how people use the Internet across the world
https://data.oecd.org/ - OECD data
http://www.bodc.ac.uk/ - British Oceanographic Data
http://www.iodp.org/resources/access-data-and-samples - Data from the International Ocean Discovery Program
http://www.dbis.informatik.uni-goettingen.de/Mondial/ - Mondial database
https://petewarden.github.io/iPhoneTracker/ - iPhone tracker
https://www.cia.gov/library/publications/the-world-factbook/ - CIA World Factbook. Basic information about every country in the world, including governance, demographics, geography, etc.