Belonging to Earth

Belonging to Earth:

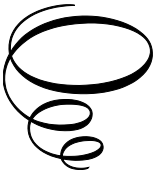
One Health Stories to Save our Planet and Ourselves

By

Michael Lairmore and Michael Wilkes

Edited by Susan Salter Reynolds

Cambridge Scholars Publishing



Belonging to Earth: One Health Stories to Save our Planet and Ourselves

By Michael Lairmore and Michael Wilkes

Edited by Susan Salter Reynolds

This book first published 2025

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Copyright © 2025 by Michael Lairmore and Michael Wilkes

All rights for this book reserved. No part of this book may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior permission of the copyright owner.

ISBN: 978-1-0364-4770-0
ISBN (Ebook): 978-1-0364-4771-7

“The Earth does not belong to us: we belong to the Earth.”

Interpreted from Chief Seattle (c. 1780–1866) a leader of the Duwamish and Suquamish tribes, which lived in the Puget Sound region of what is now Washington State, USA.

TABLE OF CONTENTS

PREFACE

OUR INTERCONNECTED WORLD

"Tell me the facts and I'll learn. Tell me the truth and I'll believe. But tell me a story and it will live in my heart forever."
—Native American Proverb

The Covid pandemic forced us to contemplate our interconnected world. Events in distant lands altered our everyday lives, and a tiny infectious agent had a lethal global impact. How could a virus from a faraway place impact the world so severely and so quickly? The pandemic, like a black cloud, enveloped us, ended our ability to travel to work, go on vacations, visit our neighbors, and even greet people with handshakes. It required those in the health professions to reconsider their commitment to caring for others when faced with a risk to themselves and their families. This microscopic organism brought death to the vulnerable and originated in some dark place in nature. We desperately yearned to find out where it came from and how to stop it, to end the nightmare. Public health systems worldwide struggled under the weight of uncertainty, evolving "best practices", and managing misinformation and skepticism. Governments blamed each other as they tried to protect their own citizens before being willing to help a broader global population. New variants of the pathogen challenged the brightest virologists, immunologists, and physicians to develop novel methods of detecting and combating the insidious pathogen. Scientists and wildlife veterinarians searched hidden caves and wildlife markets, to identify how SARS-CoV2 spilled over from its natural ecosystems and spread throughout the world.

This was not the first time for disease detectives. While Covid provided unprecedented challenges to our health and planet, the pandemic was predicted years earlier. The history of humankind has countless examples of devastating plagues, some of which changed the course of history. As human populations migrated and numbers expanded, we sought to tame the natural environment to meet our needs – for development, for economic gain, or simply for convenience. As a society some learned to be humble in

the face of the vastness and power of a new disease that swept across the planet and quickly killed millions of people while others did not change their behaviors. Infectious diseases are not the only threat facing humankind and the planet we share with all living things. Environmental threats, from toxic chemical spills to climate change, are in news headlines daily. As the dominant species in our world, humans have created threats to plants and animals that require a fundamental new way of finding solutions to the problems we have created.

By ignoring the benefits of biodiversity and exploiting natural resources upon which all animals, including humans, depend upon, we have set in motion events to poison our water, disrupt our climate, pollute our air and contaminate food supplies. The relationship between the health of the earth and all living things is deeply interconnected and rooted in cultural, social, economic, spiritual, and ecological dimensions. In many ways our advancement as a society has been remarkable but often at the expense of the land, its resources, and the ecosystems we inhabit. Indigenous peoples across the globe have learned over millennia to respect and appreciate nature. Earth and all its inhabitants are viewed as partners in a reciprocal relationship with human existence.

Indigenous people developed traditions, knowledge, and experience necessary for sustainable resource management. Yet modern cultures have chosen to ignore these lessons. As humans formed larger civilizations with new ideas about the nature of the world, their desire to conquer new territories and hoard the wealth overrode an appreciation of how they were part of a larger and more complex system of life. The Covid pandemic was one more example of what happens when humankind ignores nature's warning signs.

The concept of learning from the natural world has been with us since antiquity. Through his writings Hippocrates (c.460-c.377 BCE) taught that wellbeing depended on the environment. Before the advent of medical specialization in the 1800's, anatomists, scientists, biologists, and physicians recorded similarities in structural features, physiological processes, and pathologies between animals and people. In the 1960's Calvin Schwabe, a veterinarian and public health scientist who studied zoonotic parasitic diseases, coined the term "One Medicine" to emphasize the similarities between human and veterinary medicine and the need for collaboration to effectively cure, prevent, and control illnesses that affect both humans and animals. In 2007, the American Veterinary Medical Association, the American Medical Association, and the American Public Health Association

formed a One Health Initiative Task Force to create recommendations to bring together human and animal health in the context of the environment to address the problems at the interface of animals, people, and the environment.

The stories in this book demonstrate the links between these domains and the power of using a "One Health" approach to medicine and science. Uniquely trained people from multiple disciplines bring their skills to comprehend the complex connections between animal and human health. By sharing data, tools, and approaches in a transdisciplinary manner, today's One Health practitioners are providing a window into the future to help preserve the health of the planet. The good news is that when working as synergistic networks, these disciplines can engage and think creatively beyond their specialty or policy focus and work towards solutions. This approach has garnered the attention of health organizations worldwide, as evidenced by the recent call to action led by the World Health Organization (WHO), and other international agencies involved in human, environmental, and animal health. In 2023 four international health organizations (the World Health Organization, Food and Agriculture Organization, and the World Organization for Animal Health) issued a call to action emphasizing the need for collaboration and commitment from all countries and key stakeholders to prioritize and implement One Health policies. By promoting transdisciplinary and transnational collaboration, strengthening workforces, and investing in One Health, the "Quadripartite" organizations seek to establish a healthier planet and mitigate future health threats.

Threats to these three interdependent domains – people, animals, and the environment – extend beyond new and re-emerging infectious diseases like Covid. While humans would like to think we can control our world, we face many threats brought on by our hubris, and frequently through conflicts including wars. Refugees displaced from their homelands face unprecedented challenges to survive. Our planet is heating up from climate change brought on by the overuse of fossil fuels. Unsustainable agricultural practices and deforestation have brought on the destruction of fragile ecosystems. Our overuse of toxic chemicals has led to the near extinction of insect pollinators we depend on to help us grow our food. By dumping plastics, chemicals, and our sewage into our waterways we have enhanced risks to water and food supplies. Rising water temperatures in our oceans and waterways have devastated coral reefs, created toxic algae blooms, and threatened aquatic species critical to the planet. These complex worldwide problems require integrated approaches to thwart the destruction of ecosystems, speed effective public responses, and eliminate barriers between public health

sectors to combat emerging health issues. We must foster new collaborations between our siloed domains of science, medicine, ecosystems, and public health policy.

This book tells the stories and gives voice to those most directly affected when we ignore these warning signs. In sharing these stories, we show how scientists, veterinarians, physicians, environmental health experts, policymakers, and others work together to solve these complex threats. The telling of stories is as ancient as our need for us to live on our planet in peace with all the other animals and to give reverence to the environment we all must share. The heroes of these stories require skills beyond a specific expertise – building team approaches, interpersonal skills, humility, communications, and community strength. This is a work of fiction based on evidence-based scientific examples. Unless otherwise indicated, all the names, characters, businesses, places, events and incidents in this book are either the product of the author's imagination or used in a fictitious manner. Any resemblance to actual persons, living or dead, or actual events is purely coincidental.

As indigenous peoples understood, we do not own the earth; we are privileged to occupy and share niches within the environments of our amazing planet. The following series of stories provide warnings, but we also hope that readers can listen, learn, and find ways to protect our interconnected world.

ACKNOWLEDGMENTS

The authors would like to thank all the One Health workers across the world who work daily to advance the health of people, animals, and the planet we all depend upon. We thank those scientists, physicians, veterinarians, public health officials, and other experts who contributed to the real-life events that provided the inspiration for our fictionalized stories. We are most appreciative for the advice, proof reading, and patience of Maggie Rea and Donna Lairmore. The authors are indebted to those that reviewed the stories for accuracy and evidence-based statements including Husna Ibrahimkhail, Madeline McNelis, Chiqui Aljas, Rodrigo A Gallardo, Kirsten Gilardi, Scott Kellermann, Tierra Smiley Evans, Thomas Venturio, Tom Hinds, and David Bunn.

CHAPTER 1

THE WINGED THREAT

"Everyone likes birds. What wild creature is more accessible to our eyes and ears, as close to us and everyone in the world, as universal as a bird?"
—David Attenborough

Juan rolled over in bed and reached clumsily for the alarm. Almost knocking it on the floor, he slapped it quietly while uttering a low moan. Getting up at 4:30 am was not easy, especially after a late-night church function the night before. He gathered the covers and sat up in bed, trying not to wake his wife, Maria, who stirred softly and rolled over, grabbing the sheet. The early fall weather was beginning to turn their rented trailer colder each morning. In some of his early morning dreams he envisioned that he was locked inside the large steel coolers from the poultry plant hanging with thousands of chicken carcasses.

Today as he awoke the chilled air rushed over him like a river, causing him to shiver. Peering out the frosted and stained window, Juan stared through the morning fog covering the blurry images outside- a gravel driveway, and a yard of dirt with dried yellow tufts of grass between rectangular boxed house trailers. Blinking his eyes, he focused on the rusted car and the old swing set, part of the "perks" his landlord told him that came along with the trailer. He did not have a driver's license in the U.S. and had little need for the play equipment, as his children were grown and gone. More than that, everyday reminders of their youth made him feel that life was swiftly passing by. The stiffness in his back nagged him that he was not getting younger. He stumbled into the kitchen, fixed himself a quick breakfast burrito from last night's leftovers, and washed it down with black coffee. After rinsing his dishes in the sink, he methodically put together his lunch to take to work. He carefully made a sandwich of lunch meat with mustard and pickles wrapped in stale white bread, before placing it into his tin lunch box, along with a bag of tortilla chips.

"The breakfast of working champions." He thought, chuckling aloud.

Filling his thermos with the remainder of the leftover coffee, he sat down at the kitchen table, a plastic folding table his wife purchased at a thrift shop. Staring at the food-stained tabletop, he switched on the radio, to listen to the morning news. He grimaced upon hearing about the effects of climate change and melting of artic glaciers, turning the radio volume down and then completely off. He did not need to hear more bad news. He had to catch the bus to work, and his stop had moved further to the main highway, which took him an extra 20 minutes to walk. His arthritic knee did not help, as he grunted and pushed himself up to leave. Turning off the kitchen lights made the room shrink into darkness as Juan felt his way to the door of the trailer. Stepping down into his yard, he kept his head low to avoid the poop piles, courtesy of the feral dogs in his neighborhood. He made his way across the wet grass and began the walk on the gravel road towards the bus stop, with only the sound of crunching rocks and dirt.

The bus stopped, brakes hissing, in a small cloud of road dust. As he boarded, Juan muttered “buenos días” to the driver, who mumbled a reply and reached to shut the door, avoiding eye contact. Inside the bus was dark and filled with the aroma of worn leather and motor oil. Juan could barely make out the outline of the other migrant workers, some greeting him, others nodding half asleep. His working day had started like most mornings, to the muffled rumbles and shaking of the aging city bus traveling down the road towards the poultry farm.

After being dropped off several hundred feet from the main gate, Juan and the other workers strolled towards the security gate of Horizon Farms, whispering their greetings in low Spanish tones. They walked past the familiar signs written in Spanish and English warning of the biosecurity measures needed before entering the gate. He showed his H2A visa identification card to a bored guard at the gate. Juan Alverez was born in 1982 outside of Mexico City. The dates on the card indicated his entry and expected exit dates covering his latest stay. This season, Maria and Juan came to harvest strawberries. Their plans changed when he was lucky enough to find a job at the poultry farm, which paid better wages, part of which he sent home to help take care of his ailing parents.

Today would be far from routine for Juan. He suited up in the anteroom outside his assigned work area, putting on footwear, a mask, and his clean coveralls, which hung on a hook under his name against the wall. The climate control panel gave a green glow to the room as it displayed the temperature, humidity, and ventilation status in the houses. The smell of chicken manure and damp feathers permeated the air. As he walked into the

first of the layer houses, he immediately noticed something different about the “free range” layer chickens. These chickens were allowed several hours each afternoon in an outdoor yard with feeders. Some of the outdoor areas connected to small open grass-covered pastures adjacent to the sides of the layer house.

Inside the layer barn Juan noticed that the chickens were separating themselves into smaller groups, not their normal behavior. Some chickens held their heads outstretched with their necks extended, their beaks wide open gasping for air. A few of the chickens had puffy swollen heads with discolored, blotched, and red combs. To his horror, he found several dead chickens scattered among the flock. Their white, ruffled bodies lay in distorted heaps. The smell of fetid chicken droppings mixed with a stench unfamiliar to him, the smell of death and decomposing animals.

“Why is this happening?” He muttered to himself out loud, worried that his boss might blame him.

Juan immediately began to panic. He felt responsible for the chickens' health. He knew that, given their close living quarters, many things could go wrong. He went through his work checklist: water was on, feed was available and unchanged, and the ventilation seemed fine. So, what could be causing the chickens to die? He remembered over the past days lots of activity at the farm. Local suppliers delivered new feed and contractors made repairs to the fans at the rear of the building. Could these visitors have brought the sickness into his flock? The side doors of the houses, which were open part of the day to allow the chickens to range into an open outside enclosed lot, were operational and working. Juan walked quickly to the attached office building to call the farm manager.

With his throat tightening and his voice cracking he forced his best English, “Señor Bill, this is Juan. Could you come over here quickly? Something's wrong with the chickens in Building 15!”

On the other end of the line, Bill could tell that Juan was distressed. He was one of his best new employees, and not one to panic easily. Bill Carter was a seasoned manager of the poultry operation, having worked in various roles on that farm since his teens. He also knew that a few dead chickens in one barn meant problems in other barns.

As soon as Bill arrived at Building 15, the magnitude of the problem was clear. Walking among the dead chicken bodies in his hazmat boots and mask, he almost gagged at the smell of decomposing animals. Bill's mind

raced as he went through the many things that could go wrong in a confinement chicken operation, from mechanical ventilation failures to infectious agents. His thoughts went to his worst nightmare, avian influenza, or bird flu, which had been reported on several turkey production farms in the northern part of the state, and in wild birds throughout the county. He called Dr. Peterson, his consulting poultry veterinarian, to get an idea of what was happening. He then quickly called a meeting of his entire staff to go over the protocol for decontamination and biosafety.

Bill knew that if it *was* avian flu, it could devastate the farm, and his biosecurity measures might be too late to prevent the spread of the disease. The farm had experienced disease outbreaks in the past and he knew how disruptive shutting down production was to the entire community. Many of his neighbors worked at the poultry farm and the nearby production facility. Like him, their livelihood was linked to keeping operations open and running year round. He shivered as a cold bead of sweat ran down the back of his neck. In his mind, the loss of barn 15 was like the tip of a melting iceberg draining away profits and his year-end bonus.

****

Arriving at his office that morning, Dr. Robert Peterson was reviewing his notes from yesterday's visits and planning follow-up calls that included most of the poultry farms in the region. Peterson enjoyed his life as a poultry medicine specialist and had decided to be a "chicken vet" from as far back as he could remember, growing up on his family's midwestern poultry farm. He was proud of his efforts to help producers grow chickens in a healthy, sustainable manner. He paid close attention to the latest in animal welfare and biosafety concerns affecting the industry. Meat and eggs from commercial poultry are one of the fastest animal commodities in the world. He knew the business of poultry production and realized the intricate relationship between breeder companies, hatcheries, producers, processing plants, and feed mills. Dr. Peterson also understood the balancing act of disease control, animal biology, industry trends, public health, and of course, the politics of consumer demand, and government regulations.

"Bill how are you today?" Dr. Peterson answered his long-term client in his folksy, yet professional, voice.

"Doc, please come as soon as possible, we have sick and dead birds, it might be bird flu or something similar." Bill said, speaking quickly, partially out of breath.

Dr. Peterson asked a series of questions, aware that Horizon Farms would be his first call of the day.

“I assumed you checked the vents and temperature controls inside the building. How many barns are affected so far?” Dr. Peterson rattled off the typical series of questions to try to gain some idea of the magnitude of what he was about to face.

Hanging up the phone, he sighed and lowered his head, breathing slowly in measured breaths as he stared at his laptop. A sense of dread made his chest tighten slightly. These types of calls were the reason he sometimes awoke at 3 am, his mind racing, preventing any sibilance of rest. He knew if Bill was correct the devastation that avian influenza would have on his clients would be enormous. Adding to his anxiety, he read the night before about avian influenza, the H5N1 strain, “spilling over” into dairy cattle in Texas. Cats drinking raw milk on these farms were dying, and dairy workers were sickened from the virus infection. Was this the start of a modern-day version of a plague spreading between animals to people?

****

In Southwestern China, Wei Ming stood in her kitchen, stirring a pot of soup. The small stove held several pots of boiling chicken broth, wafting steam into the air in tight swirls. On the counter sat a mixture of chicken parts chopped and ready to add to the broth. She was well known in her village for her pork and chicken specialties. Wei lived with her two children and husband Xi. They were devoted farmers who lived their lives in quiet co-existence with the fields of rice and animals raised in their backyard in rural China. They prided themselves on their hard work and for raising enough pigs and chickens to feed themselves and still have some to sell at the local markets. As part of the community cooperative in their region of rural China, helping to feed their neighbors while earning a small profit would help them retire soon.

Xi came into the kitchen from the yard. His work clothes were covered in dirt and spots of chicken manure. He greeted his wife and tried to sample the soup before Wei shooed him away. Wei then scolded him for his appearance and asked him to change his clothes. As he turned, he felt dizzy and coughed violently. Sitting near the kitchen table he wiped his brow with his sleeve. Looking worried, Wei placed the palm of her hand on his forehead.

“You feel hot. Are you feeling, ok?” Wei asked in a concerned tone.

Xi muttered his response in between more coughing. “I’m sure it’s just a cold or perhaps something I ate last night.”

Wei scoffed at his response and told him that her soup would help, but it would not be ready until their evening meal.

Xi said he had some sad news. He told Wei that several of their chickens were dead and some of the pigs were not eating when he did his morning check. He disposed of the chickens by throwing their bodies in the local common land fill. Wei remembered learning from her friends at the cooperative that agricultural officials warned all rural farmers about the signs of avian influenza and to report it to local authorities if they observed the dreaded disease on their farm. They educated members of the cooperative that avian flu did not respect borders and may be transmitted by wild birds that migrated between countries. Xi did not think that throwing his dead chickens in the common trash pile could threaten the health of animals and people, only that it was the only way he knew to get rid of the rotting animals.

Over the next several days Xi’s cough worsened. Wei was more concerned about Xi than the loss of the chickens, and she was afraid to report the spreading disease among their own chickens. Xi developed a fever and body aches but continued with his daily routine, even shopping for Wei at the local market. As he walked through the food stalls and shops, his forehead kept beading with sweat, and his shirt became wet, highlighting his thin body frame.

The next morning, he could not get out of bed without losing his balance due to coughing. Concerned for her husband, Wei made Xi visit the local medical clinic in the next village.

****

Dr. Peterson finished collecting samples from the affected layer houses at the Horizon poultry farm, carefully labeling the tubes containing cotton swabs in plastic racks. The racks sat neatly in rows inside Styrofoam containers for shipment to the regional veterinary diagnostic laboratory. He completed the paperwork and removed his gloves with a snap before removing the rest of his personal protective equipment. There were several conditions he considered that may have caused the lethal poultry respiratory outbreak, including viruses, bacteria, and fungus. Some were less likely because their spread was typically slow and less lethal.

Amplifying his worst fears, more chickens were dying over the next several hours. Peterson had heard from his colleagues in the next county that they had a similar outbreak in a broiler operation (those bred and raised for meat production).

Fortunately, the regional veterinary diagnostic laboratory had rapid testing capabilities and was linked through the National Animal Health Laboratory Network, a federally funded program to control outbreaks of deadly diseases. By the next day, the collected samples confirmed the diagnosis of highly pathogenic avian influenza (HPAI). Subsequent genomic sequencing confirmed the virus to be the H5N1 strain.

What makes influenza viruses so elusive?

One major reason Influenza viruses are difficult pathogens to control is their segmented RNA genomes that are classified into four major types: A, B, C, and D. Their packets of genes allow them to reshuffle and mix their genes during replication if two strains infect the same cells, in some cases producing new more deadly variants. For avian influenza these are commonly called "highly pathogenic or high path" (HPAI) strains versus more common "low path" strains. Influenza types A and B are typically associated with seasonal epidemics of disease in people and influenza A viruses are associated with broader influenza pandemics. Influenza outbreaks in animals like birds and swine are closely monitored to assess their ability to infect humans. Influenza A viruses are divided into subtypes based on two proteins on the surface of the virus: hemagglutinin (H) and neuraminidase (N).

The complexity of which influenza virus may cause disease is due, in part, to the fact that there are 18 different hemagglutinin subtypes and 11 different neuraminidase subtypes. As a result, there are many potential influenza A subtype combinations that could result in human epidemics or pandemics. Knowing this, scientists, veterinarians, public health departments all work to monitor influenza outbreaks in the environment of wild birds, swine, and other animals knowing their potential to cause human infections. Equally as complex are the number of public health and agricultural policies that become involved when "spillover" of the infection occurs between species.

Under the supervision of state and federal animal health officials, Dr. Peterson worked with Bill and his staff on a biosecurity plan to isolate and "depopulate" or "cull" the remaining chickens and begin decontamination procedures. This included instructions for the entire staff to thoroughly disinfect all equipment, clothes, etc., that may have come in contact with the affected birds or their droppings. The response included warnings for

those workers in contact with the dead chickens, that H5N1 is considered a zoonotic disease and could be transmitted to humans. More tests would be available soon to understand the virus's origin and how it was related to pathogens across the globe.

Reports continued to accumulate from other states verifying that the H5N1 strain had crossed over to dairy cattle, cats on dairy farms, and several workers in close contact. For Dr. Peterson the ability of influenza viruses to mutate and adapt to new species provided a constant reminder of a future pandemic. He knew that when multiple strains of the virus infected the same animal, they have the insidious ability to undergo “recombination”, or mixing of their genes, amplifying the threat.

He explained to Bill and his staff that avian influenza strain, like other forms of the virus, can be spread in wild birds worldwide during annual migration routes between countries and continents. In subsequent meetings with factory managers, Dr. Peterson tried to provide reassurance that current public health risk was low, and that federal agencies were monitoring the outbreak carefully and working with multiple states to monitor people with animal exposures.

****

On the poultry farm Juan was tasked with the grim process of depopulating the chicken houses. As he followed the instructions to kill in mass the exposed chickens, he could not help but feel guilty. In his mind, like a recording on repeat, he kept revisiting the list of protocol breaks that could cause the deadly infection at the farm. After the culling was complete, he silently walked slowly through the chicken houses, as the rattle and whooshing noises of the large exhaust fans washed over him. Outside front-end loading tractors scooped up the tangled wet piles of dead chickens depositing them in trucks headed to the landfill, permitted to accept infected waste. Juan turned away from the scene, pulling down his facemask to wipe the tears streaming down his face with the back of his gloved hands.

On the long bus ride home, the fear of losing his job began to seep over him like a shadowy cloud before a rainstorm. He did not know what to tell Maria, his wife. It was too late to look for a new job this late in the season. Dark thoughts began to haunt him, like a runaway car careening off a cliff. As if in a dream, he felt cold and sluggish the rest of the day. Without work they would need to return to Mexico. This would mean less money and more empty shelves in their home.

The sad memories of his youth enveloped and flooded over him. As he sat on the bus, he recalled the skinny boy in borrowed denim jeans and oversized boots he wore when he started work years ago. The endless hours in the fields picking vegetables for some other family far away. His back aches and sore hands and feet as he collapsed onto his cot each night, too exhausted to wash up. He also remembered the long nights of fighting through the cold river marsh when he first crossed the border with his uncle as illegal immigrants seeking a better life in the United States. He closed his eyes as the images and sounds of the pain, loneliness, and hunger tightened around his chest like a burial shroud.

****

Walking along the levee in his wading boots, Dr. Chike Adebayo looked out across the marshland at the rising sun's red glow. The moist air was blowing in from the coast bringing with it the distant sounds of migratory birds honking overhead. As he looked up Dr. Adebayo squinted his eyes and tried to identify the species gathering and preparing to land in the rich waterways below.

Raising his binoculars to his face, he noticed a group of terns twisting in formation as they glided smoothly in, landing on the water producing expanding ripples around them. He took a pen from his backpack and methodically recorded the number and species of birds in his logbook before continuing his walk along the raised roadway bordering the flooded rice fields outside of Sacramento. Along with his backpack, he carried a small plastic utility box with partitions to hold specimens along with tubes, markers, labels, and sterile swabs.

His sampling routine was part of his regular duties as a wildlife biologist monitoring the animals of the wetlands for the California Department of Fish and Wildlife. Sometimes trying to discover causes of bird losses in the marshy landscape was like looking for a needle in a haystack. He was driven by a desire to help preserve the birds and wildlife that annually visited the Yolo Bypass wetlands. He followed the dirt and gravel road to a foot path that diverted down an embankment, allowing him to get better water access.

This was his third year on his job, and the Yolo Wetlands had become familiar to him. The over 25,000-acre Yolo Bypass was engineered to protect Sacramento and surrounding communities from flooding. The wet winter season in this area can bring dramatic shifts in water management. In addition to growing rice, the wetlands support the Yolo Wildlife Area,

considered the largest ecological restoration project west of the Everglades. This area of California is also under the Pacific Flyway, and it serves as an annual haven for millions of migratory birds seeking protection and sustenance during their long journeys north and south. The Pacific Flyway is like a river filled with massive numbers of migratory birds each year during their pilgrimage north and south across borders guided by their inherent drive to find food, better weather, and mates with which to breed and sustain their species.

Climbing down the embankment towards the water, Chike recognized that he had not sampled his area before. He scanned the horizon and noted the black dots of distant shorebirds floating out across the water. The sun produced a mirror-like reflection as it rose in the east. The outline of the city buildings of downtown Sacramento appeared like a distant wall holding back the city's people, cars, and noise. Looking down, he saw the white upturned carcasses of three dead birds floating in the black muck of decayed water plants.

He placed his sampling box and backpack on the shore. Reaching out with his gloved hands he raked the dead birds toward the shore so he could inspect and swab their bodies. Filling several tubes with coated swabs, he labeled the samples and put them in the plastic compartments of his sampling box. He carefully placed the dead birds in plastic bags for further examination back at the lab. He ran through the list of threats - botulism, bacterial or viral infections. There was no shortage of threats to migratory birds. He finished his regular sampling and trudged up the embankment to return to his university truck parked near the main road.

The morning sun rising in the distance that brought a warm breeze across the delta could not mask Chike’s feeling that he had stumbled across an emerging disaster for his beloved waterfowl. He had just read of the emerging threat of avian influenza spreading along migratory bird pathways all the way to the Southern Hemisphere, infecting birds, dairy cattle farms, and marine mammals. Could his samples contain avian influenza and be a harbinger of an impending health crisis? His tranquil morning and peaceful feelings were now replaced with a distant voice of suspicion and dread.

****

In the nearby town hospital in their rural China province, Wei sat by Xi’s hospital bed. She held his hand hiding her fear behind the N95 mask that she was asked to wear. Xi’s condition had worsened. Local doctors voiced

concern as they investigated a variety of respiratory pathogens including influenza. They knew that his condition may have implications for the health of the community. His test results came back within hours indicating that Xi was infected with an avian form of influenza. His age and the fact that he smoked cigarettes were making it more difficult for him to fend off the viral infection. Doctors sent off more tests to the provincial laboratory to clarify the nature of the virus invading Xi's lower airways.

Even if Xi's virus was a less serious type of influenza, local authorities would need to work with provincial authorities to call for a public health action plan to test animals and people in and around the village. Local public health officials understood that influenza A viruses are endemic in at least six animal species, including wild waterfowl, domestic poultry, and swine. Variants of influenza read like an alphabet soup of pathogens. They knew that avian flu infections among people are rare; they can happen when someone working closely with infected animals gets enough of the virus through contact via the eyes, nose, or mouth.

In Xi's case, his close contact with his backyard birds was a likely source. But it was unclear how many of his neighbors may have also become infected. None of this was lost on local officials. Alarms and communications were already being sent to provincial and country authorities.

The virologist working on the outbreak understood that influenza viruses can easily reshuffle their genes when they infect a body's cells. As a result, new strains can emerge, as they look for new victims to spread their progeny. Because of this nasty habit of creating new strains that could infect humans, these viruses are always at the top of the list of potentially zoonotic viral diseases, those transmitted between animals and people.

****

How does influenza cross borders so easily?

Wild waterfowl, shorebirds, and gulls have extensive migrations that cross country borders across the globe and over the Pacific and Atlantic oceans. These pathways typically occur naturally as birds move between breeding and non-breeding grounds in the East Atlantic, East Asian, and the East Pacific Flyways. As a result, these natural flyways provide opportunities for migratory birds that may have avian influenza to introduce new strains of influenza viruses across country borders. Spillover of pathogenic strains of avian influenza in marine mammals has been associated with devastating outbreaks. Once the virus crossed species, mammal-to-mammal transmission was believed to be the mode of transmission.

Wildlife biologists, epidemiologists, and scientists using modern genetic sequencing methods provide critical data on emerging highly pathogenic avian influenza viruses. This information when coupled with data from public health officials, physicians, and human diagnostic laboratories help define which influenza viruses that might spill over and adapt to humans. This One Health approach serves as a model to understand pathogens, how they are spread in nature, and their links to animal and human diseases is vital to the surveillance and public health responses against influenza. The Covid pandemic, caused by SARS-CoV2, has informed the world that infectious diseases know no borders and can spread quickly. The disruption to societies, families, economies were linked to the spread of a respiratory pathogen that was easily spread, lethal, and prone to rapid changes. All these factors are regularly considered for influenza virus infections in animals and in people.

In California, Dr Adebayo was aware of how, in 2014 and 2015, birds throughout the upper Midwest of the United States had succumbed to an outbreak of a "highly pathogenic" avian influenza strain that devastated wild birds and created major losses for the domestic poultry industry. In less than a month in 2015 approximately 40 million chickens and turkeys died or were culled due to a deadly outbreak of a highly pathogenic strain of avian influenza. Despite a coordinated response from federal and state agencies, the outbreak resulted in nearly $900 million in losses to the industry and disruptions to the nation's food supply.

A few days later, while sitting in his office reviewing the laboratory results from the samples he collected earlier in the week, Dr. Adebayo's pulse began to race. The results indicated "Samples positive for avian influenza type A." Further testing would be required to classify the samples as high or low pathogenic. He immediately began to plan his next trip to the waterway. Warnings would need to be sent to local poultry farmers,

veterinarians, and public health officials to prevent the potential seeds of a pandemic for birds and people alike. The public would certainly want to know if this new bird flu strain could bring back a human pandemic. A more troubling question that Chike did not know the answer to was, how do we stop the threat knowing that wild birds carry the pathogen through their normal migration patterns? He understood that the natural pattern of nature's creatures could clash with mankind's dominion over the planet.

Recent history was not on his side. Highly pathogenic avian influenza was detected again in 2022, and the outbreak continued. In this latest outbreak more than millions of birds throughout the United States had either died because of avian influenza infection or were killed out of fear of exposure to infected birds. Many more states were infected in the outbreak as compared to 2015. This is an enormous problem with food safety and security given the disruption of the food supply. In such a scenario, the potential for avian influenza A viruses to change enough through mutations or gene exchange and become human adapted is a constant fear for public health officials.

There are measures for poultry producers like Juan and Bill to stop avian flu pandemics. They knew that these included strict biosecurity measures on farms, rapid identification of the infection, and regulated culling requirements for commercial operations. For human medicine, vaccines and prevention are top of mind for public health officials. Bill had heard that mass vaccination of domestic poultry is being considered, but he dreaded the time and expense that this new practice would cost his company. Surveillance for circulating variants and quick public health responses are keys to stopping these types of pathogens in people. For people, these systems to be timely and effective must include public investments in diagnostic testing, coordinated policies and regulations, and public health communications.

Dr. Adebayo understood that without planning for these annual threats on wings, the migratory birds of his beloved wetlands were vulnerable to pathogens that spread easily as birds naturally gathered during their annual trips across borders. As he reflected in his office, he felt pride knowing the involvement of the many professionals and volunteers that understood the importance of systems to identify, communicate, and respond to zoonotic disease. Watching out his office window the evening sun created an orange glow across the skyline. He smiled and marveled at the gathering flock of birds flying overhead. Chike knew that infectious disease threats carried through the airways do not respect borders, but he believed that society could prepare for the outcomes when they arrive at our doorstep.

****

Juan watched silently as twelve-layer houses on the farm were depopulated in a matter of days after his initial discovery of the dead chickens. He felt his job and his life were evaporating in front of his eyes. He felt the cold helpless fear of seeing so many animals being put to death. The images would not leave him as he rode the bus home each night and the thoughts followed him into his nightmares. The daily depopulation of the chicken houses reminded him of his family's cross-border journeys. He sometimes felt like a trapped animal in a migration center, crowded together by an uncaring enemy waiting for a decision as to whether he could work or sent home to Mexico. His night terrors were relentless, often finding him awake in a cold sweat. His clock with its blurry red numbers, reflexed back at him like a demon in the darkness.

Later that week reality hit hard. "I am sorry Juan, but I have no more work for you until next season." Bill informed Juan, who sat in front of him in his office, head hanging down as he stared at the floor.

Trying to avoid the inevitable, Juan's thoughts drifted to his village when he was young. Happier memories of playing soccer with his brothers. Retelling stories in his mind helped him cope with the real world, transporting him briefly to happier times. His freedom was short lived, as Bill cleared his throat to awaken him. Juan jolted himself back sitting up in his chair to face Bill, a half-smile mask on his sunburnt face.

Thinking to himself, "How do I tell Maria that we need to go back this early?" He stared at the dirty tiles and felt like the room was spinning, and he was falling down a long dark tunnel. He suppressed the cough that started in his chest last night and wiped his brow covered with moisture from a developing fever. Juan rose and turned towards the door without mentioning his illness, which would mean more reports and paperwork. He had no health insurance and no access to medical care. What he did have was a long bus ride to his trailer and a long night of packing ahead of him.

****

In their rural village in China, Wei and Xi, understood their livelihood depended on a close relationship with animals. They did not blame their chickens for causing his illness. The birds did not purposely bring sickness to their family. Fortunately, they did seek medical help for Xi in time to save him from the viral infection and subsequent complications. Soon they could return to their life as farmers, raising animals to eat and sell.

Meanwhile, lurking in the common trash dump in their village, the seeds (infected chicken carcasses) to another influenza outbreak were available for scavengers to find and continue to spread the infection to their offspring or throughout their travels. The cycle continued, winging away across the false geographic boundaries, that we pretend separate us from the threats inherent in our interconnected natural world.

****

CHAPTER 2

A FAILURE TO BELONG

"The most beautiful people we have known are those who have known defeat, known suffering, known struggle, known loss, and have found their way out of those depths."
—Elisabeth Kubler-Ross

Ghatool, meaning "tulip" in Pashto, was beautiful – tall, dark-skinned, and with a wide smile and welcoming eyes. As she moved through the village, she attracted the attention of all the older men. But it was to Paiman, a man 20 years her senior, that Ghatool was promised. Both came from families of Hazara and Shia Muslims. As was arranged, they were married – she was 12, about to turn 13, and he was 33.

Their minority Afghan community experienced frequent violence and discrimination, most recently from the Taliban and previously from a host of other Afghan groups. Paiman spoke English, which he learned from studying engineering in Kabul with a scholarship from an American NGO. Being Hazara precluded him from getting a government or private sector job. Upon graduation, he could find no work either in Kabul nor in his village other than cleaning toilets and sweeping streets.

Paiman, his two brothers and their wives, and his mother rented a small plot of rocky land, which they had formerly owned but which had been confiscated by the Taliban government. They were now forced to pay rent. The new owner denied them any water for their crops. The village clinics lacked basic medicines and supplies, and schools were poorly staffed and had no books. Women could not attend school, and their villages lacked electricity and running water. Paiman's family lived on a terraced hillside next to a graveyard of Hazara – many graves belonging to murdered men and women, many of whom were professors and scholars who fought for a better, more equitable life.

Within a year of their marriage, his two older brothers, who had dreamed of moving to Europe, were murdered by a group of village men after being