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Zoonotic diagrams: mastering and unsettling human-animal relations

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This article approaches interspecies relations through an examination of the prevalent visual device employed in the representation of animal-human infection in the life sciences: the zoonotic cycles diagram. After charting its emergence and development in the context of bubonic plague, I explore how this diagrammatic regime has been applied in two distinct practical contexts: a plague warning sign on the Grand Canyon National Park hiking trail; and the on-line public information campaign launched by the US Centers for Disease Control and Prevention (CDC) in the wake of the Ebola outbreak of 2014-16. The article demonstrates the principal ontological and biopolitical operations of these diagrams, arguing that, far from simply summarizing epidemiological narratives of animal-human infection, they function both as pilots of human mastery over human-animal relations and as crucial sites of unsettlement for the latter.

Diagrams form one of the most persistent and pervasive tools of anthropological thinking. From Alfred Kroeber's 'tree of cultural evolution' to rendering house and village plans into analytical charts of social life, and from kinship diagrams to the complex diagrammatic analytics developed by Claude Lévi-Strauss and Alfred Gell or, more recently, in the context of ontological debates, there is hardly a key moment or turn in the discipline which is not accompanied or supported by what we may call diagrammatic pilots of anthropological reasoning. And yet, with few notable, and mostly kinship-focused, exceptions (Banks 2001; Bouquet 1996; Grimshaw 2001; Hage & Harary 1983), anthropologists appear largely uninterested in the way in which diagrams have influenced the development of ideas and debates in our discipline. Given the latter's record of reflexivity, this cannot be said to be the result of a lack of self-inspection. Rather, it seems to stem from an invisibility of the diagram as a unique mode of drawing out forms, patterns, and relations across epistemic fields and cultures. Hence diagrams constitute a blind spot for anthropology not only as regards its own practices but also as an ethnographic object.

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This article is not a review of anthropology's diagrammatic practices or thinking. Its aim instead is to approach diagrams both as visual ethnographic objects and as a mode of analytical reasoning, in the field of a specific biomedical practice. Through the study of what is perhaps the most prevalent diagrammatic regime in the study of animal-to-human infection (zoonosis), my aim is to relate to diagrams both empirically, as tools used by life scientists and public health agencies to reason about and manipulate reality, and theoretically, as models of human-animal relations. This article will argue that by taking these diagrams 'visually' seriously, we are able to arrive at an understanding of them not merely as simplified schemata of animal-human infection, but as a practice of 'visual reasoning' (Frappier, Meynell & Brown 2013) that embodies and reproduces fundamental principles as regards interspecies relations. This, it will be argued, allows us to arrive at an anthropological understanding of human-animal relations which integrates biopolitical and ontological perspectives under the rubric not of 'the mastery of nature but of the relation between nature and humankind' (Benjamin 1986: 93).

The scope of diagrams

More than thirty years ago, W.J.T. Mitchell (1981: 623) called for a new, critical diagrammatology: a 'systematic study of the way that relationships among elements are represented and interpreted by graphic construction'. Yet in spite of their ubiquitous application across the sciences, their popularity through works on data visualization (Tufte 1990; 1997), and the long-standing interest shown by cognitive scientists (Cheng, Lowe & Scaife 2001; Glasgow, Narayanan & Chandrasekaran 1995; Larkin & Simon 1987) and historians and philosophers of science (Brown 1996; Catley & Novick 2008; Frappier *et al.* 2013; Lüthy & Smets 2009; Mahoney 1985; Sheredos, Burnston, Abrahamsen & Bechtel 2013), anthropologists have only recently started to pay attention to diagrams as components of scientific visual regimes. In his first book on lines, Tim Ingold drew briefly on Darwin's sole diagram from *The origin of species*, reflecting on the significance of the phyletic line in rendering continuity in evolution a '*reconstituted* continuity of discrete individuals in a genealogical sequence' (2007: 114, emphasis in the original). More recently, Matthew Daniel Eddy (2014) has provided a compelling visual anthropological analysis of eighteenth-century chemical diagrams, whilst, in his examination of public health in Southern Chile, Cristóbal Bonelli (2015) has drawn our attention to the neglected but ethnographically important operation of 'protocolscapes'. Finally, Elizabeth Hallam (2016: 91) has investigated diagram-using and diagram-copying practices amongst anatomy students from the point of view of 'the skill of correlation' between illustrations and the human body. Such studies have trod the path for a sustained anthropological engagement with this mode of visualization in the sciences.

What we lack to this day is a genealogy of diagrams across different disciplines, with Martin Jay (2010) recently criticizing the first attempt of the kind, by John Bender and Michael Marrinan (2010), as overly culturalist, insofar as it fails to contextualize diagrammatological transformations in terms of the historical processes surrounding them. Still the two Stanford scholars' work has stressed, following Lorraine Daston and Peter Galison (1992), the need to approach diagrams as 'working objects'; in other words, as 'objects [that] never duplicate a reality external to them, nor are entirely the result of pure imagination, but somehow fall productively between the two' (Jay 2010: 158). This is a perspective that resonates with Ursula Klein's approach of 'paper tools' (2003) as well as with developments in the study of diagrams in the field of architecture

and digital design. Following Anthony Vidler (2000: 17), what the latter allows us to see is how 'the diagram becomes less and less an icon and more and more a blueprint – or, alternatively, the icon increasingly takes on the characteristics of an object in the world'. Such studies open the field for an examination of scientific diagrams as apparatuses of visual reasoning: at one and the same time abstractive and constitutive components of empirical realities.

Approaching diagrams in this manner, this article argues that we should treat them as a privileged field of scientific thought and practice. For diagrams do not simply aim at generating an optically available shorthand – specifically here for animal-human infection. Instead, following Charles Sanders Peirce's definition, 'the diagram is a skeleton-like sketch of its object in terms of relations between its parts, but what makes it apt to reason with, to experiment on, respectively, is the fact that it is constructed from rational relations' (Stjernfelt 2000: 363). Aspiring to this ostensible ability of diagrams to 'represent a definite form of Relation' (Peirce, in Stjernfelt 2000: 365), life scientists and public health agents employ them not simply to represent animal-human infection, but so as to offer the general public a universal deductive framework for understanding how animal diseases 'translate' into human ones. In short, in terms of the 'demands [they] make on their viewers' (Hall 1996: 9), zoonotic diagrams function as no less than an epidemiological Rosetta Stone, forging universally recognizable linkages between animals and humans. Rather than simply representing a fact, they are tools for rendering infection intelligible as a relation that spans the species divide – an epistemic thing, in Hans-Jörg Rheinberger's sense of the term (1997), that forges a dynamic yet unstable common ground between humans and nonhuman animals.

The case examined in this article is the most prevalent diagram of animal-human infection over the past sixty years: zoonotic cycles. This is a type of 'thinking diagram' (Topper 1996: 241) that draws out the way in which a given pathogen circulates amongst nonhuman animal species, often with the help of insects, as well as the way in which it spreads to humans. The particular diagrammatic regime was introduced in the 1930s and it reached its standard form in the context of post-Second World War epidemiology. It remains today a central visual reasoning device in the field of epidemiology and the most widespread means of visualizing animal-human infection in the lay press, in popular science, and in communication strategies forming part of public health campaigns.

In examining this diagrammatic regime, I will begin by focusing on its development and application in the study of a well-known but constantly rediscovered disease with which my research has engaged in the past five years: plague (*Yersinia pestis*). Being the original field of emergence of zoonotic cycles, this offers us a unique opportunity to explore how these diagrams configure not simply animal-human infection, but also the broader spectrum of human-animal relations, and particular ways in which the latter should be 'mastered' by humanity. The article will then proceed by examining two contemporary applied instances of these diagrams and the way in which these complicate our understanding of the above processes.

Zoonotic cycles

The notion of zoonosis already appears in medical dictionaries by the end of the nineteenth century (Dorland 1900; Gould 1894), coinciding with bacteriological breakthroughs in support of the idea that human disease may derive from nonhuman animals. Nevertheless, its use remained limited until the 1940s, when it acquired prominence in studies of animal-human infection. Indeed the rise of zoonosis to

normative status relied upon a broader epistemic shift, leading R.B. Heisch to identify it as a 'study' or 'problem in ecology' (1956: 673). In this shift from previous models of animal-human infection in terms of an extraneous invasion towards what Heisch called a 'holistic and synecological approach' (1956: 673), a key role was played by one disease: plague. The discovery of plague's causative agent (the bacterium known today as *Yersinia pestis*) by Alexandre Yersin in Hong Kong in 1894 and the ensuing pandemic that consumed more than twelve million lives across the globe (Echenberg 2007) marked one of the most intensive studies of any infectious disease at the turn of the twentieth century. Part of this vast scientific production was the study of plague not only in urban environments, where rats and their fleas were soon discovered to be playing a central role, but also in 'the wild'. This rich and complex research trajectory cannot be followed here – still, it is important to note that it formed a global network of 'biocolonial exchange' (Anderson 2000), where language barriers were broken down by systematic and in-time translations, reviews, and summaries, as well as by visits (often long-term ones) of international plague researchers to labs, research units, and outbreak foci across the globe. Debates about plague amongst 'wild' hosts, which would eventually be coined 'sylvatic plague' (following Jorge & Roubaud 1928), played an important role in developing ecological understandings of the disease. The most influential of these derived from the work of Karl Friedrich Meyer, a Swiss-born professor of bacteriology at Berkeley, California.

In his work for the Sylvatic Plague Committee in the late 1930s, Meyer underlined the need to move away from what he would later coin 'the belief that plague is invariably imported' (1942*a*: 22), and the 'suppressive', vector-eradication-focused public health approach accompanying it.[1] His proposed line of inquiry focused instead on how plague persists amongst diverse rodent populations, which he saw as the natural reservoirs of the disease (Honigsbaum 2015). Though Russian plague research had already established the existence of such sylvatic reservoirs, Meyer's achievement consisted in reconsidering the questions raised by this notion within an emerging epistemic framework: ecology.[2] Drawing critically on notions of population dynamics introduced by Charles S. Elton in his now classic *Animal ecology* (1927), as well as on ideas of plague as a population-regulating mechanism (Elton 1925), Meyer described plague ecology in terms of 'periodic-cyclic fluctuations', pertaining to 'the interrelations between the plague bacillus, the rodent and flea population and the factors of the environment' (1942*b*: 147, 156).

It is, then, in Meyer's work that we see the first example of what I will refer to as the 'zoonotic cycles' (Fig. 1): a diagrammatic device that employs drawings (or sometimes photographs) in conjunction with geometric schemas, whilst functioning as a visual trope that bridges scientific and lay publics by appearing in both scholarly journals, popular science outlets, and the daily press when the need arises to discuss an animal-derived infectious disease.

Whilst earlier visualizations employed mostly linear, one-way 'storyboards' that showed how from a rat, positioned on the top of the list-like schema, plague spread through a flea to humans below (e.g. Rogers & Megaw 1930; Wu, Chun & Pollitzer 1936), Meyer (1938) introduced a more circular visual model of infection. Here plague can be seen to be transmitted amongst and between different rodent species via fleas, whence it attacks humans. This was a diagram that drew on Elton's visualization of food cycles (1927) forming a visual apparatus central to emerging ecological approaches of infectious disease in terms of infective chains.[3] Further

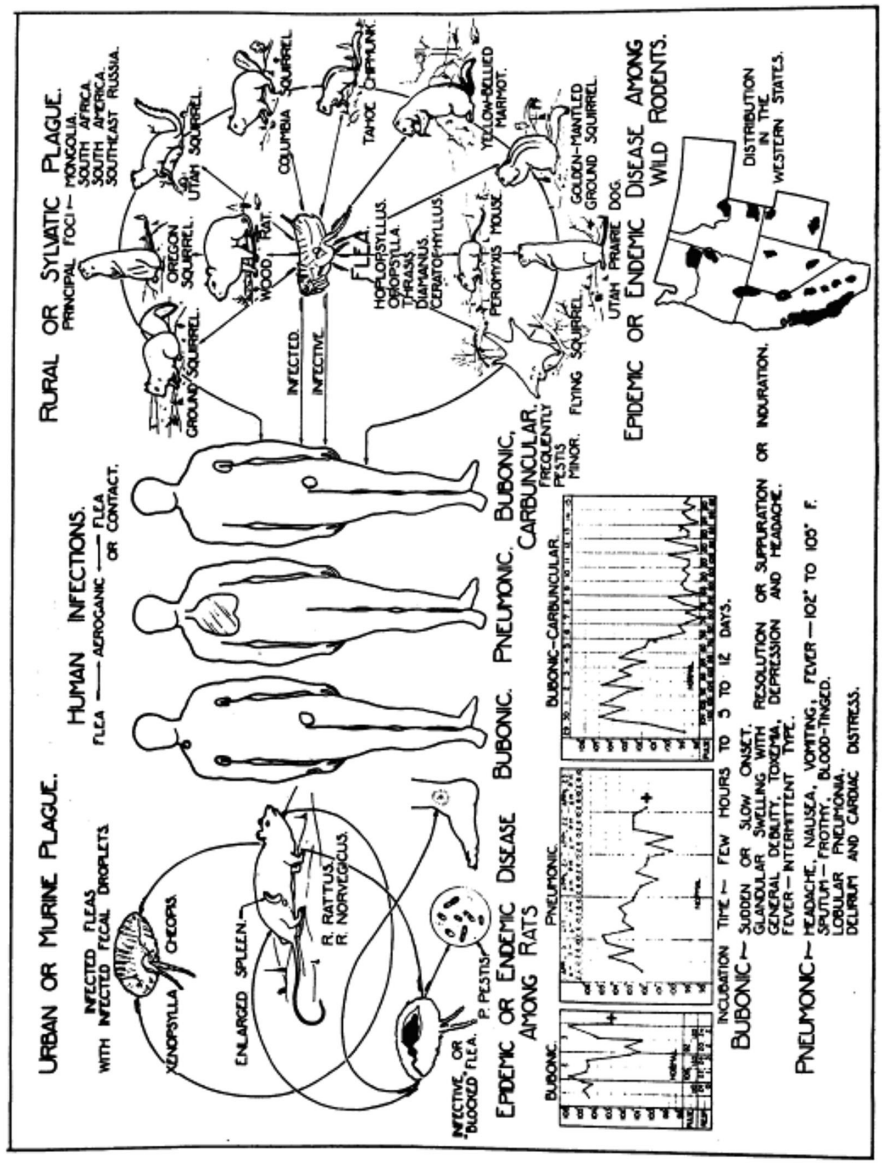

Figure 1. Karl Friedrich Meyer's 1938 diagram of urban and sylvatic plague. Note how the flea sits at the centre of the 'sylvatic plague' cycle. (Meyer 1938: 1154; courtesy of The American Public Health Association.)

simplified and schematized in the aftermath of the Second World War, plague diagrams would henceforth comprise cyclical models of inter-rodent pathogen transmission. These diagrams would increasingly begin to resemble feedback loops, in accordance with the growing cybernetic paradigm at the time (see, e.g., Davey & Lightbody 1961).

Indeed in an influential paper published during the war, Meyer suggested that plague is 'a self-regulating phenomenon which is capable of description' (1942*a*: 9). As Mark Honigsbaum (2015: 300) has argued, what distinguished Meyer's approach from Charles Elton's was that, whilst configuring plague as a self-regulating phenomenon, his 'focus is always on the environmental and ecological conditions that are likely to disrupt the biological balance'. It is, then, this 'description' of plague as a precariously homeostatic system that the new model of the zoonotic cycles sought to achieve. However, as we will see in detail below, what has often been lost in providing this diagrammatic description is the central epistemic principle promoted by Meyer: that the former could be accomplished only to the extent that the ecology of the infection is set centre stage.

The resulting, typical zoonotic cycle still in use today is generally aimed at 'illustrat[ing] some of the transmission cycles' of a disease (Chamberlain 2010). Whether applied to plague (e.g. Fig. 2) or to other zoonotic pathogens, these diagrams are usually composed of three main components: (a) schematic host and vector figures, usually humans, nonhuman animals, and insects; (b) pathway lines or arrows demarcating pathogen transmission; and (c) the blank surface on which these are inscribed. In order to understand the operational field of these visual devices, we need to explore how the diagrammatic regime emerging out of the interrelation between these components is based on hierarchical levels of integration which articulate them in a unified visual field (Ingold 2007). If Laura Perini (2013) is right in arguing that what distinguishes diagrams from other visual representations is that they are 'relatively non-replete', then what becomes analytically pertinent is to examine the (austere) economy between these components, in the sense of the term explored by Giorgio Agamben (2009) – as a *dispositif*, a relation between relations that guarantees structural cohesion: the graphic trinity of zoonotic cycles.

The key component in this diagrammatic economy is, in every case, the human figure. Functioning as the end-point of infection, it usually assumes a generic, formalized contour, inhabiting the top-right corner of zoonotic cycle diagrams. This position guides our left-to-right text-reading gaze towards the *telos*, or 'dead-end' of human infection.[4] Moreover, the relation between, on the one hand, the cycling arrows between animals and fleas and, on the other hand, the arrows breaking loose from this cycle and ending up at the human target functions in a powerful symbolic way suggesting affliction; much like the classical arrows of Apollo Smyntheus, the plague bringer, or the arrows of pestilence piercing the body of Saint Sebastian in Renaissance depictions of plague (Boeckl 2000). These schematic markers operate not simply as connecting lines between two or more figures, but as aetiological trajectories, and, at the same time, as visual metaphors of affliction and contamination long entrenched in European representations of pestilence.[5]

At the same time, investing in norms of a top-down, list-associated reading gaze, this zoonotic diagram sets humans quite apart from the chain of infection between 'natural' hosts and vectors of the disease. It is indeed common for the human figure to inhabit the top-right quarter of the diagram all by itself, whilst other hosts or vectors populate the two left-hand-side quarters of the image. Seen from this perspective, humans appear to

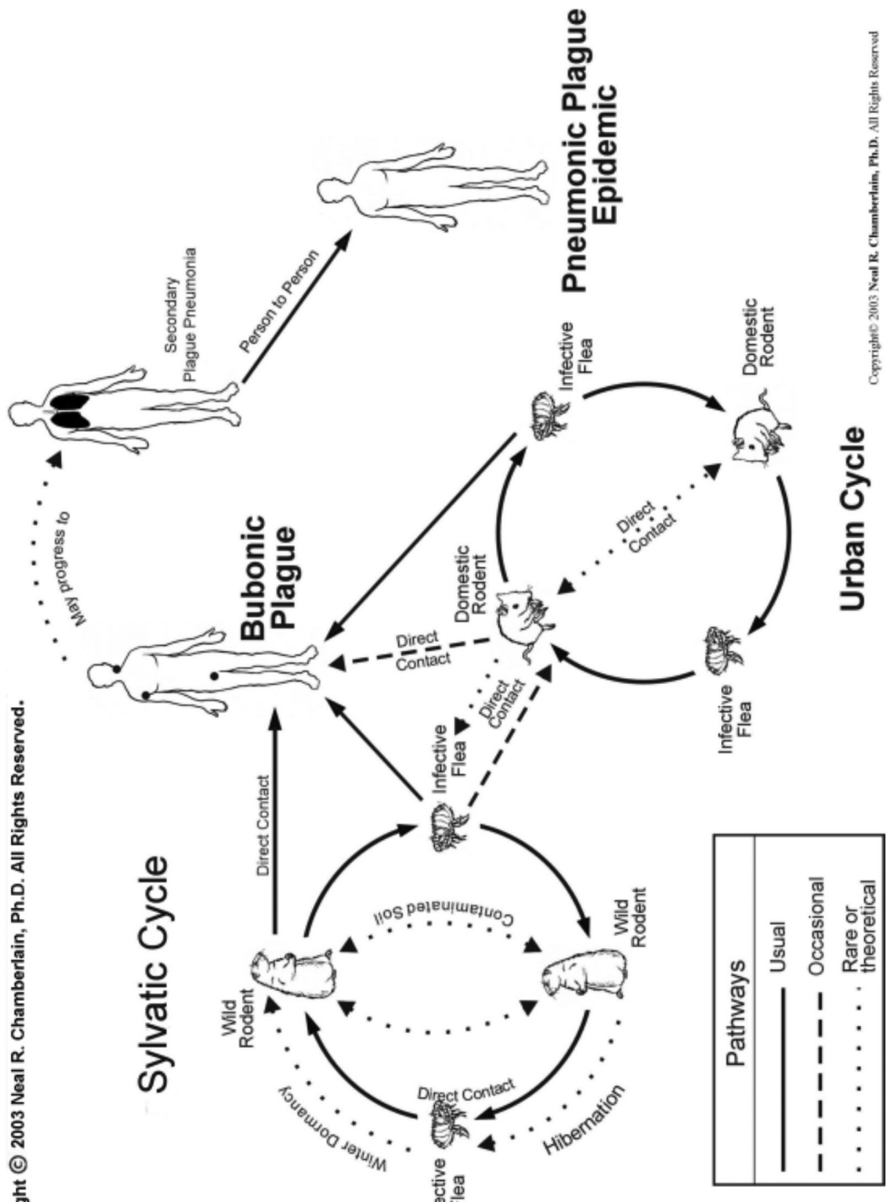

Figure 2. An example of zoonotic cycles applied to plague in contemporary studies. (Courtesy of Neal R. Chamberlain, Ph.D.)

belong to a separate taxonomic stratum of the natural world; a nature outside nature. Hence we can say that, in these diagrams, infection is configured as both a vital field of commensality and a 'zone of indifference' or 'missing link' (Agamben 2004: 37) between animals and humans.

This operation is further enhanced by the fact that in these diagrams the human figure usually appears in a singular form, or, when in a dyad (such as when diagrams want to depict the possibility of pneumonic plague infection between humans), with the second human figure even further away or altogether removed from the plane of the diagram. By contrast, nonhuman animals almost always appear in pairs or multitudes connected by looping arrows; a visual device which conveys not simply that the pathogen circulates amongst given animal hosts, but that these hosts *reproduce* it in a feedback and largely homeostatic manner, until, for some reason, it reaches a threshold or tipping point and spreads to humans. It is therefore important to examine how these diagrams function not only as 'a way of dividing up space, classifying regions of space' (T. Mitchell in Smets *et al.* 2011: 99), but also as a way of dividing up time and, in turn, different species or life forms *in terms of time*.

In a wide range of zoonotic cycles diagrams, the spatio-temporal threshold leading to human infection is depicted as conditioned upon an event known as the epizootic. The operation of this category becomes clear if we briefly examine its visualization in a recent, much-acclaimed study of plague and its relation to the climate (Ben-Ari *et al.* 2011) (Fig. 3). Reflecting an analytical stress on the impact of scalar climate variables on plague epidemiology, in the diagram featured by Ben-Ari *et al.*, zoonotic cycles are employed in ways that integrate environmental factors in the visualization of animal-human infection. Arrows are used to 'represent connections affected by climate with a color-coding depending on the most influential climate variable on this link' (Ben-Ari *et al.* 2011: 2). The usual feedback loops are hence enriched by means of these multiple, coloured markers, indicating that the reproduction of plague is dependent on factors such as soil moisture or temperature. At the same time, however, a complex field of spatio-temporal features and relations seems to be in place. Through the employment of shaded rectangles, infection is compartmentalized into three partially overlapping grey areas labelled 'enzootic cycle', 'epizootic cycle', and 'zoonotic cycle'. If 'zoonotic' signifies the moment where animal-to-human infection is actualized, 'enzootic' refers to a process during which a pathogen circulates within a given animal population without any major mortality observed. 'Epizootic', in turn, refers to phenomena of kill-offs or massive mortality events during which large numbers of the host population become infected and die. In this way, the various agents of plague (humans, domestic animals, wild animals, fleas) and their linkages are situated on three overlapping pathogenic fields, whose dynamic spatial inter-positioning plays a vital role in the hierarchical integration of the said agents into the visual field of zoonosis. Fleas reproducing the pathogen in an apparent vacuum (as they seem unconnected to any specific animal) are positioned at the remotest corner of the enzootic cycle rectangle. They are the furthest point, or, in this schema, the ultimate reservoir of the disease. Closer to humans stand what the diagram coins 'wild and semi-domestic' rodents. These and their feedback loops inhabit both the enzootic and the epizootic cycle rectangles. From there a straight black arrow strikes directly at humans, who occupy, as usual, the top-right corner of the diagram. This is a transgressive trajectory, spanning directly the distance between the grey rectangle of the epizootic and that of zoonosis. Finally, we have a 'domestic animal' cycle, where camels, goats, and rats are rendered into 'bridges' between the epizootic

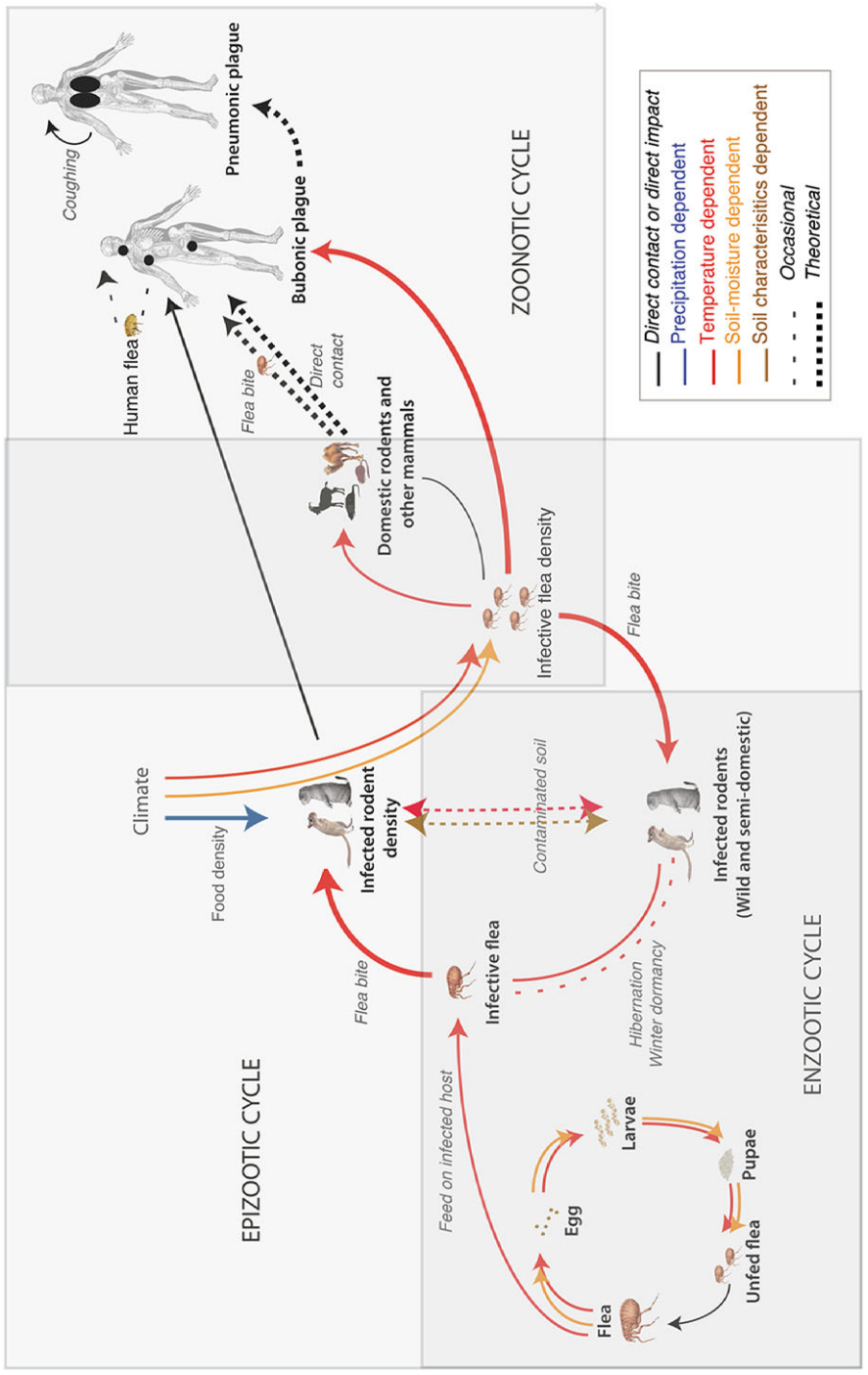

Figure 3. Ben-Ari *et al.*'s zoonotic cycles model of plague; note inter-laps between different 'cycles'. (Ben-Ari *et al.* 2011; courtesy of *PLOS*.)

and the zoonotic cycle – the enviable position of, at one and the same time, a mythic mediator and cybernetic amplifier.

Even though, in the caption accompanying the image, the authors note that the rectangles 'somewhat arbitrarily delimit epizootic, enzootic and zoonotic cycles' (Ben-Ari *et al.* 2011: 2), this diagram unambiguously configures nonhuman animal and human infection as a pathogenic process fundamentally mediated by an epizootic event.[6] This diagrammatization of zoonosis fosters an image of fleas as the ultimate source of plague, belonging to, as it were, 'deep nature', far removed from humans, and of epizootics as the mediating, evental mechanism leading to human infection. In this way, it creates a two-layered remoteness of humanity from what is imagined as the natural and original abode of the disease.[7] And, at the same time, this visualization configures disease as a process through which a temporal sequence of quantitative changes (enzootic to epizootic) within the realm of nonhuman animals leads to a dialectical, and lethal, qualitative transformation: animal-to-human infection.

This is a condition that renders human infection predictable and, as a result, preventable. It is thus part of a sanitary-utopian vision well entrenched in the reassuring, if misleading, certainties of what we may call high-modern epidemiology. Human infection will occur (by means of the epizootic, as a quantitative change, leading to zoonosis, a qualitative one) unless the final, pestilential arrow leading from animal cycles to humans is severed through the insertion of some sort of 'noise' (DDT flea-eradication or rat-proofing of domestic and commercial infrastructures, in the case of plague). The threshold visualized by this diagram is hence rendered a knowable and preventable incident – a process that can and must be mastered by humanity.

In a characteristic anthropological materialist turn, in his influential, if 'genre-defying', *One-way street*, Walter Benjamin (1986: 93) noted that our modern predicament is characterized not so much, as Theodor W. Adorno would have it, by the mastery of nature (*Naturbeherrschung*), but instead by the mastery 'of the relation between nature and humankind'. Agamben (2004: 83) is right to note that the key to this formula is 'only the "between", the interval, or, we might say, the play between the two terms, their immediate constellation in a non-coincidence'. Insofar as the proper place of disease has been defined as belonging to a natural realm encompassing yet separate from humanity, and the process of transmission has been defined as one necessitating a cybernetic or dialectical transformation (quantity/epizootic into quality/zoonosis), the 'between' forming the locus of human mastery is in turn defined as nothing less than the elusive but actionable threshold between the two realms.

We can, then, already see the way in which arrows and figures interrelate in this diagrammatic regime so as create a radical divide and at the same time a zone of indistinction between humans and nonhuman animal hosts of plague. However, as Ingold (2007: 39) has stressed, the blank surface behind or around these components should not be overlooked as an a-signifying 'taken-for-granted backdrop for the lines inscribed on it'. To understand the human-animal economy configured by zoonotic cycles, and the form of human mastery it necessitates, we need to consider the relation between geometric and iconographic components (lines and figures) of the diagram and its surface as a meaningful one; indeed, as a relation whose apparent invisibility is an important analytical component of its articulation.[8]

Diagrams fundamentally constitute new forms of linkages. Yet this is not simply a question of sketching, sorting, and valorizing these links, but also a question of effacing or erasing them. Kenneth Knoespel (2002) has noted the double etymology of the term

'diagram' in Greek, as related to the verb *diagrapho* and the noun *diagraphe*. Whereas the verb refers to a process of marking or tracing a trajectory, the noun refers to a crossing out of a word, or, metaphorically, writing off a person. The blank backdrop on which the lines and figures of zoonotic cycles commonly appear should be read as part of this double operation. As a result, the 'blank' may be read as a diagrammatic component that allows and fosters scientific generalization. On the one hand, in terms of a Peircean reading of diagrams, this allows 'the direct observation of general truths', so that, 'when contemplating the diagram the user [may] abstract from the accidental qualities of the image and focus upon what is central to the diagram' (Stjernfelt 2011: 212). On the other hand, it is this non-graphic element that enables diagrams to appear, circulate, and be acted upon as generally applicable schemata of zoonotic infection. In other words, what is established by the blank backdrop is nothing less than the de-located, de-temporalized universality of the scientific principle graphed on it. Going back to our zoonotic cycles examples, it is precisely this blank that configures plague as an 'objective' disease that needs referents but no social or historical context: a self-regulating phenomenon that can be 'described' not, as Meyer hoped, because we know enough about its ecology, but to the extent that this ecology has become 'naturalized' – that is to say, indistinct.

The zoonotic cycles diagram can, then, be said to be a sort of 'immutable mobile': a term referring to 'objects which have the properties of being *mobile* but also *immutable*, *presentable*, *readable* and *combinable* with one another', bearing a pronounced 'panoramic' function, in Bruno Latour's sense of the terms (1986: 7, emphasis in original; 2005). In other words, this diagram is a device that provides its viewers with the universal principle of zoonotic infection as regards a particular disease whilst at the same time 'giving the impression of complete control over what is being surveyed' (Latour 2005: 188). Anthropologists are in fact very familiar with this diagrammatic operation: a way of modelling sociocultural relations that arose in our discipline at the same time as zoonotic cycles became prominent in epidemiology. Following Pierre Bourdieu's well-known analysis of Lévi-Strauss's diagrams of the Bororo village (1993; 1997), these are symptomatic of structuralism insofar as their reality is constituted through a view from above that ignores the mêlée on the ethnographic ground. Similarly, in the case of zoonotic cycles, we have an operation that allows human-animal relations to be conceived as a totality 'in which all interactions are reduced to symbolic [or in our case bacterial] exchanges' (Bourdieu 1977: 96).[9]

As a visual technique of interspecies mastery, this panoramic or, if we prefer, panoptic view may then be said to generate a de-historicized image of nature as a totality articulated through a series of trophic and microbial exchanges. Therein humans are posited, concurrently, both as the (dead) end-point of this cycle of exchange and as actors outside of it. In other words, this is a vision of human infection from nonhuman animal sources as an extra-societal exchange; an invasive form of communication from nature into culture. In this way, whilst operating within a disease ecology framework, such diagrams represent infection not as a historical and relational potential of the irreducibly interspecies fabric of social, political, and economic life, but, instead, as a contraband import, or pollution from a separate realm of existence. This zoonotic model thus encompasses a distinctly naturalist vision of human-animal relations as predicated upon 'a discontinuity of interiorities and a continuity of physicalities' (i.e. the simultaneous commonality of life and difference of being; Descola 2013: 172). And, at the same time, it articulates these relations on the grounds of exception: as relations

that 'necessarily function by means of an exclusion (which is also always already a capturing)' of humanity from the animal realm and 'an inclusion (which is also always already an exclusion)' of infection into the realm of humanity (Agamben 2004: 37). Crucially, the dynamic interrelation of ontological and biopolitical operations unfolds on the terrain of the 'chain of infection'. For the sanitary-utopian aspiration to liberate humanity of zoonotic disease is based on nothing less than a vision of universal 'breaking of chains'; a separation and, at the same time, unshackling of humans from animals through the application of DDT, rat-proofing, and so on – methods that would isolate the pathogen in its 'natural reservoirs', which collectively define the animal realm. In this way, whereas separation from animals is seen as a sufficient means of protection of humans from zoonotic disease, animals themselves are defined as ultimately hygienically unredeemable – they are, in other words, rendered indistinct from disease. Hence the naturalist ontology which in Descola's heuristic model defines humans and animals as unified under the rubric of nature is unsettled by a radical divide that sees disease as a mode of being which is only inherently proper to nonhuman animals, and only tentatively, or, as sanitary-utopians would have it, *temporarily*, part of the human species.

What happens, then, if, with these analytical tools in hand, we seek to approach some current diagrammatic practices of zoonosis on the ground? How is the operation of the zoonotic cycles model described above affected, obscured, or altered when situated in different, concrete practical contexts? I would like here to discuss two examples of the employment of such diagrams, so as to examine how this both reflects and complicates the operation of these visual devices. The first case concerns the utilization of zoonotic cycles in plague warning signs in US National Parks, and in the Grand Canyon in particular, as observed in the summer of 2016. The second case concerns the visualization of Ebola transmission in US Centers for Disease Control and Prevention (CDC) public communication campaigns in the course of the recent epidemic in West Africa (2014-16).

Do Not Feed the Squirrels!

Walking along the well-trodden Hermit Road on the Grand Canyon's South Rim, one eventually reaches Hermit's Rest, where the traveller may catch the shuttle back to the 'Village' or else continue down the steep and perilous Hermit Trailerhead. Either way, a striking visual threshold punctures the road to refreshments, buses, or adventure alike. Just before entering the area where one may get a much-deserved snack, a fresh water refill, and a good view over the Canyon, one is faced with a well-designed double-faced rectangular warning display titled 'Do Not Feed the Squirrels!' (Fig. 4). The sign urges hikers to 'prevent plague', claiming that, 'Every day, several people are bitten by rock squirrels at Grand Canyon National Park. Squirrels have fleas that can carry plague'.

People stop, read and even try to Google the URL link contained in the image; a group of teenagers finds the whole thing to be cool and snaps 'tongue-out' selfies next to it. I have often come across similar signs and reactions in other US National Parks where plague is endemic. In fact a large number of North American human plague cases every summer (many of them fatal) are the result of such 'contact'. No wonder, then, that the general reaction towards the display is not to bypass it. 'I had not realized these squirrels also carry the disease', a middle-aged male hiker from Colorado tells me, though he is well acquainted with its native carriers, the ubiquitous prairie dogs. His wife explains

Figure 4. Do not Feed the Squirrels! Grand Canyon National Park, July 2016. (Author's photograph; courtesy of the Grand Canyon National Park.)

to their children what it all means, whilst I overhear a worried couple discussing the recent plague warning issued on one of the popular hiking trails in nearby Flagstaff. Arizona may not be 'the land of the plague and the home of the flea', as nearby New Mexico is sometimes lovingly called by American experts in the field, but it is still a well-established focus of the disease. Returning to the display itself, I notice that the diagram dominating it is a clever variant of the zoonotic cycles model. Centre stage sits a rock squirrel whose body and head are positioned in such a way as to appear to be addressing us or perhaps inviting us to feed him/her through the employment of some sort of auratic gaze. Seductively cute but lethal seems to be the message here. Anchored on such an ambivalent animal portrait, this photo-diagram aims to construct a clear and unambiguous 'chain of infection' narrative. The central image of the squirrel is positioned at an equal distance on the periphery of an arrow-punctuated circle from a 'magnified' flea and a visibly scratched or bitten human hand. The arrows, all emerging from the squirrel, eventually lead to the human hand, with 'Fleas bite' and 'Squirrels bite' written on either side of the latter. The vision of interspecies peril is further punctuated by the coloured interior of the diagram, which presents us with yet another visual innovation. For this does not play the role of a blank backdrop – a role fulfilled, again

innovatively, by the general background of the display, which, in white letters against a yellow backdrop, in a manner resembling David Cronenberg's *They live!*, bears the barely readable but omnipresent injunction 'Don't feed the squirrels! Don't feed the squirrels!' By contrast, the interior of the cycle of infection and its pestilential arrows may be best seen as the central message of the whole diagram insofar as it is meant to connote both the result of being bitten by a squirrel and the medium of plague contamination: blood – a substance embodying the ontological and pathological commensality of humans and squirrels.

This ethnographic instance, then, presents us with a reproduction of the zoonotic cycles' 'immutable mobile' and, at the same time, with a bold transformation of it, signified by a change in form: rather than being implicated in a system of pathogenic cycles, here animals and humans form part of a single, unified cycle of infection. This, on the one hand, enhances the optical proximity between the animal source of infection and humans whilst also making for a 'denser' or at least more direct-looking chain of infection. It hence underlines the urgency of caution and the unambiguousness of the interdiction 'Do Not Feed the Squirrels!' Yet, on the other hand, this operation also renders zoonotic transmission no longer dialectical or cybernetic, but simply a mechanical process, which means that the desired human mastery in question no longer concerns the identification and control of a threshold of interspecies existence, but simply the avoidance of individual contact between a given human and a given animal. In this way, the diagram relapses to pre-ecological epidemiological reasoning, succinctly expressed in an aphorism produced over a century ago: 'The prophylaxis of plague primarily comprehends the single basic fact that it is a rodent disease, and that if man allows himself to come in intimate contact with rodents and therefore to be exposed to the danger of plague, it is his own fault' (Rucker 1912: 786). Enhanced by the introduction of a highly saturated symbolic field at the centre of the diagram (the blood-red infill of the cycle of infection), the diagram offers an image of interspecies immediacy. This is the result of the Grand Canyon case being a hands-on, in-locus zoonotic diagram, insofar as the immediate presence of plague in the space inhabited by its intended audience renders any information complexity or ambiguity supposedly superfluous or even lethal in its potential generation of non-conformity. If Hallam (2009: 84) is right to point out that 'diagrams are particularly useful in depicting and summarising processes that unfold over time', what this case makes clear is that they are equally good in condensing and communicating proscriptions and prescriptions. For the goal of the particular diagram is not for the audience to comprehend plague infection, but for it to obey a basic rule that will prevent it from being infected with the dreaded disease: Do Not Feed the Squirrels!

The case of the plague warning sign at the Grand Canyon National Park thus allows us to see how, when applied on the ground, the graphic transformation of zoonotic cycles may lead to significant changes in the operation of these visual devices. In this case, the transformational potential of scientific diagrams rests not so much in rendering unseen complexities into unified visible forms (Lynch 1990) but in deriving from the epistemic object of zoonosis an unequivocal biopolitical injunction.

An altogether different field of practical possibilities is presented to us upon examining the employment of zoonotic cycles by the CDC in its on-line campaign aimed at making Ebola comprehensible to health workers and the general public during the recent West African epidemic.

Ebola panoramas

As of 2014, the US CDC website has featured electronic information packages which explain Ebola's transmission pathway, why it is unlikely to become airborne, as well as ways of preventing infection and recognizing the disease through basic diagnosis. Part of this rich output is a digitally generated image or 'infographic' depicting the life cycle of the Ebola virus, titled 'Ebolavirus Ecology' (CDC 2014) (Fig. 5).

In examining how, in this instance, zoonotic cycles are transformed into tools of public health communication, we first note an amplification of the operation observed in Ben-Ari *et al.*'s plague diagram (Fig. 3). Set against a pastel-coloured landscape (in lieu of the usual blank backdrop), infection appears to be originating from what is depicted as deep nature (the 'Enzootic Cycle'); a realm whose remoteness to humans is underlined by the graphic separation of the Enzootic and the Epizootic boxes. Zoonosis is consequently visualized as a process that spans nature and culture in a violent flight of the pestilential arrow which pierces the ontological firmament and, at the same time, institutes a firm ground for biopolitical regimes of prevention. If animal-human Ebola infection is possible, this diagram seems to be telling us, it is only because the (highly racialized) heterosexual nuclear family, depicted huddled together at the end of a dirt track in front of a supposedly traditional African hut, is insufficiently removed from the other mammals depicted in that frame. We should note here the strong iconographic rendition of the human *telos* of the infection chain: the family is watching the infection fly their way in a posture of expectation or premonition, but ultimately helplessness. Ebola thus appears as a natural disaster: the long invisible hand of zoonotic infection, afflicting passive African communities whose cultural barriers from nature are insufficient to stop the spread of the disease. What allows a pathogenic, liminal commensality between humans and animals is represented as nothing other than the lack of sufficient progress (or a resistance to it) – read largely in terms of animal-human or nature-culture separation or distance. It is no accident, then, that, within the context of contemporary epidemiology, zoonotic infection is racialized as part of what are assumed to be primitive or underdeveloped forms of social and economic life. A characteristic example of this is the most recent Ebola infographic employed in the CDC's public health communication campaign on the disease (CDC 2016); a diagram which takes the iconographic turn of CDC zoonotic cycles to a whole new level (Fig. 6).

In this naturalistic diagram we see a so-called 'patient zero', the primary infection-link between animals and humans, depicted as a barefooted man dragging a dead monkey by its tail from the bush into what is supposed to look like a traditional African village; therein the disease spreads further through supposedly traditional funeral practices and interpersonal intimacy between members of the community and Ebola victims.[10] The replacement of schematic, formalized human and animal figures with such situated, ethnographically inflected images, alongside the amplification of the iconographic aspect of interspecies interaction, anchors this diagram in geographies of blame, geographic and ethnographic imaginations of infectious diseases (configuring the location, spaces, or sociocultural practices that supposedly give rise to a disease), and even unmistakably racial aspects of epidemic attribution. If this is not in itself really surprising, the reason why the acute iconographic angle of this CDC Ebola diagram should hold our attention is because it functions by direct contrast to other forms of diagrams currently utilized to problematize and understand Ebola in the scientific community.

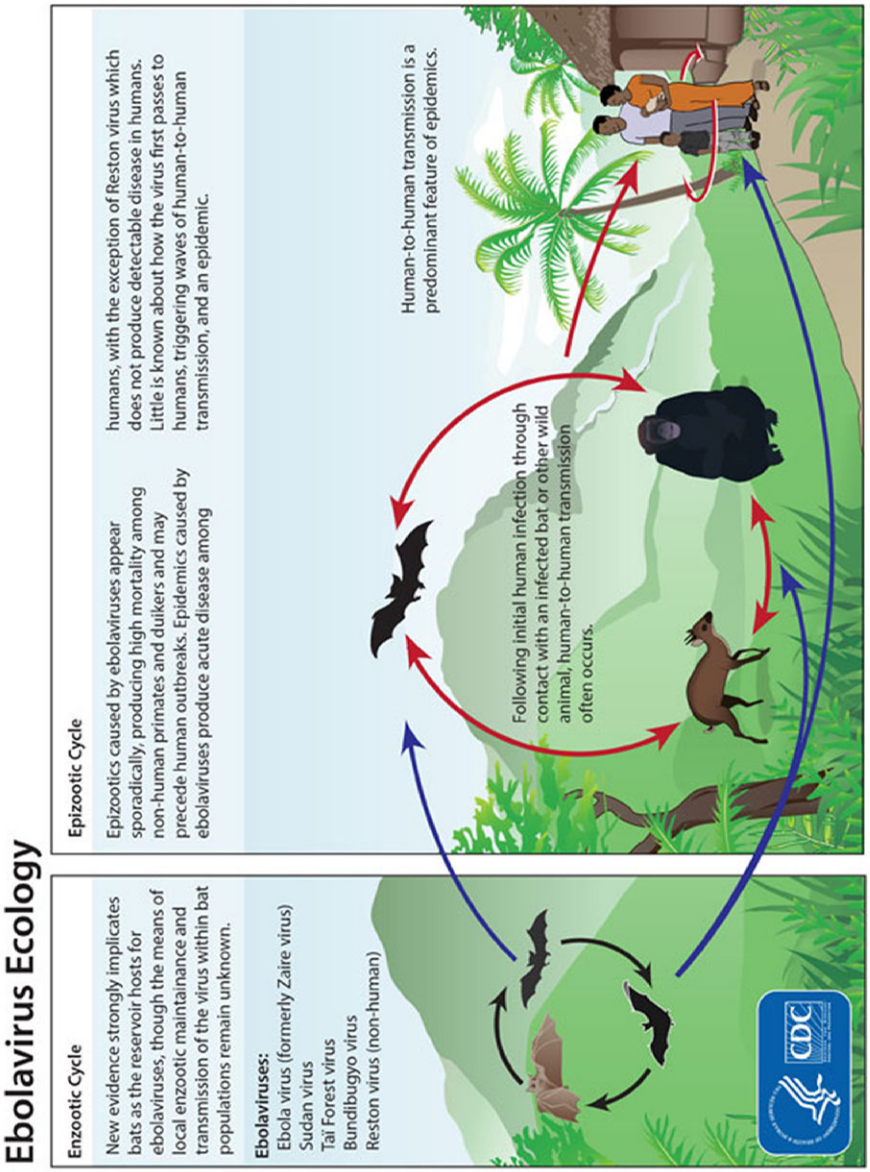

Figure 5. CDC infographic 'Ebolavirus Ecology'. (Courtesy of the Centers for Disease Control and Prevention [CDC], USA.)

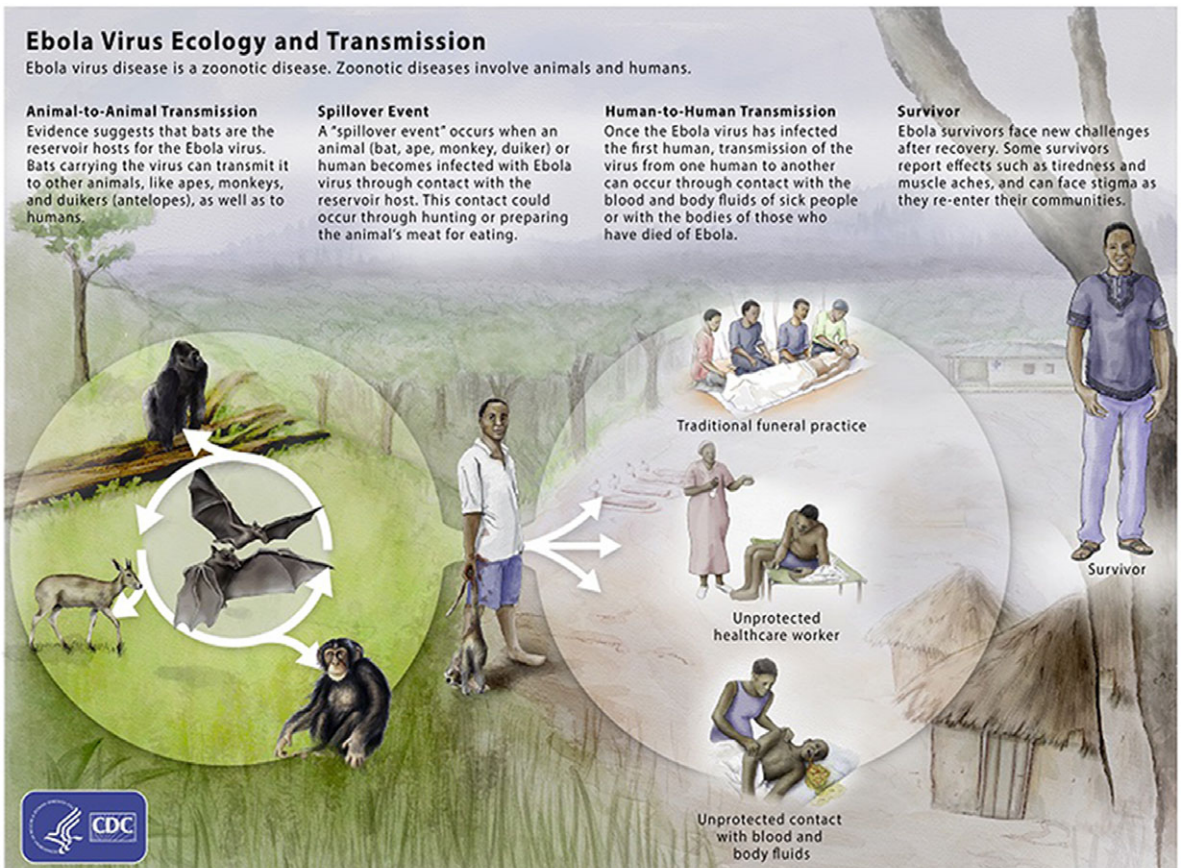

Figure 6. CDC's latest Ebola infographic, 'Ebola Virus Ecology and Transmission'; note that whilst the culprit of the 'spillover event' (denoting a species-jump of the virus) is barefoot, the designated survivor is depicted as wearing some sort of sandals. (Courtesy of the Centers for Disease Control and Prevention [CDC], USA.)

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Void of any animal or human figures (the protagonists of zoonotic cycles) and structured instead around components or drivers of infection (hunting, poverty, social cohesion, climate change, and changes in animal husbandry methods), these so-called 'spidergrams' have been employed by scientists to capture the spillover or species-jump of the Ebola virus from nonhuman animals to humans (e.g EFSA 2015).[11] In the case of these highly complex digital tools, causality appears to be giving its place to nexuses of 'influences', thus establishing a diffused evental ontology and, at the same time, diffused forms of responsibility. Aimed to seize the pathogenic rupture of the spillover event in their 'networks of drivers' (EFSA 2015: 3), for spidergrams infection is less an issue of dialectical time than one of opportune time: in other words, more an issue of *kairos*, in the Hippocratic sense of the term, than of *chronos*. Indeed the graphetic efficacy (Drucker 2014) of these diagrams depends precisely on their ability to show not only how different components are interconnected, but also how the spillover is brought about when all of them align in an (in)opportune conjunction. We can, then, say that, in a manner that resembles astrological reasoning, it is this 'aspect' that forms the *topos* of human mastery: a plane of immanence where humans, animals, and their interrelation become indistinct, and, at the same time, an exceptional process of ontogeny, in the course of which new diseases 'emerge' *as they are being transmitted* from nonanimals to humans.

What is, then, striking when it comes to the CDC Ebola 'infographics' is that whilst operating within the overall paradigm of emergence (as all Ebola science does), they continue to employ the causal form of the chain of infection as exemplified by the zoonotic cycles. What we have here is an epistemological, ontological, and biopolitical hybrid, whose efficacy, I would like to argue, derives precisely from the iconographic amplification of these diagrams. For this allows them to operate not simply as panoramic images of animal-human infection, but also, and most pertinently, as prophetic visions of interspecies relations that supposedly threaten humanity with extinction.

Mirroring the principal function of what I have elsewhere addressed as instances of prophetic photography (Lynteris 2016*a*) – the ability to foresee a spillover event, and yet to never say, or be seen as wanting for not saying, exactly how or when this will occur – the CDC Ebola diagrams portray human-animal relations as entailing, at one and the same time, a peril for local communities and a universal existential risk. For within the current paradigm of pandemic preparedness (Lakoff 2008), any local outbreak of an emerging infectious disease, such as Ebola, is seen as the first step or herald of the 'next pandemic'; an event of human-extinction proportions (Caduff 2015; Keck 2010; King 2004). The iconographic amplification of the CDC diagrams rhymes with photographic depictions of spillover sites and practices (such as hunting, bush-meat markets, and wet markets), anchoring the reception of these devices in the realm of established 'pandemic imaginaries' (Lynteris 2016*b*). What is performed in this way is the transformation of human-animal relations into a field whose mastery is of vital, existential importance not only to specific risk groups, but to humanity as a whole. And what is required in order to secure human survival, according to this narrative, is the development and adoption of 'culture' in the form of science and hygiene envisioned as the overcoming of what are assumed to be traditional ways of life. Only thus, the CDC Ebola infographic suggests, can humans become unchained from animals so effectively that zoonotic disease, and by projection the existential risk posed by the 'next pandemic', would be a thing of the past. Alternatively, were infectious disease to become proper to the human realm

of existence, this would necessarily coincide with the so-called 'pandemic apocalypse', and the end of humanity as a condition of human mastery over human-nonhuman relations.

The contextualization and practical application of zoonotic cycles in the CDC's Ebola communication campaign may, then, be said to offer us a more defined and acute view of the overall biopolitical and ontological operations of this diagrammatic regime. Yet at the same time, it reveals a series of significant transformational potentials. Deriving their communicative and performative strength from the way in which they anchor their narrative, simultaneously, in an actual epidemic urgency (the Ebola outbreak) and in the imaginary of the 'next pandemic', these diagrams manage to integrate into the zoonotic cycles regime, on the one hand, local or regional, racially inflected geographies of blame, and, on the other hand, a global prophetic faculty as regards panhuman existential risks. Borrowing from Louis Marin's analysis of panoramic urban maps, we may say that the recent CDC Ebola diagrams generate a *utopic* vision of human-animal relations, insofar as they allow us to 'see all' (the global in the local, the animal in the human, the present in the future, and vice versa), but only to the extent that they interpellate us to a viewpoint that cannot be actually occupied by anyone: 'a point of space where no man [*sic*] can see: a no-place not outside of space but nowhere, utopic' (Marin 1984: 207).

Conclusion

This article has drawn for the first time an in-depth study of the emergence and operation of what is today the most prevalent diagram used by life scientists and public health agents in the visualization of animal-human infection: zoonotic cycles. Through an examination of its constitutive visual elements, this diagrammatic regime has been shown to operate beyond a simple flattening or summarization of space, time, relation, and context. Zoonotic diagrams are not mere simplifications, abstractions, or generalizations of complex entanglements – heuristic devices, or popularizing visual props. They are instead a central mechanism for rendering animal-human infection scientifically intelligible and actionable. As such they play an important role in constituting zoonosis as an epistemic thing. And, at the same time, in their practical application in diverse contexts, they are the empirical grounds on which ontological and biopolitical aspects of interspecies existence are tested, transformed, and brought into relation under the rubric of human mastery over human-nonhuman relations. As this article has demonstrated through the examination of two distinct applications of zoonotic cycles in contemporary public health campaigns, the situated use of this visual device entails powerful potentials as regards the definition and redefinition of what comprises this mastery and how it is to be achieved. For in generating scientific layouts of human-animal relations, these diagrams do more than simply describe the latter. They are practices that instead proceed by unsettling these relations, as the operational grounds of human mastery, so that their various components accrue different scientific and symbolic value through shifting prisms of infection and infection control. As a result, if this is a process of mastering through unsettling the commonalities and differences between human and nonhuman animals, it is at the same time a process of unsettling human-nonhuman mastery itself as a social practice. It is precisely in this way that zoonotic diagrams constitute a dynamic visual ethnographic field in which different interspecies realities and imaginaries may unfold and entwine.

NOTES

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[1] The Committee was summoned following the sudden appearance of mass-scale plague epizootics amongst ground squirrels in the Sierra Nevadas in 1934, which challenged the hitherto held optimism of plague being contained on the West Coast of the USA (Honigsbaum 2015).

[2] In his critical study of Meyer's contribution to disease ecology, Honigsbaum (2015) points out that it was Elton who guided Meyer to the Russian plague literature. Meyer (1936) himself recognized his debt to the former. Russian plague research had identified Siberian marmots as a zoonotic source of plague in 1895 with research being henceforth focused on that particular animal (Lynteris 2016*c*).

[3] Cycles, as Howse, Stapleton, and Taylor (2005: 145) note, 'have been in use for the representation of classical syllogisms at least as far back as the Middle Ages'.

[4] I would like to thank Frédéric Keck for the most appropriate metaphor of a 'dead-end' in this case.

[5] One of the first uses of arrows in depicting infection in visualizations of rat-borne disease in modern times dates from 1918, when arrows are employed in a rough photographic collage published in the *Washington Times* to depict the 'transmission of the virus of infantile paralysis' (Anonymous 1918).

[6] In fact already by 1942 Meyer expressed reservations as to whether epizootics are an adequate and necessary condition for human plague infection. Recently Gage and Kosoy (2005: 508-9) have noted that 'the evidence for separate enzootic and epizootic cycles is often unconvincing, and epizootics might simply represent periods of greatly increased transmission among the same host and fleas that support *Y. pestis* during interepizootic periods'.

[7] This long-held hypothesis has recently been challenged by research conducted by Rasmussen *et al.* (2015), which suggests that plague may have been endemic amongst humans during the Bronze Age.

[8] Questions regarding the importance of invisibility or the 'unseen' have recently been developed by Shawn Michelle Smith (2013) and I have applied them elsewhere to the field of epidemic photography (Lynteris 2016*a*). These works have argued that the visibly or apparently unseen is a key field in the articulation of the visible.

[9] See also Dorrian & Pousin (2013), Haffner (2013), and Prosser (2005: 59-61) for explorations of the 'view from above'.

[10] The implication of 'traditional funerals' as culture vectors of Ebola has come under sustained anthropological criticism as obscuring social and political complexity on the ground (Fairhead 2014; Pellecchia 2015; Richards 2014).

[11] Spidergrams, as emerging diagrammatic technologies in epidemiology, have an enhanced 'testing hypothesis' component by comparison to other diagrams, thus allowing the development of different infection and emergence scenarios (Gale & Breed 2013). For a broader discussion of web diagrams in epidemiology, see Joffe, Gambhir, Chadeau-Hyam & Vineis (2012) and Krieger (1994).

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Diagrammes zoonotiques : maîtriser et perturber les relations entre humains et animaux

Résumé

Le présent article examine les relations interspécifiques par le biais de l'examen de l'instrument visuel utilisé le plus souvent en sciences de la vie pour représenter la transmission des infections entre animaux et humains : le diagramme des cycles zoonotiques. Après avoir retracé son émergence et son évolution en relation avec la peste bubonique, l'auteur explore la manière dont ce régime diagrammatique a trouvé application dans deux contextes pratiques distincts : un panneau d'avertissement sur la peste sur le sentier de randonnée du Parc national du Grand Canyon et la campagne d'information publique en ligne lancée par les Centers for Disease Control and Prevention (CDC) américains lors de la flambée de maladie à virus Ébola de 2014-2016. Cet article démontre les principales opérations ontologiques et biopolitiques de ces diagrammes en avançant que, loin d'être simplement des récits épidémiologiques résumés des transmissions d'infections entre animaux et humains, ils servent de pilotes de la maîtrise humaine des relations avec les animaux et de foyers cruciaux de perturbation de celles-ci.

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