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Carrageenan and the Acceptance of Food Additive Toxicity, 1950-2000

Carrageenan: it is just a name squeezed onto the packaging of countless products lining the shelves of our grocery and drug stores today. It is a major export of the Philippines and essential to the economic success of this Asian island nation, so far removed from the homes and thoughts of American consumers. In the language of food chemists, carrageenan is variably called an emulsifier, stabilizer, colloid, or gum. Many products that we now take for granted – especially soymilk, chocolate and other flavored milks, dairy products, infant formulas, and nutritional supplement beverages such as Ensure or Slimfast rely upon carrageenan for their uniform consistencies. They could not be made, packaged and stored for long periods of time without this ingredient.

Carrageenan comes from seaweed and derives its name from a region on the Irish coast – “Carragheen,” “Carragahen,” or “Carraigín” – where it was originally harvested. Because of this origin, it is also called “Irish moss,” or by the more accurate name of “Irish moss extractive” – referring to the processing it has undergone. Botanically, carrageenan usually comes from the *Chondrus crispus* or *Eucheuma* species of seaweed, and sometimes from two species of red algae: *Gigartina mammillosa* and *Gigartina stellata*. It has a long (over 200 years) history as an ingredient in Irish home cooking, particularly in puddings and desserts.¹ It is credited with saving

¹ For additional concise histories of carrageenan’s use in food processing, see J. K. Tobacman, R.B. Wallace and M.B. Zimmerman, “Consumption of carrageenan and other water-soluble polymers used as food additives and incidence of mammary carcinoma,” in *Medical Hypotheses* (2001) 56 (5), pp. 589-590 as well as Lanfranco Blanchetti-Revelli, “Keeping Meat and Dairy Consumers Slim: Philippine Seaweed, American Carrageenan and the USFDA,” *Anthropology Today*, Vol. 13, No. 5 (Oct. 1997), pp. 7-8, n.1.

numerous Irish families from starvation during a famine in 1834. Thanks to its demulcent properties, it has historically been used as a home remedy and as a food for invalids, and is described as such in a popular health periodical of 1831.² But we need not go back to the 19th century to find references to carrageenan's usefulness: in May of 1956, a friendly Irishman wrote a vivid letter to the *Lancet*: "Carrageen is familiar to most people in Ireland and often consumed as a sweet there..." He describes it as a common grocery item: "It may be purchased loose from sacks in grocers' shops in towns near where it is harvested and elsewhere in packets... Nowadays its commonest use is for making a sweet which is a cross between a jelly and a blancmange... The resulting dish is light and readily taken in large quantity. Hence it has a place in the diet of invalids. Its other medical interest lies in the fact that from ancient times it has been thought to have a value in the treatment of cough, being so used by the public to some extent even now and being incorporated in some *commercial* cough-remedies widely sold at present in Ireland... if your correspondent or others not familiar with this weed would like to try some, I should be happy to oblige" (emphasis mine).³

This charming letter is quite revealing: first, it shows that carrageenan was available in its raw form "in grocer's shops" (to the extent that the writer was even ready and willing to send some to the *Lancet*'s curious correspondent). Second, it shows that Irish cooks knew what to do with raw carrageenan in making both desserts and cough remedies. Third, and most interesting for our purposes, in the mid-20th century it was beginning to be used commercially.

And we don't even need to look to the Emerald Isle for evidence of carrageenan's place in home cookery: when I recently mentioned my interest in this seaweed to an acquaintance in her 50s, she readily recalled pulling it from the coastal water near her childhood home in Rhode

² See *Reece's Monthly Gazette of Health*, January, 1831.

³ *Lancet*, May 19, 1956, p. 754.

Island, drying it on sunny rocks, and using it in homemade pudding – exactly as described in the *Lancet* letter. The other recalled doing the same thing in Maine. Indeed, the coasts of New England and Eastern Canada were important sites for seaweed harvesting prior to the successful introduction of aquaculture to the Philippines in the 1970s (more on this later).

Fast-forward to the 21st century and much has changed. Few – if any – shoppers are likely to find raw carrageenan for sale in their local stores. Should they really want or need to purchase some, they could probably do so only through a large corporation found on the internet, and probably only in prohibitively large quantities, since these distributors are accustomed to dealing with large, possibly multinational, companies. Upon finally receiving carrageenan on their doorsteps, few people would know what to do with it.

But on one important matter the *Lancet* writer was prescient: the home use of carrageenan might have declined, but its *commercial* use has exploded – reflecting the dramatic expansion of the processed-food industry over the course of the 20th century, and especially since the post-World War II era.

The transformation of America’s food supply began during the 1930s. Although the American economy on the whole suffered during the Great Depression, the food industry actually grew significantly (one of the few industries to do so). Economic circumstances necessitated domestic changes: women increasingly went to work outside the home; this obviously left them with less time for food preparation, thus helping to create a market for “relatively cheap and nutritious processed foods.”⁴ At the same time, new food-processing technology – partially stimulated by the necessity of feeding the soldiers of World War I – made

⁴ Michael A. Bernstein, “Why the Great Depression was great: toward a new understanding of the interwar economic crisis in the United States,” in *The Rise and Fall of the New Deal Order*, ed. Steve Fraser and Gary Gerstle (1989).

it possible to create new products, particularly those that could be packaged and stored for long periods of time.⁵ Carrageenan first entered the marketplace as an additive during this post-World War I boom in food processing.⁶ Technology not only enabled the invention, packaging, and storage of novel food items; it also supported new methods of transportation and distribution which brought the new products to more and more American consumers.

This transformation of the American food supply continued to accelerate during the inter-war years and reached its apex after World War II. Supermarkets transformed the food-shopping experience in the 1950s and by 1960, an astonishing 60% of the offerings on their shelves had not even *existed* at the end of World War II. By 1964, commercial food processing was the largest manufacturing industry in the United States.⁷ All of this provides important background for understanding the ubiquity of a product like carrageenan in today's food supply. A network of factors – economic, political, and technological – have interacted and made possible the proliferation of what can accurately be called industrialized, engineered food.

Today, carrageenan is a well-established and essential ingredient in countless products lining our grocery store shelves. The increase in carrageenan consumption that began during the first half of the 20th century shows no signs of slowing. It is generally believed that carrageenan levels in the average Western diet have increased over the 20th century and will continue to do so

⁵ Canning was the first modern food-storage technology; it was invented by Nicolas Appert in 1809 as an entry into a Napoleon-sponsored contest during wartime. Clarence Birdseye's invention of the freezing process that would eventually become Birdseye frozen vegetables also had a profound impact on food storage. See E.C. Hampe and M. Wittenberg, *The Lifeline of America: Development of the Food Industry* (1964), p. 99.

⁶ Carrageenan is reported to have been introduced to food processing in 1937. It is coincidental and interesting that this was also the year that the dentist Weston A. Price published his book *Nutrition and Physical Degeneration*, in which he compared the health of primitive people and Westerners and concluded that a primitive diet was far healthier than a diet of processed foods (which he recognized as dominating the Western diet in 1937!).

⁷ See *The Lifeline of America*, p. 99ff.

unless restrictions are enforced.⁸ When the Joint FAO/WHO Expert Committee on Food Additives (JECFA) met most recently (June, 2007 in Geneva) and evaluated the safety of carrageenan, it noted, “the previous dietary exposure estimate for carrageenan...may be outdated. The Committee therefore recommended that a new dietary exposure evaluation, employing specific food type and use level information, be undertaken, ensuring that new uses are adequately taken into consideration.” At this meeting, the Committee chose not to specify an Acceptable Daily Intake (ADI) for carrageenan consumption *except* in the case of infant formula. In this case, “the Committee was of the view that based on the information available, it is inadvisable to use carrageenan or processed eucheuma seaweed in infant formulas.”⁹ While in one sense, the Committee’s recent decision will have no immediate impact on carrageenan consumption among adults and children, its precautionary stance on infant formula could encourage skepticism and confusion among consumers: what is it about the safety of this substance that makes it potentially harmful to the human body? Is a health risk acceptable for everyone except infants? Dr. Joanne Tobacman, who has been studying the dangers of carrageenan consumption for over a decade, calls it a “wolf in sheep’s clothing” and has suggested that companies avoid using carrageenan in their products and that consumers avoid ingesting it.¹⁰ In 2006, Dr. Tobacman and three of her colleagues published results showing “that exposure of human intestinal epithelial cells to carrageenan triggers a distinct inflammatory

⁸ See, for example, Joanne Tobacman, “Review of Harmful Gastrointestinal Effects of Carrageenan in Animal Experiments,” in *Environmental Health Perspectives* 109, October 2001, p. 983.

⁹ Summary and conclusions of the sixty-eighth meeting of the Joint WHO/FAO Expert Committee on Food Additives, issued July 12, 2007.

¹⁰ Joanne Tobacman, “Carrageenan: Response,” in *Environmental Health Perspectives* 110, June 2002, p. A288.

pathway.”¹¹ She has also observed that “exposure to undegraded as well as to degraded carrageenan was associated with the occurrence of intestinal ulcerations and neoplasms.”¹²

Finally, she believes that carrageenan warrants study as a possible factor in the development of breast cancer.¹³

This obscure seaweed, formerly a common Irish cooking ingredient, has become not only an object of international trade and economics, but also an object of international scientific and medical controversy. It has become a “scientific object.”¹⁴ While it is probably safe to assume that the vast majority of American consumers are unaware of carrageenan’s history, its increasing ubiquity in our food supply, and its potential health consequences, there has for some time been a concerned and vocal minority of consumers, physicians, and scientists who urge caution. The best-selling author and high-profile doctor of integrative medicine Andrew Weil implicates carrageenan in both colon cancer and inflammatory bowel disease; he advises everyone to avoid it. A casual internet search will produce innumerable indictments of carrageenan as a cause of ulcerative colitis (UC) and of gastrointestinal harm in general. Those writing these warnings frequently cite, as their main piece of evidence, carrageenan’s well-established role in the laboratory: it is used to create *experimental models* of UC and colon cancer in guinea pigs. This is a crucial piece of carrageenan’s “scientific biography:” in

¹¹ See “Carrageenan induces interleukin-8 production through distinct Bcl10 pathway in normal human colonic epithelial cells,” in *American Journal of Physiology* 292, November 9, 2006, p. G829.

¹² “Review of Harmful Gastrointestinal Effects of Carrageenan in Animal Experiments,” in *Environmental Health Perspectives* 109, October 2001, pp. 983-994.

¹³ See Joanne Tobacman, “Filament Disassembly and Loss of Mammary Myoepithelial Cells after Exposure to Lambda-Carrageenan,” in *Cancer Research* 57, July 15, 1997, pp. 2823-2826; and note 1 above.

¹⁴ See *Biographies of Scientific Objects*, ed. Lorraine Daston, University of Chicago Press, 2000 and *The Social Life of Things: Commodities in Cultural Perspective*, ed. Arjun Appadurai, Cambridge University Press, 1997.

experimental settings, it causes a disease in guinea pigs that can be debilitating in humans. For many consumers, this fact alone is evidence enough that carrageenan is dangerous and unfit for human consumption. Like much health-related information in the 21st century (from the reliable to the ridiculous), the dissemination of carrageenan warnings has largely been possible thanks to the internet.¹⁵ Unknowingly, these consumers are applying the Delaney Clause, as well as the Precautionary Principle, to their own purchasing and eating behaviors. The Delaney Clause was part of the 1958 Food Additives Amendment; it ruled that *any* substance found to cause cancer in a laboratory animal (at *any* dosage, even the most miniscule) must be excluded from the food supply. This zero-tolerance policy emerged at a particular moment in the history of American cancerphobia and cancer consciousness. As Jean-Paul Gaudillière has written, “the postwar status of cancer was deeply shaped by the image of the ‘invulnerable man,’ fighting disease with science,” and perhaps, with draconian regulation (*de jure*, if not *de facto*).¹⁶

If the 1958 Amendment had been followed to the letter, we would obviously not find carrageenan – or many other additives – on the ingredients lists of processed foods. Fifty years have now passed since the Delaney ruling, and the consensus among experts on Food and Drug Law is that it has been rendered largely ineffective by subsequent, “softer” amendments. The most important of these was the creation of the “GRAS List.” “GRAS” (“Generally Recognized

¹⁵ The status of carrageenan in the 21st century thus involves food processing, laboratory experiments, and health concerns of both “conventional” and “alternative” populations. Two articles provided helpful methodological models for understanding carrageenan in this way: Harmke Kamminga, “Vitamins and the Dynamics of Molecularization: Biochemistry, Policy and Industry in Britain, 1914-1939” in *Molecularizing Biology and Medicine: New Practices and Alliances, 1910s-1970s*, ed. Soraya de Chadarevian and Harmke Kamminga. Harwood Academic Publishers; and Ilana Löwy, “The Experimental Body,” in *Medicine in the Twentieth Century*, ed. John Pickstone and Roger Cooter, Harwood Academic Publishers, 2000.

¹⁶ For a concise narrative of the history of cancer in the 20th century, see Jean-Paul Gaudillière, “The Cancer Century” in *The Cambridge History of Science, Vol. 6: The Biomedical and Earth Sciences since 1800*, ed. Peter Bowler and John Pickstone (New York, Cambridge University Press, forthcoming).

as Safe”) substances were excluded from the definition of “food additive” as defined in the 1958 Food Additives Amendment. As reported by the FDA’s Office of Food Safety, “Congress recognized that many substances intentionally used in a manner whereby they are added to food would not require a formal premarket review by FDA to assure their safety, either because their safety had been established by a long history of use in food or by virtue of the nature of the substances...” Congress also “exclude[ed] from the definition of ‘food additive’ substances that are generally recognized, among experts qualified by scientific training and experience to evaluate their safety (‘qualified experts’) as having been adequately shown through scientific procedures (or, in the case of a substance used in food prior to January 1, 1958, through either scientific procedures or through experience based on common use in food) to be safe under the conditions of their intended use.”

Thus, while the Delaney Clause itself expressed “zero tolerance” for carcinogenic substances, the GRAS designation, and especially its application to pre-1958 additives, actually enacted a de-facto policy of “innocent until proven guilty.” Having been used in processed foods for at least two decades prior to 1958, carrageenan easily landed on the GRAS list – a designation it maintains today. Just prior to the Delaney Clause, in 1957, Wilhelm Hueper had written, “the mere passage of laws...without providing adequate means to enforce them, might produce in the population a deceptive impression of safety, and would represent an unrealistic approach to a public health problem of great human and economical importance.” Hueper’s concern would prove to be prescient.¹⁷

In 1969, with the GRAS list slightly more than ten years old, President Nixon ordered a “critical evaluation of the safety of GRAS food substances. The GRAS review became a major

¹⁷ Wilhelm Hueper, best known for his work on occupational cancers, argued strongly for rigorous and systematic evaluation of potentially carcinogenic food additives. Please see note 38.

project at FDA's former Bureau of Foods (now the Center for Food Safety and Applied Nutrition). Nixon's decision was a response to a White House conference on Food, Nutrition, and Health. The GRAS review was carried out by a group of scientists called the 'Select Committee on GRAS Substances' (SCOGS)."¹⁸ The FDA reports that "By 1982, after 10 years of work, SCOGS had produced 151 detailed reports covering over 400 substances. This review did not include all GRAS substances but a provision was made to allow individuals to request reviews of particular substances."¹⁹

In 1997, the FDA proposed a new rule (which had not been finalized as of October 2006). This rule "invited interested persons who conclude that use of a substance is GRAS to notify [the FDA] of those conclusions..." This "Notification Procedure" seems to shift the "burden of proof" of safety to those with an interest in seeing their products/additives approved as GRAS. The FDA makes these notifications available to the public on its website. The Administration's website also features a database called "Everything Added to Food in the United States" ("EAFUS") which one can use to locate past assessments and, if applicable, toxicology reports on food additives. EAFUS is a massive database; retrieving information from it requires patience, perseverance, and resistance to computer-induced eyestrain. Searching for carrageenan leads to twelve separate entries, different varieties, some of them with additives of their own.

In summary, carrageenan has been used in food processing long enough to exempt it from the 1958 Food Additives Amendment; it is "endemic" to our processed foods. Food additives in general seem to enjoy "innocent until proven guilty" status, perhaps as a way of lightening the workload of the admittedly overburdened FDA. Finally, detailed information on

¹⁸ USFDA Center for Food Safety and Applied Nutrition, Office of Food Additive Safety: cfsan.fda.gov/~dms/opascogh.html.

¹⁹ USFDA Center for Food Safety and Applied Nutrition, Office of Food Additive Safety: cfsan.fda.gov/~dms/opascogh.html.

individual additives (including twelve different varieties of carrageenan) is available, but not necessarily in an accessible or user-friendly format. Thus, the burden of determining safety can be seen as resting with those consumers who are motivated enough to search through large (and often contradictory) quantities of information. Still, the fact remains that additives shown to be carcinogenic to animals are regularly included in processed foods in the United States; carrageenan is but one example. Making the situation more complicated is the fact that any ingredient that amounts to less than 2% of a product's total content need not be listed on the label. Dr. Tobacman has pointed out that this obviously makes it difficult to eliminate all carrageenan from individual diets.

In addition to the FDA, foreign and international regulatory agencies are concerned about additives, and one frequently finds that European authorities are more cautious and conservative than their American counterparts when it comes to food safety (as in the case of GMOs, the most frequently-cited food technology prohibited in Europe but allowed in the US). The previously-mentioned ban on using carrageenan in infant formula resulted from a meeting of the Joint Expert Committee on Food Additives, a collaboration between the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO). The Codex Alimentarius Commission is the regulatory agency of the FAO and WHO. When this Commission ruled against setting an Acceptable Daily Intake for carrageenan, but in favor of eliminating it from infant formula, it raised an important question which has implications beyond carrageenan alone: "to what extent an ADI...[could be] applied to infants below 12 weeks?; what scientific principles should apply to the evaluation of additives intended for this group of the population?; and whether the establishment of an ADI in itself was sufficient or whether other

issues had to be addressed?”²⁰ The Committee “pointed out that toxicological studies had not directly covered the developmental period in question” (i.e. infancy). Recently, scientists, pediatricians, and consumer advocates have decried the lack of research into the effects of certain pharmaceuticals (from over-the-counter cold medicines to prescription-only antidepressants) on children.²¹ Although a food additive might not seem to warrant as drastic a warning as the FDA recently issued for these drugs, the JECFA’s restriction on carrageenan in infant formula is indicative of a growing awareness that most toxicological research thus far has involved only adults. It is also worth noting that a recent high-profile study reported that hyperactivity among children decreased when food additives were removed from their diet.²²

While the public is accustomed to reading about toxic substances in the context of the environment, industry, and chemicals, the food supply is less commonly associated with toxicology. The National Library of Medicine maintains a vast array of resources related to human health, one of which is its Toxicology Data Network (“TOXNET”). Here, anyone can locate toxicology reports on individual substances. This database contains over 3500 entries on carrageenan. In comparison, both *The New England Journal of Medicine* and the *Journal of the American Medical Association* each contain fewer than five entries on carrageenan. In the *Lancet*, there are only 17 references, but they do capture an interesting debate (to be discussed shortly). Thus, literature on carrageenan published in medical journals is dwarfed by that published in toxicology reports. Since the beginning of large-scale processed-food production in the 1930s, substances have been used for both food and non-food purposes, and have made the

²⁰ Codex Alimentarius Commission, September 2007.

²¹ See, for example, “Regulators Want Antidepressants to List Warning,” *The New York Times*, March 23, 2004.

²² See, for example, “Some Food Additives Raise Hyperactivity, Study Finds,” *The New York Times*, September 6, 2007.

transition from laboratory to grocery store. Cooking has always involved chemistry.²³ But the intersection of food and toxicology is a disturbing development. The International Agency for Research on Cancer (IARC) classifies degraded carrageenan as “Group 2B: possibly carcinogenic to humans” and native carrageenan as “Group 3: not classifiable.” As the IARC’s categories indicate, carrageenan is broadly classified as either degraded or undegraded; higher-quality “food-grade” carrageenan should be of the undegraded variety and have a higher molecular weight than the degraded variety (also called poligeenan). As with any manufactured product, there is a range in quality, from the very high to the very low. The more degraded the carrageenan, the greater the potential risk to humans. Though carrageenan has been designated as GRAS by the FDA, important details, with consequences for health, have been neglected. As Dr. Tobacman has written: “in 1979, the proposal to include the average molecular weight requirement of 100,000 and the associated viscosity requirement in the Code of Federal Regulations was withdrawn. It was anticipated that a new rule-making proposal on carrageenan that would comprehensively address all food safety aspects of carrageenan and its salts would be published in about a year, but this has not been forthcoming.”²⁴

For home cooks who used local, self-harvested carrageenan, distinctions such as degradation level and molecular weight were nonexistent. They pulled the seaweed themselves from the coastline to the cooking pot, or perhaps purchased it from a local grocer. While there is no reason to assume that this “pure” carrageenan was safe while today’s is toxic, the seaweed used by home cooks in the mid-20th century was *not* processed with the large-scale technology currently essential to the food industry. The many varieties of carrageenan available today reflect

²³ An informative (and entertaining) source is Harold McGee, *On Food and Cooking: The Science and Lore of the Kitchen*, New York: Simon and Schuster, 1997.

²⁴ “Review of Harmful Gastrointestinal Effects of Carrageenan in Animal Experiments,” in *Environmental Health Perspectives* 109, October 2001, p. 983.

the changes that industrialization, commercialization, and globalization have brought to our food supply and the increasingly porous boundary between food and chemical engineering.²⁵

Carrageenan is a locus not only of biomedical controversy (though that is my primary interest) but also of international economic competition and negotiation. It has attracted the attention of at least one anthropologist, Lanfranco Blanchetti-Revelli, who has studied “the ways intrasystemic interests and overlapping conflicts have conditioned the world market for carrageenan.”²⁶ Blanchetti-Revelli is not concerned with carrageenan’s safety status, but rather its role as a commodity, arguing that “the global seaweed/carrageenan economy emerged as an unequal system of exchanges dominated by transnational capital.”²⁷ As a small nation and former British colony, the Philippines stood to benefit from its ability to cultivate *Eucheuma* seaweed relatively easily and inexpensively. This process began in 1971-72 and reached a turning point in 1979, when the Philippines surpassed Canada in carrageenan production and over 50,000 Filipino families were involved in what was rapidly becoming a highly profitable activity.²⁸ For several years between the mid-1970s and mid-1980s, the carrageenan market was dominated by one United States company, Marine Colloids International (MCI). Blanchetti-Revelli attributes

²⁵ For an indication of current culinary interest in hydrocolloids, see the recent *New York Times* article, “Food 2.0: Chefs as Chemists,” November 6, 2007 (notably featured in *Science Times*). It is also noteworthy that job advertisements for analytical chemists in the 1970s and 1980s required expertise at developing and working with gums and colloids (such as carrageenan). It would be interesting to explore any relationships between the development of the food industry and the discipline of analytical chemistry.

²⁶ Lanfranco Blanchetti-Revelli, “Keeping Meat and Dairy Consumers Slim: Philippine Seaweed, American Carrageenan and the USFDA,” *Anthropology Today*, Vol. 13, No. 5 (Oct. 1997), pp. 6-13; 7.

²⁷ Blanchetti-Revelli, 7.

²⁸ For a discussion of aquaculture in the Philippines, see “They Plow the Waves for the Squire of Seaweed,” *The New York Times*, June 5, 1995.

MCI's success to its "sensitivity for local marketing practices."²⁹ This harmonious relationship continued until 1984, when the United States' FDA questioned the safety of a Philippine product called "Semi-Refined Carrageenan" (SRC)³⁰ and banned it from use in "the lucrative food additives market in the U.S."³¹ Not surprisingly, this ruling (which was also enacted by the WHO and the United Nations' FAO), severely handicapped the Philippine economy. Then, in 1990, the FDA reversed its ruling and allowed SRC back into US food products.

In his study of the complicated (and still partially classified) negotiations that ensued between Philippine seaweed producers and the USFDA over the status of SRC, Blanchetti-Revelli identifies some surprising competing interests. He writes: "I couldn't explain what clout the Filipinos might have used in dealing with the American authorities...A hint to help understand the issue was given me by a new occurrence in the spring of 1991: the introduction among American fast-food consumers of a fat-free cheeseburger, the 'McLean' by McDonald's. The new product owes its dietetic properties to carrageenan from Philippine seaweed, which is used...to fill the spaces originally occupied by fat..."³² Whatever we might think of this (circumstantial) evidence – compelling, amusing, revolting – we should not conclude that McDonald's was solely responsible for the reintroduction of Philippine seaweed into the American marketplace. Blanchetti-Revelli also observes that, at the time of the FDA's 1990

²⁹ See Blanchetti-Revelli, p. 9 for a discussion of *suki*, a business/trading arrangement native to the Philippines. He observes that MCI's respect for *suki* was a crucial factor in its productive relationship with Philippine seaweed producers. In contrast, European carrageenan producers were unable to replicate MCI's achievement and thus had difficulty entering the increasingly lucrative carrageenan market.

³⁰ The distinction between Refined Carrageenan (RC) and Semi-Refined Carrageenan (SRC) is not the same as that between Undegraded and Degraded. RC and SRC refer specifically to *Eucheuma* seaweed and post-date the degradation distinction. Thank you to Dr. Joanne Tobacman for clarifying this.

³¹ SRC remained allowable in pet food. See Blanchetti-Revelli, 10.

³² Blanchetti-Revelli, 11.

decision, the United States was in the process of renewing its leases on two Philippine military bases and that this perhaps played a role in negotiations. Moreover, American interests competed amongst themselves: US carrageenan producers would obviously benefit from keeping a cheaper, competitive Philippine product *out* of the market, while small US meat producers, wanting to produce low-fat or fat-free meat products (in the style of the “McLean”), could more easily afford cheaper *Philippine* carrageenan. Blanchetti-Revelli’s goal is not to determine exactly what convinced the FDA to change its ruling, but rather to show how the Philippine seaweed industry succeeded in the “niche-like ‘free space’ created by competing interests active at the core of the world economy.”³³ His assumption throughout his article seems to be that SRC *is* safe and was excluded from American food products only because of economic motives.³⁴

Relative to long-standing concerns about the safety of *any* carrageenan in the human diet, this story of Philippine-US negotiations may seem minor. But it provides a compelling illustration of the multifaceted nature of global commodities posing potential health hazards. The debate over Philippine carrageenan runs parallel to the larger debate about the safety of *all* carrageenan, which has become even more ubiquitous in our food supply since Blanchetti-Revelli’s 1997 article (despite the failure of the McLean burger). Obviously, *Eucheuma* seaweed growing from Philippine reefs offers little financial reward in its native state. It becomes a lucrative global commodity only when transformed into a “value-added product.” The power of such a transformation is captured in the story of Louis Deveau, former President of Marine Colloids. Deveau has had a long and successful business career and received many accolades. In

³³ Blachetti-Revelli, 12.

³⁴ “Without denying that political/commercial interests may influence FDA food safety considerations, it is important to notice that FDA rulings remain altogether bound to a burden of proof that has to follow accepted scientific standards of evidence. Influential as the Philippine Government pressures may have been, the FDA ruling occurred only after [provision of] convincing evidence that RC was safe.” P. 11.

2006, he was awarded an honorary “Doctor of Commerce” degree from St. Mary’s University in Canada. He was celebrated for his “development of an *entirely new industry* – seaweed farming in the Philippines and Malaysia.” Marine Colloids was described as “a diversified, fully integrated company, *processing wild seaweeds into value-added agricultural products, animal feeds, fertilizers, food ingredients and cultivated seaweeds for global food markets*” (emphases mine).³⁵ It is this “processing” from “wild” to “value-added product” that not only transforms Philippine seaweed into American carrageenan, but also creates an entirely new object of inquiry for concerned consumers and medical researchers.

Blanchetti-Revelli observes that American demands for low-fat meat products helped to stimulate the Philippine carrageenan market. Dr. Joanne Tobacman, reflecting on her own decade of research into carrageenan’s safety, also observes that “low fat concerns have dominated the public consciousness about diet for a long time.”³⁶ This focus has perhaps diverted attention and resources that could have otherwise studied the health consequences of food additives. As David Cantor and David Hess have shown, diet has always been a controversial subject in cancer research, which may be related to the general lack of interest in studying cancer *prevention* as opposed to *treatment*. It is interesting that much of the only high-profile research into diet and cancer has historically focused upon fat intake, particularly in the form of red meat.³⁷ Although the ostensible purpose of the Delaney Clause in 1958 was to eliminate *all*

³⁵ The full press release can be found at: <http://www.smu.ca/newsreleases/2006/17-17-10-2006.html>

³⁶ Personal communication, January 7, 2008.

³⁷ See David Hess, “The Raw and the Organic: Politics of Therapeutic Cancer Diets in the US,” *Annals of the American Academy of Political and Social Science* 583: 76-96; and David Cantor, “Meat, Modernity and Cancer Control in the Early Twentieth Century” (unpublished manuscript, 2006). David Cantor’s article “Between Prevention and Therapy: Gio Batta Gori and the National Cancer Institute’s Diet, Nutrition and Cancer Program, 1974-1978” (unpublished

carcinogens from our food supply, and although in 1957 Wilhelm Hueper called for increased research into food additives, this has never been a priority. If diet has historically been a low priority in cancer research, food additives have been even lower.³⁸ Robert Proctor's *Cancer Wars: How Politics Shapes What We Know and Don't Know About Cancer* explores both the production of scientific knowledge and the production of ignorance ("agnotology"). "Social forces can leave scientific gaps," he writes, "historians of science can profitably study those gaps – the rich history of scientific non-events."³⁹ And according to Hess, "the science [of diet] is all 'undone,' and given current funding patterns, it is likely to remain undone for a while."⁴⁰ Clearly, a systematic and rigorous study of food additives and carcinogenesis – which Wilhelm Hueper called for in 1957 – is a significant scientific non-event.

As we have seen, the biography of carrageenan is complex, involving several competing interests. In a series of 17 letters published in the *Lancet* between 1956 and 1981, we can hear individual voices expressing their concerns about carrageenan in the human diet. The *Lancet* thus

manuscript, 2007) discusses a period of great potential for diet as a subject of cancer research. Unfortunately, this opportunity was short-lived.

³⁸ See W.C. Hueper, "The Potential Role of Non-Nutritive Food Additives and Contaminants as Environmental Carcinogens," *Acta: Unio Internationale Contra Cancrum* 13, (1957) 220-249. At this time Hueper represented the NCI and was Chairman of the Cancer Prevention Committee of the International Union Against Cancer. Fifty years ago he cited many of the issues with which we are concerned today. One observation is particularly relevant to carrageenan: "This problem has moreover a certain international importance because of the importation of raw and processed foodstuffs from countries of production into countries of consumption...*The actual or possible existence of cancer hazards related to carcinogens in foodstuffs therefore poses a serious public health problem, since the daily and life-long exposure to such agents would represent one of the most important of the various potential sources of contact with environmental carcinogens for the population at large...*" (emphasis mine, p. 220). For more on Wilhelm Hueper, see Robert Proctor's *Cancer Wars*, pp. 36-48.

³⁹ Robert Proctor, *Cancer Wars: How Politics Shapes What we Know and Don't Know about Cancer*. Basic Books, 1995. P. 12.

⁴⁰ Hess, "The Raw and the Organic," p. 90.

offers a revealing encapsulation of the carrageenan debate and the impossibility of finding consensus when so many competing interests are involved.

All but one of these letters appeared in either 1970-1971 or 1980-1981. The exception is the 1956 description of carrageenan in Ireland, which was introduced earlier as an indication of carrageenan's status as a home-cooking ingredient in the mid-20th century. The remaining 16 letters all appeared between 1970 and 1981, and not a single one originated in Ireland. Three are from the United States (Seattle; Evansville, Indiana, and Washington, D.C.), two are from Paris, and the remaining 11 are from various locations in England. Two voices are noteworthy because, first, they write on three or more occasions each; and second, they represent competing viewpoints on carrageenan's safety and, most likely, competing interests. One voice is that of a pair of researchers, R. Marcus and James Watt. They repeatedly urge caution in the use of carrageenan in the human diet. The other voice is that of a four researchers representing the British Industrial Biological Research Association (BIBRA), a toxicology-assessment firm. They repeatedly assert that carrageenan *is* safe for human consumption. The remaining voices participating in the discussion come mainly from various hospitals, largely British, and most frequently represent departments of Pathology, Immunology, and Gastroenterology.

In 1970, Dr. S. Bonfils of Paris reported that "I and my colleagues have...prescribed [carrageenan] to hundreds of ulcer patients without noting any colonic symptoms...My 12 years' experience of the clinical use of degraded carrageenan, as well as the toxicological and pharmaceutical investigations I have carried out, lead me to the conclusion that in human beings it is free from side-effects and from risk of toxicity to the colon."⁴¹ This doctor's deliberate use of carrageenan – especially degraded carrageenan – in the treatment of ulcer patients is

⁴¹ *The Lancet*, August 22, 1970, p. 414.

surprising and perhaps disturbing in light of today's concerns about safety. However, the *Lancet's* 1956 letter referencing carrageenan's efficacy as a throat and cough demulcent showed that long before it was viewed with suspicion, the seaweed was thought to have some therapeutic value. Thus, the carrageenan debate is not solely about "neutrality versus harm," but also occasionally about "salubrity versus harm." And once carrageenan becomes ubiquitous in processed foods and industrial products, health is merely one aspect (maybe just a minor one) of the debate: the economic and functional/practical advantages of using carrageenan may easily outweigh potential (and, according to many, unproven concerns about negative health effects).

The controversy over certain foods and substances as both health hazards *and* health promoters is well-known through the work of Bruce Ames, a biochemist at Berkeley "who shocked the world in 1983 with his thesis that natural carcinogens are likely to pose a far greater hazard than industrial pollutants."⁴² Ames has argued that such foods as bruised broccoli and peanuts (which contain aflatoxin)⁴³ have significant carcinogenic potential. To many, such a claim is shocking – far more shocking than the claim that carrageenan is healthful. Still, Ames' unconventional position shows that even something as apparently virtuous as broccoli can provoke controversy.⁴⁴

⁴² Proctor, 133.

⁴³ Aflatoxin can be lethal, but is naturally found in peanuts, pistachios, hazelnuts, almonds, Brazil nuts and dried figs. At the same meeting at which they discussed carrageenan, the JECFA also considered aflatoxin. They "noted that reduction of aflatoxin dietary exposure is an important public health goal; particularly in populations who consume high levels of any potentially aflatoxin-contaminated food." Soy is another controversial food product that might be an interesting object of study.

⁴⁴ For more on Bruce Ames, see *Cancer Wars*, Ch. 6, pp. 133-152. Although the carrageenan used as a food additive today is hardly pure seaweed, it still seems to benefit (in the minds of consumers) from its association with something "natural." I recently dined at an organic, raw-foods restaurant in San Francisco that listed "Irish Moss" as an ingredient in its desserts. This is the raw material used to make carrageenan and, according to Dr. Tobacman, may have the same negative effects on human cells.

Dr. Bonfil's is the first and last attempt in the *Lancet* to assert carrageenan's therapeutic value. Subsequently, both carrageenan's utility in experimental models of disease *and* its safety for human consumption will become the most important issues for researchers writing into the *Lancet*. The experimental model in question is that of inflammation and ulcerative colitis (UC) in guinea pigs. One writer notes that carrageenan-induced ulcerations in these laboratory animals warrant attention "because of the obvious importance of developing an experimental model for ulcerative colitis," a disease affecting a growing number of Westerners. "Unquestionably, this writer concludes, "Marcus and Watt's finding represents a most promising lead to the development of an experimental approach to the study of ulcerative colitis." Thus, at the start of the 1970s, researchers were still searching for a reliable experimental model of this particular disease; the carrageenan-guinea pig arrangement would soon become commonplace. While developing an experimental model for a widespread and debilitating human disease has obvious benefits, it can also have troubling implications: if a tool (carrageenan) effectively induces pathological changes in a laboratory animal, then should we be concerned that it induces those same, or similar, changes in humans? The four researchers representing the British Industrial Biological Research Association conclude: "it seems unlikely that carrageenan ulceration in the guinea pig offers an experimental model for the human disease."⁴⁵ To what extent does establishing the efficacy of carrageenan (or any other tool) in an experimental model of disease implicate it in causing that very disease? Is it necessary to abandon a potentially powerful experimental model (as BIBRA wanted to do) in order to exculpate a particular tool from involvement in human disease? In some cases, is it impossible to have our cake and eat it too? Marcus and Watt recognize this dilemma: "We find it difficult to understand why Professor

⁴⁵ *The Lancet*, October 31, 1970, p. 932.

Maillet and his associates should conclude that carrageenan-induced ulcerations of the colon may be particular to the guinea pig...Our experience has been that the rate of production and severity of ulceration depend on several factors including the type of carrageenan used.”⁴⁶ In *Cancer Wars*, Proctor shows the power of “what PR men call Gibson’s Law – ‘For Every Ph.D. there’s an equal and opposite Ph.D.’”⁴⁷ While the *Lancet* is hardly the cite of a PR campaign for carrageenan, its letters do show that the substance’s defenders and detractors are committed to their respective positions.

A short letter of September 19, 1970, sent by Dr. J.G. Davis of London, raises issues of carrageenan’s safety that are still subject to active debate today, 38 years later. Davis was prescient in his observation that “The possible effects of ingested carrageenan, ...require very careful consideration in view of the increasing use of these gums in foods, especially in the new substitute or ‘synthetic’ foods which will inevitably play an increasing role in foods all over the world.” Davis is also noteworthy for his recognition that “a new use, or an increasing use, of any substance can lead to the development of the ability of normally present organisms to attack it, or to the ‘evolution’ or appearance of new types of organism able to do so...microorganisms are capable of an infinite variety of tricks.” Davis avoids taking a strong stance either for or against carrageenan use, choosing instead to urge caution; apparent certainties about biology can easily be overturned by the adaptive and evolutionary capabilities of microorganisms. Finally, Davis foreshadows the 2006 ruling of the Joint Expert Committee on Food Additives: “...the widespread use of carrageenan in foods for infants as well as for adults merits a thorough study of the problem.”⁴⁸

⁴⁶ *The Lancet*, October 17, 1970, p. 828.

⁴⁷ Proctor, *Cancer Wars*, 10.

⁴⁸ *The Lancet*, September 19, 1970, p. 610.

The Lancet seems not to have published a carrageenan-focused letter again until 1980, when the persistently-cautious team of R. Marcus and James Watt submitted an update and reappraisal of carrageenan's safety: "In August, 1972, the U.S. Food and Drug Administration imposed restrictions on the use of degraded carrageenan as a drug or food additive. However, undegraded carrageenan, which must undergo degradation during passage through the gastrointestinal tract (since it is absorbed and absorption of such a high molecular weight material without degradation is inconceivable), is still incorporated into a wide variety of foods as a stabilizer." Much of the *Lancet* debate in 1970-71 focused on two related issues: first, whether carrageenan could be used to create an experimental model for human ulcerative colitis and second, whether carrageenan posed a threat to humans. But by the time of Marcus and Watt's letter in 1980, not only has the experimental model been accepted, but carrageenan has been implicated in additional illnesses: "Besides ulcerative disease of the colon, associated lesions such as squamous metaplasia...have also been seen in animals fed degraded or undegraded carrageenan long term...What is disturbing – yet not unexpected – is reports that in rats undegraded carrageenan fed in the diet enhances colorectal carcinogenesis...and that degraded carrageenan produces colorectal cancer. There is a need for caution in the use of carrageenan or carrageenan-like products as a food additive, especially since other, safer stabilisers are now available."⁴⁹ Almost exactly one year later, the *Lancet* printed another letter which is intriguing in light of the recent JECFA decision *not* to establish an ADI for carrageenan. This letter reported on research into possible immunosuppressive effects of dietary carrageenan, and warned: "These findings have important implications in that the doses of undegraded carrageenan which exerted the immunosuppressive effect...were *well below* the acceptable daily

⁴⁹ *The Lancet*, March 15, 1980, pp. 602-603.

intake (500 mg/kg daily) set by the Joint FAO/WHO Expert Committee on Food Additives.” The authors concluded: “Whilst it may be true that carrageenan ‘has been used in foods for at least two centuries,’ such a statement takes no account of the increase in carrageenan consumption, principally in dairy products and slimming diets, that has almost certainly occurred in recent times.”⁵⁰ As we have seen, consumers’ desire for low-fat meat and dairy products may have assisted the re-introduction of Philippine carrageenan into the American marketplace; and research into diet and cancer has frequently focused on the effects of animal fat (or lack thereof) rather than the potential carcinogenicity of fat replacers such as carrageenan.

Proponents of carrageenan’s safety frequently cite two main issues when challenging the research of their opponents: first, humans are not physiologically the same as guinea pigs, rabbits, rats, or mice. Thus, on the basis of animal studies alone, it is impossible to conclude that carrageenan poses a threat to human health. Second, carrageenans can vary in their level of degradation and molecular weight (as discussed already). While the lowest quality might not be safe, they argue, the highest, food-grade quality *is* safe. This issue was brought to popular attention in 2004 when Eden Foods (a large natural-foods manufacturer established in 1968) published a lengthy response to “irresponsible and inaccurate information...concerning carrageenan.” The company provided an impressive amount of information, much of it technical, in order to reassure its customers: “There are two types of carrageenan, undegraded (food-grade) and degraded (hydrolyzed with acid). Undegraded carrageenan has been used on a huge scale in food production worldwide since the 1930s, and its safety has been assured by the FDA...Chemically treated, degraded carrageenan however, is a known carcinogen (cancer causing agent) and is not used or permitted in food production, but is frequently used to

⁵⁰ *The Lancet*, March 21, 1981, p. 671.

experimentally induce intestinal inflammation in animal studies.... Eden Foods would like to assure all that we only use the food grade, undegraded carrageenan... We hold documentation showing that absolutely no chemicals are used in producing our carrageenan and that it is the highest quality food grade, undegraded carrageenan. As it is quite expensive, we use a very small amount of it (less than 0.03 percent including water) to prevent separation of liquids, to improve performance, and for a smooth mouth feel.”⁵¹ Eden Foods is unusual in issuing such a detailed statement and in elucidating the distinctions among types of carrageenan. Still, as we know, some researchers have questioned whether undegraded, “high-quality” carrageenan really is safe, or whether it actually undergoes degradation during the digestion process. In a 2001 article, Drs. Tobacman, Wallace, and Zimmerman proposed an intriguing hypothesis: “low molecular weight carrageenan may contaminate food-grade carrageenan, and acid-hydrolysis leads to shortening of the carrageenan polymer to the degraded form, poligeenan. It is not unreasonable to speculate that normal gastric acid and acid contained in foods co-ingested with carrageenan may act upon ingested carrageenan and convert some of what is ingested to the lower molecular weight poligeenan during the actual process of digestion.”⁵² The authors present an additional and fascinating degradation scenario: “some intestinal bacteria possess the enzyme carrageenase that degrades carrageenan. Hence, it is possible that humans, either by endogenous acid secretion, by co-consumption of acid foods, or by the action of intestinal flora, may degrade carrageenan into the lower molecular weight poligeenan.”⁵³ Reading this description recalls the 1970 *Lancet* writer who warned, “microorganisms are capable of an infinite variety of tricks.” These tricks certainly complicate the question of carrageenan. The hypothesis of Tobacman, Wallace and

⁵¹ See http://www.edenfoods.com/articles/view.php?articles_id=82 for the full Press Release.

⁵² Tobacman, et al in *Medical Hypotheses*, p. 596.

⁵³ Tobacman, et al in *Medical Hypotheses*, p. 596.

Zimmerman indicates that the distinction between degraded and undegraded carrageenan is too simple when considered within the complex physiological processes of digestion; while the label of “undegraded, food-grade carrageenan” might reassure consumers and thus serve manufacturers well, it does not actually ensure safety. In short, the case of carrageenan is far from closed.

Today, Dr. Tobacman and her colleagues are using carrageenan of high molecular weight, and at low dosages, thus making experimental models more realistically applicable to humans and attempting to avoid some of the controversies raised in the *Lancet* debate – namely that harm to guinea pigs does not imply harm to humans. As already mentioned, they have provided the first evidence of carrageenan-induced damage to human intestinal epithelial cells. This may succeed in bringing greater attention to carrageenan as a health hazard (inflammatory bowel disease *is* a known risk factor for colon cancer). Several years ago, Tobacman and her colleagues published a discovery that will perhaps attract increasing attention from scientists and the public: they demonstrated a time-trend correlation between carrageenan consumption and breast cancer. They concluded: “although time-trend correlations represent a weak form of evidence, when significant positive correlations are found, they can support further evaluation. This appears to be the conclusion that emerges with regard to consumption of several of the gums, including carrageenan.”⁵⁴

Will its association with cancer (especially breast cancer) rather than intestinal inflammation (a less politically and emotionally compelling condition, despite its strong correlation with colon cancer) have any effect on the status of carrageenan in the global food marketplace? Will research into food additives eventually become, in Proctor’s words, a

⁵⁴ Tobacman, et al in *Medical Hypotheses*, p. 596.

scientific event, as opposed to a “non-event?” Wilhelm Hueper, calling for such research in 1957, wrote that “the consumer is a member of a ‘captive’ population which may be subjected to potential, long-delayed health hazards which he has neither consented to, nor is able to avoid.” He recognized, 50 years ago, “a potentially serious public health problem especially since the modern food production, processing and merchandising methods necessitate the use of many food additives and contaminants for safeguarding an adequate food supply to the urbanized and industrialized population of many countries.”⁵⁵

In 1970, R. Marcus and James Watt (of the *Lancet*) responded to Dr. Bonfils, who had treated ulcer patients with carrageenan: “We assume that on ethical grounds it would be hard to justify a more prolonged experiment with a preparation known to be ulcerogenic to the colon in several animal species.”⁵⁶ Today, we acknowledge that the public becomes the subject of “prolonged experiments” with newly introduced pharmaceuticals, but the situation with food additives is perhaps not as obvious. Society – or at least sub-sections of it – enters a new experimental situation to which it might or might not have consented. We seek assurance from such things as the FDA’s “GRAS” designation even while participating in such experiments. The curious history of carrageenan – the seaweed that both made the “McLean” burger possible *and* destroyed cells in laboratory settings⁵⁷ - shows that the biography of a scientific object can be a complex narrative of economic, political, technological, and biological factors, marked along the way by scientific events and non-events.

⁵⁵ Hueper, 231; 243.

⁵⁶ *Lancet*, October 3, 1970, p. 726.

⁵⁷ Dr. Tobacman first became interested in carrageenan when it (unexpectedly) killed cells in her laboratory.