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2. SCIENCE COMMUNICATION WITH THE PUBLIC: A CROSS-CULTURAL EVENT

1. INTRODUCTION

Scientist denies cancer cure quote May 8, 1998.

> NEW YORK (AP) Nobel laureate James Watson denies telling a reporter a researcher whose experiments have rid mice of malignant tumors 'is going to cure cancer in two years.'
> Watson, co-discoverer of the structure of DNA, was quoted as having made that prediction in a front-page story in Sunday's New York Times...
> Watson, in a letter to the editor published in Thursday's Times, said he told Times science writer Gina Kolata at a dinner party six weeks ago that the drugs, endostatin and angiostatin, 'should be in the National Cancer Institute trials by the end of this year and that we would know, about one year after that, whether they were effective.'
> Times spokesperson, Lisa Carparelli said, 'We're confident of the story we ran and don't wish to be in a position of quarrelling with a respected source and authority. We're glad we were able to let Dr. Watson further explain his view.'

This miscommunication between Watson and Kolata probably reflects differences between the community of scientists and the community of journalists. Key differences between the two cultures may have been veiled by the fact that both people spoke English, a language in which terms or phrases have multiple meanings and shift their meanings from context to context. Thus, an expression uttered in the context of scientists talking among themselves may have quite a different meaning on the front page of the New York Times. Perhaps both Watson and Kolata overlooked the cultural differences that defined their two communities.

This chapter focuses on the communication between different cultures, particularly between the culture of science and the culture of a public immersed in their everyday lives. Cultural anthropology suggests that science communication with the public is a cross-cultural event. If people do not clearly identify the cultures involved in the act of communicating, people risk the quagmire of miscommunication. A critical analytic understanding of the culture of Western science, and of the cultures of various audiences, is a prerequisite to effective science communication with the public. In the first part of this chapter, I summarise this prerequisite to effective communication, while in the second part, I describe effective communication in terms of culture brokering, illustrated in part by a case study of a recent Canadian science centre exhibit.

S.M. Stocklmayer et al. (eds.), Science Communication in Theory and Practice, 23–45.

2. A CULTURAL PERSPECTIVE ON WESTERN SCIENCE

Before we can think about the cultural aspects of science communication with the public, we first need to clarify what cultures and subcultures are. Then we need to understand how people cross cultural borders to communicate with each other. Last, we need to become conversant with anthropological research into the ease with which people cross cultural borders. In this section, I develop several key anthropological concepts that are applicable to the realm of science communication with the public.

2.1 Culture

Cultural anthropologists such as Geertz (1973, p. 5) have defined culture as

> an ordered system of meanings and symbols, in terms of which social interaction takes place.

This statement accurately describes the scientific community engaged in research, as scientists develop more accurate and sophisticated systems of meanings (theories, models, laws and principles, often expressed symbolically), and as they publish their manuscripts in journals (formal social interaction) to establish the validity of their ordered system of meanings. In addition to communicating through formal publications, social interactions take place in person, by e-mail, by telephone, at conferences, in the lab, in the field, and in bars or at other informal gatherings. According to Geertz's definition, science can be thought of as a culture with its own language and conventional ways of communicating for the purpose of social interaction within the community of scientists.

In an anthropological study of a high-energy physics community, Traweek (1992) described culture in a more detailed way:

> A community is a group of people with a shared past, with ways of recognizing and displaying their differences from other groups, and expectations for a shared future. Their culture is the ways, the strategies they recognize and use and invent for making sense, from common sense to disputes, from teaching to learning, it is also their ways of making things and making use of them (pp. 437-438, italics in the original).

By treating physicists as working within cultural borders, Traweek discovered some fascinating behaviour and bizarre communication by Japanese high-energy physicists as they negotiated between the subculture of their Japanese national physics community and the subculture of the international physics community. Traweek found that risk taking, power, culture, and subjectivity were all intermingled in ways that encouraged Japanese physicists to conform with their Japanese national physics community. This made it difficult for these Japanese physicists to cross the cultural border into the international community of high-energy physics. Japanese physicists were the target of pejorative humour, sarcasm, and cultural reprisals from their Japanese colleagues. Therefore, Japanese high-energy physicists had to cross into the culture of international physics with great care and subtlety by using humour, selected conformity and politics, so as not to offend their Japanese colleagues in high-energy physics. By recognising the cultural differences between Japanese high-energy physicists and international high-energy physicists, Traweek could better understand the otherwise bizarre communication among some Japanese physicists. Perhaps there is a lesson here for James Watson and Gina Kolata - they should have recognised science as a culture, a culture with borders that must be crossed if outsiders are to understand the communication conventions of that culture, and if insiders are going to communicate effectively with the public.

Consistent with both Geertz's and Traweek's definitions of culture, Phelan, Davidson and Cao (1991) suggested that culture be conceptualised as the

> norms, values, beliefs, expectations, and conventional actions of a group. (p. 228)

This cogent definition helps to clarify how science is a cultural phenomenon. Science content can be subsumed under 'beliefs'. The communication conventions of scientists are guided by the norms, values, and expectations of the culture of science, and by the specific norms, values, and expectations of the specialty field of the scientist, that is, the his or her paradigm or scientific subculture. Other definitions of culture have guided research in science communication (for example, Banks, 1988; Bullivant, 1981; Ingle and Turner, 1981; Jordan, 1985; Maddock, 1981; Samovar, Porter and Jain, 1981; and Tharp, 1989). From these works one can establish the following list of attributes of culture: communication (psycho- and socio-linguistic), social structures (authority, participant interactions), customs, attitudes, values, beliefs, worldview, skills (psychomotor and cognitive), behaviour, and technologies (artefacts and know-how). In various studies, different attributes of culture have been selected as a focus on a particular interest in multicultural communication. The definition of Phelan *et al.* (1991) of culture (above) is advantageous because it has relatively few categories and they can be interpreted broadly to encompass all anthropological aspects of culture and subculture.

Just as there are paradigms (subcultures) within the culture of science, there are subgroups in everyday life, most commonly identified by race, language, and ethnicity, but which can also be defined by gender, social class, occupation and religion. Consequently, an individual simultaneously belongs to several subgroups; for instance, an oriental female Muslim physicist or a male middle-class Euro-American journalist. Large numbers and many combinations of subgroups exist due to the associations that naturally form among people in society. Each identifiable subgroup is comprised of people who generally embrace a defining set of norms, values, beliefs, expectations, and conventional actions. In short, each subgroup shares a culture, often called a 'subculture' to convey an identity with a subgroup. One can talk about, for example, the subculture of females, the subculture of the middle class, the subculture of the television media, or the subculture of a particular science museum.

2.2. Border Crossing

An everyday scenario will illustrate the difficulties people can encounter whenever they move between cultures or between subcultures:

> George and Gracie Smith flew from North America to Spain, physically crossing political borders, but not crossing cultural borders. After waiting 45 minutes in a restaurant for their dinner bill to arrive, George finally became vocally irate over the waiter's lack of service. The waiter, in turn, became hurtfully perplexed over the fact that his impeccable manners were not appreciated.

Misunderstandings can arise whenever one of the players does not recognise a cultural border that needs to be crossed for effective communication (Aikenhead, 1996).

People often cross cultural borders so easily that they do not realise they are even there - for example, when people move between the subculture of their friends and the subculture of their family home. But for people whose peer culture is vastly different from their home culture, transitions between friends and home can be psychologically hazardous and these transitions need to be negotiated carefully. Similarly problematic are the border crossings between humanist and scientific subcultures of Western society. This problem was identified by C.P. Snow (1964) in his classic *The Two Cultures*, pointing out the inability of people to speak to one another between these two cultures.

For people who feel at ease in both a humanist and scientific culture, however, border crossing is no problem. Border crossing for them is smooth. When people feel at ease like this, cultural borders seem invisible or nonexistent. It is when people begin to feel a degree of psychological discomfort with another subculture that border crossing becomes less smooth, and needs to be managed. Contributing to their discomfort may be some sense of disquiet with cultural differences or their unwillingness to engage in risk-taking social behaviour (depending on the situation, of course). When the self-esteem of people is in jeopardy (for instance, when playing badminton with players much better than they are or when participating in an unusual social occasion such as wearing a Halloween costume), border crossing could easily be hazardous. People may react in various ways to protect their egos. Even worse, if psychological pain is involved, avoidance is the natural response and border crossing becomes impossible. These descriptors of the ease of border crossing - smooth, manageable, hazardous, and impossible - are categories that Phelan *et al.* (1991) derived from their anthropological study of high school students who had to cross cultural borders between their homes and their school. This category system was helpful to Costa (1995) in her study of students' feelings of ease in science classes. The category system will be helpful in this chapter for understanding the role of a science communicator.

Border crossing into the culture of science can be made smoother for the public if science communicators know the culture of the everyday world of the public, and can contrast that culture with a critical analysis of the culture of science (its norms, values, beliefs, expectations, and conventional actions). But even more, a science communicator must consciously move back and forth between the public's everyday world and the scientists' world - switching norms explicitly, switching values explicitly, switching conceptualisations explicitly, switching expectations explicitly, and switching language conventions explicitly. The role of a science communicator is described in more detail later in this chapter.

2.3. Values and Norms

One principal component of any culture is its values and norms. Values and norms guide scientists whenever they decide between, for example, competing theories or competing experimental methodologies (Chubin, 1981). Values and norms are learned by the apprentice scientist and they become important aspects to his or her paradigm (Hawkins and Pea, 1987; Kuhn, 1970). Longino (1990) refers to this set of discipline-centred values as constitutive values (for example, parsimony, accuracy, open-mindedness, objectivity, etc.) In contrast to constitutive values, she points to the social context outside of science in which scientists live daily. She refers to these cultural values as contextual values. Her research documented cases in which these contextual values (rather than constitutive values) influenced the decisions taken by scientists over what 'facts' to believe. She concluded that science-as-practised (as opposed to science-as-imagined) is not value-neutral. The value-neutrality of science has also been falsified by other studies (Casper, 1980; Graham, 1981; Snow, 1987; Ziman, 1984). Those who believe in the neutrality of science contend that science is free of contextual values, not constitutive values.

Therefore, science communicators must be aware of the values and norms that are potentially inherent in the language conventions of scientists (their discursive practices). For instance, one constitutive value, scientific objectivity, is often communicated to the public through science textbooks. Textbooks, however, camouflage more subtle contextual values, for example, the value 'technoscience fix' (Carlsen et al., 1994; Factor and Kooser, 1981) - the idea that solutions to societal problems (such as water contamination) only require more scientific knowledge and more innovative technologies.

Moreover, when one examines the constitutive values within science, one discovers differences between the constitutive values espoused by scientists, and the constitutive values actually practised by scientists (Mitroff, 1974). For instance, scientists publicly revere objectivity but many rely on subjective hunches in the privacy of their labs. Holton (1978) explained this apparent conflict in values by distinguishing between two types of scientific activity - 'private science' and 'public science'. Each has a different social setting and therefore a different communication audience. Public science is communicated in journals, conference proceedings, textbooks and news releases, while private science is done in labs and communicated in personal notebooks, letters, e-mails, and informal conversations.

Private science communication is not necessarily guided by the same values and norms as communication in the public science arena. For example, subjectivity and closed-mindedness have advantages in private science but never in public science where objectivity and open-mindedness form the cultural expectations. It is interesting that research on scientists who analysed the Apollo moon rock samples in the early 1970's indicated that those who were held in high esteem by their colleagues used conflicting sets of values and norms (values and norms associated with public and private science), while those who were considered mediocre by their colleagues embraced only public science values and norms (Gauld, 1982).

Sociological research into present-day practices of scientists (e.g. Latour, 1987) concurs with Holton and Gauld. Scientific activity embraces two legitimate, dichotomous sets of values (norms and counter-norms). When public-science values and norms define the whole enterprise of science, they propagate myths about the nature of science because they hide the function of the private-science (sometimes guided by, for instance, subjectivity and closed-mindedness). Miscommunication is ripe whenever statements expressed in the social context of private science are repeated in the social context of public science. This distinction may shed light on the mis-communication between James Watson and Gina Kolata. Did Watson neglect to express his enthusiasm in the language conventions of public science (appropriate for the front page of the New York Times)? Did Kolata neglect to recognise Watson's expression as private science? Perhaps both failed to recognise the cultural border between the two subcultures - private science and public science - each with its own set of norms, values, beliefs, expectations, and conventional actions. When people do not see a cultural border to cross, they run the risk of miscommunicating.

Compared with scientists, the general public expresses an even wider array of values and norms, many of which conflict with those embraced by the culture of science. Cobern (1991) explored a way to identify clusters of values that seem to inform the public's general outlook on the world. Drawing upon the work of anthropologist Kearney (1984), Cobern investigated the way that people's worldviews may predispose them to being sympathetic or antagonistic toward the worldviews conveyed by much of Western science. Cobern and Aikenhead (1998) illustrated the ease of communication between a science teacher (Mr Hess) and students who generally shared his worldview toward nature (that is, orderly and understandable, governed by physical forces which can be fully understood by tearing nature apart and analysing the pieces - reductionism). On the other hand, students who possessed alternative worldviews toward nature, such as those formulated on aesthetic or spiritual orientations toward nature, had communication problems with Mr Hess. Worldview is a convenient concept that embodies fundamental

> presuppositions about what the world is really like and what constitutes valid and important knowledge about the world. (Cobern, 1996, p. 584)

Worldviews are basic culture-laden frameworks from which daily values and norms flow.

In summary, science communication with the public will be more effective when people recognise science as a culture having many subcultures (such as paradigms, as well as private and public subcultures). For both insiders and outsiders to the culture of science, cultural borders must be crossed before effective communication can take place between those two groups. These border crossings can be smooth, managed, hazardous, or impossible, depending upon the cultural differences experienced by individuals, and depending upon their resourcefulness and motivation to cross otherwise hazardous or impossible borders. Scientists are guided by a complex and dynamic set of cultural values and norms, as is the general public. Similarities and differences between these two groups may be better understood by considering their different worldviews.

3. THE CULTURE OF SCIENCE AND THE PUBLIC DOMAIN

The division between science and the general public manifests the theory/practice dichotomy endemic to Plato's eidos and praxis. This remnant of Greek culture continues to characterise Western thinking today. Western science tends to isolate itself in eidos (idealised pure knowledge), rendering itself superior to praxis (practical knowledge needed for action), according to Platonic Greek tradition. Therefore, understanding science communication predicated on that distinction becomes difficult for people for whom a theory-practice distinction does not exist. The problem can be eased somewhat by the communicator expressing the cultural features found on both sides of this cultural border.

How is scientific knowledge actually used outside the culture of science, in people's commonsense and professional life-worlds, that is, in praxis? A cherished myth in the culture of Western science is the belief that people can directly apply scientific knowledge to their everyday world (Aikenhead, 1980; Layton, 1991; Ryle, 1954; Solomon, 1983). Reality is much different. Based on case study research in the UK, Jenkins (1992) commented that using science in the everyday world is

> no more a straightforward application of the scientific knowledge acquired at school or in other formal contexts than technology is merely applied science. Rather it is about creating new knowledge or, where possible, restructuring, reworking and transforming existing scientific knowledge into forms which serve the purpose in hand. Whatever that purpose (political, social, personal, etc.), it is essentially concerned with action or capability, rather than with the acquisition of knowledge for its own sake. (p. 236)

This conclusion guides us in helping the general public negotiate what would otherwise be a hazardous border crossing between their everyday culture and the culture of science. One hazard is the fact that scientific knowledge must be deconstructed and then reconstructed in the context of everyday use (Layton, 1991). In the context of teaching science Layton, Jenkins, Macgill and Davey (1993) concluded:

> The nature of the transformation needed is not a matter which has hitherto commanded much attention from science teachers, although it has been a preoccupation of engineers for a century or more.....The essence of the problem is that the concepts developed by scientists in their quest for understanding [eidos] do not always map with exactitude onto the design parameters in terms of which practical action has to be planned [praxis]. As a result, for science to articulate with practice, some reworking is often required. (p. 129)

This communicative challenge has plagued science educators as they contemplate how to communicate with students over the use of science content outside of the classroom. The same challenge exists for all science communicators.

A case in point was a student (Melanie) who found border crossing into the culture of science hazardous when studying the topic of heat (Aikenhead, 1996). In spite of her high motivation to participate in hands-on group activities, Melanie could not cross the cultural border into the science of heat and temperature. Her difficulty may have arisen from her having a worldview at odds with the worldview generally embraced by science. Cobern (1996) argued,

> ...it is not that the students fail to comprehend what is being taught, it is simply that the concepts are either not credible or not significant' (p. 601) because 'for students it is aesthetic, religious, pragmatic, and emotional concepts that have scope and force with regard to nature. (p. 597)

Thus, a general distaste for mechanistic reductionist concepts (a central feature of a conventional scientific worldview) might explain why students such as Melanie choose not to integrate the scientific concepts of heat and temperature into their everyday notions of hot and cold (Kilbourn, 1980).

In the adult world of consumers, Layton *et al.* (1993) discovered that a scientific understanding of heat energy had no consequence to lay people managing domestic energy problems in their life-world. Layton and his colleagues seriously questioned the objective of science education to teach what is rarely usable in the everyday world. In the words of Wynne (1991):

> ordinary social life, which often takes contingency and uncertainty as normal and adaptation to uncontrolled factors as a routine necessity, is in fundamental tension with the basic culture of science which is premised on assumptions of manipulability and control. (p. 120)

These lessons from science education apply directly to the communication of science with the public. The more that someone's worldview differs from the one conveyed by Western science, the less smooth (the more impossible) will be their border crossing into the culture of science and, as a consequence, the more they challenge science communicators. Communicating effectively requires a knowledge of one's audience. Challenges can be met more realistically when we recognise that this communication is a cross-cultural event. Cultural gaps must be bridged, not just by content knowledge bridges (that is, the naive belief that the public only needs more accurate knowledge), but by bridges that communicate the norms, values, beliefs, expectations, and conventional actions of scientists (the culture of science).

Some useful distinctions among people in the public domain were identified by Ogawa (1998b) in the context of science education reform in Western countries. He described three types of orientations the public will assume towards science. His first type concerns whether a person understands science (science literacy versus science illiteracy). His second type of orientation addresses a more emotional aspect, whether a person supports science (a pro-science or anti-science position). Ogawa's third type of orientation deals with an ideological belief that scientific knowledge is the only valid form of knowledge to use in any context. This belief, often called 'scientism', privileges scientific knowledge over all other ways of knowing (Nadeau and Désautels, 1984). Thus, Ogawa's third type of orientation consists of pro-scientism versus anti-scientism. In short, Ogawa contends that people's stance toward science will be influenced by how they fit into these three types of orientations. Thus, their receptivity to, and engagement in, scientific communication will vary according to their literacy in science, their support of science, and their allegiance to scientism. Ogawa's scheme generated six orientations of people:

i. science-literate, pro-science, pro-scientism folk ('science believers');
ii. science-literate, pro-science, anti-scientism folk ('science contextualists');
iii. science-literate, anti-science, anti-scientism folk ('authentic anti-scientists');
iv. science illiterate, pro-science, pro-scientism folk ('science fanatics');
v. science illiterate, pro-science, anti-scientism folk ('science vigilantes'); and
vi. science illiterate, anti-science, pro-scientism folk ('neo anti-scientists').

These categories can sensitise science communicators to the challenges that face them and their Western audiences.

4. WESTERN SCIENCE AND NON-WESTERN CULTURES

Communication barriers are even more pronounced between Western science and non-Western cultures. Researchers have investigated the obstacles encountered when one teaches Western science to non-Western students. Their findings are highly relevant to science communication with the public. Because science tends to be a Western cultural icon of prestige, power, progress, and privilege, the culture of science tends to permeate the culture of those who engage it, with cultural assimilation being one possible negative consequence (Baker and Taylor, 1995; Dart, 1972; Jegede and Okebukola, 1991; MacIvor, 1995; Ogawa, 1995). This assimilation threatens indigenous cultures, thereby causing these people to experience Western science as a hegemonic icon of cultural imperialism (Battiste, 1986; Ermine, 1995; Linkson, 1998). Science communicators in the global village need to extend their cultural sensitivity to a public outside of Western culture.

The encroachment of Western culture occurs, in part, because it is hidden in the Trojan horse of Western science. Different cultures have reacted differently to this encroachment. Aboriginal, Japanese, and Islamic peoples represent three cultural groups that have fought against such assimilation. Each group is discussed here in turn. Emphasis is given to Aboriginal peoples because they are the most under-represented group in Western science. Nevertheless they must deal with Western scientists in the areas of health, land management, and ethics (MacIvor, 1995; Wolfe, Bechard, Cizek and Cole, 1992). Their perspective helps us understand the cultural borders that most people in the global village must cross before effective science communication can succeed.

4.1 Aboriginal Cultures

Knudtson and Suzuki (1992) documented various indigenous knowledge systems around the world that describe and explain nature. Aboriginals, they claimed, possess powerful knowledge systems that convey wisdom, a key element missing in Western science. Aboriginal knowledge about the natural world (Aboriginal science) contrasts with Western scientific knowledge in a number of other ways. The following summary of Aboriginal science is based on sensitive and scholarly analyses by Christie (1991), Ermine (1995), Kawagley (1990), Linkson (1998), McKinley (1996), Mitchie, Anlezark and Uibo, (1998), Peat (1994), Pierotti and Wildcat (1997), Pomeroy (1992), and Roberts and Wills (1998). They wrote about the Maori in Aotearoa (New Zealand), the original peoples of Australia, and the First Nations peoples on Turtle Island (America).

Aboriginal and Western science differ in their social goals: survival of a people versus the luxury of gaining knowledge for the sake of knowledge and for power over nature and other people. They differ in intellectual goals: to co-exist with mystery in nature by celebrating mystery versus to eradicate mystery by explaining it away. They differ in their association with human action: intimately and subjectively interrelated versus formally and objectively decontextualised. They differ in other ways as well: holistic Aboriginal perspectives with their gentle, accommodating, intuitive, and spiritual wisdom, versus reductionist Western science with its aggressive, manipulative, mechanistic, and analytical explanations.

The Western world has capitulated to a dogmatic fixation on power and control at the expense of authentic insights into the nature and origin of knowledge as truth (Ermine, 1995).

> They even differ in their basic concepts of time: circular for Aboriginals, rectilinear for scientists. (p. 102)

Aboriginal and scientific knowledge differ in epistemology. Pomeroy (1992) summarises the difference found on Turtle Island:

> Both seek knowledge, the Westerner as revealed by the power of reason applied to natural observations, the Native as revealed by the power of nature through observation of consistent and richly interweaving patterns and by attending to nature's voices. (p. 263)

Ermine (1995) contrasts the exploration of the inner world of all existence by his people with a scientist exploring only the outer world of physical existence. He concludes:

> Those who seek to understand the reality of existence and harmony with the environment by turning inward have a different, incorporeal knowledge paradigm that might be termed Aboriginal epistemology. (p. 103)

Along similar lines, Roberts and Wills (1998) compare a fundamental Maori ontological principle of 'whakapapa', an orientation to the past that connects a person to the creators of the land, with a Western scientific future orientation that embraces a preoccupation with matter and causal mechanisms.

Battiste (1986) explicates a Turtle Island epistemology by giving detail to what Pomeroy (1992) called 'naturequotes voices':

> A fundamental element in tribal epistemology [lies] in two traditional knowledge sources:
> 1. from the immediate world of personal and tribal experiences, that is, one's perceptions, thoughts, and memories which include one's shared experiences with others; and
> 2. from the spiritual world evidenced through dreams, visions, and signs which (are) often interpreted with the aid of medicine men or elders. (p. 24)

On the one hand, subculture science is guided by the fact that the physical universe is knowable through rational empirical means, albeit Western rationality and culture-laden observations (Ogawa, 1995); while on the other hand, Aboriginal knowledge of nature celebrates the fact that the physical universe is mysterious but can be survived if one uses rational empirical means, albeit Aboriginal rationality and culture-laden observations (Pomeroy, 1992). For example, when encountering the spectacular northern lights, Western scientists would ask, 'How do they work?' while the Waswanipi Cree ask, 'Who did this?' and 'Why?' (Knudtson and Suzuki, 1992). We can learn more about the culture of Western science the more we contrast it with other ways of knowing nature.

The norms, values, beliefs, expectations, and conventional actions of Aboriginal peoples contrast dramatically with the culture of Western science. Western science has been characterised as essentially mechanistic, materialistic, reductionist, empirical, rational, decontextualised, mathematically idealised, communal, ideological, masculine, elitist, competitive, exploitive, and impersonal (Fourez, 1988; Kelly, Carlsen and Cinningham, 1993; Rose, 1994; Snow, 1987). By comparison, Aboriginal sciences tend to be thematic, survival-oriented, holistic, empirical, rational, contextualised, specific, communal, ideological, spiritual, inclusive, cooperative, coexistent, and personal. Based on these two lists, Western science and Aboriginal sciences share some common features (empirical, rational, communal, and ideological). Consequently, it is not surprising that efforts are underway to combine the two knowledge systems into one field called 'traditional ecological knowledge' (Corsiglia and Snively, 1995). While a romanticised version of the peaceful coexistence of an Aboriginal with the environment should be avoided, Knudtson and Suzuki (1992) document the extent to which environmental responsibility is globally endemic to Aboriginal cultures. It is this quality that led Christie (1991), Pierotti and Wildcat (1997), Roberts, Norman, Minhinnick, Wihongi and Kirkwood, (1995), and Simonelli (1994) to define scientific ecology and sustainable Western science in terms of Aboriginal cultures. Simonelli (1994) quoted a Lakota ceremonialist's view of science and technology:

> This is not a scientific or technologic world. The world is first a world of spirituality. We must all come back to that spirituality. Then, after we have understood the role of spirituality in the world, maybe we can see what science and technology have to say. (p. 11)

Deloria (1992), also of the Lakota nation, challenged Western science's objectivity and validity when he spoke about improving the culture of science by getting scientists to adopt an Aboriginal sense of contextualised purpose.

Differences between the culture of Western science and the cultures of indigenous Aboriginal students help to explain the apparent reticence of students to learn about heat and temperature, or about any other Western science concept (Aikenhead, 1997; Schilk Arewa, Thomson and White, 1995; Sutherland, 1988). The cultural borders around Western science are seldom smooth for Aboriginal peoples. For instance, in an American study of third grade children, Schilk *et al.* (1995) concluded, that the perceptions Indian students had of scientists, largely dictated by popular media, were in direct conflict with their Iroquois values (p. 3):

> Interviewer: Do you think you could be a scientist?
> Client: That's not something Indians do. I couldn't hurt things or blow things up.

As long as Western prestige, power, progress, and privilege continue to affront the wisdom of traditional knowledge of the land, science communication worldwide will be challenged. More than ever before, science communicators in the 21st century will be engaged in helping both Western scientists and Aboriginal peoples communicate with each other.

4.2. Japanese Culture

Japanese people, for the most part, resisted the encroachment of Western culture fairly successfully until the mid 19th century, when they were forced by the threat of physical violence to open their country to American commerce and technology (Shelley, 1993). Western science followed in due course. Before this cultural invasion, Japanese people had a knowledge of nature, of 'shizen', which encompassed descriptive and explanatory elements as well as cosmological characteristics (Ogawa (1997):

> Everything surrounding human life (for example, mountains, rivers, plants, trees, insects, fish or animals) has its own spirit, which can communicate with each other as well as with the people living there. Thus, the special feelings summarised by the 'one-bodiness', which means that human beings and every natural thing are one body in total, are felt by the Japanese. (p. 176)

Elsewhere Ogawa (1998a, p. 158) asserts that most Japanese feel and are familiar with such spirits. Fortified by a feeling of animism, Japanese people cannot regard natural things as mere objects of value-free inquiry, as Western scientists tend to do. Although the word 'observe' is translated into Japanese by 'kansatsu', that is not an accurate translation because kansatsu connotes a close spiritual-like relationship, much different from the objective relationship presupposed by the Cartesian dualism (the mind/matter dichotomy) that forms a cornerstone to a Western science worldview (Kawasaki, 1996b).

The observer-object relationship connoted by kansatsu is not unique to Japanese culture. Most Aboriginal languages lack a verb 'to observe' with a Cartesian connotation. For example, Canadian Plains Cree use the verb 'kanawapamew' to indicate a visual connection to an animate object. The verb changes as the human sense changes to hearing or touching, and as the classification of an object changes to inanimate - connoting a very different relationship. Similarly, feminist writers have critiqued Western science for its hegemonic Cartesian discourse (Rose, 1994; Scantlebury, 1998). For example, Barbara McClintock's highly successful scientific research, described in Keller's (1983) *A Feeling for the Organism*, supports the view that alternative observer-object relationships can successfully advance Western scientific knowledge.

Discourse is highly dependent upon one's worldview. Because discourse is central to science communication with the public, we need to be sensitive to our own language, to the language of Western science, and to the language of our audience. For instance, to describe scientists observing a distant galaxy requires a different discourse depending upon the audience. An effective communicator should be able to acknowledge the audience's conventional meaning of 'to observe' and then be able to articulate the cultural border that needs to be crossed in order to appreciate what scientists have done when they have 'observed' that galaxy. In short, the science communicator must help an audience cross the cultural border into science sufficiently to engage in the act of communicating.

Returning to the topic of Japanese culture, the accelerated acculturation of Western science that followed the American incursion of 1863 was consciously controlled by the Japanese intelligentsia. They were very much aware of the cultural border between Western nature and Japanese shizen (Kawasaki, 1996a). The cultural border is identified today by such expressions as, 'I may wear a Western suit, but I have a bamboo heart'.

The degree to which Japanese people embrace Western materialism and its ideology of progress, is the degree to which Western assimilation seems to have succeeded (Suzuki and Oiwa, 1996). However, Japanese people have exhibited a type of acculturation of Western science that protects their bamboo hearts. They transform this foreign element into something quite new.

> The paradox is that Japanese culture through its long history has been able to adopt various components of foreign culture without losing its own identity. (Ogawa, 1998a, pp. 142-143)

Thus, Western science is transformed into something different, even though it is still called Western science or 'neo-science' by Ogawa (1997).

This information helps to explain Traweek's (1992) observations of the difficulties experienced by high-energy Japanese physicists when they attempted to move between the subculture of Japanese physics into the subculture of international (Western) high-energy physics, described earlier in this chapter. Perhaps the Japanese high-energy physicists were negotiating the boundary between 'neo-science' and Western science by switching worldviews and values/norms as they crossed the border. Ogawa's analysis also points out that if we wish to communicate Western science to a Japanese public, we must cross two cultural borders: from Western science to a transformed Western science (neo-science), and then to the everyday culture of Japanese society. Corresponding challenges exist for science communicators in societies other than Japan.

Even within Western cultures, Western science was shown (earlier in this chapter) to be transformed into a different knowledge system whenever science is used for practical action (Jenkins, 1992; Layton, 1991; Layton *et al.*, 1993). The similarity to the Japanese transformation of Western science into neo-science is striking.

In summary, science communication is much more complex than transmitting scientific information. One needs to respond to the multiple cultures or subcultures involved, not only within the culture of Western science, but within one's audience. If a science communicator does not realise the culture-laden nature of science as practised in Euro-American institutions (Western science), and the culture-laden nature of its discourse, then he or she runs very high risks of creating misunderstandings in an audience. If a science communicator does not critically analyse his or her own linguistic conventions, and those of his or her audience, then he or she runs very high risks of mis-communicating with the public. Sensitivity to our discourse is fundamental to science communication with the public.

4.3. Islamic Cultures

The encroachment of Western (Greek) thought into Islam has a very different history from either the attempted colonisation of Aboriginal peoples or the acculturation of Japanese people. The history of Islamic science during the 8^{th} to 12^{th} centuries is largely characterised by a multicultural synthesis involving knowledge and technique from China, India, Greece, and Arabian nations (Krugly-Smolska, 1992).

Today, Islamic nationalism has created several views toward Islamic science, with different sects (or movements) defining Islamic science differently. Sardar (1997) described five competing views. One major issue in this debate is an epistemological issue. It concerns re-establishing the relationship between revelation (knowledge found in the Qur'an) and reason (inductive empirical knowledge).

> Revelation in Islam is above reasoning, but not above reason. Neither is reason above revelation. This subtle relationship was destroyed when Greek thought became dominant in Muslim societies. (Sardar, 1989, p. 13)

One of Sardar's (1997) five categories of Islamic science - 'mystical fundamentalism' - was the object of interest in Irzik's (1998) analysis of Islamic science in modern Turkey. Irzik contended that in their search for an Islamic science, 'radical intellectuals' reject Western science in terms that parallel critiques by Japanese people (Kawasaki, 1996a) and by Aboriginals (Christie, 1991; Ermine, 1995).

> These [radical] intellectuals also criticize industrialization on the grounds that production for the sake of ever more profits has turned human beings into mere puppets of Capitalist consumer society manipulated by mass media, deprived them of their religious-spiritual values, and enslaved them to the greed for material wealth. (Irzik, 1998, p. 167)

A significant segment of the global public will likely perceive scientific knowledge generated in Western institutions as laden with Western values and morally bankrupt. Communicators of science must keep in mind the various socially constructed realities of different publics.

For instance, Sardar's (1989) balance of revelation and reason has been replaced in some Islamic quarters by a radical form of Islamic science in which a hierarchy of revelation over reason exists. This hierarchy is dedicated to the principle of unity in which Allah, humankind, and nature (bodies and souls included) exist 'in harmony with the natural order of things' (Irzik, 1998, p. 173).

No matter what the culture, a fundamentalist public anywhere will present a great challenge to effective science communication worldwide. Even in Western cultures, for instance, Ogawa (1998b) pointed out that some of the public (science believers, science fanatics, and neo anti-scientists - described earlier) embrace a pro-scientism ideology called 'scientific fundamentalism' by Sardar (1997). This fundamentalism will be of particular interest to those science communicators who catch themselves inadvertently communicating this fundamentalist scientism without being aware of the ideological baggage attached to their communication, and therefore being surprised by the negative reaction from their audience.

4.4. *Summary*

Communication of science with the public will occur in various cultural contexts each one populated by a different public. Not only are there diverse publics to be considered, but there are pluralistic sciences to be acknowledged. Western science has tended to dominate Aboriginal science, Japanese science, and Islamic science, not because of any intellectual or moral superiority but because Western science is embedded in a culture that has colonised large portions of the planet. Western science has been invested with much more authority then, for instance, everyday commonsense science, not because Western science is necessarily more valid in that context, but because its culture is associated with prestige, power, progress, and privilege. A question of truth is hybridised with a question of social or political privilege. These are some of the ideological features to science communication with the public of which a communicator must be aware.

5. CULTURE BROKERING

Challenges to effective science communication with the public have accumulated throughout this chapter. Potential solutions to these challenges were suggested. These solutions had common features in that they recognised the cultural nature of any science (Western or otherwise), the need to cross cultural borders when communicating science, and the need to be sensitive to the subcultures of the audience. They also recognised the need to acknowledge such cultural components as values, norms, ideologies, histories, epistemologies, and linguistic conventions, on both sides of the cultural border.

Stairs (1995) referred to people who facilitated Canadian First Nations peoples movement between Aboriginal and Euro-Canadian society as 'culture brokers.' A culture broker helps people move back and forth between cultures and helps them resolve any conflicts that might arise.

Communicating science to the public has traditionally been a process of transmitting scientific facts, principles, and triumphs (Dierking and Martin, 1997). This has largely been a one-way process (Layton et al, 1993). By re-conceptualising this communicating process as a two-way cross-cultural event, and by taking on the role of culture broker, a communicator's task changes fundamentally. A culture brokering science communicator acknowledges and respects the cultural perspective of his or her audience, a cultural perspective that has norms, values, beliefs, expectations, and conventional actions, some of which may conflict with those of Western science. The audience's indigenous science is neither ignored nor marginalised. A culture broker will identify the cultural border that separates the public's indigenous culture from the culture of Western science. In addition, the cultural nature of Western science is established, perhaps through an explication of some of its cultural features.

These aspects of culture brokering form a foundation for increasing the effectiveness of communicating Western science to the public; in other words, for increasing the ease with which the public can cross the cultural border into Western science, enough to participate in the communication intended by the science communicator.

This cross-cultural event is made even smoother when a science communicator consciously and explicitly moves back and forth between the culture of Western science and the cultures of the audience (audiences are often multicultural). This can be accomplished verbally, by labeling each side of the cultural border with some type of linguistic marker. This might be achieved, for example, by referring to a group of high-energy physicists as 'a tribe of physicists'; by relating stories that serve as defining moments of contrast, such as. the newspaper story that began this chapter; and most of all, by making it overtly clear which culture we are communicating in at any given moment, and by making it overtly clear when we cross into another culture. Visual and auditory cues constitute the creative substance of communication while humour is often its winning style.

A realistic goal for culture brokers is to make transitions across borders smoother for our audience by transforming: impossible borders into hazardous ones, hazardous borders into manageable ones, or manageable borders into smooth ones.

When crossing cultural borders, we invariably switch norms, values, beliefs, expectations, and conventional actions. This switching is done overtly for more effective communication. Both the communicator and the audience are aware of the critical changes in language conventions, in epistemology, in worldviews, and in ideology, that accompany the cultural border crossing event. This awareness defines the goal of a culture brokering science communicator.

6. A CASE STUDY OF SCIENCE COMMUNICATION

In 1997 at the Ontario Science Centre in Toronto, a radically different interactive exhibition opened. It is called *A Question of Truth.* It makes explicit the intimate relationship between scientific knowledge and social responsibility, in a cultural and political context (Pedretti, Mclaughlin, Macdonald and Kithinji, 1998).

The public is expected to learn more about their own views of science and to explore the culture and practice of science-in-action, not idealised science. *A Question of Truth* illustrates some of the key features identified in this chapter that contribute to effective communication with the public. The title of the exhibit expresses irony in that its content demonstrates a socially constructed truth, not an absolute truth inherent in scientism.

The exhibit engages people in three themes: frames of reference, biases in society and science, and science and the community. Pedretti and her colleagues (1998) described these themes this way:

> The exhibit ... is designed to examine several questions about the nature of science itself, how ideas are formed and how cultural and political conditions affect the actions of individual scientists. Practitioners of science are portrayed as having a point of view, one which is derived from personal, cultural and political aspects of their lives. The ultimate findings of science are shown to be human products of our society. The exhibit traces lines of bias throughout our western scientific history. Ideas which have

> remained unquestioned for centuries are examined anew for their roots in human prejudice. (p. 4)

For instance, in the section 'Point of View' (a frame of reference theme), visitors are introduced to navigational beliefs of Pacific islanders, two views of the solar system, and different calendar systems. The exhibit constantly poses the question, 'Can you accept points of view different from yours?' Some science literate visitors became rather surprised when they learned that scientific (sun-centred) models of the solar system are not as useful as earth-centred models when it comes to navigating or creating calendars.

The education guide to *A Question of Truth* (OSC, 1997) warns educators who are planning a field trip to the new exhibit:

> Please be aware that certain [sub]exhibits such as the Science & Prejudice video, Sex & Science, the Confinement Box, Slavery; Who is Civilized? and Speak Up! present some controversial views. Powerful questions and feelings could arise among both adults and young people. (p. 6)

Reactions have indeed been powerful. Pedretti *et al.* (1998) assessed the impact of the exhibit and found that

> deconstructing long standing and deeply entrenched views of science can create tension and dissonance. (p 25)

A very small minority (8%) thought that *A Question of Truth* had no place in a science centre (perhaps people belonging to Sardar's 'scientific fundamentalism' or to Ogawa's 'pro-scientism' groups?). One main reason was the fact that *A Question of Truth* challenged their stereotype images of science by portraying

> science as a human endeavour (and therefore socially and culturally bound, subject to error, differing views and values. (p. 19)

Pedretti and her colleagues raised the following point in the conclusion to their study of the public's interaction with *A Question of Truth*.

> Science centre exhibits need to consider a more contextualized approach to their portrayal of science; one which recognizes the contributions of many cultures to our understanding of the natural world, and one which recognizes science as a human activity: value laden and contextually bound. This kind of exhibitry needs to be developed in addition to, or in tandem with, traditional phenomenon-based exhibits. (p. 25)

This conclusion addresses several features of culture brokering in science communication. Every culture develops a science that fits its unique needs (Feyerabend, 1988). Western science is but one way of rationally perceiving reality (Ogawa, 1995). Culture brokering requires a pluralistic understanding of science–a multi-science perspective.

Every science is embedded in a culture, including Western science. Any science is necessarily a social activity guided by norms, values, beliefs, expectations, and conventions with which social action takes place. These features can be contrasted with those held by a particular public with whom one is communicating a science.

Although *A Question of Truth* gave emphasis to a critical examination of Western science, the exhibit did attend to participants expressing their own views. Border crossing was facilitated by the questions posed and by the contexts in which visitors confronted those questions. However, the participants by and large were left to their own to handle any cultural conflict that may have arisen. Although interactive science centres tend to be more conducive to smoother border crossings than the more traditional museum displays, these centres, at present, still require the public to negotiate cultural borders by themselves. The public needs culture brokering communicators.

7. CONCLUSION

This chapter began with a miscommunication between scientist James Watson and journalist Gina Kolata. That miscommunication seems ironic because it was Watson himself who did so much towards communicating science effectively to the public when he published *The Double Helix* in 1968. His readers were made aware of the paradigms of practice, the cultural metaphors, the social conventions, and the competitive struggles that characterise science-in-action. His book lay bare for public scrutiny many of Western science's cultural features, even more vividly than subsequent scholarly treatises on the social construction of science (e.g. Latour, 1987; Latour and Woolgar, 1979; Longino, 1990). Watson portrayed fellow scientists as developing an ordered system of meaning and symbols (a helical model for DNA) in the context of social interactions. These social interactions were so poignantly portrayed that some people thought the book should be X-rated.

Latour (1987) criticises journalists who report every new development in technoscience as a breakthrough in the progress of humanity. He points out that they fail to communicate science culture effectively to the public by not, for instance, identifying the ideology of scientism associated with 'technoscience breakthroughs' by asking, for example, 'progress for whom?' A critical analytic understanding of the culture of Western science is a prerequisite to effective communication with the public. Western scientific knowledge and technique must be seen as socially constructed within paradigms of practice, and socially determined by cultural metaphors and conventions, by economic interests, and by competition for privilege and power.

This prerequisite knowledge about Western science was informed in this chapter by such anthropological concepts as culture, subculture, assimilation, acculturation, worldview, and ease of border crossing; and by related concepts such as constitutive and contextual values, norms and counter-norms, public and private science, ideology, and epistemology. These concepts were introduced throughout the first part of the chapter.

Because science is necessarily embedded in a culture, science does not transfer easily into other cultures, including the subculture of everyday praxis in Western nations. This problematic transferability was amplified by communication problems that arose when Western science was taught to a non-Western public. Western science, with its own set of norms, values, beliefs, expectations, and conventional actions, turns out to be only one way of making sense of nature. Not only do we science communicators need to be sensitive to multicultural audiences, but from time to time we will need to consider multiple sciences as well.

Sensitivity and knowledge are prerequisites to becoming an effective culture broker who can help audiences cross the cultural border into Western science, smoothly enough to engage with the science communicator. Culture brokering will be a new role for most communicators. It will take extended practice to cultivate and perfect.

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