

Avian Influenza
(The Bird Flu)
A Worldwide Cause for Concern

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for the
International Foundation *for the*
Conservation of Natural Resources
(IFCNR)

April 2004

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AVIAN INFLUENZA

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INTRODUCTION

The yearly ritual of nations attempting to brace themselves against “Flu Season” brings a week or two of fever, coughs, sore throats, runny noses, aching muscles, headaches, abject fatigue and among society’s most vulnerable – the infirmed, the very young and the very old – pneumonia and death. In terms of dollars lost to economies due to the flu in humans, the United States alone tallies some \$71 to 167 billion each year. Worldwide 250,000 to 500,000 humans, 36,000 in the U.S. and 4,500 to 9000 in Canada¹ die from influenza annually, typically but not always most are among the elderly.

While no comparison can be made between the life of a chicken or duck and that of a human being, the toll from avian influenza, “bird flu,” is equally astounding in terms of the animal lives taken and its affect on humans associated with their care. To most who dwell in urban sectors of industrialized nations, outbreaks of avian influenza provide curious news items and a fleeting thought or two over whether or not the price of a daily meal will rise. To those in developed and developing nations alike whose livelihoods depend upon trade in poultry products, avian flu is devastating personally and economically. Health officials familiar with the ever-evolving nature of influenza viruses know too that “bird flu” has the potential for mutating into a lethal form of influenza posing a real and potentially horrendous threat to human lives.

When avian flu was discovered among British Columbia poultry farms, Health Canada envisioned the worst-case scenario predicting that between 11,000 and 58,000 Canadians could die if avian flu jumped from poultry to humans. Highly infectious forms of avian flu are the most destructive to domestic poultry. Conversely, mild variants of species-jumping flu are the most feared by public health officials. Early victims are not sickened enough to seek the confines of a sickbed. Instead they continue to mix and mingle with fellow humans on the job, in schools, at sports events packed with tens of thousands of potential victims where a sneeze or cough spewing airborne infectious droplets at the rate of 150 feet per second, a handshake or contaminated public washroom sink can spread the disease with great rapidity. The globally devastating Spanish Flu of 1918-1919 that took anywhere from 20 to 100 million or more human lives began as a very mild form of influenza.

Typically the urban dweller in a “First World” nation such as the United States thinks of poultry farms in terms of tens of thousands of birds per farm. How else would another tens of thousands of supermarkets keep seemingly endless supplies of plucked and portioned, plastic wrapped poultry ready for purchase day or night? In truth, large poultry farms whether in the United States, Canada, Europe or Southeast Asia are most effective in supplying global mass markets with a bountiful variety of chicken, turkey, duck and other poultry products. According to Dr. He Changchui, assistant director-general and regional representative for Asia and the Pacific for the Food and Agriculture Organization (FAO) of the United Nations, Eastern and Southeastern Asian farmers raise an annual inventory of some 6 billion birds. But, throughout Asia the small farmer is important too. Some 200 million Asian farmers keep between 10 and 100 chickens, ducks, geese, turkeys and quail and provide an important part of the food and income “security” of rural sectors of Asia.ⁱⁱ

Counting only the early months of 2004, avian influenza has already wrought a legacy of economic despair among Asia's large and small poultry farmers. With the end of March roughly 100 million birds, mostly chickens and ducks, died or were culled due to "bird flu" outbreaks in nine countries (Cambodia, China, Indonesia, Japan, Laos, Republic of Korea (South Korea), Thailand and Vietnam) throughout Asia.ⁱⁱⁱ The ability of certain strains of avian influenza to jump across the "species barrier" caused 24 deaths of humans in Vietnam and Thailand as of April 9, 2004.

Canada killed 19 million birds in British Columbia virtually wiping out 80 percent of that province's poultry farmers. In the United States avian influenza caused the deaths of 9000 chickens in Texas and another 400,000 birds in Maryland, Delaware and Pennsylvania. Across the Atlantic, twenty four thousand birds were culled in the Netherlands.

Influenza, whether its target is humans or domestic poultry, migrates swiftly around the world. Wherever it appears, its presence signals health and economic woes. In humans, influenza brings loss of productivity along with its physical ailments. Spread throughout poultry farms, it is devastating. Even to the far distant urban consumer, the rise in food costs caused by bird flu has a powerful ripple effect raising costs among processors, grocers, and restaurateurs.

In any form, influenza is yet one more stressor weighing in against the ability of the world to provide its inhabitants with a plentiful, stable, and secure food supply. It's history as the precursor of pandemics more deadly than combat casualties of all the World and regional wars of the 20th Century compounds the importance of world and national health officials' ability to react quickly to counter the potential of yet another deadly influenza episode. For all these reasons and more, avian flu is indeed a worldwide cause for concern.

Equally as unfortunate a fact of life as is the presence of influenza is the hollow ring to many of the preventative recommendations made by national and international animal health organizations from the U.S. Department of Agriculture, the U.S. Centers for Disease Control, the World Health Organization, the Office International des Epizooties (OIE)/World Organization for Animal Health, Health Canada, and others. In fact, many of the recommended "preventative" measures appear to be dangerously counterintuitive.

Public and animal health officials find themselves between the proverbial "rock and a hard place" in their attempt to mitigate conditions that create potential epidemics and pandemics of avian influenza. Wild birds are known as vectors for the various strains of influenza virus. Culling nature's wild bird species flies against the sacrosanct principles of biodiversity that currently dictate much of the world's public policy regarding environmental protection and the very important role wild birds play in the health and production of agricultural products. However, the only other option, namely, keeping domestic poultry away from "nature" is very unnatural. Sheltering great numbers of birds within enclosed buildings sets the stage for mass flock infections.

This paper presents a summary of current knowledge about influenza, avian influenza and raises questions, some fairly obvious, some difficult, that are not yet part of the public discussion of this very serious food security problem.

A PRIMER ON INFLUENZA VIRUS

Hippocrates first described a disease outbreak among his fellow ancient Greeks that had all the characteristics of influenza in 412 BC. Since that ancient documentation, the “flu” has been as ubiquitous as death and taxes. For millions of humans throughout history, influenza in fact brings the former.

Influenza viruses are members of the Orthomyxoviridae family of RNA viruses. Biologically three types of influenza viruses exist: A, B, and C. Typically, the type A viruses are of most concern among Humans, pigs, marine mammals, and birds. Type B has been found in the seal population, and proves fatal. The Influenza C virus has been reported in swine. A fourth member of the family is the Thogotovirus associated with ticks.

For humans, influenza types A and/or B are the cause of the recurring infamous winter “Flu Season.” In the United States, seasonal epidemics affect approximately 10% to 20% of the human population. Even with the most modern and sophisticated medical treatments available, Americans suffer an average of 36,000 deaths a year. Canadians lose nearly 10,000. Globally flu-related lethality figures are between 5 and 15% of the population causing a quarter to half a million human deaths.^{iv}

While the purpose of this paper is to provide an overview of the impact of avian flu, any work dealing with influenza must bring in references to influenza’s relationship to humans and other animals. Understanding influenza in terms of its historical and biological relationship with humans underscores the importance of dealing decisively with strains of flu carried by and afflicting other animals particularly because some strains of the virus can cross over the so-called species barrier and infect other species, most notably humans.

Tracking the path of avian influenza begins with wild birds. Wild ducks, geese, sea gulls, shorebirds and others in the wild are the avian influenza viruses’ natural host. While wild birds do not get stricken with avian influenza and are typically asymptomatic, they are seen as the key vector for infecting domestic poultry lacking the immunity of their wild cousins.

Some experts estimate that 30 percent of wild ducks nesting in Canada carry the various forms of avian flu.^v In wild ducks, the majority of avian influenza strains replicate in cells lining the waterfowl’s intestinal tract as well as in their lungs and upper respiratory tract.

Migratory over flights or temporary respites at a pond or field by wild waterfowl, unaffected by the influenza viruses they carry, leave infected feces to contaminate farmyards and wild habitat. That sets the stage for infecting domestic chickens, ducks, turkeys and quail lacking their wild cousin’s immunity and for viral mutation into species-jumping strains that threaten human lives.

Scientific knowledge holds that Influenza B viruses circulate most strictly among humans although the World Health Organization’s literature on influenza surveillance suggests it has been found among and can be lethal to marine mammals such as seals.

The greatest focus of human and animal health officials is on type A viruses that infect and sicken humans and non-human animals alike. Among those animals capable of contracting influenza are ducks, chickens, pigs, ferrets, minks, whales, horses, and seals. Pigs are natural carriers of influenza viruses and are susceptible to all of the avian influenza viruses. The variants found in whales, seals and minks are traced back to aquatic birds.

In humans, “Flu shots” help prevent illness from type A and B viruses, but not from type C. Fortunately type C flu viruses cause only mild respiratory illnesses and rarely are linked to epidemics because they appear unaffected by flu vaccines.

Type A viruses differ from Type B viruses by virtue of the fact that they are identified by sub-divisions of proteins found on the surface. Those proteins are called hemagglutinin (H) and neuraminidase (N). The H and N designations are used to sub-type viral strains. There are 15 known H subtypes and 9 N subtypes. Only three subtypes of H (H1, H2 and H3) and two subtypes of N (N1 and N2) are known to circulate widely in humans whereas all subtypes have been found in wild birds.

Of particular importance to humans are A(H1N1) and A(H3N2). A new A(H1N2) strain was typed on 6 February 2002. That variant was identified as a new virus as far back as 1988, circulating in England, Israel, Egypt, and China. The A (H1N2) strain appears to have resulted from a naturally caused rearrangement of genes of the currently circulating A(H1N1) and A(H3N2) viruses.

Influenza viruses are constantly evolving. They undergo major and minor modifications through two different mechanisms: **antigenic drift** and **antigenic shift**.

Antigenic drift is the mechanism responsible for creating the “small changes” in the gene structure of a virus. Both A and B viruses change through this mechanism. Antigenic drift is also responsible for the flu epidemics inflicted upon humans almost every year.

Antigenic drift occurs because influenza viruses lack a mechanism for “proofreading” and repairing errors that occur in the gene coding of their surface proteins (H and N) during replication. Uncorrected errors result in a change in the genetic composition of the virus replacing the existing strain with a new “antigenic” variant that is not recognized by the flu victim’s immune system. Immunity built up from contact with the virus before antigenic drift mixed up its genetic identity becomes useless and the potential victim is once again vulnerable to catching this version of “the flu.” In most years, one or two of the three virus strains in the influenza vaccine are updated to keep up with these changes.

Antigenic shift describes “significant changes” in the genetic structure of a virus and occurs only in type A viruses, including the subtypes that are usually restricted to non-human species. Antigenic shift happens when at least two different strains of virus are present in a host or after transmission of viruses from different hosts. Two individual viruses swap or “re-assort” genetic materials with the resultant “shift-built” virus containing an entirely different number of N and/or H proteins than either of the donor “parent” viruses. If the product of the antigenic shift is indeed a “new” virus never before seen on earth, no susceptible target species (human or non-human) will have prior established immunity. These new viruses created through antigenic shifts are the villains that cause highly lethal pandemics.

The 20th Century saw three influenza pandemics (worldwide infections) among the Earth’s human population. Each swept the globe within one year of being detected. Once a new pandemic influenza virus emerges and spreads, it typically continues to circulate among its victim populations for a number of years.

◆ **1918-19: Spanish Flu [A (H1N1)],** caused the highest number of known flu deaths.

Misnamed due to military propaganda spin attempting to blame Germany for using “germ warfare” by sending the flu across the Atlantic by infecting North American movie theaters and exporting contaminated aspirin tablets, “Spanish Flu” is believed of United States origin. Medical research detectives traced it back to March 1918 when a U.S. Army company cook named Albert Gilbert reported to the Camp Funston (Now Fort Riley) Kansas infirmary with a “bad cold.” Within hours over a 100 soldiers had the same symptoms. Within a month Spanish Flu was in most U.S. cities and landed in Europe with the American soldiers preparing for the final battles of World War I.

Spanish Flu took more lives than all of the battlefield horrors of World War I and the four years of the Black Death/Bubonic Plague from 1347 to 1351. India was the hardest hit with 16 million deaths. The United States lost 675,000 including 43,000 members of its military (more than its combatant casualties from World War I and II, Korea and Vietnam).^{vi} Nearly 230,000 died in Great Britain; 225,000 in Germany; and 166,000 in France. Worldwide estimates of the “Spanish Flu” mortality range from as many as 20 to 50 to 100 million. No one knows for certain the exact toll. Battles could not be waged. Spain’s government closed. Trains did not run. The New York City port was idle. The British Navy could not sail for three weeks. Life expectancy dropped from 51 years in 1917 to 39 years in 1918. Canada, most of Africa and South America, however, seemed immune, as the flu appeared to bypass each.

The Spanish Flu, an apparent mixture of bird, pig and human influenza viruses, was unique compared to other flu outbreaks medically. Nearly half of those who died were young, healthy adults between the ages of 20 and 40. Spanish Flu victims’ lungs filled with a red fluid causing them to virtually drown.

- ◆ **1957-58: Asian Flu [A (H2N2)]**, caused about 70,000 deaths in the United States and a million in total globally. This virus was first identified in China in late February 1957. By June the Asian flu spanned the Pacific Ocean and began its lethal work in the U.S.
- ◆ **1968-69: Hong Kong Flu [A(H3N2)]**, caused approximately 34,000 deaths in the United States and between one and four million across the world. Type A(H3N2) viruses still circulate today.

AVIAN INFLUENZA (AI)

By some estimates there are nearly two dozen known type A influenza viruses. Within the world of influenza, birds are an especially important species precisely because all known A subtypes circulate among but do not sicken wild birds and because wild birds are considered to be the viruses' natural hosts. Those viruses that infect domestic birds lacking the immunity of wild fowl are called "Avian Influenza" viruses.

Type A viruses usually do not make wild birds ill. Direct or indirect contact between domestic flocks and migratory waterfowl – most notably wild ducks, geese, sea gulls, and other aquatic wild birds – can have disastrous consequences for domestic birds.

Avian influenza manifests in two forms. One form causes only mild illness and is known as "low pathogenic avian influenza." Most avian influenza viruses are of this type and typically cause little or no clinical signs in infected birds. When it does, it can be expressed as ruffled feathers or reduced egg production.

The second form is known as "highly pathogenic avian influenza" (HPAI). This form was first recognized in Italy in 1878. In 1983-1984 Pennsylvania was hit by an outbreak of HPAI resulting in the death of more than 17 million birds at the cost of nearly \$65 million. Mexico was hit in 1992 with an outbreak that took nearly three years to control. Pennsylvania has had two smaller outbreaks, one in December 1996 that lasted through April 1998 with the loss of 1.2 million birds and the other from November 2001 to January 2002 where 170,000 birds were killed.

For Poultry, HPAI is extremely contagious, rapidly fatal with a mortality rate between 50% and 100%. It is not uncommon for birds to die the same day that symptoms first appear.

The symptoms for the HPAI are quite varied but include; lack of appetite, ruffled feathers, nasal discharge, coughing or sneezing, and fever. Sometimes birds show weakness and a staggering gait. Hens may lay soft-shelled eggs and then quit laying altogether. Sick birds may sit or stand in a semi-comatose state with their heads touching the ground. Combs and wattles might be blue and puffy with some slight hemorrhaging at their tips. Profuse diarrhea, excessive thirst and labored breathing are also symptomatic. For the highly pathogenic form, studies have shown that a single gram of contaminated manure can contain enough virus to infect 1 million birds.

Introduction of the virus into a domestic flock occurs several ways. The most obvious, that offers the greatest exposure of domestic poultry with contamination from wild fowl, is the farm practice of raising "free-range" domestic poultry where the vulnerable animals roam freely about the landscape. They may share a water supply with wild birds. Droppings from infected wild birds can contaminate unsheltered land and water.

A second method allowing the virus to spread to other flocks is through the movement of infected birds, contaminated equipment, egg flats, feed trucks, and transport of the virus via the shoes and clothing of farm workers and other animals, such as rodents. Limited evidence also suggests that flies can act as yet another vector for spreading the disease.

It must be noted that strains of the influenza virus that are considered examples of "low pathogenic" avian influenza in wild fowl quickly mutate into HPAI among infected domestic poultry. Once introduced into a flock, infected birds excrete the virus in high concentrations in their feces and discharges from the nose and eyes. These secretions contaminate the dust and soil, which if inhaled, quickly, infect the entire flock.

Avian influenza spreads globally several ways. One is through the live poultry trade. Another, as referenced earlier, is via migratory birds, including wild waterfowl, sea birds, and shore birds that carry the virus over long distances between states and nations and excrete it in their droppings.

Avian viruses are relatively common throughout waterfowl habitat. And, they are hardy organisms. The virus is killed by heat exceeding 56 degrees Celsius for three hours or 60 degrees C for 30 minutes. It can survive, at cool temperatures, in contaminated manure for at least three months. In water, it can survive for up to 4 days at 22 degrees C and more than 30 days at 0 degrees C. It is, however, easily killed by a number of disinfectants and soaps, making bioremediation fairly straightforward.

Animal or human health officials should not take low pathogenic avian influenza viruses lightly. Research and history show that when low pathogenic AI viruses are allowed to circulate in poultry populations, within 6 to 9 months the virus can mutate into a highly pathogenic strain. This characteristic is a perfect example of the parallel characteristics of avian and human influenza.

At its onset, the Spanish Flu virus could be described as being caused by a "low pathogenic" virus. As noted, the first case was discovered in a soldier with minor symptoms preparing to set sail for Europe and World War I. The Spanish Flu virus' initial "low pathogenic" character escalated to its becoming highly pathogenic, a killer without a global peer.

As with human strains, low pathogenic avian influenza viruses are disarmingly dangerous. The lack of debilitating symptoms can allow it to circulate and infect numerous birds before intervention with remedial action begins.

During the 1983-84 avian flu epidemic in the United States, A (H5N2) circulated for approximately six months as a low pathogenic strain, then mutated into a highly pathogenic form. This variant had a mortality rate approaching 90 percent. During the 1999-2001 epidemic in Italy, the A (H7N1) virus, also initially of low pathogenicity, mutated within nine months into a highly pathogenic form, causing the death or destruction of more than 13 million birds. The World Health Organization (WHO) recommends immediate efforts to control all outbreaks involving low and high pathogenic strains alike.^{vii}

The phenomenon observed since mid-December 2003 where a growing number of countries have reported outbreaks of highly pathogenic avian influenza in chickens, ducks, several species of wild birds, and in other mammalian species in rapid succession is historically unprecedented and highly disturbing.

Recent Avian Influenza Outbreaks and Impact^{viii}

Countries affected (as of 15 April 2004)

COUNTRY	DATE REPORTED	Type	ANIMALS AFFECTED	HUMANS AFFECTED	PATHOGENICITY
Republic of Korea	17-Dec-03	H5N1	Layers, duck, magpie	No	High
	23-Mar-03	H5N1	Chicken	No	High
Vietnam	08-Jan-04	H5N1	Chicken, quail, duck, muscovik duck	Yes	High
Japan	12-Jan-04	H5N1	Chicken, crow	No	High
Taiwan, Province of China	20-Jan-04	H5N2	Chicken, duck, pheasant	No	Low
Thailand	23-Jan-04	H5N1	Chicken, duck, goose, quail, turkey, stork, house cats, white tiger, leopard	Yes	High
Cambodia	24-Jan-04	H5N1	Chicken, duck, goose, turkey, guinea fowl, wild bird	No	High
Hong Kong, SAR	26-Jan-04	H5N1	Peregrine falcon	No	High
China	06-Feb-04	H5N1	Chicken, duck, goose, quail, pigeon, pheasant, black swan	No	High
Lao PDR	27-Jan-04	H5N1	Chicken, duck and quail	No	High
Pakistan	28-Jan-04	H7N3	Chicken		High
		H9N2	Layers	No	Low
Indonesia	06-Feb-04	H5N1	Chicken, duck and quail	No	High
	24-Mar-04	H5N1	Chicken	No	High
United States of America	11-Feb-04	H7N2	Chicken	No	Low
		H2N2	Chicken	No	Low
	23-Feb-04	H5N2	Chicken	No	High
		H7N2	Chicken	No	Conducting study
Canada	19-Feb-04	H7N3	Chicken	Yes	Low
	09-Mar-04	H7N3	Chicken	Yes	High
Netherlands		H7**	Chicken	No	
	Feb-03	H7N7	Poultry, pigs	Yes	High
South Africa			Commercial poultry	No	Low

THREATS TO HUMANS FROM AVIAN INFLUENZA

To date, three strains of avian influenza virus are known to jump the species barrier from birds to other non-human animals to humans with the result of illness and death among humans. Of the three, the A (H5N1) variant is the most lethal.

A (H9N2) is not highly pathogenic in birds, however it did cause mild illness in two children in 1999 and in mid-December 2003. Each incident occurred in Hong Kong.

A (H7N7) is the second strain to jump the species barrier with the infection of 83 poultry workers and their families in the Netherlands in February 2003. This strain infects pigs and humans.^{ix} The vast majority of its human victims (79) contracted conjunctivitis. Six of those infected individuals also reported flu-like symptoms. Three others exhibited either flu-like symptoms or other mild illnesses that could not be classified as flu-like or conjunctivitis. A 57-year-old veterinarian visited one of the infected farms early in April of 2003 and died April 17 of that same year of acute respiratory distress syndrome associated with the virus.^x

Canada reported its first human cases of the A(H7)^{xi} strain on 5 April 2004. Both cases were poultry workers in British Columbia. The first individual was culling infected birds when he “may have been accidentally exposed in the eye.”^{xii} Consistent with the A (H7N7) strain, the worker developed conjunctivitis and nasal discharge. He was treated and the symptoms were fully resolved. The second worker developed conjunctivitis after close contact with infected birds. He too was treated with all flu-like symptoms successfully countered.

A (H5N1) is the first avian influenza variant to jump the species barrier and accounts for most of the avian flu outbreaks in Asia. The lethality of this strain makes it one of the most troubling to world health officials. Approximately 68 percent of humans infected with A (H5N1) die.^{xiii}

In 1997, 18 people in Hong Kong contracted the virus. Six died of severe respiratory disease. Within three days, Hong Kong’s entire poultry population, estimated at 1.5 million birds, was destroyed to reduce opportunities for further direct transmission of the virus to humans.^{xiv}

As of 15 April 2004, a total of 34 humans contracted the A (H5N1) strain of the bird flu, according to the World Health Organization. Of these 34 confirmed cases, 23 died. All occurred in Southeast Asia with 12 cases and eight fatalities in Thailand, and 22 cases with 15 deaths in Vietnam.^{xv} Each of the Vietnamese incidents involved direct contact with infected poultry within three days of when the symptoms began to develop.^{xvi}

It should be noted that the fact that the highest rate of human infections with the A (H5N1) virus are found in nations where 80 percent of poultry production is on small farms and backyard holdings makes implementation of effective control measures extremely difficult.

Two mechanisms exist for the transmission of Avian Influenza to humans.

- DIRECT TRANSMISSION: BIRD TO HUMAN
- INDIRECT TRANSMISSION: HUMAN TO HUMAN

Direct Transmission requires that humans must come into direct contact with diseased birds carrying a form of avian influenza capable of jumping from bird to human victims. Individuals working in the poultry trade are at the greatest risk from the virus being transmitted by means of fecal or nasal discharge to a victim’s mucus sites (mouth or eyes). Once the virus becomes airborne it can land on the

exposed surfaces of the mouth, nose, eyes or being inhaled into the lungs.^{xvii} The U.S. Centers for Disease Control recommend use of disposable particulate respirators in addition to other protective equipment.^{xviii}

Indirect Transmission has a number of intermediate steps before the avian virus mutates into a form where humans are capable of passing it onto other humans.

Two barriers traditionally keep viruses relatively species specific. The main condition required before a virus can be passed from one species to another is the fact that a live virus must be effectively transmitted from the host to the victim. Fortunately, numerous mechanisms in live specie bodies and the environment frustrate easy transmission.

The second hurdle relates to mechanisms that bar effective dissemination among a non-originating species' population. For an influenza strain originating in a non-human species to become the cause of a human pandemic, the virus must undergo "genetic reassortment."

Genetic reassortment is the process where a virus incorporates most of the genes of a human virus while at the same time, altering or maintaining its own hemagglutinin and/or neuraminidase (surface proteins). The resulting 'new' virus is capable of being transmitted from one human to another while donning a surface protein to which humans have no immunity. This reassortment of genetic structure is an example of an antigenic shift.

Although antigenic shift occurs rarely, it has long been thought that one condition favorable to the process is humans living in close proximity to domestic poultry and pigs. Because pigs are susceptible to infection by both avian specific and mammalian viruses, including human strains, they serve as a critical "mixing vessel" for the scrambling of genetic material from both human and avian viruses.^{xix} Evidence is also mounting that, for some of the 15 avian influenza viruses, humans themselves can serve as those "mixing vessels," driving the need for effective culling of infected flocks and bioremediation measures where humans are in close contact with a high number of infected poultry.^{xx}

There are only two or so cases in this new wave of avian influenza with the markers of a human-to-human infection, raising the fear that one of the highly pathogenic avian influenza viruses managed to cross the last barrier to human infection.

The first such case involved a family in Viet Nam. On 2 February 2004, the World Health Organization's global influenza program announced that avian influenza was identified in three women of a family that lost a male relative to avian influenza. At the outset of the investigation it was not clear whether the women came in direct contact with infected poultry or not. Investigators found one woman may have contracted the disease when she prepared a wedding meal of duck. More troubling was the fact that the other two women cared for the man who died of the disease. WHO officials feared close contact between the infected male and his female relatives was the mode of transmission. Because the virus in all three cases contained only avian genes and no human genetic material, WHO researchers concluded that transmission had to be direct.^{xxi}

An as yet unresolved incident in the Netherlands is potentially more troubling. More than 80 individuals came down with the highly pathogenic A (H7N7) strain in 2003. Dutch authorities reported evidence of possible transmission of the virus from two of the poultry workers to three family members. All three family members contracted conjunctivitis and one had additional influenza-like illnesses.^{xxii} It does not appear at this time that additional individuals had contracted the virus. There is no further information as to whether the virus strain was mapped and if so, if it contained avian, human, or mixed genetic material.

The Centers for Disease Control and Prevention, in a brief *Fact Sheet*, cited evidence of two additional cases of suspected human to human transmission of avian influenza in the late 1990s. The first was in

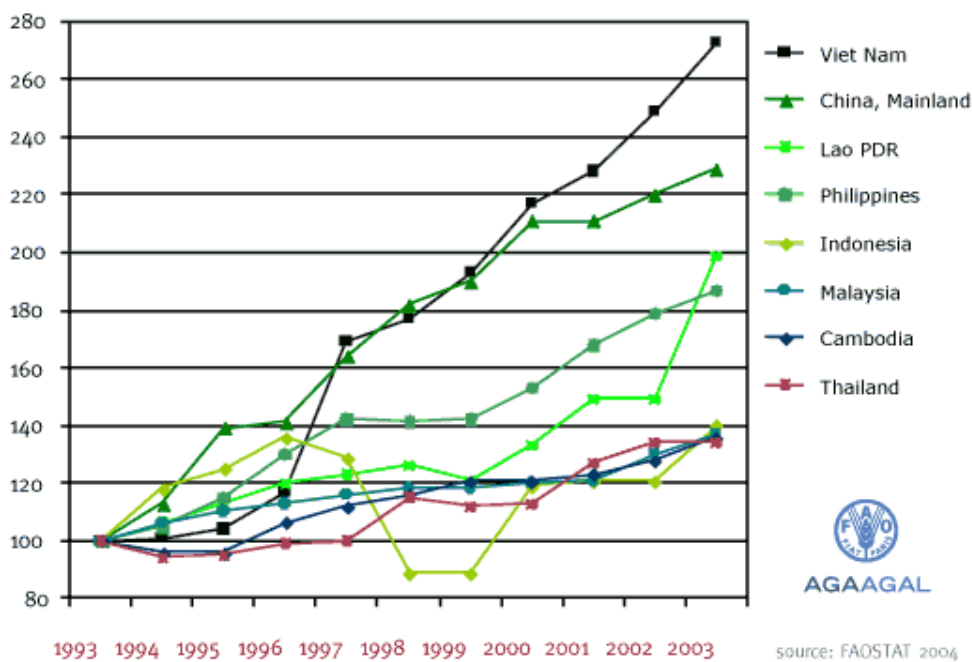
1997 during an outbreak of A (H5N1). During this outbreak, 18 people were hospitalized and of those six died. It was noted that person-to-person infection may have occurred. With those cases, individuals who were infected by other people tended to have less severe symptoms and the chain of infection appeared relatively short.

In 2003, two members of a Hong Kong family that had visited China contracted avian influenza A (H5N1). One recovered, the other died. It is unclear how these individuals were infected. One additional family member who stayed in China died of a respiratory illness but no testing was ever done and no further cases have been reported.

Separating humans from infected poultry is a commonsense preventative measure. However as Figure 1 illustrates, poultry production contributes greatly to the economies and food supplies of the most highly affected countries. For this reason, appropriate culling measures may be additionally difficult to implement.

Figure 1^{xxiii}

Growth in Poultry Meat Production SE Asia



Economic considerations aside, efforts to eliminate diseased birds should not be curtailed. Failure to contain avian flu strains that threaten to cross the barriers to human infection enable the potential of yet another worldwide episode to occur. Available evidence increasingly points to a heightened risk of transmission to humans when outbreaks of the A(H5N1) influenza are widespread in poultry. That is, as the opportunity for contact increases, so do the chances of human infection.

The danger with increased rates of human infection is that the risk increases for a new virus subtype to arise reprising a global tragedy with astounding numbers of human casualties such as the world encountered with the 1918-1919 Spanish Flu pandemic.

ECONOMIC IMPACT OF AVIAN INFLUENZA

When assessing the impact of an event such as the global spread of avian influenza (AI), economic considerations rank high on the list of concerns. However, there is a relative scarcity of figures as to its projected global economic impact. Although desirable, meaningful figures are very difficult to derive and there are several very good reasons why.

The first reason is that the various strains of avian flu virus have not been eradicated. They continue to spread from one flock to another, one nation to another. One form or another of the virus will appear to die out in an area only to reappear several months later. In Italy during the 1999-2000 outbreak of the highly pathogenic strain, four months after the outbreaks appeared to have been abated, the virus returned in a low pathogenic form and caused 52 additional outbreaks.^{xxiv} For this reason alone, a meaningful assessment other than one that is a “snapshot” of a specific period in time is difficult. This random pattern can be seen in the repeated declarations by nations that avian flu has been “eradicated” within their boundaries one week only to see a new incident reported the next.

David Halvorson of the University of Minnesota^{xxv} draws attention to an additionally complicating issue. The cost of low pathogenic avian influenza is significantly lower than the cost of the highly pathogenic form in terms of destruction of poultry and its impact on the poultry industry of a region. Halvorson, et. al, speculate the difference may be as great as 100-fold. Primary factors that drive the cost differential between the low and high pathogenic varieties are the control measures employed and the public’s reaction to an outbreak.

The opposite appears to be true when attempting to apply standards of measurement of cost when looking at avian flu strains that traverse the species boundary and afflict humans. Then the potential of infection increases with the low pathogenic variant versus that of high pathogenic strains. Infected humans not ill enough to be confined to bed spread the flu virus throughout their sphere of human activity. Cost of lost productivity, medical treatment, etc. increases economic loss however tracking those amounts suddenly becomes very tentative as those manifesting mild symptoms are found farther away from the epicenter associated with an avian origin.

Looking at losses incurred directly from the illness of commercial poultry one has to differentiate between high and low pathogenic outbreaks. There is a broader menu of control measures that can be used to contain contamination by the low pathogenic virus than with the HPAI. In the Minnesota outbreak, control measures ranged from monitoring to biosecurity redemption to controlled marketing. The cost was approximately \$2 a bird with additional costs due to delayed replacement of the flock. When destruction of the flock is practiced, the cost will be bird value. In the case of egg producers you must consider the additional cost of the loss of production. Should it become necessary to cull the flock, the economic impact will range from \$1 to \$2 a bird for broilers to more than \$100 a bird for turkey breeders.^{xxvi}

In an outbreak of highly pathogenic AI, there is no option but to destroy the flock. Because the virus is so easily transmitted, typically neighboring flocks are quickly destroyed to contain the contamination. For example, in the Gonzales County outbreak of the A (H5N2) virus in February 2004, inspectors were able to trace the origins of the virus to two live bird markets in Houston. To control the spread of the virus, both markets were depopulated, cleaned, and disinfected. As a precaution, three additional live bird markets in the Houston area were also depopulated, cleaned, and disinfected.^{xxvii} This containment strategy, naturally, raises the economic costs exponentially. The recent outbreak in Italy resulted in \$112 million in compensation for destroyed birds, but it was estimated that the indirect costs of the outbreak topped \$400 million.^{xxviii}

For both high and low pathogenic strains, it is common practice to allow the birdhouses to remain empty for a time, which can be a substantial cost to poultry producers. For a 10,000-bird turkey house to

remain empty for a week costs about \$1,600. It is recommended that an infected house remain closed for close to six weeks. However, Halvorson, et. al. argue that this is a more cost effective measure than repopulating the flock to have it re-infected, necessitating its destruction.^{xxix} Another alternative that can raise costs significantly is the razing of older birdhouses and replacing them with new structures. A new birdhouse structure can cost from \$20,000 to \$175,000 each in the United States.

Finally, always a difficult issue is how to measure the human impact.

When a poultry house is closed for a period of weeks or destroyed and rebuilt, more than the income of the poultry farmer is lost. Farm workers tending the birds or growing feed are idle. Truck drivers paid to transport birds to processors have no fares. Processing lines are shut down. Refrigeration transport from processor to retailer stands by with no product to ship.

There are additional costs of virus control. As mentioned, clean up costs (biosecurity), testing of 'suspicious' flocks, vaccination, and increased veterinary care are but a few.

In today's litigious society, another area of potential cost must also be taken into account. That is the issue of potential liability, which brings legal fees and insurance costs. The Insurance Information Institute issued a topic sheet on the potential impact of avian influenza on the insurance industry. Here they are speculating about potential cost risk areas.

- First is the issue of worker's compensation for individuals infected with the virus where that benefit is available.
- A second concern is tort-related exposure or legal liability if the infected poultry finds its way into the food supply and makes someone ill.^{xxx} The threat of a lawsuit is always a possibility even though the World Health Organization does not feel that processed poultry or eggs from infected birds pose a health threat to humans.^{xxxi}

One precaution that consumers should take is to fully cook poultry to a minimum internal temperature of 60-70 degrees Celsius (This is a lower temperature than recommended to remove most other bacteria, which is 77 degrees Celsius).

- However, what the Insurance Institute did not calculate was the cost to family, friends, and communities of the loss of human life, not only in terms of economy but emotional suffering as well.

The Delmarva Peninsula is the tri-state area of Delaware, Maryland and Virginia on the Eastern shore of the Chesapeake Bay where the recent round of avian flu first struck in the United States. It is touted in local literature as the birthplace of modern poultry production and is home to some 1824 commercial poultry farms of significant size. Roughly 15,000 local residents are employed in some phase of poultry processing. According to a 1998 Price Waterhouse study, each poultry-processing job creates 7.2 additional indirectly related jobs. For Maryland, poultry growers contribute 37 percent of that State's agricultural industry. Their share is put at \$600 million of Maryland's \$1.6 billion farm revenues. In national standings, Maryland ranks seventh in broiler production.^{xxxii}

The next most immediate negative impact of an outbreak of avian flu for a poultry producing area over and above local loss is the shutting down of international markets. At present (15 April 2004), 50 nations have some type of ban operating against the import of poultry products from the United States. Some nations placed a ban on the import of poultry from the United States in its entirety while others banned the import of poultry coming from known avian flu infected states.

U.S. broiler chicken exports were expected to total about 5.3 billion pounds this year, up 7 percent from 2003 until the bans were set in place. The U.S. exports about 15 percent of its chicken, which was worth \$2 billion last year alone.^{xxxiii} However, things may be looking up for the U.S. poultry industry as the EU recently announced that it was loosening its ban on poultry imports.^{xxxiv}

In spite of the good news, stock prices of top U.S. poultry companies fell at the end of February 2004 as one nation after another announced their trade bans. As the reversal of the decision by the E.U. demonstrates, the trade bans may not last for the entire year and nations are modifying the conditions of the bans.

However, a lingering concern is that while the general ban continues on the export of U.S. beef with the bans on poultry, the U.S. will see a protein glut this summer. A large surplus should serve to drive prices down. The pork industry has already seen a small slide in stock prices due to the 'meat glut' speculation. Smithfield Foods Inc. saw its shares drop 13 cents in spite of a positive earnings report^{xxxv}

Pakistan recently issued a report noting that the bird flu scare cost the industry approximately Rupees 5.4 Billion (as of 1 April 2004, \$94 million).^{xxxvi} This is not just in the cost of flock depopulation and decontamination, but consumer demand had plummeted. Halvorson's cost wild card.

In addition, the World Bank estimated, for Vietnam only, that the cost to the economy may be about 0.3% of GDP or the equivalent of US\$116 million.^{xxxvii} But, using a worst-case scenario, assuming a six-month loss of output and a decline in tourism similar to that of SARS, that cost skyrockets. They estimate that the economy could lose 0.9% of GDP. When combined with the loss of capital due to culling all of Vietnam's flocks, the cost increases to US\$680 million or 1.8% of Vietnam's annual GDP. As Halvorson indicated, cost clearly correlates with disease containment strategy, which correlates with the virus type.^{xxxviii}

WILDLIFE, GAME BIRDS, AND AVIAN INFLUENZA

As previously discussed, wild birds are the natural carriers of avian influenza and are the natural means of the global dissemination of the virus. The question is whether massive culling of wild birds ought to be employed as a preemptive measure to contain the further spread of the virus.

In the *FAO Special Report on Avian Influenza*, it appears that the experts discussed this strategy. They concluded that wild birds perform critical functions in the environment, primarily controlling crop pests. Without birds performing their natural function in the environment, crops could fail, leading to massive famine. In essence, this is analogous to the cure being worse than the disease. Instead, the recommended strategy is to keep wild birds and domestic flocks separated as much as possible. In addition, states are encouraged to implement vaccination programs, limit the trafficking of wild birds, prohibit the mixing of wild and domestic birds in live markets, and establish and encourage widespread education and surveillance programs.^{xxxix}

That strategy may appear the only option available, but is it practical, workable, and capable of achieving success? A close look suggests it is none of those. The Delmarva Peninsula is in the geographic middle of the path of the migratory flocks of hundreds of thousands of Canada geese, swans and ducks known as the Chesapeake Region of the Atlantic Migratory Flyway. Wild waterfowl winging their way from flu rich Canadian nesting fields are ubiquitous throughout this important poultry producing region.

As for commercial gamebird and ratite (emus, ostriches, etc.) producers, their flocks are uniquely exposed to potential carriers of the virus. Many gamebird producers condition their birds for release by placing them in screened-in flight pens. If not carefully maintained, small birds and rodents gain access and can potentially expose the stock to the virus. Small birds can be carriers of the virus, while rodents can carry the virus on their fur and feet. Ratites are usually allowed access to open range, making it nearly impossible to completely isolate stock from other avian species.

Avian influenza has already infected some gamebirds and ratites. Short of vaccinating every bird at a tremendous cost, agricultural extension service advisories recommend certain commonsense preventive measures that can be undertaken to reduce the risk of infection or the spread of the virus.

Recommendations for avian flu prevention among game bird and commercial poultry producers are identical.

- Move or locate new facilities away from ponds or other waterways. Migratory waterfowl are the prime candidates for the global spread of the virus. Also, do not allow these fowl to feed in or near your facilities.
- Make facilities 'unfriendly' to wild birds. For example, reduce feed spillage and dispose of old feed, do not allow sparrows or starlings to establish nesting areas around the facility, and repair all holes in flight pen screening.
- Isolate breeding stock from offspring and keep them in confinement.
- When farm workers visit birds, they should visit the most valuable birds first, then move to the less valuable. Never reverse the process during the day unless you or they bathe and change clothing and shoes.
- Finally, stay away from other gamebird and ratite farms, clean equipment, practice good waste management, provide foot baths containing disinfectant at the entrance to all rooms or pens, and contact local extension offices immediately upon finding sick or dying birds.^{xl}

Game bird breeders believe they are doing the environment a service as well as making a living or supplementing income from regular jobs when they raise and sell their birds to clients. Some purchasers are dog trainers, some run game shooting reserves, and some are landowners who simply enjoy the tranquility of stocking a pond or hedgerow with quasi-wild animals. Others openly buy birds for the specific purpose of releasing them into the wild.

State wildlife biologists cringe at the idea of releasing game birds in areas inhabited by poultry farms. Their fear is the potential of these birds acting as virus vectors of infection.

The intrinsic problem with these recommendations is that they are somewhat self-delusional. Isolating commercial poultry or domestically raised game birds from wild migratory fowl simply won't happen in any way that is economically viable. Attempting to apply what amounts to sterile technique to farm practices in terms of avoiding contamination from virus-infected matter being kept from clothing, dirt stuck to shoes or farm equipment tires, feed, water etc. is again a good idea whose translation into action is unlikely to occur.

Two obvious approaches are rarely addressed or if they are they are glossed over as impractical. They are elimination of the virus via vaccination and in the alternative providing domestic poultry with the same immunity evidenced by their wild relatives. By pretending that the "preventative measures" of isolation will in fact provide protection to animals and humans alike, world health officials are opting for an ostrich-like "head in the sand" strategy than one that aggressively seeks answers to as yet unsolved problems. Maintaining the status quo and hoping for a change is foolhardy and potentially quite dangerous. Embarking upon the path of scientific discovery tied to attacking the virus or building immunity in potential victims offers real hope.

Conclusions for Concern

On 16 March 2004, Dr. Anirfi Asamoah-Baah, Assistant Director-General, World Health Organization Communicable Diseases, presented in an opening address before the meeting on influenza pandemic preparedness, some unsettling conclusions.^{xii}

- First, the strain A (H5N1) is causing death and disease in an “unusual range of mammalian species.” Migratory birds are being found dead and have tested positive for the antibodies. Cats, pigs, and zoo tigers have all tested positive for the virus or antibodies.
- Second, the virus does not show signs of being eliminated globally and as long as it is present in poultry populations, there is a risk that the virus can mutate.
- Third, there are three prerequisites for the start of a pandemic.
 - First, a new virus must emerge to which the population has little to no immunity.
 - Second, the virus must be able to replicate in humans and cause disease or illness; that is, operate effectively in humans.
 - Finally, that the new virus can be efficiently transmitted from human to human.

We have, at present, met two of the three conditions and when or if this last condition is met is entirely unpredictable.

“We live in a world where health resources are unevenly distributed. This is a bleak reality of global public health. The regions where populations are the most vulnerable are often those where surveillance is weak, where local economies have already suffered, where drugs are in short supply, and where resources to purchase vaccines and drugs are limited. Yes, it is in these countries where you might find the greatest opportunities to slow a pandemic.”^{xiii}

If another influenza pandemic is inevitable, as some argue it is, the policies and procedures established now will help us in the future to contain its global impact. The world must be better prepared. If farmers or health officials are to look at the state of “preparedness” to thwart future outbreaks of avian influenza the report would of necessity be in the “failing” category.

The current animal health lore, as noted earlier, urges farmers and nations to make domestic poultry production operations “unfriendly to” and “isolated from” access by wild birds. Further precautions urged on the world’s farmers not to contaminate healthy poultry flocks with avian flu from water supplies, dirt, clothing, etc. continue to build a futuristic vision of poultry farming as something akin to the austere and sterile conditions of microchip manufacturing.

The economics involved in mass vaccinations, confining birds in “virus proof” shelters, and safeguarding against human transmission of avian influenza to the flocks are unrealistic. Recommendations suggesting that poultry farms be located in regions away from migratory bird flight corridors are equally implausible.

The combined efforts of Delmarva’s poultry producers as well as biologists from federal agencies and three state agriculture and wildlife departments cannot divert migratory waterfowl from centuries old flyway. They certainly will not opt to relocate a culturally entrenched poultry raising and processing industry out of the flyway path. And, it should be remembered that the Atlantic Migratory Flyway is but one crossing the United States, Canada and points south. Migratory flight paths of wild birds encircle the globe from the Americas to Europe to Asia.

It is also a safe bet that if U.S. poultry growers find it difficult to practice “sterile technique” in their day-to-day farm chores, certainly Asia’s 200 million small poultry farmers will prove equally incapable of practicing that same sterile technique in caring for their miniscule but economically important flocks.

Keeping domestic poultry in confinement may provide one measure of safety against direct contamination by wild birds. However, at the same time, confining great numbers of birds under one roof sets the stage for massive infections and die-offs should one or more strains of the elusive and determined avian influenza virus slip past the safety measures and infect a single bird.

How to deal effectively with avian influenza is not hopeless. In fact, as noted earlier, there are a number of points to consider that offer considerable hope.

STEPS TOWARD THE FUTURE

Step 1: Inventory Production Techniques

The first step toward a hope filled future is to take a step back and re-evaluate poultry production techniques.

The poultry industry must take a step back and take a hard look at every element of its business from feed to housing to raising the animals to processing and everything in between. Nothing can be ignored or glossed over.

National and international agricultural animal health officials currently recommend segregating commercial poultry from their wild counterparts. As noted the move “away from nature” may not be the correct path to pursue. The further organisms – human or non-human – get from nature in terms of nutrition, socialization, living conditions etc. the greater the stress load they tend to endure. More stress traditionally equates to diminished immunity from disease and opportunist viruses such as avian influenza.

Employing an objective inventory of these elements has the potential of identifying points of vulnerability to contamination and infection. Investigating the redesign of each sector including feed in terms of nutrition, production, transportation, storage and distribution; housing, occupant density, lighting, and ventilation; live-bird transportation and processing to closer mimic or duplicate nature may result in determining more effective measures to prevent infection and perhaps in a more hardy, disease resistant animal.

Step 2: Genetic Research

Today hybridization is the name of the commercial poultry game. Broilers and layers are among the most highly genetically manipulated organisms in the world, albeit by traditional crossbreeding methods versus the gene-implanting shortcuts biotechnology allows today. Modern poultry hybrids are about as far from their wild cousins as Wall Street brokers specializing in risk arbitrage are from North Carolina tobacco farmers.

Quite literally the genetic engineering of farm animals into high production quality “food animals” has left traditional farm species of chickens, ducks, geese, and turkeys that were common on farmsteads for hundreds of years up until the mid to late 20th Century as among the most endangered species on earth.

Just as the survival skills of the Wall Street trader left alone in the Amazon basin might be found lacking, so do, one might surmise, would be the ability of modern poultry to survive in the wild. Still, it should be remembered that today’s roaster wrapped in plastic with a pop-up thermometer in its breast is genetically descended from Asia’s wild fighting chickens.

The point? Perhaps running away from nature may not be the correct direction. That statement must not be construed as the regurgitation of extreme animal rights or environmental ideologies. It’s part of a larger question that must be posed to animal health scientists.

Behavioral science, for humans and non-humans alike, demonstrates that “unnatural” stressors precipitate reduced immunity to disease. If we push our domestic poultry even farther from “nature” are we doing them a service or simply making them more vulnerable? If the latter is the case, the argument can and should be made that poultry production techniques must be re-examined from top to bottom. The vertical nature of the poultry business – from egg, to chicken, to slaughter, to processing into “family packs of wings, thighs, and breasts” – should be assessed to determine if the now-recommended flight from nature is warranted.

It is the belief of the authors of this paper that fleeing nature is a result of looking at the issue of avian influenza from the wrong point of view. Given the advances and tools of modern biotechnology, the opposite approach appears to offer the greatest promise for everyone concerned.

In nature, the wild cousins of today's hybrid domestic poultry are little bothered by avian influenza. They have hardy immune systems that present a defense against illness and death from the various strains of AI virus. The question among public health officials should be "how can domestic poultry acquire that same immunity"; not how can we segregate domestic fowl farther from nature. That is where the stalwart men and women of genetics enter the scene.

Tasking the considerable force of investigators working in the field of genetic biotechnology with isolating the genetic material that enables wild birds to live healthy lives in the midst of a murky soup of avian influenza viruses and transferring that protection to domestic poultry appears to be a potentially fertile field of research.

Another area where biotechnology may help is with the issue of vaccines and vaccination of domestic poultry.

Given the fact that human flu vaccines vary in their composition and effectiveness depending upon the strain of flu expected to assault human habitat, the question arises regarding just how practical pursuing the idea of vaccinating literally millions upon millions of domestic poultry may prove. The cost in developed nations will be astronomically high. For Third World poultry producing nations where the poultry population is raised on small, isolated farms, overseen by poor families and poor nations mass vaccination campaigns are beyond unrealistic.

How to wage a cost effective mass inoculation campaign appears once again to be research meat for the table of genetic investigators bent on answering the question: If wild fowl can develop immunity to a variety of AI virus strains, why can't a vaccine be developed with similar abilities?

If geneticists can provide an answer, they are quickly faced by yet another, namely how to create a cost effective and efficient mass inoculation system affordable by First and Third world poultry farmers alike. Immunizing multiple billions of chickens, ducks, turkeys, quail, and other domestic farm fowl is not as easy as lining up a regiment of soldiers. Poultry tends to ignore such orderly conduct. Here too the answer may well be found in biotechnology.

The concept of genetically engineering crops to produce and deliver vaccines for human afflictions certainly can be adapted to poultry, if, and it is a big if, vaccination is the route preferred over tweaking the immune systems of modern agriculture's hybridized food animals.

Biotechnology appears to be a hope-filled path to pursue. However, it is not one without its highly audible and influential critics. The campaigns of protest now alleging the potential of environmental and health problems with genetically modified crops will undoubtedly hound efforts to conquer avian influenza through biotechnology. Critics of biotechnology are persistent, if anything, in their skepticism over the merits of biotechnology to improve the lot of human, animal, and plant health.

Certainly, there is an opportunity cost in dealing with the concerns of anti-biotech groups such as Friends of the Earth and Greenpeace as their objections potentially can cause delays in the process of devising a creative and alternative means of dealing with avian influenza.

Modern agriculture, the various government agencies overseeing agriculture and animal welfare, and genetic researchers need a coordinated strategy that addresses research needs, public policy, and risk analysis. The only caveat is that the strategy employed in countering negative criticism must avoid both

scientific technical jargon incomprehensible to the public and the techniques associated with product or brand marketing and advertising as well as traditional Public Relations "spin."

If biotechnology is to be allowed to address the very real problems associated with avian influenza, it must win support among consumers, policy makers and the press via a credible and persuasive campaign of ethical advocacy. Any less will result in years of acrimony and potentially the same sort of consumer and public policy manipulation that brought about the five-year ban on genetically enhanced foods throughout Europe.

If public health officials are to make real inroads in protecting poultry and humans alike from the scourges of avian influenza, it is recommended that they begin to search for longer-term, creative ways to deal with the virus. We recommend they shift focus away from emergency remediation and containment policy to finding in nature what keeps nature immune. We believe that on its face this is far more promising than attempting to hide one's chickens from over-flights of wild fowl.

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