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Scientific underpinnings of biotechnology regulatory frameworks

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ABSTRACT

Part of what is presently missing at domestic regulatory levels (and that is important at the international level as well) is a detailed understanding of what the rules of, and for, regulation should be, who the actors, stakeholders and major decision makers are and finally, how to get agreement about the rules. Greater insights into the system of rules that underpin regulatory frameworks for agri-food and biotechnology products in genetically modified (GM) crop- adopting nations will provide value by clarifying the evidence used to commercialize these technologies. This article examines the public documents available from Canada, the United States, the European Union and the Organisation for Economic Cooperation and Development regarding the development of regulatory risk assessment frameworks for products of biotechnology to determine what science grounds these frameworks. The documentation used to provide the initial structure to the existing regulatory frameworks identifies the linkages, connections and relationships that exist between science, risk assessment and regulatory policy. The relationship between risk and regulation has never been more critical to the commercialization of innovative agricultural products. Documenting the role of science-based risk assessment in regulations and how this has changed over the 20 years of experience in regulating GM crops will identify changes in the risk/regulation relationship.

Introduction

In spite of countless and ongoing insinuations made by environmental non-governmental organizations (eNGOs) that genetically modified (GM) crops are not regulated, 2016 represented 30 years of biotechnology regulation. While there were reports released on biotechnology prior to 1986, this year was the date of the first report released on the governance of this innovative technology. In 1983, the Organisation for Economic Cooperation and Development (OECD) established the Group of National Experts on Safety in Biotechnology [1]. After three years of work and assessment, this group released the initial document containing three broad recommendations entailing a further 14 specific recommendations. This initial report was followed in 1992 and 1993 by other OECD reports focusing specifically on field scale research and food and agriculture, safety considerations and food safety. In the intervening decades, hundreds of risk assessments have been undertaken by national regulators and scientific associations. These foundational reports precipitated the regulatory approval and commercial release of GM crops in North America, South America, Europe, China and South Africa during the 1990s.

As the technology of GM crops progressed from laboratory proof of concept to greenhouse trials, open field trials, regulatory assessment and finally commercial production, the regulatory systems in many jurisdictions were in development, becoming standardized in the mid-1990s when the initial GM varieties were approved in Canada and the US in 1994. The process of developing the initial regulatory frameworks was a collaborative one that involved representatives from multiple government regulatory agencies, private companies and public sector institutions. Given that governments' understanding of the scientific research and implications of such technology was limited, it became necessary to utilize an expert-led process, based in science, which ended up taking several years. The basis of the processes were to identify potential instances where risk could change as a result of the application of the new technology. Participants were involved in undertaking the requisite research to inform all stakeholders about their risk undertakings and whether there could be a change in risk such that it warranted additional regulatory oversight. As the various points of risk identification were assessed, knowledge was gained regarding the potential for changes in risk and whether risk thresholds would need to change. After all of the risk points had been scientifically investigated, the results of the process provided the regulatory frameworks for risk assessment of GM crop varieties.

The objective of this article is to investigate what science was undertaken, prior to, and during this period of regulatory development,

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how it was shared and to what extent it helped to form the basis of the resulting regulatory systems in support of GM crop adoption. For the context of this article, 'science' refers to the scientific research conducted on the investigation of a technology on plant health, safety, productivity and so forth. The identification of the underpinning science behind existing regulatory systems will provide unique insights into how science forms the basis for policy development within innovative sectors. For this article, 'policy' will refer to the rules and terms set out by organizations to help reach a certain level of guidance or structure, whereas regulations are the rules made by governments in which compliance is mandated or imposed. In addition to this, we provide insights into how knowledge flows happen at a global level during the rapid, global expansion of new scientific technologies.

The article is structured as follows. The subsequent section provides a review of the documents that contributed to the development of GM crop regulatory frameworks. The third section provides a structured analysis of the foundational documents. The remaining sections provide an analysis of the findings, concluding with a summary.

Background

The initial creation of transgenic organisms occurred in research laboratories in California in the early 1970s [2,3,4]. At this time, researchers were using a common bacteria used in research, *E. coli*, to cut, extract and reinsert genes from one part of the bacteria's genome to another location, ultimately becoming known as recombinant DNA (rDNA) research. Initial rDNA publications based on *E. coli* were published in 1973, allowing the researchers, academics and broader health experts to gain not only greater understanding about the future applications of this technology, but also raising legitimate concern about the safety of rDNA, researcher exposure and the potential for accidental release. The first public event where it was possible to identify that formalized discussions regarding the safety and risks of rDNA research was the 1973 Gordon Conference on Nucleic Acids. Attending scientists "… were concerned that unfettered pursuit of this research might engender unforeseen and damaging consequences for human health and the Earth's ecosystems." [5]. These conversations and discussions resulted in a call for a public moratorium on any further rDNA research in 1974 [6]. The objective of the moratorium was to ensure that research scientists could learn more about gene splicing.

The 1975 Asilomar Conference brought together leading researchers and governmental regulators to engage in full and open discussions. The conference focus was to discuss the risks, safety and any potential liabilities of the research, the conditions needed to ensure that these were adequately addressed and what precautions would be necessary to end the moratorium, allowing GM research to proceed. With the world's leading rDNA research experts in attendance, the Asilomar Conference was able to developed safe research guidelines and practices themselves, rather than having them imposed by government. Officials of the US National Institutes of Health (NIH) participated in the conference, which enhanced the transparency for scientific and public scrutiny. Appropriate steps were taken to ensure the prevention of any risks regarding containment standards for virus and bacteria research that could potentially harm humans if widespread exposure occurred [7].

Knowledge about the application of rDNA research grew rapidly, moving from the initial bacteria research in the mid-1970s to plants in the early 1980s. In 1983, the Miami Winter Symposium on the molecular genetics of plants had three of the four world-leading researchers presenting their research involving transgenic tobacco [8–10]. This symposium was a sharing of knowledge about applying gene technology to agriculture, with no discussions about the potential risks of GM plants or about how to regulate the technology.

Scientific underpinning research

While the science of rDNA technologies advanced rapidly through the 1970s, there was also a parallel process evolving on how to best regulate them, albeit with a lag [11]. Arguably, the launch point of rDNA technology was the 1972 patent application by Chakrabarty seeking to patent a modified bacterium. This application ultimately required the remainder of the decade to resolve, with a ruling coming from the US Supreme Court in 1980 that it was indeed legal to patent living life forms.

As identified in the preceding section, the first formal discussion about safety of the technology occurred at the 1973 Gordon Conference, followed by the research moratorium and the 1975 Asilomar Conference on research safety. It was the Asilomar Conference that provided the first suggested policies regarding rDNA research as this event created the good laboratory practices required to conduct rDNA research. With the laboratory standards in place, it took several years for the research to advance to the point that it evolved from research involving bacteria to the plant and animal kingdoms [12].

Proceeding the Asilomar Conference private industry began to explore the science of rDNA, assessing the innovation and potential benefits for their firms. In the still relatively young and small European Economic Communities (EEC, later known as the European Union; EU), there became a need to develop safety measures. By 1978, the EEC put forward a proposal across its Member States to establish and promote general precautions against potential hazards associated with rDNA research in biotechnology [13]. In additional to taking precautionary measures, the EECs Economic and Social Committee hosted networking and information exchange meetings. One meeting referred to as 'Genetic Engineering: Safety aspects of recombinant DNA work', took place in May 1981. No policies were proposed at this event, but rather, it was an effort to bring together a collection of individuals involved with research, policy, industry, consumers, religion, and trade groups to share their insights and concerns [14].

One of the first industrial nations to release documentation on the governance of rDNA technologies was Canada. This began with a background document for the Ministry of State for Science and Technology on how to develop and promote biotechnology in Canada [15]. In 1981, the Task Force on Biotechnology released a document titled, *Biotechnology: A Development Plan for Canada* [16]. This report examined the scientific research capacity within Canada to meaningfully engage in the research and the research network that would need to be established to allow for enhanced research capacity.

In 1982, the OECD published the report, *Biotechnology: International Trends and Perspectives,* which summarized the present biotechnology research and defined the term biotechnology for the purpose of aligning its use internationally [17]. In addition to benchmarking the terminology of biotechnology, the 1982 OECD report highlighted which areas should be of priority, future trends and issues.

By 1983, the National Biotechnology Advisory Committee in Canada released a report titled, *National Biotechnology Strategy*. This identified that the National Research Council of Canada in partnership with Agriculture Canada could be a strategic resource in supporting universities and private companies in establishing research programs. This was the same year that the OECD established their expert group and the Miami Symposium reported the initial scientific publications on transgenic tobacco research. It was also in this year that the US National Research Council released *Risk Assessment in the Federal Government*, known as the Red Book [18]. The objective of this study was to assess the US policies of carcinogens and other health hazards, it was this risk assessment of risk which helped the US shape their following policies on biotechnology.

By the time that the first field trials for GM crops were being conducted in 1986, the OECD released their initial report on the safety of rDNA technologies [1]. Additionally, this was the year that the US released its Coordinated Framework for the Regulation of Biotechnology, which was federal government's first effort to regulate biotechnology, in which the Federal government finalized its initial biotechnology policy [19]. Two years later the US Congress addressed in the *New*

Developments in Biotechnology the new for public policy in the areas of criteria to review the potential risks of biotechnology, the administrative process behind this, and research used to support the criteria [20]. In Canada, it was not until 1988 that serious efforts began on how to best regulate biotechnology when the Canadian Agricultural Research Council held a workshop titled Regulation of Agricultural Products of Biotechnology [21]. There were 108 attendees: 65 from the various government agencies and research organizations; 27 from numerous private industry firms; 14 from Canadian universities; and 2 from the US Department of Agriculture [22]. The workshop was divided into four major sessions. The first focused on the need for regulating new technologies and the existing state of regulations in the US, the EU and Canada. The second session focused on the regulatory situation in Canada and discussed the Seeds Act, Plant Quarantine Act, the Animal Disease and Protection Act, the Feeds Act, the Fertilizers Act and the Pest Control Products Act. The third focused on the science behind GM plants, animals and microbes, while the fourth was a multi-stakeholder perspective on issues and concerns about the regulation of biotechnology.

Following the Canadian Workshop, in 1989, the US' National Research Council released *Field Testing Genetically Modified Organisms: Framework for Decisions*. The intent of this report was to evaluate the potential introduction of genetically modified plants and microorganisms on the environment under field-testing conditions [23]. The NRC report emphasized the importance of first establishing field-testing to determine the utility of introducing GM plants and microorganisms into larger-scaled environments and commercial use. By 1992, the Food and Drug Administration came forward with the *Statement of Policy – Foods Derived from New Plant Varieties*, clarifying the policy of rDNA under the FFDCA [24]. Such clarification was needed to ensure that industry clearly understood the extent of the policy in relation to science, safety and regulations prior to new plant varieties reaching the market and its consumers.

By the early 1990s regulatory frameworks were beginning to solidify and the gaps of uncertainty were being targeted through the commissioning of specific research documents, working papers and reports. The OECD contributed to this through the release of three documents in 1993. The first was on safety of scaling up crop plants created by biotechnology, which was a more in-depth version of the 1992 OECD *Safety Consideration for Biotechnology* [25,26]. The second 1993 paper by the OECD was a safety evaluation of food derived by biotechnology and the third focused on traditional crop breeding practices as a baseline for future biotechnology [27,28]. By 1995, the first regulatory approvals for the commercialization of GM crops were granted in Canada and the US.

Europe in the 1980s had yet to make any confirmed directive policies for their Member States on biotechnology, allowing industry to continue research on biotechnological advancements. Running parallel to the Europe's biotech advancements, was the question of whether they were performing as well in biotechnological research as the US and Japan, and if public policy could play any role in this. This particular concern sparked the EECs 'Industrial Biotechnology in Europe' conference in 1985. A total of 26 individuals from government, the European Commission and industry, both pharmaceutical and agricultural, came together to discuss and encourage future growth in biotechnology [29]. Following this event, the EEC passed Directive 90/219/EEC, on the policies of containing GMOs in 1990, and 90/220/EEC on the deliberate release of GMOs into the environment (90/220/EEC no longer in force) [30,31]. However, it was not until 1998 that the Member States put in place Directive 98/44/EC, the legal protection of biotechnological invention (patents) [32].

Fig. 1 identifies the significant conferences, events and publications that led to the establishment of the initial regulatory frameworks for products of biotechnology. This process involved multiple jurisdictions and organizations spanning well over a decade, involving hundreds of scientists and experts.

Analysis

As time progresses, policy development is typically based on previous research and knowledge, thus, influencing the next generation of research and policy. Today, the scale and scope of biotechnology regulations for agriculture and other sectors is large. However, in the 1970s and 1980s this component of science was relatively small and new as the initial policies were being discussed, negotiated and implemented. This section examines the flows on knowledge that existed as were utilized by Canada and the US as both countries developed their initial biotechnology regulatory frameworks.

To evaluate the influence of biotechnological knowledge and scientific research, on the policy development process, publications (both peer reviewed science articles and government reports), international agency documents (i.e. OECD), workshop reports (both commissioned studies and the proceedings) and conferences have been reviewed (Table 1). A total of 16 key publications or proceedings from Canada, the US, EU and the OECD have been identified to have contributed to the provision of scientific knowledge required to develop existing regulatory frameworks. There is evidence of previous research, documents and knowledge being included in subsequent publications. As the body of research knowledge about the preliminary biotechnology discoveries and advances grew, the early publications become references in subsequent publications. By starting with the documents that formed the basis of the existing regulatory frameworks in both Canada and the US, it is possible to identify previous documents that contributed to increasing the body of knowledge. We track not only the reference to science-based knowledge, but the number of experts involved in the discussion of this knowledge as it helped to frame regulatory frameworks.

Unfortunately, the transparency of which scientific research was used to justify or support policy and regulations is limited. Based on the regulatory process and the documentation of imposed regulations, the scientific research conducted and used in support of said regulations is often not documented. While former policy and regulation makers have insinuated that science helped to lead the current regulations we have today, there are only a limited number of documents publicly available which offer referencing to scientific research directly or consultation with those scientific researchers and experts at the time.

The references drawn from the list of publications above have been analyzed in an attempt to determine the degree to which knowledge and research within each of Canada, the US, EU and the OECD influenced one another. Evidence of this would be identified by citations. Publication references from the various documentation identified in Table 1 were aggregated into the four origins and then searched for cross-citation (Fig. 2). The five publications from the US had a total of 718 references to publications, meetings and legislation. The OECD's six documents had 426 references, while only Canada's CARC workshop document reported all of the 56 references used to analysis Canada. Of the EU's three documents found, only the 1978 EEC document offered three informal references within the text of the document. There was surprisingly little overlap of shared references between the two leading commercializers of biotechnology with the expertise knowledge of the OECD. Canada's CARC workshop held in 1988 shared only two references with OECD's reference list. Between the OECD and US articles there were 13 shared references between the publications from 1986 and 1993 (Table 2). There was only two reference which overlapped between Canada and the US.

The lack of cross-citation is more than a little surprising, but perhaps this is framed by the present context for information sharing. The proliferation of online information available through academic journal and government regulatory agency websites provides near instantaneous access to the most recent dissemination of knowledge. Prior to today's use of the internet as the standard research venue, access to knowledge occurred, but at a considerably slower pace. Science-based knowledge was published in hardcopy and then mailed

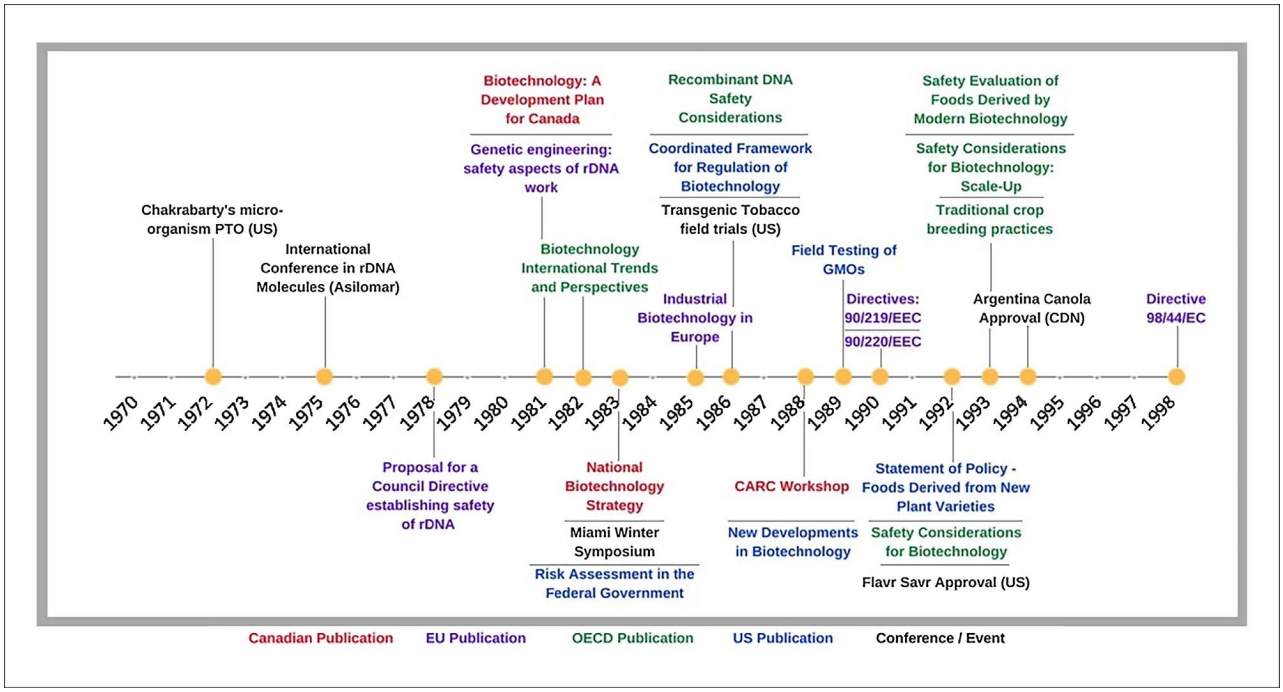

Fig 1. Governance timeline for biotechnology.

Table 1
Publications of Biotechnology Research.

Year	Report title	Source	References	Participants /Experts	Contributors /Authors	Acknowledge-ments
1978	Proposal for a Council Directive establishing safety measures against the conjectural risks associated with recombinant DNA work.	EU	3	–	–	–
1981	Biotechnology: A development plan for Canada	Canada	N/A	–	235	–
1981	Genetic Engineering: Safety aspects of recombinant DNA work.	EU	N/A	105		
1982	Biotechnology: International trends and perspectives	OECD	67	14	3	–
1983	Risk Assessment in the Federal Government	US	143	–	19	35
1985	Industrial Biotechnology in Europe	EU	N/A	–	26	–
1986	Coordinated Framework for Regulation of Biotechnology	US	N/A	–	–	–
1986	Recombinant DNA Safety Considerations	OECD	10	88	–	–
1988	CARC: Workshop	Canada	56	108	–	–
1988	New Developments in Biotechnology	US		22		122
1989	Field Testing Genetically Modified Organisms	US	354	–	54	–
1992	Safety Considerations for Biotechnology	OECD	22	N/A	–	–
1992	Statement of Policy – Foods Derived from New Plant Varieties	US	7[1]		1	
1993	Safety Considerations for Biotechnology: Scale-up of crop plants	OECD	24	86	–	–
1993	Safety Evaluation of Foods Derived by Modern Biotechnology	OCED	26	64	–	–
1993	Traditional Crop Breeding Practices: An historical review to serve as a baseline for assessing the role of modern biotechnology	OCED	277	13	28	–

Note: N/A means not applicable.

to subscribers, while government reports were published and copies then shared with government publication sections of university libraries. While today's decision-makers have the ability to access the best and most recent global technology impacts and risk assessment findings, 30 years ago, decision-makers seem to have relied strongly on domestic reports, findings and analysis. This would be the case for the Canadian and US regulatory framework developments. In contrast, the OECD did draw on a diverse set of international experts as they discussed the state of the technology, identifying knowledge gaps that would need to be studied.

Perhaps the one striking observation that clearly stands out in Fig. 2 is the lack of knowledge sharing between Canada and the US. This is not to say that there was no knowledge sharing, and documents available in Canada show that representatives of US regulatory agencies did attend some of the events held during the regulatory framework development process. Based on conversations with those in attendance at the CARC event in 1988, US regulators were accorded observer status. This meant that the US regulators had, at best, minimal input and were simply there to observe the discussions, questions and knowledge findings so that this information could then positively contribute to the process to develop US regulations.

At this time, there was certainly a lower level of reciprocity between states. In the mid-1980s, the Canada-US Free Trade Agreement (CUSTA) did not exist, nor did the World Trade Organization. Both

[1] The US Federal Food, Drug and Cosmetic Act's Statement of Policy – Foods Derived from New Plant Varieties, offered seven references in which two were listed as Anonymous and another two were not based on publications but rather letters between biotech professionals.

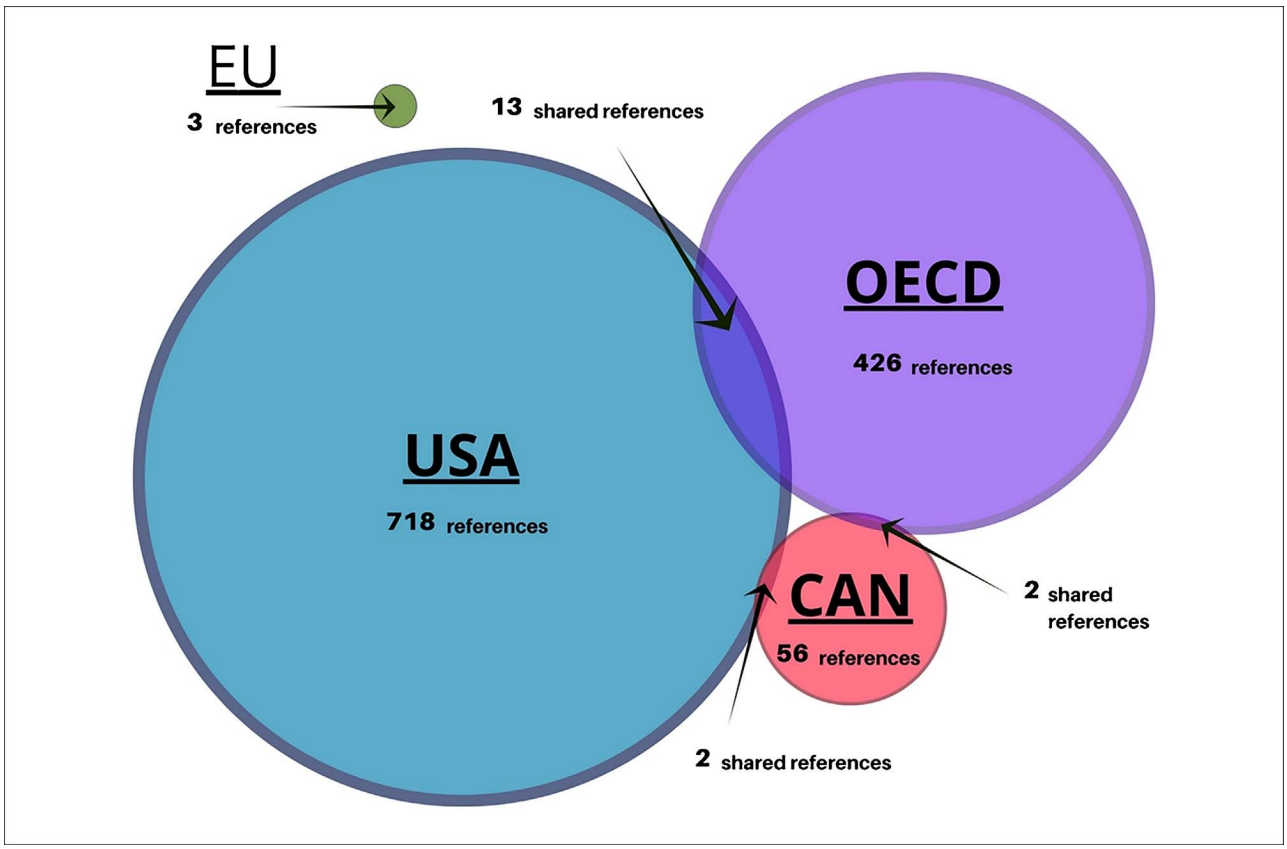

Fig. 2. Venn diagram of biotechnology regulatory development knowledge flows. References shared amongst national publications represented a minimal proportion of the research cited.

Canada and the US were involved in the dialogue and negotiations that ultimately established CUSTA in 1988, so while there were the beginnings of political and trade openness at senior administrative levels, it is less certain that this reciprocity existed at the lower bureaucratic levels. The term 'globalization' was not one that was present in government language at this time.

Given the historical relationship between regulators and domestic academics and scientists, it is quite probable that the comfort and trust from these relationships continued over to the discussions involving the evaluation of whether crop biotechnology offered any differentiation in risk from what was already approved for production in Canada. While some private companies were involved in plant biotechnology in Canada at this time, the leaders in this research were the universities. One of the leading universities in Canada at this time was the University of Saskatchewan, with field trials of GM canola and GM flax beginning in 1986. Public and private knowledge was being generated on the biotic and abiotic aspects of the crops, which satisfied the regulatory requirements to proceed with the development, drawing less on international research of a comparable nature.

One other items that stands out from Fig. 2 and Table 2 is the lack of integration of OECD documents into the regulatory development process in Canada and the US. OECD documents are typically viewed as a codification of knowledge at a point in time, an expert consensus. Yet, while the OECD cites its own previous studies, these are not showing up as being cited by either the Canadian or US process. This observation was unexpected, as we fully expected to see OECD documents forming the basis of regulation development in both countries; however this does not appear to have happened. Further research is required.

The EU functions more similarly to the OECD than either Canada or the US, as it is a collection of Member States, rather than representing only one set of values and policies. As a result, it made it difficult to find documented policies which offered insights into underpinning research of scientific policies and directives that underpin the EU regulatory framework. While we were unable to find reference overlap between the EU and the other documents, we note that one of the three EU references was in regard to the 1975 Asilomar conference.

Conclusions

Applying present day notions to knowledge sharing, communication and dissemination makes analysis of the same process 30 years earlier a challenge. Our inherent bias from near instantaneous access to knowledge forces us to engage in different conceptualization of how knowledge flows functioned prior to the facilitation resulting from the internet.

As protocols for field trials developed in the late 1980s, experts did not view this technology as different from those that had previously been used to create new plant varieties. As a result, regulatory development was considerably more of a domestic issue than present day development of regulations in a globalized community. The experts drawn upon and the scientific knowledge used indicate that those tasked with the development of biotechnology regulatory frameworks did indeed draw upon the most up-to-date and complete perspectives possible.

While fewer cross-citations than expected were evidenced from our analysis, the important message is that the biotechnology regulatory frameworks that were established have worked perfectly, from a scientific perspective. No single biotechnology derived crop or food product has entered the market and proved to be unsafe. The systems established in both Canada and the US have delivered what they were designed to do: consistent and timely decisions on risk assessments and product safety. Consumer confidence in the products of biotechnology has lagged. However, consumer attitudes are not solely based upon their interpretation of the science-based principles underlying the

Table 2
Cross-Referenced Publications.

Shared Reference	US or CDN Publication	OECD Publication
Harlan, Zohary. Distribution of wild wheats and barley. Science 1966; 153:1074–1080.		93- Safety Consideration for Biotech.: Scale-up 93- Traditional Crop Breeding
Baker. The evolution of weeds. Annu Rev Ecol Syst 1974; 5: 1–24.	89- Field Testing (US)	93- Safety Consideration for Biotech.: Scale-up
OTA. US Congress. Impacts of Applied Genetics: Micro Organisms, Plants, and Animals. OTA-HR-132. 1981.	88- New Dev. Biotech. (US)	82- Biotechnology International Trends and Perspectives 86- Recombinant DNA Safety Considerations
Bull AT, Geoffrey H, Lilly MD. Biotechnology: International Trends and Perspectives. Paris: OECD Press; 1982.	88- CARC (CDN)	86- Recombinant DNA Safety Considerations
OTA. US Congress. Commercial Biotechnology: An International Analysis. OTA-BA-218. 1984	89- Field Testing (US)	92- Safety Consideration for Biotechnology
Austin, Baer, Helgeson. Transfer of Resistance to Potato Leaf Roll Virus from Solanum brevidens into Solanum tuberosum by Somatic Fusion. Plant Sci 1985; 39:75–82.	89- Field Testing (US)	93- Traditional Crop Breeding
Brill. Safety Concerns and Genetic Engineering in Agriculture. Science 1985; 227:381–384.	88- New Dev. Biotech. (US) 89- Field Testing (US)	
Colwell, Norse, Pimentel, et al. Genetic Engineering in Agriculture. Science 1985; 229:111–112.	88- New Dev. Biotech. (US) 89- Field Testing (US)	
Gillett, Stern, Levin, Harwell, Alexander, Andow. Potential Impacts of Environmental Release of Biotechnology Products: Assessment, Regulation, and Research Needs. Ithaca: Ecosystems Research Center, ERC-075. 1985.	89- Field Testing (US)	92- Safety Consideration for Biotechnology
McGaughey. Insect Resistance to the Biological Insecticide Bacillus Thuringiensis. Science 1985; 229:193–195.	88- New Dev. Biotech. (US)	92- Safety Consideration for Biotechnology
Bishop. UK release of Genetically Marked Virus. Nature 1986; 323:496.	88- New Dev. Biotech. (US)	92- Safety Consideration for Biotechnology
Fraley, Rogers, Horsch. Genetic transformation in higher plants. Crit Rev Plant Sci 1986; 4:1–46.	89- Field Testing (US)	93- Safety Consideration for Biotech.: Scale-up
OECD. Recombinant DNA Safety Considerations. Paris: OECD Press; 1986.	88- New Dev. Biotech. (US)	92- Safety Consideration for Biotechnology
Ow, Wood, DeLuca, et al. Transient and Stable Expression of the Firefly Luciferase Gene in Plant Cells and Transgenic Plants. Science 1986; 234:856–859.	88- New Dev. Biotech. (US) 89- Field Testing (US)	
Ross. Potato Breeding: Problems and Perspectives. Berlin: Parey. 132 pp.	89- Field Testing (US)	92- Safety Consideration for Biotechnology
Davis. 1987. Bacterial Domestication: Underlying Assumptions. Science; 1986; 235:1329: 1332–1335.	88- New Dev. Biotech. (US) 89- Field Testing (US)	
Downey and Rakow. Rapeseed and Mustard. Principles. In: Fehr, editor. Cultivar Improvement. New York: MacMillian; 1987.	89- Field Testing (US)	93- Traditional Crop Breeding
Djordjevic, Gabriel, Rolfe. Rhizobium: The Refined Parasite of Legumes. Annu Rev Phytopathol; 1987; 25:145–168.	88- CARC 89- Field Testing (US)	
Marx. Assessing the Risks of Microbial Release. Science; 1987; 237:1413–1417.	88- CARC (CDN) 88- New Dev. Biotech. (US)	
Schippers, Bakker, Bakker. Interaction of Deleterious and Beneficial Rhizosphere Micro-organisms and the Effect of Cropping Practices. Annu. Rev. Phytopathol 1987.	88- CARC (CDN)	92- Safety Consideration for Biotechnology
OTA. US Congress. New Developments in Biotechnology Field-Testing Engineered Organisms: Genetic and Ecological Issues. 1988.	89- Field Testing (US)	86- Recombinant DNA Safety Considerations
National Research Council. Field Testing Genetically Modified Organisms: Framework for Decisions. Washington: National Academies Press; 1989.		92- Safety Consideration for Biotechnology 93- Safety Consideration for Biotech.: Scale-up
Tolin, Vidaver. Guidelines and regulations for research with genetically modified organisms: a view from academe. 1989.	89- Field Testing (US)	92- Safety Consideration for Biotechnology
Tiedje, Colwell, Grossman, Hodson, Lenski, Mack, Regal. The planned introduction of genetically engineered organisms: Ecological considerations and recommendations. 1989.	89- Field Testing (US)	92- Safety Consideration for Biotechnology
OECD. Traditional crop breeding practices: an historical review to serve as a baseline for assessing the role of modern biotechnology. Paris: OECD Press; 1993.		93- Safety Consideration for Biotech.: Scale-up

regulatory systems, but rather are based on eNGO communications about the regulatory systems. Consumer emotions cannot trump the scientific evidence of 30 years of safe regulation of GM crops.

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