Unit 2.5 Vertical connections: How does the ubiquitous generation and propagation of novelty in the Anthropocene System affect the pursuit of sustainable development?

The previous Unit reviewed the ways in which particular places are connected with one another. The connections included both natural or anthropogenic flows involving materials, energy, or information. The places included households, firms, communities, states, regions, etc. We focused implicitly on linkages among places at the same hierarchical level, which we captured in the term "horizontal connections." We argued that while horizontal connections are ubiquitous in nature-society systems, they are often incomplete. The result is persistent heterogeneity and individuality of different places in the Anthropocene System. Implications for the system's dynamics are profound.

In this Unit we turn to a second kind of connections: those that provide vertical linkages across hierarchical levels of the Anthropocene System. These, too, are ubiquitous and multi-directional, encompassing such phenomena as the impact of global climate change on local well-being, the impact of local industrial emissions on global climate and, more generally, vertical connections among macro, meso and micro levels of system activity. We focus here, however, on one very particular group of vertical connections with enormous implications for sustainable development: those connections involved in the generation and propagation of novelty in the Anthropocene System. Novelty can take biological, technological, or institutional forms. Its emergence is facilitated by the persistent heterogeneity of that system noted above. It usually originates under very specific local or niche conditions (e.g. the legendary garages of Silicon Valley, or the Wuhan markets of covid). But when such local or micro-level novelty is taken up at higher levels, it can spread rapidly and change the dynamics of larger systems.

What forms of novelty matter for sustainability? Some are clearly damaging to human well-being, inequitable in their consequences, and inconsistent with the goals of sustainable development. For example: the emergence of novel zoonotic diseases made increasingly likely human actions including deforestation and over-crowded and unsanitary rearing of animals for consumption; the invention of some technologies including things like toxic chemicals in widely-use flame retardants and non-stick cookware; the emergence and spread of conspiracy theories and 'fake news' and the related re-emergence and spread of autocratic governments.

Novelty has also led to more equitably distributed benefits to society as a whole and may be consistent with sustainable development. For example: the invention of high-yielding rice and wheat crops as part of the Green Revolution that led to increasing food production around the world that more than kept pace with the rapid population growth of the 20th century; The development of antiretroviral drugs capable of treating the HIV virus; the emergence of spread of values like our own courses focus on the importance of intra- and inter-generational equity.

Still other novel developments -- whether biological, technological or institutional -- clearly play a role in the dynamics of the Anthropocene. But whether they support or impede sustainable development depends on context. The pursuit of sustainability is centrally about learning how to help generate novelty at the micro-level and to propagate promising results to meso- and macro-levels through the management of vertical connections.

To prepare for this Unit, please:

a) **Read**: Geels, F. W., Kern, F., & Clark, W. C. (2023). System transitions research and sustainable development: Challenges, progress, and prospects. *Proceedings of the National Academy of Sciences*, *120*(47), e2206230120. https://doi.org/10.1073/pnas.2206230120
This article provides an updated account of how promoting the goal of transitions toward sustainability requires close attention to vertical connections and, particularly, the generation and propagation of innovation.

b) **Read**: Schot, J., & Geels, F. W. (2008). Strategic niche management and sustainable innovation journeys: Theory, findings, research agenda, and policy. *Technology Analysis & Strategic Management*, *20*(5), 537–554. https://doi.org/10.1080/09537320802292651

c) **Read**: Anadon, L. D., Chan, G., Harley, A. G., Matus, K., Moon, S., Murthy, S. L., & Clark, W. C. (2016). Making technological innovation work for sustainable development. *Proceedings of the National Academy of Sciences*, *113*(35), 9682–9690. https://doi.org/10.1073/pnas.1525004113

d) **Read**: Matson, P. A., Clark, W. C., & Andersson, K. P. (2016). *Pursuing sustainability: A guide to the science and practice*. Princeton University Press. https://pursuing-sustainability.stanford.edu/ . Read the case study, "An international success amid uncertainty: Ozone and the Montreal Protocol. pp. 179-186.

e) **Review as needed**: Case studies for London and Alaska introduced earlier in the course and available in the Course Library.

Study Questions to help you get the most out of the readings:

I. The readings highlight the important role of bottom-up innovations in the pursuit of sustainability. What innovation – in technology or policy – can you imagine that would best improve the prospects for sustainable development in Fishbanks? How did innovations affect the development pathway of the Stratospheric Ozone case presented in the Matson et al. book?

II. For the case studies on London and Alaska:
   a. Identify ONE source of novelty that is highly relevant to the pursuit of sustainability in the teaching case you have chosen to focus on. Is the novelty biological, technological or institutional? Explain how the source of novelty you picked is relevant to sustainability.
   b. What are the processes through which the novelty you identified in (a) initially emerges? What are the processes through which this novelty succeeds and spreads from the micro-level into the meso-level. *(Note that in the readings, the words level and scale are used to mean the same thing).*
   c. What modification of the structures or processes you identified in (b) above could best advance the pursuit of sustainability in your application region? Why?

III. For the sustainability challenge you selected as "your case," respond to the same 3 queries posed for the London and Alaska cases in II (above).

Digging deeper (optional materials for further exploring frontiers in the pursuit of sustainability):

f) Geels, F. W. (2006). The hygienic transition from cesspools to sewer systems (1840–1930): The dynamics of regime transformation. *Research Policy*, *35*, 1069–1082. https://doi.org/10.1016/j.respol.2006.06.001

This piece explores the socio-technical transition from cesspool to sewer systems in the Netherlands. The conceptual section is a little weird, but the empirical case study nicely illustrates the complexities involved in shifting a socio-technical system from one state to another. We include it here, because it complements the London case and London's struggles to manage its own waste, but discusses the challenge in the language of innovation and vertical connectivity.