UNDER THE MICROSCOPE:

THE NEW FACE OF FOOD-BORNE ILLNESS

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Biographical details

Dr Griffiths was born and raised in Swansea, S. Wales. He took his BSc degree in Applied Biology at North East London Polytechnic and his PhD was obtained from Leicester University where he studied the biochemistry of thermophilic microorganisms under the supervision of Sir Hans Kornberg.

Dr Griffiths was appointed to the staff of the Hannah Research Institute, Ayr, Scotland in 1974 and, in 1980, he was appointed head of the Dairy Microbiology group. In 1990 Dr Griffiths was appointed Chair in Dairy Microbiology in the Food Science Department at the University of Guelph. Dr Griffiths' chair is funded jointly by the Dairy Farmers of Ontario and the Natural Science and Engineering Research Council of Canada (NSERC). Dr Griffiths is Program Chair for the M.Sc. in Food Safety and Quality Assurance being offered at Guelph and he has recently been appointed Director of the Canadian Research Institute for Food Safety.

His current research interests include rapid detection of foodborne pathogens; factors controlling growth and survival of microorganisms in foods; and beneficial uses of microorganisms. Dr Griffiths has authored more than 150 peer-reviewed articles.

Dr Griffiths is an Associate Scientific Editor of the Journal of Food Science and serves on the editorial board of Food Research International, Journal of Dairy Science, Journal of Food Protection and International Journal of Food Microbiology. He is also a member of the Management Board of Journal of Food Protection. He is on the editorial boards of the Encyclopaedia of Food Microbiology and Encyclopaedia of Dairy Sciences. He is a member of two International Dairy Federation Expert groups and serves on the Expert Scientific Advisory Committee for Dairy Farmers of Canada. He is a member of the working party on Academic Education in Food Microbiology of the International Union of Microbiological Societies and was the G. Malcolm Trout visiting scholar at Michigan State University in 1999.

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There is now epidemiological evidence that there are as many as 76 million cases of food-borne illness occurring annually in the U.S., resulting in about 325,000 hospitalizations and 5,000 deaths. As well as this immense social impact, there is a large economic burden resulting from health costs and loss of productivity. It has been estimated that illness linked to just 7 pathogens (i.e. *Clostridium perfringens*, *Escherichia coli* O157:H7, *Listeria monocytogenes*, *Salmonella*, *Staphylococcus aureus* and *Toxoplasma gondii*) costs the U.S. economy approximately $US 35 billion each year. When you take into consideration that this does not include the leading cause of food-borne illness, *Campylobacter jejuni*, and that there are about 40 known microorganisms linked to food-borne illness, the true economic costs may be substantially higher. As a rule of thumb, because the size of the Canadian population is about one tenth that of the U.S., we can predict that annually in Canada there are approximately 7.6 million cases, 35,000 hospitalizations and 500 deaths from food-borne illness; at a cost to the Canadian economy of more than $CDN 52 billion.

This is not just a North American problem. Food-borne illness is on the increase worldwide and food safety is taking centre stage in the globalization of trade in food commodities. There have been several international trade disputes over issues linked to food safety. The most recent example is the ban the French have imposed on the importation of British beef because of the fear of bovine spongiform encephalopathy (popularly known as "Mad Cow" disease) and its link to the variant form of Creutzfeld-Jacob disease. This ban has remained in place despite rulings by the European Union stating that British beef is safe for consumption. The issue of food safety is also high on the agenda for the "Seattle Round" of the World Trade Organization negotiations.

There are many factors that have led to the increase in food-borne illness. Changes in farming, processing and retail practices have exerted a pressure on the food chain. Intensive rearing of animals has made the spread of food-borne pathogens easier and has made the adoption of good husbandry practices essential to minimize the risk of infection. The consumers' appetite for "healthier", more natural foods has led to an increased reliance on the cold chain to maintain the safety of foods. This burgeoning demand for low-fat, less salt, sugar-free food has meant that we are removing many of the components of food that inhibit the growth of bacteria. For example, *E. coli* O157:H7 survives slightly better in extra-lean than in regular ground beef. The health-food kick has opened up another can of worms. Are these products to be regulated as foods or pharmaceuticals? A survey conducted by researchers at Health Canada has shown that about 10% of these products had microbiological counts in excess of 1 million/g and nearly 18% had coliform counts above 100/g. Clearly something needs to be done to improve the quality of these products.

As the number of food companies dwindles due to acquisitions and mergers, there has also been a tendency to centralize processing sites and this has meant that foods have to travel longer distances to reach their ultimate destination; a practice that places even greater pressure on the refrigeration units required to keep food cold. In addition, we are eating-out more often than previous generations and so we are increasingly dependent on the hygienic practices of others to insure that the food we eat does not become contaminated.

Populations are becoming more mobile. We are traveling abroad to "exotic" locations in greater numbers. At our destinations we are exposed to new foods containing microorganisms that we may not have encountered before. Thus, traveler's diarrhea is a relatively common phenomenon and we may bring back more than just our suitcases from these journeys. In its new surroundings, the "bug" has a field day due to the lack of immunity in the population which is now exposed to its delights. It is not just people that travel. As mentioned previously, there has been an explosion in international trade in agri-food products and we are at the mercy of food production and processing practices over which we have little control. There have been several examples of food-borne illness linked to imported foods, such as *Salmonella* in Mexican cantaloupe melons, *Cyclospora* in Guatemalan raspberries etc. However, Hazard Analysis Critical Control Points (HACCP) is becoming the cornerstone of legislation aimed at insuring safe food production and processing practices globally.

As we grow old our immune system becomes less able to combat infections, and this becomes significant as the average age of the Canadian population increases. It has been projected that by 2025, the largest sector of Canadians will be between 60 and 64 years old. This population aging phenomenon is being observed in all industrialized countries. In the U.S., the number of people over the age of 75 has more than trebled between 1950 and 1990. Other sectors of the population also have compromised immune systems. These include pregnant women, the young and those already suffering from illness. The latter group may include people suffering from autoimmune diseases such as AIDS, or include those undergoing chemotherapy to combat cancer, or taking immunosuppressant drugs to prevent rejection of organ transplants. Again, using U.S. data, the number of AIDS patients over the age of 13 has risen from about 30,000 cases in 1988 to about 230,000 cases in 1996 and the number of people receiving organ transplants has nearly doubled in the same period. These demographic trends will ensure that food-borne illness remains a problem well into the 21st century.

Better detection and surveillance systems for food-borne illness have also contributed to the increase in numbers of food-borne illness observed in recent years. Molecular techniques are already well established for surveillance of food-borne illness through the PulseNet system operated by the CDC in Atlanta. As the sophistication in the molecular biology tools at the disposal of the food microbiologist expands, we will be able to detect and identify lower numbers of food-borne pathogens in our food supply more rapidly. This will supply the epidemiologist with even more reliable methods to rapidly establish links between illness and the source of infection. An automated method for genotyping of bacteria, the RiboPrinter, played an important role in quickly establishing the link between cases of listeriosis and contaminated wieners produced at the Bil Mar plant of Sara Lee.

To a large extent, the factors contributing to food-borne illness discussed above are under our control. However, there is increasing evidence that food-borne pathogens, particularly bacteria, can rapidly change and acquire characteristics not associated previously with the species. A good example of that is the acquisition of Shiga-like toxin genes by *E. coli* to produce strains that are more virulent and, at the same time, have become more resistant to acidic environments. Microorganisms can evolve in a variety of ways. Mutations can occur in their own genome or they can acquire genetic material from other organisms by a variety of means such as transformation, conjugation or transduction. The transfer of plasmids from one cell to another plays an important role in acquisition of antibiotic resistance. Once present in the cell, genetic elements called transposons can transfer genes from plasmids to chromosomes.

As well as possessing a great ability to adapt, bacteria can interact with their environment in other ways. For example, cells of *E. coli* O157:H7 can "bury" themselves in the stomata of lettuce leaves. Other examples of this microbial game of hide-and-seek are the association of *Salmonella* with alfalfa sprout seeds and the penetration of the crevices of raspberries by *Cyclospora*. We also know that bacteria are not distributed evenly in the environment. They can attach to surfaces and produce a protective coating of exopolymeric substances (EPS). The cells in this bacterial community, known as a biofilm, are more resistant to disinfectants and are very difficult to dislodge. Clearly we need to better understand the ecology and signaling mechanisms of food-borne pathogens to develop more effective strategies to combat them.

Bacterial food-borne outbreaks are generally the result of holding foods at improper temperatures, inadequate cooking, use of contaminated equipment or poor personal hygiene. About 30% of outbreaks are linked to food service operations, such as cafeterias and restaurants, and about 17% of infections are acquired in the home. However, an increasing proportion of food-borne illness is acquired due to mishandling at processing plants. The latter outbreaks are usually characterized as involving a large number of cases, distributed over a wide geographical area. Figures amassed in the U.S. between 1990 and 1998 show that when foods associated with food-borne illness are broken down by the number of outbreaks, contaminated meats account for about 29%, produce (fruits and vegetables including juices and salads) account for about 24% and seafood about 14%. However, when the same data are analyzed based on the number of individual cases of illness, meat accounts for about 20%, produce for about 41% and seafood about 8%. This indicates that the outbreaks involving produce result in a greater number of cases than outbreaks involving meat. In fact, the number of produce-related outbreaks per year in the U.S. doubled between 1973-1987 and 1988-1992.

What can we do to quell this rising tide of food-borne illness? Certainly more research is needed to better understand food-borne illness. At the organism level, we must start to describe events that occur in foods at the molecular level, as well as gaining a better understanding of the microbial ecology of animals and foods. By investigating the evolution and emergence of food-borne pathogens, we shall be able to predict how pathogens respond to changes in agricultural and food processing practices. To be able to develop effective vaccines we need to better define how food-borne pathogens cause illness. At the host level, we need to understand the role of colonization of both animal and human hosts in transmission of food-borne illness. This will allow us to devise intervention strategies to minimize animal carriage of food-borne pathogens; thus reducing problems due to cross-contamination. Using the knowledge gained by studying microbial physiology and food ecology, we can develop effective control strategies for food-borne pathogens throughout the food chain. Also, by studying the effects of processing on microorganisms at the molecular level, we can optimize existing and novel food processing and preservation techniques. By developing molecular epidemiology and surveillance tools we shall be able to identify and model the factors involved in the spread of food-borne illness, thereby improving human health. Quantitative Risk Assessment (QRA) models are an important part of this modeling strategy. These QRA models will help to prioritize research and develop communication strategies to formulate effective food safety policies. Through initiatives, such as the creation of the Canadian Research Institute for Food Safety at the University of Guelph, we can make a start on tackling some of the tasks identified above.

There is no doubt that we must treat the production of food as an integrated event involving the primary producer, the processor, the retailer, regulatory agencies, and the consumer. Each link in the chain bears a responsibility to ensure the safety of our food supply. The farmer has an obligation to adopt good farm practices and, to their credit, many producer organizations are actively promoting the introduction of quality assurance schemes on the farm. Processors are having to bear greater responsibility for the safety of their products and mandatory implementation of HACCP will inevitably come about. New processing technologies, such as irradiation, will undoubtedly be an important part of the armoury in the fight against food-borne illness. At the retail level, better food handling and sanitation procedures are necessary. Again new technologies, such as chlorine dioxide mists, may play a role in controlling pathogens associated with fresh produce. At the regulatory level, better and more uniformly-applied certification procedures for all food handlers from farm to fork are required. Government agencies also have a crucial role to play in food safety education and in the communication of risks associated with food-borne pathogens. Finally, consumers are now more aware of food safety through constant media attention but this awareness has not been translated into safe practices in our own kitchens. When things go wrong we look for others to blame, we must recognize the risks associated, for example with undercooked ground beef, and take responsibility for our actions. It is only through concerted action at all points along the food chain that we can guarantee the safety of the food we eat.