The Several Meanings of Global Health History: The Case of Yellow Fever

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I am writing a global history of yellow fever aiming to interrogate the yellow fever story at the global, international, and national levels.[1] Mark Harrison did this for a number of diseases in his recent study of commerce and contagion.[2] Yellow fever has engendered a fund of excellent historical scholarship by Jamie Benchimol, Marcos Cueto, Ilana Löwy, Nancy Stepan, Liora Bigon, and many others.[3] My research at the Rockefeller Archive Center examined materials created before the 1948 founding of the World Health Organization. I wanted to ask, for example, if we ought to think of yellow fever as a global disease. More precisely, when did it become that, if it did? It wasn't long ago that some of our colleagues, especially the more sociologically inclined, chanted the mantra that "All science is local!" This was in some ways a reaction to the historiography of Alexandre Koyré, a Russian émigré working in Paris who coined the term "scientific revolution." He and others enjoined historians of science to focus on theory while others claimed that quantification and replication of results constituted the heart of scientific advance.

Virology, and yellow fever research in general, is especially recalcitrant in regard to replication of results. Even the Nobel Laureate Max Theiler, who won the Nobel Prize in Physiology or Medicine in 1951 for his work on the yellow fever vaccine, tried but failed to re-derive neurotropic or viscerotropic properties from the 17D lineage and French yellow fever vaccines. The 17D vaccine and its descendants are now the standard vaccine lineage for most of the globe.

So what is a global disease? My approach has been to ask what circulates and what does not circulate. Does a disease count as a global disease if there is widespread concern about it yet it hasn't spread to every corner of the globe? Yellow fever isn't global in this last sense. But it is a global threat and climate change and accelerating urbanization could extend its range. So concern is widespread and we don't know its possible futures. We need to think too about the ecology of yellow fever within populations (Mirko Grmek's term pathocenosis is relevant here), which have other diseases. As Jamie Benchimol reminded us a few years ago, diseases such as dengue and possibly Zika may expand in yellow fever's wake.

Currently, gene editing and biotechnological tools (e.g. CRISPER-CAS 9) are being applied to study and attack the disease and its vectors. These new strategies of suppression and containment, sometimes proffered as preludes to eradication, could themselves occasion problems. Thus efforts to suppress the main vector of yellow fever by gene-drive technologies and possibly by self-limiting technologies, could cause the yellow fever virus to shift vectors and become widespread in mosquitoes with habits different from the main urban vector, the *Aedes aegypti* mosquito. This could place humans at greater risk during most hours of the day and in different micro-environments. Today yellow fever's epidemiological footprint is mainly an African one. But in January 2017 the governor of Brazil's Minas Gerais State declared a state of emergency due to the disease. Hence yellow fever is at least a re-emergent disease, and at least a disease of global potential in terms of disrupting travel, commerce, and public health in expansive regions of the globe. It is a worrisome and recalcitrant disease even if it is not truly global in presence.

Past efforts to study, eradicate and control the disease were not fully global but were bi-hemispheric, transnational, and trans-imperial, and this report focuses on a part of the larger story, particularly on French and American research. But four organizations enabled a largely successful effort to control yellow fever. In terms of funding, in addition to the Pasteur Institutes in Paris and Dakar and the Rockefeller Foundation, two other agencies conducted yellow fever investigations leading to advances in yellow fever suppression, virology, and vaccinology. These last two agencies are the Wellcome Bureau of Scientific Research funded by the London pharmaceutical company of Sir Henry Wellcome, and the Oswaldo Cruz Institute of Rio de Janeiro. The Oswaldo Cruz Institute owes its origins to plague work. Its role in the yellow fever story merits more attention than I can give it here. These four agencies worked closely with military, civil, and colonial authorities. For example, the Rockefeller Foundation's International Health Commission (renamed Board in 1916 and Division after 1927), hired the U.S. army's William C. Gorgas to lead their yellow fever efforts. The four agencies exchanged personnel

and techniques frequently and scientists in the laboratory and field came to see, represent, and finally control yellow fever in new ways. As a result, older mapping techniques were updated and advanced to produce innovative medical cartography. Relations between these four agencies flowed back and forth in evolving and asymmetric fashion not unlike the international and national networks of research portrayed in Marcos Cueto's recent article on Mexican physiology.[4] Additionally, agency agendas sometimes clashed with those of both colonial and metropolitan administrators; this was particularly so whenever quarantine regulations threatened. It's clear that the British and French wanted only their own vaccines, and not those of rival powers, used in their respective colonies.

The Rockefeller Foundation's divisions and commissions outdistanced the other three agencies in terms of funding yellow fever research; however, yellow fever was only one of many diseases and health concerns targeted by the Foundation after the Rockefeller Institute for Medical Research opened in 1901. In 1914 the Foundation's new International Health Commission reveled in its successful effort to control hookworm infections in the American South and the mines of California.[5] The hookworm campaigns had been directed at ensuring the availability of healthy laborers. Yellow fever was the philanthropy's second large disease initiative. Initially, the yellow fever campaigns followed the advice of Dr. Henry Rose Carter who wrote: "Get rid of the yellow fever mosquito. Disregard the human host—the man sick of yellow fever—and concentrate on the control of the insect host—the mosquito."[6] A preventive vaccine for yellow fever, however, was only achieved by studying mosquitoes and both human and animal populations. Eventually, Rockefeller yellow fever programs spent about $330,000,000 in today's dollars.[7] Yet yellow fever research wasn't an overarching priority and the Foundation spent even more on war relief. Although heavily involved in the Pan American Sanitary Organization (later the Pan American Health Organization), the Foundation terminated most of its yellow fever activities after the 1948 founding of the World Health Organization.

Foundation officials were very good at keeping track of their partners and writing about it. For example, they had the Medical Director of the American Joint Distribution Committee in Paris, the typhus expert Harry Plotz, keep any eye on and report on Pasteur Institute activities in the 1920s.[8] These records enable us to see accounts of the same incident seen from divergent viewpoints and understand the key yellow fever concerns of both the Rockefeller's International Health Commission and the Pasteur Institute.

Commerce, Trade, and Science in Paris and New York

Shortly after the assassination of Archduke Franz Ferdinand in July of 1914, and about three weeks before the opening of the Panama Canal, the Foundation's International Health Board considered the potential health consequences of the canal. Discussions began between General William Gorgas and Rockefeller officials. As one of their many memos on the topic summarized,

> Radical changes have been wrought in trade relations; countries and ports between which there has been little or no exchange are to be brought into close relations; *pest-holes* of infection that have been relatively harmless because of their isolation are going to be on the world's highway of commerce and travel.[9]

Here, Wickliffe Rose, director of the International Health Commission, was clearly responding to diplomatic concerns sounded by British and Asian medical authorities who feared that yellow fever might gain a foothold in Asia.[10] He was measured, however, and thought that the great Scots physician and malariologist, Patrick Manson, was overly alarmist about yellow fever spreading to Asia. Still,

Rose warned of the "incalculable" devastation to follow if the disease indigenized in Asia. There, he continued, it would become a "continual menace to the rest of the world."[11] This seems to be a global view of disease. But is it? More precisely it's a statement comingling regional diplomatic and health concerns of global potential. International Health Commission yellow fever activities were principally designed to protect trade, that is commerce and travel, rather than labor as had been the hookworm campaigns.[12] In this then yellow fever differs from the hookworm campaigns though of course labor and trade are intertwined. To summarize, then, the agency's initial concerns were boldly international and possibly global, although no more than weakly humanitarian.

In May 1920, Gorgas and Rockefeller staffer General Robert E. Noble set sail for West Africa. In London, the malariologist and Nobel Laureate Ronald Ross told the team that yellow fever did not exist in West Africa. Gorgas fell ill and eventually died in London, but Noble and others spent fifteen weeks touring French, Belgian, and British holdings in West and West Central Africa. They saw no cases of yellow fever, but Noble wrote of how the vast area, larger than the United States east of the Mississippi River, was so absolutely different from "anywhere in South or Central America; here [in Africa], one is dealing with a population that is but one degree removed from barbarism."[13] Later Rockefeller agents considered using the viscerotome in Africa to harvest post mortem liver tissue and confirm diagnoses but signaled problems as Africans had a habit of hiding their diseases and their dead from outsiders. As Ilana Löwy's has shown, the Rockefeller viscerotomy program in Brazil, which functioned from 1923-1940, was beset by similar prejudices and a myriad of problems. Possibly too, following Löwy's delineation of "field" and "laboratory focused" styles of yellow fever activities in Brazil, Africa required a more resolute focus on laboratory methods or at least something additional to the successful mosquito control efforts at many locations in the Americas.[14]

Let's look now to Paris. Scientists at the Pasteur Institute and the International Health Commission expressed similar sentiments as regards health and economic prosperity. For example, the Pasteur Institute's Albert Calmette worked with the Institute's Director, Emile Roux, to bind together the various Pasteur Institutes abroad, referring to them and the Paris institution after the fashion of Pasteur himself by characterizing them as "temples of the future, wealth and well-being."[15] Theirs was a gospel of prosperity founded on science, but certainly neither the French nor the Americans sought universal health for everyone.

By the 1920s French and American collaborations existed on tuberculosis, yellow fever, typhus, and other diseases. Rockefeller seemed poised to co-fund the training of public health professionals at the Pasteur Institute but the project collapsed. [16] Correspondence between employees of the International Health Commission and its successors and Pasteur Institute personnel reveals the entire range of sentiments including competition, cooperation, accusations of faulty scientific work and concern over administrative, national, and institutional agency. In this the yellow fever story constitutes a kind of prelude—but on balance a cooperative one—to the acrimony of the 1980s over characterization of the AIDS retrovirus at both the Pasteur Institute and the U.S. National Institutes of Health.

The Paris Pasteur Institute and its associated Pasteur Institute in Dakar provided pivots for French yellow fever research. The main brief of yellow fever research fell to Auguste Pettit's laboratory in Paris. This location facilitated the exchange of materials, personnel, and information between the French and Americans. In addition, the Rockefeller Foundation had an office in Paris and monitored French efforts and developments. Pettit had moved to the Pasteur Institute in 1908 to direct the laboratories of the Nobel Laureate and malariologist Alphonse Laveran. He was a skilled parasitologist who confirmed that antibodies present in blood serum were specific to the species of invasive parasites. The correlation between specific antibodies and a specific disease-causing organism revolutionized at least three subfields of the yellow fever story; diagnosis, distinguishing between

efficacious and ineffective therapies, and later the medical cartography of the disease. Pettit's laboratory transferred the virus to monkeys and then to horses and developed an experimental yellow fever vaccine for monkeys containing immune horse serum.[17] The French worked intensively on the horse as vehicle to produce serum. This is not unlike the snake-serum studies done at the Instituto Butantan in Sao Paulo, Brazil, where six liters of drawn blood from a horse immune to certain snake venoms could produce 2.5 liters of serum for distribution to human snake bite victims. The Rockefeller Institution researcher Hideyo Noguchi and the Wellcome researcher George Findlay also used horses. After the virus was adapted to mice around 1930 the research community quickly embraced the mouse as an experimental platform.

There have been so many epidemics of yellow fever since its presumed diffusion from Africa. In 1896, Pasteur Institute scientists created the first microbiological laboratory in Africa at Saint-Louis de Senegal. Epidemics of yellow fever struck the cities of Saint-Louis de Senegal and Dakar in 1900 and again in 1912. In between, another epidemic of 1908-1909 struck the French Caribbean colony of Martinique. The French Ministry of Colonies had gained independence from the French Navy in 1893, and the Ministry soon employed Pasteur Institute scientists as consultants to investigate and control colonial diseases. The typical French mode of intervention was to send a mission of scientists out from Paris and sometimes include colonial service engineers.

The Pasteur laboratory in Africa relocated to Dakar in 1924 to become the Pasteur Institute of French West Africa. A year later in 1925 the Rockefeller International Health Commission established laboratories in Yaba, near the city of Lagos, as part of its West Africa Yellow Fever Commission. Vestiges of localism and heterogeneity in disease nosology persisted even after isolation of strains of the yellow fever virus. Was there one yellow fever, or were there several? As one scientist at Yaba argued in late 1920s, South American and African samples of yellow fever virus provoked very different symptoms in laboratory animals. They

were likely two separate diseases. Yellow fever was recognized as a single disease in 1930 thanks to laboratory investigations in New York City by Wilbur Sawyer, Wray Lloyd and others. The team first examined virus samples taken from Dakar and the Rockefeller Yaba laboratory and found them to be indistinguishable in terms of provoking yellow fever in monkeys. The team also tested and compared these first two strains with samples isolated by Henrique Arago of the Oswaldo Cruz Institute and others gathered in Bahia. These experiments unified the disease and simultaneously put to rest Hideyo Noguchi's bacteriological theory of yellow fever.[18] Yet the idea that there was more than one yellow fever was by no means universally accepted. Still, it complicates the yellow fever story and as Christopher Hamblin's recent book of fevers reminds us, we need to resist seeing unity when it was not there.[19]

In October of 1927 Auguste Pettit from Paris, accompanied by his sister who served as his secretary, and the Physician General and inspector of colonial medical services, visited West Africa.[20] Commission member Dr. George Stéfanopoulo, Pettit's laboratory leader in Paris and later chief for the Pasteur Institute's yellow fever service, remained in Paris.[21] He was a naturalized French citizen of Greek origin and already a physician who had studied tropical diseases in Egypt. In Paris since 1919, Stéfanopoulo obtained a French M.D. degree in 1924 under Pettit with a thesis on serotherapy for polio. No one at the Pasteur Institute was more focused on yellow fever research than Stéfanopoulo.

The use of immune serum and sometimes blood from recovered yellow fever victims to treat yellow fever victims had been around since at least 1892 when Carlos Finlay had used the technique, and of course the laboratories that became the Oswaldo Cruz Institute also elaborated serotherapy. In 1928, Stéfanopoulo, Pettit, and a collaborator worked with the newly-isolated but poorly characterized yellow fever virus and prepared immune serum in monkeys and horses.[22] They then immunized other monkeys with this serum mixed with active virus and conferred immunity on other monkeys. Simultaneously, Max Theiler and Andrew

Sellards at Harvard University had provoked an immune response by combining the live virus with immune serum recovered from human survivors of the disease. Doses were exported to Africa and also to Brazil, but not tested at either location.[23]

The International Health Division made a modest investment of $10,800 in Stéfanopoulo from 1934 to 1938.[24] The award supported Stéfanopoulo's work on three projects; first, the improvement of immune serum which he was already engaged in; second, resolving the problems of vaccination particularly in the French colonies, and thirdly, to collaborate with Rockefeller scientists to identify endemic areas of African yellow fever and provide diagnostic tests. [25] A 1933 Division memo described him as "the only man in Paris working on yellow fever and [he] is almost the only one in the French-speaking world. Roux has charged him with all responsibilities for study of the disease at the [I]nstitute."[26]

Opinions of Stéfanopoulo soon changed. The physician George K. Strode was at the Foundation's Paris Field Office and met with Stéfanopoulo in September 1934 to discuss "a number of problems." According to Strode, Stéfanopoulo regarded his position at the Pasteur Institute as unsatisfactory. He also resented that he had not been promoted to be Pettit's Chief of Laboratory and claimed that he would resign if he did not get the promotion and also a salary increase. It is hard to say if Stéfanopoulo was serious about resigning, or whether receipt of Rockefeller monies influenced his decision to stay. But he stayed at the Pasteur Institute and was Chief of its yellow fever service when he died in Africa in 1949. What is clearer is that his research in 1934 was less about virology than therapeutic toxicology, and he conducted a number of tests of arsenic on monkeys. Stéfanopoulo also criticized his colleague Jean Laigret's vaccination program in Africa which utilized a vaccine derived from a Syrian man in Dakar. This French strain sometimes called the Laigret-Sellards strain was administered with small pox vaccine. It became the second most administered vaccine after the 17D vaccine derived by the Rockefeller team. Stéfanopoulo claimed private sources had informed him that the Laigret

vaccine had produced several cases of paralysis and possibly deaths and wanted to take the issue to the International Office of Public Hygiene.[27]

Let's return to the last of the three charges of the International Health Division's grant-in-aid to Stéfanopoulo, the task of mapping yellow fever's footprint with immunological surveys. Early on, then, Rockefeller officials viewed Stéfanopoulo as the laboratory lynch pin of French yellow fever efforts and their link to suppression of yellow fever in the French colonies of West Africa. To summarize, though, from the perspective of the circulation of methods and techniques as well as concern for the disease, the Rockefeller Foundation and Pasteur Institute approaches to yellow fever were different. The Foundation's Yaba laboratory in Africa was focused principally on and dedicated primarily to yellow fever research. The French on the other hand continued a mission-oriented strategy involving commissions of experts sent from Paris, either to sites of epidemics, or to general laboratories with multiple responsibilities such as those at Dakar and Tunis. There were also two separate major strains of vaccine, one French and the other American with different methods of production and administration. Divergent strategies for attacking yellow fever are also evident at the various African yellow fever conferences held in the inter-war years. Thus I would term yellow fever research in the interwar and early Cold War periods as predominately transnational, trans-imperial and bi-hemispheric rather than global.

A key technology of 1931 altered how yellow fever was seen and described. This was the mouse protection test developed by Wilbur Sawyer and Wray Lloyd in New York. It can measure the level of immune serum present in human and animal populations. A basic mouse test required drawing blood serum from an immune animal, injecting the serum into other mice, and then exposing those mice to the yellow fever virus and immune serum and composing a sero-protection index by calculating how long the mice survived or how quickly they died. Immunity of the target organism was then scored as complete, partial, or non-existent. About 6 mice would be sacrificed in each simple test. Stéfanopoulo took thousands of white

mice to Africa and used this test. Previously, researchers had used guinea-pigs, monkeys and many other organisms to study immunity as Fred Soper and De Andrade did in Brazil. The new mouse protection test technology altered cartographic practices by accelerating them and making them cheaper.

Maps constitute a kind of rhetorical device to argue for certain theories of disease. The Rockefeller International Health Board, unlike the Pasteur Institute as far as I can tell, had access to a robust cartography department. Nearly all International Health Board annual reports contain maps. I have elsewhere examined early uses of the term medical geography and mapping techniques in the French and French colonial context and won't go into details here.[28] But with geography, of course, we need to ask questions: What is the scale of the investigation; what determines the presence or absence of the disease; and what sort of map was constructed. There is an additional feature too with the study of past epidemics: how reliable are retrospective diagnoses, and how generalized was the idea that there might be several yellow fevers? The mouse protection test surveys brought precision to observational and historical reports of yellow fever's presence or absence and provided additional layers of information.

Yellow fever mapping began in the 1790s with the activities of New York physician Valentine Seaman, who experienced a wave of what we think was the largest ever yellow fever epidemic in recorded history. That epidemic, centered on the French Caribbean colony of Saint Domingue, killed between 20,000 to 30,000 people. Seaman studied the disease by observing the dock areas of New York and attending to yellow fever's victims.[29] His spot maps note the location of yellow fever cases and deaths. Seaman thought that miasmas arising from waste on the docks and harbor caused the outbreak, so his maps argued against theories of imported contagion.[30] A few years later in 1819, Félix Pascalis, also of New York, published another series of maps in this same tradition. Both men thought that there was only one yellow fever not several.

When Rockefeller mapping efforts began, the American epidemiologist Wade Hampton Frost who had direct experience with yellow fever, was promoting John Snow's 1854 cholera map of Broad Street in London as a "cartographic emblem of bacteriological thinking."[31] Frost was the first professor of epidemiology at the Johns Hopkins University and a scientific director of the Rockefeller International Health Division.[32] He was also an advocate of laboratory methods and collaborated with Lowell Reed of the Johns Hopkins University's department of Biostatistics to produce the first mathematical expression of the epidemic curve. Division mapping efforts incorporated ratios of immune and non-immune populations as well as geographical displays at multiple levels including the global level.

In contrast, Pasteur Institute scientists continued largely in the mission-oriented and spot map traditions producing itinerary maps and sketches. Results were often expressed in simple numerical and tabular fashion. This was the case with two early Pasteur Institute yellow fever missions, one to Senegal in 1901, and another to Martinique at the end of that decade which investigated an outbreak of 1908 and 1909. The mission to Senegal produced an extremely detailed report which noted times, dates, progression and location of disease victims. Even the exact hospital beds where the victims had died were noted. The investigators in West Africa had no agreed upon vector for the disease, although the preliminary results of the Walter Reed Commission in Cuba, which had identified the mosquito as the agent of transmission, were known. Thus general sanitary procedures were counseled.

In the Martinique epidemic, after general agreement that the disease was transmitted by mosquitoes, investigators tallied both suspected and confirmed cases of the disease. Confirmation was done on symptomatology and not routinely confirmed from post-mortem liver examinations. The archives of the commission contain a wealth of field notes noting the time needed to travel between communes. Locations such as Fort de France were mapped in detail for the presence of cases and for mosquito infestations. They also considered the frequency of mild cases of the disease in creole populations and speculated that these might play a role in the

propagation of epidemics. When the Pasteur mission arrived, they collected maps and rendered others on site. No maps existed for the Fort de France suburb of Crozanville, so investigators employed creoles to assist them and commented that unlike African peoples, Martinique's creoles were good natured, docile, and willing to help.

Early Rockefeller efforts at yellow fever mapping in Yaba began after agents purchased maps in London and elsewhere. The earliest maps were spot maps. These were regional maps of West Africa and often recorded the city where victims died or contracted the disease. They also recorded the ethnicity of the victim. Rockefeller cartographers also developed a system of colored symbols to display information. Some maps noted the total number of cases in each location, while others recorded only that the disease was present or absent. What is clear is that the Rockefeller mapping effort was highly-refined and more sophisticated than French efforts. By 1933 the use of mouse protection tests was evident in cartographic practices and draft maps noted that information was missing on the French colonies of West Africa and this is what Rockefeller scientists hoped Stéfanopoulo would provide.[33]

Sero-protection technology and mapping was well advanced by 1935 and work would continue after World War II. After the discovery of the jungle yellow fever cycle, Max Theiler and others in the field began testing immune levels and presence of the virus in both animals and humans. Rockefeller investigators produced a few non-human animal immunity maps displaying the ubiquity of the virus.[34]

Mouse protection test technology became a global element of the yellow fever story, or at least it circulated widely and became standard in the various scientific communities and networks that I have examined so far. Later, early Cold War maps attempted to summarize all that was known about yellow fever on a global scale inclusive of human and animal immunity, dates of disease outbreaks, and even global mosquito distribution maps.

In 1948 the American Geographical Society hired the French Physician Jacques May to lead its new Department of Medical Geography and produce a comprehensive "Atlas of Diseases." A large map from that series appeared in 1952 and charted the global distribution of dengue and yellow fever.[35] By this time the Rockefeller Foundation had exited yellow fever activities but in his notes to the map May thanked three International Health Division physicians including Henry W. Kumm who had worked on yellow fever in Brazil. The mouse protection test rendered possible a section of the map on yellow fever immunity which was broken down by the ages of those sampled. According to May, until 1933, parts of Africa were thought to be free of subclinical yellow fever. The discovery of the jungle cycle of yellow fever and the adoption and application of mouse tests on both humans and animals for antibodies to yellow fever, however, revealed the disease's truly vast footprint and, of course, signaled the end of the dream of eradication sounded by Henry Rose Carter and Fred Soper.

I have tried to use the yellow fever story to interrogate global disease history and evaluate the concept of the circulation of ideas and techniques. But I am still unsure if the concept of global history and circulation of techniques and knowledge captures the historical reality of what was happening on the ground. Further, I have done little more than mention the Brazilian and larger South American context. Warwick Anderson and others have pointed out how the concept of global medicine and health obscures the colonial heritage of health actions. In the case of the yellow fever story, it may also neglect inter-philanthropic dynamics and possibly national styles, such as the American and French cases probed here. The mouse protection test became standard and global or nearly so with astounding rapidity, so some elements of yellow fever science circulated across international and national professional networks. Others, such as vaccine production and administration remained in separate spheres until recently. The French vaccine was distributed to 50,000,000 people in the French African sphere, and an additional 100,000,000 doses went to Portuguese, Belgian, and British African

colonies. Dakar produced the French vaccine until 1982 when it converted to the 17D version in consultation with the World Health Organization.[36] Prior to this date the French and American sides of the story seem more of an international, national and trans-imperial story than a global one. As I keep crafting a global history of yellow fever, I want to provide room for its nuanced and asymmetric character and provide an appreciation of the diversity of programmatic, locational, fiscal, epistemological, and technical factors merited by the yellow fever story.

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[1] The author thanks all who have assisted in this research and notes especially Tom Rosenbaum of the Rockefeller Archive Center (hereafter RAC) and Daniel Demellier of the Pasteur Institute archives. He also thanks the RAC for an archive research grant, and audiences who gave helpful criticism of this project at the Oregon State University Center for the Humanities, the Oswaldo Cruz Foundation/FIOCRUZ of Rio de Janeiro, and at the 25th International Congress for the History of Science and Technology also held in Rio de Janeiro. Especially helpful were comments and questions from two scholars who have written much on yellow fever, Jaime Benchimol and Marcos Cueto, both of FIOCRUZ.

[2] Mark Harrison, *Contagion: How Commerce has Spread Disease* (New Haven and London: Yale University Press, 2012).

[3] Length limitations preclude extensive end notes and complete attribution of scholarship.

[4] Marcos Cueto, "An Asymmetrical Network: National and International Dimensions of the Development of Mexican Physiology," *Journal of the History of Medicine and Allied Sciences* 71 (2016): 43-63.

[5] Greer Williams, *The Plague Killers* (NY: Charles Scribner's Sons, 1969), 41.

[6] Quoted in Anne-Emanuelle Birn, *Marriage of Convenience: Rockefeller International Health and Revolutionary Mexico* (NY: University of Rochester Press, 2006), 53, and referenced as H. R. Carter to W. Rose, RG 5, Series 2, Special Reports, Box 2, File 135, RAC.

[7] Greer Williams, *Virus Hunters* (NY: Alfred A. Knopf, 1959), 156. Williams gives a somewhat smaller estimate of more than $12,000,000 (inclusive of salaries) in Williams, *The Plague Killers*, 315.

[8] Anne Marie Moulin, "The Pasteur Institutes between the two world wars. The transformation of the international sanitary order," pp. 244-265 in Paul Weindling, ed. *International health organisations and movements, 1918-1939* (Cambridge: Cambridge University Press, 1995), 252.

[9] RF, International Health Board/Division records, RG 5 (FA115), Series 1: Correspondence; Subseries 1_02: Box 39, 970.2, F 601, IHC Annual Report, 2nd, 1916, "Eradication of yellow Fever," typescript copy, p. 6. Italics added.

[10] Wickliffe Rose, "Memorandum on Yellow Fever: Feasibility of its Eradication," Oct. 7, 1914, RAC, RFA, RG 5, International health Board/Division, ser. 300, box 22, fol. 135, referenced in Marcos Cueto, "Sanitation from above: Yellow Fever and Foreign Intervention in Peru, 1919-1922," *Hispanic American Historical Review*, vol. 72 [1] (1992): 1-22.

[11] Wickliffe Rose, "Memorandum on Yellow Fever: Feasibility of its Eradication," [copy] Oct. 27, 1914, https://search.lib.virginia.edu/catalog/uva-lib:2222501 (accessed 24 April 2017).
[12] E. Richard Brown, *Rockefeller Medicine Men: Medicine and Capitalism in America* (Berkeley: University of California Press, 1979).
[13] Robert E. Noble, [1920], RF Record Group 5, Box 52, Series 2, I.H.B., I.H.C. 495 West Africa 2-54-3, folder 331, on p. 29.
[14] Llana Löwy, "Epidemiology, immunology and yellow fever: The Rockefeller Foundation in Brazil, 1923-1939, *Journal of the History of Biology* 30 (1997): 397-417.
[15] Moulin, "The Pasteur Institutes between the two world wars," 249. The quotation is from the 1920s.
[16] Moulin, "The Pasteur Institutes between the two world wars," 252-253.
[17] Berthe Kolochine-Erber, "Auguste Pettit, 1869-1939," *Annales de l'Institut Pasteur* 63 [6] (1939): 525-530.
[18] W. A. Sawyer, S. F. Kitchen, Martin Frobischer, Jr., Wray Lloyd, "The relationship of yellow fever of the Western Hemisphere to that of Africa and to leptospiral jaundice," *Journal of Experimental Medicine* 51 [3] (1930): 493-517.
[19] Christopher Hamlin, *More Than Hot: A Short History of Fever* (Baltimore: Johns Hopkins University Press, 2014).
[20] "The Report of Dr. Pettit on Yellow Fever in Africa," *Journal of the American Medical Association* 91 [23] (1928): 1817; "Société Médico-Chirurgicale de l'Ouest-Africain, Séance du 20 Novembre 1927," *Bulletins de la Société de pathologie exotique et de sa filiale de l'Ouest africain* 20 (1927): 1020-1024; Lasnet, "Note sur la fièvre jaune au Sénégal en 1927," *Bulletin de l'Académie nationale de médecine*, 100 (1928): 758-763; "Conférence intercoloniale de Dakar," *Bulletin de l'Académie nationale de médecine*, 100 (1928): 763-764.
[21] B. Kolochine Erber, "G. J. Stefanopoulo (1893-1949)," *Annales de l'Insitut Pasteur* 1949 (12): 648-649 notes he remained in Paris.
[22] Pettit, Stefanopoulo and Frasey, "Sérum anti-amarilique …," *Comptes rendus des séances de la Société de Biologie*, XCIX (1928) : 841-842, and idem. "Pouvoir préventif et curative du sérum anti-amarilique, » 1114-1116.
[23] Pierre Mollaret, *Le Traitement de la Fièvre Jaune* (Paris: J.-B. Ballière et fils, 1936): 64-67.
[24] RF records, projects, RG, 1.1 (FA386) Series 500: France, Subseries 500.00: France-Yellow Fever, International Office of Public Hygiene-Yellow Fever, Box 14, folder 1.1 500 14 156, memo of 23 September 1933.
[25] RF records, projects, RG, 1.1 (FA386) Series 500: France, Subseries 500.00: France-Yellow Fever, International Office of Public Hygiene-Yellow Fever, Box 14, folder 1.1 500 14 156, folder on "Pasteur Institute, Paris –Stephanopoulo [sic], Georges T. (yellow Fever Studies), 1933-1939, memo of 23 September 1933.
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