Wild Yam: The Rhizome of the Pill

Kira Bre Clingen

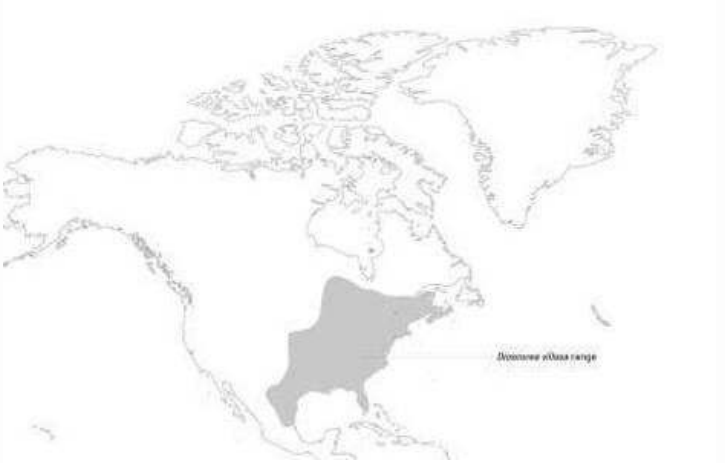
The slender leaves of a specimen of *Dioscorea villosa*, collected in Massachusetts in 1903, are pressed, preserved, labeled, and stored in the Harvard University Herbaria.[1] The winged seedpods are flattened between the leaves, and the vine dried, turning from a bright, light green to faded brown. Though the herbaceous plant, informally known as “wild yam,” can grow up to 30 feet, the sample is much shorter, coiled to fit onto one standardized piece of paper for botanists and other researchers to study. This specimen exemplifies the limitation of the standard botanical herbarium sheet: the plant is desiccated, the stem is trimmed, and the roots and rhizomes, which are vital to the story of wild yam, are torn off. The herbarium sheet represents the plant as portable, inert matter, instead of a living being with deep connections to the landscape and people where it grows. As a form of botanical representation, the sheets turn the plant into a discrete unit of a resource that can be extracted and removed from its broader living assemblage.[2] In the twenty-first century, we can acknowledge and engage the multi-faceted and multiplicty of stories excluded by the herbarium sheet by rethinking drawing conventions to anchor these plants in the landscapes they have grown and continue to grow.

Dioscorea specimen collected ...

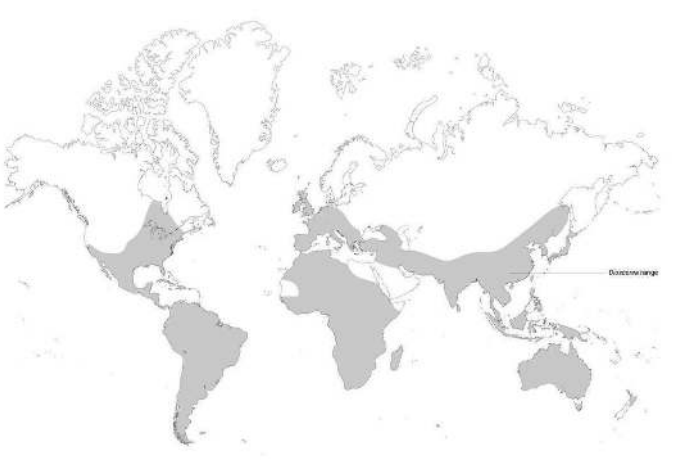
Rhizomes are often confused with roots. They are found underground, but they are stems. The rhizome grows underground horizontally, and sends out roots and shoots from nodes. Rhizomes allow plants to reproduce asexually from the node. Many familiar plants, including bamboo, ginger, hops, and wild yams, also have a subterranean rhizome.[3]

The rhizome of a wild yam in t...

Dioscorea villosa is native and widespread across the eastern United States, and its rhizomes (which are omitted from the herbarium sample) have been used in indigenous and modern medicine for hundreds of years. Starting in the early twentieth century, colonial bioprospectors—researchers seeking commercially valuable botanical resources—began harvesting *Dioscorea villosa*'s rhizomes to mass produce the birth control pill. Since the 1960s, the rhizomes have reshaped lives, landscapes, and water bodies across the globe.[4] This story is lost in the faded tangle of stems presented on the herbarium sheets. To untangle its complex narrative, we require new forms of representation that expand on the plant's subterranean rhizomes.



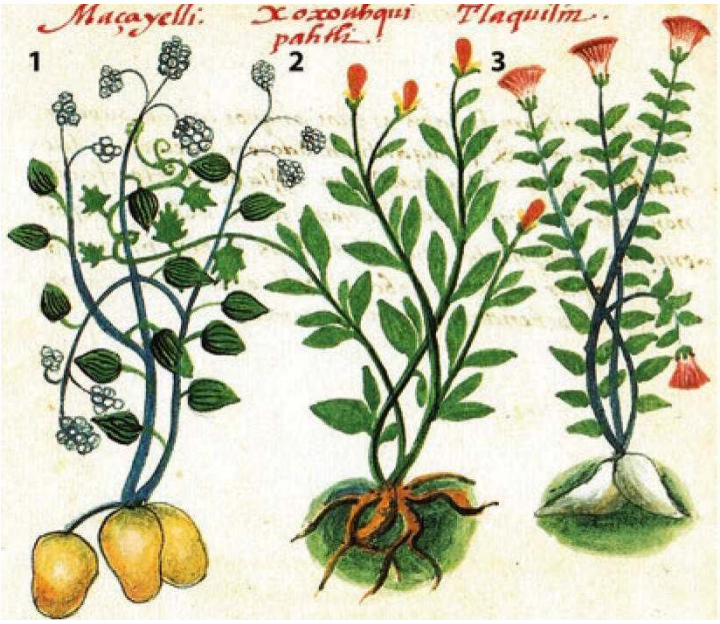
Dioscorea villosa is hardy across eastern North...



The native and introduced distribution of the...

Dioscorea villosa growing in the...

Representing the Roots



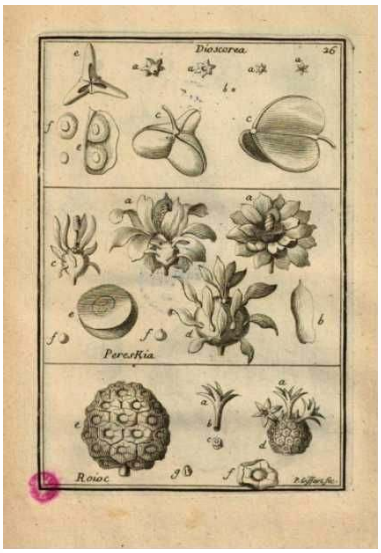
Medicinal macayelli, xoxouhqui chalchiutl and...

Long before the 1903 herbarium sample was flattened, dried, and adhered to a paper sheet, a watercolor-painting of *Dioscorea villosa* with its associated name in Nahuatl, *macayelli*, was immortalized in a Mexican herbal known as the *Badianus Manuscript* (1552).[5] The herbal was written by Aztec physician Martinus de la Cruz and translated into Latin by Juannes Badianus, an Aztec lecturer at the Colegio de Santa Cruz de Tlateloco. In it, an indigenous artist portrayed the whole plant, from its three-tuber underground rhizomes and root system to its above-ground complex of vines laden with flowers and winged seed pods with equal emphasis.[6] In addition, the herbal documents the plants' medicinal properties used by indigenous populations of the Americas. Indeed, its text describes *Dioscorea villosa* or *macayelli* as a pain reliever.

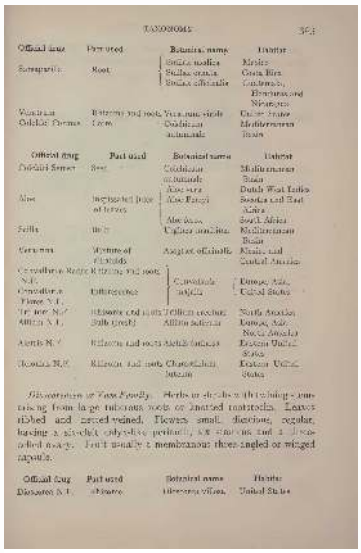
While representing whole plants with roots had become a somewhat standard practice in European illustrations of plants, the painting nonetheless helps the reader understand that its medicinal qualities derive from the whole plant, not only what is visible above ground. In this way, the painting poses questions about the limitations of images in communicating therapeutic information, the agency of indigenous artists in creating plant portraits, and the roles of images and text in the transmission and dissemination of medicinal knowledge.

What’s in a Family Name?

Dioscorea villosa was used by indigenous peoples in North and Central America for centuries before it was encountered, described, and drawn by colonial botanists. The genus Dioscorea was named by Charles Plumier, a French colonial botanist, who encountered the plant during his journeys to the Western Caribbean in 1689, 1693, and 1695, to explore and investigate species for botanical resources. In 1703, Plumier published a description and illustration of *Dioscorea* along with many other findings from his three botanical expeditions in *Nova Plantarum Americanarum Genera*.[7] Like other European botanists of his day, Plumier was sent to the Americas to selectively explore and investigate species for the purpose of finding commercially valuable botanical resources, a practice now known as bioprospecting. As Gian Carlo Delgado, a researcher at the Interdisciplinary Research Centre on Sciences and Humanities National Autonomous University of Mexico writes, bioprospecting “relies on the knowledge of rural and indigenous communities that have established an intimate relationship with nature since precapitalist times.”[8] Botany became another tool of colonial expansion in the eighteenth century that continues to extract indigenous knowledge to this day.[9]



Charles Plumier's...



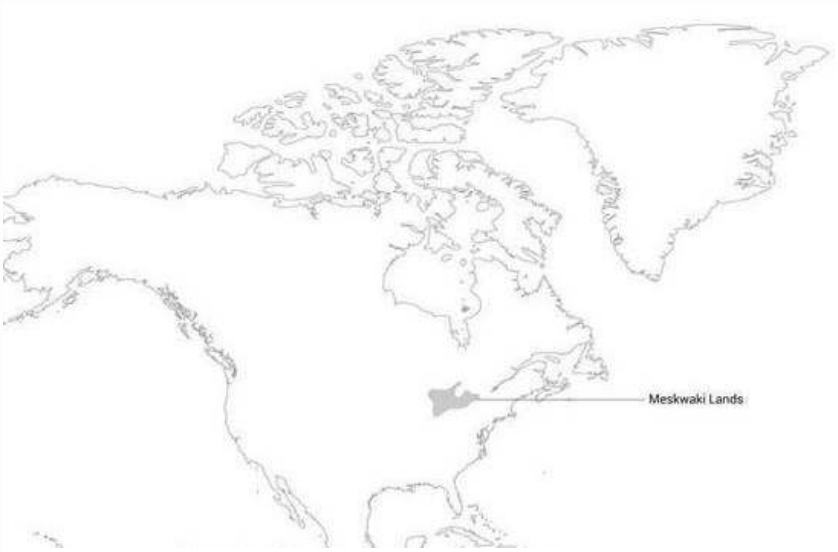
Dioscorea villosa list...

Botanists like Plumier relied on local knowledge to collect samples and knowledge of plant species to catalog. Plumier named the genus *Dioscorea* after the Greek physician and botanist Pedanius Dioscorides, who published his work on medicinal plants in *De materia medica*, an herbal encyclopedia that was used in European medicine from its creation around 50 CE well into the sixteenth century. [10]

Dioscorides

American botanists also obtained information from indigenous groups and published about the medicinal uses of the species. In his 1887 book *American Medicinal Plants: An Illustrated and Descriptive Guide to the American Plants Used As Homeopathic Remedies: their History, Preparation, Chemistry and Physical Effects*, botanist and physician Charles Frederick Millspaugh identifies many uses of the plant including treating bilious colic, which we know as gallstones, as a way to induce sweating and cause vomiting, and to treat coughs. The plant is also noted to treat dysmennorhea and kindred afflictions, which we know as menstrual cramps.[11] Millspaugh offers a method to extract a tonic from the roots, which are abundant and easy to collect.[12] In 1917, Otto Wall also recorded how indigenous communities used the plant in temperate climates in *A Handbook of Pharmacognosy*. For example, he noted how, in the Great Lakes Region, the Meskwaki Nation used the plant to reduce pain during childbirth, and as an analgesic and reproductive aid. [13]

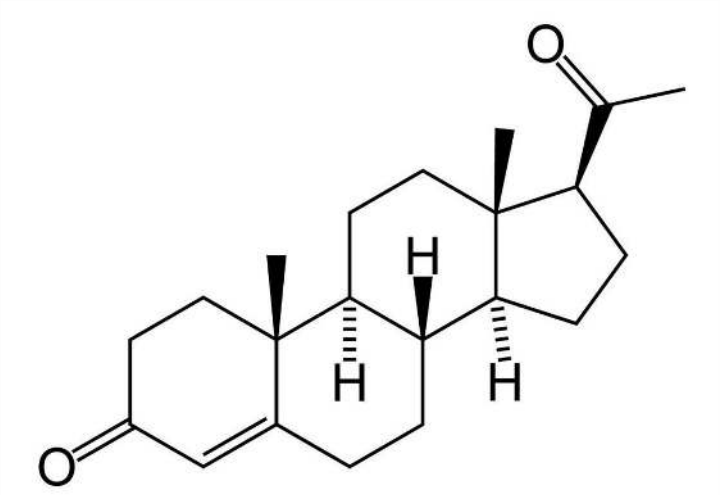
Botanists wrote extensively about the medicinal uses of *Dioscorea villosa* throughout the eighteenth and nineteenth centuries. But the exploitation of *Dioscorea* and other species in the genus accelerated during the twentieth century, when *Dioscorea villosa* became a central figure in the global development of the sex hormones needed to create the birth control pill. This effort relied on massive biopiracy operations in Mexico, where the plant's medicinal uses were first recorded in Early Modern period documents.



While botanists like Otto Wall documented the ways in whic...

Dioscorea villosa in the...

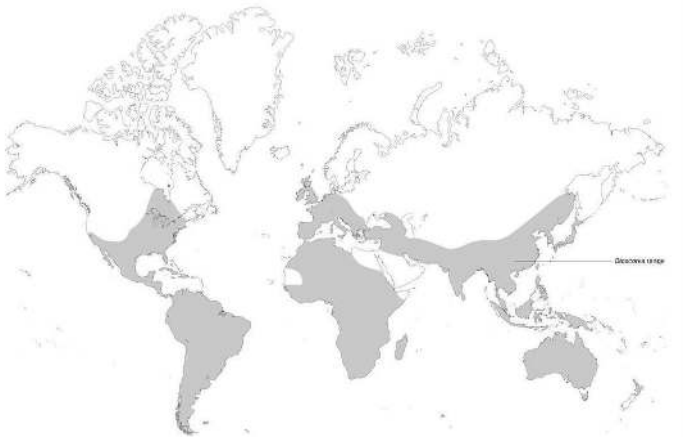
Modern Chemistry: Inventing the Marker Degradation



The chemical structure of progesterone, which can...

In 1938, Russell E. Marker, a chemist working at Pennsylvania State University, successfully synthesized the sex hormone progesterone from sapogenin, a naturally occurring compound in sarsaparilla (*Smilax regelli*), an herbaceous plant native to the eastern United States where Marker was working. (Progesterone had been discovered by doctors earlier in the 1930s, who used the sex hormone to treat menstrual disorders and pregnancies.) The process to synthesize progesterone, the Marker degradation, is named for him.[14] Finding the synthesizing of progesterone from sarsaparilla prohibitively expensive, Marker knew he needed a different source to make progesterone more affordable. A paper written by Japanese colleagues alerted him to their discovery of the compound diosgenin, which they had extracted from the roots of *Dioscorea tokoro*, a wild yam species abundant in eastern Asia.[15] The finding sent Marker to the Penn State library to study its botanical collection in search of a widely distributed source of diosgenin. In the end, Marker found his answer outside his laboratory in the local roots of *Dioscorea villosa*.

Marker was not a botanist, nor was he particularly interested in plants. Yet, in 1940, he published a paper describing how he had successfully extracted “the powdered rhizomes of *Dioscorea villosa* with a procedure similar to that used in the isolation of sarsapogenin.”[16] He compared a sample of diosgenin that his Japanese colleagues sent to confirm his results. That same year, he was also able to produce progesterone from diosgenin. Marker’s experiments confirmed that the genus *Dioscorea* was a readily available source of diosgenin that could revolutionize the expensive production of progesterone.



The native and introduced distribution of the...

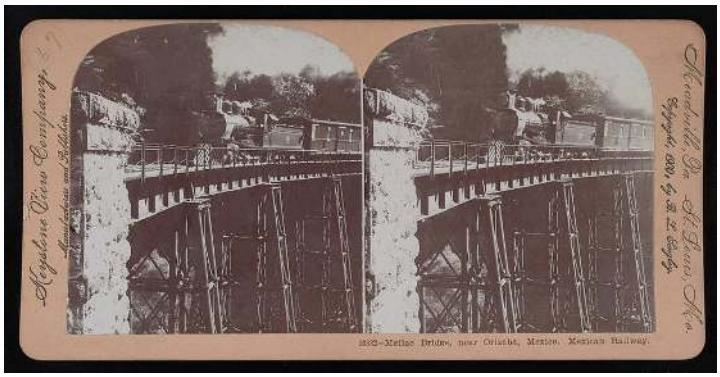
Striking Out: Marker in the Mexican Landscape

Despite its seeming abundance, the yield of diosgenin from *Dioscorea villosa* was low, and therefore not economically feasible. Marker tried producing the compound from other plants, including Beth root, or *Trillium erectum*, which he gathered on an expedition to North Carolina. He noted “the roots are only about the size of your thumb. Collection of one hundred pounds a year would be about the limit.”[17] In 1942, he updated his findings, writing “the easy conversion of diosgenin to progesterone made necessary the investigation of additional plant sources.” He lists eight additional species, all sampled in the eastern United States.[18]

Red Trillium plant, Mer Bleue

Marker ultimately decided that “no plant in northern North America contained sufficient material to be an inexhaustible source of steroids for medicinal purposes,” and set out beyond the eastern United States in search of an economically feasible source of diosgenin, focusing on the genus *Dioscorea*.[19] Botanists from Penn State connected him to their networks, and while spending time with a botanist in Texas, he opened a random book by his bedside where he saw the image of a large, tuberous root. The caption read, “This specimen was collected just where the highway from Mexico to Veracruz, between Orizaba and Cordoba, crosses over the Barranca [gorge] de Metlac.” Marker left for Mexico in 1941, searching for a species he knew in his extremely limited Spanish as *cabeza de negro*.[20]

An aerial view of Orizaba in Veracruz (Keystone...



The Mexican railways bridge in Metlac (Kesytone...

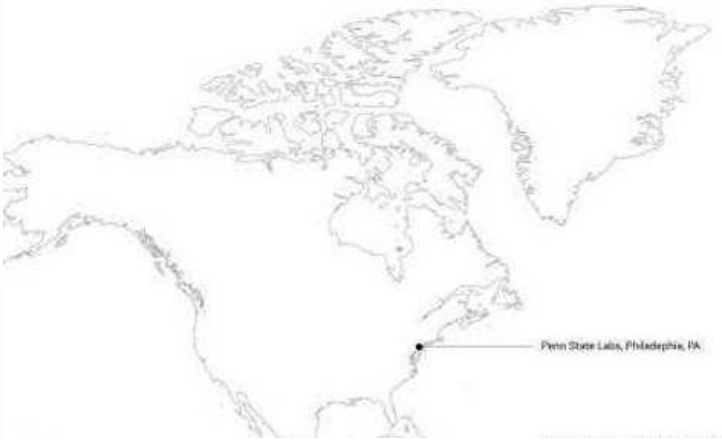
Cañada de Metlac

World War II shortened Marker's first collecting trip in Mexico, and he returned to the country in 1942, travelling with a local botanist who confirmed the *cabeza de negro* species as a relative of *Dioscorea villosa*, named *Dioscorea macrostachya*, now called *Dioscorea mexicana*, which was found in Veracruz in central Mexico.[21] After a falling out with the Mexican botanist, Marker boarded a bus for Orizaba, Veracruz, where he asked a local shop owner, Alberto Moreno, for a specimen. Moreno helped him load two large tubers of *cabeza de negro* onto the bus. On his return trip, Market had to bribe a local policeman so that he would let him take only one of the two tubers back to his lab.[22]

A thicket of Dioscorea climbing the understory...

Marker isolated Dioscorea mexicana as a specimen th...

Marker committed an act of biopiracy in bringing the plant back to the United States. He had entered the sovereign state of Mexico with an introductory letter expressing his interest in "working on some hormone projects intimately related to the National Defense [of the United States]."[23] He viewed the plant as a natural resource for drug development, without consideration of the deep-rooted history or indigenous traditions associated with the plant.[24] For Marker, the species were interchangeable, except for the amount of diosgenin in their roots.[25]



Marker crossed the border back into the United...

The massive roots of Dioscorea mexicana were...

In the following decades, the Mexican steroid industry reshaped the Mexican landscape. Marker himself collected 20 forms of Dioscorea throughout Mexico. He readily abandoned *Dioscorea mexicana* for *Dioscorea composita*, known locally as *barbasco*, for its higher diosgenin content.[26] Marker co-founded the pharmaceutical company Syntex to cultivate and collect wild yams, test the rhizome, and produce diosgenin.[27] At its height, Syntex employed 25,000 Mexican farmers to cultivate and harvest wild yam, and 3,000 factory workers to produce diosgenin. An infrastructure of roads and distribution facilities was established across Veracruz to facilitate the exploitation of barbasco for the pharmaceutical trade.[28] The farmers collected 75,000 tons of roots per year for the production of the birth control pill, which was developed over two decades after Marker originally discovered *Dioscorea* as an economical source of diosgenin to produce progesterone.[29]

From Plant to Pill

Birth control pills arrayed at a pharmacy in 1968 a...

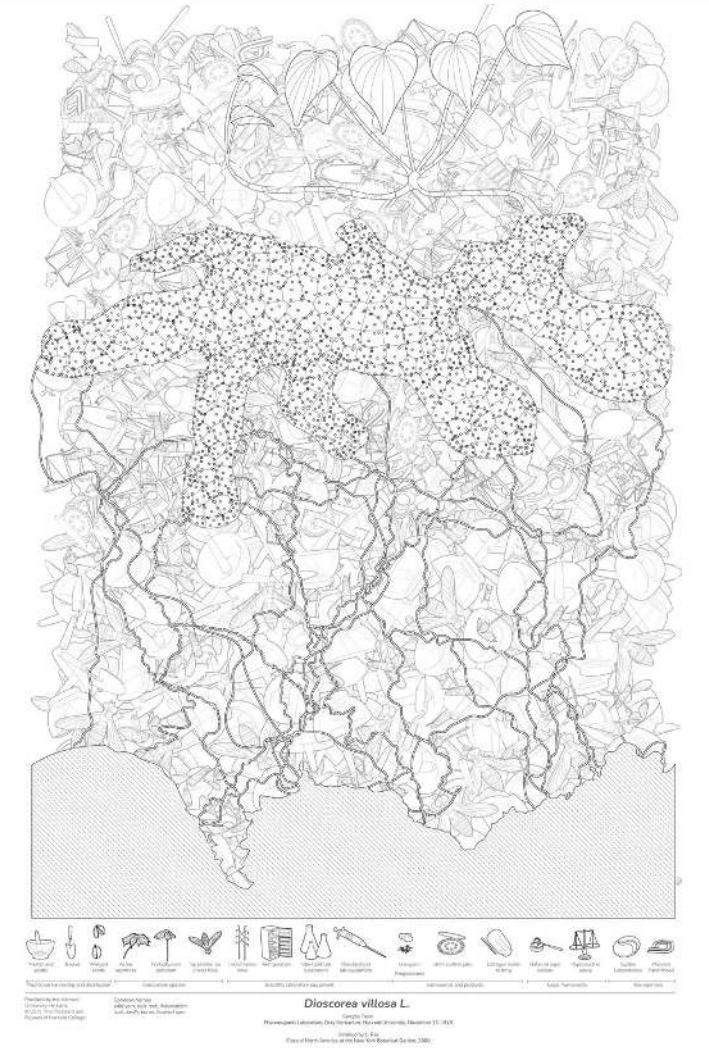
In 1951, chemist Carl Djerassi, working at Syntex, developed a synthetic form of progesterone, called progestrin, from barbasco rhizomes, but did not develop it into a contraceptive.[30] The next year, biologist Gregory Pincus, funded by Katherine McCormick and Margaret Sanger of Planned Parenthood and working at the Massachusetts Institute of Technology (MIT), successfully synthesized a two-ingredient estrogen-progesterone pill. The invention had revolutionary implications for women around the globe.[31] The clinical trials for the pill could not be conducted at MIT because birth control studies were banned in Massachusetts, and MIT could incur a $1,000 fine per trial. Instead, the team began medical trials of the pill in Puerto Rico, which have since been condemned for their lack of informed consent by today's standards.[32]

Plants in the *Dioscorea* genus were cultivated around the world for economic gain as lab tests began in the late 1950s, with scientists breeding tubers with higher diosgenin concentrations for use in manufacturing the pill. Clinical studies in Sri Lanka, the United States, Haiti, Hong Kong, Japan, and Mexico began in 1960, and by 1961 half a million women were using the pill to regulate menstruation and pregnancy.[33] Today, the pill is available across the globe, and is one of the most popular forms of contraception, despite ongoing attempts to regulate its use.[34]

The pill is used by over 20% of women of...

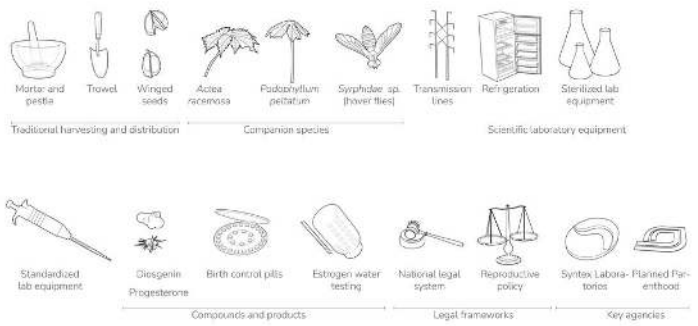
Re-Rooting Dioscorea villosa

Dioscorea villosa and the birth control industry have reshaped human life on Earth. And so, a new, complementary herbarium sheet is needed to address the complexity of the scientific revolution that Marker's experiment with *Dioscorea villosa* set in motion. By redrawing the plant with its attendant agents–the mortar and pestle that indigenous women used to create medicine, the trowels used by Marker to collect the root, the laboratory equipment used to isolate diosgenin,the birth control pill that resulted from Marker's experiments, and the diosgenin flowing from the plant's rhizomes to the global oceans–we can understand the plant's reach: from the eastern United States to the entire globe.



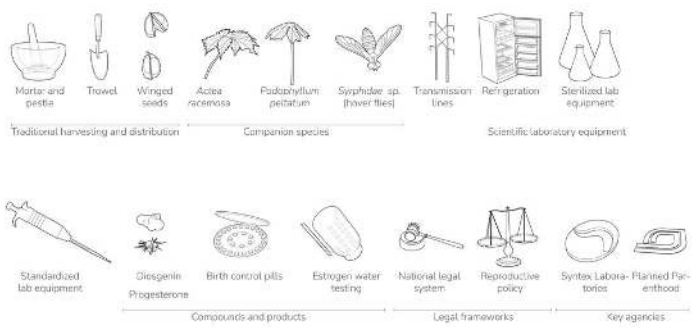
A new herbarium sheet enlarges the rhizome to...

Situating the plant in this entanglement of reproductive hormones, policy, and moving into the present, the story of *Dioscorea villosa* and its role in the development of the birth control pill becomes more complex. Global use of the pill has come with side effects. Most alarming is the influx of progesterone and estrogen, another sex hormone used in many birth control pills, into municipal water systems, resulting in hormones flowing through sewers into water bodies across the globe, thus remaking the chemistry of the oceans, our largest commons, at a planetary scale. The increasing synthetic hormone levels in our water systems impact the fertility of humans as well as marine and terrestrial animals.[3536]



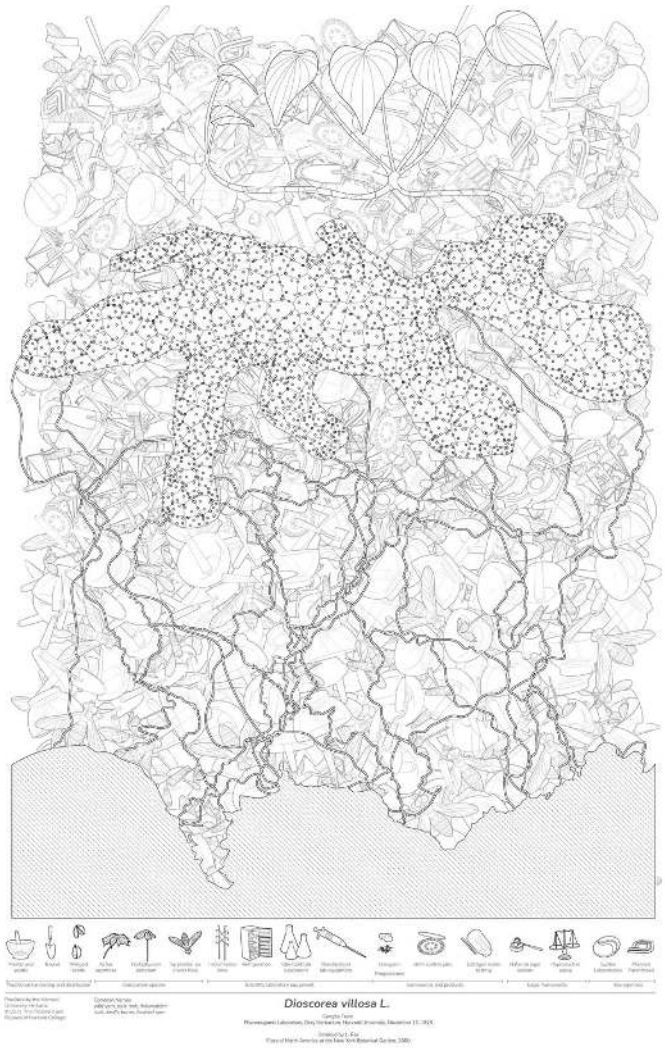
The story of Dioscorea villosa cannot be adequatel...

Ironically, the plant's success and distribution on land has led to critical risk, as habitat destruction and over-harvesting threaten its very own existence. *Dioscorea villosa*, as well as other *Dioscorea* species, are commonly harvested for reproductive supplements. The plant deteriorates rapidly after harvest, which privileges low-volume harvesters who supply small amounts, increasing patchy habitat destruction.[37]



The demand for Dioscorea villosa and other simila...

Despite the transformation of the plant from a weedy vine growing on roadsides and in deep thickets to an influential commodity, traded for the chemicals in its rhizomes, herbarium sheets still represent *Dioscorea* as a leafy specimen devoid of underground life and its broader impact. This continued botanical representation for a plant that has been at the center of bioprospecting campaigns for almost a century fails to communicate the ongoing entanglement of a plant exploited for economic gain.



The lines extending from the tuber can be read as...

Acknowledgements

The proposed herbarium sheet was conceptualized and developed in Thinking Through Soil, a seminar taught by Seth Denizen at the Harvard University Graduate School of Design in Spring 2021. Sam Naylor assisted in drawing the template format for the herbarium sheet.

References

1. E.W. Hervey, *North America: US and Canada (Region): United States of America: Massachusetts: Bristol County: New Bedford.* 1903. ↩
2. Yota Batsaki, “The Apocalyptic Herbarium: Mourning and Transformation in Anselm Kiefer’s Secret of the Ferns,” *Environmental Humanities* 13, no. 2 (2012): 391–413. ↩
3. Encyclopedia Britannica, “Rhizome.” *Encyclopedia Britannica* 2020. Accessed May 29, 2022. ↩
4. North American Native Plant Society, “*Dioscorea villosa*, Wild yam.” *North American Native Plant Society*. Accessed March 27, 2021. ↩
5. Arthur O. Tucker and Jules Janick, *Flora of the Codex Cruz-Badianus* (Cham, Switzerland: Springer International Publishing, 2020), 46–47. ↩
6. Tucker, *Flora*. ↩
7. Charles Plumier, *Nova plantarum americanum* (Paris: Regis and Regix Scientiatum Academiae Typrographum, 1703). ↩
8. Gian Carlo Delgado, “Biopiracy and Intellectual Property as the Basis for Biotechnological Development: The Case of Mexico,” *International Journal of Politics, Culture and Society* 16, no. 2 (2002): 297–318. ↩
9. Londa Schiebinger, *Plants and Empire: Colonial Bioprospecting in the Atlantic World* (Cambridge, MA: Harvard University Press, 2004). ↩
10. Gabriela Soto Laveaga, *Jungle laboratories: Mexican peasants, national projects and the making of the pill* (Durham: Duke University Press, 2009). ↩
11. A.F. Sievers, *The Herb Hunter’s Guide*. Misc. Publication No. 77. Washington, D.C.: USDA, 1930. ↩
12. Charles Frederick Millspaugh, *American medicinal plants: an illustrated and descriptive guide to the American plants used as homeopathic remedies: their history, preparation, chemistry and physiological effects* (New York: Boericke and Tafel, 1884–1887). ↩
13. Otto A. Wall, *A Handbook of Pharmacognosy* (St. Louis, MO: C.V. Mosby Co., 1917). ↩
14. American Chemical Society and Sociedad Quimica de Mexico, *The “Marker Degradation” and the Creation of the Mexico Steroid Hormone Industry 1938-1945* (University Park, PA: American Chemical Society, 1999). ↩
15. T. Tsukamoto, Y. Ueno and Z. Ota, “Constitution of diosgenin. I. Glucoside of Dioscorea Tokoro Makino,” *Journal of the Pharmaceutical Society of Japan* 56 (1936): 931–940. ↩
16. Russell E. Marker, D.L. Turner, and P.R. Ulshafer, “Sterols. CIV. Diosgenin from certain America plants,” *Journal of the American Chemical Society* 62 (September 1940): 2542–2543. ↩
17. Russell E. Marker, interviewed by Jeffrey L. Sturchio at Pennsylvania State University on April 17, 1987. Philadelphia: Science History Institute, n.d. Oral History Transcript 0068. ↩
18. Russell E. Marker, R.B. Wagner and Paul R. Ulshafer, “Sterols. CXLVI. Sapogenins. LX. Some New Sources of Diosgenin,” *Journal of American Chemical Society* 64 (1942):1283–1285. ↩
19. Pedro Lehmann, “Early History of Steroid Chemistry in Mexico: the story of three remarkable men,” *Steroids* 57, no. 8 (1992): 403–408; Laveaga, *Jungle*. ↩
20. Lehmann, “Steroid.” ↩
21. R. Govaerts, P. Wilkin and R.M.K. Saunders, *World Checklist of Dioscoreales:Yams and their allies,* Kew: The Board of Trustees of the Royal Botanic Gardens, 2007; Laveaga, *Jungle*. ↩
22. Lehmann, “Steroid;” American Chemical Society, *Marker.* ↩
23. Laveaga, *Jungle*. ↩
24. Marker successfully synthesized progesterone from *Dioscorea mexicana*. Because he failed to secure American pharmaceutical interest, he moved to Veracruz and cofounded Syntex Laboratories in Mexico City in 1944. This marked the beginning of the Mexican steroid industry, which would shape the global industry for years to come. Marker was only involved in Syntex for a few years. He permanently moved back to the United States in 1956 after the United States established an embargo against Mexico, accusing the Mexican government and Syntex of monopolizing the market for diosgenin, the profitable source of which was squarely within Mexico’s borders. See Cory Hayden, *When Nature Goes Public: The Making and Unmaking of Bioprospecting in Mexico* (Princeton: Princeton University Press, 2020). ↩
25. Cory Hayden, *When Nature Goes Public: The Making and Unmaking of Bioprospecting in Mexico* (Princeton: Princeton University Press, 2020); Gary Gereffi, *The Pharmaceutical Industry and Dependency in the Third World* (Princeton: Princeton University Press, 2017). ↩
26. Marker, Oral History. ↩
27. Laveaga, *Jungle*. ↩

28. Ignacio Chapela, “Biodiversity in the Age of Information: A Critical Analysis of Conservation Initiatives Associated with the Discovery of New Pharmaceuticals,” in *Biodiversity, Biotechnology, and Sustainable Development in Health and Agriculture: Emerging Connections* (Washington, D.C.: Panamerian Health Organization, 1996). ↩
29. Marker, Oral History. ↩
30. Syntex, *Syntex Annual Report* (Mexico City: Syntex Laboratorios, 1963). ↩
31. Planned Parenthood, *The Birth Control Pill: A History*. ↩
32. Marker, Oral History. ↩
33. Syntex, *Syntex Annual Report* (Mexico City: Syntex Laboratorios, 1963). ↩
34. Zava, “Contraception around the world: interactive map,” Online Doctor. May 5, 2014. Accessed online April 19, 2021; Zack Beauchamp, “Here’s a map of the countries where the pill is fully subsidized (it includes Iran),” *Vox*, June 30, 2014. Accessed April 19, 2021. ↩
35. Caldwell et al., “An Assessment of Potential Exposure and risk from Estrogens in Drinking Water,” *Environmental Health Perspectives* 118, no. 3 (2010): 338–344. ↩
36. Carl Fisher, Claudia Martins, Ed George, and Pranathi Perati, “Expanded Analysis of Human Hormones in Drinking Water Using Solid-Phase Extraction and Liquid Chromatography Tandem Mass Spectronomy,” *ThermoFisher Scientific*, 2009. ↩
37. Andrew Pengelly, “Dioscorea villosa L. Wild yam,” *Appalachian Plant Monographs* (Laurel, MD: Tai Sophia Institute Appalachian Center for Ethnobotanical Studies, 2011). ↩