

Introduction to One Health

An Interdisciplinary Approach to Planetary Health

Sharon L. Deem • Kelly E. Lane-deGraaf • Elizabeth A. Rayhel



with website

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*To our children Aoife, Caleb, Charlie, Laura, and Saoirse, and to the readers of this book,
whose actions shape Planetary Health.*

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Foreword

Introduction to One Health: An Interdisciplinary Approach to Planetary Health

A Foreword by Daniel M. Ashe

President & CEO, Association of Zoos and Aquariums
Former Director, US Fish and Wildlife Service (2011–2017)

In the introduction to their visionary textbook, authors Sharon Deem, Kelly Lane-deGraaf, and Elizabeth Rayhel quote Abraham Lincoln: “*the best way to predict the future is to create it.*” With this book, they take a giant leap in creating a future where we recognize and respect, and where our institutions and actions more fully reflect the interrelationships between humans, animals, and the environment – a philosophy called *One Health*.

The twentieth century was marked by tremendous progress in our understanding of the environment, and the effect of human economy and ecology. We built great institutions, framed in academic disciplines like biology, ecology, hydrology, forestry, oceanography, engineering, and the many medical sciences and disciplines. We split the world into wetlands, prairies, forests, farm, ranch, range, rivers, lakes and oceans; and fish, and mammals, and insects, and plants. And we built great corresponding institutions, like the one where I served for 22 years, the last six as its director: The US Fish and Wildlife Service.

Leaders and visionaries, including Aldo Leopold, Rachel Carson, Olaus, and Mardy Murie, and David Suzuki have long inspired us to think beyond our disciplinary training and our institutional boundaries. New

interdisciplinary disciplines have emerged, but they suffer a common infirmity. They are disciplines themselves.

One Health is more philosophy than discipline. It incorporates human, animal, and environmental health as inherently interrelated, interdependent, and inseparable. The authors, at once, respect and encourage disciplinary scientific expertise, but recognize that evidence-based science is not enough. They recognize that driving societal change requires that science be packaged in ways that fit into a broad milieu of cultural, religious, political, and economic beliefs. Their text is a roadmap to follow in pursuing Leonardo da Vinci’s notion of a complete mind: “*Study the art of science; study the science of art. Learn how to see. Realize that everything connects to everything else.*”

Their writing is clear, concise, and compelling. It helps us to see that our health, indeed, is connected to everything around us. They use historical examples from Hernando de Soto’s 1539 expedition up the Mississippi River, to modern-day Ebola outbreaks. The Lewis and Clark Corps of Discovery is linked to infectious diseases that devastated native peoples, mercury contamination, westward expansion, slavery, economic development, and modern-day environmental inequity and injustice. Their work is a literal melting pot, mixing all the complexity of today’s global economy and ecology, pouring it into a conceptual mold that allows us to more effectively aggregate human, animal, and environmental health into *One Health*.

One Health is about connection. It is about the recognition that humans, animals, and environment are indivisible. It is about humility, unintended consequences, and the fact that decisions that we make today will shape the immediate and the distant future. It is about finding solutions by looking for something beyond traditional notions of interdisciplinary coordination – what the authors call a *transdisciplinary* approach.

One thing is certain. We cannot address the interrelated challenges of climate change, pollution, extinction, biodiversity loss, invasive species, infectious diseases, poverty, injustice, and inequality with the same approaches of the past. We cannot just continue to seek better coordination between

disparate disciplines and institutions. We've known for decades that human, animal, and environmental health are linked. *The canary in the coal mine* is an adage that recognizes it explicitly. Coal miners knew that their environment, and ultimately their health, could be safeguarded by a sensitive, sentinel bird. *One Health* expands this simple concept to reflect twenty-first century complexities and opportunities.

One Health is a powerful introductory text. Let's hope it inspires a new generation of *One Health* professionals, in diverse fields throughout the sciences and humanities, to envision and create a future where we link human, animal, and environmental health. Our future prosperity depends on it.

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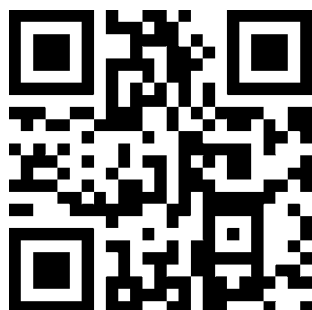
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Part I

An Introduction and Impetus for One Health

1

Why One Health?

The Mississippi River today is the source of economic strength and cultural movement throughout the USA. The Mississippi reaches more than 2300 miles from Lake Itaska in northwestern Minnesota to the Gulf of Mexico (Figure 1.1). The fourth largest watershed on the planet, it covers 32 states and 40% of the landmass of the USA and reaches from Appalachia to the Rocky Mountains. Pre-dating the European expansion into the Americas, Native American cultures thrived along the Mississippi River Basin. The Ojibwe, the Kickapoo, the Potawatomi, the Chickasaw, the Cahokia, the Choctaw, the Tunica, the Natchez, and many more peoples lived and flourished along the Mississippi River. Culturally diverse and rich in tradition, the peoples of the Mississippi River basin used and respected animals and the environment throughout their traditions. Focused on fishing and hunting, small-scale farming, and foraging, the traditions of the peoples of the Mississippi River are as varied as the people themselves, but importantly, these traditions shared a focus on maintaining a balance between humans, animals, and the environment. The culturally diverse native peoples of the Mississippi River region could truly be considered the first **One Health** practitioners of the region.

In 1539, Hernando de Soto of Spain became the first European to witness the majesty and power of the Mississippi River. In his explorations and quest for gold, de Soto and his men frequently interacted with native

peoples. The Spaniards, from their first landfall, exploited native peoples. Language and culture differences, not surprisingly, emerged frequently. de Soto traveled with one translator, who spoke the language of only one tribe. As a result, skirmishes between the Spaniards and the native peoples often broke out while traveling. When the army with which de Soto traveled, numbering approximately 620, encountered a local community, they demanded use of the food stores, preferring this to hunting. As a result, the Spaniards consumed nearly a year's worth of food in only a few days in each community they encountered, with devastating impacts on the survival of these local communities. de Soto and his men also routinely enslaved men, women, and children, demanding individuals carry their equipment and gear, care for their horses, provide cooked food, lodging, and sexual services. Native peoples who resisted were frequently raped, tortured, had their homes and crops burned, and/or were killed. The violence of the initial European arrivals to the Mississippi region resulted in the murder of an uncountable number of native peoples.

The devastation of the communities of Native Americans is not the only devastation de Soto and his men wrought on the Mississippi Basin. The Spaniards were exploring to claim the land for Spain and loot the region of its gold, silver, and other precious metals. In addition to men, de Soto brought with him 220 horses and 100 pigs.

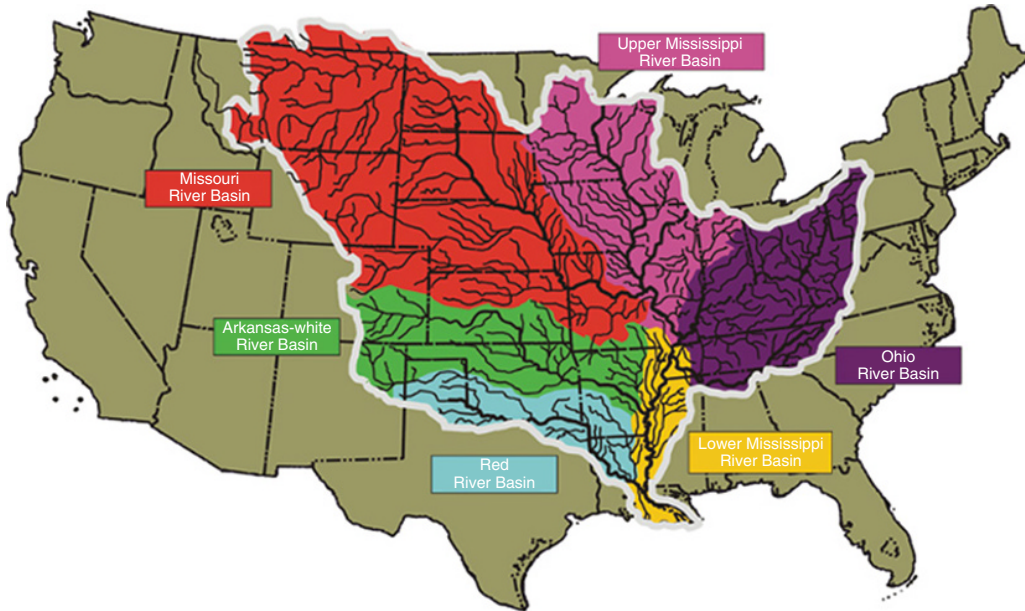


Figure 1.1 Mississippi River watershed.

The movement of this army of people and animals from present day Florida west through Louisiana, north through Arkansas and into Missouri, and then south to Texas left in its trail a swath of deforestation, biodiversity loss, and pollution – all One Health threats. For example, while the Spaniards exploited Native American paths for travel as much as possible, they also carved many new paths through the forests and prairies that they crossed. The livestock brought along also created significant problems for the landscape. Feeding these animals created an additional burden for the land, taxing the ecosystems as the traveling herd of between 300 and 1000 domesticated animals trampled vast swathes of pristine forest and prairie vegetation. Rats and other stowaways from their ships would, in time, become invasive and drive their own ecological catastrophes. de Soto's herd of pigs, which grew from 100 to over 900 by 1542, brought its own unique environmental and ecological threats.

The normal behaviors of pigs – rooting for tubers, wallowing in mud, and trampling vegetation – wreaked havoc on native plant

life and, importantly, their feces introduced an entire suite of novel pathogens to an area, contaminating local water supplies as they defecated across the south. An often overlooked consequence of early western explorations was the introduction of lead shot into the Americas; with this, de Soto and his army slaughtered countless native animal species and introduced the potential for lead pollution into the Mississippi River basin.

In what could be considered one of the earliest intercultural One Health threats, the greatest devastation brought by de Soto and his men was not the rape and pillaging of the land and local communities but the introduction of novel infectious diseases into naïve populations. In the wake of de Soto's army, smallpox and measles spread rapidly through the diverse tribes of native peoples of the Mississippi Basin, who were exposed to these pathogens as de Soto and his men traveled through their communities. Smallpox alone killed an estimated 95% of the people with whom the Spaniards came into contact, effectively eliminating entire communities in their wake. This drastically altered the make-up of the Native American

landscape well before the French and English returned some 100 years later. de Soto did not survive his expedition, dying on the banks of the Mississippi River of a fever without finding a single piece of gold or silver. More than half of his men perished along the way as well.

Fast forward 150 years to 1682, when, after exploring its reaches and seizing upon the economic and strategic benefit of the Mississippi River system, René-Robert Cavelier, sieur de la Salle claimed the river for France. The southern stretches of the Mississippi Basin briefly fell under the control of the Spanish in 1769; in 1803, the USA, not even 30 years old, purchased the entirety of the Mississippi River watershed as a part of the Louisiana Purchase. When in May of 1804, William Clark, Meriwether Lewis, and 31 others set forth from St. Louis, MO, to find a Northwest Passage, a water route to the Pacific, they were tasked with acting as cartographers, naturalists, and cultural emissaries for the young country. Thomas Jefferson, who commissioned the expedition in 1803, believed that the most critical role for the commissioned explorers was to act as diplomats for the nation among the several Native American tribes the group would encounter. The Corps of Discovery, as the expedition came to be called, ultimately made contact with 55 independent groups of Native Americans and First Peoples, frequently trading for food and medical supplies as well as befriending many tribes people.

Lewis and Clark traversed nearly 8000 miles. Their expedition is touted by many as a model of inclusion – a black man, York, and a Shoshone woman, Sacagawea, were essential members after all. However, their inclusion hints at the exploitative nature of the Corps itself. York was a master hunter, bringing in a large portion of the game that fed the Corps throughout their journey, and acted frequently as the expedition's most stalwart caregiver, providing care to ill expedition members. Still, York was Clark's slave. He was not a paid member of the Corps of Discovery, despite his critical role in its

success. Sacagawea was kidnapped as a teen by the Hidatsa and then sold to her “husband” Charbonneau. As property, neither York nor Sacagawea could refuse participation in the 8000 mile journey. Still, Sacagawea, like York, played a vital role in the expedition, acting as translator and helping with the group's welcome by many Native American peoples.

In all, the Lewis and Clark expedition, while fondly remembered today, was considered at the time as something of a failure. They discovered no Northwest Passage; the northern route chosen by the group was arduous and challenging in a way that the southern route across the Rockies is not and so was not used by later settlers. They mapped lands, documented plants and animals, and improved diplomatic relations with Native peoples, but they also opened the country to western occupation that drastically altered the landscape, replaced the diversity of plants and animals with corn and cows, each with long-term ecological consequences, and ravaged Native American communities through broken treaties, forced migrations, and massacres.

Lewis and Clark's expedition had two additional repercussions in the US West: the spread of sexually transmitted diseases (STDs) and widespread mercury contamination to the environment. STDs were not introduced to Native Americans by the Corps of Discovery; French and Canadian fur-trappers accomplished this. However, STDs spread through the Corps rapidly. As the men traveled west and as they encountered local tribes, it was common for members to trade goods for sex, and frequently, wives of chiefs of several High Plains tribes were shared with expedition members in order to benefit from the men's spiritual power. The result of this was the spread of STDs across the northwest, as the Corps of Discovery shared infections between peoples who would never have otherwise come into contact with each other. At the time, there were few treatments for STDs available, with modern medicine of the day advocating a

strong course of mercury pills and bloodletting. As a result of the rampant STDs, members of the Corps of Discovery were also all exposed to toxic levels of mercury. Additionally, heavy use of laxatives, brought on by the lack of plant materials and overconsumption of meats in their diets causing chronic constipation, further increased mercury levels among the expedition's members, as these, too, were mercury-based. As a result, it is possible to retrace the steps of the Corps of Discovery by following the path of environmental contamination of mercury from latrine pits. While not frequently considered through this lens, the Lewis and Clark expedition and its outcomes are a One Health journey, both from the perspective of collaboration and data acquisition, including the detailed accounting of flora, fauna, and people, and from the complex health concerns introduced during their journey.

As the westward expansion of the USA proceeded through the early 1800s, due in part to the doors opened by the Corps of Discovery, one significant question for new territories was whether or not to allow slavery. Resolved by the Compromise of 1850, which settled the issue via a process referred to as **popular sovereignty**, newly established territories were allowed to decide the issue of slavery independently by vote. Voting at this time was, however, limited to white men. Not long after Lewis and Clark departed from Missouri, Dred Scott, a slave born in Virginia, moved with his owners to St. Louis, Missouri. Located south of the **Mason-Dixon Line**, but north of the lines drawn by the Missouri Compromise, Missouri in the 1830s was a slave state. Once there, Scott was sold to John Emerson, a US Army doctor. As a part of his work, John Emerson traveled extensively, taking his slaves with him. As a result of this, Dred Scott and his family found themselves living in Illinois – a free state – and the Wisconsin territory – a territory that, under the Compromise of 1850, had voted to not allow slavery. In 1842, the Emersons returned to Missouri, taking up residence in St. Louis. In 1846, Dr. Emerson died, leaving his slaves

to his widow, Eliza (Irene) Sanford Emerson. Upon John Emerson's death, Dred Scott attempted to buy his and his family's freedom from the widow, but she refused. And so, with the help and encouragement of local abolitionists, Dred Scott sued for his freedom in 1846. In total, the Scotts had lived for more than nine years in free territories, and according to the doctrine held by Missouri's courts at the time, "Once free, always free," there was a precedent to support his claim. After 11 years, the case landed before the US Supreme Court, where in a 7-2 decision, the Court ruled against Scott, citing property rights as the justification, and nullifying the 1820 Missouri Compromise in the process. The outrage of this ruling, what has come to be known as the Dred Scott Decision, fanned the flames of civil unrest over "the slavery question" in the USA and came less than four years before the country erupted in war over the issue of slavery in 1861. Dred Scott died a slave less than one year after the Court's ruling, in 1858.

William Clark died in 1838 and was buried in Bellefontaine Cemetery, a beautiful cemetery and arboretum in St. Louis, MO; just 20 years later, Dred Scott was buried in Calvary Cemetery, an equally beautiful Catholic cemetery in St. Louis, MO. A single street separates the two cemeteries. While seemingly disparate, the stories of William Clark, Dred Scott, and the Mississippi River have shaped the region into what it is today. The actions of the past set the path for the realities of today. As such, it is possible to examine how the actions of early Americans shaped the current cultural and environmental health of the region.

St. Louis, MO, now sits as the Gateway to the West. As the second largest city on the Mississippi, it has grown up with the river as a unique part of its cultural identity. The river is the economic and cultural anchor of St. Louis, binding the city to its history in numerous unseen ways. For St. Louis, the cultural reliance on natural resources and the economic and cultural exchange brought by the Mississippi harkens back to Lewis and

Clark's roles as cultural emissaries and naturalists of the Corps of Discovery. Resource extraction, epitomized by long-term iron mining in the area, and the vast loss of habitat through **urban sprawl** are reminiscent of de Soto's approach to exploration. Missourians' love of green spaces, embodied by Forest Park, the largest urban park in the USA, and their ardent support of conservation-minded state agencies, such as the Department of Natural Resources and the Department of Conservation, stem from the values placed on the balance between humans, animals, and the environment. And finally, St. Louis' continued status as one of the most segregated cities in America, brought into sharp focus with the recent events in Ferguson, MO, a suburban area of St. Louis, is a direct result of the country's still-open wound of slavery, as exemplified by the Dred Scott Decision.

The legacy of St. Louis' rich and complicated history is playing out in a myriad of ways today. More than 175 million tons of freight move along the Mississippi River, creating jobs for thousands of people. The river is also the source of rich biological diversity, providing habitat or resources for more than 260 species of fish, 60% of American birds, at least 60 species of mammal, and numerous reptiles, amphibians, and freshwater mussel. The Mississippi is the source of drinking water for more than 18 million people. St. Louis benefits from all of this economic and ecological wealth. The landscape of St. Louis has been shaped physically both by the river and by the social and economic divide between the city residents, established in the years following the Civil War. In the early twentieth century, systemic **redlining** – racist housing policies at federal, state, and local levels – prevented the integration of black and white communities. North St. Louis is now almost exclusively black while south St. Louis is predominantly white. The Delmar Divide – a street that separates north from south, black from white, and frequently, poverty from wealth – spans the city. This Divide has significant consequences for health.

For the people of St. Louis, the zip code into which one was born is the most significant factor for predicting overall health, including rates of heart disease, diabetes, and cancer. City residents living north of the Delmar Divide have an average life expectancy of 12–15 years less than their counterparts living south of the Divide. In some places, this gap stretches to as many as 35 years. The racial and socioeconomic divides, embodied by the Delmar Divide, extend beyond traditional health metrics. Residents in south St. Louis have higher rates of home ownership and a greater access to education, with a rate of college completion at more than twice the rate of residents in north St. Louis. Historic decisions determining where people of color could live, anchored in the state's slave-owning past, have also exposed the residents of north St. Louis to a significant amount of toxic pollutants over time, including heavy metals, from pollution-generating industries, such as lead smelts, refineries, and limestone and iron mines. This long-term exposure to toxic pollutants, which manifests into significant human health costs today, is but one disparity in human and environmental health separating north and south St. Louis.

Surprisingly, this Divide is also significant for the health of urban wildlife. For example, the Camillo laboratory at Saint Louis University has examined bee and other insect pollinator populations across St. Louis and found the diversity of bees is significantly greater in St. Louis than in the rest of Missouri, suggesting that urban ecosystems may promote population diversity. Dr. Gerardo Camillo suggests this is likely due to the loss of habitat in rural areas, where agricultural monocultures dominate the landscape. Wild bees are, more frequently than not, ground-nesting species, and the patchiness of urban green spaces – neighborhood parks and gardens – can promote native wildflower growth, creating small, viable habitats for the insects.

Similarly, the Lane-deGraaf laboratory at Fontbonne University's Center for One

Health has explored the effect of the Delmar Divide itself on urban wildlife populations. Preliminary work out of the Lane-deGraaf laboratory has shown that the Delmar Divide has had profound impacts on populations of urban mammals, resulting in differences in not only physical and population size of raccoons (*Procyon lotor*) but of their **population genetics** as well, suggesting that long-term environmental inequalities throughout the history of St. Louis have the ability to shape the current population dynamics of urban wildlife.

Raccoons are common carriers of the roundworm, *Baylisascaris procyonis*. *B. procyonis* is an important zoonotic parasite that can infect children, who may come into contact with the eggs of the parasite through play in raccoon-feces-contaminated playgrounds or sandboxes. In the work out of Lane-deGraaf's laboratory it is shown that *B. procyonis* is most commonly found in children in areas with high rates of poverty, especially in those areas with high rates of building vacancies. In St. Louis, the **incidence** of *B. procyonis* is increasing only among children living in north St. Louis, where the **prevalence** of raccoon roundworm and vacant buildings is high but available park space is low. In a true One Health synergism, the rise of this parasite is linked to the long-term income inequality of St. Louis, demarcated by the Delmar Divide that drives disparities in environmental health, the effects of which inextricably link human, animal, and environmental health.

This is not just a story of St. Louis. This is a story of connection. Humans, animals, and the environment are indivisible. They are connected not only with each other but with each other through space and time. Decisions made by parents directly affect their children; actions of preservation or pollution done in the past affect the current environment. Acts of health and humanity made locally have global repercussions, with potentially far-reaching, unintended consequences. Decisions made today will shape the future. We are all connected; human

health, animal health, and environmental health really is only One Health.

1.1 Book Overview

We wrote this book as an introduction to One Health; it is our intention for the reader to acquire a clear understanding of One Health: what it is, why it is important for planetary health and how one may be a part of it. This text has an interdisciplinary point of view that will make it valuable to the growing number of One Health majors, minors, and certification programs in universities throughout the world. The text will also be of value to graduate programs in the sciences, including the health sciences (e.g. veterinary, medical, ecological), serving as an introduction to One Health alongside the more traditional courses in these fields.

What then do we mean by One Health? In this text, we define One Health as the collaborative effort of multiple disciplines – working locally, nationally, and globally – to attain optimal health for people, animals, and the environment. For many of us, as daily news of worrisome health events across the globe from climate change and pollution to infectious diseases in frogs, bats, and people, the One Health approach is a path to start finding solutions, not simply fret over the problems. It may be obvious to some that there is a connection between humans, animals, and the environment, or the **One Health Triad**. What may be less evident to people just starting out in a career is why the need for a **transdisciplinary**, holistic approach. For many decades, there has been division within the sciences, but the incorporation of lessons learned by working across these silos of knowledge is critical for complex problems. After years of creating isolated silos, whether within human medicine or veterinary medicine but also between professions, it is time for experts across disciplines to work together in the increasingly complex and interconnected world of the twenty-first century.

The idea that human, animal, and environmental health are connected has been around, in various renderings, for many years. It is not surprising, then, that many terms have previously arisen evocative of One Health. These include **One Medicine**, first put forth in the 1960s and **Conservation Medicine** introduced in the 1990s. You also may hear of **EcoHealth**, **Ecosystem Health**, and **Planetary Health**. Each has a slightly different definition and/or may have slightly different areas of focus or mandate. However, in this textbook we hope the idea of a need for an interdisciplinary approach for planetary health as an imperative to face real world twenty-first century issues, no matter the term used, is abundantly evident.

Important to a One Health approach are the variety of disciplines associated with health that are necessary for the success of

this holistic approach. An often used image to identify One Health, produced by a One Health group in Sweden, shows this diversity (Figure 1.2). However, many of the logos used today display the One Health Triad, with the imagery that shows the interconnections between human and non-human animals and the environment (Figure 1.3). Another way to view One Health is from a thematic point of view. For example, one may identify with the **translational medicine** or ecological viewpoint present within One Health. With translational medicine we see a cross-taxa approach to the health challenges facing humans, which incorporates the shared knowledge of health between animals and humans. Alternatively, the ecological side of One Health focuses more on understanding the relationships of living organisms within their physical environments. This focus

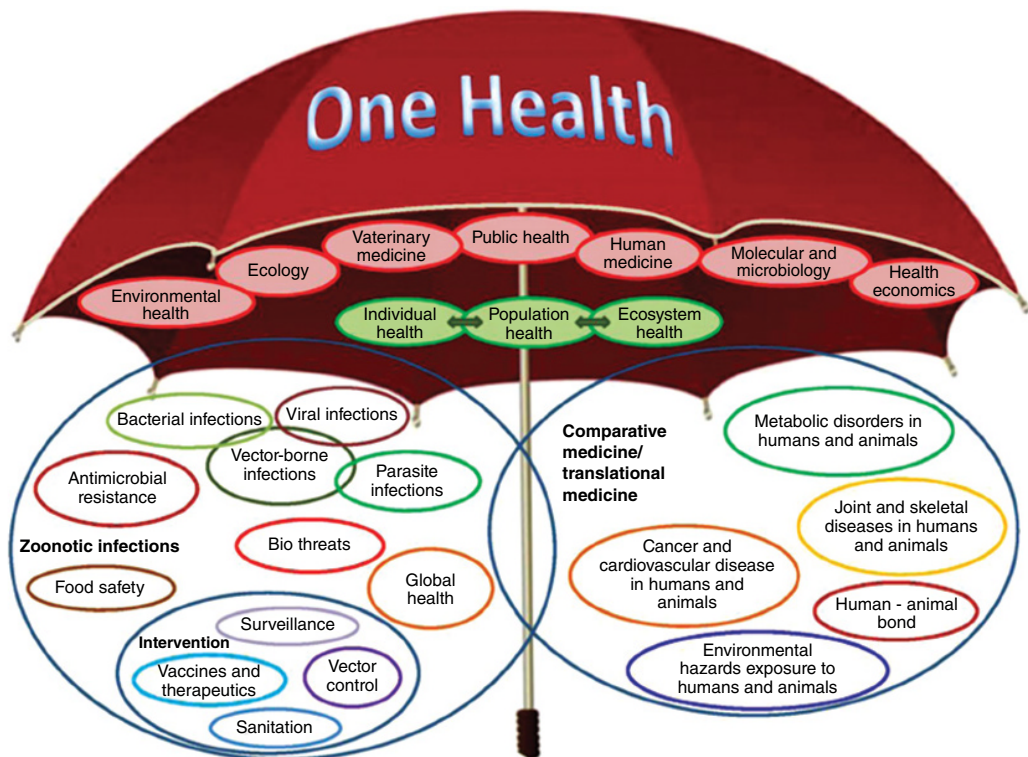


Figure 1.2 One Health Umbrella, as developed by the group “One Health Sweden.” *Source:* Courtesy of One Health Sweden.



Figure 1.3 Fontbonne University Center for One Health logo, representing the One Health Triad. Be sure to note the person in the white space in the center.

explores how environmental health has direct and indirect impacts on planetary health itself, including human and animal health.

The book is divided into 15 chapters that are further categorized into six overarching themes. In each chapter, there is an abridged excerpt from an audio interview with a One Health Practitioner, whose work is salient to the chapter discussion, and a case study that is co-authored by a 2015–2016 Fontbonne University undergraduate student from either the Honors seminar on One Health or the One Health program’s capstone course: Conservation Medicine – One Health in Action.

Part I, *Introduction and Impetus* (Chapters 1–3), includes an introduction to One Health, as well as an understanding of why a One Health approach is essential at this critical point in the planet’s history. This introduction shows how dependent the health of all life is to one another. In Chapters 2 and 3, we dive deeper into the connections linking the health of humans, animals, and environments as we consider the “**six degrees of One Health.**” In Part II, *The One Health Triad* (Chapters 4–6), we examine environmental health (Chapter 4), animal health (Chapter 5), and human health (Chapter 6) through the lens of One Health. In Part III, *Practitioners and their*

Tools (Chapters 7 and 8), we explore the opportunities and necessary skills for One Health practitioners. In Part IV, *How to Start a Movement* (Chapters 9 and 10), we address the challenges involved in educating and communicating with the global public concerning science, risk, and the need to change. In Part V, *The Humanities of One Health* (Chapters 11–13) we explore One Health as it exists within the humanities. All the evidence-based science in the world will not be effective unless it can be packaged through the humanities in a way that people find fits into their cultural, religious, political, and/or economic beliefs.

Finally, in Part VI, we explore *Where We Go From Here*. Thinking about the challenges and opportunities that connect our global environment (Chapter 14), we may also see how this planetary approach opens up new possibilities as we move into a culture of One Health. In Chapter 15, we look at the past, present, and future of One Health and consider how the movement started, where it sits today, and examine the ethics of possible scenarios of the future of One Health. There are many possible directions the One Health movement may take, and the future of One Health is in all of our hands today. As stated by many people, the future is hard to predict. However, Abraham Lincoln reminds us that, “the best way to predict the future is to create it.” We hope the readers of this book help to create the future of One Health.

1.2 Conclusions and Welcome to One Health

Whether you are new to the One Health movement or looking for a refresher in your current One Health work, this book will be of value to your practice. As the above introductory story exemplifies, we realize that viewing the health challenges of the twenty-first century through a One Health lens, requires an appreciation of the past, awareness of the present, and concern for the