CHAPTER TWO

2.0 LITERATURE REVIEW

Literature on science communication is used as a guide and reference in this study as this subject is quite extensively studied in many countries. Moreover, the principles of science communication could be applied to biotechnology communications since the issues in both subjects are often similar. This chapter will dissect the issues that have been discussed, deliberated and studied in the area of science communication in the past namely science communication approaches and theories; public understanding of biotechnology, attitude and opinion; media coverage, role of scientists, journalists and other players; challenges in science communication; non-traditional science communication methods practiced; and experience in a number of countries.

2.1 HISTORY OF COMMUNICATING SCIENCE

Bensaude-Vincent (2001) tracks back the origin of science communication to the early eighteenth century. During this time, a number of popular books helped popularise Newtonianism, electricity and chemistry. This was the time when experiments were carried out in the elegant private cabinets of a small number of wealthy aristocrats, or in small physics laboratories equipped with electrical and chemical instruments. This led to public interest in science which was associated with amateur practices of science. Despite the existence of a strong academy of science in Paris with appointed full-time researchers, there was no clear demarcation between amateurs and scientists (Datson, 1991; Goodman, 1994). These amateurs shared certain values, such as meritocracy, tolerance, and reason, and standards of conduct and helped promote public opinion as a political force (Bensaude-Vincent, 2001). Bensaude-Vincent (2001) also quotes Louis Figuier, one of the most prolific and successful scientific writers of his time as saying, “science is a sun: everybody must move closer to it for warmth and enlightenment”. The assumption of this era was that the sun shines for everyone not just for an elite group. Thus, science has to be placed within everyone’s reach and to get everyone interested in science. This too, suggests that science is not only a source of knowledge and power but the centre of the cultural system.

During the nineteenth century numerous attempts were made to achieve this goal. Hundreds of books, journals, and magazines endeavoured to place science within everyone’s reach. It was a wide-ranging operation that mobilised all the existing means of distributing information: lectures, conferences, magazines, books, encyclopaedias, exhibitions, museums, observatories, botanical and zoological gardens, cinema, radio and television (Bensaude-Vincent, 2001). In 1860s, there were 15 scientific periodicals published in Paris and approximately the same number published in London (Sheets-Pyenson, 1985). Although the number of popular science periodicals could not be ascertained, Bartan (1998) describes 1860s as the time when popular science journalism flourished in England, with many new journals being produced. During this time editorial commentary and reviewing the progress of science became more important. Among these journals, some are still published today including *The Scientific American*, founded in 1845, and the British weekly *Nature*, founded in 1869.

In the USA, during the half-century between 1860 and 1910, the “new knowledge” of science became publicly available through the popular media of Chautauquas, Lyceums, travelling and permanent zoological collections, local and national expositions, and the press, especially magazines. Indeed, periodicals were dominant means for conveying images of science to the public; and for locating the emergent scientific enterprise within American culture (Whalen and Tobin, 1980). The French and British newspapers' scientific news moved into the daily columns along with political, social, economic, and literary news. Later weekly scientific columns were created and science became an integral part of ordinary life. Numerous other attempts help achieve the goal of making science the centre of the cultural system. Bensaude-Vincent (2001) reported that hundreds of books, journals, and magazines endeavoured to place science within everyone's reach.

During the second half of nineteenth century, dozens of science museums were opened in Britain. After the South Kensington Museum was created in 1853, some 100 museums were created in 1870s and 1880s. During the end of the century, the German Empire founded a series of about 50 museums. The Deutsches Museum opened in Munich in 1903 and became a model for many other museums for educational purpose (Schaffer, 1996). Popular science literature further encouraged science consumption. From the small, cheap booklets to large expensive dictionaries, a wide range of books and serial publications were sold to suit all tastes, classes, and economic conditions (Bensaude-Vincent, 2001).

One key strategy used by science publishers to create an audience was to diversify their readership. The same volume of popular science literature was published in slightly different versions and distributed in different forms to manufacturers, farmers, clergymen, women, and children (Bensaude-Vincent, 2001).

As science rapidly advances and the need to engage the public becomes more evident in the late 20th century, many countries moved into developing policies on Public Understanding of Science. A report entitled "Life Sciences and Biotechnology – A Strategy for Europe" by Commission of the European Communities (2002) outlined the need for public consultation on life sciences and biotechnology. A section of the report is produced below:

"A revolution is taking place in the knowledge base of life sciences and biotechnology, opening up new applications in health care, agriculture and food production, environmental protection, as well as new scientific discoveries. This is happening globally. The common knowledge base relating to living organisms and ecosystems is producing new scientific disciplines such as genomics and bioinformatics and novel applications, such as gene testing and regeneration of human organs or tissues. These in turn offer the prospect of applications with profound impacts throughout our societies and economies, far beyond uses such as genetically modified plant crops."

The report further acknowledged that in Europe and elsewhere, intensive public debate has emerged and given rise to significant public attention. The European Commission encouraged a dialogue that is inclusive, comprehensive, well informed and structured. It believed relevant information is essential for meaningful dialogue and providing it required focused and pro-active efforts. The Commission also believed that there is a general need to enhance public trust in the role of science in societies. It feared that intense public debate on life sciences would stifle Europe's competitive position, weaken their research capability and could limit their policy options in longer term.

In view of this, the European Commission and EU member states have made considerable efforts to close the gap between science and the society. In 2002, a debating forum was set up within the framework of the 'Science and Society' action plan, the aim of which is to further the development of national policies in a number of areas, including discourse with civil society (European Commission, 2002). In the UK, a White Paper, 'Realising our Potential' led to the establishment of the Office of Science and Technology (OST); and the publication of the Bodmer Report, 'Science & Society' and 'Science in Society' from 1985 to 2002 (Bodmer, 1985). Italy started Festivals of Science and Technology (European Commission, 2002) and Germany, in 2002, launched a project on Public Understanding of Science and Humanities (PUSH) to promote better dialogue between science and the public (Jasanoff, 2005). All these policies led to the evolution in science communication theories which is discussed next.

2.2 THEORIES IN SCIENCE COMMUNICATION

2.2.1 The Deficit Model

The initiative to deliver better quality scientific information and facilitate dialogue between scientists and the lay public in the United Kingdom saw the publication of the *Royal Society Bodmer Report* (1985) which urged scientists to develop new attitudes towards science communication. Also known as "Public Understanding of Science", this report was named after the chair of the working group, Sir Walter Bodmer. The Bodmer Report led to a number of studies in measuring the extent of scientific literacy within different social groups and gave rise to the "deficit model" of public understanding of science. One of the main outcomes of the Bodmer Report was the setting up of CoPUS (Committee on Public Understanding of Science), a tripartite organisation with representatives from the Royal Society itself, the British Association for the Advancement of Science, and the Royal Institution (Miller, 2001). The "deficit model" is based on the strategy of transferring packets of scientific knowledge from a privileged and literate group to the less educated sections of the population (Massarani, 2004). In this formulation, the public are assumed to be "deficient", while science is "sufficient" (Gross, 1994; Burns et. al., 2004; Medlock et. al., 2007).

This model was also based on the assumption that if members of the public just received more information about science and technology issues, their new understanding would lead to support for new innovations (Sturgis and Allum, 2004; Medlock et. al., 2007; Shults, 2008). This model adopted a one-way, top-down communication process, in which scientists, with all required information filled the knowledge vacuum in the scientifically-illiterate general public as they saw fit (Miller, 2001). No dialogue or deliberation was incorporated into public understanding procedures under this model (Medlock et. al., 2007). Communication process was basically seen as one-way flow of information from science to society, overlooking the element of dynamic interaction between these two structures (Shults, 2008).

The "deficit model" was later criticised for its simplistic approach to the issue of communication and was largely cast aside as insufficient and, on its own, potentially harmful for technological development (Medlock et. al., 2007). The more trenchant critique is one that suggests the existence of other knowledge domains that influence attitudes towards science and technology in opposite or conflicting ways to factual science knowledge (Sturgis and Allum, 2004). These authors suggest that culture, economic factors, social and political values, trust, risk perception, and worldviews are all important in influencing the public attitudes towards science. This is similar to Wynne's (1989) "lay expertise" model which is discussed later. However, Sturgis and Allum also suggest that while these criticisms are undoubtedly in many ways valid, they do not sufficiently merit the scrapping of the "deficient model" entirely.

2.2.2 The Contextual Approach

Newer models for science communication recognise the limitations of the "deficit model" and have complemented learning activities with more interactive, dialogical consultations (Medlock et. al., 2007). It is recognised that the public do more than just learn when receiving messages from scientists. They form impressions which are not just based on the messages they receive but based on the problems they encountered and communication with peers (Kim, 2007). One such model is the "contextual approach" introduced by Wynne, Irwin, Latour, Collins and Pinch, Jenkins, Layton, Yearley, McGill, and Davey over a decade ago (Miller, 1998). This approach recognises that public consists of groups with diverse interests, and technologies are seen as open-ended and continually impacted by social and political factors and therefore the approach perceives technology as a legitimate matter for public debate (Mayer and Stirling, 2004). This approach also sees the generation of new public knowledge about science much more as a dialogue in which, while scientists may have scientific facts at their disposal, the members of the public concerned have local knowledge and an understanding of, and personal interest in, the problems to be solved (Joss, 1998). Contextualists focus on the interaction between the public's social values, social identity, and alternative forms of knowledge, and actions of experts (Nisbet and Goidel, 2007). Massarani (2004) echoes these views and sees this approach as requiring recognition of the public as an important actor in disseminating information of science, and as enabling individuals to take stance that is simultaneously participatory and critical towards the role of knowledge in decision-making processes. The "contextual approach" is based on the importance of interaction between science and society, and acknowledges particular circumstances of the recipients of scientific information and of their existing knowledge and beliefs (Gregory and Miller, 1998).

In the UK, the 2000 report from the House of Lords entitled "Science and Society" seeks the replacement of "deficit model" with the "contextual approach" (House of Lords, 2000). In 2002, CoPUS passed a resolution concerning the "deficit model" which admitted that this model is no longer appropriate to the wider agenda that the science community is now addressing (Royal Society, 2002). However, Miller (2001) warned that the end of deficit model does not mean there is no knowledge deficit. Government and industry pay out large sums of money to scientific researchers. If there is no gap between what scientists and members of the general public know about science, then something is very wrong. Scientists and lay people are not on the same footing where scientific information is concerned and knowledge, hard won by hours of research, and tried and tested over the years and decades, deserve respect.

2.2.3 The Lay Expertise Model

The lay expertise model gives importance to local knowledge, sometimes called "lay knowledge" (Wynne, 1989). Some examples include local farming and agricultural practices, and indigenous knowledge of traditional medicine. The lay expertise model argues that scientists are often unreasonably certain, and even arrogant about their level of knowledge, failing to recognise the contingencies or additional information needed to make real-world personal or policy decisions (Lewenstein, 2003). Although there is some similarity between contextual and lay expertise models (Burns et. al., 2003; Gregory and Miller, 1998), Lewenstein (2003) argues that it should be seen as distinct. Unlike the contextual model, which assumes the value of scientific knowledge but recognise the complexity of delivering it, a lay expertise model assumes that local knowledge may be as relevant to solving problems as technical knowledge. The lay expertise model is also subject to criticism like any other models as it gives importance to local knowledge over the reliable knowledge produced by the modern scientific system.

2.2.4 The Public Participation Model

This model emerged because of the importance of social trust as an issue in policy disputes about scientific issues (Lewenstein, 2003). This model emphasises a series of activities intended to enhance public participation and in turn feed into and increase trust in science policies. These activities include consensus conferences, citizen juries, deliberative technology assessments, science shops, and deliberative polling (Hamlet, 2002; Joss, 1999; Wachelder, 2003). The public participation activities can be driven by a commitment to "democratise" science, taking control of science from elite scientists and politicians and giving it to public groups through some form of empowerment and political engagement (Sclove, 1995).

However, the public participation model is also criticised as it carries a commitment to a particular stance about political relations and tends to address politics and not public understanding of science. This model also tends to focus on process of science and not substantive content and sometimes has an "anti-science" bias (Lewenstein, 2003).

2.3 THE PUBLIC OPINION, ATTITUDE AND UNDERSTANDING ON BIOTECHNOLOGY

A number of authors over the past decades have written about public perceptions of scientists and have observed a diverse opinion on this subject among the public, reflecting both positive and negative views. Basalla's (1976) study's reveals that society sees scientists as sinister and socially irresponsible, mentally unstable, and easily manipulated or dominated. They are seen as pawns doing the dirty work for either big business or the military (Shortland, 1988). These dangerous characters will kill if necessary (Lewenstein, 1989). Gerbner, Gross, Morgan and Signorelli (1981) found that the scientists are perceived to fail ultimately. A number of other studies portray scientists in a negative light as an eccentric, antisocial, elite and privileged group (Long & Steinke, 1996), and being so dedicated that they will spend most of the day at work (Basalla, 1976; Nelkin, 1995), and wearing white coats or suits to differentiate themselves (Shortland, 1988). Long and Steinke (1996), too found that science in general is often depicted as mysterious, magical, or dangerous. There is also fear among the public that scientists might lose control of their research or their technology, to the detriment of society (Basalla, 1976). Thus, scientific research and technology are distrusted because of possible unforeseen ramifications. This negative perception of science and scientists is often attributed to entertainment television that disseminates a full range of familiar and conflicting cultural myths of science and technology as weird and frightening; omnipotent but dangerous; always progressing boundlessly but out of control; offering hope for the future, or even salvation; but also perhaps society's annihilation (Gerbner, Gross, Morgan and Signorelli, 1981).

However, there are positive perception of science and scientists as well. Davies (1963) in a study found that respondents held scientists in high regard and described them as intelligent, educated, and dedicated. Many thought that scientists were interested in discovery, derived satisfaction from work, and were concerned with the social value of their studies. Davies also showed that most respondents indicated that scientific research brings many benefits to the world such as health improvements, a higher standard of living, and technological advancements. Other studies that found more positive views of scientists include Mead & Metraux (1957) which reported that teenagers and children perceived scientists to be good. This is also reported by Potts &

Martinez (1994) who, in addition said that high school children believe that scientists are essential, brilliant, and dedicated, and science is a source of unlimited power.

While scientists are at the epicentre of science and technology development, media plays an active role at the peripheral by bringing the society closer to such developments. A number of authors have indicated the influential role media plays in shaping public opinion on science. A survey conducted by the International Service for the Acquisition of Agribiotechnology Applications (ISAAA) (Juanillo, 2003) among the Malaysian public showed that the media plays an important role in shaping the public perception on biotechnology. The findings of this survey is consistent with Metcalfe and Gascoigne (1995) who stated that Australians too are highly influenced by the role the media plays in their lives. Australians' view on science and technology is likely to be dictated by media coverage and images. This is further echoed by Barns (1989) who claimed that mass media representations are probably the most important factor that influence the public perceptions of science and technology though other factors outside media such as education and direct experiences with technological processes or products do play a role.

Thus, it is not surprising that media becomes the key information course on scientific development and the works of scientists when formal education ends, though there may be other sources that provide information on science such as science museums. It is through television and other mass media that individuals receive much of their knowledge about science and scientists (LaFolette, 1990; Nelkin, 1995). Juanillo's (2003) survey on public understanding, perceptions, and attitudes towards agricultural biotechnology in Malaysia, Philipines, Vietnam, Indonesia, and Thailand reveals media as the most important sources of information for the public in these countries. Media too enjoys high credibility among the public concerning public health and safety issues relating to agricultural biotechnology. This was also reflected by a study carried out by Amin (2007), where the most frequently used sources of information on biotechnology by Malaysian stakeholders are the mass media (radio, television, and newspapers), followed by the surrounding people, including family and friends.

However, Juanillo's (2003) survey highlighted that mass media do not adequately cover news and information on biotechnology. Nelkin (1995) reported that as science plays a pivotal role in everyone's life and good understanding on this subject matter enables informed-decision making process, citizens generally show interest in science and technology and they want media to cover science news more often. A study conducted in the United States indicates that 50 per cent of Americans were very interested in science discoveries and new technologies, 70 per cent in medical discoveries, and 52 per cent in environmental issues (León, 2008). Another study conducted by Rogers (1999) confirms public interest in science and that it is accorded equal importance compared to any other major areas covered in the media such as current issues and sports. Similar observations were made in Europe where surveys by Eurobarometer (European Commission, 2005) carried out in 32 countries indicate 88 per cent of Europeans are "very interested" or "moderately interested" in new medical discoveries; 87 per cent in environmental pollution; 78 per cent in scientific discoveries, and new inventions and discoveries.

Priest (2001) found that relatively higher knowledge and awareness as measured by attention to biotechnology in the media were associated with increased support of both medical and agricultural biotechnology. As mentioned earlier, most previous research focuses on the relationship between media coverage of biotechnology and public support towards this technology. All these literatures shows the significance of science reporting by the media and the role they play in creating awareness on science among the public.

In the Malaysian context, Amin (2007) assessed key variables for specific attitudes, including perceived benefits, perceived risks, encouragement or overall attitude, moral concerns, familiarity and risk acceptance. She found those with higher levels of education tended to have better biotechnology knowledge. Scientists, including biotechnologists and biologists, policy makers and biology students were in this category. The factors that contribute to certain groups having better level of understanding were not determined by the author. Understanding these factors could contribute towards reaching out to other sectors of the society effectively.

2.4 BIOTECHNOLOGY COMMUNICATORS AND STRATEGIES APPROACHED

The dominant concept employed in public understanding of science basically takes the information provider's point of view (Kim et. al., 1996). The public is implicitly expected to equip itself with scientific literacy, which includes basic scientific vocabulary, and some level of understanding of scientific methodology and of scientific (and technological) impacts on society (Miller, 1983). These are assumed to be useful and necessary for a citizen to cope with daily life in modern society, mainly for decision making (e.g. on policy issues), rather than problem solving, by individual or collective means.

Given the broad-spectrum nature of biotechnology and its interrelation with various fields, communicating biotechnology commands the involvement of specialists from different fields besides scientists and members of the media (Whitley, 1985). Whitley also argues that collaboration with other specialists helps gain reputation and resources from non-scientists who are responsible for allocation of funds for research. Kyvik (2005) reports that the audience is made of general audience (the population at large) and targeted audience (e.g. health personnel, medical doctors, teachers, students and social workers) which require diversified communication strategies.

Shults (2008) in his PhD dissertation suggests that one of the most important issues of public communication is a need for dialogue between the chief participants of the communication process: scientists, journalists, and institutional public information officers or public relations officers working in scientific institutions. He stresses that before the information based on the knowledge produced by scientists reaches the public, it should pass through two more participants of the communication process: journalists and institutional public officers. This model is based on a simple technical scheme "sender-transmitter-receiver" developed by engineers in 1940s, called the "linear model". Christensen (2007) later presented this model and identifies scientists and society as two opposite poles of communication zone where other participants might also play some roles, i.e. journalists and public relation officers. The "linear model" is depicted in Fig. 2.0.

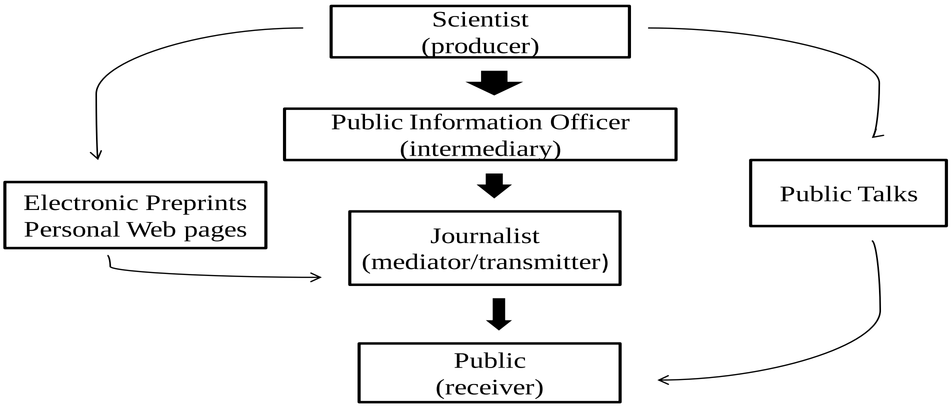

Figure 2.0: Linear model (Christensen, 2007)

Kim (2007) echoed Christensen's model which is illustrated in Figure 2.1 as the unidirectional information flow model, showing scientific information flow from the scientist to the public.

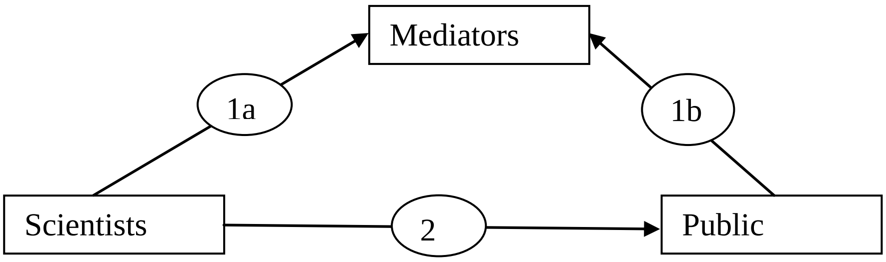

Figure 2.1: The Unidirectional Information Flow Model (Kim, 2007)

Mediators are often mass media and their role has been studied in terms of media portrayal of science. Information flow from the mediators (mass media) to the public (Path 1b) stipulates that the public can and do consume key content in media portrayals of science and technology. However, the failure of the expected effects from unidirectional information flow through mediators has led, out of desperation, to "direct" efforts to diffuse scientific information to the public (Path 2). Numerous initiatives to facilitate that flow have been introduced by scientific communities, governments, parliaments, nongovernmental organisations (NGOs), and lay publics in Europe and the United States (Clark and Illman, 2001; Edwards, 2004).

2.5 MEDIA COVERAGE OF SCIENCE

Numerous studies have addressed media coverage of science, however, the importance given by editors to science news, and the training of journalists in covering science news is not widely covered. The literature on these areas is even scarcer on Malaysian data. The latest study on media coverage of biotechnology in local newspaper was carried out by Samani et. al. (2011). These researchers did content analysis on four main newspapers over a period of 10 years to compare the frequency of biotechnology news before and after the National Biotechnology Policy. Sources of information for journalists and editors were also compared during the period of study. Another study on media coverage of science in Malaysia dates back to 1984 (Ramanathan) on the number of science stories covered; how many of these were local and how many foreign; what types of science stories were covered; the nature of the programme, i.e. news, features/reports or editorial/commentaries. This author found that the average for science news coverage on radio on the National Network (Rangkaian Nasional) was 1.39 per cent, while it was 2.73 per cent for the Blue Network (Rangkaian Biru). Science coverage on television accounted for an average of 5.7 per cent on RTM's network I, 7.4 per cent on RTM Network II, and 0.5 per cent for TV3. This study also noted that many of the science news events reported in Malaysian mass media were not of local origin. Ramanathan's (1984) analysis on newspapers for the period of two-week during August-September 1984 showed that there was an average of 2.54 per cent science coverage in *New Straits Times*; 0.75 per cent in *The Star*; 2.5 per cent in *Utusan Malaysia*; 1.3 per cent in *Berita Harian*; 2.8 per cent in *Tamil Nesan*; and 2.6 per cent in *Tamil Osai*. It is important to note that this data is obsolete today as there have been tremendous changes in the electronic media with the emergence of many private channels and the rebranding of national television channels. The newspapers have also had a major facelift and introduction of new sections such on science and information technology, and agriculture. Data on the current trend of media coverage of science is lacking and this study attempts to fill in the vacuum.

A number of studies have addressed media coverage outside Malaysia, especially in the United States of America. Nisbet and Lewenstein (2002) found that media coverage of biotechnology increased from 1970 to 1999 in *Newsweek* and *The New York Times*. The areas covered were mainly on new scientific developments and issues on regulation and key actors cited were researchers and industry representatives. Their analyses included both agricultural and medical biotechnology. The coverage was found to be largely positive towards science with some negative news, largely focussed on economic costs and scientific progress.

Ten Eyck and Williment (2004) who looked at *The New York Times* and *the Washington Post* for the period of 1977-2001 found that coverage of medical biotechnology was more likely to be framed in more positive terms than agricultural biotechnology. This phenomenon became more prominent near the end of the sample period with the strong emergence of genetically modified crops and products in the American market. Despite the apparently mixed newspaper coverage of agricultural biotechnology, survey research has shown that those with very high interest in biotechnology still see its coverage as fundamentally flawed (Besley and Shanahan, 2005). Gunter, Kinderlerer, and Beyleveld (1999) interviewed a number of journalists and scientists and found out that both these groups felt that biotechnology coverage was too sensational and risk oriented.

Brossard and Shanahan (2007) observe that coverage of biotechnology needs to be looked at from an issue-cycle perspective. According to them, even though biotechnology is a very important scientific development, news media will not always devote prominent attention to it; other issues will take their place on the agenda as the press and the public consider them worthy of attention. Brossard and Shanahan (2007) depict this phenomenon in Figure 2.2. Four distinct phases can be seen in this model. When an event or crisis is identified, the media notifies the public and triggers public interest and alarm. This phase is called "alarm discovery". If the event attracts enough attention, a period of "mobilisation" ensues. This is when media and political attention are normally focussed on the risks associated to the said event. During this period, the media often tends to sensationalise the news and overestimate the actual risks. However, this phase does not last long, and the public attention will turn elsewhere. This is also when other institutions associated to the event will perform their own public relations activities. The "mobilisation" period is followed by "policy measures". This is the period where policy discussions and measures are often taken and some decisions or resolutions are made. In fact sometimes it is also decided that no action need to be taken. At the end of the "resolution" period, the public and media attention on this event dies off and reaches a plateau.

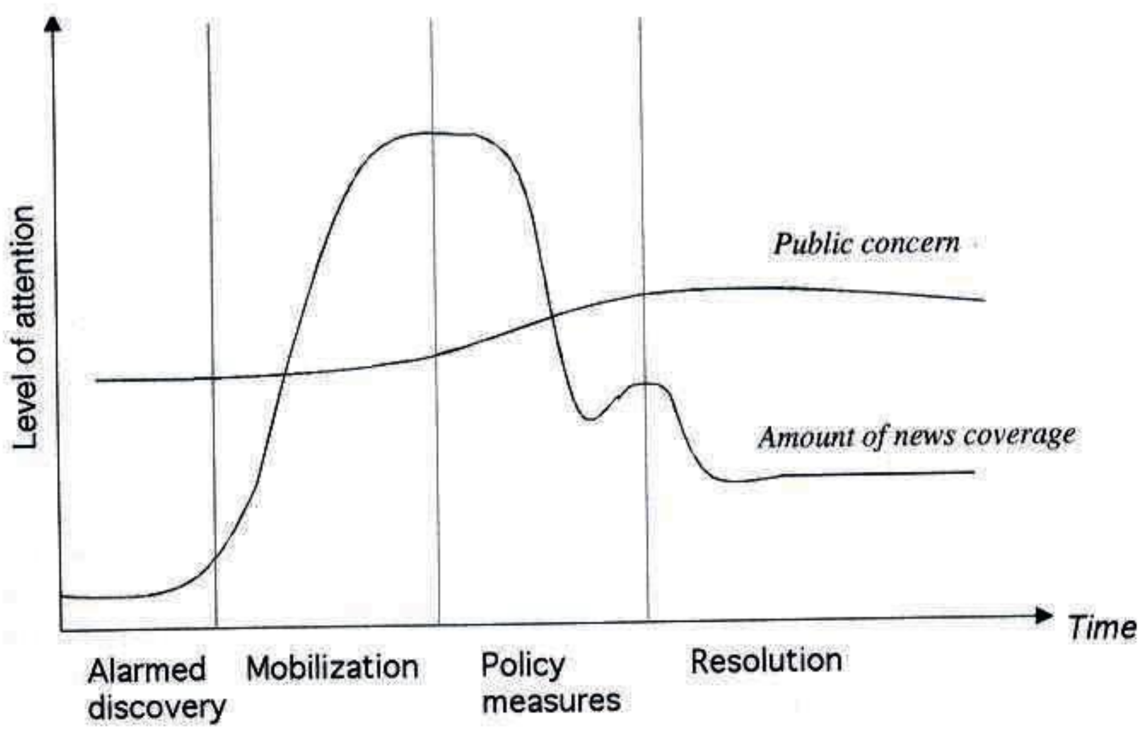

Figure 2.2: Issue attention cycle (Brossard and Shanahan, 2007)

This study does not intend to look into the angle of media coverage of science, whether it is more positive or negative but will study the frequency of science news in the media to assess how much the public is informed on this subject, and the involvement of scientists and journalists in disseminating news on science. Whereas, most previous studies concentrated on the influence of media in shaping public opinion and perception, and the relationship between media use and biotechnology opinion, however, research on the reasons why scientists are reluctant to reach out to the public and cooperate with journalists are lacking. Little research has also sought to show the lack of science news on mass media and why journalists and particularly editors shy away from writing and publishing science news, which this research seeks to address.

2.6 SCIENTISTS' VIEW OF PUBLIC UNDERSTANDING OF BIOTECHNOLOGY ACTIVITIES

A scientist stated during his presentation at the Risk Communication for Scientists, Communicators and Administrators Conference in Florida in 2000 (Kolodinsky, 2007):

> *"Consumers are not intelligent enough to understand anything about agricultural biotechnology so we shouldn't even try to provide them with any information". (Kolodinsky, 2007)*

This implies an attitude amongst some scientists who feel science is beyond the comprehension of the masses and it is a waste of time to engage them in deliberating scientific activities and research. However, the Wellcome Trust (2000) survey found that 84 per cent of scientists agreed that scientists have a duty to communicate their research findings to the public. Many scientists feel it is their moral obligation to take part in public engagement activities because (a) they feel they have privileged access to information that should be in the public domain and/or (b) because taxpayers' money ultimately may fund their research. Similar research towards scientists' attitudes is absolutely lacking in Malaysia. It is important to gauge what Malaysian scientists feel about the need to engage in science communication and inform the public about the research and scientific activities, get their feedback and listen to their concerns particularly in the field of biotechnology. Information on scientists' attitudes towards public engagement would be useful to address their constraints and reluctance in playing a role as biotechnology communicator. This area is addressed in this research which would eventually provide useful data for the development of the national framework for biotechnology communication strategy.

The Wellcome Trust (2000) commissioned a survey on "The role of scientists in public debate" in which 1,540 scientists were interviewed about their attitudes toward science communication and, in particular about the importance of the public understanding of the social and ethical implications of scientific research. The results showed more than half of the scientists had participated in science communication activities in the previous year, and 56 per cent wanted to spend more time on this. In a follow up study by the Royal Society (2006), 1,485 scientists were asked what science communication activities they do, and what were the factors that facilitate or inhibit their role in communicating science. The need to spend more time in research came as the main inhibiting factors with 64 per cent of scientists pointing to this constraint. Scientists who are involved in science communication are viewed less well by peers according to 20 per cent of the scientists. Other studies cited the fear of being taken less seriously by scientific colleagues if engaged in science communication activities (Gascoigne and Metcalfe, 1997; Weigold, 2001), fear of being misquoted (Weigold, 2001), and repercussions following communication of potentially sensitive and controversial research (Wellcome Trust, 2000).

A survey conducted by Poliakoff and Webb (2007) with scientists at the University of Manchester revealed that scientists who already participated in public engagement activities intended to continue doing so and scientists who have not participated in public engagement events did not intend to start. This survey reconfirms the previous surveys (Gascoigne and Metcalfe, 1997; Weigold, 2001; and Wellcome Trust, 2000) about the negative attitude towards participation in science communication activities. Lack of skills to take part is also a major constraint (Weigold, 2001; and Wellcome Trust, 2000).

Davies (2008), in her research sums up that scientists are usually engaged in one-way communication when talking about their research or about science. Public communication is assumed to involve the transmission of science from scientists to the public, with no return flow of knowledge. Her research also shows that scientists find it very challenging to make their research presentation relevant to the audience on a personal level. When scientists find it difficult to communicate with laypeople, they revert to discussing intrascientific communication – communication within the scientific community, such as publishing papers or presenting at conferences. In spite of social scientists' proposed communication models that are more interactive and that takes the audiences' knowledge and culture into consideration, Davies' study shows that these models are not popular among scientists. This could be due to the lack of training for scientists to engage with the public and also the lack of a national strategy that coordinates biotechnology communication initiatives in a coherent manner. Cormick (2011) reported that the underlying success factors of biotechnology communication initiatives in Australia are the existence of a coordinated and strategic approach. The "Inspiring Australia" (2010) further provides a national approach for community engagement with the sciences and this report carefully considered communication of science as broadly as possible, drawing participants not only from natural and physical sciences, mathematics, engineering and technological sciences, but also from education, social sciences and humanities. Thus, this research seeks to propose a national framework for biotechnology communication in Malaysia to ensure suitable models are used by all scientists.

In spite of some reluctance shown by scientists in engaging themselves in science communication activities, another tradition is covered by newer and narrower concept of "civic scientist" introduced by former US President Bill Clinton's science advisor

Neal Lane (1999). “Civic scientist” refers to a scientist who communicates with general audiences and brings knowledge and expertise into the public arena to increase awareness about science and/or facilitate discussion and decision making on issues of importance to society (Clark and Illman 2001; Greenwood and Riordan 2001).

2.7 THE CONFLICT BETWEEN SCIENTISTS AND JOURNALISTS

Many literatures have described the stereotypic image of scientists that lead to their isolation in their ivory tower and refusal to cooperate or work closely with journalists (Gascoigne and Metcalfe, 1997; Shortland and Gregory, 1991). On the other hand the communication barrier that exists between scientists and journalists is also attributed to the stereotypic image of journalists. Several literatures outline the differences between scientists and journalists that create the barrier between them. Gunter et. al. (1999) says a number of problems in scientist-journalist interactions undoubtedly are rooted in cultural differences between the two professions.

Shortland and Gregory (1991) summarise these difference:

“Scientists see science as a cumulative, cooperative enterprise; journalists like to write about individual scientists who have made a revolutionary breakthrough. Journalists like controversy; scientists thrive on consensus. Journalists like new, even tentative results with exciting potential; scientists prefer their results to go through slow process of peer review and settle into a quiet, moderate niche in the scientific literature – by which time journalists are no longer interested. Scientists think that accuracy means giving one authoritative account; journalists feel that differing views add up more complete picture. Journalists’ work has to fit the space available; scientists’ academic papers can be of any length. Scientists work at the pace imposed by the nature of the research; journalists are in the hurry to meet a deadline. Scientists must qualify and reference their work; journalists have to get to the point.”

The above conclusion is shared by a number of authors who concur that there are huge cultural differences between the two professions (Radford, 2002; Valenti, 1991; Friedman, 1986). Radford (2002) outlined the critical differences between scientists and journalists as scientific research takes a long time to complete which includes peer review and publication. However, the entire process of writing an article by a journalist happens during a day’s working hours. Another distinction revealed by Radford is that a scientific paper can be circulated, indexed and cited, and serve the laboratory’s, or the author’s primary purpose, without being read at all. However, a newspaper report that is not read by anyone is a futile effort of the journalist and editor. On top of being balanced, fair, accurate and topical, a newspaper report must be read. Friedman (1986) observes that editors and reporters tend to value stories that contain drama, human interest, relevance, or application to the readers. He further notes that a reporter who breaks a story is given far more credit than one who follows up with detail and this creates a short-term focus for reporters.

Valenti (1999) described scientists as someone who value advanced knowledge; technical language; near certainty; and quantitative, complete, and narrow information. Journalists, on the other hand, according to Valenti tend to be generalists; applied, who focus on what is relevant to society; noncumulative and very fast. Nelkin (1984) observes that scientists are constrained by the importance of autonomy and the internal review process, while journalists are constrained by their need for audience appeal.

According to Fell's (1994) observation, some of the common accusations made by scientists against journalists are: trivialising rather than simplifying their work; making mistakes in their reporting; having a tendency to exaggerate; and displaying a universal reaction of blaming editors and subeditors for headlines and any errors. Journalists, meanwhile, see scientists as long-winded, afflicted by jargons, difficult, and being hung up on detail and accuracy. Scientists have often encountered difficulties in working with journalists. This constraint is further aggravated by the fact that scientists are traditionally not encouraged to communicate across boundaries of science and in some cases are sanctioned to do so. This is mainly due to the distrust of media among the scientific community because media coverage does not conform to norms of scientific publication such as, an impersonal style; high level of accuracy; or peer review prior to publication (Gunter, et. al., 1999). Journalists are often blamed for inaccuracy, lack of objectivity, and an unscientific attitude in their coverage. Dunwoody and Ryan (1985) further affirm that this experience among the scientists is not rare.

The other important cultural difference between scientists and journalists is that scientists are engaged in lengthy investigations in which initial findings are replicated many times before they can be accepted. However, journalists are more concerned on why a piece of research was done, who did it, what its significance is in a social context as much as in a scientific context, and what consequences will flow from it. Thus, journalists often may not wish to wait for the length of time it takes a scholarly community to attain confidence in research evidence (Gunter, et. al., 1999).

2.8 OBSTACLES FACED IN COMMUNICATING BIOTECHNOLOGY

Popularising science is not an easy task, especially in developing countries. Amor (1984) observes that in developing regions, where illiteracy is still high, traditional values and superstitions are deeply rooted in the people's customs and behaviour. As a result, people are usually distrustful of innovation and change and a strong defence is built against scientific information. Scientists are confronted by this difficult task of breaking through this strong defence. How much this is relevant to the Malaysian scenario has not been supported by any local study. However, considering Malaysia's adult literacy rate which is 92 per cent according to UNICEF, and also Amin's (2007) observation that people with higher levels of education have better understanding of biotechnology, there are strong possibilities that Malaysian publics could be turned into attentive audience if there is a proper national biotechnology communication strategy. This is coupled with the strong governmental support towards the development of biotechnology. This is the expected outcome of proposing a framework for biotechnology communication in Malaysia, which this research seeks to accomplish.

The public's unwillingness to try to understand science is another obstacle faced by scientists according to Corfield (2003). Amor's (1984) observations conform to other major studies carried out on the same subject such as mistrust of the media, inability to communicate with the public, the bureaucratisation of science, stringent rules and codes of ethics, and inappropriate research direction. In a survey conducted by Davies (2008), a respondent suggested that communicating science to the public is a difficult process as it is hard to be clear and understandable as well as interesting. And communicating a research work that is not directly relevant or applicable to the public does not interest them. The problems scientists experience when talking to lay people is not only that they have to explain their finding in simple language and find metaphors and models illustrating abstract and unfamiliar concepts, but also that they face an information demand very different from that of their fellow scientists (Gunter, et. al., 1999).

Treise and Weigold (2002) describe other problems and challenges faced by scientists such as language differences, a lack of reward or incentive to communicate science, and receiving criticism for saying "too much". Davies (2008), in her study points out that even when public communication is seen as a worthwhile thing to do, it is strongly constructed as difficult. She states that it is hard to interest the public in research work carried out by scientists if it is not directly relevant or applicable to them. Lack of time is another obstacle faced by scientists in working with the media. The other reason for scientists not talking to the media, as cited by Nelkin (1995) is the priority given by scientists to peer review in the research process.

A different set of obstacles are faced by the journalists. Although there are genuine interests among journalists to cover science news, they face many challenges. Treise and Weigold (2002) cite some problems such as low levels of support from news organisations, reporters' lack of scientific knowledge, newsgathering norms, and editorial pressures. Hartz and Chappel (1997) surveyed journalists and found that they complained that scientists often failed to explain their work in understandable terms to journalists or the public. Journalists find it difficult to get scientists to communicate the components of their research that are relevant to the public. The survey carried out by Dennis and McCartney (1979) reveals that many science writers are unhappy with the priorities of their editors who prefer sensational stories to articles on science. Friedman (1986) further observed that editors often write story headlines and control story revisions where reporters feel they are writing for editors and not the public.

Science news has to compete for space with other topics and this reduces the chances of including the "background material and qualifications useful in conveying complex technical issues" (Nelkin, 1995). Another problem faced by journalists is when scientists cross the journalistic line of wanting to review an article before publication (Valenti, 1999) and instead of limiting comment to mistakes, they decide to edit the text to their own scientific style of reporting (Corfield, 2003).

Journalists too face difficulties in making scientists understand what is newsworthy. Journalists work is based on news values and agenda. Some areas of science enjoy more attention from the media compared to the rest and this is related to the "news value" of the subject matter. Galtung and Ruge (1965) defines news value as a series of factors "that seem to be particularly important" in the selection of news. Hall et.al. (1978) describe news value as a "deep structure or a cultural map that journalists use to make sense of the world", whereas León (2008) defines news value as the criteria that media professionals use to select the events they cover. Contrary to journalists' view on news value, scientists expect everyone to show interest and excitement in their area of research. León observes that the selection of news is a complex issue that not only involves news value of the subject but also other factors. Clark and Illman (2006) reported that previous research has indicated the factors that contribute to the selection process and these include: interests, experience level of journalists and editors, the need to attract the "right sort" of audience, as well as events and trends within the sphere of science and technology. Hansen (1994) studied the journalistic practices of science reporters in the British press and concluded that the main criterion followed by specialist journalists is "relevance to the reader".

2.9 THE NON-TRADITIONAL APPROACH TO SCIENCE COMMUNICATION

Formal science education is where many young people lose interest in science, however, developing effective communication strategies are still elusive (Imura, 1999). Science educators and researchers are becoming increasingly interested in studying informal opportunities to learn about science outside school (Korpan et. al. 1997). Thus, non-traditional approaches are increasingly adopted with the explicit aim of furthering the public interest in science. Several examples of non-traditional methods of communicating science are presented in this section.

Mitsuishi et. al. (2001) created a “Scientist Library” in an effort to implement and evaluate the effectiveness of this method of science communication. The Scientist Library was constructed with the goal of transmitting each scientists’ personality and research to give a global view of the present state of science. Eighty eight scientists from the field of biology responded to this project, and provided their biographical profiles, personal history, present work, their thoughts about their research, the origin of their interest in science, attitudes to research and life, experiences of failure, hobbies and so on. A rich variety of photographs, picturing activities like sports, fishing trips, and experiments were included. This information on a CD-ROM was well received by the public who wanted more information about scientists and their research.

Another non-traditional method of communicating science is by using comics (Tatalovic, 2009; Carter, 1988; Nagata, 1999; Barnes 2006; Wietkamp and Burnet, 2007). Comics are a popular art form especially among children and as such provide a potential medium for science education and communication (Tatalovic, 2009). Many common fiction comics actually contain reference to accurate scientific ideas and facts

(Carter, 1988). Children enjoy reading comics and both the visual appeal of a graphic representation and the tendency towards intriguing narrative (which can be humorous while educational) make comics an excellent vehicle for conveying scientific concepts in an interesting way (Weitkamp and Burnet, 2007). Comics have been used for promoting health and the psychological means of coping with childhood diseases such as cancer and diabetes; examples include *Captain Chemo* comics in the UK and *Omega Boy vs Dr. Diabetes* (Barnes, 2006) in the USA. Fiction comics can also be effectively used in enhancing learning about biochemistry – using excerpts from manga comics helps students memorise concepts (Nagata, 1999).

Arcand and Watzke (2010) wrote about “From Earth to the Universe” (FETTU) which is yet another effort using informal learning strategies. FETTU is a major project for the International Year of Astronomy 2009 (IYA2009), a global effort initiated by the International Astronomical Union (IAU) and the United Nations Educational, Scientific and Cultural Organization (UNESCO) to celebrate the 400th anniversary of Galileo’s telescope. FETTU is a worldwide effort to bring astronomical images and their science to the public in non-traditional locations such as public parks, metro stations, shopping malls, hospitals, libraries, and even prisons. FETTU has the ability to play a role in increasing the public’s scientific awareness and promoting widespread access to current knowledge by utilising voluntary participation in viewing image exhibitions in unexpected yet public places (Arcand and Watzke, 2010).

Other approaches include theatrical communication of science (Magni, 2002), science cafes (Norton and Nohara, 2009), annual school competitions on sustainable development (Schuurbiers et. al. 2006), and “science in the park” (Riise, 2006). These approaches are believed to provide new opportunities to engage the public. Preliminary evaluation data from FETTU programme suggest that this type of event has the potential to spark interest in astronomy, and hence, science and math topics (Arcand and Watzke, 2009). Norton and Nohara (2009) reviewed the value of science café as an educational tool and concluded that it has contributed to a number of teaching goals related to both knowledge and personal skills among graduate students. Rodari (2009) reported that informal education experiences have strong non-conceptual and non-verbal components, and quite emotional, aesthetical, motivational and social ones. Riise (2006) observed that the non-traditional approach is very fruitful when thinking about how to reach to targets from different social and geographical backgrounds. These literatures provide promising hypothesis for non-traditional approaches to be introduced to Malaysian audience, justifying the case study of MyBio Carnival.

2.10 TRAINING ON SCIENCE COMMUNICATION FOR SCIENTISTS AND JOURNALISTS

Training for scientists on media skills and for journalists on science might be one of the key enablers towards successful science communication. However, this area is not well studied in previous researches. Although scientists increasingly realise the direct connection the media have to the topics on the public agenda, they still may not have the confidence, experience, skills, or willingness to communicate with the media (Dunwoody, 1999). In a study conducted by Gascoigne and Metcalfe (1997), prior to a media training workshop, scientists stated they believed journalists generalised their stories, were not hardworking individuals, and viewed scientists negatively. These scientists too said that journalists were generally neutral or negative in their coverage of scientific information. However, after participating in the workshop, most of the scientists regarded journalists as helpful, reliable, accurate, trustworthy, interested, and hardworking. This study stressed the need for media training for scientists. Gascoigne and Metcalfe's observation is similar to a survey conducted by Hartz and Chappell (1997) who found that scientists who are inexperienced in media training are fearful of misinterpretation and inaccuracy. Respondents in this survey saw the media as exploitive, manipulative, and sensationalistic in their reporting of scientific findings.

Reed's (2001) study concluded that both scientists and journalists agreed that it would be more appropriate to educate scientists about the media than to educate journalists about science, because science contains complex and difficult-to-understand issues. Nelkin (1995) affirms that although many journalists agree on the need for greater technical education when it comes to science, there are reservations as well. If journalists know too much about a technical subject, their writing may become overspecialised and difficult for the public to understand. Palen (1994) observes that most journalism graduates are not exposed to science journalism issues, or it is done in passing during basic and advanced reporting courses.

The only study paper that cites Malaysian example is by Sulaiman (1984). He writes that a workshop on science writing organized by BERNAMA (the national news agency) revealed that only one out of 14 participants had a science degree. He further concluded that there were no school of mass communication or journalism in universities in the country conducting courses in science writing.

2.11 INTERNATIONAL COMPARISONS

Many countries have developed science communication policies and strategies to encourage scientists to be more involved in engaging the public in the last few decades. In the U.K. recommendations made by the Wolfendale committee required all scientists who receive grants from public funds to accept responsibility for explaining their work to the general public (Wolfendale, 1995). In the 1993 white paper "Realising our potential," the U.K. government declared its commitment to the promotion of public understanding of science (HMSO, 1993). By 1995, many scientists, engineers, and research students were engaged in promoting greater public appreciation and understanding of science, engineering, and technology (Pearson, 2001).

In Germany a coalition of scientific societies, backed by federal funding, launched a project on Public Understanding of Science and Humanities (PUSH) in 2002 to promote better dialogue between science and the public (Jasanoff, 2005). The programme was then renamed "science in dialogue" (Schnabel, 2003). In Spain, "Science Fairs" are perhaps the events that foment closest interaction between scientists and the public (Martin-Sempere et.al., 2008). The first science fair was held in A Coruna in 1996, and since 2000, annual fairs have been held in seven different locations: A Coruna, The Balearic Islands, Barcelona, Castilla-La Mancha, Madrid and Seville. According to Martin-Sempere et. al. (2008), the motivation of scientists involved in the fair is related to the desire to stimulate the public's interest in and enthusiasm for science and scientists.

In Brazil, there are about 100 science centres throughout the country, most being small in size, which were set up in the last decade to communicate science. 1990 saw the creation of RED-POP, an interactive network that brings together about 70 members throughout the continent, including centres and programmes of science and technology in Latin America and the Caribbean (Massarani, 2004).

Science communication is a hot topic in Denmark as a result of the University Act which came into force in May 2003 (The University Act, 2003). The Act lists science communication as the third obligation for the universities, in addition to research and teaching. Consistent with European developments, the reasoning behind the new University Act is the government's desire to attract younger people to science education and to make the universities more socially accountable. The Ministry of Science established a science communication think-tank which immediately aligned itself with the new University Act in giving a lot of importance to the dialogue between researchers and the public (Nielsen, 2005). This basically supports the internationally widespread perception of Danish science communication as being dialogue-oriented and engaging, as it emerges from consensus conferences (Felt, 2003) and values understanding of science above appreciation of science when it comes to science communication.

2.12 CONCLUSION: THE RELEVANCE OF LITERATURE REVIEW AND LIMITATIONS

Literature on science communication is used as a basis and reference in this research to understand issues, challenges and factors that influence biotechnology communication. Much research to date on public understanding on science does not have a special focus on any particular fields of science, which leads to generalisation. Though the principles of science communication, its issues and challenges are common, emerging fields such as biotechnology has specific issues such as fear of the unknown, ethical and religious concerns, and safety and environmental issues. Thus, biotechnology communication merits a special study to understand its stakeholders, communicators, and the publics.

The scientists-journalists conflict and their role as science communicators have been much discussed in previous studies (Friedman, 1986; Gascoigne and Metcalfe, 1997; Gunter et. al., 1999; Radford, 2002; Shortland and Gregory, 1991; and Valenti, 1991). What is seriously lacking is research on other stakeholders such as teachers, religious scholars and policymakers. There also have been no previous attempt in Malaysia to study the biotechnology communication initiatives in Malaysia and the roles of all its players. This study attempts to fill this void in the Malaysian context. A large number of researches have been dedicated to understanding scientists' perspective of public understanding of science and factors that influence their involvement with the public (Gascoigne and Metcalfe, 1997; Poliakoff and Webb, 2007; Royal Society, 2006; and Wellcome Trust, 2000). These literatures are valuable in understanding the perspectives of Malaysian scientists which has not been studied previously.

A number of studies have indicated the role of the media in shaping public opinion and as a major source of information on science related topics (Barns, 1989; LaFolette, 1990; Metcalfe and Gascoigne, 1995; and Nelkin, 1995). Media monitoring on biotechnology is also widely studied, though most research are not Malaysian-centric (Brossard and Shanahan, 2007; Nisbet and Lewenstein, 2002; and Ten Eyck and Williment, 2004). Two studies were carried out in Malaysia by Ramanthan (2004) and Samani et. al. (2011). However, an understanding of the basic attitude of the media towards reporting and communicating biotechnology, especially in Malaysia, is lacking. Basic information on the frequency of biotechnology coverage, media's source of information, training on biotechnology, editorial support, impact of a science desk in communicating biotechnology, and media attitude and factors that influence their role in communicating biotechnology, have not been studied in Malaysia. This is addressed in this research.

Although public attitudes towards science, and biotechnology, have been studied in previous research, the limited studies carried out in Malaysia focuses on public perception on biotechnology only. Two such studies in Malaysia were conducted by Amin (2007 and 2003). To fully understand the public's areas of interest, sources of information, their need to understand biotechnology, and their perception towards the credibility of communicators, and what shapes public perception to biotechnology, more research is clearly needed. Such data is vital for the development of a robust biotechnology communication strategy in Malaysia. Hence, the focus on these areas in this research.

Previous studies provide a lot of information and data for international comparisons in science and biotechnology communication in a number of countries such as the UK (Wolfendale, 1995), Latin America (Massarani, 2004), Spain (Martin-Sempere et. al., 2008), Germany (Schnabel, 2003; and Jasanoff, 2005), and Denmark (The University Act, 2003). This research provides valuable lessons for Malaysia as experiences in these countries can be adapted to address local needs and concerns. A number of reports on non-traditional approach towards communicating science are also available which serve as a good reference to introduce these elements into a biotechnology communication strategy in Malaysia (Arcand and Watzke, 2010; Barnes 2006; Carter, 1988; Korpan et. al., 1997; Magni, 2002; Mitsuishi et. al., 2001; Norton and Nahara, 2009; Tatalovic, 2009; Nagata, 1999; Wietkamp and Burnet, 2007). These reports serve as good reference to compare the effectiveness of a case study of a non-traditional biotechnology communication activity, MyBio Carnival in Malaysia which is addressed in more detail in Chapter 6.