SCIENCE CENTRES AND LEGITIMACY

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Abstract

This thesis is a theoretically informed critical examination of the dual-legitimating role of science centres in contemporary North America through a case study of the Arizona Science Center (ASC), Phoenix, Arizona. By dual-legitimacy is meant the process by which an institution legitimates both the messages it delivers and its own authority to do so. The science centre is first distinguished from laboratory science practice, its non-science educational role emphasised, and its social role contrasted with that of the public understanding of science movement.

The basic concept of legitimacy as an organising principle is argued for based on the thought of Ernest Gellner. The methodological issues of a single case study are considered in terms of generalisation and objectivity. An approach is advocated that is both multi-methodic and reflexive.

A history of the science centre movement is provided that sees the science centre as a distinctive museum type, developing from a broad range of influences over the last three hundred years. The emergence of science centres in the late 1960s is related to social and political issues of the Cold War and an examination is given of the social significance of interactivity. This story provides the context for the development of ASC in the 1980s. This leads to the opening of a new science centre in Phoenix in 1997 and the meaning of its new building and the destination experience it offers are considered in terms of local legitimation among a variety of other institutions.

An overview of the national science centre movement is provided and ASC is taken as a typical centre. The way ASC legitimates itself to potential visitors is examined in terms of the characteristics of its visitors and the messages it places in the media to attract them.

A detailed examination is provided of the nature and meaning of ASC's offerings in art, exhibits, planetarium shows, giant-screen films, and demonstrations. It is argued that ASC offers different models of science and that much of its message is carried through being embodied by its visitors rather than cognitively understood by them. The result is that the science centre experience is a mixture of many elements with many aims, even though it carries what appears to be an ahistorical, asocial, apolitical message about science. An examination of some of the resulting tensions is given together with consideration of whether the embodied science of science centres ultimately achieves its goals.

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1. Foundations

1.1 Basic Approach

The issue of science centres and legitimacy first suggested itself as a research question in the period 1997-1999 when the Arizona Science Center (ASC), Phoenix, Arizona, employed the author as a research consultant. From over 100 observational studies and surveys of visitors administered at the Center as part of the author's consultancy, it was clear that the vast majority of Center's various users found the experience both educational and enjoyable (for example, Arizona Science Center, 1997c). In addition, the science presented was received as authoritative and the institution considered a legitimate source of knowledge about and experience of science. From similar findings around the United States and elsewhere, it appeared that such legitimacy was not unique to the Arizona Science Center, but rather typical of this type of museum (Association of Science-Technology Centers, 1998). The research reported below began in January 2000 and was completed three years later. The task was to examine, through a case-study of ASC, how such institutions construct and maintain their view of science and how they represent it to their publics, in effect, how they define science and how they define themselves as its representative and interpreter.

This thesis shares an approach with studies of other museums that are, "... theoretically-informed critical readings of cultural products," to borrow a phrase from Sharon MacDonald (2002: 9). The writers MacDonald cites as taking this approach in museum studies are Mieke Bal (1996), Tony Bennett (1995), Carol Duncan (1995), Donna Haraway (1989),[1] and Barbara Kirschenblatt-Gimblett (1998). All these studies were written in the 1980s and 1990s, but were inspired by a variety of previous theories, forming that broad perspective now called cultural studies. MacDonald sees them sharing a common purpose: "Such analyses seek to explore the possible significations of specific representations through an understanding of broader cultural practices of meaning construction" (MacDonald 2002: 9). That is, they deal with particular types of museums or particular exhibitions within them, using anthropological, philosophical,

[1] MacDonald cites the year 1992 for Haraway in her footnotes, but has no corresponding year in the bibliography. Haraway's work of direct relevance to this thesis are (Haraway 1991, 1997). The work cited above was first published in the journal Social Text in 1984 and republished in 1989.

sociological, psychological, political, and/or aesthetic theories, to offer new readings of museums and culture.

By examining and revealing "significations of specific representations," these studies draw variously from a tradition that relies heavily on cultural semiotics and subsequent developments in theories of meaning that have influenced structuralism, poststructuralism, deconstructionism, and post modernism. One of the difficulties of summarizing this extremely broad intellectual heritage is that the "tradition," particularly as it applies to museums, only becomes apparent in retrospect. Its members do not form a self-conscious school of thought and, more significantly, use different theories for very different conclusions about museums. Carol Duncan, for instance, draws on the theoretical work in anthropology of Mary Douglas and Victor Turner in her study of the public art museum as a ritual space. Tony Bennett in his analysis of the "exhibitionary complex" compares and contrasts the social theories of Michel Foucault and Antonio Gramsci. Mieke Bal in her explorations of the meaning of display finds inspiration in the work of feminist and post-colonial thinker Gayatri Chakravorty Spivak. Donna Haraway and Barbara Kirshenblatt-Gimblett draw eclectically from a wide array of contemporary theorists in anthropology, science studies, cultural studies, post-modernist theory, and feminism. The common heritage of all these writers may be seen more clearly, however, when Roland Barthes is included in the list of exemplars, a thinker who may be considered a progenitor to them all.

Almost fifty years ago, in two very short magazine articles that were collected later in the book Mythologies (Barthes 1972), Barthes examined museum exhibitions as elements of "mass culture." His approach was to critically review exhibitions on plastics and the "Family of Man" to reveal their hidden or "mythic" meanings. His analytical tool was semiotic theory (what he called semiology) and in a final essay on how representation worked in culture remarked that, "Semiology has taught us that myth has the task of giving an historical intention a natural justification, and making contingency appear eternal" (1972: 142). His approach suggests that the analyst's task is to reveal and in a sense reverse this process, demythologizing the world-taken-for-granted. We find the same approach and intention today among MacDonald's selected authors. Although the details of their theoretical perspective may differ, they all share

Barthes' view of museum display as a form of ideological (mythic) speech suitable for analysis and deconstruction. This thesis takes a similar view, although, as will be made clear in the next chapter, the term "legitimation" is preferred to "ideology."

1.2 Analysing the Science Centre

This study treats the modern science centre as its focus. Based on evidence from a case study of the Arizona Science Center (ASC), it aims to examine the assumptions made by and about such institutions, drawing freely from many other subject areas, including philosophy, science studies, history, museum studies, and cultural studies. While analyses of museums of art, history, and natural history have something of a tradition of this kind of approach (as MacDonald's list attests), it has rarely, if ever, been applied to science centres. This may be because science centres are a relatively new form of museum and one presumed to deal exclusively with issues of informal science education rather than the production of culture. Such an a priori assumption, however, is precisely what this thesis aims to investigate. It seeks to be as foundational as possible. Such an approach is not without criticism, however. MacDonald, for instance, in the very sentence that approvingly named the approach "theoretically-informed critical readings," writes, "... I am critical of analyses that simply 'read off' production and intention (or, indeed, consumption) from 'texts'" (MacDonald 2002: 8-9).

There are at least two objections implicit in this criticism, one concerned with authority, and the other concerned with veracity. First, why should such an analysis, indeed any "reading off," be treated as privileged? Second, on what basis should the truth-claims of such a reading be accepted? The two objections are linked, because if cultural studies have taught us anything it is that claims to authority and veracity are interdependent. The answer to the first question is that any analysis offers only one possible reading of the "text," for there are many others.

The interconnecting issues of power, authority, and knowledge in the writing of Foucault in particular (Dreyfus and Rabinow 1983; Foucault 1970, 1972, 1980) and postmodernist thought more recently has influenced every discipline in the social sciences and humanities (Anderson 1995; Jamerson 1998; Lyotard 1997a, b; Rosenau 1992; Sarup 1993; Seidman 1994). The result is that none of the modern theoretically informed readings of museums makes a strong claim to absolute knowledge or unassailable authority. In the language of postmodernism they avoid becoming "master narratives." The danger of avoiding absolutism, however, is to court relativism. So, if there are many possible readings of the same "text," how do we choose among them? We are left, perhaps, simply saying that examples of the approach advocated here illuminate particular fields of inquiry in compelling and striking ways, which "make sense" once the reader sees that which is represented through the particular theoretical lens offered. Feminist theory, as used variously (but differently) by Haraway, Duncan, and Bal, for instance, means we can no longer ignore the sexual politics of cultural production and consumption in museums, but this does not preclude other equally important readings based on theories of ethnicity, post-colonialism, media studies, techno-cultural theory, etc. Each theoretical framework can claim to offer a well-founded interpretation. However, this is not to say that all interpretations should be treated as true; evidence also matters.

Part of making the case for any particular interpretation and distinguishing its characteristics, even in the face of what can be called the modern crisis in epistemology, involves marshalling empirical evidence. We look not simply for a good theory, but a good application of that theory, using real examples. Haraway uses the example of taxidermy at the American Museum of Natural History in New York City to make broad points about gender-bias in science and museum science display (1989). Bal (1996: 23-56) uses an example from the same museum to examine the display and interpretation of "Asian peoples" in the light of post-colonial thinking. Kirshenblatt-Gimblett (1998: 177-200) uses the museum of immigration at Ellis Island as a way to examine how museums may also be produced and used as shrines. Many of the examples of the approach advocated here, then, use a case-study approach. They examine real museums and real exhibits, linking description to theory to deepen the understanding of both.

This case study similarly draws on a variety of theories and presents a variety of forms of evidence to make its case. The main motive for doing so here is to broaden the understanding of the science centre experience. An adequate understanding of this experience includes not only its interactive exhibits and their educational impact, but also the significance of pre-visit understanding created by marketing, the meanings carried by the building's art and architecture, and the experiences created by giant screen film and planetarium presentations and science demonstrations. An organizing principle is to study a wide range of what comprises the average visitor's experience at a science centre. This is the focus of chapters 4-7. No single theory illuminates or interprets this experience fully and so many theories are used to interpret the evidence.

The danger of such an approach is that its wide array of subject matter, using diverse methods to bring forth evidence, and drawing freely on many theories for interpretation, may appear disjointed. An alternative way to view the result, however, is as *bricolage*, a term coined by Claude Levi-Strauss to describe the construction of myth by pre-literature cultures, but now used broadly to refer to the juxtaposition of ad hoc materials to produce new significance. The materials "at hand" here are the full array of experiences and impressions that make up a visit to a science centre. What the following chapters will show is that this experience is not a single or unified one carrying any simple notion of science. It will be argued, instead, that the science centre experience is essentially motley. By motley is meant the diverse social and cultural forces that produce an institution that creates an experience that can best be interpreted as a series of competing and unresolved tensions (see section 7.3, page 200).

This thesis will begin by examining three approaches in the current literature that each explains science centres within a single overarching explanatory framework. They contend 1) that science centres are or should be concerned with contemporary scientific work, 2) are merely and exclusively educational, and 3) are places that are clear about their role in and contribution to the public understanding of science movement. Each of these approaches is considered in turn.

1.2.1 Science Centres, Science Laboratories, and the Practice of Science

Frank Openheimer, the founder of the Exploratorium, and in many ways the founder of the science centre movement, wrote in 1968 of his desire to fashion a new institution on the model of the laboratory:[2]

> There is ... a growing need for an environment in which people can become familiar with the details of science and technology and begin to gain some understanding by controlling and watching the behavior of laboratory apparatus and machinery.... (1968: 206).

It was to be a museum where visitors would personally and directly experience the methods and activities of "real" scientists. This bold ambition – to provide the direct experience of scientific practice – proved more difficult and elusive than Oppenheimer and others may have imagined. This was no less than the attempt to overturn the historical process of the previous hundred years in which scientific practice had gradually left the museum. As described by Steven Conn, using the example of natural history museums, but in a way that is also applicable to other forms of science museum:

> Interested less and less in examining extensive collections of specimens and interested more and more in the theoretical, the microscopic, and finally the genetic, scientists left museums and located themselves and their work in university laboratories (Conn 1998: 26).

How successful Oppenheimer was in reversing this process and bringing the laboratory to the museum can be gauged from a consideration of the nature of actual laboratory practice and comparing it with its science centre version. Fortunately, extensive data on laboratory work became available from a movement in the sociology (and philosophy) of science that began in the early 1970s that produced a large number of studies of the sociology of scientific knowledge (SSK) and its practices. Collectively, they offer a critique and move away from the philosophical idealism associated with earlier sociologists of science, in particular, Robert Merton (1942 [1973]). Merton emphasised the normative structure of science, focusing on its supposed formal characteristics:

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[2] The notion of laboratory is so central that Hilde Hein subtitled her history of the Exploratorium "The Museum as Laboratory" (Hein 1990).

ethical (scientists use morally and technically efficient methods), universal (science is impersonal and objective), communal (scientific knowledge is public, available to everyone), disinterested (scientific work has no special motives), and possesses organised scepticism (scientific work takes nothing for granted). While Merton's model still has its supporters – John Ziman is a prominent example (Ziman 2000) – those engaged in more relativist and constructivist explorations of scientific knowledge argue that scientific truth it is not independent of the social context of its production in the ways suggested by the Mertonian model. At best, Merton's model is a possible goal or aspiration, but is far from how scientific knowledge is produced in practice in labs.

While there were (and still are) many streams of research in the SSK movement, most of its authors agreed that scientific knowledge is a social product that needs to be explored through the study of real scientific endeavour (Biagioli 1999; Pickering 1994).[3] Of particular significance was a new emphasis on ethnographic study, which formed a test of and departure point from the Mertonian model. This focus on actual laboratory practice is associated, in particular, with Bruno Latour and Steve Woolgar's landmark study of scientific laboratory research (Latour and Woolgar 1979).[4] It is useful to compare and contrast their notion of laboratory practice with the supposed "laboratory" of the science centre, which, as described below, owes more to the Mertonian approach. The most significant and obvious difference is that "real" laboratories are involved in the <u>production and creation</u> of scientific knowledge within the scientific community, whereas, science centres are involved in its <u>presentation and interpretation</u> to a non-scientifically professional public, even though the aim was for science centres to reproduce the essentials of the lab experience for visitors.

For Latour and Woolgar, laboratory science is fundamentally a semiotic and social process; one that involves constant struggle with rival labs and their mutual use of instruments and inscriptions as weapons in battles to turn statements into facts. What they called "a cascade of literary inscriptions" by scientists is central, including note taking in the lab, instrument readings, statistical tables of results, drafts of science

[3] This view also influenced the philosophy of science, for instance (Hacking 1983).
[4] Jane Gregory and Steve Miller see Latour and Woolgar's contribution as distinctive, but broadly in the intellectual tradition known as the "strong program" of the sociology of scientific knowledge (Gregory and Miller 1998: 64).

publications, and so on, such that, "The production of paper is acknowledged by participants as the main objective of their activity" (Latour and Woolgar 1979: 71).

An important distinction is made between "science in the making" (science practice) and "ready made science" (the "facts" so constructed). Latour later described this distinction as the Janus-face of science (1987: 32ff). His work chronicles the process by which science-making work in labs, if successful, goes from a highly contested and, therefore, well defended struggle and ends up as received fact parcelled into one or more ready-made "black boxes." A black box is not a contested scientific entity, but one so well known that it forms part of the world-taken-for-granted within continuing scientific practice. Many such black boxes form the operational basis – in theory, method, and equipment – of any new "science in the making."

In the book Science in Action, Latour describes the process that creates a very narrow social network of science practice – what in contemporary terms would be described as a community of practice, albeit a highly contentious one (Wenger and Snyder 2000). Ultimately, this community contains only those with the same career advantages, training, and the intellectual, material, and time resources as the writer/scientist who claims a new scientific fact. The vast majority of the population is thereby excluded and must rely on "popularized" sources for information and interpretation. Latour includes himself as such a populariser and comments:

> It is hard to popularize science because it is designed to force out most people in the first place. No wonder teachers, journalists and popularizers encounter difficulty when we wish to bring the excluded readership back in (1987: 52).

The scientific community of each area of knowledge, according to Pierre Bourdieu, jeopardises the particular kind of social capital this process creates if appeals to authority are made outside the field of scientific study, thus, inhibiting most scientists from becoming popularisers (Bourdieu 1999). Bourdieu notes the disapproval by competitor peers when instead of (legitimate) *publication* (in peer-reviewed journals) scientists seek (illegitimate) *publicity* from the press before publication. He comments, " ... the same distinction lies behind the hostility towards certain forms of popularisation, which are regarded as self-publicisation" (Bourdieu, 1999: 47, footnote

5). This process cannot simply be reversed – by the efforts of the public understanding of science movement, for instance (see section 1.2.3, page 23) – for the production of scientific knowledge functions through exclusionary social practices, not inclusionary ones.

There are only two possibilities for the excluded public: they may gain some understanding of the general process of "science in the making" by reading ethnographies like Latour's or they can understand some of the black boxes made along the way through various forms of science popularisation. It is this second choice that science centres and science museums take, for their efforts are focused almost exclusively on explicating "ready made science." They are at liberty to do this because the content of the black box is no longer the site of scientific contest and struggle.

With "ready made science" in the science centre setting there is little need for inscriptions, for their use to establish facts is no longer the goal – the facts have already been established. What text there is comes mainly in the form of simple instructions for operation and general statements on the underlying principle(s) displayed (label text). Instead, the main activity is a ritual re-enactment of practice, through the manipulation of a controlled set of activities, which recreates or illustrates the black box phenomenon, procedure, or principle. At best, visitors may discover or rediscover for themselves the notions that the exhibits display. Compared to the work of laboratory science, the science centre "lab" is, like the Mertonian model of science, idealised and highly abstract. Indeed, science centre exhibits are subject to several layers of abstraction.

The first level of abstraction is found in the very act of museum display. In an essay on the "political economy" of ethnographic objects in museums, Barbara Kirshenblatt-Gimblett writes:

> Fragmentation is vital to the production of the museum both as a space of posited meaning and as space of abstraction. Posited meaning derives not from the context of the fragments but from their juxtaposition in a new context. As a space of abstraction, exhibitions do for the life world what the life world cannot do for itself. They bring together specimens and artifacts never found in the same place at the same time and show relationships that cannot otherwise be seen (1998: 3).

If a Latourian science centre were to be constructed – one paying due deference to the social construction of scientific knowledge – such an institution would still suffer the problems of fragmentation and abstraction Kirshenblatt-Gimblett refers to. But such institutions do not exist and science centres instead concentrate on a second level of abstraction: those "clear, elementary principles," as John Durant called them (1992: 10), contained in Latour's black boxes.

Like many ethnographic objects, these boxes are separated from their origins and then brought together from a wide variety of times, places, and disciplines in order to make new connections in the science centre. They are organized in broad themes such as The World Around You, All About You, and Networks, to take examples of titles of some of the galleries at ASC.

The results of a review of just over 200 of ASC's exhibits[5] show that only one exhibit portrayed laboratory science work: a video in the All About You gallery featuring white-coated lab researchers working on diabetes among local Native Americans. Broadening the notion of science practice to any inclusion of a scientist, an oncologist was shown in the All About You gallery explaining basic concepts in a video on skin cancer. A surgeon was shown video-projected onto a mannequin, performing and narrating heart-bypass surgery. The National Library of Medicine's "new database on human physiology" was referred to in the label text of the Body Zoom exhibit. The names of scientists are included in several exhibits: the French mathematician Lissajous in the label text at the compound pendulum exhibit in the Fab Lab. The name of the eighteenth century scientist Daniel Bernoulli was contained in the title of the Bernoulli blower exhibit in The World Around You gallery. "Engineers and geologists" from the Phelps Dodge Morenci Copper Mine in Arizona were referred to in general at an exhibit displaying core rock samples in The World Around You gallery. No science practice or scientists were referred to in the Networks gallery. In total, approximately four percent of exhibits reviewed mentioned science practice, showed professional scientists, or

[5] This review was made in May 2002 in the All About You gallery (77 exhibits), Networks gallery (51), Fab Lab gallery (21), and The World Around You gallery (55). Sections of All About You and The World Around You were temporarily removed to house a temporary exhibit.

mentioned scientists by name, and among them only the Bernoulli blower was an interactive exhibit.

These examples and the vast majority of other science centre exhibits remain true to the abstracted view of science given to the public by science centres. These exhibits do not involve the visitor in the actual activity of real scientific work, but rather offer models (many of which are interactive) of an objectively pure empiricism. Once the focus is on the scientific principle, rather than the equipment or recording devices of scientific inscription, the exhibit designer is free to employ a third level of abstraction to illustrate and interpret the content of the black boxes. As we shall see in the chapters to come, science centres use a variety of techniques to do this, in particular, analogies, and metaphors (for example, see section 5.1.1, page 120). The results may be highly interactive and hands on, yet far from the activities of "laboratory life." Indeed, they come to have their own museum existence in this realm of triple abstraction.

Concerns over the lack of treatment of contemporary scientific practice in museums have been voiced in the United Kingdom (Farmelo and Carding 1997) and, more recently in the United Sates through the NSF-funded Public Understanding of Research ("Leading Edge") initiative (Museum of Science Boston 2001).[6] In both cases, the proposed methods by which new research (rather than ready made science) should be transmitted to the public are new electronic media, such as high-definition television broadcasts, webcasting, distribution of CD-ROMs, etc. Only a few examples exist: the Wellcome Wing of the London Science Museum, HD-TV Broadcasts from the American Museum of Natural History in New York, and the NSF-funded initiative coordinated by the Museum of Science, Boston, mentioned above, to name the most prominent. Even if coverage of "leading edge" science was to increase greatly in the future, however, it is unlikely that costly (an average of $600 per square foot) and relatively slow-to-develop and slow-to-change interactive exhibits would be the chosen medium of delivery. Ironically, it is likely that information about hands-on, ever-changing, "science in the making" will be delivered by the quicker to produce and much

[6] Related to this discussion was a concern voiced about the overly deterministic (rather than stochastic) nature of interactive exhibits when science centres were first planned in the United Kingdom (see, Lucas 1987).

quicker to update hands-off methods (broadcasts, public speakers, the World Wide Web, and other electronic media mentioned above).

The vast majority of exhibits in the modern science centre remain wedded to the interactive and hands on experience that was Oppenheimer's model. Nevertheless, they are not the laboratory activities he hoped for, but rather the black boxes of received scientific knowledge. Despite the changes in notions of how scientific knowledge is constructed and, indeed, despite the broad changes in notions of epistemology in all branches of knowledge (Foucault 1972; Hacking 1999; Lyotard 1997a; McCarthy 1996), science centres largely eschew these concerns, reflecting views of scientific knowledge Merton would recognize more readily than Latour. There is no single reason for this, but the sense of certainty engendered by a Mertonian view is perhaps more palatable to the public than the potential relativism of the constructivist alternative. It must be also be remembered that the science centre model of science closely resembles the model found in schools, which is consequentially one shared by the majority of the "non-scientific" public. In addition, such an understanding is safe, for its established scientific facts are unlikely to cause offence to visitors or sponsors compared with exhibits taking on contested social and moral issues. Finally, it is a view of science many science centre professionals believe in personally. The interconnection of these strands is examined in the chapters to come.

The significance of this rather traditional view of science is returned to in the final chapter, but it is worth pointing out here that despite the modern crisis of epistemology such a view is still extremely popular and that, indeed, its popularity may be related to the crisis. Roger Silverstone noted a parallel between the academic deconstruction of certainty and what he considered the public's "retreat into fantasy" (1989: 187).[7] In the face of this, the science centre offers a comforting level of certainty. The world is comprehendible in terms of basic principles that can be experienced and even played with. In an age of uncertainty, science centres neither doubt the truths they display nor embrace irrationality. Their optimistic faith in an understandable and controllable

[7] Silverstone attributes this thought to Christine Brooke-Rose (1981).

nature continues to have broad appeal and gives a sense of security, which, in a reflexive way, makes science attractive.

The science of science centres becomes separated into the invented (technologies) and discovered (science). The discoveries of science, isolated from their social construction, are presented as simple aspects of nature. Latour, when commenting on the process by which the "whitish stuff" separated by a centrifuge in Svedberg's lab in the 1920s became the object we now call protein, noted how ubiquitous the black box process is. Furthermore, he noted that the exploration of the black box is central to the education of children generally:

> This process is not mysterious or special to science. It is the same with the can opener we routinely use in our kitchen. We consider the can opener and the skill to handle it as one black box which means it is unproblematic and does not require planning and attention. We forget the many trials we had to go through (blood, scars, spilled beans and ravioli, shouting parents) before we handled it properly ... It is only when watching our own kids still learning it the hard way that we might remember how it was when the can opener was a "new object" for us, defined by a list of trials so long that it could easily delay dinner for ever (Latour 1987: 92).

What science centre exhibits do is to show the novice how the can opener works and strives to do this avoiding the "hard way," substituting museological techniques aimed specifically at making the "new object" an enjoyable and educational experience. It is important to note here what has happened to the black box we started with. In the world of science practice the content is so well known and understood "... it becomes part of tacit practice and disappears from view!" (Latour 1987: 43). In the science centre, it is exactly the reverse. The black box becomes the central focus of attention precisely because it is not (yet) understood.

1.2.2 Science Centres and Science Education

In a recent review of learning in museums and galleries, the section on science and technology museums contained the view that, "... most of what we know about visitors comes from research in this type of museum" (Hooper-Greenhill and Moussouri 2002: 11). John Falk and Lynn Dierking (and other associates of their Institute for Learning

Innovation) produced a considerable amount of this research in the United States, particularly on science-technology centres, and they point out that:

> ... learning in museums is now a more important topic than ever. A generation ago it was a topic of interest, but not importance, to the museum community; today it is a topic fundamental to the very essence of museum survival and success (Falk and Dierking 2000: xiii).

It was no doubt some relief to practitioners, then, when in the same section they were able to pronounce, "We are here to say undeniably that *people do learn in museums*" (emphasis in original) (2000: xiii). It is clear that as Eilean Hooper-Greenhill succinctly put it, "The educational role of the museum has become part of cultural politics" (Hooper-Greenhill 1999: 4). It is important to examine Falk and Dierking's bold claim as a political statement in some detail because, while not wishing to deny the importance of learning in museums, this thesis argues that there are cultural and social elements of the museum experience that can be usefully analytically separated from modern notions of learning. To make such a distinction, however, is to run counter to an important contemporary trend that advocates ever-broader notions of museum learning.

Over roughly the same period in which the political importance of learning in museums has grown and been recognised, so too has a much broader account of learning. Falk and Dierking, for example, are now able to draw on a very wide range of learning theories, including the motivational theories of Mihalyi Csikszentmihalyi's investigations of intrinsic motivation (Csikszentmihalyi 1988; Csikszentmihalyi and Henderson 1995); Howard Gardner's idea of multiple intelligences (Gardner 1983, 1993); George Hein's version of constructivism (Hein 1992; Hein 1998; Hein and Alexander 1998); neo-Vygotskian arguments about socio-cultural learning and communities of learners (Martin 1996a; Rogoff 1990; Rogoff and Lave 1984; Vygotsky 1978); and, citing some of their own work, even evolutionary and neurological arguments (Falk and Dierking 2000: 60-65).

That many aspects of these theories and approaches are mutually incompatible is not at issue for Falk and Dierking, because their purpose is more to advocate the importance of museums as sites of learning than to build a single theory or set of consistent theories. The result is that educational research forms part of the legitimating process for museums in general and science centres in particular.

Given the stakes for museums ("survival and success"), it is perhaps no surprise that so many theories are marshalled to provide so much evidence for their conclusions. The danger is that if the definitions of learning are overly broad and general they may cease to make any substantive claims at all. If learning becomes coterminous with any and all experience, for example, it becomes difficult to see what in theory could count against it, and while this may be good politics, it is surely bad reasoning. As Anthony Flew remarked on the philosophical issue of falsification and assertion, "Someone may dissipate his assertions completely without noticing he has done so. A fine brash hypothesis may be killed by inches, the death by a thousand qualifications" (Flew 1966: 226). The recent history of learning theory as applied to museums, arguably, has followed a similar path. Lisa Roberts' book From Knowledge to Narrative (1997), for instance, chronicles much of the positive side of this history and ends with a call to both broaden and rethink what counts as learning and teaching in museums to include the whole gamut of visitor meaning-making. The challenge is to develop a justification for such an approach to museums that does not render learning trivially true. That is, having failed to find much evidence for learning in narrower notions, which relied on knowledge and skills-based definitions, broader notions (which may include the affective, behavioural, emotional domains, etc.) may end up claiming that everything is a form of learning. This move empties its own assertion of any real meaning and, importantly for this thesis, precludes examination of other culturally significant non-cognitive behaviours. This is not to say that broad definitions of learning cannot be justified, but rather they are particularly vulnerable to attack at their outer margins. In chapter 7 (section 7.5, page 218), the "boundary issues" for science centre notions of education are returned to and re-examined.

This boundary issues become particularly problematic when broad definitions of learning are argued for based on political strategy. An example of such an argument can be found in a short article by the staff of the Institute for Learning Innovations. Beyond evidence based on research findings, they comment:

> ... in our minds there is also a pragmatic reason to use the term "learning" when discussing the impact of museum experience. The term has political currency in a changing world with diminishing resources and a need for innovative approaches to education, a niche that museums and other free-choice learning entities fill well.... We should be playing an advocacy role which supports broader views of where, how and why learning takes place (Dierking et al. 2002: 4).

Citing the case of the Georgia O'Keefe Museum in Santa Fe, New Mexico, which lost its status as a tax-exempt institution when the City successfully argued that it was not offering education, Dierking et al, go on to say:

> Learning is one key that ties the institution of museum to the cultural values of the community. Undermining the widespread public perception that learning takes place in and from these settings is extremely short-sighted (2002: 4).

The risk of advocating such a pragmatic approach is that its political significance may soon begin to dictate what should count as learning, rather than the research findings themselves. At this point, the tail begins to wag the dog. Unfortunately, the museological literature rarely steps back, as it were, from the museum community to examine the cultural politics of how museums, museum professionals, and museum researchers justify their role in and for society through arguments about learning.

While advocacy of too broad an understanding of learning may have its logical and political problems, too restricted a definition also has its troubles. For example, viewed narrowly in terms of knowledge:

> The data suggests that adult visitors rarely demonstrate significant recall of facts and concepts encountered during museum visits. The research on children visiting as part of school trips is more equivocal, but many of the studies fail to show significant concept learning (Falk and Dierking 1992: 97).

It is tempting, perhaps, at this point to widen what counts as learning and critically associate such narrow views with the formal (coercive) educational system and the short-comings of its accountability and assessment systems. At the same time, as a major consumer of its offerings, the museum community while broadening its notions cannot afford to simply abandon the narrow definitions of learning. The result is the free choice or informal learning sector co-opts, while simultaneously moving beyond what it casts as characteristics of the formal system, and ends up with the following type of formulation:

> We need a to develop a comprehensive museum-centered model that embraces certain elements of main-streaming learning theories, but that prescribes a much stronger role for the variables of motivation, beliefs, and attitudes of the personal context and for the influences of social and physical contexts (Falk 2001a: 99).

The consequences of this can be seen in the science centre movement through its professional organization in the United States, the Association of Science-Technology Centers (ASTC), when it makes the claim that, "Science centers are an integral part of the educational infrastructure" (Association of Science-Technology Centers 2001: 21). They cite impressive statistics about science centres world-wide to make their point: 86 percent offer school field trips, 89 percent offer classes and demonstrations, 71 percent develop curriculum materials, 75 percent offer school outreach programs, 83 percent offer teacher workshops, 45 percent offer after school programs, etc., and the figures are even higher for the United States (2001: 21-24). Significantly, all of these statistics are about services science centres provide to the formal educational system, mainly schools.

Even though Hooper-Greenhill and Moussouri, quoted above, suggest that much research on learning was performed in science museums, nowhere in ASTC's annual statistical account of the positive effects of science centres are there reports of their effect on family learning, informal learning, free-choice learning, or any term used to describe the educational claims made by researchers examining free-choice or informal learning. The reason for this is simple: there are no standard measures of informal learning from which national or worldwide statistics can be constructed. If such measures did exist, and proponents of informal learning on both sides of the Atlantic are close to suggesting they do, they would undoubtedly be used to argue for the sector's general social worth. For now, they must rely on small-scale studies of particular institutions (such as ASC), which employ a variety of techniques, approaches, and definitions of learning.[8] It must be pointed out, however, that along with staff in other types of museums, science centre professionals try to keep up with the latest in the diverse and rapidly developing field of learning theory. For example, ASTC has responded by producing two short volumes entitled What Research Says about Learning in Science Museums (Association of Science-Technology Centers 1990, 1993) and promotes through resale studies on specific aspects of learning in science museums (for example, Dritsas et al. 1998) as well as more general literature on museum education (for example, Hein 1998).

The overall result is that science centres can point to general effects (at least demographically) in the formal educational sector and more anecdotally in the informal sector through a variety of small-scale studies. This leaves considerable room for doubt. Gillian Thomas and Tim Caulton, for example, looked at what they called "Interactive spaces" – a definition for Caulton (1998) that includes science centres and children's museums – and their main conclusion was that while interactives have proved popular, whether they are educationally effective was an unresolved issue. They concluded:

> The effectiveness of interactive exhibits to attract the public and to provide an enjoyable day out, a memorable occasion is not in doubt. What is questioned is how their educational validity can be enforced. (Thomas and Caulton 1996: 121).

The educational effectiveness of science centres is the fundamental debating point in their study and while not everyone agrees that science centres are educationally valuable (Beetlestone 1987; Bradburne 1998a; Karpf 2002), most agree that they should be.[9] What is significant for this study is the uneasy distinction the literature tries to make between the formal and informal sectors and the differing forms of learning that go on in each.

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[8] The Research Centre for Museums and Galleries at the Department of Museum Studies, University of Leicester is developing such generic learning outcomes in its Learning Impact Research Study.

[9] A useful summary of some of these issues, as they apply specifically to science centres, can be found in (Errington et al. 2001). The articles, by David Anderson and Keith B. Lucas (2001) and by Susan M. Shocklmayer and John Gilbert (2001), both contain brief introductions that summarize much of the literature.

Falk (2001b) examines the informal learning issue in the introductory chapter of a book of papers originally presented at a conference in 1998 on what he calls "the informal science education infrastructure." For Falk, there are problems with the notion "informal" and in its place suggests "free-choice." While his characterisation of informal as simply referring to the "physical setting" is unconvincing, his definition of free choice as stressing social context and personal motivation is certainly helpful (although whether choice implies freedom is perhaps assumed here, without the discussion it deserves). Whether they want to be or not, as we have seen, he and other researchers of learning in museums are involved in the rhetoric of museums (see, for example, Durbin 1996; Hooper-Greenhill 1999; Roberts 1997). Part of the distinction between the formal and informal sectors is shown in the admirable characteristics of the informal as social, voluntary, self-paced, and non-sequential. All of these characteristics are in keeping with the values of an open, free, democratic society. This may all turn out to be well founded and reasonable, but in so dominating the discussion on museums, and science centres in particular, it begins to appear that learning so viewed is the only issue worthy of consideration and that the battle is merely over what counts as learning and how it can be demonstrated.[10]

This thesis seeks a more foundational approach that asks not which definition of learning is correct or whether or how people learn in science centres, but what role do such statements and debates play in the discursive formation of science centres? The suggestion that is discussed in the chapters to come is that the science centre movement, just like the researchers who examine it, has an ambivalent relationship to the more powerful formal educational system. School children on field trips and teachers in educational workshops, after all, are major customers of science centre services and yet science centres are often critical of the way science is taught in schools. The science centre offers its inquiry-based learning through interactivity as a polemical alternative to what it sees as the knowledge-based approach of most schooling.

There is reason to think that a good deal of this talk is more rhetorical than substantive. The very success that science centres have in attracting teachers to their workshops on a

[10] An important exception is Sharon MacDonald's notion of "cultural itineraries" and subsequent work by Theano Moussori (Macdonald 1993a, b; Moussouri 1997).

world-wide basis suggests that there may be much more overlap in approaches to learning than is usually suggested. The self-discovery and inquiry-based methods advocated in science centres are also strongly advocated in science education in schools (Duckworth et al. 1990; Lansdown et al. 1971). A recent summary of contemporary educational theory suggests that the broad definition of learning advocated by the museum community was first promulgated by researchers in the formal system (Bransford et al. 1999). It may be that with the increasing convergence on what counts as learning, there is no clear and distinct difference in the two sectors in terms of how people learn ("learning is learning" as George Hein put it[11]), but rather the social meaning of learning in each sector is fundamentally different. For example, the reasons for assessing learning are significantly different in the formal and informal sectors.

In the formal sector, the primary goal is to judge the individual or cohort (class, school, region, institutional level, nation) in order to assess progress (or lack of it), determine the next level in the system (which class, school, or university one can go to), or credential or graduate the participant out of the formal system. This is the case whether or not the definition of learning is narrow or broad. A secondary goal is to assess the competence of the teacher, school, etc., to provide adequate education.

In the informal sector, there are no consequences for the individual visitor or user assessed. The results of learning in a science centre do not determine what one can study next, nor does it confer status. By contrast, these measures are used primarily to assess the effectiveness of the exhibit, exhibition, or institution. These assessments may have a significant impact on the informal institution's ability to show educational effectiveness or gain public and private support, but they have no consequence for the subject of assessment as an informal learner.

The social location of assessment is thus a crucial element in not only why we measure, but also the methods used and their political consequences. The different social locations of learning and the different purposes for which it is assessed means not that one system is better than another, but that they are simply different social and political

[11] Personal correspondence (2002), commenting on his intended response to (Dierking, et al 2002).

arenas. All of the above would be true even if the notions of learning were common across the two domains, which they may be.

The social location of learning in the science centre is both related to the formal system as a major customer and the informal settings of recreation where learning is seen as "life long" and/or "family-based." As we shall see below, depending upon the context, science centres variously suppress mention of education and learning, stress the nature of free choice learning, or detail the characteristics of their offerings in terms of formal national and state educational standards. This changing usage is an important element in science centre discursive practice, forming part of the movement's struggle to find a distinctive voice. The nature of their day-to-day operations goes a long way to explain the struggle, for they cater both to school groups looking for formal educational gains in science knowledge and skills and family groups seeking informal recreational/learning experiences. The characteristics of these groups are described more fully below (see section 4.2.4, page 97). The result is the inner- and outer-boundary issues of science centres as they struggle to meet the needs of their various users (for further discussion, see section 7.5, page 218).

The struggle the science centre movement has with learning is related not simply to its theory of learning, but its theory of knowledge. For George Hein, in his often reproduced formulation, the continua of learning theory and epistemology produce four types of educational theory: didactic/expository, discovery, stimulus-responses, and constructivism (Hein 1998: 25). Hein is an avowed proponent of constructivism as the appropriate approach to educational theory for museums. The science centre movement, however, does not fit so neatly into his schema for while it tends to advocate a constructivist approach to learning by its visitors it simultaneously adopts a realist epistemology when it treats the knowledge created by scientists. That is, it strongly believes that the active participation of the visitor is required for learning, but it also believes in an external, objective state of affairs that has an existence separate from the learner. The Vygotskian-inspired approach of ASC, called I-CM, that attempts to reconcile these difficulties and is discussed in chapter 7 (see section 7.3.2, page 208). One might best characterise it as half-constructivist (the visitor's half): learners through interaction and experience with exhibits construct or come with their own understandings, but they may and often do contain misconceptions, even errors that the science centre experience is specifically designed to address.

These remarks are not aimed at suggesting that a particular theory of learning should be preferred, but that arguments about learning theory adopted by the science centre movement should be a subject for study, not a presupposition of it. Viewed in this way, a space may be created in which the rhetorical and political nature of the language of learning may be examined as it operates in the discursive practices of science centres. It also opens up the possibility of viewing at least some of the visitor experience as non-learning, yet significant. This suggests that between an overly broad and overly restrictive notion of learning in science centres is an educational theory still very much in the making. Finally, the notion of non-learning visitor experiences should be seen positively, that is, just because experiences may not be defined as educational, does not mean they are unimportant. On the contrary, it is argued here that a key element in an adequate understanding of science centres is their role as safe places for the ritual embodiment of scientific truth. This role, as will be argued in the chapters to come, does not fit easily into existing theories of learning and is largely independent of visitor cognition.

1.2.3 Science Centres and the Public Understanding of Science

The section above aimed to show that it is possible to step back from the issues of education and learning and see that they form a component in the rhetoric of science centre claims to legitimacy. A similar approach is taken here to talk about science centres and the public understanding of science.

Frank Oppenheimer in A Rationale for a Science Museum (1968), quoted above and often treated as a founding document of the science centre movement began as follows:

> There is an increasing need to develop public understanding of science and technology. The fruits of science and the products of technology continue to shape the nature of our society and to influence events which have a world-wide significance. Yet the gulf between the daily lives and experience of most people

> and the complexity of science and technology is widening (Oppenheimer 1968: 206).

This is a classic statement made by a leading professional science educator of the day on the need for the public to understand and appreciate what he called "... the gap between the experts and the laymen." Clearly articulated here is the "deficit model" of the public understanding of science. Professional scientists have this knowledge; the public does not. It can be argued, however, that a deficit notion is implicit in any formulation of the public understanding of science agenda no matter how inclusive that formulation may be, for of its nature there is always posited a public in need of an understanding possessed by others (ultimately, scientists).[12] Despite reformulations over the years that have tried to avoid this top-down model, the concerns Oppenheimer voiced in the 1960s seem as true today as when he wrote: "For many people science is incomprehensible and technology frightening. They perceive these as separate worlds that are harsh, fantastic and hostile to humanity" (1968: 206).

It must be remembered that Oppenheimer made these remarks before the movement that is now called the Public Understanding of Science (PUS) became organized with its own university departments, academic publications, journals, and conferences, some backed by national governments. Conversely, we can see the public understanding of science movement (in lowercase) going back at least a hundred years and arguably earlier to such "populist" activities as the public lectures of Michael Faraday.[13] For the sake of clarity, the modern, uppercase movement may be seen as an historical product of the lowercase movement we may more generically call the popularisation of science. The PUS movement really became organized in the 1980s in the United Kingdom when, as Simon Knell described it:

> ... the Royal Society became the parent to a worldwide movement known as the public understanding of science .... Whether or not it was an attempt to inform or control (if it is possible to distinguish between the two), the movement was certainly wedded to a notion of cultural orthodoxy sustained by science (Knell 2002).

[12] This point was made by Steve Fuller (1998), but revisions have been made to the basic model to avoid these problems, see the discussion below of Irwin and Healey's attempt to do so.
[13] The popularization of science as a form of PUS is remarked on by a number of writers (Boddington 1998; Knell 2002; Lewenstein 1994).

John Durant's name is synonymous with this movement.[14] He was appointed the first professor of the Public Understanding of Science at Imperial College, London in 1989. He was also the founding editor of the journal Public Understanding of Science, and the editor and author of many books and articles on the subject, including editor of Museums and the Public Understanding of Science (1992), a collection of short articles, which, interestingly, contains no contribution specifically about science centres. Durant's introductory essay, however, distinguishes science centres sharply from science museums:

> Generally speaking, a science centre comprises one or more relatively open spaces in which are located a large number of free-standing interactive exhibits, where as a science museum comprises several relatively closed spaces in which are located a small number of permanent or temporary exhibitions. Typically, a science centre interactive is a device that embodies an elementary scientific or technological principle, and visitors are encouraged to 'play' with this device, usually with a minimum of textual or other guidance, in order to 'discover' the principle for themselves. A science museum exhibition is a scripted 'story' about an entire area of science or technology, told with the assistance of many different objects, interactives, captions, and (increasingly) audio-visual and electronic media (Durant 1992: 8).

The article goes on to contrast the two types of institution: the science centre provides "bite size chunks," while science museums offer "a menu of ... scientific dishes." The science centre experience is one of "personal experience of striking natural phenomena" whereas the science museum gives an experience, "encountered through the history of striking technical achievement." The image of science promoted by science centres is one of "clear, elementary principles waiting to be discovered by anyone with sufficient child-like curiosity and adult patience," whereas the science museum offers an image "of sure and solid progress in the mastery of nature" (1992: passim).

Despite Durant's slightly critical tone toward science centres, some of these distinctions are helpful and suggest that, perhaps, despite a museological literature and institutional definitions that generally treats them as part of the same subject area (science in

[14] Most of the significant work in this field has been produced by scholars in the United Kingdom, but the movement does have its United States counterpart, most particularly in the contributions of Bruce V. Lewenstein (1992; 1994; 1998; 2000).

museums), they may be two very different types of institution pursuing different means to, arguably, different ends. Ultimately for Durant, these differences boil down to one: without collections of scientific instruments, science centres have only the single purpose of promoting the public understanding of science. Whereas, science museums collect, preserve, and display precious objects and in addition promote the public understanding of science (Durant 1992: 8), suggesting that he thought science centres were ultimately unnecessary. Since then, invited contributions to the journal he founded have debated the science centre movement, with the score so far: one article of mixed results (Beetlestone et al. 1998), one negative (Bradburne 1998a),[15] and one positive (Persson 2000). The results of such evaluations, of course, are in large measure a result of what their authors' count as science, their notion of the public, and what counts as understanding.

A summary provided by Alan Irwin and Peter Healey in their testimony to the House of Lords on these issues is a useful starting point (Irwin and Healey 2000). They suggest there are three basic models of the relationship between science and the public. The Enlightenment Model, which is diffusion and trickle down from scientific elites to an outside public; the Economic Model, which emphasises science as an economic asset that involves the public in supporting or opposing scientific research; and the still emerging Democratic Model, where the public as citizens and consumers are directly involved in science policy.[16] They stress that the three models co-exist and compete with each other, forming the current diversity of views on science and society.

While these models are sociologically important, they reinforce an epistemology of science that requires further consideration. Each model assumes that there is a group or segment of society that produces science and at the other end is a yet-to-be informed public that consumes its products and findings, even in the democratic case. In between are the mediators of science, those individuals and institutions that translate and simplify science: the schools and universities, the media (principally television, newspapers, magazines, and more recently, the Internet), and informal science learning institutions, principally, libraries, science museums, and science centres. The problem

[15] This article appeared in two journals in the same year (see also, Bradburne 1998b).
[16] A PowerPoint presentation of the model is also available at www.spsg.org/pus.

with this model of models is that it fails to recognize that science is both mediated and produced in each domain of the model. Scientists do not simply produce knowledge or technology for others to interpret, but they are themselves actively involved in a social, personal, political, and economic process of interpretation, just like the institutions of science mediation they often criticize for bias and oversimplification. So too are the institutions of mediation and the public that "receives" their messages. Two consequences of this interpretation are important to this study. The first is to recognize that science is interpreted in all components of the model, for each component has a notion of what is meaningful and important. The second is to recognize that science is thereby produced in all components of the model. That is, just as an art gallery creates what it interprets (art), then so too scientists, science centres, and the public create the science they interpret. The ontology of science (what it is) is integrally related to the social setting in which it is created. This study is concerned with the way science centres both interpret science and simultaneously create a notion of what counts as science.

We can still ask, however, whether the science interpreted (and created) by science centres has significance for the goals of the public understanding of science movement, regardless of which model or combination of models explains it. Geoffrey Thomas and John Durant suggested many reasons why the public ought to have a better understanding of science (1987), which later became the theoretical underpinning for Jane Gregory and Steve Miller's examination of Science in Public (1998: 10-18). For Thomas and Durant, science needs public understanding to work effectively in a tolerant society, which when effective leads from public understanding to public appreciation of science. More generally, modern economies require public understanding of science, because so much of a national economy is based on sales of scientific ideas and applications. On a political world scale, the public understanding of science leads to investment in large-scale prestigious scientific endeavours, such as the International Space Station or the Human Genome Project, and defence. A scientifically literate citizenship benefits because an understanding and appreciation of science helps individuals make better sense of the world around them and prepares them for an increasingly scientific and technological job market. Scientifically educated citizens benefit their particular democracy through informed voting. In the cause of equality, public understanding of science erodes the culturally divisiveness of the scientifically literate and illiterate. Finally, there are the cultural, aesthetic, and moral benefits of scientific literacy, not least an appreciation of science as, arguably, the most significant achievement of the Western World.

The model of abstract science promoted by science centres and described above seems far removed from the political, economic, and moral issues of the scientifically literate informed-citizenry envisaged in Thomas and Durant's account. Science centres, compared with science museums, hardly seem to engage in such issues at all. Indeed, public controversy over science exhibitions appears to be exclusively a science museum issue, with such celebrated examples as the Science in American Life (Molella 1997; Molella and Stephens 1996) and the Enola Gay (Gieryan 1998) exhibitions at the Smithsonian. Sharon MacDonald makes a distinction between the two sorts of museum that may help to explain why:

> The former [science museums] seek to present science entirely contextualized in a "slice of history" in a particular community, whereas science centres are more concerned with universal laws and principles which transcend particular times and places (1998b: 15).

This concern with "universal laws and principles" is indeed a characteristic of science centres. It must also be noted that she correctly observes that this concentration has resulted in, "... rather scant commentary on their political motivations and effects" (1998b: 15). Indeed, one might suggest that by concentrating on the abstract in science, there are no political effects, but this absence is itself a very significant political (non-)statement that is returned to below, when the findings of the case study have been presented. In particular, the ways in which the shared trust between funders and science centres and their "portfolios of interest" operate by self-censure to determine the content of science centre exhibitions (see section 7.2, page 197).

At this stage, a few preliminary and defensive points on behalf of science centres can be made. First, science centres mainly focus on "science for children" so their proponents could argue that the science they tackle is necessarily foundational to engagement with the issues of a scientifically literate citizenry. Second, as long as the science they focus on is not research "science in the making," the social and moral issues of science may not arise. Third, the contemporary moral, social, and political ramifications of science may not be easily translated into the preferred interactive mode of delivery. While there are of course exceptions – The *What About Aids?* travelling exhibition, which visited ASC in 1999, is a good example[17] – the norm is the omission of any direct engagement with the social consequences of contemporary science. Such omission remains the science centre movement's Achilles heel. In a defence of such criticisms by J. M. Bradburne, Per-Edvin Persson writes:

> Contrary to what Bradburne maintains, science centres show an increasing attention to processes and society in their exhibitions. I think there is a general trend towards trying to provide explanation and context in exhibits ...
>
> While there is a need to provide more context and background, and to pay attention to the surrounding society, the main product of a science centre is still to highlight phenomena and scientific principles (2000: 455).

There is real ambivalence here; there is a desire to do more, but reluctance to truly take on the issue. The contemporary situation is that science centres are heavily involved in a lower case public understanding of science, but have hardly begun to engage the challenges of the uppercase Public Understanding of Science.

1.3 Structure of Thesis

This chapter has dealt with a number of foundational issues, arguing that its approach has intellectual antecedents in a variety of cultural studies of museums, but they have not previously been applied to science centres. This approach was then used to step back from the usual critiques of science centres to examine why they tend not to treat "science in the making," why the learning and education perspective is significant but not the only way of evaluating their impact, and why they do not fully embrace the goals of the PUS movement.

[17] Developed by the National AIDS Consortium in collaboration with the U.S. Centers for Disease Control and Prevention.

The second chapter deepens the discussion of some of the issues introduced above, in particular, the meaning and use of the term legitimation. It also examines the implications of the case study approach adopted. Chapter 3 examines the history of science centres, the formation of the Arizona Science Center, and the symbolic meanings of its building. Chapter 4 considers why people decide to visit science centres and how ASC targets its message about science. The next two chapters are a detailed presentation and analysis of "doing science" (Chapter 5) and "showing science" (Chapter 6) in science centres. Chapter 5 examines the gallery experience at ASC, provides a detailed interpretation of selected exhibits, and offers an analysis of the nature of science exhibit encounters. Chapter 6 offers an interpretation of the various ways ASC shows and promotes science through its special presentation of planetarium shows, giant screen films, and live demonstrations. In Chapter 7, the main theoretical issues introduced in this chapter are revisited and the implications of the motley of the science centre (as analyzed in chapters 3-6) are re-examined in terms of a series of tensions, which in turn reflect tensions in society about the meaning and significance of science in contemporary society. This chapter also revisits the notion of legitimacy introduced in chapter 2. In particular, Ernest Gellner's account of legitimacy is compared and contrasted to the way it is used by Bourdieu to explain the legitimacy of art museums. The popular legitimacy of the science centre is linked to Anthony Giddens' notion of trust and the chapter ends with recommendations for future research.

2. Issues of Theory and Method

This chapter provides a theoretical and methodological justification for the case study that follows. This work is both archaeological and genealogical in Foucault's sense of the terms (Dreyfus and Rabinow 1983; Foucault 1972). It is archaeological in that it seeks to analyse the discourse or serious speech acts that comprise its double claim to legitimacy – both for science and science centres. It is genealogical in that it also attempts to explicate the conditions, limits, and institutional forms that define their use.

The case study will show that acts of legitimation by ASC, and the science centre movement of which they are a part, are negotiated with a variety of other social groups and institutions, and require constant renegotiations that are, ultimately, only partially successful. Social legitimacy, despite borrowing its meaning from legal concepts, is not achieved by passing some single agreed upon test, but rather is a set of rhetorical claims that must constantly be remade in the eyes of "evaluators" who come in many forms: museum professionals, educators, government agencies, private foundations, politicians, the media, and, arguably most importantly, the general public.

This chapter also examines the methods used to present the findings from which its theoretical arguments derive. This work is eclectic in its use of both theory and method and it is important, therefore, to provide a rationale before proceeding.

2.1 Legitimacy as an Organising Principle

Science centres are concerned with legitimacy in two related senses. First, science centres represent particular understandings of science to the public. They celebrate and commend science, attempting, to encourage the public – children in particular – to see science as non-threatening and understandable. Put simply, science centres legitimate science. Second, science centres present themselves as key purveyors of science in the informal or free-choice learning environment of a museum setting. Put simply, science centres legitimate science centres.

Jean-Francois Lyotard remarks on the importance of "double legitimation" in modern conflicts over the nature of scientific knowledge and points to its long history: "The question of the legitimacy of science has been indissociably[1] linked to that of the legitimation of the legislator since the time of Plato" (Lyotard 1997a: 8). In the context of the science centre, the process is somewhat in the opposite direction to the one Lyotard emphasises, where he comments on the status of the "legislator" as providing legitimacy to science. Here we see science providing legitimacy to science centres. Science centres draw much of their authority from the widely accepted view that science provides unique access to an understanding of the world. The process is less unidirectional than these emphases suggest, however, and is better thought of as reciprocal. This dual-legitimising function shows that science centres are not autonomous presenters or scrutinizers of the claims of science, but are active promoters of particular formulations of science. While this provides the basis for a theoretical critique, it is not intended to be prescriptive; indeed, it is tantamount to a *category mistake*[2] to expect science centres to be self-critical and reflexive in a way that scholarly interpretation is at best. Instead, while science centres are to be understood as institutions of practice deeply implicated in the promotion of the science they present, the museological task is to understand how and why they operate as they do and how they legitimate these activities. The focus, then, is to understand the legitimating process rather than to rectify it.

Legitimation is thought by some to be simply a component of the ideological. Robert M. Young assumes as much when he writes, "The concept of ideology refers to legitimation and to the intrusion of values into putative facts" (Young 1992: 165). There is something to be said for such a definition, but there is also a case for treating legitimation as a separate theoretical tool. It is precisely this possibility that makes it a useful analytical category in the case of the science centre movement.

The problem with adopting "ideology" as this study's organising term is that it is a notoriously difficult and slippery concept to define. Terry Eagleton in his book length examination of Ideology begins with a listing of sixteen definitions currently in circulation (1991: 1). A number of these are themselves deeply ideological in the sense

[1] Term in original.
[2] A philosophical term coined by Gilbert Ryle and now used to refer to any inappropriate combination or confusion of categories, such as, "The number 7 is yellow."

of being full of the "intrusion of values," particularly those suggesting the ideological always involves a measure of falsehood and distortion, usually unknown to their proponents. What begins as a descriptive category can, thus, soon become polemical. The difficulties of untangling these issues become compounded when the subject matter for consideration is science and its interpretation. Eagleton points out the historical irony:

> Ideology in our own time has sometimes been sharply counterposed to science, so it is ironic to recall that ideology began life precisely as a science, as a rational inquiry into the laws governing the formation and development of ideas (1991: 64).

Making a contemporary case for or against the ideological nature of science quickly becomes bogged down in even deeper philosophical issues of whether our basic understanding of science and ideology require that they be conceptually separated (Althusser 1971) or understood to be deeply interpenetrated (Marcuse 1964). This dichotomy places this study on the horns of a dilemma. Adopting either option inevitably involves the kind of assumption this study seeks to avoid. The solution is to attempt a certain methodological agnosticism (see section 2.2.2, page 43) on the subject of the claims of science to objective truth and to adopt a more neutral way into the theoretical issue of interpreting science. The adoption of the concept of legitimation, for example, albeit one not often employed in discussions of museums,[3] helps circumvent some of these problems by placing attention on the actual social consequences of science in science centres rather than on the apriori meaning of the terms employed to describe it.

Legitimacy is a relatively neutral and useful term, which, as Ernest Gellner put it:

> ... conveys the fact that such and such a personage, institution or procedure is held to be authoritative, binding, or valid in a given society, without at the same time committing the speaker himself to any kind of endorsement of the values in question (1974: 24).

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[3] An important exception is Pierre Bourdieu and Alain Darbel's study of art museums (1991) discussed in section 7.2, page 187.

The term, thus, opens up the possibility of a relatively value-free exploration of the political power of ideas about science in contemporary society and of science centres as parties to this authority. In this study, the way science centres promote ideas of science and how their publics accept them (which, as mentioned above, they usually do) can be examined without approving or disapproving of any particular view of science or of science centres' role in this. Gellner suggests that the term legitimacy has other advantages:

> It applies not merely to the political sphere, but also to any other, for instance the realm of the cognitive. In our world, it is not merely rulers and regimes, but also types of ownership, production, education, association, expression, thought, art, and research which can have or fail to have, legitimacy in the eyes of beholders and practitioners. This wider range of applicability satisfies an age for which not merely the form of government.... but equally all other aspects of social life can be questioned, challenged, and placed *sub judice* (1974: 25).

The term legitimacy, therefore, has the advantage of providing a conceptual perspective within which we may not merely examine the fact that science centres are involved in the exercise of power and authority for themselves and the content they represent, but that they need to make a convincing case for it. In other words, in contemporary society the institutions through which the dialogue of power takes place must make and constantly remake their case to their "beholders and practitioners." For Gellner, this is a problem peculiar to modernity, but for others it is a characteristic of society as such.

Since Gellner wrote about these issues, broader notions of society have emphasized the dynamic and dialogic aspects of cultural formation. In this view, the legitimacy of the ideas and institutions that Gellner lists above are not merely challenged and revised as part of the process of modernity, but are always in the process of re-construction as part of having a society to begin with. Rather than society being a given and relatively static structure it can be thought of as constantly being "performed" (to use an ethnomethodological term) by its members:

> According to the performative view, society is constructed through the many efforts to define it; it is something achieved in practice by all actors, including scientists who themselves strive to define what society is (Strum and Latour 1999: 117).

In the Gellner-like formulation of society, science seeks legitimation because of the processes of social complexity and division in modern society (Gellner 1974; 1988; 1992), whereas in what may be called the performative formulation, science seeks legitimation as part of a basic process by which its members define for themselves what society and science mean (Strum and Latour 1999). For Gellner, legitimation could in theory be achieved once the *sub judice* issues of modern society are resolved, but this is not true for the performative formulation, for legitimacy must constantly re-establish its authority for each social actor. In this study, however, a choice between rival theories of social formation does not need to be made, as the term "legitimacy" is useful and functions similarly in both.

While for Shirley Strum and Bruno Latour, legitimation is not historically determined, for Gellner there are "characteristic periods," such as our own, in which legitimation issues are distributed throughout society. This view has a certain affinity to Foucault's notion of *epistemes* and the process of discursive formation that constructs them. Discursive formations are the various claims to legitimacy that are couched as statements of authority, knowledge, and power, which once circulating as authoritative speech acts are studied, repeated, and passed on as general understanding to others (such as visitors to museums). In a sense, these serious speech acts produce the objects about which they speak, for example, science in science centres. For Foucault, at least in his early writings, it was only speech acts he was interested in for he believed that, "... what gives speech acts seriousness ... is their place in the network of other serious speech acts and nothing more" (Dreyfus and Rabinow 1983: 58). While this formulation ultimately will not do – the non-discursive is also necessary – it certainly points to the necessary, if not sufficient, conditions that must be attended to in any understanding of the interpretation and production of science in science centres.

Serious speech acts are rather rare and elusive for they are things of great value (cherished because they are so important, but often operating unconsciously). They are not often written down or spoken directly, but must be constructed by archaeological or genealogical methods, to adopt Foucault's terms. In another sense, however, they are ubiquitous, forming the taken-for-granted, shared background of practice that is constantly in operation. Either way, the serious speech acts of science centres must be discovered or brought to mind, articulated, and interpreted – what in the work of Foucault is described as interpretative analytics (Dreyfus and Rabinow 1983: passim).

The final theoretical point, and one that again owes much to Foucault, is the role as authority in the legitimating process of knowledge and power claimed by science centres. The authority that science centres struggle to wield as they attempt to speak for science should not be conceptualised in any simple way as given to them or imposed on them "from above," such as from the scientific establishment, the interests of capital, or government. While one does not wish to abandon the useful and important concept of hegemony, any simply formulation of its meaning is unsatisfactory here. Through Foucault's notion of power we can gain a more subtle understanding in which hegemony operates "on the ground" through local legitimating struggles (Chen 1996: 313-314). Foucault argued that power was best understood as a set of social relationships that operate in multiple and multidirectional ways through discourse. Furthermore, inspired by Nietzsche, Foucault argued that power does not suppress knowledge, but is produced through it:

> We must cease once and for all to describe the effects of power in negative terms: it "excludes," it "represses," it "censors," it "abstracts," it "masks," it "conceals." In fact power produces reality; it produces domains of objects and rituals of truth. (1979a: 194).

This is particularly important to an understanding of science centres as institutions involved in the articulation of science, because:

> "Truth" is centred on the form of scientific discourse and the institutions which produce it; it is subject to constant economic and political incitement (the demand for truth, as much for economic production as for political power); it is the object, under diverse forms, of immense diffusion and consumption (circulating through apparatuses of education and information whose extent is relatively broad in the social body, not withstanding certain strict limitations); it is produced and transmitted under the control, dominant if not exclusive, of a few great political and economic apparatuses (university, army, writing, media); lastly, it is the issue of a whole political debate and social confrontation ("ideological" struggles) (Gordon 1980: 131-132).

Foucault's formulation enables us to see science centres as secondary institutions that are part of the apparatus of the "diffusion and consumption" of science. While not primary or dominant political and economic institutions, they are, nevertheless, part of a cultural "apparatus" that creates and disseminates science/truth. The discursive formation at the heart of this enterprise is one of constant struggle, the struggle among those in society who say what counts as true, and the struggles of its consumers to accept or reject such truth.

According to Sharon McDonald, science centres tend to promote an understanding of science that is abstract, law-like, and universal, rather than socially and historically rooted (Macdonald 1998a). It could be argued that such a position renders the science of science centres beyond normal social criticism, after all, how can you argue with the immutable laws of nature? However, criticisms are increasingly levelled against any "metanarrative" views of science. For Lyotard, and others influenced by him, the knowledge that science claims to have discovered or created cannot be divorced from the political and social power that allows it to be claimed as knowledge (Lyotard 1997a; Reid and Traweek 2000; Schiele 1994; Young 1992).

Despite these objections, what might be called the "modernist" model of science prevails in science centres. This model has both advantages and disadvantages. By divorcing its account of scientific knowledge from the historical, social, and economic realms, it avoids becoming embroiled in such issues. It also does not become associated, as some science museums have, with nationalistic or imperialist notions of scientific power and progress (Black 2000; Pridmore 1997). Conversely, it can have little to say on social issues, but rather simply promotes the findings of science and products of technology in a way many have difficulty relating to in a personal way. Instead, such an approach seeks to educate the public about the nature and aesthetics of abstract science (Hein 1990) and away from misunderstandings or naïve notions (Borun et al. 1993). What ultimately legitimates the science centre is the power of this model to satisfactorily embody a socially acceptable notion of science.

2.2 Issues of Method

The theoretical approaches and methodological techniques used in this thesis are all focused on the examination of the form and content of the notion of science embodied and promoted by the Arizona Science Center. This examination contends that a detailed case study examination reveals how science centres present and constructs notions of science and why the results are so popular with the public, even in an era when the authority of science is often called into question in other institutions.

The single case study, however, immediately raises the problem of whether its findings can reasonably apply more widely. The issue is the classic one of generalisation. In addition, I work at the institution I am studying (the use of the personal pronoun is deliberate, see below) and, therefore, my study's objectivity is an issue.

The arguments presented here are based on the findings of a variety of research methods, which taken together are best characterized as qualitative in the sense suggested by Jennifer Mason (1996), for they are grounded in an interpretative philosophy that uses flexible techniques that are sensitive to social circumstances to generate "rich, contextual, and detailed data." Importantly, Mason's definition of qualitative method does not stipulate which practical techniques are involved and does not rule out the use of quantitative data. Reference to statistical data produced by ASC and elsewhere, and the reworking of some of these data, are offered at several points in the pages to come, but they are marshalled at the service of an interpretative approach and are not meant to carry arguments alone. Instead, they take their place with semi-structured interviews with key informants: Sheila Grinell, the Center's Chief Executive Officer; Chevy Humphrey, the Vice-President for Marketing and Development; Laura Martin, the Vice-President for Education and Research; Grant Slinn, the Director of Exhibits (until 2000); and, BJ Freeman, an ASC Board member. In addition, findings are drawn from a content analysis of publicity and educational documents from ASC and other centres; a broadly sociological and philosophical analysis of the use and meaning of the building, murals, programmes, selected exhibits and exhibitions; and a content analysis of demonstration and planetarium show scripts. See appendix for details (page 227).

2.2.1 Generalisation

The problem of generalisation arises both at the inductive and deductive level. That is to say, findings made about this particular science centre are generalised to other science centres (the inductive level) and wider theoretical generalisations are drawn from this single instance (the deductive level). Both types of argument deal with the problem of extension, but with induction the movement is at the same levels of argument (the congruence of conclusions and premises), while with deduction the level of argument changes from that of empirical findings (facts, if you will) to theoretical conclusions and their implications.

At the inductive level, this study will argue that it is reasonable to think that other science centres are like ASC. Museums that choose to adopt the title of science centres belong to a characteristic museum type. Indeed, they belong to what is generally recognized as the science centre movement. It is a working assumption here that museums that do this have a "family resemblance" or recognizable ideal-typical characteristics even if there are variations among them. This is already accepted practice and there are a variety of technical and scholarly publications that treat science centres as a recognizable museum type: (Alvarez 1988; Anderson and Alexander 1991; Beetlestone et al. 1998; Bradburne 1998a; Caulton 1998; Csikszentmihalyi 1988; Danilov and Association of Science-Technology Centers. 1985; Grinell 1992; Hughes 2001; Koster 1999; Persson 2000; Phillips 1986; Simmons 1996; St. John and Grinell 1993; Wellcome Trust 2000). Nevertheless, there is some confusion over whether science museums and science centres can be clearly distinguished and this is discussed in detail below (section 4.1, page 86).

The characteristics this literature identifies are numerous. Science centres contain interactive exhibits rather than scientific apparatus or specimens. Exhibits are designed to exemplify general scientific principles. Science centres need not and often do not deal with their locality or the history of science. They characteristically feature exhibits on human perception and the principles of basic physics, built or inspired by the founding science centre institutions of the Exploratorium and Ontario Science Centre (Butler 1992). They are designed to provide a variety of direct hands on science experiences. This last point has produced the criticism that all science centres are the same or at least contain many of the same exhibits (Bradburne 1998a; but see Persson's reply, 2000). As far as this is true, findings from any particular science centre at the inductive level can be more generalized than for many other museum types.

Science centres, particularly in the United States, also share organizational and operational characteristics: they are found in (most) major metropolitan areas; are often built in inner city and/or redevelopment "downtown" areas; are financed by a mixture of federal, state, and philanthropic interests (particularly individual and corporate donors); and are administered by generalist museum professionals (rather than subject specialist curators).

The specific case for ASC's generalisability is based on its typicality. As will be shown below, based on ASTC figures (Association of Science-Technology Centers 1998, 2001) it is a medium size centre, has an average size budget, an average size building, and exhibit topics found in many other centres, displayed in average size gallery space. The generalisations made here, however, cannot be extended beyond the United States. As we will see in the chapters to come, the social, cultural, and economic circumstances of the U.S. have created a particular understanding and regard for science among the public, a particular understanding of what science centres offer, and a particular form of science centre management and funding.

A number of general deductions may be made about science centres based on findings from ASC at the interpretative level (and, therefore, theoretically). For example, science centres play a legitimating role for science and thus help keep science positively valued; and that science is not merely represented in science centres it is also constructed. The question becomes, what are the standards for deciding that the move made from finding to theory is at least plausible and at best true? Gellner, in describing his approach to philosophical history, provides an account that amounts to a model:

> Conclusions are extracted from clearly stated assumptions; various possible conclusions are then checked against available facts. Assumptions are revised if the implications fail to tally with the available facts (Gellner 1988:13).

The point is that much work at the theoretical level derives not from facts directly but from working assumptions like those outlined above. The facts of the case study are then brought in to affirm, disprove, or revise these assumptions. This is no more than to say the assumptions that inform research questions are logically and temporally before data collection, but the whole process is iterative and reflexive (the issue of reflexivity is discussed below, section 2.3, page 49). The working assumption adopted here is that a number of theoretical questions can be answered by a detailed examination of a typical contemporary science centre. They are:

- How should the popularisation of science in science centres best be characterized? It will be argued that what may be called the "abstract principles model" will need to be expanded.
- In what way is the representation of science in a science centre also the production of science? This is particularly significant when the nature of embodied activity and the witnessing of science by visitors as forms of science activity are examined.
- What theory of knowledge best characterizes how popularisation, representation, and production of science in science centres are formed? It will be argued that two models predominate.

The ultimate test of both the inductive and deductive generalisations argued for below is reasonableness based on the explication of an iterative and reflexive process, bolstered by statistical generalisations from other science centres with similar visitor demographics.

The problem of generalisation is also linked to the problem of objectivity discussed below (section 2.2.2, page 43). Michel de Certeau associates the two ideas in his examination of the theoretical and methodological approaches of Pierre Bourdieu and Michel Foucault. He describes the two thinkers as adopting a two-fold "recipe" of "cutting out" and "turning over:"

> The first move *cuts out* certain practices from an undefined fabric, in such a way as to treat them as *a separate population*, forming *a coherent whole* but *foreign* to the place in which the theory is produced.
>
> The second move *turns over* the unit thus cut out. At first obscure, silent, and remote, the unit is inverted to become the element that illuminates theory and sustains discourse (Italics in original, de Certeau 1984: 62-63).

De Certeau explains that this model of theoretical generalisation is by no means unique (see Gellner's model above, for instance) and, indeed, it is "an old recipe, frequently used." He cites the ethnographic work of Sigmund Freud and Emile Durkheim as examples, remarking that, "Neither of these authors has observed the practices he is dealing with" (1984: 64). The problem is characterised as endemic to the approach, "... located far away from knowledge and yet possessing its secrets" (1984: 64). These two realms (the place where the empirical "cut" is made and the place – the academy – where the "turn over" takes place) are apparent even when the study is of contemporary culture and the author has a close relationship to the data source.

2.2.2 Objectivity

The question of the reliability and validity of findings based on a single case study are compounded when the author is an employee of the organization he is studying. The implication is that such a role is inherently biased. The defensive argument that a place in the academy offers little extra protection (for it does not guarantee objectivity either) may be true, but still does not answer the original charge. The issue can be considered at three levels: the personal and practical constraints of employment, the methodological problems of participant-observation, and the more general question of whether objectivity is obtainable in theory.

At the practical/personal level, it is necessary to use the first person pronoun. Thus, dropping briefly what Donna Haraway called the standard voice of "modest witness." For Haraway the very nature of third-person voice, that of supposed scientific/academic neutrality, is implicated in power/knowledge/authority problems of "speaking" in science:

> The modest witness is one of the founding virtues of what we call modernity ... he is endowed with the remarkable power to establish facts. He bears witness: he is objective; he guarantees the clarity and purity of objects. His subjectivity is his objectivity (Haraway 1997:24).

Avoiding only temporarily the inherent problems Haraway goes on to chronicle, I am employed by the Arizona Science Center and have worked their since 1997, first as a research consultant and then, from 1999, as an employee in the Department of Education and Research. My title is Research Scientist and my job is to evaluate the Center's educational programs, exhibits, and visitor experiences. I also write proposals for funding to federal agencies and foundations for educational programming. During the study period for this thesis, the Center's staff was aware that I was conducting research both for the Center and for my thesis. The research presented here was not conducted as part of my employment, although unpublished reports I created as an employee are cited and referred to as secondary material and, in several cases, reanalysed and reinterpreted.

The issue of confidentiality is important to address. No internal or confidential documents were used in the creation of this thesis, although much of my understanding necessarily derives from unpublished and confidential sources – memos, email, informal conversations, etc. An attempt is made, however, to base as much as possible of what is presented here on publicly available sources: from observations made of the museum experience at exhibits and presentations, to analyses of brochures, flyers, catalogues, publicity, and other publicly distributed documents. The ASC research reports cited here were produced as part of my routine duties and while they are not normally circulated to the public, they are available from ASC with the permission of executive staff members. Many have been distributed and some previously cited in publications and conference papers. In most cases, data included here from ASC reports have been reanalysed and presented for the first time. In addition, when remarks made by informants are cited they come from tape-recorded, "on the record," interviews.

My role as staff researcher means that I did not develop the exhibits, programs, and publicity I present and interpret below. I had no direct responsibility for the delivery or management of the programs reported in the chapters to come. Furthermore, even though I was employed to undertake empirical studies of the impact of programs and exhibits on audiences, these studies did not include any of the deeper analysis, interpretation, and deconstruction offered here. They were relatively simple reports of the results of various data collection exercises. As their author, I certainly had a privileged access to their findings, but conclusions about their significance are only offered here.

Methodologically, a serious attempt is made to avoid judgments as to the truth, value, and moral worth of the subject presented. The approach is more broadly phenomenological in a way that has roots in the thought of Husserl and Weber. The theoretical implication is that understanding is the goal rather than explanation. Arriving at a satisfactory understanding requires that several "self-understandings" be listened to and critically examined: museum professionals who develop the exhibits and programs, the publics that experience them, and students of museums who present these understandings to an academic audience.

The meeting or "fusion" of horizons, to use a term from Hans-Georg Gadamer, is essentially dialogic and part of a "hermeneutic circle" (Bauman 1978; Palmer 1969). My role as a staff researcher has placed me partly in each camp and partly outside, even within ASC. I work closely with museum educators, exhibit designers, and administrators, but do not produce the content examined here. I work closely with the visiting public on a daily basis, but I am not a member of that public. I offer this academic thesis, but am not situated in an academic department (indeed, the department I am affiliated with is some 8,000 miles from where I work). The hermeneutic act requires moving among these horizons or, to use the language of de Certeau, linking the place of cutting to the place of turning over. The dialog that is created is the embodiment of an examined subjectivity, which may be the closest to objectivity we can obtain in cultural studies. One might say that while there may be no final escape from the biases we bring to bear, there is a great deal of difference between being conscious of them or not, and between trying and not trying to understand and engage them.

Despite the careful drawing of boundaries around the use of materials and the efforts to balance empathy with objectivity, the question of personal bias remains. After all, the understanding and interpretations offered are of some particular phenomena, selected by some particular person with his (my) own historicity. Without trying to settle the debate between Gadamer and Habermas as to whether there are biasing processes outside of the hermeneutic process or whether "systematically distorted communication" occurs within it (see Wolff 1992), some writers attempt to deal with the issue by stating where they stand politically and personally (for example, Haraway 1997; Weinstein 1998). However, given that I wish neither to champion nor change the institution I examine, but understand it, of greater relevance is the intellectual training that I believe resulted in the inevitable inclusions and omissions of my study.

My approach and the methods adopted are eclectic, partly because of my biography and partly because of the current state of museum studies. Biographically, I was trained in the methods of philosophy, religious studies, and sociology during my years as an undergraduate, postgraduate, and finally Research Fellow at Leeds University from 1973-1984. More specifically, my training included ordinary language philosophy, the phenomenological study of religion, and the empirical and statistical study of social beliefs. I have since applied these varied methods and approaches to the study of American criminal justice, education, health care, and now museum studies as both a research consultant and employed researcher.

Museum Studies is a new academic subject area, arguably less than twenty years in the making (Hooper-Greenhill 2000). This means there is still plenty of experimentation and innovation in methodology as the subject develops in a variety of university departments around the world. It is clear, however, that since 1989, when Susan Pearce was appointed director of the Department of Museum Studies of Leicester University, the "Leicester group," if one can use such a term, is associated with structuralism, post-structuralism and post-modernist thinking. I place the work presented here in that tradition, which is multi-methodic and reflexive, adopting and examining the limitations of sociological, philosophical, and historical methods. Much in what follows, for example, is inspired by Barthes' careful analysis of cultural products (Barthes 1972, 1974, 1982), Foucault's insights about the relationship of knowledge and power (Dreyfus and Rabinow 1983; Foucault 1970; Gordon 1980), de Certeau's exploration of strategies and tactics (de Certeau 1984, 1997; de Certeau et al. 1998), and Bourdieu's notion of cultural capital (Bourdieu and Darbel 1991; Jenkins 1992).

Such an intellectual heritage, however, suggests that it may have difficulties bracketing values, which is central to the phenomenological approach subscribed to above. After all, post-structuralist thinking is fundamentally at odds with the science centre model of how scientific knowledge comes about. Bias at the theoretical level may thus be seen as a form of unavoidable apriorism. The answer to this apparent problem is to distinguish issues of epistemology from those of ideology and then to re-examine the question. Ian Hacking provides a useful assessment of the issues in his account of the supposed social construction of natural science (1999: 63-92). He points out that, indeed, there are genuine disagreements (what he calls the "sticking points" of contingency, nominalism, and external explanation) over how scientific knowledge comes about. Fundamentally, this comes down to whether scientific knowledge includes social factors or whether knowledge is internal to science itself, the former position being associated with social constructionists and the latter position with scientific realists. The important thing to note is that both sides agree on the truth of what is found by science, it is the only the degree to which extra-scientific factors play a role that is at issue (see also, Pickering 1994).

This thesis suggests that science centres express a view of science in which there are, "... eternal, objective, ahistorical, socially neutral, external and universal truths, and that the assemblage of these truths is what we call physical science" (Hacking 1999: 78, quoting Sheldon Glashow). At the same time science centres offer a hands-on, interactive entry to this "assemblage of truths," suggesting that they exemplify both constructionist and scientific realist leanings (see above, section 1.2.2, page 14). They do this because they are not fundamentally in the business of creating scientific knowledge, but of representing it to various publics.

To follow Hacking's argument, it is not the *formation* of scientific knowledge that is at stake here, but rather its *treatment* in each side's "un-masking." The social constructionists un-mask the ideology of the authority and power of realist science and (often) its suppression of other forms of knowing. The scientific realists un-mask the leftist political agendas and lack of "real" scientific knowledge by constructionists. The result is the "science wars." But as Hacking points out, almost all those who actually work in the field of modern science studies appear to have the highest regard for science. By in large, they do not deal with the un-masking issues of scientific ideology, but concentrate instead on issues of scientific epistemology (Biagioli 1999; Fuller 1993, 1997; Giere 1999; Newton 1997; Pickering 1994; Reid and Traweek 2000; Schiele 1994; Ziman 1984, 2000).

This thesis, then, is concerned with the way the "ideology of science" in its representation in a science centre comes about and is maintained, but it is not directly concerned with whether scientific knowledge as such is socially constructed or not, nor whether the science is "true" by either side's criteria. Viewed in this way, and adopting phenomenological bracketing, the issue can be examined while remaining epistemologically agnostic.

In another sense, however, this thesis is inevitably concerned with the nature of science, because Steve Fuller was surely right when he wrote that:

> Generally speaking, practicing scientists are only a small fraction of those who contribute to any socially acceptable definition of science. Among the other contributors are practitioners in other disciplines (especially the social sciences), who model their own fields on the scientific exemplars of the day; science policy makers; and *especially science popularizers* ... [italics added] (Fuller 1997: 33).

Science centres are, clearly, one of those popularisers. To speak of science centres as part of the social construction of science is to speak elliptically, for they are more properly involved in the definition of the concept of science rather than the production of science (knowledge). The very act of selection, the forms of display, and the interpretations provided place museums in a definitional role. This thesis seeks to examine this definitional role of science centres.

2.3 The Multi-methods Approach and the Issue of Reflexivity

The approach argued for here suggests that to gain a broad understanding of science centres entails adopting a variety of methodologies and theoretical perspectives. Such a study must also reflect back on its approach in order to be aware of the strengths and limitations of the methods and theories adopted.

On the strengths side, Douglas Kellner argues for a multi-approach (what he calls "a pragmatic contextualist approach to theory"):

> A multiperspectival approach holds that the more theories one has at one's disposal, the more tasks one can perform and the more specific objects and themes one can address. Further, the more perspectives that one brings to bear on a phenomenon, the better one's potential grasp or understanding of it could be (Kellner 1995: 25).

The argument Kellner uses for such an approach to media studies is adopted here for museum studies, with the caveat that there may be hidden dangers if theories turn out to be mutually exclusive. Carefully applied, however, the adoption of a multi-methods and multi-theory approach provides a comparatively rich way to understand how science centres operate and the social significance of their activities.

On the limitations side, it was argued above (section 1.2, page 4) that any interpretation is just that – an interpretation. It is worth briefly re-examining the implications of this because this interpretation claims at some level that its findings are true. Steven Woolgar pointed to the reflexive issue at stake here when he commented, "Scholars are asking what significance should be granted to the fact that production of scientific knowledge about the world is itself a social act" (Woolgar 1988: 1). This observation suggests there may be a problem if the claims made here amount to scientific truth claims. However, if they do not, what then is their status? Indeed, what is the status of any account? These are philosophical issues much broader than the particular concerns examined in this study. They question the entire interpretive enterprise of modern museum studies, of which this is a part. The issue inevitably arises because much of this tradition, including this study, is a debate with the ghost of Foucault and the status of his "interpretive analytics" is still an issue (Hooper-Greenhill 1992; Lidchi 1997;

O'Brien 1989). Among Foucault's commentators, perhaps Hubert Dreyfus and Paul Rabinow provide one of the most succinct ways of stating the, arguably, un-resolvable reflexive problem:

> A doctor can stand outside a patient and treat him objectively, but a practitioner of interpretative analytics has no such external position. The disease he seeks to cure is part of an epidemic which has also affected him (1983: 202).

The circularity can soon approach the vicious, as it does when Katherine Hales suggests:

> It is only a slight exaggeration to say that contemporary critical theory is produced by the reflexivity that it also produces (an observation that is, of course, also reflexive) (Hayles 1999: 9).

Ultimately, there is no getting outside the systems we seek to understand and interpret. Opting for one side or other of the truth claim argument does not, however, solve the problem. Instead, we can take Foucault's own defence and say, "I am fully aware that I have never written anything other than fictions. For all that, I would not want to say that they were outside the truth" (Quoted in Dreyfus and Rabinow (1983), Foucault 1979b).

3. A Place for Science

This chapter examines the science of science centres and the historical influences that contributed to its modern institutional form. The status of science centres as museums is considered, their divergence from artefact-centred science museums, and the non-museum factors that influence their development. The creation of ASC is discussed as part of the continuing growth of the science centre movement. The political, economic, social, and symbolic significance of ASC's new building is examined and an interpretation offered of the building's message about science. As a special place set aside, it is also seen as part of a typical pattern of inner city redevelopment in the U.S. Located in central Phoenix, it is an institution in a destination area filled with a variety of other attractions. A model of its distinctive and multi-faceted experience is provided. Finally, an examination is made of the various legitimating practices that were under taken in the process of creating a place for science in Arizona.

3. 1 Science Centres, Museums, and Science Centres as Museums

The very concept of science centres is "fuzzy" (see below, page 89). On the one hand, many visitors to the Arizona Science Center spontaneously used the term "museum" in survey comments about the Center.[1] When asked to name other science centres they had visited, among them were the Chicago Museum of Science and Industry and the Franklin Institute in Philadelphia (Arizona Science Center 1998i). On the other hand, the scholarly literature, particularly in the United Kingdom, still makes a distinction between science centres and science museums, even though such distinctions were never that precise in practice. This is partly a function of what has become the standard history of the movement: in the late-nineteenth and early twentieth centuries important science museums were created, mainly in major European cities, followed in the late 1960s by a new type of interactive-based institution created in North America (Butler 1992: 77-107). Since then, the two types of institution have influenced each other, such that science centres are now introducing artifacts and science museums (and children's museums) are replete with interactives (Beetlestone et al. 1998: 7).

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[1] References are made throughout to unpublished studies, mainly the results of surveys, performed by the author as part of his work at ASC. ASC studies written by others or written by the author and reanalysed for this thesis are noted when appropriate.

This standard account is unsatisfactory in a number of ways. Many major science museums developed a certain level of interactivity and visitor participation before science centres existed. Many science centres, particularly those influenced by the Ontario Science Centre, included artifacts from their inception.[2] In addition, it is far too limiting to include only museum-based influences on the historical development of science centres. The reality is more complex. While science centres were in a number of ways a radical break from science museums, at the same time they were deeply influenced by them (and by elements outside the museum tradition altogether, see below, section 3.1.3, page 57). For example, Oppenheimer wrote about his personal experience of art and science museums and the significant influence of visits he made when on a Guggenheim Fellowship in 1965 to the science museums of Europe (Starr and Oppenheimer 1982). William O'Dea, the first Director General of the Ontario Science Centre, was previously the Senior Keeper of Aeronautics at the Science Museum, London and as Stella Butler put it, "His guidance provided a link between the traditional museum approach of artefact-based displays with the new idea of hands-on exhibits"(1992: 85). Therefore, while the new institutions were strongly influenced by the old institutions, the question remains of how radical a departure the science centre movement really was.

3.1.1 Science Centres vs. Museums

The departure from a collections-dominated approach raises the legitimate question of whether science centres thereby evolved into some other kind of institution. Kevin Moore defined museums as institutions where <u>material culture</u> is interpreted for public benefit (Moore 1997: 23-28). For Moore, several institutions have developed in and from museums proper that may look superficially like museums, but are really in some other type of business. Quoting the concerns of C. Watkins, Moore picks out science centres in particular for criticism:

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[2] So did the Exploratorium before its official opening (Hein 1990: 32).

> If such centres are allowed to become museums what does it any longer mean to be a museum, in the eyes of the public? 'By blurring our understanding of what museums really are, we open the field up to the assaults of the business world'(Watkins 1994: 28-29) (Moore 1997: 25).

In the case of science centres (and children's museums), Moore concludes they are in the education business. While one can concede that, indeed, science centres are in the education business that does not automatically preclude them from the museum business. Education is now an accepted defining characteristic of all museums. One solution is to adopt whichever organisational definition suits. For example, according to definitions adopted by the American Association of Museums (AAM), science centres are museums, but not according to the United Kingdom's Museums Association (MA) and the International Council of Museums (ICOM). The choice of museum definition it not purely academic for it has important economic implications. In the United States, recognition by the AAM in the 1970s meant that science centres were eligible for Government funding through the Institute for Museum and Library Services (IMLS). Something similar may happen in the United Kingdom. With the influx of new money for capital expenditure provided by national lottery grants approved by the Millennium Commission, the new science centres are now considering ways to tap into museum funding streams for their future programmes (Wellcome Trust 2000).

Stella Butler tried to explain the distinctive approach of science centres as a development where, " ... emphasis would not be on collecting objects, but on communicating ideas" (1992: 77). This explanation is simply too vague, for while it would be true to say that general scientific principles are important in science centres, it would be untrue to say that earlier museums were unconcerned with ideas or that science centres are without artifacts. Rather, science centres have reversed the priority given to ideas and objects. This is also true for a number of other modern museums, which, for the want of a better term may be called conceptual museums. These non-collections conceptual museums include children's museums, planetaria, science centres, and a number of museums dedicated to social issues, for example, the Museum of Tolerance, Los Angeles; the Holocaust Museum, Washington D.C.; and the Newseum, Washington, D.C.

The approach taken here is to adopt a broad understanding of museums that makes no assumption based on material culture and that sees science centres as part of more general changes in the nature of museums. Where Moore's nominal definition draws a line beyond which a museum cannot go and should not go, the notion adopted here is to think of science centres as a relatively new development within the museum field.

3.1.2 Antecedents to Science Centres

Eileen Hooper-Greenhill provides a useful comment on the nature of museums, which helps frame a broader perspective:

> There is no essential museum. The museum is not a pre-constituted entity that is produced in the same way at all times. No "direct-ancestors" can be identified. Identities, targets, functions, and subject positions are variable and discontinuous. Not only is there no essential identity for museums ... but such identities as are constituted are subject to constant change as the play of dominations shifts and new relations of advantage and disadvantage emerge (1992: 191).

An important shift the science centre introduced was the de-centring of the object from the heart of the museum (Gurian 1999). The object still had an important place when the Exploratorium and the Ontario Science Centre opened in 1969,[3] albeit a different role in each institution.

For the Exploratorium, the role of the art object and the science exhibit was combined. Oppenheimer defined the institution as a museum of "science, art, and human perception." Many of the exhibits began as art objects, including those from the travelling exhibition Cybernetic Serendipity, which later formed the basis of its "collection" (see below, page 63). Other exhibits were created by commissioned artists and artists-in-residence; for example, the Sun Painting by Robert Miller, the Tactile Dome by August Coppola, the Aeolian Harp by Douglas Hollis, etc. (Hein 1990: 147-170).

[3] They are recognised as the most influential, but according to Ibramsha Yahya others had opened earlier: The Science Center of Pinellas County (1960), The Pacific Science Center (1962), The Center for Science and Industry (1964), The New York Hall of Science (1966), The Fernback Center (1967), and The Lawrence Hall of Science (1968) (Yahya 1996).

The Ontario Science Centre had an eclectic approach, creating exhibits on general themes (such as transportation and costume), which included historical artifacts and even full installations, as described, for example, by Grant Slinn who was an early staff member at the Ontario Science Centre (and later Director of Exhibits at ASC):

> The biggest Canadian scientific achievement that we consciously celebrated was insulin. With Banting and Bess we literally harvested the lab and the thing I remember was being involved with getting the original stairs that went from College Street up to the second floor where his lab was located. And they were actually in the exhibit for a very long time until they got increasingly worn and people said they weren't safe any more.

While science centres did not abandon artifacts completely, it is true to say that their importance over time diminished. Where exhibits could be related to place, person, or time – say, the reconstruction of Galileo's experiments with simple machines or the reconstruction of nineteenth century devices that explored visual perception – new science centres were likely to present them as general, abstract science concepts. This was reinforced by the approach of science centres to label text, which was characteristically framed in the form of "to do and to notice," rather than "who, when, and where."

Despite overlaps, the traditional museums' and the new science centres' approach to the object can be contrasted to bring out the change in emphasis the science centre represents. The traditional museum object is essentially complete in itself – a prized art piece or an artefact of social or historical significance – displayed for gaze and contemplation. Accompanying text usually provides the provenance of the unique artefact or explains it as a real example from a set of other real objects. Objects are interpreted in terms of their inherent qualities (beauty, social or historic value, and rarity) and metonymically linked with the social milieu they come from and/or to their creator or discoverer. Their *raison-d'etre* is authenticity, to be selected and displayed to view.

The interactive exhibit is incomplete until a person acts; it requires human choice and initiative. It is not for looking at, so much as kinaesthetic encounter with.

Accompanying text usually provides instructions for operation and explanation of a principle or phenomenon. It only becomes an object if it is also a work of art. It only has a provenance if it is also a work of art. The usual encounter is, thus, not with an artefact, but an illustrative device. Devices provide a direct manifestation of an abstract principle, such as angular momentum, or a natural phenomenon, such as gravity. Their *raison-d'etre* is to have isolated the principle or phenomenon for experience.

A corollary of the de-emphasis of the object (and the presence of the device) is the de-emphasis of history. This is in stark contrast to other types of museum – including science, history, art, and natural history museums – in which time still plays a central role. By contrast, the interactive science centre plays out its drama on a stage of universal truths where contingent social and human history appear not merely unwanted, but irrelevant.

3.1.3 Science Centre History Beyond the Museum

Hopper-Greenhill's account of museum development allows us to widen the discussion beyond the scope of normal museological history to include various non-museum influences. Viewed from this broader perspective, the roots of these relatively new museums go back some 300 years. For example, the use of science devices for public teaching purposes began in the mid-seventeenth century when the subject of experimental philosophy was first taught at Oxford University in England and the University of Leiden in Holland (L'E Turner 1998: 103). The pedagogical science device, therefore, has some roots in formal science education, but according to Barbara Stafford, there was also an informal educational corollary (Stafford and Terpak 2001; Stafford 1994).

Stafford argues that an important historical change took place as the "witty and hermetic conceits" of the Jesuits of the high baroque period were transformed in the eighteenth century from devices that "decorated the surface of privileged leisure" into machines for "rational recreation" (Stafford 1994: 47-58). Using language that could equally apply to contemporary educational theory in science centres, she describes the intent of those who promoted the study of emerging disciplines of optics, mechanics, astronomy, geometry, and physics through "mechanical amusements:"

> Participatory enactment, I suggest, was central to the aim of rational recreation. It made abstraction concrete by picturing the practices of science. Material was internalized interactively (1994: 47).
>
> ... rational recreations were a sort of joyful diligence. Instructive scientific games were existential rehearsals. They incarnated the unselfconscious art of experimentation fundamental to the laboratory and in ordinary life. Both as instrumentalized performance and as illustrated guide to serious amusements, the genre phenomenologized instruction (1994: 51).

Other strands of this history include public scientific demonstrations, as described by Steven Shapin, where, "[Robert] Boyle and his associates developed a variety of relatively novel techniques to assist the transition of experimental and observational experience from the individual to the public domain" (Shapin 1996: 107; see also, Shapin and Schaffer 1985). This began with relatively small and closed groups for "witnessing" scientific experiments in seventeenth century England and developed into the audiences for the highly popular public science lectures associated with Sir Humphrey Davy and continued by Michael Faraday in the nineteenth century.

By the end of the nineteenth century there had developed in Europe and the United States communities of increasingly professional scientists (who through scientific publications performed "remote witnessing" for each other) and an interested lay public for them to inform. There were several means by which science went public, including demonstrations and lectures in museums – both "respectable" museums and the P. T. Barnum-style exhibition (Alexander 1998; Harris 1973) – learned societies, mechanics institutes, as well as popular books and magazines (for a summary, see Gregory and Miller 1998: 19-51).

During this period, new strands of public education and private amusement were added: scientific devices employed in school science experimental demonstrations, the manufacture of scientific toys, particularly those that illustrated the new science of human visual perception (Crary 1990; L'E Turner 1998), and the popularity of World Expositions and World's Fairs (Conn 1998; Rydell 1984; The Queens Museum 1989).

Despite these growing opportunities for public and private science literacy, museums were generally not places for people to interact directly with the devices of science until the science centres recently organized these various strands. There were examples from the major science museums of science models, dioramas, and simple interactives from the about the early 1930s. The Deutsches Museum demonstrated industrial engines from 1925 (Mayr 1990). The London Science Museum opened the Children's Gallery, which included dioramas and hands-on exhibits, in 1931 (Science Museum London 1957). The Chicago Museum of Science and Industry featured push-button devices and live demonstrations in the 1940s (Butler 1992; Caulton 1998).

To summarize the complex literature of popular science display, public science was directed at the appreciation of scientific and industrial progress rather than as an arena for self-discovery through hands-on exploration or demonstration, even in the case where elements of direct involvement were introduced. The example of the Science Museum Children's Gallery in London, which so impressed Oppenheimer in the 1960s, is instructive. Its original guide, written in 1935, described the goals of social progress the models and dioramas were meant to illustrate:

> The Children's Gallery serves as a general introduction to the main collections, but it is concerned more with what things *mean* in early life than with how they *work.*
>
> ... you see also in the eleven scenes of this [transportation] series how all the means of travel and of carrying goods have gradually developed from the beginning of human history to the present time, and it will be evident to you how important this development must have been in the spreading of knowledge and trade, the building of empires and the prosecution of wars, and how it must have been one of the fundamental things in fashioning the world we know [emphasis in original] (quoted in, Follett 1978: 115).

Similarly, the industrialist Julius Rosenwald spoke in an interview in the late 1920s of his hopes for the new Museum of Science and Industry in Chicago:

> American inventive genius needs greater stimulation and room for development. I would like to have every young growing mind in Chicago to be able to see working models, visualizing developments in machines and processes which

> have been built by the greatest industrial nation in the world (quoted in, Pridmore 1997: 21).

Ironically, it was not until the 1960s that a different approach was taken, fuelled by a sense that the progress science museums promised and celebrated could no longer be assumed.

3.2. The Modern Science Centre Emerges

Sheila Grinell[4] in an often-quoted account of the period wrote:

> In the late 1960s, after the decade of reform in science education that followed Sputnik's launch in 1957, several institutions opened that elaborated on the concept of interactivity. The Exploratorium in San Francisco, and the Ontario Science Centre near Toronto eschewed historical and industrial collections in favor of apparatus and programs designed to communicate basic science in terms readily accessible to visitors. These institutions postulated that displays and programs carefully designed to provide first-hand experience with phenomena could captivate ordinary people and, in the best of circumstances, stimulate original thinking about science (1992: 6-7).

A number of elements of this account are worth considering. First, the movement began as a product of events concerned with Cold War issues. Second, the science centre movement followed science educational reform, rather than initiating or being a part of it (see below, page 64). Third, the concept of interactivity is "elaborated," not created. Fourth, Grinell suggests that historical and industrial collections were avoided, whereas, here it is suggested it was more a change in emphasis and interpretation. Fifth, the term "first-hand experience" is used rather than "hands on." Sixth, the goal is to captivate and perhaps produce "original thinking," not necessarily knowledge or appreciation of scientific progress.

3.2.1 Cold War Connections

The science centre movement's connection to the Cold War era is significant even though it was initiated over a decade after the launch of Sputnik. Frank Oppenheimer,

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[4] Grinell became Executive Director of ASC in 1993; she was previously the co-director of the Exploratorium with Frank Oppenheimer, a consultant to science centres across the U.S., director of ASTC, and Associate Director for the New York Hall of Science.

the brother of Robert Oppenheimer, also worked on the Manhattan Project and in the 1950s was a victim of McCarthyism, loosing his teaching position at the University of Colorado and moving for a while out of professional science. It is no surprise, perhaps, that he would eschew the political, historical, and social dimensions of science and concentrate on an abstract mixture of science, aesthetics, and experimentation in the development of his new museum (see Macdonald 1998b: 16-17). In the place of the social and historical, he stressed the individual and creative elements of scientific discovery. While Oppenheimer's biography is of some relevance, due to the lasting influence of the Exploratorium, of greater significance were issues affecting the whole of society at the time, notably the Cold War perception that there was a crisis in science and technological education, part of the general panic about Western society falling behind Eastern Block achievements.

The creation of the Ontario Science Centre was in part a manifestation of these Cold War fears. The government of Ontario originally commissioned the Centre as part of Canada's official centennial celebrations (although it did not open in time). Thinking for the project began many years earlier at the height of the Cold War, with the intention to highlight and inspire children and their families to connect to a science and technology that was useful for society. Where the Exploratorium emphasized principles and aesthetic abstractions, the Ontario Science Centre featured applications of science in everyday life. Its designers included historical and contemporary real-live artifacts, but they too believed in the superiority of direct experience over static display. As Grant Slinn described the Ontario Science Centre's first interactives:

> We basically automated an awful lot of classic physic experiments. A little bit of influence from Charles and Marie Eames and Mathematica and certainly there was the classic Pythagorean triangle that rotated and water inside went from one side to the other, and the comb that appeared to roll up hill when viewed from the side, and so on and so forth. ... They had optical illusions, music, see your voice, see sounds, a collection of Hammond organs, when they still had motor driven tone generators in them. ... A lot of stuff on magnetism, the traditional pulley puzzle, you pull the rope and lift the weight, mechanical advantage situations, things like that.

The new science centre approach was meant to intrigue the public and interest them in science activities. Government was also interested because they provided a new means to inform the public about science and perhaps encourage children to develop scientific careers. By the time the new institutions came along the panic had somewhat subsided, but the concern to keep up with the Russians in science and technology was widespread and long lasting and affected both informal and formal science education for almost 20 years. As Holdzkom and Lutz described the situation for formal education in the United States:

> The launching of Sputnik aroused public interest, awakened a "sleeping giant," and ignited a crash program for curriculum reform in science education. This burst of activity resulted in some of the most current, innovative, and spectacular changes in the history of American public school education. The period that followed has come to be known as the Golden Age of Science Education (1955-1974) (Holdzkom and Lutz 1984: 16).

Many new science curricula were introduced during this period, including a number that Frank Oppenheimer helped develop before he created the Exploratorium: The Physical Science Study Committee (PSSC) curriculum and the Elementary Science Study (ESS) curriculum (Hein 1990: 13). The affinity between the science curricula movement and what was happening in the new museums is clear:

> These new science programs emphasized learning by doing while focusing on current concepts in science. Laboratory activities were an integral part of the class routine. Thus, higher cognitive skills and an appreciation of science were emphasized ... The emphasis was on pure science, doing what scientists do – not on applications of such knowledge (Holdzkom and Lutz 1984: 5).

A study of the reform period by John Rudolph suggests the era was perhaps less "golden" than the remarks above suggest, at least socially and politically. Rudolph characterises it as a period in which elite scientists of the day, particularly those who had worked closely with government on defence work during the Second World War, now worked to build trust, faith, and deference to professional scientists during this perceived new crisis. New school curriculum laboratory activities were designed for a minority of high school seniors – "science for the few in the best interests of the many" (Rudolph 2002: 197). The resulting model of the laboratory shown in texts books, films, and lab experiments, was designed as much to control information as to provide it:

> For what the public really saw was not the messy, conflicted workplace populated by researchers, administrators, and military contractors, but rather a tidy little anteroom arranged to look like a laboratory housing scientific work as the scientists imagined it could be, or should be. The point was to make sure that visitors would not be inclined to wonder what lay behind the far door (Rudolph 2002: 196).

By the late 1960s, things changed rapidly. The rhetoric of science education as laboratory activity was still around, but in San Francisco in particular "alternative" values were also having an effect on all aspects of cultural life. John Beetlestone et al, remarked that, "Late 1960s San Francisco was not a normal environment, but one where a new, open, evangelical movement could take root" (1998: 17). In addition, the first Americans had stood on the Moon, beating the Russians, and demonstrating U.S. scientific and technological superiority, just as the new science centre movement got underway. The need to show national scientific progress diminished and a new ethos developed in which science could be an avenue of self-discovery for everyone, not just the scientifically educated elite destined to take their place in the university-industrial-military complex.

Heilde Hein's account of Oppenheimer's new institution reports that the very first exhibits were not the type we would now associate with the Exploratorium. Surprisingly perhaps, given the approach the institution is credited with creating, they included a part of the Stamford linear accelerator and "... a collection of materials assembled and contributed by NASA, commemorating the August 1969 lunar landing of the Apollo 11 mission, which coincided with the museum's opening" (1990: 32). These exhibits looked back to an earlier era of science display. It was only when the Cybernetic Serendipity exhibition became available a few months later that Oppenheimer felt there was content, "... which seemed to embody and harmonize everything the Exploratorium was trying to express" (Hein 1990: 33).

The cybernetics exhibition, which was first developed by the ICA (Institute of Contemporary Art) in London, was considered noteworthy enough for the Exploratorium to use it for its official opening in October 1969, keep it running for several years, and to incorporate many of its exhibits into its permanent collection. What is more significant, and unfortunately not examined adequately by Hein, is the importance of cybernetics as a basic model and inspiration for interactive exhibits, employing feedback mechanisms that changed with human interaction. These exhibits meant cybernetics was not simply an interdisciplinary subject for engineers, mathematicians, and early computer scientists, but also in keeping with the values of the time a, "... technologically utopian structure of feeling, positivistic, and 'scientistic'" (Quoted in, Shanken 2000), an ethos which had a lasting influence on the world of science exhibit design (certainly longer than in the art world from which it originally sprang).

3.2.2 The Social Significance of Interactivity

The terms "interactive" and "hands-on" have become, as Tim Caulton put it, "Largely interchangeable in both public and professional use," (1998: 2.). With the entry of computer-based virtual and simulated interactivity computers in science centres since the mid-1980s and the varied possibilities of direct manipulation of scientific objects, instruments, and devices that illustrate abstract principles the distinction is, arguably, worth maintaining. At this stage, though, a working definition of science centre exhibits is offered, based on Caulton's: A hands-on or interactive science centre exhibit encourages individuals or groups of people working together to understand and discover scientific phenomena through physical exploration that involves choice and initiative.[5]

It should be noted, however, that while new reforms in science education were developing apace during the reform era, those working in science centres may not have been so aware of them, even though a stress on hands-on and interactivity in the new museum had its parallel in general theories of learning influential among educators at the time. Slinn comments:

> We did have some contact from the educational community, but by the time that contact started to happen we were, I think, in existence, had a style and a character.[6]

[5] Caulton's definition was broader and applied to science centres and children's museum exhibits and, therefore, did not specifically mention science.

[6] A similar conclusion was confirmed by Sheila Grinell (personal communication, August 2002) that science centres developed their approach largely in isolation from professional educators, although they were generally aware of the science reform movement).

The opportunity for the visitor to have first-hand science experience in the museum, while an important innovation, was also a revival that attempted to bring the process of science back to the museum. In the early part of the nineteenth century, museums were central to the active creation of scientific knowledge (Arnold 1996), but since then knowledge production in science has shifted away from the museum as science has moved from, "Documentation in the archives; then specimens in the field; and finally artifacts in the laboratory" (Fuller 1997: 28). The laboratory metaphor was not fully realised in the science centre, but the direct experience model was an attempt to reconnect the public to the world of real scientific endeavour even if the resulting experience was decidedly abstract.

As already noted, a new type of museum emerged that was much less rooted in history or place than the traditional science museum. No longer concerned with the achievements of the past (or the present), the visitor was invited to be both the experimenter and experimented upon in a process of direct self-discovery. The visitor side of the interactive cybernetic loop is oddly rather overlooked in the literature, which tends to define interactivity as changes that take place in the exhibit, whereas the changes that take place in the visitor are, arguably, more significant. As Beetlestone, et al., put it, "In many of the best interactives, the action is all in the visitor's head" (1998: 7).[7]

No longer concerned with particular places, the visitor experienced first-hand the universal truths of science, which, by definition, apply everywhere and at all times. This had enormous practical advantages: new museums did not require unique collections of expensive and rare artifacts for display, rather, they could draw from the array of established scientific principles and modern science's constantly expanding areas of knowledge (the source of new exhibit topics) and simply purpose-build what they needed. The Exploratorium was able to export this approach through its marketing of exhibits and its famous Cookbooks of do-it-yourself designs (Bruman 1991; Hipschman 1990, 1993). Grinell points out

[7] The implications of this are explored in Chapter 5 (page 118ff).

that although the content in the Cookbooks were influential, they were not so detailed that each new centre could simply build exact replicas of the originals:

> Cookbooks aren't plans. You can't build the stuff from Cookbooks. The cookbook is just a sort of description, so you have to go off and build it by yourself. You have to mess around with it in order to get it.

The Ontario Science Centre exported its Science Circus exhibits around the world and many new centres adopted its style of presentation. The consequence is that with local variations many science centres now look somewhat alike and certainly contain many of the same basic physics topics, with local variations in execution, based on the basic set of tried and tested Exploratorium and Ontario Science Centre exhibits.

The result of the success of the pioneers was a steady stream of new science centres and science museums, children museums, zoos and other types of museum adopting the their techniques. ASTC was formed in 1973 with 24 members and has grown steadily since, with over 500 members in 2002 (according to its website),[8] at least one in every state in the U.S., and over 40 other countries on all continents except Antarctica (Association of Science-Technology Centers 1998: 1). An analysis of the year various ASTC member museums opened, from a 1996 directory and statistical portrait of ASTC and CIMUSET members, revealed the ten year increment profile shown in table 3.1 (Association of Science-Technology Centers & International Committee of Science and Technology Museums 1996).[9] It should be noted that this is a "retrospective view" from the perspective of self-definitions in 1996. In addition, these data only go up to 1995.[10] Assuming the same rate increase for the whole of the decade, 94 science-technology centres would have opened in the 1990s. The directory also reported that at this time 49 percent of all members were in the process of expanding. A state-by-state analysis of those that had opened in the period 1980-1995 revealed this was a nation-wide phenomenon, with new facilities opening in 38 of the 50 states, but with a particular concentration in California and Florida (10 and 8 new institutions,

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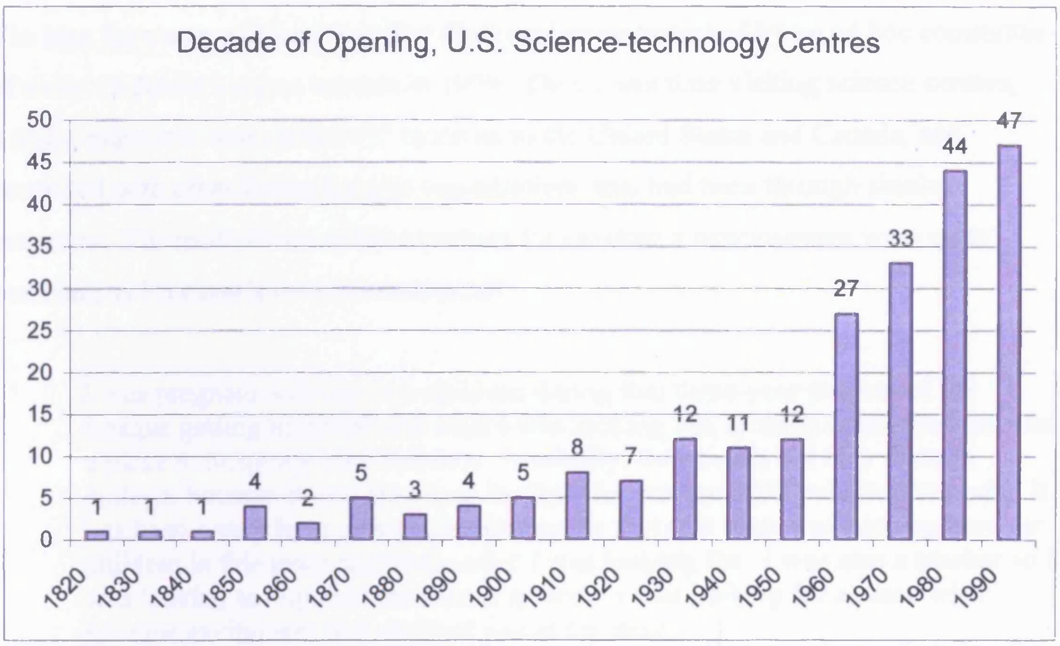
[8] The number is constantly updated at www.astc.org. The number reported here was current in July 2002.
[9] It was not possible to isolate interactive science centres from these data.
[10] Museums in the U.S., including science centres, have seen a decline in visitors since the events of September 11th. The longer-term effects are unclear.

respectively). This may be a function of U.S. demographics and the shifting of population from the "rust belt" to the "sun belt." If so, the story of ASC provides a good example of a national trend.

Table 3.1: Graph showing decade of opening, U.S. science-technology centres



3.3 Development of the Arizona Science Centre

3.3.1 First Phase

The Junior League of Phoenix developed the idea of creating a new museum for children in Phoenix in the late 1970's. Junior Leagues are philanthropic organizations, which began in 1901 as an offshoot of the settlement house movement in New York City. Their founder, Mary Harriman, was a college student from a wealthy family who organized many other well-connected young women to work among the poor of the lower Manhattan to improve child health, nutrition, and literacy. The organization spread rapidly throughout the U.S. and by the 1950s many Junior Leagues were involved in public school reform, the launch of children's television programming, and the founding of a number of children's museums. The basic story of ASC's development can be pieced together from a semi-structured interview with BJ Freeman, Trustee of ASC, and the only Junior League member still involved from the founding group.

The idea for a new museum was first discussed and researched by an ad hoc committee of about 15 Junior League women in 1979. They spent time visiting science centres, science museums, and children's' museum in the United States and Canada, and consulted with other Junior League organizations that had been through similar exercises. The motivations of the members for creating a new museum were quite personal, as Freeman's own interests attest:

> I was pregnant with my two children during that three-year process of the League getting involved and what I was looking for, looking down the line, was a place to bring my own children. Ironically, they came, but they were in college, because it took that long for this [the current ASC building] to open. It has been a very long process, but it was the fact that there was nothing here for children in this town and that's what I was looking for. I was also a teacher so I was looking to augment the school system. I was looking for a place with genuine excitement that grabbed you at the door...

The Junior League awarded $100,000 for the development of a museum plan, a considerable investment and much larger than their normal grants. When the committee began work, it was looking to develop a place for children that could have become either a science centre or a children's museum. Once their "research and development" was well under way – which included a commissioned feasibility study for a new museum[11] and local fund raising from local Lion's and Kiwanis Club's, etc. – the Junior League committee handed responsibility over to a community board and the Arizona Museum of Science and Technology was incorporated as a non profit corporation in 1982. For a while during this period there was a joint advisory and Junior League board, which included some, "... big power names ... It was the Superintendent of Instruction, Carolyn Warner, and people like that."

[11] A study in 1987 anticipated the facility open by 1990 and that by 2000 would have a annual attendance of 730,000 (Wetzel Associates 1987).

One of the key findings of their research became the basis of their fund-raising: Phoenix was the only major U.S. city without a science centre. It was pitched, therefore, as in part an issue of civic pride. The next two years involved raising money for facilities and exhibits and recruiting key local business and political leaders to take an active interest in the project. Business people gradually replaced educational and community members on the Board of Trustees over the years. The listing of the Board of Trustees from December 2001, for example, lists only three community representatives, but 37 from the area's leading companies and commercial interests, including representatives of the following industries: property construction and development, mining, newspapers, airlines, medical technologies, banking, accounting, telecommunications, public utilities, departments stores and retail shopping, and high-technology manufacturing.

There was also a close relationship to Phoenix city government, principally in these early years through the personal support of Margaret Hance, Mayor of Phoenix. As Freeman described it:

> We wanted the city to give us a site. We wanted a dollar a year kind of arrangement and we went through every public and private building imaginable. We went through schools. We tried everything. ... It was a huge process, lots of politics. Several of the community board members really wanted us in Papago Park[12] and the mayor, Mayor Hance at that time, who was really committed to this project said, "I'm not going to allow you to go out there. It's just not gonna happen." So, we lost some Board members, because we were staying with downtown, which had no redevelopment at that point and was seen as a losing proposition. But, we were so tightly knit with the mayor's office at that point, had so much support, that we were determined to stay, to make downtown work.
>
> They thought we would bring people downtown. That's why we got so much support from them.

After an exhaustive search of the central business district, the facility opened in 1984 in a 10,000-square-foot (929 square-metres) storefront in downtown Phoenix, a mile or so from the current building. Somewhere in the region of $300,000 was raised for exhibits

[12] A public park on the border of the cities of Phoenix, Tempe, and Scottsdale, nine miles from downtown Phoenix, which also contained the Desert Botanical Gardens and the Phoenix Zoo.

and during 13 years of operation (1984-97) it served nearly a million people (a number exceeded before the end of the third year in the new facility).

Grinell described two basic models for the development of U.S. science centres. The A-model, which she calls "Grow as you go," was the Exploratorium approach. Starting with, "People who are 'professional volunteers' or have some affiliation with science education or teaching." They often start small, like the Phoenix example, with a storefront. Cynthia Yao provides a description of this type of model in her case study of the Ann Arbor Hands-On Museum, which was included in Grinell's book on starting and running science centres (Yao 1992). Grinell described the second model as:

> Model-B is the giant, get everything all ready for your grand exposition; your grand opening. This is more the World' Fair line; more in the Ontario Science Centre line. For this model, you usually need a huge influx of government funding.

ASC, in its final form can be thought as a combination of elements of both ideal types. The first phase followed Model-A, but its expansion and move to a new facility was closer to Model-B.

3.3.2 Second Phase

In 1988, Phoenix voters approved a City of Phoenix bond issue to support a range of city services including monies for capital projects for cultural institutions. This was part of a revitalisation effort spearheaded by the then Phoenix City Mayor, Terry Goddard. According to local accounts, the city never had much of a downtown and even this was being left behind in the 1980s as the city began another dramatic growth curve and business, entertainment, and population moved further away from the urban core (Gammage Jr. 1999: 55-57; Luckingham 1989: 238-240). According to Freeman, the bond proved the perfect opportunity to move to a larger facility. There were increasing demands on a facility that was becoming rapidly outgrown and the exhibits were aging. The difficulty of selling science as culture, though, was clearly a problem as Freeman explained:

> It probably would have been hard in this valley to have moved the next step without a bond issue, because we didn't have that strong a constituency.
>
> ... even when we have our fundraising event it's a little harder to get people to come because they don't quite see us as being the place to be. I think it's respected, but I think it's like everybody feels about science in general. It's not that warm. It doesn't get your blood going. You know, what engineer ever has his heart race? It's still a little techy, a little geeky.

Lacking the cultural capital of arts and botanical gardens organizations in its appeal to potential donors, the Science Centre found itself fortunate to become a beneficiary of city government funding specifically earmarked for culture as a component of downtown revitalisation. The bond funds provided $20 million for the construction of ASC's new building. With land value and parking, the City's contribution was approximately $30 million. Freeman recalls it as a difficult period:

> Having the city as our partner made us end up with a building that architecturally we would never have designed ourselves. It was a yin/yang thing. It cost us in some ways and yet we couldn't have done it without them. So, it's again one of those partnerships that we've had to make work. I think the architectural charette that decided... when we picked the architect, that whole process was just very, very difficult.

The Board of Trustees hired Sheila Grinell as Executive Director in 1993 after the architect was chosen and after the basic design was in place. A capital campaign was launched by the Center, which ultimately added another $19 million. On January 5, 1997, the storefront centre closed, to reopen in a new, 120,000-square-foot (11,148 square metres) facility on April 13, 1997.

The complex nature of its funding and ownership, although not unusual in other U.S. science centres (Association of Science-Technology Centers 1988, 1998, 2001; Beetlestone et al. 1998: 16), means that its local public are not quite sure of the status of the institution they are visiting. A survey of general visitors administered shortly after the building opened, revealed that from a choice of four options fifty-one percent did not know if ASC was private-for-profit, private-non-profit, run by the city of Phoenix, or run by the state of Arizona (Arizona Science Center 1997c). Only 16 percent of respondents opted for the correct answer: private-non-profit.

The City of Phoenix reports that in the last 14 years, "More than $2.1 billion of private and public monies has [sic] been invested in downtown."[13] Projects completed by this infusion of finance include municipal and federal courthouses, a major league baseball stadium, a shopping mall with 24-film multiplex, the Burton Barr central library, Phoenix Museum of History, NBA basket ball arena, expansion of the Phoenix Art Museum, renovation of the Orpheum Theater, the Herberger Theater, parking garages, and the Arizona Science Center. During 1998-2000, although only about 34,000 people worked in the area, over 12 million visitors were attracted to its cultural, sports, and entertainment attractions, according to the City of Phoenix official website. Other cities around the United States have made similar investments in their downtowns and science centres have featured in many of these revitalization efforts; Columbus and Cleveland, Ohio; Kansas City, Missouri; and Tampa, Florida are just a few recent examples.

In the summer of 2000, a smaller area, one-mile square (2.59 square kilometres), within the Phoenix downtown, was designated "Copper Square" to form what the Phoenix Downtown Partnership of local businesses and institutions called "the beginning of a new brand identity."[14] The purpose of Copper Square downtown revitalisation is described as, "Designed to attract new visitors, encourage existing visitors to participate in multiple activities, and increase business and residential development." ASC is one of many attractions of the area meant to share this brand identity.

Even with its variety of attractions, however, participation in multiple activities is rare: for example, over 80 percent of respondents to a survey at ASC reported they were visiting the Centre without going elsewhere downtown (Arizona Science Center 1997d). Surveys have shown that both general visitors and organized groups stay an average of just over three hours at the Center and then leave for home or school (Arizona Science Center 1998b, e). Similar consumption patterns are found at other attractions in the area (Behavior Research Center 1999b, 2000). Downtown Phoenix thus functions as an event-based area that offers a set of isolated experiences. This is partly a function of operating hours: ASC is open from 10 a.m. to 5 p.m. daily, whereas the theatres and

[13] On the City's website: www.ci.pheonix.az.us/BUSINESS.dtowndev.html
[14] Information comes from the Copper Square website: www.coppersquare.com

sports arenas present mostly evening events, but the audiences for ASC's neighbouring museums do not greatly overlap. The result is that visitors come to ASC to purchase an individual experience rather than visit multiple venues.

ASC's new building provides one of several downtown attractions, but like so many other U.S. cities, Phoenix's new public buildings are not merely "destination attractions," but also civic monuments. The symbolic significance of having such sites and recognisable buildings to house them has significance for the whole region. It certainly has appeal for business and not just those in the downtown area. It helps local high-tech industries in the surrounding metropolitan area, for example, recruit employees with the promise of cheap housing, good weather, and all the amenities of a "real" city.

3.4 ASC's Building

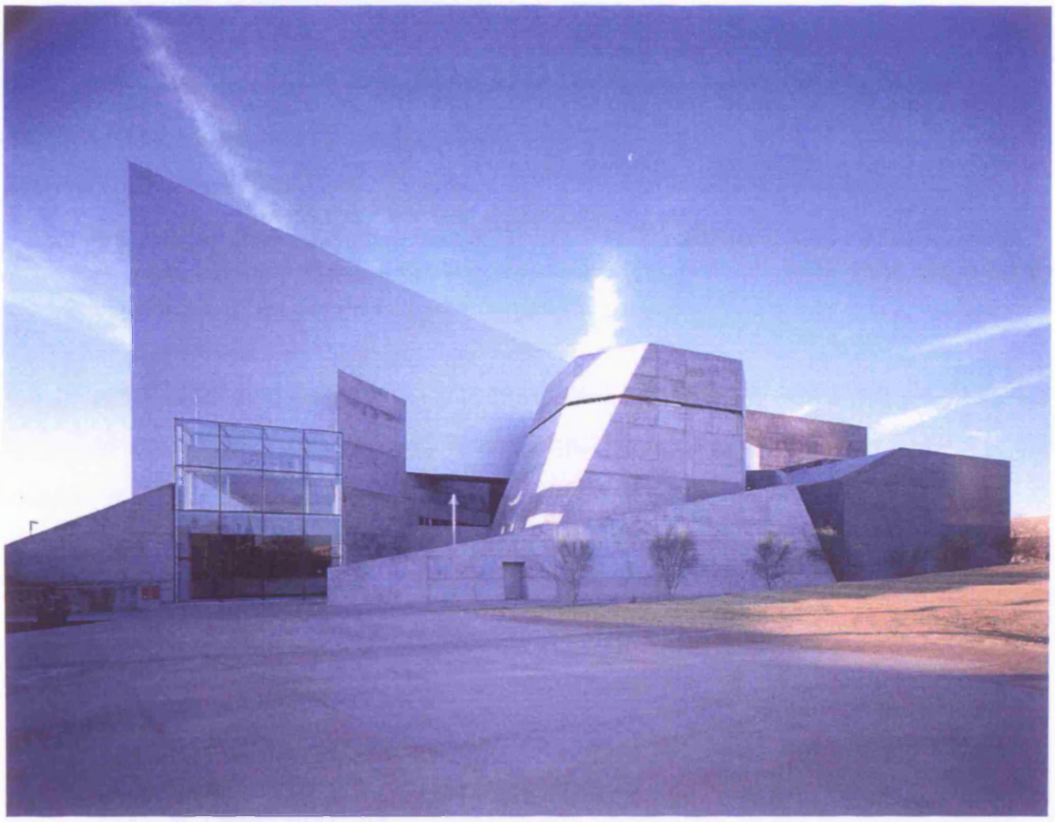
The visitor approaching the Arizona Science Center encounters a striking physical structure (see figure 3.1). Antoine Predock, the building's architect, wrote a short account of his vision for the Arizona Science Center, which is examined sentence by sentence in what follows (see website, Predock 1999b).

Predock's description begins with a simple account of the building's purpose and location:

> This museum for the City of Phoenix, completed in 1997, houses exhibition space, a demonstration theatre, a special format film theatre and a planetarium, along with educational and support facilities. The site is located at the edge of Heritage Square along a major traffic route into the centre of Phoenix.

Heritage Square is a collection of older Phoenix buildings moved to the site in the 1970s at the beginning of the City's downtown redevelopment scheme. In the 1990s, ASC, the Phoenix History Museum, and a car park were added to form Heritage-Science Park.The building is a place for housing a museum, but it is not specifically linked to the notion of a science centre, rather natural and urban connections appear to be more in mind: "The building blends, in an abstract manner, influences drawn from geological events with site-specific concerns and urban opportunities." Specifically, the building refers to the idealised topology of the Southwest's mesas and canyons and the building's actual location in a downtown area of central Phoenix. Contrasting with these abstract notions, the building creates an actual presence where, "Silhouette and horizon merge with the phenomena of light, water, reflection and mirage."

Figure 3.1 Photograph of ASC building looking south



ASC is a grey concrete structure. The way the light plays upon its surfaces at different times of the day and at different times of the year creates a constantly changing landscape of surfaces. The sharp lines of the building's silhouette are seen as one approaches against a sky that is brilliantly clear and blue for about 300 days a year. Light and shadow are a constantly changing form on the building's surface, sometimes producing an almost translucent effect. The mention of water and mirage is also a reference to the building's symbolic meaning in a desert environment.

> The resulting architecture is a highly processional and participatory journey, beginning with a descent into the earth in the entrance courtyard and transition into sheltered light in the lobby, culminating in a celebration of the sky in the peak gallery with its celestial viewing terrace.

The public and ritual nature of the building is evident here, reminiscent of Bennett's notion of museums as places to see and be seen (Bennett 1995) and Duncan's notion of museums as places of ritual enactment (Duncan 1995). Here Predock is emphasizing the "processional" and "participatory journey" his building engenders. He sees many of his buildings as giving form to a kind of dance. As a student at Columbia University, New York, choreographers such as Jennifer Masley and Merce Cunningham influenced him and his buildings are designed with a strong sense of bodies moving in space through processional and choreographic events.

> By sinking galleries, planetarium, theatre and curatorial spaces into the earth, thermal stability and enhanced coolness is assured while setting the stage for the building's other passive energy responses.

The procession created down or up stairs and ramps in entering and using the building heightens an approach used in other Predock buildings created in and for the hot desert southwest (including the nearby Nelson Art Center in Tempe). These buildings are designed to take advantage of the open-ended "performances" created by visitors who follow his processional pathways, while at the same time providing practical shelter and coolness below ground.

> The building acts as both an edge and a seam within its context, providing a pedestrian crossover into Heritage Square from the south, while establishing itself as a destination for occupation and exploration with a series of shaded decks, bleacher seats, terraces and courts, which belong as much to the public realm as to the museum itself.

Predock stresses that while the building creates its own space (an edge) it also connects and is connected to other parts of the local environment (a seam). The "edge" and "seam" language stress the abstract qualities of the building. The language that describes the building as "a destination for occupation and exploration" points to the function of the modern museum as such, but also to the forms and shapes of the building itself. For Predock, there is an isomorphism between its form and function.

Much of the form (decks, bleacher seats, etc.) is found on the outside of the building close to the pedestrian crossover. The building, thus, occupies both a public space (the building's shell) and a private space (the museum below and inside). This external and internal difference is remarked on by Predock: "The Center has the feeling of a citadel, somewhat enigmatic in that the inner life of the building – the hidden inner world of science – is not revealed externally" (Predock 1999a: 119).

The building is not the only one in the area that is a destination. Destination buildings dominate the area, including those that are close neighbours to ASC: the Diamondbacks baseball stadium, two public car parks, the various historic houses and museums of Heritage Square, and the Phoenix Convention Center.

> The resulting building form is one, which is intended to stimulate a multitude of responses: at times, these are powerful visceral connections to the desert place, at other times they are as ephemeral as a mirage.

The final sentence reconnects his description to the mirage image used above. A mirage is, of course, the optical phenomenon where reflected images of distant objects are seen. The distant objects refer to the rugged desert landscapes found well beyond the building's urban setting, but ephemerally coded in its structural references.

There are strong symbolic connections between architecture and science. Adrian Forty, for example, notes, "It is striking how many of the metaphors in the lexicon of day-to-day architectural speech have been drawn from science" (Forty 1999: 213) and he goes on to discuss the architectural concept of circulation, deriving from medicine, and a variety of other metaphors from fluid and static mechanics. If there is a natural affinity between the language of science and architecture it is well expressed by Luca Basso Peressut, particularly in the section of his book on science museums that features 15 science-technology centres from around the world, including ASC (1998).

Peressut argues that modern science-technology museums (most examples cited are science centres as defined here) have certain common characteristics that involve the relationship of the building to exhibits (1998: 15-39). These elements also apply to Predock's building in Phoenix. First, is a tendency to subordinate the internal architectural elements to a backdrop or "black box." This may be contrasted with modern art museum spaces, which have a tendency to become "white cubes" (O'Doherty 1986). The main architectural elements, thus, remain on the building's exterior with interior spaces often having minimal decoration and no natural light. Second, gallery spaces are usually large and open to accommodate what Frank Oppenheimer referred to as, "A wood of natural phenomena through which to wander." Compared with many contemporary art museums (Newhouse 1998), modern science centres have a clear separation of architectural display and exhibit display. Third, this means the architect must find other opportunities to "create a dialogue" with the museum's content.

According to Peressut, there are three modes of architectural/science "dialog" each of which can be found in various degrees in Predock's building in Phoenix. The first are buildings embodying "allegories of science, " for example the reference to the bow of a ship in the New Metropolis (now called Nemo) building in Amsterdam or the "flying saucer image of the planetarium" at the St. Louis Science Centre. In ASC's case, Predock adopts a more abstract notion of geometric shapes and volumes (Predock 1999a: 118). Visitors to ASC, thus, experience the abstraction of science and what for Predock is its hidden nature, expressed in the very structure that houses science in its exhibits.

The second mode of architectural presentation of science makes the building itself a science exhibit. A good example is the Museum of Science and Industry (MOSI) in Tampa, Florida, also designed by Predock, which is described by Peressut as a "true exhibition machine," working to accommodate the subtropical conditions of Florida (1998: 128). Similarly, Predock's building in Phoenix uses passive and evaporative cooling elements and sunken courtyards to make the most of its desert environment. This mode, while clearly a feature of the building, is not emphasised or strongly interpreted by ASC.

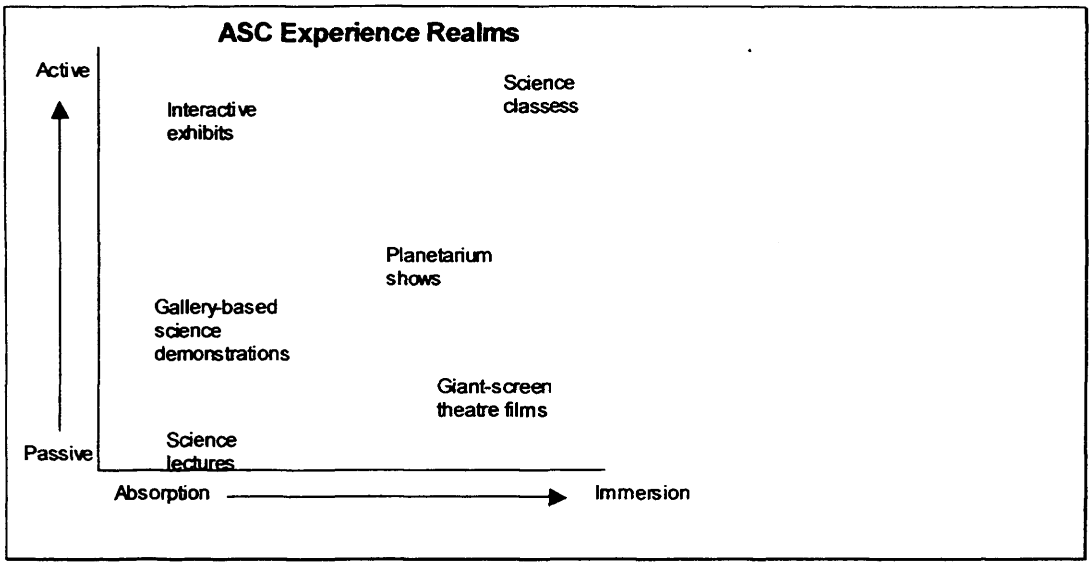
The third mode noted by Peressut is found in buildings that attempt an integration of technology and nature. Predock's building can be seen as somewhat ambivalent on the issue and Peressut finds in ASC an expression of anxiety about the, "Possible effects of a brutal technology on the environment, the destruction rather than the construction of places and territory" (Peressut 1998: 136). Certainly, the coded meaning of the building is not clear to all its users, indeed, a local councilman was ridiculed in the local press shortly after the building's opening when he queried whether the building's concrete exterior was going to be painted to give a more "finished" appearance. It is not surprising, then, that not everyone reads in the building the meanings suggested here. The allegorical and connotative meanings of modern buildings are not intuitively obvious and sometimes require some kind of guide to their symbolic language, as Umberto Eco pointed out in his essay on exposition architecture (Eco 1986). What is clear to whoever visits is that they are encountering a special building set aside for a special purpose.

3.5 Inside the Destination Experience

Unfortunately, the literature that has examined science centres has concentrated so exclusively on the interactive exhibit experience that it is easy to overlook science centres' diverse offerings. ASC, for example offers a distinctive experience with diverse elements. The Center is able to function well in this destination situation as it offers multiple experiences in a single setting. For instance, as well as interactive exhibits ASC regularly offers live science demonstrations and tabletop activities in the gallery areas, drop-in and pre-booked science classes, planetarium shows, and giant-screen documentaries. There is also a food court and science shop. Somewhat less regularly, it also offers field trips, summer camps, overnight camps, guest speakers, and special events and activities presented by outside experts. Groups and individuals also hire the centre for their own events, including business meetings and parties, wedding receptions, and proms, etc. While not all experiences are available at every visit, a diverse set of changing experiences is available each time visitors arrive.

Joseph Pine and James Gilmore offer a typology of "experience realms" that is helpful in a theoretical understanding of science centre experiences (Pine II and Gilmore 1999). They distinguish two axes of experience, one that indicates the degree of participation (from passive to active) and one that indicates the connection of the visitor to the experience (from absorption to immersion). The result is a four-fold model: passive-absorption is "entertainment;" active-absorption is "education;" passive-immersion is "aesthetic;" active-immersion is "escapist." Pine and Gilmore write, "Companies can enhance the realness of any experience by blurring the boundaries between realms" (1999: 38) and so can science centres and museums. The next chapter will show that the Science Center experience is one of commingled entertainment and education and, therefore, how the boundaries of their model are blurred in this case. Figure 3.2 below, thus, treats them not as distinct realms, but rather as continua that provide a conceptual space where experiences may be mapped.

Figure 3.2 ASC experience realms



(Adapted from, Pine II and Gilmore 1999: 30)

Interactive exhibits and science classes are both highly active, but classes (some of which operate as "drop-ins") involve a higher degree of immersion in direct hands-on, inquiry-based activities on particular science topics. Gallery-based science demonstrations are presented in small theatres with some controlled audience participation, which places them as a little more active than science lectures, which are usually presented to adult audiences in the evening. Planetarium and giant-screen movies are both placed toward the immersion end of the continuum, but planetarium shows, with the ability to interact with the audience through voting consoles in each seat, are counted as more active.

In next two chapters, individual elements of the ASC experience will be analysed in depth (interactive exhibits, planetarium shows, giant screen films, and gallery-based demonstrations), but at this point it should be clear that ASC provides a multidimensional experience. When they enter the Center, visitors must make several choices about the mix of experiences they want to have. It is aptly described as a menu, because before anything is consumed they must have decided between general admission to the Center or general admission and a film and/or a planetarium show. Depending upon the age of the visitor and the items chosen, the admission fee (as of January 2001) can cost between $5 and $11 per person. Demonstrations, tabletop activities, new temporary shows, and special events by outside experts are usually included with the price of admission. Visitors make this second level of choice as the events are announced or they happen across them.

In the three hours of a visit, then, a number of choices must and may be made, not including the visit to the store (in ASC's case called Awesome Atoms) and a break for food (available in ASC's "food court"). A large part of science centres' success can be found in their ability to provide experiences in all four of Pine and Gilmore's experience realms. Their description of an ideal commercial experience can be found at ASC and are characteristic of other successful science centres:

> The sweet spot for any compelling experience – incorporating entertainment, educational, escapist, and aesthetic elements into an otherwise generic space – is similarly a mnemonic place, a tool aiding in the creation of memories, distinct from the normally uneventful world of goods and services. Its very design invites you to enter, and to return again and again. Its space is layered with amenities – props – that correspond to how the space is used and rid of any features that do not follow this function (Pine II and Gilmore 1999: 43).

The visitor, then, when approaching and entering the modern science centre, is aware of the range of experience offered. Science centres are successful enough institutions for the public, even those entering a new place or visiting a science centre for the first time, to know the likely form the experience is to take. The buildings that house science centres are often, as in ASC's case, modern structures that reinforce the notion of a separate and special place for science. Others, such as the Exploratorium, the Pacific Science Center, and the New York Hall of Science are found in reused buildings from world and state expositions, which similarly suggest a notion of the exhibitory complex and its ritualised separation from the ordinary flow of life.

3.6 Local Legitimation

Within the space of a few years, an idea among a group of women to have something for local children to do developed into a design for a science centre. It developed further, from a presence in a small storefront property in downtown Phoenix to one of the state's major destinations in its own multi-million dollar building designed by a leading internationally renowned architect. Many factors combined to make this possible.

When the centre was first envisioned, there was already a successful model ready and suitable for import. The organizing group was able to create local interest by pointing out that this was an amenity other cities possessed, but Phoenix lacked. The idea was given multiple justifications: it provided something for children to do; it was in keeping with the latest educational theory; it was dedicated to a subject that promoted the city and state's present and future wealth and prosperity: science; and it had a record elsewhere of providing an experience that could draw a considerable (fee-paying) audience. To make this happen, city government and local businesses were willing to support such a proposal and so were the voting public.[15] ASC was an integral part of the renovation of downtown Phoenix in the1980s when in the storefront property and a part of its redevelopment in the 1990s in the purpose-built facility. If the science centre lacked the cultural capital of the theatre or the symphony, it made up for it in popularity with schools, school children, and families and, in addition, could claim to be a vital educational service.

[15] ASC was part of a second bond issue for cultural organizations, which received voter approval in 2001. ASC will use its share of monies ($10 million) to expand its current facility.

Its model of science presented also had considerable advantages. It could be imported virtually ready to go. While there was always a desire to feature "science as experienced and applied by people in Arizona," this meant in practice that exhibits would still deal with science in the form of fundamental concepts and phenomena. Locality determined the choice of topic rather than its form of presentation. It also meant that the science centre method (hands-on and interactive experiences) appeared to be celebratory and fun without being ideological or political. Educational institutions could recognise a familiar model of science that business and government interests could sponsor and promote. The site-specific emphasis on science in Arizona, albeit one using a universalistic ethos, was a strategic move that enabled both local government and local companies to name and sponsor individual exhibits, groups of exhibits, and even whole galleries. For example, the State Department of Energy sponsored energy-related exhibits, the Phelps-Dodge mining company sponsored exhibits on geology, the Good Samaritan health organization sponsored exhibits on human biology, the America-West Airline sponsored exhibits on aviation, and so on.

As part of a national movement, the Board of Trustees was able to import not only exhibits and a model of how to interpret them, but also experienced staff that knew how to get things done. Sheila Grinell had been part of the science centre movement since its inception and she was able to assemble a team of experienced designers, educators, and marketers to implement her vision. In particular, she recruited Grant Slinn from the Ontario Science Centre to develop exhibits for the new centre and Laura Martin from the Children's Television Workshop in New York City to develop educational programming and research.

While this small group of people implemented the vision, it required that the notion of science it portrayed should gain the approval of a very diverse group of interests, from community groups and educators, to government officials and private industry. While this is a particular story of a particular group of people building a particular institution, it is also, as described above, typical of many aspects of the development of science centres in the United States. Many started in exactly the same way, as grassroots movements that grew into relatively large and successful institutions.

This struggle for legitimation for the Centre and the model of science it embodied in its exhibits and programmes can be seen in ideological terms as the construction and imposition of a model of science by a ruling group, who through the spectacle of display are aiming for the acceptance of their myth of abstract science. The problem with this formulation is that it assumes a cohesive ruling group to promote, if not develop, the model. In practice, the interests of the ruling group, as far as there was one, was not so singular or so focussed on science. Various factions and interests – from media, businesses, politicians, educational organisations, foundations, government, etc. – were able to work together here because the resulting institution served their diverse interests (which were not all to promote the virtues of this notion of science.) Other motivations included: People will be attracted to downtown, the homeless will leave downtown, people will be educated in basic science, the institution is a point of pride, children will be more likely to take up science careers, the public will see the names of companies and be favourably disposed towards them, parents will have another leisure time option, people will want to move to/visit/approve of Phoenix, etc. In a certain sense, the promotion of this particular model of science was less important than other social and economic motives. It is this model of science, however, that made some of these other purposes possible. Its efficacy was that it was able to fit so many different purposes without appearing to have one of its own other than to present basic and neutral science. It is, thus, a model with legitimacy in a variety of arenas.

It is perhaps easy to imagine this model of science somehow existing in a neutral, yet authoritative space, above and beyond the practical concerns, political battles, economic and social interests, cultural values, institutional jealousies, etc., that were involved in creating this place for science. Remembering Foucault, however, we should see this model as an embodiment of the power/knowledge relations the institution spoke from and for. Its model of science was enabled and constrained, indeed, constructed by its articulation in the network of various discursive practices, which were themselves embedded in a network of material practices, some of which were mentioned above.

The apparent neutrality of the science centre model of science – which will be examined more critically in chapters 5 and 6 below – can be seen here to function reflexively. It presents itself as merely concerned with basic concepts and principles of science and, thus, something all parties can agree to. It claims not to advocate any truths other than the basic laws of nature. Add to it a family-focused, enjoyable, and educational method of delivery and everyone is for it. The science centre movement, thus, legitimates what its supporters want to do for their students, visitors, and/or customers, even if each of their more prosaic goals is quite different. In return, they can each give support to the science centre and, thus, legitimate its authority to speak for its supposed apolitical model. The result is mutually reinforcing. The degree to which this apolitical model is itself deeply political, however, is the subject of examination in subsequent chapters.

4. The Decision to visit a Science Centre

This chapter examines the pre-visit context and the decision to visit a science centre, using the Arizona Science Center (ASC) as a case study. Logically, the potential visitor (or a least one member of a potential visitor group) must be aware that the museum exists, must have some idea of what it offers, and must develop a desire to visit. The decision is often based on a rudimentary understanding of what a science centre has to offer from word-of-mouth reports and local coverage by the media, and is made from among the myriad of other options vying for people's attention, free time, and money.

The first part of this chapter provides statistical data on the popularity of science centres in the United States. An examination is also made of the public's awareness of ASC and how the creation and marketing of the Center's image affects those who have (and have not) visited the Center. The chapter also provides an account of ASC's comparative popularity and the demographic characteristics of its typical visitors.

The chapter concludes with a discussion of theoretical consequences of these data and argues that the demands of marketing, the model of science presented to the public, and the audience's understanding and consumption are central to science centres' legitimation.

4.1 Science Centres: The U.S. Picture

Science Museums are popular. Table 4.1 shows the percentage of U.S. adults (surveyed every two years since 1983) reporting they had visited a science or technology museum at least once in the last year:

Table 4.1 Percentage of U.S. adults reporting visiting science and/or technology museums one or more times per year: 1983-2001

	1983	1985	1988	1990	1992	1995	1997	1999	2001
	Percentage								
All adults	61	58	59	59	62	61	60	61	66
Male	62	58	57	59	60	59	63	63	64
Female	60	57	61	60	63	63	58	60	68
Formal education									
Less than high school	43	37	36	30	40	32	34	37	54
High school graduate	63	61	64	66	64	64	64	63	64
Baccalaureate degree	78	78	80	79	78	80	78	83	81
Graduate/professional degree	83	79	81	76	78	83	75	79	83
Attentiveness to science or technology[1]									
Attentive public	72	70	61	69	67	71	68	73	75
Interested public	66	60	63	60	61	65	66	67	68
Residual public	51	53	56	57	61	54	51	52	62
	Sample size (number)								
Total	1,631	2,005	2,041	2,033	1,004	2,006	2,000	1,882	1,574

Source: Based on Table 7-50 (National Science Board 2002).

Table 4.1 shows the percentage of the total adult U.S. population in each category (so totals do not sum to one hundred) reporting they had visited a science and/or technology museum at least once in the previous year. The table contains several interesting results. First, the majority of the adult population of the United States over a nearly 20-year period reported visiting a science or technology museum at least once a year. Second, this is true for both women and men. Third, while the rate of visiting increases as levels of formal educational increase, high percentages of all educational levels attend, and in 2001, those with the least formal education (less than high school) showed the greatest increase. Fourth, while those with an interest in science (the "attentive public") were significantly more likely to visit, the percentage is still high among those who otherwise show little interest in science (the "residual public"), particularly in 2001 (see footnote to table 1 for definitions).

[1] The attentive public is defined as an individual that is "very interested" in that issue, is "very well informed" about it, and a regular reader of a daily newspaper or relevant national magazine. Those who report that they are "very interested" in an issue area but do not think that they are "very well informed" about it are classified as the "interested public." All others are classified as members of the "residual public." The attentive public for science and technology combines the attentive public for new scientific discoveries and the attentive public for new inventions and technologies. Anyone who is not attentive to either of those issues but who is a member of the interested public for at least one of those issues is classified as a member of the interested public for science and technology. All others are classified as members of the residual public for science and technology.

With an overall U.S. population of about 275 million and assuming that children visit science and technology museums at the same rate as adults (which the Association of Science-Technology Centers assumes in producing its national statistics, see below), we may conclude that approximately 181.5 million Americans visited a science or technology museum at least once in 2001. This very large number suggests science and technology museums have broad popular appeal. It is not possible, however, to disaggregate this number further to report the number of people visiting interactive science centres.

ASTC refers to all its member institutions as science centres (433 in 2001) and yet identifies only 54 percent of them as science-technology centres or science museums (which include space, health, and medical museums). Unfortunately, like the Science Board of the National Science Foundation (NSF), it does not disaggregate its statistics on science centres in a way commensurate with the science centre definition adopted here or as discussed in much of the scholarly literature. Included in ASTC's definition are not only science-technology centres, but also children and youth museums (12 percent), natural history museums (10 percent); zoos, botanical gardens, and aquariums (6 percent); and other/unknown (18 percent). These are not useful categories for this study, but correspond to those developed by the Institute for Museum and Library Services, the federal agency with responsibility for museums, and adopted by other national organizations such as the NSF and the American Association of Museums.

Based on a survey of 186 of their members extrapolated to *all* members, ASTC reported a worldwide visitorship of 177.81 million to its 433 member museums and a United States visitorship of 120 million for its 304 member museums in 2001 (Association of Science-Technology Centers 2001: 14). Further breakdowns into types of science museum were not available from published sources. It may not always be practical to distinguish museums neatly into the clear and distinct types that the literature refers to as science centres and science museums, but the reference to all ASTC museums as science centres has certainly caused some confusion in the literature. The arguments over whether science centre visitorship is growing, stagnating, or even declining, for example, is based on the same statistical sources reported above (Bradburne 1998a: 241;

Persson 2000: 450-451). The numbers they use, therefore, include an unknown number of non-interactive science centre museums as defined here.[2]

Following the suggestion of Wendy Pollock, ASTC's Director of Research, a list was compiled of those centres that were "full" or "governing" members of the association and, therefore, "clearly science centres" or science museums with a substantial use of interactive devices,[3] plus those that identified themselves as "science centers" in the sourcebook of statistics (personal communication, Pollock 2002). The result was a list of 50 United States interactive science centres with an annual visitorship of approximately 23.1 million.

These widely differing numbers suggest not only differing definitions, but also the differing purposes these numbers serve. Pollock pointed out two very important issues related to the attempt to define interactive science centres and estimate their total number of visitors:

> The boundaries around "science center" are fuzzy, probably fuzzier than for most other types of museum, which is one reason (in my opinion) this is open to interpretation. Science centers, in their late 1960s/early 1970s form, have influenced other kinds of museums. So, the Franklin Institute started out as a technology museum, but it morphed into a place that would call itself a science center, using "interactive" techniques.

The fuzzy nature of the definition and the increasing number of "hybrids" has resulted in ASTC adopting a very broad understanding, which also helps their arguments about the significance of the science-technology centre movement as a whole. Pollock comments:

> I have noticed that people outside the U.S. ... make a much clearer distinction between "science center" and "museum" than I think most people do here. I wonder if that has something to do with the fact that the form has evolved here, whereas it was imported in more fully developed form into the U.K., etc.

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[2] Plus numbers reported by Persson from the 1st and 2nd Science Center World Congress.

[3] Members must fulfil 10 criteria including, "Be primarily science centers or museums with substantial exhibits, demonstrations, and programs designed to further public understanding of science; be interdisciplinary in nature, with emphases on physical sciences, life sciences, and technology; make extensive use of visitor-participation techniques; and be involved in extensive educational activities" (www.astc.org).

While the adoption of a broader definition of science centre certainly makes sense, given ASTC's organizational aims and the difficulty of deciding the increasing number of borderline cases, this study will maintain a more restricted notion for a number of reasons. This view reflects usage in the published literature, although there is clearly some confusion. There are a sizeable number of interactive science centres in the United States (at least 50) and elsewhere. Despite being a "late 1960s/early 1970s form," many such centres have opened in recent years, including ASC. It is worth retaining the theoretical distinctions made by MacDonald, Durant, and others between types in order to examine the various messages museums deliver for and about science.

4.2 The Local Picture

4.2.1 Awareness of ASC

The Arizona Science Center is located in the heart of "downtown" Phoenix, the sixth largest city in the United States with a population of 1.3 million in 1998, which itself is located in a metropolitan area of 11 contiguous cities with a combined population of 2.8 million (The Greater Phoenix Convention and Visitors Bureau 2000). The decision to visit the Center requires the public, particularly the local public, know that it is there and available to them. Periodic surveys of the public's awareness of ASC by a local market-research company show that the majority of those who live within an hour or so of travel to its location have heard of the Center (Behavior Research Center 1996, 1997, 1999a).[4] Indeed, awareness of ASC in the Phoenix Metropolitan Area increased from 59 percent in 1997 (when ASC opened its new building) to as high as 71 percent in 1999 and has remained in the low 60's since.

Awareness of ASC is extremely high given the local population's rapid growth and turnover, both of which turn awareness of ASC into a constant marketing challenge. Population growth is considerable: more than 100,000 new people move into the area

[4] Results are from telephone interviews with 700 local residents. Awareness was defined as those saying they knew "a lot, some, or a little" about ASC. Those saying "the first time they had heard" or "not sure" were treated as unaware.

each year (Phoenix vies with Las Vegas as the fastest growing metropolitan area in the United States). The turnover of population (or "churning") refers to the unusual phenomenon in Arizona of three people leaving for every five that arrived during the 1980s (Gammage Jr. 1999: 49), indeed, population growth and density are the main reasons people give for why they might move out of the area (Morrison Institute for Public Policy 1999: 24). Thus, a high growth rate exacerbates churning. The net effect is both a constantly growing population to reach and a considerable loss through migration of those reached in the past. Faced with these challenges, ASC succeeds in attracting approximately 400,000 visitors per year, the vast majority of whom live in the metropolitan area. Table 4.2 shows the total number of visitors to ASC from its opening in 1997 through 2001.

Table 4.2: Visitors to the Arizona Science Centre 1997-2001

Calendar Year	**Total visitors**
1997	427,243[5]
1998	400,622
1999	327,693
2000	346,397
2001	432,834
Total	**1,934,829**

4.2.2 Visitors and Non-visitors

Awareness is a necessary, but far from sufficient condition for a visit. Two ASC studies in 1998 by the author compared the demographic characteristics and opinions of those who had and who had not visited the Center to explore some of their reasons (Arizona Science Center 1998d, j). The data presented here come from a reanalysis of those data, but excludes those who had not heard of the Arizona Science Center, producing a revised sample of 184 respondents.

[5] The Centre opened in April 1997, thus 1997 data are for nine months.

The first study includes the responses from 102 local adults who were demographically similar to ASC's general visitors: mainly women (59 percent), average age 40, but with a slightly higher percentage of college or postgraduate degrees (67 percent compared with the mid-50 percent range) found in most ASC visitor studies. Forty-six percent had visited the Center, 54 percent had not. Respondents who had visited the Center were demographically similar to those who had not in age, gender, educational background, and family income, but their perceptions of the Center were different. The survey asked respondents to check whether they agreed or did not agree with short phrases describing the Center. Table 4.3 shows the percentage agreeing to each item for both groups:

Table 4.3: Percentage of adults agreeing to descriptive phrases about ASC

Characteristic	Percentage of those who had visited ASC	Percentage of those who had not visited ASC
Educational	83%	71%
Fun	81	49
Fits my interests	51	42
Good place to take guests	47	42
Something really different	36	29
Reasonable cost	34	9
Open at convenient hours	30	11
Mainly for children	30	20
Convenient location	28	13
Good for a short visit	19	13

Not surprisingly, those who had not visited had lower percentages of agreement on all items, in particular, 81 percent of those who had visited thought the Center was "fun," compared to only 49 percent of those who had not. In addition, while 34 percent of those who had visited thought it a "reasonable cost," only 9 percent of those who had not thought so. In addition, cross tabulations revealed that 72 percent of those who had visited checked ASC as both fun <u>and</u> educational, compared with only 26 percent of those who had not visited. It is not possible to tell from these data, however, whether visiting the Center changed perceptions or whether they visited because of having such different views.

A second study of 82 local adults who had heard of ASC (with a similar demographic profile to the first study in terms of age, gender, educational background, and family income) probed these issues further.[6] Forty-nine percent reported they had visited the Center, 51 percent had not visited. The survey included a number of questions that were added to examine characteristics that might explain the differences between those who had and had not visited ASC. The survey asked respondents to indicate their levels of agreement with three statements. Table 4.4 shows the percentages showing levels of agreement (defined as "strongly agree" and "agree") for both groups:

Table 4.4: Percentages of adults agreeing to statements about interest in science, museum visiting as a child, and attending cultural events

	Those showing agreement	
Statement	**Percentage of those who had visited ASC**	**Percentage of those who had not visited ASC**
I am very interested in science/new technology	75%	61%
My family often took me to museums when I was a child	31	14
I regularly attend cultural/arts events	29	26

Those who had visited the Center were moderately more likely to say they were very interested in science/new technology (75 percent), than those who had not (61 percent). More significantly, those who had visited ASC were more than twice as likely to have been taken to museums when a child (31 percent), compared to non-visitors (14 percent), however, museum visiting as a child was a minority activity for both groups.

[6] The two samples were derived by very different methods. The first questionnaire was distributed to ASC's Board of Trustees who distributed it to their employees. The second was distributed to local community groups that ASC volunteers were members of.

When given a list of science topics – space, medical discoveries, earthquakes/natural disasters, health/nutrition, weather, computers/the Internet, Astronomy, psychology/the brain, mathematics – to indicate interest (signified by reading books or magazine articles, or watching programs about science topics on television), those who had visited showed the same levels of interest as non-visitors, except for the topic of "space" (63 percent of visitors were interested, compared with only 38 percent of non-visitors).[7]

In both studies respondents were asked to say which of five locally popular museums they had visited and/or heard of: the Phoenix Zoo, the Desert Botanical Gardens, the Heard Museum (of native American art and culture), the Phoenix Art Museum, and ASC. Both studies showed that there was high awareness and high levels of visiting the suggested institutions by both ASC visitors and non-visitors. Overall, the Phoenix Zoo had the highest rates of visiting (90 percent and 89 percent of respondents in the two samples had visited at some time). ASC had the lowest rates of visiting (46 percent and 49 percent, respectively). This was understandable given that the new ASC building had been open less than two years at the time of these surveys. ASC was, however, the second most visited museum the year before the study (38 percent, compared to 42 percent for the Phoenix Zoo, according to the second study).

The second study also asked respondents how many times in the previous six months they had been to various other venues in the area. Results showed that visitors to ASC were less likely than non-visitors to go to professional sporting events, but more likely to attend events in the Phoenix downtown area, go to professional music or theatre performances, and go to giant screen films (other than at ASC).

The two groups had subtle but important differences in experience of visiting museums as children, interest in science, and involvement in a variety of cultural activities. The weakness of these studies, though, is that they considered the respondent in isolation from their family circumstance, in particular, whether they have children in ASC's target age range in the household. This factor alone, arguably, could account for two otherwise demographically similar groups having a roughly fifty-fifty split in visiting

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[7] These surveys were administered well before the Center presented space-related exhibitions (e.g. Aliens . . . Are We Alone?) or demonstrations about the International Space Station (discussed in section 6.3.2).

ASC or not. The market research studies of awareness suggest this is not the case, however, as child-related issues (having children in the household, their age being too young or too old etc.) were mentioned as a reason for not visiting the Center by a maximum of four percent of respondents to any survey. In addition, the view that ASC was mainly for children was checked by a minority in both studies of those who had visited and had not visited (see table 4.3 above).

The reasons respondents gave for not visiting the Center in the two ASC studies and in the market research studies are rather similar and amount to being too busy and/or not interested. In the second ASC study, 64 percent of those who had not visited checked "Intend to, but it isn't a priority." This suggests that rather than having a good reason for not visiting, respondents simply did not have a good reason to visit. The marketing challenge, then, becomes to raise the priority of ASC visiting among the other leisure choices people make.

4.2.3 ASC's Popularity and its Competition

The Arizona Science Centre is just one option among many in a variety of leisure time options. It must not only compete with mass entertainment – television, cinema, the Internet, etc. – but also a wide variety of local popular cultural attractions from professional sports arenas, to national and state parks, and other local museums. In 1997 and 1998 in the Phoenix area, more people reported visiting a museum or attending a local art or cultural event (70 percent) than attending local major college or professional sports events (50 percent) (Morrison Institute for Public Policy 1999).

In 1999, the Arizona Science Centre, with a calendar year attendance of 327,693, ranked 23rd in a list of Arizona's top attractions developed from research by the Arizona Office of Tourism (The Business Journal 2000). The list of the 50 top attractions in the State of Arizona included 21 outdoor parks and wildlife areas, 14 museums, seven cultural heritage sites, three sports stadiums, three miscellaneous sites (a scenic railway, a ski resort, and the Biosphere2 research facility), and two western themed attractions. Outdoor attractions comprised not only the greatest number of sites, but also the greatest number of visitors: Grand Canyon National Park ranked first with 4,930,151 visitors; Saguaro National Park ranked second with 3,424,051 visitors; Lake Mead National Recreation Area ranked third with 2,546,104 visitors; and Glen Canyon National Recreation Area ranked fifth with 2,467,199 visitors. The highest ranked museum was the Phoenix Zoo, at eleventh with 1,200,000 visitors. Table 4.5 shows the number of visitors to each of the 14 most popular museums:

Table 4.5: Visitors to top ranked museums in Arizona in 1999

Museum Name	**Type of museum**	**Number of visitors in 1999 (to the nearest thousand)**
The Phoenix Zoo	Zoo	1,200,000
Phoenix Art Museum	Art	567,000
Reid Park Zoo	Zoo	526,000
Arizona Science Center	**Science**	**328,000**
Wildlife World Zoo	Zoo	310,000
Heard Museum	Art	250,000
Pima Air and Space Museum	Science	202,000
Tucson Museum of Art	Art	182,000
Flandrau Science Center/Planetarium	Science	150,000
Pueblo Grande Museum	Archaeology	108,000
Desert Botanical Garden	Botanical	100,000
Kit Peak National Observatory	Science	100,000
Sharlot Hall Museum	History	100,000

Zoos, art museums, and various science museums were well represented. Competition for patronage also came from other cultural institutions with smaller annual visitorships. In the Phoenix metropolitan area, for example, there are over fifty museums (C.A.M.A. 1999). In addition, there are many other small museums throughout the State competing for the public's attention.

A survey conducted in June 1998 asked 200 visitors which other major attractions they had visited in the last two years and if they had ever visited another science centre (Arizona Science Center 1998i). Tables 4.6 and 4.7 summarise the results:

Table 4.6: Attendance of ASC visitors to other attractions in previous two years

Attraction	Percentage visited in last two years
Zoo	75
Theme Park	53
Art museum	46
National Park	44
Some other museum	26

Table 4.7: Percentage of ASC visitors that had ever visited another science centre

Ever visited another science centre?	Percentage
Yes	58
No	39
Not sure	3

Ninety-three percent of those responding had visited at least one of the listed attractions in the previous two years; 52 percent had visited three or more. Those from Arizona were more likely to have visited a zoo than out-of-state visitors (79 percent and 58 percent, respectively) and more likely to have visited an art gallery (49 percent and 29 percent, respectively). The results suggest the Center attracted those with enough disposable income to visit Zoos and theme parks, but that a sizeable minority were not otherwise museumgoers. Indeed, 54 percent had not visited an art museum in the last two years, 74 percent had not visited any other museum, and over a third had never visited another science centre.

4.2.4 Profile of ASC Visitors: Organized and Informal Groups

While all of the statistics in the tables above reflect the number of visits by individuals to science centres, an arguably more useful unit of analysis is the group, as visitors rarely decide to attend or actually attend museums alone. Groups have two main forms: organized and informal. The ASC situation is described from a composite of a series of audience research reports and an analysis of monthly statistical reports of ticket sales produced since the Center opened.

Organised groups make up approximately a third of ASC visitors (between 120-130,000 per year) and informal groups approximately two-thirds (280-270,000). Organized groups comprise mainly school groups (80 percent), the rest are other local organizations such as scouts, brownies, retiree associations, and preschool groups of 15 or more members.[8] Informal groups comprise mixed-aged family members and friends.

The average organised group visiting ASC has approximately 60 members. It should be noted that school groups are specifically targeted with special publicity materials that emphasise the formal science educational content. The 2000-2001 ASC Educator's Guide, for example, includes the grade-appropriate levels for each planetarium show, giant screen film, and school outreach program (Arizona Science Center 2000a). It also includes the statement, "Field trips to the Center meet all State Department of Education standards" and the term "science" is used 13 times (not including titles). As will be shown below, this is a quite different from the marketing message directed at general visitors in informal groups (see sections 4.3.1-2, page 101ff).

The following characterisation of informal groups comes from several ASC reports (Arizona Science Center 1997a, b, 1998c, 1999b). The reports show a consistent pattern: there were various groupings of sex and age, but three quarters contained at least one female and all had at least one adult (children alone are not admitted to the Center). Taking the 1999 report as typical: the average group size was 3.6 members; 23 percent of groups contained preschool-aged children, 74 percent contained school-aged pre-teens, 17 percent contained teenagers, 96 percent contained non-retired adults, and 17 percent contained a retiree. The modal informal group contained an adult female, one school-aged female, and one school-aged male, but there were many variations of group composition. Overall, groups contained more females (56 percent) than males (44 percent), and more children (58 percent) than adults (42 percent).

According to several analyses of zip codes collected at the Center's ticket counter, approximately 75 percent of visitors live in Arizona, indeed, most live within a half-

[8] Only groups of fifteen or more are eligible for advanced ticket purchasing and reduced prices.

hour's drive of the Centre (Arizona Science Center 1997d, 1999e, 2000c). In-state friends and relatives usually accompany those from out-of-state visiting ASC.

During the first few years that the new ASC building was open, visitors were routinely asked how they first heard of the centre. Answers to an April 1998 study are typical: 62 percent said "Word of mouth," 16 percent said "Newspapers," nine percent said "Magazines," six percent said "TV," three percent said "Radio," and four percent said, "Don't remember" (Arizona Science Center 1998e). In later studies of visitor reactions to temporary exhibits, audiences were asked how they first heard about the exhibition and, although levels of media awareness increased, word-of-mouth was usually still the most popular source mentioned (Arizona Science Center 2000b, d, e, g, 2001a). Clearly, word-of–mouth was the major way knowledge of the Centre and its offerings circulated. It is likely that a large percentage of word-of-mouth includes children who had visited on field trips reporting to their parents, who subsequently visited as a family group.

4.2.5 Typical Visitors

Visitor surveys at ASC suggest the typical adult decision maker is a mother who lives within a half-hour drive of the Center (Arizona Science Center 1997a, c, 1998a, b, c). She is most likely visiting with two children and plans to visit only this museum and not other museums or downtown attractions. In social background, she is likely to be Caucasian and have a college degree, but did not major in science. For pastime activities with her family, she favours outdoor recreational activities, visits the local zoo with the family at least once a year, but is not an art or history museumgoer. Her children go to public schools in Phoenix or one of the other towns or cities in the area. One of the children may have already visited the Center on a school field trip. The typical child visitor is as likely to be visiting in a school group as a family group, but slightly more likely to be a girl than a boy.

A survey administered in January 1999 to adults in school and family groups asked them about their visit planning (Arizona Science Center 1999d). When asked, "Who first suggested making the visit to the Science Center?" a minority of respondents in both groupings reported suggesting the visit themselves: family groups (28 percent), other groups (5 percent). This is necessarily the case statistically, of course, given that the average school group at the Center has approximately 60 members and the average family group has 3.6 members, but it is important to note that for most visitors the idea of visiting is not their own.

Respondents to the survey were asked to say when they decided to visit the Center: two-thirds of group members had planned their visit for a week or more prior to the visit, while most family groups had made their decision within a few days of the visit. For both groups a minority had made the decision that day: family groups (28 percent), other groups (8 percent). Generally, a visit to ASC is not a spontaneous idea.

Family group visitors typically encounter only about a third of the over 300 exhibits in an average visit of just over three hours. Parents choose whether to buy exhibit or combination tickets and how long they spend in each gallery, but children tend to make the choice about how much time to spend with particular exhibits. Parents follow and join in, reading the label text (often out-loud) and talking to their children about what is going on in exhibits or to help make them work. Time on exhibits varies from a few seconds to up to 10 minutes or more, depending on interest and the type of exhibit. Computers, for example, generally keep visitors longer than mechanical devices. There is usually very little inter-group activity, but lots of intra-group activity. Families go to science demonstrations in the gallery-based theatre areas or to tabletop demonstrations in the galleries as they are encountered or announced over the public address system. Time away from exhibits includes breaks for food, bathroom visits, a film and/or a planetarium show, and movement between floors. As a result, total time with exhibits is usually little more than an hour. There is little on-site pre-planning – using the gallery map of seeking guidance from staff, for example – and exhibits are randomly encountered and randomly missed, although most visitors say they aim "to see everything."

4.3 The Message

4.3.1 The Media and ASC

The task of "getting the word out" is a considerable challenge to any museum, but as the demographic circumstances in Phoenix make clear, it is particularly difficult for ASC. Like many other non-profit organizations, the fiscal resources for publicity are limited and so ASC relies considerably on free and donated publicity, for which it must compete with many other social and cultural institutions. The sources of awareness of ASC include the word-of-mouth of those who themselves were made aware through mass media coverage by television, radio, newspaper, and magazine news and advertising and ASC's own marketing efforts. Most of this coverage is "earned media," as Chevy Humphrey, ASC's Vice President for Marketing and Development, explained:

> Earned media is media you don't buy. It's free media. They're covering you because they want to cover you and you're not paying them to do this. We create media events. For Aliens we landed a spaceship on the tallest building in Arizona and that earned us a lot of media to support our advertising campaign.[9]
>
> We thought that you had to spend a lot of money on advertising. The first round with Aliens, and the second round, when we did Jurassic Park, we found that we were earning more media than we could possibly spend on advertising, because our budgets are so small. So, we really push for the PR, the "earned media" dollars up front, and we supported it with a small advertising campaign. With these travelling shows, you find media will attach to it. They love the idea and they will work with you in printing stories. These local community newspapers will push their local publications to do stories on the exhibitions and then you plug in maybe one ad per month and that works.

A study of local media coverage during two three-month periods in 1999 and 2000 examined newspaper, magazine, and television coverage reported to ASC by a local clipping agency.[10] Table 4.8 shows the number of items examined:

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[9] Aliens and Jurassic Park refer to two temporary exhibitions presented at ASC.

[10] These data were not included in ASC reports and were reanalysed and summarized here for the first time.

Table 4.8: Items of media coverage of ASC February-April 1999 & 2000

Month	1999	2000
February	49	56
March	45	43
April	63	50
Total	**157**	**149**

ASC received an average of 51 media "spots" per month, which can be extrapolated to over 600 per year. Coverage came from 38 print sources, and eight television stations.[11] Eighty-one percent of items that mentioned ASC were from print media and 19 percent were from television.

A content analysis of print materials revealed that they mentioned an average of 90 activities at the Center per month, or over a 1,000 a year. Most (58 percent) were general listings of upcoming events and exhibitions, usually in a supplemental section of the publication with other cultural and entertainment events. The following table shows the combined frequency of different types of ASC activities mentioned in print media in the two periods:

Table 4.9: Print media coverage of ASC in 1999 & 2000 (combined)

Activity	Frequency
Temporary exhibits	156
Miscellaneous items	116
"Adults' Night Out"	77
Giant screen films	66
Classes	55
Planetarium shows	48
Gallery-based activities	11
Permanent exhibits	8
Total	**537**

Print media mentioned temporary exhibits more than any other type and permanent exhibits least. This points to the way media tends to feature "events as news." While

[11] Radio coverage was not included in this study, although some of the Center's marketing during this period featured local radio stations.

the Center does want its new and changing shows and programs to gain media attention, it also wants to spread the message about its permanent exhibits. The media, however, is much more likely to inform the public of the former than the latter simply because permanent exhibits are rarely seen as news, except when museums open or develop new galleries. Indeed, the vast majority of ASC references by print media featured listings for current or upcoming events. The 116 "Miscellaneous items" in table 4.9, for example, included upcoming summer camps, current special educational programming, a federal award for the Center's computer club for teens and its programs, coverage of upcoming fund-raising golf tournaments, outreach programs, volunteer events, etc. Adults' Night Out events were the listings for upcoming adults only lecture series that ran during each of the survey periods. Giant screen films, classes, planetarium shows, and gallery-based activities all referred to current (that day) or future offerings in the form of listings.

Arguably, more important than the amount and type of coverage is the nature of the message the coverage contains. The use of "key" descriptive terms ("fun," "play," "educational," "exploration," "new," and "ever changing") – suggested by ASC's senior staff at the time to characterize the Center's experience – was analysed and found only nine times in the 537 items. Overall, these data show that the print media featured the Center regularly and thus helped raise awareness among the public, but predominately, only new activities were covered. Current programming and temporary exhibits were much more likely to be featured than the permanent offerings. In addition, the form in which the bulk of coverage appeared provided few details and rarely featured the descriptive terms senior staff hoped the public would associate with the Center.

These data suggest audiences are attracted to ASC through mass means, but the reality is a little more complicated. Some of the temporary offerings at the Center, in the form of films and temporary exhibitions, were themselves products of or heavily associated with the mass media, such as the film Everest and the temporary exhibits associated with the Jurassic Park films and the Titanic exhibition of artefacts. These connections provide "main stream" media with a reason to take notice and the diffused audience something to think and talk about. Humphrey summarized this process as the need to constantly provide new attractions:

> We try to appeal to new visitors, but [we are] also trying keep our return visitors coming back, because people want change. It's not like the old days where you just go to the museum to see the same things over and over again. There's so much variety out there and we have a lot of competition. A lot of non-profits don't see themselves as being part of that entertainment community, but we are competing with a lot of these people – with malls, with movies, with art museums, with botanical gardens – we're competing for people's time and we're competing for people's money.

Humphrey's remarks provide a candid account of the contemporary science centre's economic reality. Such "bottom line" constraints feature strongly in and arguably may determine what science centres say they are and what they offer their publics. ASC is typical of United States science and technology museums in relying heavily on "earned income," of which admission fees are the largest percentage. According to ASTC figures, earned income for their members accounts for a higher percentage of income in the United States (57 percent) than outside (ASC reported for these data an earned income of 59 percent.), where on average 76 percent of income comes from public sources (Association of Science-Technology Centers 2001: 32-33). The reliance of U.S. science-technology museums on earned income is also found in comparison to U.S. museums generally, which reported in 1999 that only 29 percent of income was earned (American Association of Museums 2000).

4.3.2 ASC Produced Images

Even though the Center's marketing department works to frame and place stories, local media outlets largely control "earned media." By contrast, there are other marketing materials – leaflets, maps, handouts, websites, newsletters, catalogues, etc. – that are directly controlled by the institution and can be taken as a reflection of the message it wants to distribute to specific targeted audiences. In the summer of 2000, for example, ASC created a full-colour brochure and distributed it at the Center and via publicity racks of airports, hotels, car rental facilities, etc. It shows on the cover a child of about 10 years of age spinning on the Momentum Machine exhibit (see figure 4.1). The brochure's text directly addressed the potential visiting parent (a photograph of a mother with a child is shown on the inside, see figure 4.2), who is, according to Humphrey, "The local mom, aged between 30 and 45, with kids." The following is the text from the inside fold of the leaflet:

> ***An experiment in fun.*** You and your kids can make amazing things happen at the touch of a button, the turn of a knob, or a hop and a jump. The Arizona Science Center is packed with over 300 hands-on exhibits that let you be part of the action. Explore a 90-foot long "Arizona" rock wall, pilot a simulated airplane flight, dive into the human body, step into a virtual reality adventure, and much more. Within our $47 million, state of the art Center, you can explore everything under the sun – and above it too. All with the unique flavor and perspective of Arizona.
>
> ***Amazing sights and sounds.*** The fun and learning do not end with our exhibits. You can also navigate your way through the solar system in the planetarium and see the world in a new way in our giant, five-story film theater.
>
> ***Wonders never cease.*** Rediscover the fun over and over as the Center brings you travelling exhibitions throughout the year. These full-scale exhibitions are exciting additions you won't want to miss.

The focus here is on permanent exhibits – with temporary exhibits mentioned last and as a reason to return – and the language is full of action and activity words: touch, turn, hop and jump, explore, pilot, dive, step, navigate. The terms "fun and learning" are linked, but the word "science" only appears in the institution's name. The back of the brochure includes the Center's slogan, which changed in the summer of 2000 from "Take your brain for a spin" to "Hands-on, eye-opening fun," literally a move from the brain to the hand and eye.[12] The cover reinforces the notion of activity for children with the caption, "Come out and play."

[12] Humphrey characterized the change of slogan as a "Change from something that can describe just about any activity, to one that applies uniquely to the Science Centre."

Figure 4.1: Front cover of ASC publicity leaflet (2000)

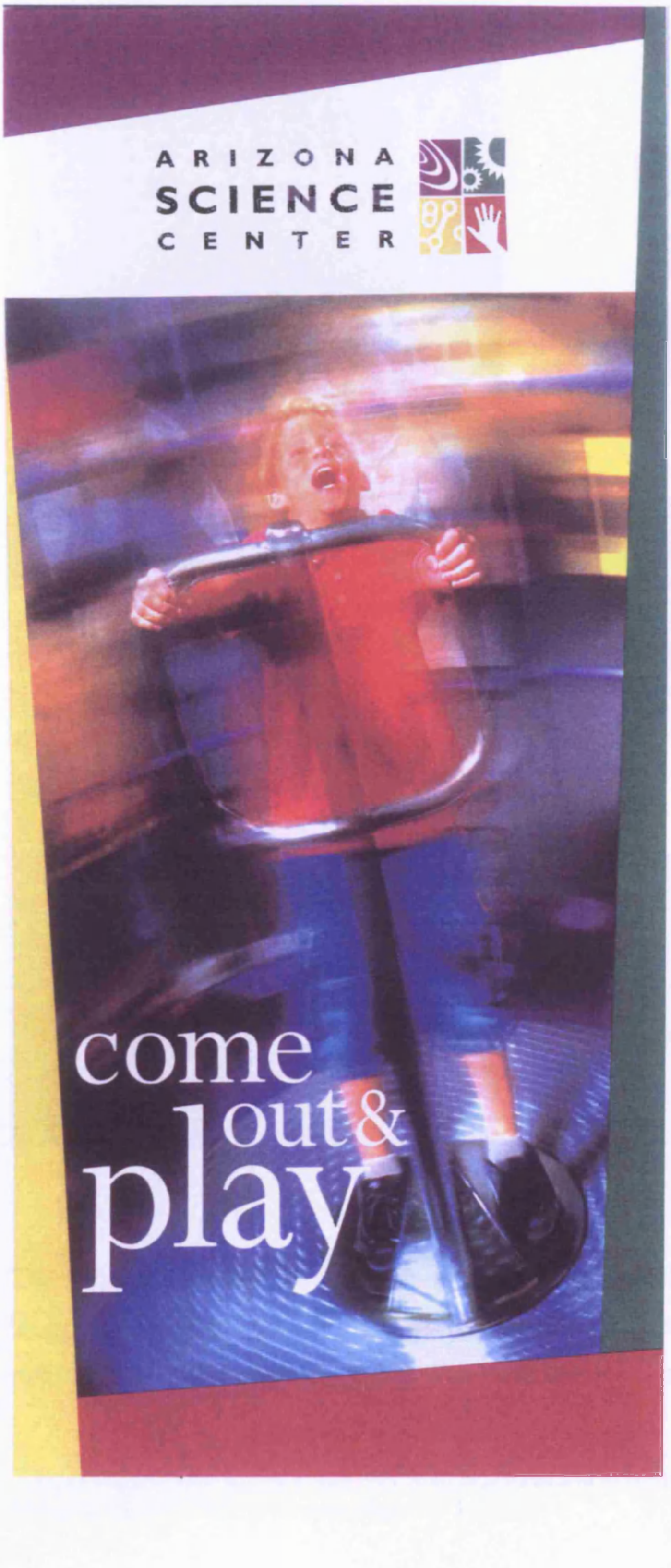
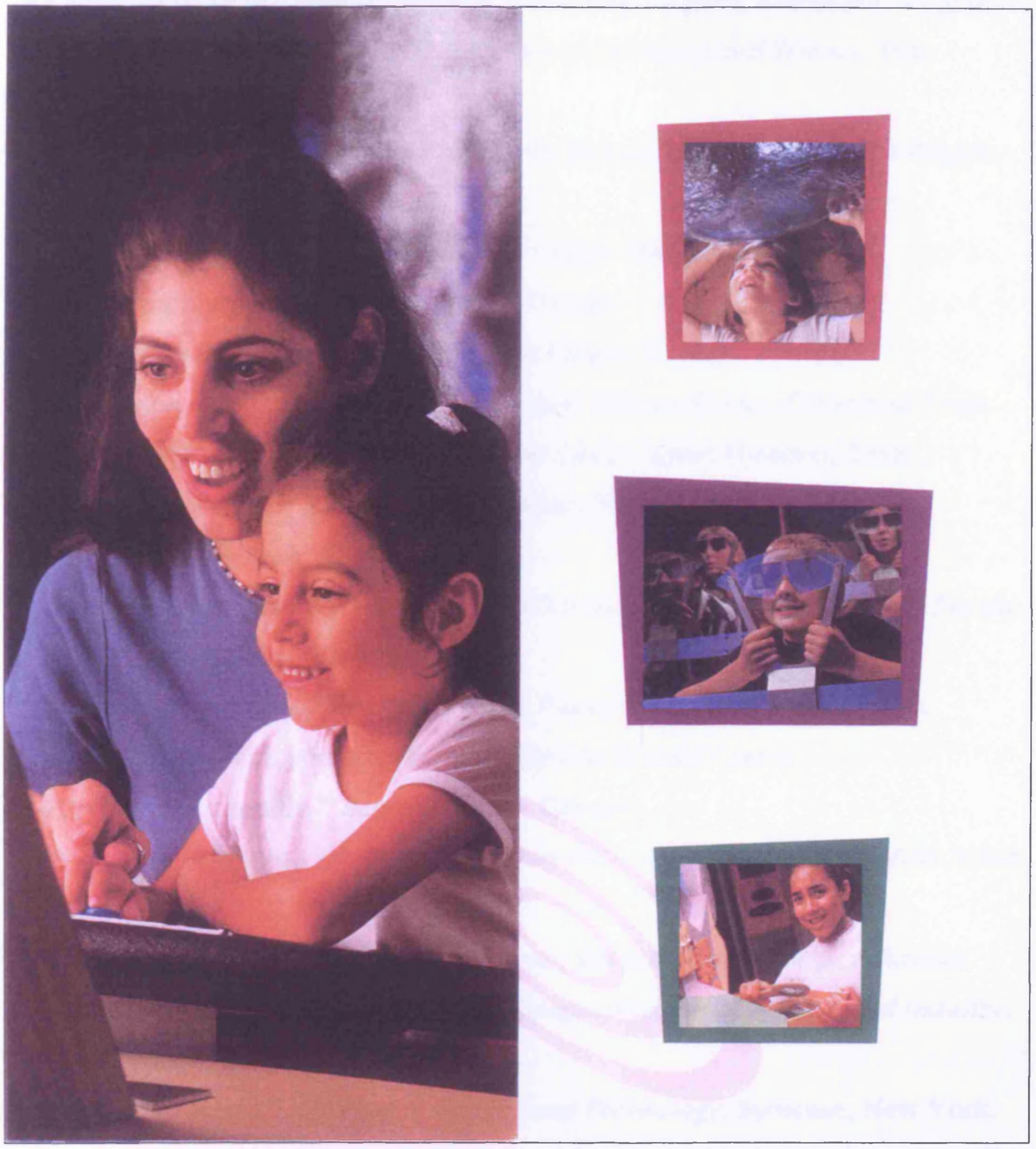


Figure 4.2: Inside photographs from ASC leaflet (2000)



The Arizona Science Center is not alone in the use of such activity and fun-related language and imagery, for it is typical of the science centre movement as a whole, as the following slogans from other North American centres show:[13]

[13] These slogans were selected randomly from brochures and web sites from the ASTC member web listings in October 2000 (www.astc.org).

"Discover the explorer in you." *Exploration Place*, Wichita, Kansas.
"An amazing place to discover." *Science Museum of Virginia*, Richmond, Virginia.
"Nothing beats a day of discovery." *Museum of Discovery and Science*, Fort Lauderdale, Florida.
"A world of discovery awaits you inside." *California Science Center*, Los Angles, California.
"Discover the wonder." *Maryland Science Center*, Maryland.
"Where fun is a science." *Scitrek*, Atlanta, Georgia.
"Learn to have some fun." *Orlando Science Center*, Orlando, Florida.
"We have fun down to a science." *Great Lakes Science Center*, Cleveland, Ohio.
"There is intelligent fun out there." *Houston Space Center*, Houston, Texas.
"Where science = fun." *Liberty Science Center*, Jersey City, New Jersey.
"Hands on fun." *Scitech*, Aurora, Illinois.
"Fun for everyone" and "Where science isn't a subject, it's an experience." *Pacific Science Center*, Seattle, Washington.
"Where learning is always fun." *Discovery Place*, Charlotte, North Carolina.
"Have a little fun with your grey matter," *Ontario Science Centre*.
"Science you can handle." *Scitrek*, Atlanta, Georgia.
"Where 'hands-on' turns minds on." *The Ann Arbor Hands-on museum*, Ann Arbor, Michigan.
"Let's take a mind trip." *Mid America Science Museum*, Hot Springs, Arkansas.
"Adventure on the edge of imagination." *Oregon Museum of Science and Industry*, Portland, Oregon.
"Explore your world." *Museum of Science and Technology*, Syracuse, New York.
"The fascination destination." *Ohio Center of Science and Industry*, Columbus, Ohio.
"The playground for your head." *St. Louis Science Center*, St. Louis, Missouri.
"Where the door to your brain opens daily." *The Exploratorium*, San Francisco, California.

"Fun" is the most used term (nine times), with "discovery" and "science" next most popular with five references each. "Science" and "fun" are linked three times ("Where fun is a science." "We have fun down to a science." "Science = fun."). The other two uses of the word "science" play on negative connotations to contrast the science centre experience with school science ("Where science isn't a subject, it's an experience") and with the passive study of an abstract matter beyond ordinary understanding ("Science you can handle.")

A similar approach to the presentation of the Center can be seen in the small amount of paid media advertising ASC developed with its contracted media consultants.[14] Figure 4.3 below shows an advertisement for ASC's temporary exhibit, Aliens ... Are We Alone? The advertisement ran in the major local newspaper, The Arizona Republic, at the beginning of the temporary exhibit's engagement in February 2000 (circulation approximately 600,000). Its wording refers directly to elements of pop and mass culture: Mr. Universe contests and Aliens from outer space. The "scientific" focus of the exhibition is not mentioned until the third line ("Discover what life on other planets might be like"), following the more science fiction claim that, "Aliens have landed at the Arizona Science Center and you won't believe your eyes."

The use of humour and references to mass cultural phenomena work to place the Science Center as a non-threatening friendly place to visit, using themes familiar to a public that may have little acquaintance with the actual science of an exhibition. In the case of Aliens... Are we alone?, the science in the exhibition dealt with a variety of topics, from the physics of the solar system to the chemistry of life in DNA.

ASC's marketing took a similar approach in its publicity for much smaller temporary exhibits, for example an exhibit on bats (see figures 4.4 and 4,5 below). The exhibit concerned the ecological importance of bats and their worldwide distribution and variety. Much of the exhibit dealt with dispelling myths about their nature and behaviour. Despite this, publicity employed some of the very myths the exhibit debunked as a way to connect to a wider audience. The language used in the text, for example, played on the popularity of Batman films, television show (evoking the Batman theme song), and comics ("Holy cave dwellers! ... Quick, to the Bat Cave.")

[14] The company that developed the images and copy discussed here, Riester-Robb, are a leading local marketing firm that is best known for developing an extremely successful anti-smoking campaign for the State of Arizona that became a national model.

The logo created for the show, used in a banner on the building and on special event handouts, also linked visually to the Batman theme (see figure 4.5) even though there was no reference to it in the exhibition.

Figure 4.3: Newspaper advertisement for "Aliens ...Are We Alone?" temporary exhibition (2001)

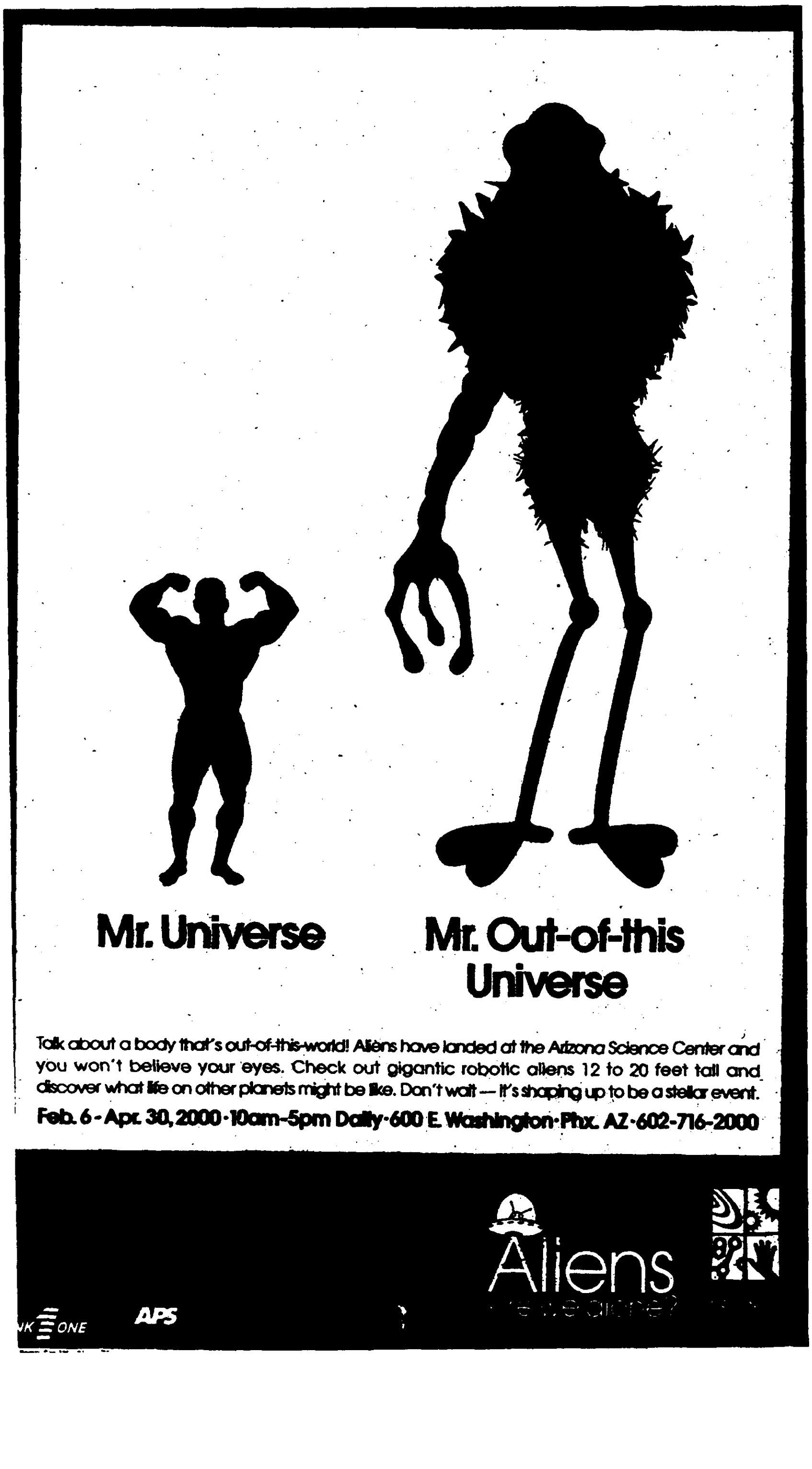


Figure 4.4: Newspaper advertisement for "Bats" temporary exhibition

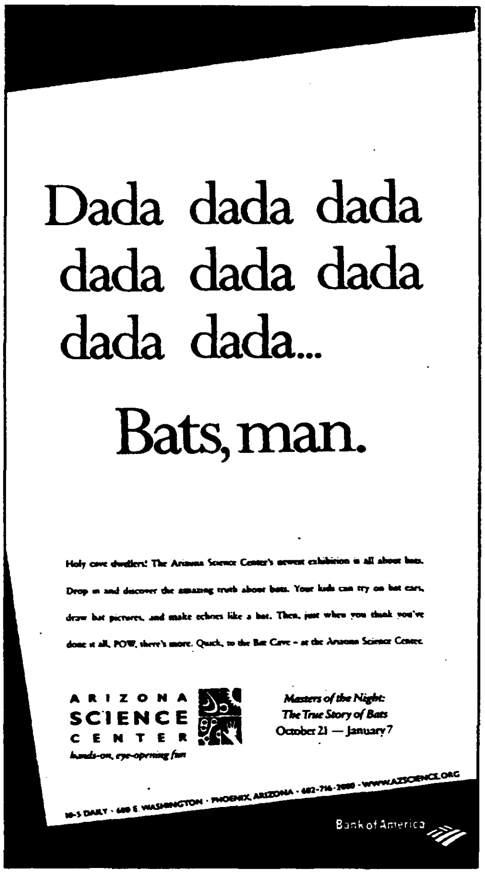
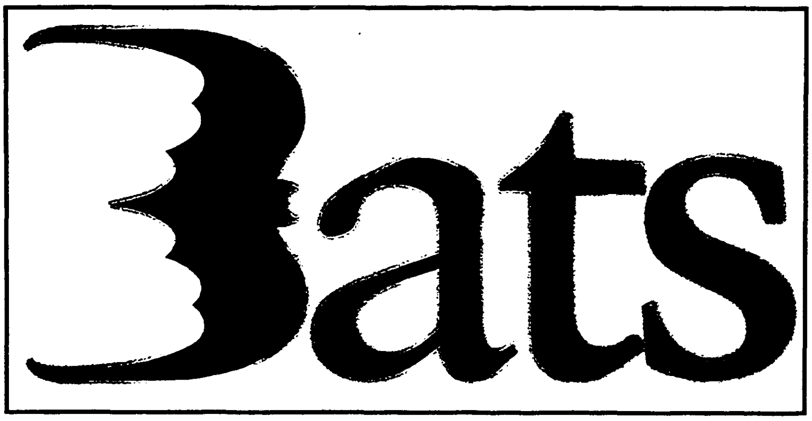


Figure 4.5: Logo for "Bats" temporary exhibition



While a wide range of the Center's temporary exhibits, events, and programs are given local media coverage, it is mainly as shown above, in the form of simple listings of current offerings. Coverage of permanent exhibits is sparse, even though they fill the bulk of the typical visitor's time at the Center. A series of studies of temporary exhibitions during the year 2000, show that a minority of visitors came specifically to see the temporary exhibitions (Arizona Science Center 2000d, e, f, g), but this changed in 2001 and 2002 with the introduction of "block-buster" travelling exhibits on the Dinosaurs of Jurassic Park and Titanic: The artefact exhibit. ASC's own paid and contributed advertising also features temporary exhibitions rather than its permanent exhibits. In addition, this advertising tends to connect temporary exhibitions to mainstream mass culture rather than the scientific ideas the exhibits contain. Only ASC's brochure features the permanent exhibits, but even there, the overriding general image is of a place to take children that offers hands-on fun activities, or as the current slogan puts it, "Hands-on, eye opening fun." Overall, specific scientific notions are conspicuously absent from the publicity information the Center has to offer. The reasons for this may be examined through a consideration of the characteristics of audiences.

4.4 Understanding Science Centre Audiences

While there are many definitions of popular culture (Storey 1996, 1998), there is an obvious and simple sense in which it is merely, "Culture that is well liked by many people" (Williams 1976: 237). In that sense, science centres are part of popular culture. It is not, however, popular culture produced by local people for their own amusement, but culture produced by experts in the display and interpretation of science developed specifically for recreational consumption. Recent research has concentrated more on the consumption side than the production side of this subject and has produced a substantial literature on how audiences use (and reuse) popular cultural products. According to the summary of this work produced by Nicholas Abercrombie and Brian Longhurst, audiences can be distinguished into three main types: simple, mass, and diffused (1998). Visitors to science centres have many of the characteristics of simple audiences, for there is:

> ... a certain immediacy in the experience ... the context is spatially localized and, typically, takes place in a public space. There is a reasonable distinction between producers and consumers ... Events involving simple audiences of this kind are exceptional, depend on a certain ceremonial quality, and demand relatively high levels of attention and involvement (Abercrombie and Longhurst 1998: 44).

Visits to science centres are special "outings" like others such as concerts, plays, sporting events, carnivals, public meetings, etc. Interestingly, Abercrombie and Longhurst do not mention museums in their account of simple audiences, perhaps because their ideal type is theatrical performance. While the museum has its own characteristics that are distinct from theatre, the museum experience shares many elements: it is public, it occurs in specialized spaces set aside for its ritual enactments (Duncan 1995), and its form of communication is direct and relatively short. This may be compared to the mass audience (characteristically consuming television, radio, and recorded music and film), which is often private, does not involve specialized location, is less formalized and ceremonial, and communication is indirect and often elongated (Abercrombie and Longhurst 1998: 57-68).

Their final category of the diffused audience, influenced by the work of Roger Silverstone (1994) and Baz Kershaw (1996), supersedes simple and mass audiences to argue that being an audience now infuses all of life. Television and talking about it are central to modern social discourse and society itself has become imbued with performance. One finds this particularly in the service industries, from shop assistant "greeters" to restaurant waiters (Pine II and Gilmore 1999). The significance of this for museums in general and science centres in particular is the effect this has on audience expectations and styles of consumption. The implications are that the contemporary science centre audience expects the same professional standards of performance and the same sophistication of message that are routinely produced by the mass media. Through constant exposure to media, visitors to science centres are experienced and sophisticated in decoding and constructing new meanings from the variety of performances and messages they are exposed to.

The model of audiences proposed by Abercrombie and Longhurst links the diffused audience back to the simple audience and, simultaneously, vastly generalises it. Life itself becomes a series of face-to-face audience-performance encounters: "Life is a constant performance; we are audiences and performer at the same time; everybody is an audience all the time" (Abercrombie and Longhurst 1998: 73). This is a model of life as spectacle. Although their case may be overstated, it is clear that science centres must compete for audiences in a contemporary world of spectacle, dominated by audiences and performances in which media intervenes everywhere. It also suggests that the performative nature of science centre activity is a well-understood and previously encountered role even among new visitors.

For Roger Silverstone, the experience offered by the science centre becomes not merely a vehicle for media promotion, but a reflection of that media. Take for example his description of the Ontario Science Centre (written before the Internet and MTV):

> Science and technology are here on display in a fragmented, interactive pot-pourri of reality and fantasy, where the invitation is to the child, and the child in the adult, to play, and where the structure of the exhibition mimics the fragmentary ephemerality of television in its generation of the minor didactic episodes which stand as the echoes and shadows of grander and more coherent narratives. Everything is fast-forward. Everything is user-friendly.
>
> The exhibition is entirely one with the current media environment, transforming science and technology into a game and breaking down science's classificatory and explanatory structures into a multi-media rhetoric all of its own. The visitors move in and out of this synaesthetic experience like viewers through an evening's television ... (Silverstone 1988: 233).

Like many other commentators, Silverstone tends to see the science centre as a failed science museum and, therefore, fails to judge it in its own terms, but his insight into its affinity with the "current media environment" is important and can help explain how science centres are understood and used by their audiences.

Among the many thousands of visitors to ASC each year are a sizeable minority who have had no previous experience of visiting a science centre (about a third according to the data reported above). Many must rely for information on images carried by the various forms of mass media and/or the reports of their family and friends. According to Silverstone's view, many will replicate patterns of consumption from other arenas (such as from television to museum). Where possible, an attempt is made by ASC to frame the potential visitor's expectations and experience through media publicity and images. As shown above, these attempts are only minimally informative, usually no more than a line or two telling the potential audience what is currently on offer or an advertisement linking a temporary exhibit to images circulating more generally in the mass media.

Concentrated and simplified, science centre images are more about the *form* of the experience as hands-on fun for children, than about science *content*. This is not to say that ASC does not promote a public image of science, it does, but the image is experiential rather than conceptual: science is something you do and a science centre is somewhere anyone can go to do it in a safe and user-friendly environment. This means that the model of science in science centres as described by Durant and MacDonald, which stress the underlying basic principles, is largely absent. Instead, the emphasis is on the empirical activity, not the rational generalisations that derive from it.

If the dominant media model is that science in a science centre is all child-centred and activity-based, the view of the public that actually visits is somewhat broader. A survey of 93 adult general visitors to ASC in 1997 asked them to indicate who the Center was for (Arizona Science Center 1997f). The survey used a five-point scale from "Only for Kids" through "Only for adults." Eighty-eight percent checked the middle item, "For kids and adults," and only 12 percent checked "Only for Kids." A similar scale asked them to indicate what the Center was for from "Only for fun" to "Only for learning." Ninety-eight percent checked "For fun and learning" and a mere two percent checked "Mainly for fun." These results suggest that visitors themselves see the centre as more diverse: for children, adults, fun, and learning. The significance of ASC as a fun site for learning about science is found in another 1997 survey of adult general visitors who were asked to check items (from a list of nine options) that influenced their decision to visit that day (Arizona Science Center 1997e). Of the 63 percent who checked "It's educational" (the highest scoring item), 52 percent also checked, "Thought it would be fun." This confirms similar conclusions by Falk and Dierking:

> Contrary to popular belief, there is no evidence that visitors come to museums either to learn or have fun; almost without exception they came both to learn and have fun. The individuals who choose to go the museum seek a learning-orientated entertainment experience (Falk and Dierking 2000: 87).

According to Humphrey, such findings are to be expected. The public already knows from family members or other experiences that the science centres, as museums, carry educational content. The aim is to carefully place and craft this message, using all the marketing techniques available, so that the audience also knows two important and distinctive elements of the science centre experience: It is different from the traditional hands-off museum; it is different from the traditional ways of learning in schools. This means placing a stress on active fun. For marketers, it is always more important to say what is positively offered, rather than negatively avoided. The surveys cited above on visitors' perceptions give support to this notion, as do others studies cited above on reactions to temporary exhibits. No respondents in any of these studies reported that the exhibitions failed to deliver. No respondent reported expecting to encounter Batman, nor, conversely, did any respondent suggest there was too much science. In fact, the public seemed to accurately read the coded message of science centre marketing and the vast majority appreciated and enjoyed what they experienced.

The ever-changing population and the fierce competition amongst competitors for its time and attention means ASC must constantly strive to establish and then re-establish its message. It relies for its survival on income from tickets and finds the key to high levels of visiting in constantly placing new offerings in the market place and before the public. This is precisely what local media is also looking for: new items to cover, new events taking place.[15] It is no surprise, then, that print coverage is predominately in the form of listings. It is also no surprise that ASC constantly offers new temporary exhibitions (at least three times a year), new films and planetarium shows, new festivals and special events, new courses and classes. New opportunities to consume these especially constructed commodities are constantly on offer. Seen in this way, science centre products begin to look like manifestations of Guy Debord's "society of the

[15] An executive of the Arizona Republic newspaper is a Trustee of ASC and the newspaper has sponsored several ASC programs and temporary exhibitions.

spectacle" in which spectacles must constantly reproduce themselves (1994). While it is easy to be critical of the social economy of spectacle and see it as Debord did as an "uninterrupted monologue of self praise" by the ruling order (1994: 19), it can also be argued that in its own terms science centres deliver on the expectations they create. In fact, their media-based messages provide little more than an upbeat, positive image of science as enjoyable and non-threatening. This is close to the view the United States already has about science (although it is unclear what part science centres play in creating such positive views). Eighty-six percent of Americans believe, "Science and technology are making our lives healthier, easier, and more comfortable;" 89 percent think, "Most scientists want to work on things that will make life better for the average person;" 85 percent think, "Because of science and technology, there will be more opportunities for the next generation" (National Science Board 2002: 7-12).

The danger in the science centres' media message is that it is so partial. It presents a science that is, at first sight, asocial, ahistorical, and apolitical. In its place, it offers science as pleasure, but as Douglas Kellner points out, "Since Foucault, it has become a commonplace that power and knowledge are intimately intertwined and that pleasure is bound up with both" (Kellner 1995: 39). Pleasure can be seen variously as the means by which the public is informed, but also the means by which it may be led away from understanding. The chapters to come will try to unravel some of this intertwining to reveal the social, historical, and political messages of science centres.

5. Exhibits at the Science Centre: Doing Science

This chapter examines a selected group of exhibits at ASC and the variety of ways they speak about and for science. Rather than selecting exhibits on physics or the psychology of human perception,[1] which have been the subject of considerable promotion and scrutiny in the literature (Allen 1997; Anderson et al. Forthcoming; Ansbacher 1999; Borun 1983; Borun et al. 1993; Crowley et al. 2001; Crowley and Galco 2001; Doherty et al. 1996a; Doherty et al. 1996b; Exploratorium Teacher Institute 1991; Feher and Rice 1985; Gammon 1999; Kennedy 1990; Krstanovich et al. 1991; Murphy et al. 1996; Russel et al. 1988; Shocklmayer and Gilbert 2001), exhibits were chosen on human biology. This subject area is under-researched, but well represented in science-technology museums and a topic that will produce even more science exhibits in the near future. New and in development travelling exhibits on human biology cover such diverse topics as human bones, women's health, sound and hearing, the human genome, microbes, the body's defences and digestive system ("Grossology"[2]), and new surgical techniques (Association of Science-Technology Centers 2002 (March/April)). Recent funding from the National Institute of Health, through its SEPA grants has also encouraged a number of science centres to develop exhibits related to new research findings in human biology, but as Grant Slinn observed:

> ... science centres grew up with increasing awareness of and understanding of the human body. Human body exhibits are always among the best exhibits you can do if you do them well.

Those analysed below are among the many exhibits Slinn was responsible for developing with other staff for the Arizona Science Centre. The examples chosen show the diversity and complexity of contemporary science centre exhibits on the topic. Some involve direct experience of real phenomena and some are models, metaphors, or analogies. Some involve simple mechanical operation and some involve complex electronic equipment.

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[1] Many science centre exhibits, as described below, are implicitly about perception.

[2] Grossology was featured at ASC May-September, during which time the psychology exhibits from the All About You gallery were removed.

All exhibits analyzed can be treated as devices with many possible readings and are interpreted here as polysemic texts. Analysis begins by interpreting the context in which they are displayed. This chapter begins with an analysis of the human biology murals that frame the entrance to the All About You gallery and that provides a model for understanding how human biology science is dealt with in the gallery.

Based on the findings of this analysis, and a detailed consideration of the exhibit examples, the second part of the chapter looks at science centres more generically. It considers the way exhibits illustrate science, make claims for the authority of science, and make claims for the science centre as the voice of mediation. This chapter, therefore, is concerned with how science centres convince through their exhibits.

5.1 Visiting the All About You Gallery

5.1.1 Murals

The first major gallery that visitors encounter at ASC is called All About You. It is located on the ground floor and has approximately 125 exhibits.[3] According to the description in the Center's map, this area is where "Hands-on exhibits reveal the workings of the body and mind" (see figure 5.1). The gallery has exhibits on human biology (to the left as visitors enter the gallery), psychology (to the right), and exhibits that feature brain-mind feedback (in the middle of the gallery). The gallery covers an area of approximately 6,500 square feet (604 square metres). Visitors entering the gallery pass through an entrance with a series of photomurals (figures 5.2-5.3) that frame the experience. The murals reflect the diversity of visitors (and its staff)[4] and carry an implied message about the gallery's topic and the way science is treated within it.

[3] Most visitors encounter a smaller gallery first, but since the building opened this area mainly featured temporary exhibits. In the autumn of 2000, it was converted to a gallery called Energy in the Air (shown in figure 5.1). In 2002, the area was again used for temporary exhibits.
[4] All of those featured in the murals had a connection to ASC as staff members and their families or as volunteers.

The people displayed in the photomurals are of diverse ages, ethnicities, sizes, physical abilities, etc. Doors can be opened in the torsos of certain pictures to reveal illuminated illustrations of internal organs. The mural below (figure 5.3) shows another approach, with the superimposition of body systems (nervous, digestive, skeletal, musculature, and circulatory). Using different techniques, all the murals illustrate the same message: we are different on the surface yet the same underneath.

Figure 5.1: ASC map of ground floor

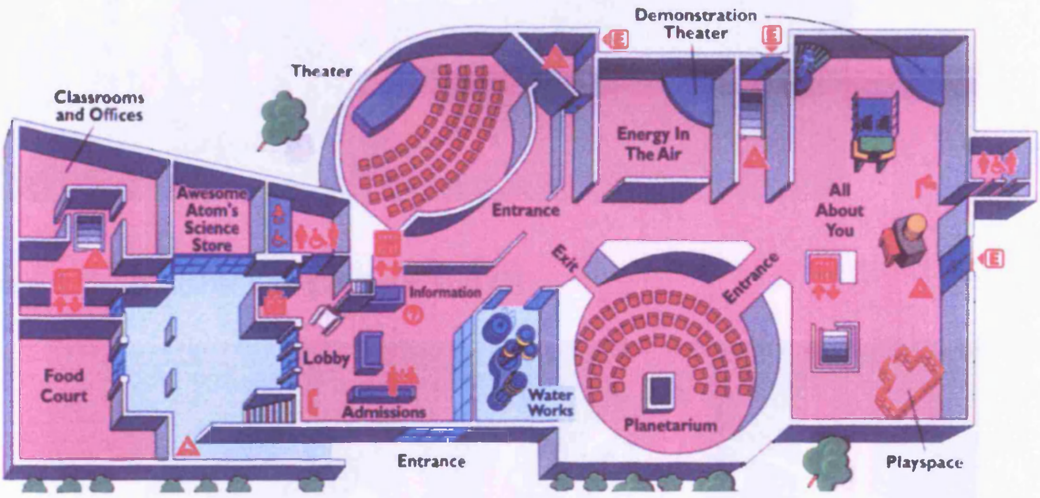


Figure 5.2: All About You gallery mural

Figure 5.3: All About You gallery mural (2)

The gallery is dedicated to revealing the underlying regularities and similarities of the human condition. In this sense, the gallery is All About You no matter who you are. The implied notion of who you are, though, is complex. Many exhibits in the gallery show that the faculties that control and regulate our sense perceptions, while universal and predictable, can often mislead us. The single exhibit housed in this threshold area deals precisely with this point (figure 5.4).

The exhibit comprises two chairs placed either side of a frame that suggests a mirror, but it is actually constructed of alternating strips of mirror and glass, such that the image seen from either chair is a composite of each participant's face.[5] The label text attached to the exhibit reads:

> **Do you have your father's nose ...** or your mother's eye's, or your grandmother's ears? Everyone looks for family resemblances among relatives, and relatives of people we know. We all share characteristics and yet each of us is unique.

Figure 5.4: "Do you have your father's nose ..." exhibit

[5] Versions of this exhibit are found in many science centres.

The exhibit demonstrates the confusion and diversity of surface appearance, while suggesting that the perceiving self – the psychological and physical apparatus beneath appearance – produces the same effect in both participants, and must, therefore be caused by shared mechanisms of perception. The exhibit in a sense dissects these mechanisms (which are the subject of other exhibits in the psychology gallery), making the perceptive visitor aware of how their brain, and their companion's, puts together the image they see before them as a whole face, even though they know it is an illusion made of them both. What is seen is not an image of a person's individuality – as seen in a mirror's reflection or another person seen through clear glass – but an amalgamation created by alternate layering of reflection of the self and someone else. The text appears to refer to physical effects, but operates as much psychologically. A unified view is thus provided on both ends of perception: that which is seen and that which is doing the seeing. It is important to note, however, that awareness of the physical or psychological mechanisms involved are not necessary for this to be a successful and enjoyable experience. In a sense, the point of the exhibit is enacted with each pair of participants regardless of their level of understanding. The photograph illustrates how non-participants can also witness the exhibit's effect.

The label text carries a similar message to the murals, although here it is directed at the genetic similarities of families rather than the human species as a whole. Despite the conclusion of the label text, the experience suggested by the exhibit is more of a blending of characteristics than a demonstration of uniqueness. The joy of the exhibit experience (which is often accompanied by visitor laughter) comes from the novelty of seeing oneself with someone else's eyes while they see you with their nose. That is, visitors look for and respond positively to the layered and blended effect rather than, as the text suggests, "Everyone looks for family resemblance." The promise made by the text and illustrated by the murals, however, is that there are underlying explanations for this surface variegation and if visitors do perceive family resemblance, science can explain that too.

The significance is that many science centre exhibits reveal that our sense perceptions are easily tricked and, therefore, essentially to be doubted, while the underlying scientific ideas that explain why (both psychological and physical) provide more certainty and veracity. This exhibit, thus, encapsulates general arguments about science that the visitor's body will re-enact many times in exhibit encounters to come in the gallery. This suggests that cognition is only one part of the experience and that, in practice, it is often by-passed and yet the exhibits still have their effect. This notion will be examined more fully below through other exhibit examples, but two points are worth making at the outset: first, the exhibit's truth is embodied with each instantiation. That is, the scientific argument is made true by doing, rather than understanding. Second, the exhibit-visitor encounter creates participation and observation, often combined in bodily experience. In figure 5.4, where the adult holds a child's head still, we can see facilitated training in the role of participant-observer. This is real skill building; the visitor to be successful in a science centre must control the gaze and know how to observe both as an active participant and as a thoughtful observer of the physical and mental states created in the exhibit encounter.

The murals and the exhibit are also a depiction of the kinds of experience the visitor will have of human biology. The gallery contains exhibits on human biological systems, it deals with the skin and what lies beneath it, it explores common human genetic characteristics, and it features (in the psychology and feedback systems areas in particular) various aspects of human cognition and perception.

The notion that we are literally all the same underneath is also connected to a more fundamental metaphoric message about the nature of science; that surface diversity is explained by the deeper and often hidden commonalities. Surface variety or counter intuitive phenomena are explained by hidden or underlying regularities; those principles the literature suggests are a key characteristic of science centres. It is no wonder perhaps that so many science centre exhibits deal with perception and visual illusions. According to Sheila Grinell, work by the British psychologist Richard Gregory on visual illusion was an important influence on and incorporated into many exhibits at the Exploratorium and, of course, in Gregory's own centre, the Bristol Exploratory. These exhibits have had a lasting influence on other science centres around the world.

This message also has a social and political dimension. Even though the murals point to a literal and a metaphoric deeper understanding of science, they simultaneously celebrate modern pluralistic America (see figure 5.5, below). The socio-political message of the gallery is that we can see our differences and diversity, but that should not blind us to what we (more) fundamentally have in common. Science explains what we have in common. We see a mirror image not only of ourselves (the mural includes a small mirror), but the pluralistic values of our modern liberal democracy, illustrated in the images of a social setting containing smiling African-Americans, Asian-Americans, Native-Americans, Latinos, and European Americans. Reflexively, while not dealing with these social issues directly, but rather as the social framework within which the gallery's experience is provided, science appropriates these positive social values and appears to embrace them.

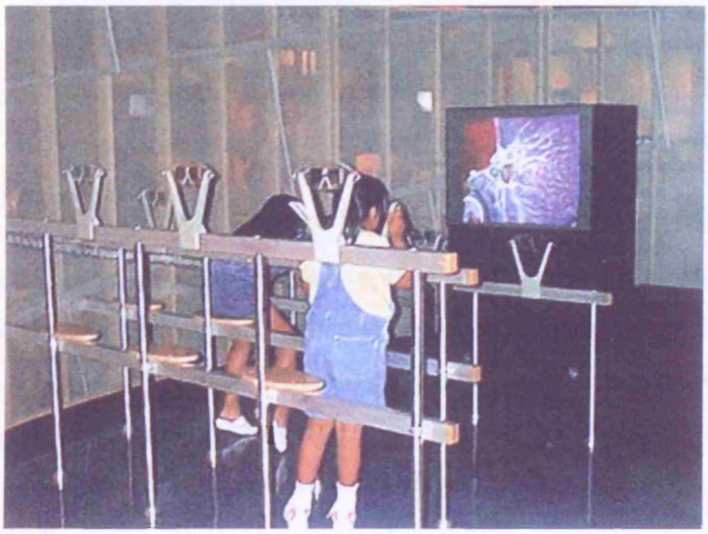
Figure 5.5: All About You gallery mural (3)

5.1.2 Body Zoom

An exhibit called Body Zoom is often the first encountered as visitors move beyond the threshold of the All About You gallery. The exhibit features data from the Visible Human Project, which, using different design approaches, is also found in a number of other science-technology museums, including The Tech Museum in San Jose, the Exploratorium in San Francisco, and the Science Museum's Wellcome Wing in London. It occupies approximately 150 square feet (14 square metres) of space as visitors enter the human biology section of the gallery.

During an observational period recorded in March of 2001 lasting approximately 45 minutes, 85 percent of groups entering the gallery spent some time at the exhibit. Observations that were more detailed were made of the behaviour of the first person to interact with the exhibit among 38 family groups (totalling 65 visitors) using the exhibit. Seventeen of the 38 observed were adults. Time spent at the exhibit varied from 2 seconds to one minute 23 seconds, with a mean of 15 seconds, although, the total video loop displayed by the exhibit lasted six minutes. Only three read the accompanying label text, but those who did spent a much longer time (a mean of 58 seconds) with the exhibit than those who did not (a mean of 11 seconds).

Figure 5.6: Body Zoom exhibit



The exhibit allows up to eight users to simultaneously view a large video monitor through special glasses mounted on three viewing-frames arranged at different heights (in 2002 the glasses were removed for technical reasons and not replaced). The exhibit is not user activated, but runs automatically on a six-minute cycle. It is accompanied by a light jazz soundtrack with no spoken commentary, echoing the slow rotation and soft melting of the 3-D images on the screen.

Over half of those observed looked through more than one set of glasses; one boy was observed to look through all eight. Only two groups were seen to hold a conversation about the experience; most viewed through one or two spectacles for a few moments and then moved on to other exhibits. One conversation by two boys involved whether the images looked the same through different glasses. The other was a conversation in which an adult male read out some of the text panel – about the image being of a "convict" – to a male child who said, "It looks weird."

Using terms from visitor research, these observations suggest that the exhibit had high power of attraction (to 85 percent of groups entering the gallery), but low holding power (only two of 38 observed stayed at the exhibit for more than 30 seconds of the six minute display). Its power of attraction may be related to the ease of knowing what to do, as children as young as three or four years of age knew without instruction that the task was to look at the screen through the mounted glasses. Its lack of holding power may be related to there being no user-initiated action. The fact that so many moved on to other glasses, suggests they may not have known clearly what they were looking for or they were expecting user activity. Neither of the two conversations recorded referred to the images as 3-D.

From the observations reported above, time with the exhibit was associated with text reading, but it is not known if reading caused the longer time – this was probably so as it takes about a minute to read the two text panels – or if the text was read as a result of wanting to spend time at the exhibit. Whichever it was, reading the label text provided important information the visitor was otherwise unlikely to know.

The first line of the first text panel told the reader what they were viewing: "This is a six-minute video voyage into, through, and around the body of 38 year-old male."[6] The use of the term "voyage" is significant for the artist who created it also had a commercial CD-ROM of similar material available called "Body Voyage." Use of the term also suggests a ride or journey, thereby turning a real human body into a terrain to be traversed as part of a leisure activity. This contrasts strongly with traditional museum approach to treating the human body, particularly representations of cadavers, with utmost seriousness and respect.

Even though the moving and melting images seen by visitors were in ghostly, iridescent colours, the text assures the reader, "All the views you see are real – this man's body looks like this inside." The truth is, of course, that the views while based on "real" images were also artistic renderings and alterations of a body that was, "X-rayed, sliced thin, and photographed." The role of the artist in creating the "voyage" was explained in the second paragraph:

> This 3-D video voyage is a world premiere, created for the Arizona Science Center by world renowned artist, photojournalist, and writer, Alexandar Tsiaras from images in the National Library of Medicine's new database on human physiology.

The exhibit was described as an art installation, rather than a science exhibit. The exhibit was also described as a creation from the archive of the National Library of Medicine, but there was no explanation in the first panel of why the archive exists or what it is used for. The second text panel went into a little more detail: "In 1989 the National Library of Medicine began a project to create a 'virtual cadaver' as a model for research." Missing, however, was the scientific rationale for such a project or any reference to the resulting research, which is substantial. A bibliography by the National Library of Medicine in 2000 listed 425 scholarly publications related to the Visible Human Project and over 700 licenses had been issued to companies and researchers to use the data.[7]

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[6] In 2001, the label text was condensed into a single panel. The text commented on here corresponds to that available when the observations reported above were made.

[7] Available online at http://www.nlm.nih.gov/pubs/cbm/visible_human.pdf.

Biographical information about the "38 year-old male" was minimal: "Joseph Paul Jernigan, a healthy convict on death row, donated his body." This is in sharp contrast to the news coverage given by print media in 1994-5, around the time the original archive images were made available on the Internet. The story continues to be of interest: the subject of a featured article by Gordon Grice in the New Yorker (2001) and an award winning documentary film, Blue End, by Kasper Kasics (2000). When the story first ran, however, it was both the scientific story and the history of Jernigan that caught the headlines, for he was a convicted murderer who donated his body following execution in Texas. For example, the Jernigan story became a feature article in Life magazine in 1997. The story was headlined, "The visible man: The execution and electronic afterlife of Joseph Paul Jernigan," and began with a richly detailed narrative account of Jernigan's life and death:

> The prisoner sat on death row, hoping for life. His had not been a good one so far. Booted out of the Army for drug use, Joseph Paul Jernigan of Waco, Tex., turned to robbery. When surprised in the act of stealing a microwave oven, Jernigan stabbed Edward Hale, 75, then killed him with Hale's own shotgun. "I know I did wrong," Jernigan said. "I have no one to blame but myself." Sentenced to death in 1981, he spent 12 years in prison before his final plea for clemency was denied. The next day, the 38-year-old ate his last meal – two cheeseburgers, fries and iced tea. At 12:31 a.m. on August 5, 1993, a lethal dose of potassium chloride ran through a catheter into his arm. "I'm glad it's over," said his victim's nephew. "He won't be back on the street." But Jernigan is back. In an electronic afterlife, he haunts Hollywood studios and NASA labs, high schools and hospitals. And in death, he may finally do some good for humanity (Dowling 1997).

Richly descriptive and personal language is also found in the Gordon Grace article (2001). Grace reported that Jernigan refused to eat his last meal. ASC text, by contrast was depersonalised:

> The body was CAT-scanned, scanned by MRI, and then frozen in a block of ice. The frozen body was sliced into sections one millimeter thick, and every section was photographed.

This is characteristic science centre label text where the convention is that personal names are rarely mentioned, except as an attribution to an artist. Narrative techniques that connect the "reader" to a story are even more rarely used in science centres (Martin and Leary March 1997). Visitors are often addressed in the second person, in explanations of what is happening:

> Each lens blinks on and off 60 times a second in synchrony with the images on the screen. The alternating images are separated by a computer. Your brain interprets the images as a three-dimensional object.

The second person pronoun is used to connect the device to the perceptual experience. Finally, the text explains what the visitor should do, switching from the indicative mood to a command: "Look at the screen using the glasses to see the effect."

This exhibit contains a mixture of four aspects of an exhibit encounter that are given significantly different treatments. The *aesthetic* element appears dominant; the experience is a virtual voyage through a human body to musical accompaniment. Next, the *technology* of the exhibit is stressed, both how the original images were created from the donated body and how the exhibit uses them to create the 3-D voyage. The two aspects that are given the least attention are the *scientific* and the *narrative*. That is, the Visible Human Project's significance as a scientific reference tool for anatomy, virtual surgery, and the coming together of researchers in cellular and structural biology and radiology to produce the images are not explained. Finally, the story of the life, death and "after life" of Joseph Paul Jernigan, while having a significant place in the print media, is hardly mentioned in the label text.[8]

The net effect is to externalise and virtualise the human body to such a degree that the visitor can journey through the representation with little thought of the existential status or the ethical issues of a person re-created in this form (what in cyber-literature is called a shade (Csordas 1997)). Gordon Grice sees a similar issue in the Visual Human Project as a whole:

> This is the paradox of the Visual Humans: people may find them repulsive in theory, but, because they have become electronic, they don't invoke our taboos against dealing with corpses. We can handle them without the defiling touch of flesh and blood. It's as easy as watching TV (Grice 2001: 41).

[8] For the treatment of science in print media see (Nelkin 1987).

In the Body Zoom exhibit, we are prompted to note our own internal state and how the computerized technology fools our brain into perceiving these images as three-dimensional. The resulting experience is an abstract one, but aesthetically and emotionally abstract rather than scientifically abstract, for the scientific implications of the Visible Human Project are hardly dealt with. The floating and melting body – virtualised by the artist's refashioned images and 3-D glasses for viewing – moves the viewer away from the direct realization that this is/was the body of a real person, so much so that the text reiterates: "All the views you see are real – this man's body looks like this inside."

Body Zoom takes the objective stance of science even if it does not deal with scientific details. While the print media portrayal focuses on the themes of Jernigan's life circumstances, here they are minimised. Instead it is what Catherine Waldby, in her study of the Visible Human Project, described as, "... the body treated as organ-ism, as an assemblage of tools, whose value lies in its capacity as useful machine" (Waldby 2000: 55). Its useful capacity is as archive and map, terrain for anatomical study, tool for surrogate surgery, and finally, in this exhibit, tool for entertainment and education. In the science centre, it becomes a video experience based on, but far removed from, an actual encounter with Jernigan. In the tradition of other science centre exhibits, stereoscopic viewing technology provides visitors with optical experiences that may remind them of their own brain-based corporeality through the celebration of a high-tech re-creation of a virtual human.

It is a truism that it is not exhibits in science centres that provide real humans, but the visitors themselves. Indeed, of the 70 plus exhibits in the gallery on human biology only one (a display of the digestive system) contains any human tissue.[9] The visitor provides the corporeal, whereas, the exhibits are models and metaphors for various aspects of humans physically, psychologically, and often both. As Slinn remarked, "That's the nice thing about doing human body exhibits. Everybody brings in the raw

[9] A warning is placed outside the area that houses the exhibit that warns Native Americans of the presence of human tissue.

material for the exhibit to the science centre." By contrast, the material of the exhibit is de-personalised, de-contextualised, and in a sense, de-humanised.

There is an affinity here between the exhibit's implicit model of science as disinterested and objective and the treatment of the human body in science centre exhibits. The body looses its halo of taboo and/or squeamishness to produce such popular temporary exhibitions as Zap Surgery and Grossology,[10] and the many exhibits of the All About You galley, including Body Zoom. What might be thought of as science centres' least scientific aspect – their willingness to turn anything into a game, an interactive exercise, or object of fun – is equally a way of demonstrating that nothing for science is off limits, everything in ourselves and the world is suitable for exploration.

5.1.3 Pregnancy and Birth

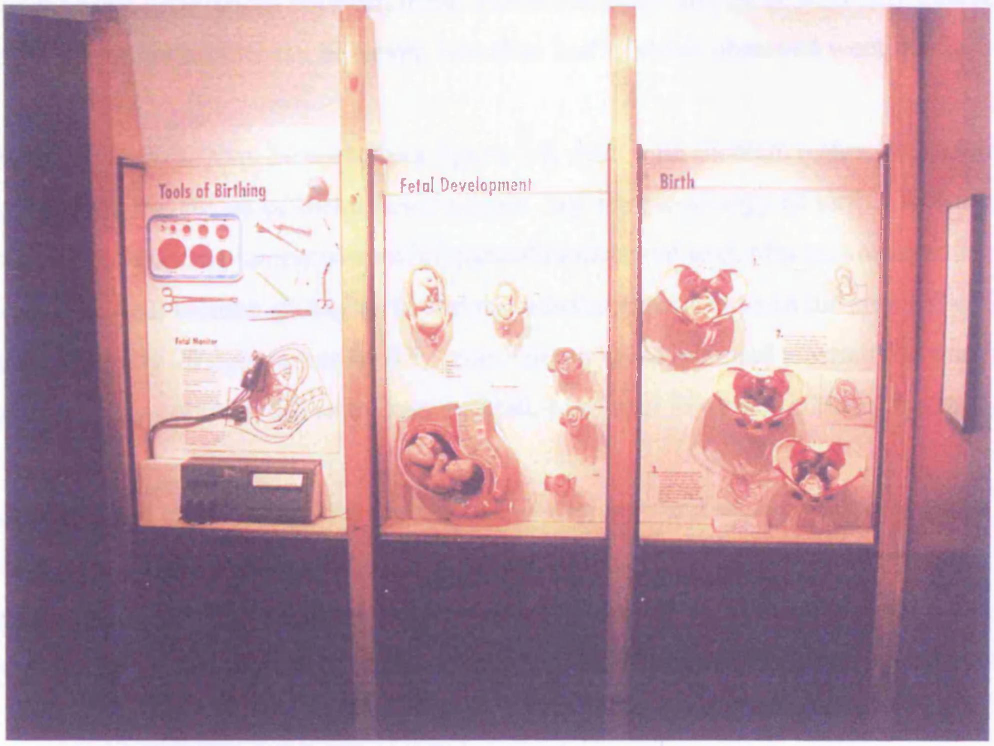
Close to the Wheel Chair Race exhibit and next to the All About You demonstration theatre (see map figure 5.1) is a set of six exhibits on pregnancy and birth. Part of the group is in the main exhibit area (figure 5.7) and part in an enclosed area behind (figure 5.8). The focus of the analysis presented here are the ultrasound exhibits.

[10] Zap Surgery has five modules, each presenting a specific surgical technology: lasers, endoscopes, ultrasound, cryosurgery, and the Gamma Knife. Grossology is described as a, "Science-in-disguise exhibition ... about many of the slimy, oozy, crusty, stinky things characteristic of the human body" (Association of Science-Technology Centers 2002 (March/April)).

Figure 5.7: Pregnancy and birth ultrasound exhibits

Figure 5.7 shows two video monitors. The monitor on the left has a shallow trough of water next to it covered with a plastic shield. A sonogram image is displayed on the screen when a button is pressed and a visitor's hand is submerged in the water. The video on the right has four buttons in front of the monitor, labelled "Face," "Heart," "Boy or Girl," and "Spine." Pressing each button shows a different sonogram video clip, ranging from 18 to 43 seconds. In the area behind the wall (figure 5.8) are four other exhibits on pregnancy and the delivery process, including a wall-mounted five-minute video of a birth (mounted to the left and above the exhibits, but not shown in figure 5.8).

Figure 5.8: Interior exhibits on pregnancy and birth



In May 2002, observations were made of 57 groups (with 120 members) who interacted or approached any of the pregnancy and birth exhibits. The total average time spent with the complete group of exhibits was 1 min 21 seconds, ranging from 5 seconds to just over 6 minutes. Time with the sonogram exhibits and those inside were calculated separately (only 12 visited both areas): average time with the sonograms exhibits, among the 45 who interacted with them, was 1 minute 6 seconds. The average time inside the area, for the 24 who went, was 1 minute 10 seconds.

For the sake of comparison, observations were also made of general visitors to the Center at the main ticket counter an hour or so before the exhibit observations. General visitors were 47 percent male, 53 percent female, 58 percent children, and 42 percent adult. Those interacting with the pregnancy and birth exhibits were 32 percent male, 68 percent female, 57 percent children, and 43 percent adult. Those attracted to the exhibits, therefore, were slightly more likely to be female (15 percent more likely), but just as likely to be children compared to the visiting public overall. There were no gender or age differences between those who went inside and those who only interacted with the sonogram exhibits, however, less than half of those observed went inside.

The inside area, as may be seen from figure 5.8, dealt with medical technologies used during birth, the stages of foetal development, and the physiology of birth. This area used traditional, non-interactive techniques of models and text, plus an auto starting video of a local woman giving birth that ran when someone entered the area. The area (approximately 70 square feet or 6.5 square metres) also included a bench for watching the video. By contrast, the sonogram exhibits were user initiated and user controlled.

Located in the gallery area, the sonogram exhibits were in a main circulation locale and were approached by most visitors walking by. As described above, the sonogram images produced by ultrasound were created by placing a hand in a trough of water or by pressing buttons to display short video clips. Label text, on the table to the left of the water trough and beneath the video screen on the right, were similar in tone to the language of the Body Zoom exhibit and dealt with abstract science and not its application or social significance. For example, the text next to the water trough was as follows:

> **Why can't I hear anything?** You can only hear sounds waves in the audible frequency range between 20 Hz and 20 KHz or up to 20,000 cycles per second. Sounds above this frequency range are called ultrasonic and sounds below are called subsonic. Ultrasonic units usually operate at frequencies between 305 and 7 MHz, or up to 7 million cycles per second. Our ears just can't hear those frequencies.

This text does not refer to pregnancy and birth or any other application of ultrasound technology. It does not even explain why the ultrasound demonstration uses water.[11] Instead, a rather technical description is given of the audible and inaudible range of sounds waves, stated in the form of an answer to a question that visitors were never

[11] Ultrasound waves are transmitted through matter (in this case water) and the composition of the substance determines the velocity of the sound wave that passes through it. When the waves hit a boundary between two substances (water and hand) there is a change in velocity and some of the sound energy is reflected back. This is transferred into graphical form on the monitor (sonogram).

heard asking or discussing. The connection to the topic of pregnancy is only made in the second short label text located next to the video clip buttons:

> **Why use sound waves instead of X-rays?** X-rays are high energy waves than can damage the fetus.[12] Ultrasound waves are low in energy so the fetus is not damaged during examination.

A number of writers have commented on the cultural significance of ultrasound, mainly from a feminist perspective (Cartwright 1995; Hentoff 1991; Kristol 1993; Petchesky 1987; Stabile 1992; Taylor 1987). Ruth Hubbard, for example noted:

> ... the use of ultrasound imaging has been the most crucial innovation for changing the cultural perception of the fetus. Earlier in the century, obstetricians had used X-rays to visualize fetuses, but that needed to be discontinued when X-rays were shown to increase the incidence of childhood leukemia. (Of course, no one knows for sure that ultrasound is risk-free, but so far no problems have been documented and it has become routine to use ultrasound imaging to visualize fetuses, during pregnancy.) Real-life ultrasound imaging has rendered pregnant women transparent and encouraged the culture to bond with "the fetus." Nowadays, fetuses are not only female or male; they swallow, pee, suck their thumbs, and their pictures can be shown to relatives and friends (Hubbard 1994: 312).

It is striking given this that no mention is made in the text about what ultrasound is used for medically or culturally. There is no mention, for example, of its use as a screening or diagnostic tool or as a routine method for determining gender. There is only mention of its preference over X-rays and, therefore, its endorsement as a safe technology.

The omission of any reference to the medical use and social meaning of ultrasound can be seen as a way of staying strictly within the science arena, avoiding any social and cultural issues, of which there are many. In particular, two controversies are avoided. First, the way Hubbard describes the pregnant woman as "transparent," points to feminist objections to a whole range of medical surveillance technologies that increasingly depersonalise women or view them as potentially harmful vessels to the foetuses they incubate as reproductive machines. Second, and as a corollary of the first, is the use of ultrasound technology to create representations of what can be called foetal

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[12] U.S. spelling retained in quotations.

personhood. Indeed, the "foetal person" features in a variety of settings today, including advertising (Taylor 1987), "first family photo albums" (Kristol 1993; Petchesky 1987), art installations (Cartwright 1995), and arguments on both sides of the abortion debate (Hentoff 1991; Hubbard 1994; Stabile 1992).

Despite what may be seen as the reticence of the label text, the endorsement of personhood of the foetus is not entirely sidestepped in these exhibits. The length of each video clip increases the more person-centred they become: "Spine" runs 18 seconds, "Heart" runs 30 seconds, "Face" runs 38 seconds, and "Boy or Girl" runs 43 seconds. At the end of the "Boy or Girl" sequence, the following caption appears over the sonogram image: "I'm a boy!" The text uses a phrase reminiscent of the announcement of a birth, except this is in the first person. Here it refers to a foetus, reflecting the way ultrasound technology is now routinely used to determine gender. As the phrase suggests, its use does even more and announces the foetal person (personally). It is perhaps no surprise, then, that ultrasound exhibits are encountered first, outside a set of exhibits on pregnancy and birth that are housed in a womb-like enclosure. It models exactly the way the visualising technology of ultrasound relates to broad cultural issues of pregnancy and birth, but without engaging those issues directly.

ASC staff who work in this area mentioned that mothers with children often go to these exhibits and talk about their experiences of ultrasound,[13] indeed, during the observations period reported above, several women were overheard discussing sonograms with children. One mother remarked to a boy of about eight years of age, "I have a photograph of you like that." No one was heard discussing the issues dealt with in the label text. Nevertheless, the exhibits bring up a set of extremely important cultural issues. The text may avoid mentioning them, but they are apparent and a connection is made, in the first family pictures sense, by at least some of those who are attracted to the ultrasound exhibits.

In the two groupings of exhibits interpreted so far – Body Zoom and the set of exhibits about pregnancy and birth – we are dealing with two relatively new visualisation

[13] From personal communications with Gallery Coordinators responsible for demonstrations and educational activities in the galleries.

technologies. They are included in a set of exhibits in a science centre on human biology precisely because they are new tools that have recently extended our ability to see and understand the human body. The exhibit text in both cases engages in an explanation of those technologies, but not the social or moral implications they raise. The technical aspect seems entirely within the remit of the science centre approach to science, but their cultural implications are not engaged and, perhaps, avoided. The implications of such new technologies are profound, however, for both raise fundamental questions about how far human life extends – one before birth and the other beyond death. Just like the technologies themselves, however, the science centre attempts to show them without commenting upon them. For Donna Haraway and others, however, neutral positions are impossible. She links the use of such instruments of visualisation to, "the history of science tied to militarism, capitalism, colonialism, and male supremacy" and sees a long list of such technologies as a form of "unregulated gluttony" (Haraway 1991: 188-189). Science centres are institutions that popularise and normalise new technologies, but without exploring their social and cultural meaning.

5.1.4 Food is Fuel

The next exhibit for consideration is Food is Fuel, in which a stationary bicycle attached to a pedal-powered turbine funnels air into a clear tube that raises a multicoloured ball into the air (see figure 5.9). This is quite different style of exhibit to Body Zoom: It is mechanically simple to operate, initiated by the visitor, and has a variable outcome. Most significantly, it involves the visitor not as a relatively passive viewer, but a more active, direct participant, using his or her whole body.

Exercise bikes are a science museum staple, with centres developing their own variations and interpretation on the basic model of a single peddling participant. ASC's example is one of its most popular exhibits, especially with children, and at busy times and whenever school groups visit, it is common to see queues of 10 or more visitors waiting their turn.

Figure 5.9: Food is Fuel Exhibit

From 51 observations of visitors made in February 2001, the average length of time at the activity was only 10 seconds. Activity was usually little more a fast pedalling action and then the next person in line would try. Seventy-five percent of those observed were children. A number of small children tried, could not reach the saddle, and gave up. Excluding those who could not peddle the exhibit, the average time increased to 15 seconds. The longest time spent was 1 minute 15 seconds. Only two of those observed, (both adults) read any of the label text. The basic activity of peddling was immediately understood from a general familiarity with stationary exercise bicycles, but as explained below, few participants showed the behaviour expected by its designers.

The label text explained that if a visitor peddled for one hour they would burn the equivalent calorific value of various foodstuffs marked on the clear tube. For example, the lowest point on the tube was marked by a picture and the caption "About ten grapes," a little higher was a picture and the caption "About 1 carrot," etc. Exhibit label text on the front of the tube was as follows:

> **Food is fuel**. Your body uses food for energy. The labels on the cylinder show you how much food you would have to eat to keep the ball floating at that level for an hour.
>
> Of course, you wouldn't need to eat the same food that is shown on the cylinder; just food with the same amount of calories. Pedal the bike and see how food efficient you can be.

In contrast to the Body Zoom label text, the reader was addressed directly throughout and was told what to do and what to notice. The simple concept of the exhibit, as the text explains, was to show the relationship or equivalence in calorific terms between exercise (body output) and the body's fuel (input shown as various foodstuffs), although there was no explanation of calories.

This is a classic design for an interactive exhibit: the visitor does something with their body (peddles a bicycle) that produces a change in the exhibit (raises the ball) and the effect is controllable and continuous, that is, the ball goes up or down with the rate of peddling. The combination of physical activity with control over the effect is very rewarding. It is, perhaps, no surprise, therefore, that this is a popular exhibit in terms of attraction, even though it does not involve sustained activity or holding power. No one, of course, was expected to peddle for an hour, but visitors might be expected to match up a rate of peddling with a chosen food marked on the tube (this was difficult to observe, but was recorded only once among those observed).

Despite the short amount of time visitors spent, the exhibit exemplified many of the characteristics that social psychologists refer to as "flow." Flow is experienced in intrinsically rewarding behaviour: the task was within the ability of visitor to perform, there was a limited field of stimulus, and the action to be performed was clear and provided unambiguous feedback (Csikszentmihalyi and Henderson 1995). These conditions were first applied to the art museums' aesthetic experience and then seen as highly desirable characteristics of science centre exhibits too (Csikszentmihalyi 1988).

Marlene Chambers used the flow concept to critically compare information-driven exhibits that strive to teach "specific facts or principles" to experience-driven exhibits that promote "flow:"

> … the ultimate goal of providing a discovery opportunity is to give the visitor a flow experience: a sense of being competent and in control and a chance to find new, personally significant insights in the activity (1990: 11).

Chambers recognizes that "flow" is an experience that experts in a given field often feel, but novices do not. Thus, the kind of experience the expert may have with this exhibit can be expected to be quite different from the novice. The terms "expert" and "novice" are not defined in any formal way, for the expert in this case does not need to be an expert in medical science. They can simply be relatively knowledgeable about the connection between exercise and diet, which, presumably a large percentage of the population are (adults in particular), many having used sports exercise equipment for precisely the effect the exhibit is meant to illustrate. For the novice this might be a new discovery, for the expert the confirmation of an understanding already possessed albeit in a novel form. Thus, for Chambers, the trick for this or any other exhibit is to find activities for novices that "... facilitate discoveries that share the nature of the expert's flow experience" (1990: 11). The Food is Fuel exhibit both passes and fails this test, because there is a "flow" experience most novice visitors feel, but this is not the same experience experts have about the confirmation of their knowledge of food as fuel, nor the experience intended by the exhibit designer.[14]

The majority of "novice" visitors peddle as quickly as possible to see how high they can make the ball go in the tube. The most vigorous try to see if the ball can be made to eject out of the open top and, as reported above, the activity is usually completed in a matter of 15 seconds or so. Children can often be observed waiting in line to see if they can make the ball go higher than those ahead of them and conversations are very often about who was the "winner." A form of flow experience is apparent in this activity, after all, it is within the ability of almost everyone who tries to peddle the bicycle, their attention is focused on the limited field (making the ball rise), and the feedback is clear (peddle faster and the ball goes higher). Visitors clearly enjoy the exhibit as experienced in this way and complete it to their satisfaction with a sense of accomplishment, but one may doubt that the "intended" or expert discovery is often made. As noted above, visitors rarely read the text (it is sited beneath the cylinder and cannot be read at the same time as peddling) and very few show behaviour embodying the explanation in the text (with the ball hovering at a particular food item for any extended period of time).

Paradoxically, the immediate reward of the exhibit (knowledge of how high the ball can go) may block further discovery and enrichment. In effect, the immediate reward of the exhibit extinguishes further exploration. This is significant if we consider that in some sense science centre exhibits are devices that give rewards, rather like food rewards given to animals in classic psychology experiments. In this case, however, the public has created an alternative reward system, perhaps because of inherent design difficulties. To peddle fast and raise the ball is intrinsically satisfying, as is the challenge to compete. These rewards are consumed without any need to consider the more abstract rewards of discovery of a connection between food and exercise. Another way to say this is that many visitors do not make inferences about the unobservable phenomena even when a device is expressly created to do so. Instead, satisfaction

[14] The "intention" was extrapolated from the label text and confirmed later in conversation with Grant Slinn.

comes from simply mastering the device by knowing what to do and experiencing immediate feedback from it. In effect, participants may master a device and extract a reward without ever discovering the scientific idea or principle it is meant to demonstrate; unless they make a connection to knowledge they already process (in this case, riding a stationary bike burns calories). In terms of the distinction introduced above, the experience may be called an unintended "flow" experience.

Whether this exhibit should be considered a failure depends upon how it is judged. As a didactic teaching device that illustrates a principle, it may well fail for most, although those who read the label text or subsequently make connections to ideas in other exhibits that are close by may learn the intended message and thereby gain the "expert" knowledge. As an experience that provides a feeling of satisfaction, however, it passes the test for almost all. Chambers argues, "After all, it is these feelings of satisfaction – not the information learned – that motivate repeat experiences and continued learning" (1990: 11). Here though, one feeling of satisfaction may, arguably, block the discovery of another. Ultimately, what may be blocked is the simple information that the user's energy input, framed as a floating ball, is an index of food-equivalent calorific values.

While this account could be read as a critique of the exhibit with an expectation that recommendations for improvement would follow, a more important and general issue is raised: visitors may be expected to create their own reward system no matter how hard the designer tries to control the situation. This may be thought of as an alternative or resistant reading of a text. That is, the path taken by some visitors is one of resistance to the intended meanings constructed by designers as authorities. The user is employing what de Certeau characterized as a "tactic" when faced with the "strategies" that are imposed on meanings by those controlling the systems of knowledge (de Certeau 1984, 1997; de Certeau et al. 1998). Such a perspective provides an important alternative to a view that sees visitors as naïve users (Borun et al. 1993) or simply consumers without an active role in the activities exhibit designers provide for them.

De Certeau saw ordinary people as spending their lives in circumstances in which "... the weak make use of the strong" (de Certeau 1984: xvii). They are willing to pay for an enjoyable activity in the museum setting, but that does not mean they are predisposed to compliance with the intentions of interpreters of scientific knowledge who are not even present. John Fiske has used this perspective to understand many of the evasions and alternative meanings consumers make in resisting the political and economic hegemony imposed by the producers of popular culture (Fiske 1987). One may also expect resistance to messages in other cultural areas, including to the science of science centres. The model that Fiske creates of the "places" and "spaces" of everyday life apply as much to science centres as the institutions he cites:

> The powerful construct "places" and "spaces" where they can exercise their power – cities, shopping malls, schools, workplaces and houses, to name only some of the material ones. The weak make their own "spaces" within those places; they make the places temporarily theirs as they move through them, occupying them for as long as they need or have to. A place is where strategy operates; the guerrillas who move into it turn it into their space; space is practiced place (Fiske 1989: 33).

Resistance can come in two main forms: a reluctance to move from the surface experience to the underlying principles or the substitution of alternative explanatory frameworks for the one provided by the science centre. Either way, the interactive exhibit of the science centre is open to criticism: if it controls too much it is authoritarian, if it controls too little it encourages mindless play (Yahya 1996). There is no research on the notion of alternative or resistant readings to science exhibits, perhaps because the authority of science exhibits is rarely questioned, but this example demonstrates how it could be tackled and interpreted.

5.1.5 Wheel Chair Race

The paradox of alternative rewards is even clearer in the Wheel Chair Race exhibit (figure 5.10). The difference is that this exhibit expressly invites some visitors into a competitive game and others to be observers of the consequences. Here, then, is a single exhibit which separates the two modes discussed so far: observers and embodied participants.

The exhibit has two wheel chairs for visitors to race.[15] A video screen in front of each participant counts down the start of the race and then displays their speed in miles per hour and a bar graph of progress towards the finish as they race each other on the steel rollers the chairs are attached to. Each race takes just over two minutes and virtually all participants complete the activity once seated. Again, this is a very popular exhibit and often long lines form; thus, it has both high power of attraction and high holding power.

Figure 5.10: Wheel chair race exhibit

The exhibit is surrounded by framing on two sides, which has attached to it the following label text (the three panels on each side of the exhibit also include cartoons of people taking exercise and the exhibit's back panel shows photographs of athletes, including one in a wheelchair):

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[15] Again, many science centres have different versions of this exhibit. For example, at the Tech, San Hosea and the Great Lakes Science Center, Cleveland, racing wheelchairs are used.

First Panel: Want to keep your arteries clean? Try exercise!

Exercise makes your heart stronger. With each beat, a strong heart pumps more blood than a weak heart. More blood pumps through your arteries and veins and helps clean out fatty sludge.

A dedicated athlete who works out a lot, like a basketball player or a wheelchair marathoner, has a very strong heart. Strong hearts beat slower than weak hearts, because they pump more blood with each beat. These athletes can have heart rates as low as 40 beats per minute.

A typical healthy heart beat rate is between 60 and 100 beats per minute. The athlete is pumping as much blood as the typical person, but in fewer beats, therefore, the athlete's heart is far more efficient.

Second Panel:

Exercise makes your heart stronger and helps your lungs expand. You grow new capillaries to feed your new muscles.[16]

Third Panel: Exercise -- It's Good for You!

Exercise changes your body in many ways, and that's usually good news. Regular exercise, like biking, dancing, swimming, walking, lifting weights, or racing in a wheelchair, builds muscle. Bigger, stronger muscles are better at walking, running, breathing, and pumping blood. But bigger muscles need more food. When you exercise and build muscle, your body grows new capillaries (tiny blood vessels). These capillaries bring food and oxygen to your growing muscles.

Exercise also helps your lungs expand to take in more air. That means that you can get more oxygen to your cells with each breath. Your blood delivers oxygen and food to your cells more efficiently. Also, the muscles in your digestive system get stronger. This helps you use the energy from your food better.

The text here goes beyond mere scientific explanation to advocate the many virtues of exercise. It is also quite long, almost 300 words in total. As a passive observer and reader, visitors are expected to able to read at least some of the text as they observe what they should be doing. As active participants, visitors do the right thing. Visitors taking part in the race become part of the exhibit for those surrounding it and simply embody the principle as illustration.

In a sense, this exhibit is doubly communal: active participation is socially competitive (which models the common form of child exercise), the virtues of which form the focus of observation for non-active participants; it also creates performers and audiences. At any one time, as many as 20 people may be engaged in and by this exhibit – two participants and their many observers. Visitors often pass from one role to the other, but the roles are clearly distinct conceptually and physically. For those performers in the race, there are no messages displayed about the nature of exercise or the advantages of an efficient heart; they only see instructions and feedback from the progress of the race. They are active physical participants, contrasting with the surrounding visitors' relatively passive role as audience to observe and read. In general, children make up the performers and adults the audience.

Similar to the Food is Fuel exhibit, the rewards of competition may block or override the other forms of experience and learning for similar reasons. This is true for both performers and audience. During observations of the exhibit, teachers were heard discussing who went faster, but no teacher was heard talking about the nature of exercise or what makes a good athlete. Both groups were redirected to the race's outcome rather than the lesson and advice found in the label text. In this exhibit, the reward (winning the race) is displayed at the end in time, average speed, and maximum speed, but not in terms of heart rate.

This exhibit distributes different goals and rewards to its different participants. To those racing the wheelchairs, the goal and reward is play in the form of competition. For those observing, the goal and reward is to understand the virtues and mechanisms of exercise. A secondary argument carried in both text and exhibit is that disability is not an indicator of fitness. In a sense, the exhibit distributes the play and learning roles among its participants. Ibrahim Yahya sees these two aspects as intrinsically linked in science centres, resulting in the goal of "mindful play" (Yahya 1996). In this example at least, we can see that these functions, although both available through the exhibit, may not always be participated in simultaneously.

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[16] This panel includes cartoons of a heart, lungs, capillaries, and a person exercising on inline-skates.

The element that may connect them for both performers and audience is conversation during and following the activity. What this example points to is how in a single exhibit different forms of activity and learning may be distributed; that interactive exhibits can also distribute the embodiment of a phenomenon (the person on the wheel chair feels the exercise, the observer watches it); and the form of experiential and informational feedback can be quite different.

This exhibit, ostensively about exercise, also carries indirect social and moral messages that layer upon each other. Exercise is good for you; competition is healthy; disability does not mean unhealthy; disabled athletes are fit, and so on; suggesting that a form of advocacy can be incorporated as long as it is not too overt or socially or morally controversial. For the observer, these are conclusions to be drawn from reading the label text, looking at the images, and observing the race. For race participants these are statements made true by their enactment.

Food is Fuel and the Wheelchair Race exhibits are relatively simple. Simple in the sense of involving easy-to-accomplish physical activities that demonstrate simple science concepts with which a number of participants may already be familiar. Even so, this discussion shows that there is no guaranteed outcome or straightforward way to ensure a connection is made between activity and underlying principle. This interpretation suggests that success may be counted in a number of ways that do not always include the direct connection of activity to *intended* outcome[17] and that other goals and visitor uses also need to be taken into account. The next section considers these issues in more detail.

[17] General intended outcomes were formulated as part of conceptual planning for the gallery and included in confidential planning documents. The conclusions about intended outcomes drawn here come from personal communications with key informants, particularly Grant Slinn, and an exhibit designer who helped develop the gallery design and layout.

5.2 Legitimation through doing

5.2.1 Two models of science

The exhibits examined in detail in this chapter fall into two broad types: those that demonstrate basic principles of science (Father's Nose, Food is Fuel, and the Wheel Chair Race) and those that introduce relatively new technologies (Body Zoom and those dealing with sonography). The latter are exhibits about technologies that have recently become widely used, but may not be well understood by the public; they are still "black boxes" for their scientific communities in the sense discussed above (section 1.2.1, page 7). This distinction suggests that there is a dual notion of science circulating in science centres. A similar concept of science, suggested by Shawn Rowe, was the focus of his short report on the differing perceptions of the term "science research" found among thirty staff members at the St. Louis Science in Missouri and three scientists and university educators. Rowe drew the following conclusion:

> Informants felt either that (1) science is a highly specialized endeavor that requires a great deal of investment in money, time, and training, and therefore is basically beyond the lay person, or (2) science is a way of seeing the world that requires curiosity, some skill and knowledge, and the ability and willingness to ask questions, so it can be open to anyone (Rowe 2001: 6).

He calls these two views "science as inquiry" and "science as lab work," respectively. While these two notions are logically opposed, he also found that most of his respondents articulated both views, "... depending on factors such as the type of science research they are talking about (palaeontology vs. physics) or the audience they are thinking of (lab work for school groups or summer camp vs. inquiry activities for families)" (Rowe 2001: 6). What Rowe found for staff perceptions of science is also manifest in their exhibit products. Those found in the various galleries at ASC, for example, can be seen to fit either and sometimes both of these models. The niceties of logical consistency are clearly not to be found in the real world of science centre exhibits and, arguably, this is how it should be.

The notion of science found in science centres reflects notions found in society at-large and, indeed, both conceptions are part of general societal understanding of modern science. On the one hand, science, as discussed above, is understood to be that branch of knowledge that explains the basic operations and mechanisms of the world and can be explored by anyone through hands-on and interactive inquiry and observation. On the other hand, professional scientists create scientific knowledge using highly specialized technologies and techniques not open or available to the public.

At the Arizona Science Center, many exhibits engage this first conception, among them are those exemplifying the basic physics of simple machines or the psychology of visual perception. These form what might be considered the "basic suite" of exhibits found so often in science centres. They derive in large measure from those developed in the late 1960s by the first science centres, which in turn derived from pedagogical and recreational scientific devices of earlier periods. But the second conception can also be found in exhibits that show newer technologies and relatively recent "scientific breakthroughs," some of which may be considered examples of the new Public Understanding of Research movement discussed in section 1.2.1 (page12) above.

The Body Zoom exhibit exemplifies both notions of science (section 5.1.2, page 127). Using special glasses, the visitor is invited to into a personal exploration of a 3D projection system, explained in terms of the visitor's visual perception. At the same time, the exhibit's content is elucidated as a break-through, nationally sponsored science project on human anatomy and its use in medical education and research. As a model of science pedagogy there is no ambiguity in promoting both models of science, for the (general) "science as inquiry" model is seen to be a preparation for the (specialised) "science as lab work" model. The public is so familiar with this model of knowledge acquisition and socialisation that it is often difficult to see it in operation. The model in fact involves several steps for "science as inquiry" involves moving beyond simple discovery and play to generalisation and conceptualisation (as described above). Not that scientific concepts can be derived unaided, an "expert" mediator (as exhibit, text, or a Demonstrator) must be present to link "surface" phenomena with an "underlying principle" that explains it. The underlying principal often involves the use of technical language and, therefore, inculcation into specialist knowledge – the first model of science, thus, preparing the way for the second.

Steve Fuller sees this model as playing an important part in the maintenance of capitalist social and economic order. Our educational system is deeply implicated for to insist on "... a mastery of Newtonian mechanics before someone can practice engineering" is part of a strategy by its producers, according to Fuller, to standardize, control, and credential scientific knowledge (Fuller 1997: 133). Fuller suggests that this "overdetermination" of knowledge has resulted in a retrospective rewriting of history obscuring the fact that, "Until the late nineteenth century, virtually all economically relevant technological innovations had been introduced by people whose formal scientific training was patchy at best" (Fuller 1997: 103). This metaphoric "retrospective colonization of the past" is also literally part of colonization when:

> It can also be seen in efforts to Westernize Third World curricula for purposes of rendering the natives 'governable' by making them epistemically accountable to standards that Western authorities can understand and evaluate (Fuller 1997: 88).

The importance here is that the "informal" educational institution of the science centre is as deeply involved in this model as the "formal" system of school and university. It can be found in ASC's mission statement that aims, "... to inspire people to discover and enjoy science using programs and exhibits that emphasize education through interaction," while it also "seeks to connect the school community and youth-serving organizations to Arizona workplaces, so that youth may identify with a productive future." The unresolved tension is that we are all scientists (first model), but some of us are more scientists than others (second model).

5.2.2 The Embodiment of Science

A key element of the science centre experience, and one not fully captured by the terms interactive or hands-on, is that, through embodied experience, abstractions become concrete. The supposed *objective* truths of science, as they are discovered in interactive exhibits, are experienced *subjectively*. Objectivity and subjectivity merge, or rather the latter guarantees the veracity of the former. This is particularly the case for exhibits of visual perception (although not exclusively so, the exhibits examined above do the same), many of which were first developed in the first half of the nineteenth century as scientific apparatus and soon became domestic amusements. Jonathan Crary in his examination of thaumatropes, phenakistiscopes, zoetropes, kaleidoscopes, and stereoscopes (all of which can be found in modern science centres) points to the way they "collapse" objectivity and subjectivity:

> In fact the very physical position required of the observer by the phenakistiscope [and other optical devices] bespeaks a confounding of three modes: an individual body that is at once a spectator, a subject of empirical research and observation, and an element of machine production. This is where Foucault's opposition between spectacle and surveillance becomes untenable; his two distinct models here collapse into one another (Crary 1990: 112).

Crary explains that scientific interest in visual perception during this period was in part a product of the demand for knowledge about humans who could be trained for industrial production, given its need for repetitive and rapid hand-eye coordination. Most of the visual perception exhibits at science centres are now little more than forms of curious amusement and demonstration of the psychology of perception, rather than serious scientific study. Nevertheless, they can be understood as a training-ground for the recreational, scientific, and technical devices of adult life and work where rationalized and controlled seeing (see figure 5.4) and manipulation are taken for granted.

It should also be noted that these devices were developed during a period in which the scientific experimentation was very often performed on the experimenter's own body. Andrew Barry makes the important link between this fact and interactive exhibits:

> Since the late nineteenth century, the significance of a scientist's body to experiment has changed. The body of the practicing scientist has become disciplined, capable of performing meticulous practical tasks and making exact observations, but no longer serving as an experimental instrument in itself... Experimental events are no longer *experienced* by the scientist; they are *recorded* by the scientists' instruments. By contrast, the relatively undisciplined body of the visitor has an increasingly important part to play in the contemporary science museum and what is often called 'the science centre.' ...

> In a manner foreign to the practice of contemporary experimental science, the body is itself a source of knowledge (Barry 1998: 100).

That is, as examined above, exhibits mediate knowledge through the body, letting users feel, touch, hear, smell physical forces, and explore their own perceptual apparatus. They are, thereby, mimetic, not of contemporary scientific activity, but the entire social apparatus of self-discipline and self-regulation and the human science's simultaneous treatment of people as both the subject and object of knowledge. These concerns are at the heart of Michel Foucault's analysis of modernity. Science centre exhibits can be seen as models for much of what Foucault wrote about the "human sciences" and the operation of knowledge and power in society (Foucault 1972, 1975, 1979a).

If it is true that embodiment is a characteristic of science centre activities but not lab activities, then the assumption in much of the understanding of science centres from Oppenheimer to Rowe of "doing what scientists do" may need to be re-conceptualised. This perspective also suggests the use of the body, particularly when it does not mirror practice, may be better understood as symbolic and ritualistic activity. Those who are not yet part of science (children) or who live largely outside it (adults who are not scientists) can visit and, in a very short period, directly experience as performers or give witness to as audiences the veracity of both models of science discussed above in this special place set aside for science. Such ceremonial activity requires neither the meticulous discipline of technical mastery nor years of education. In the liminal zone created by this special environment an experience of intensification can ritually affirm the claims of science. This perspective does not suggest that learning in these circumstances is unimportant, but rather non-cognitive elements are also extremely significant. It is the doing as much as the thinking that makes science true.

Where embodiment is it own guarantee of veracity and where exhibits are designed to unfailingly provide such experiences there is little room for debate or dialogue. Interactivity is not dialogic. That visitors make their own uses out of that which is given does not diminish its symbolic significance. It is the nature of rituals that they make things true by their enactment. In practice, the visitor has only two options: endorsement of the message provided or the creation of a contrary message "of the weak" (as Fiske and de Certeau would describe such an alternative "reading"). Even where such alternatives are taken up, there is no possibility of engaging the basis of this message or changing it. We can see varying levels of interaction within the two models of science, but no interaction with the model itself.

This chapter has explored the issue of performers and audiences using exhibits. The next chapter pursues these ideas further with a consideration of science centre planetarium shows, giant-screen films, and scientific demonstrations.

6. Shows at the Science Centre Shows: Seeing Science

This chapter deals with components of the science centre experience that are rarely considered in museological literature, namely, the various forms of science shows. This exclusion is largely a result of a perspective that defines science centres as quintessentially concerned with interactive or hands-on exhibits and then takes this central feature as the complete offering, but as examined below, many of the components of a science centre visit are decidedly hands-off and non-interactive, where visitors become an audience. Three forms of presentations for audiences are discussed: Planetarium shows, which are available in 26 percent of U.S. centres; giant-screen film shows, available in 16 percent of U.S. centres; and science demonstrations, available in virtually all U.S. centres (Association of Science-Technology Centers 1998).

At ASC, both planetarium shows and science demonstrations are created and presented in-house by staff (or adapted from material from other organizations). Scripts are examined from each type of presentation in the analysis that follows, except film. Giant-screen films are produced by independent film companies and shown throughout the world in facilities with appropriate technology; therefore, the analysis provided here is a more generic examination of the nature of such films and their significance for science centres.

Each of these types of presentation has its own qualities, but an important characteristic they share, and which may have led to their neglect in the literature, is that they do not offer a direct experience of science. These presentations may also be seem as forms of entertainment and, therefore, not given the scrutiny of educational exhibits, although there are a few studies that touch on related issues and there is an anthology on the use of drama and live presentations in science-technology centres (Bridal and McCormick 1991; Farmelo 1992; Olsen 1997).

As described above, exhibits are actively chosen in a context of free choice (the visitor must actually select, walk up to, and engage with each exhibit) and once choices are made visitor behaviour often involve direct hands-on contact with phenomena and/or visitor-device interactivity. In planetariums, giant-screen presentations, and science demonstrations at science centres, however, the visitor forms part of an audience in varying degrees of experiential immersion. The audience is out of direct contact with any physical activity or has only restricted freedom to initiate a choice of action. In addition, tickets for planetarium and film shows must be purchased in advance (often at separate entrances) and are, thus, not encountered within the free-choice setting (this is not true of demonstrations, however, as is discussed below).

Compared to the active nature of exhibit encounters, audiences at science shows are more witnesses than they are participants. To say this is not to imply that audiences are not mentally involved, but simply that the involvement is different from the direct physical choice and action found in other contexts. Science centres also promote themselves as places of active learning, suggesting an implied criticism of "passive experiences" in general and traditional science "chalk and talk" teaching methods, in particular. The theoretical significance of this distinction is apparent when we analyze museums from the perspective explored by Foucault of disciplinary institutions of social control. The implications of Bennett (Bennett 1995) and Hopper-Greenhill's (Hooper-Greenhill 2000) historical accounts would suggest that museums are generally moving away from nineteenth century disciplinary forms of the "exhibitionary complex" to less socially controlling techniques of display and interpretation and yet these new "audience" experiences are increasingly part of the museum experience, perhaps suggesting an overlooked countertrend.

6.1 Planetarium Shows

ASC contains a planetarium or, more properly, a digital-domed theatre, for it can and does display more than simply traditional star shows. A text panel at its entrance provides the following description:

> A state-of-the-art Digistar projector, moving video images, and more than 50 slide projectors turn the planetarium's 60-foot-diameter dome into an exciting virtual world. It can replicate the desert night sky, explore the interior of a living cell, travel across the solar system, and simulate whatever human imagination demands. Each of the planetarium's 206 seats are [*sic*] equipped with an interactive armrest, giving the audience an opportunity to provide feedback and choose the direction of the show. And the planetarium staff give each program a personal touch, delivering information in a fun and interesting fashion.

Approximately 42 percent of visitors to the Center attend planetarium shows (included free for members).[1] Three or four different shows are given five or six times a day in repertory, each show usually lasting approximately 40 minutes. Titles of presentations during the Center's first four years were: Are We Alone?, Arizona Skies, Black Holes, Family in the Sky, If the Earth Were the Size of a Baseball, Grand Tour of the Planets, Invisible Universe, Jurassic Planet, Light/Speed, Mars Mysteries, Moon Walkers, PlanetQuest, PlanetQuest 2000, Stargazing in Arizona, and Super Nova.

The current immersive planetarium theatre experience is the result of a series of technological advances that build on those developed for the first planetarium in 1923 by the Carl Zeiss optical company of Germany for the Deutsches Museum, Munich, Germany. Even though the technology and range of subjects that can be treated has changed significantly over time, certain elements have remained: optical images of celestial bodies are still projected on to hemispherical domes, reproducing changing views of artificial night skies. New technologies and astronomical knowledge now allow views of the universe far beyond Earth-centred perspectives and planetaria are increasingly adding non-astronomically-based content.

ASC's planetarium shows are created by its staff and utilize projectors, moving video images, and its star projector to create a wide variety of special effects. The Digistar equipment at ASC, for example, is not only able to project stars, planets and moons, asteroids, comets, meteors, ellipses and transits, etc., but also mathematical models, chemical structures, architectural models, and so on.

The audience uses armrests to provide feedback in the form of answers to questions and voting for which topics to pursue during a presentation. Unlike many other planetariums, ASC uses live presenters to narrate show scripts. While the voting technology provides some level of interaction, making the presentations less than an entirely passive experience, as will be described more fully below, the audience may respond to, but not directly initiate, action.

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[1] This figure is based on ticket sales for the first four years of operation (April 1997–March 2001).

Planetariums are often associated and confused with astronomical observatories, but a broader interpretation associates them with such technologies and representational techniques as "magic lantern" shows, panoramas, dioramas, and other non-natural forms of visual display experienced at museums, expositions, world's fairs, and, more recently, theme parks. Today these techniques include giant screen films, immersion virtual reality, 3-D holography, and so on; all technologies and techniques of simulation by which nature can be encapsulated and presented to observers. An important common characteristic noted by Scott Bukatman is the way these forms often use technologies of representation to stimulate cognition and contemplation of the sublime[2] in a world of technological powerlessness. While Bukatman did not specifically include planetariums, they clearly belong to the same set of techniques:

> The overwhelming perceptual power granted by these panoramic displays addressed the perceived loss of cognitive power experienced by the subject in an increasingly technologized world. In acknowledging anxiety while ultimately producing a sense of cognitive mastery, these entertainments frequently evoked the rhetorical figures of the sublime (Bukatman 1995:255).

Of course, the planets and stars of the night sky have been a source of awe and fascination for millennia and their simulation in a planetarium is just a modern site for their contemplation and for the contemplation of humanity's place in the cosmos. By virtualizing the experience, though, the technology that is used to simulate the natural wonder also functions to provide the sense of "cognitive mastery" that Bukatman refers to.

The ASC planetarium is a central feature of the building and occupies some 6 percent of the floor space of the centre. Antoine Predock, the architect, described it as an artificial sky that simultaneously forms the floor of the open-air Sky Terrace above it, from where the real sky can be viewed (Predock 1999b). This interplay of the real and the simulated is, thus, exploited in the building's very structure, but is reconciled or merged in the planetarium when the audience reacts to the artificial sky *as if* it were real. Immersed in the experience beneath the 60-foot domed ceiling, in their upward tilted

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[2] Etymologically, the term sublime comes from the Latin, referring to the uplifted, high, and possibly originally refers to sloping up to the lintel (*sub-* up to + *limen* lintel), which is paralleled literally in the planetarium with its sloping, domed ceiling.

seats, audiences are warned before each show to look away should they experience motion sickness (figure 6.1). The troupe works because the body accepts as real that which the mind knows is only a projection. The sense of awe and fascination from contemplating the star field is enhanced as the body feels movement through space, particularly when the sky is rapidly rotated to a different viewing angle. The double sense of anxiety and mastery associated with the sublime comes to the fore with each special effect the Digistar technology produces.

Figure 6.1: Publicity photograph of ASC's planetarium

The script of the ASC authored PlanetQuest 2000 presentation has a number of elements that exemplify the way the sublime is presented and the way in which science and technology provide reassurance faced with audience astonishment and awe. The often-used museum troupe of a journey provides the narrative structure for both the transcendent experience and its explanation.

PlanetQuest 2000 ran in the summer of 2000 and was mostly seen by family group visitors. The presentation used a mixture of Digistar effects, including projected star fields, still photographs, video, animations, and "wire-frame" simulations. Each show was narrated and led by a live presenter who also answered audience questions as the show progressed. The audience entered the theatre with backlights illuminating the dome's underlying steel framing, evoking a sense of science-fiction spacecraft architecture. The experience was thus literally and metaphorically framed by technology.

The presenter opened the show with the question, "How many times have you been on the Dorrance Planet Cruiser?"[3] This introduced the space travel notion and enabled the audience to become familiar with the built-in armrest technology that allowed them to select one of three options projected on to the dome. Their voting choices for this question were, "Never," "Once," "More than once." The results were immediately tallied and displayed on the dome as a bar graph and frequency distribution. This technology, thus, allows for a basic level of participation and choice. The audiences for PlanetQuest 2000, for example, were allowed to vote for which type of solar system journey to take: "Possible sites of life in our solar system" or "Extremes in the solar system".[4]

Feedback from evaluations of audiences for many planetarium presentations suggests audiences find the voting technology one of the most enjoyable aspects (Arizona Science Center 1998f, g, h, 1999a, c, 2000h, 2001b). The voting technology is generally used to test the audience's knowledge of the topic of the presentation, although this was

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[3] The planetarium is named after the Dorrance family, patrons of the centre.

[4] Quotations included here come from both "tours."

not part of PlanetQuest 2000. Whether used to determine choices or as a quiz, votes are always displayed on the doom and then the most popular or correct answer highlighted.

The use of computer technology became part of the story line in PlanetQuest 2000 where the live narrator repeatedly asked the computer to provide information or execute a command. In the opening segment, for example, the live narrator said: "While we're waiting for the computer to finish running through its final checklist, let's go ahead and take a look at our itinerary. Computer, please show us our Solar System." More than a technological tool, the computer becomes a character and active participant in the drama. The pre-recorded voice of a staff person taking the part of the computer provides a detailed description of an animation of the solar system:

> Mercury is the closest planet to the Sun, orbiting once every eighty-nine days, at an average speed of sixty million km, or 36 million miles. Next is Venus, at 180 million km, or 67 million miles. Venus takes 225 days to complete one orbit. Earth is 150 million km, or 93 million miles from the Sun. It takes 365 days to complete one orbit. We call this a year. At 230 million km. or 142 million miles distant is Mars, taking 687 days, or almost 2 Earth years, to circle once. Jupiter, the first of the gas giants, is 780 million km, or 486 million miles from the Sun. It takes 12 Earth years for one orbit. Almost twice as distant as Jupiter, Saturn orbits once every 30 years at a distance of 1500 million km or 890 million miles. Next is Uranus, almost 3 billion km distant, or 1800 million miles. A Uranian year is 84 Earth years long. Neptune at 4 and a half billion km, almost 3 billion miles from the Sun, takes 165 Earth years for one orbit. At the very edge of the system lies the twin planet Pluto and Charon, 6 billion km, or almost 4 billion miles from the Sun, it orbits once in every 250 Earth years.

The computer delivered this kind of detailed, fact filled information whenever the presenter requested information. The live presenter also delivered scientific information, but often commented on from the audience's perspective. Following the computer's summary of facts about the solar system, for example, the narrator commented on how the solar system appeared on the dome before again asking for information from the computer:

> Notice that the planets are not ever truly lined up in a row; on our trip today we won't be visiting them in the order they are from the Sun. .... Computer, what can you tells us about the Sun?

The computer as authority within the story of the PlanetQuest 2000 was a consistently reliable source and guide. Questions of the form, "Computer please report on Mars," "Computer, could you please give us background on Jupiter, before we go exploring one of its fascinating moons?" provided the literal and metaphorical device that delivered a stream of detailed planetary space facts.

The "computer" was also treated as the controller and monitor of the space vehicle and reported on the supposed conditions outside the space ship as it "moved" through the solar system. At the beginning of a segment on Venus, for example, the live narrator remarked, "We have an external probe on the outside of our Planet Cruiser. Computer, please report on its findings." The computer also took the ship to each destination voted on by the audience. Finally, the computer returned the audience to Earth by the means they voted for: a "roller coaster ride" or a "slingshot through a wormhole," both of which use wire-frame animation techniques to simulate rapid movement through space. These special "ride" sequences are often reported as among the most enjoyable elements in the overall experience.

The PlanetQuest 2000 script also used many references familiar to audiences of pop-culture films and television presentations of space science-fiction stories, including futuristic forms of propulsion and space colonisation:

> We don't use old-fashioned rockets anymore. Now we rely on 24th century rail-guns to accelerate us into orbit. Here goes!
>
> Prepare for landing on Triton. Beautiful isn't it? There are rumors that a hotel chain is planning to build a resort on this site!

A real difference here, though, is that science fiction films often portray ambivalence to human reliance on technology exemplified (indeed, personified) in the failures of the all-powerful intelligent computer (Bukatman 1993). HAL, the fallible computer in 2001 A Space Odyssey is but one central fictional example. PlanetQuest 2000 portrays no such uncertainty; rather, there is a celebration of the computer-controlled technospace the planetarium's digital domed theatre creates above its audience. The awe and fascination created by the visual simulacrum in the journey to the planets is all treated within the confines and confidence of the expert knowledge and reassurance that technology (computer controlled technology) creates and embodies. Science and technology through this experience are thus deeply reassuring. Even infinite space and distant worlds can be cognitively conquered, colonized, and prescribed within the safe space of the technodome.

Audiences for planetarium shows at ASC of all ages and both genders are enthusiastic about their experiences. The surveys of planetarium audiences undertaken at ASC consistently reported a high level of interest in the presentation respondents had just seen and high enjoyment of the interactive elements (armrest voting) and the live presenter's narration (Arizona Science Center 1998f, g, h, 1999a, c, 2000h). When asked what they liked best, both the visual effects and the subject content were the most often mentioned. For all surveys, high percentages of audiences (as high as 86 percent) said they would come to another presentation.

Despite these findings, a deeper understanding of what appeals in planetarium presentations is still elusive, perhaps because they are such a complex mixture of scientific fact and experiential fantasy. The script examined above, for example, contains significant astronomical information delivered in the genre of science-fiction narrative with many awe-inspiring images of the solar system. The narrative alternates between detailed astronomical facts and simulated space travel adventure. Planetarium professionals have written on the difficulties of the dichotomies they face: the well known dichotomy of entertainment or education (Brunello 1992)[5] and the less well discussed dichotomy of astronomy education and the "mystique" of the cosmos (Marshall 1997).

The analysis offered here suggests that planetarium shows appeal because they are ultimately reassuring. They may offer a glimpse of what Jon Marshall called, "... the source of wonder, this curiosity, this mysterious force which seems to beckon from the vastness of space" (Marshall 1997: 11). At the same time they provide the certainty (and reassurance) of scientific fact and knowledge, personified in this example by the all

[5] The current ASC planetarium manager who also authored the PlanetQuest 2000 script wrote this article.

knowing computer, and more generally in the technology that make this impressive simulation possible.

6.2 Giant-screen Films

Giant-screen films, or large format films as they are also called, are by-products of world exposition and theme park attractions.[6] IMAX is the best know system (but not the only one) and was developed from the very popular multi-screen attractions created for EXPO'67 in Montreal, Canada. A group of filmmakers involved in that project later designed a new system using a single projector and the resulting IMAX system premiered at EXPO '70 in Osaka, Japan. The first permanent IMAX projection system was installed at Ontario Place's Cinesphere in Toronto, Canada in 1971 and the first IMAX dome system (called OMNIMAX) debuted at the Reuben H. Fleet Science Center in San Diego, California in 1973. The connection to world expos by the IMAX Company continued with each new technological début: OMNIMAX-3D premiered at EXPO '85 in Tsukuba, Japan; IMAX-3D premiered at EXPO '86 in Vancouver, Canada; IMAX-Solido and IMAX- Magic Carpet premiered at EXPO '90 in Osaka, Japan; and IMAX-HD (high definition) premiered at EXPO '92 in Seville, Spain.

The other major company in large format films, Iwerks Entertainment Company, developed the system used at ASC. Don Iwerks created the company in 1986. Before this, he worked for the Walt Disney Company for 35 years designing technologies at Disney Land and Disney World, including attractions that incorporated large screen and multi-screen technologies.[7]

The IMAX and Iwerks companies dominate the current giant-screen business, which was estimated in 1999 to have 161 installations in the US and 345 worldwide (Price

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[6] There is no published history of large format films, the short history provided here was compiled from the following sources: (Ankeney May 21, 1999; Anon 2001; Essman 2001; Shatkin May 19, 1999).
[7] Don Iwerks was the son of Ub Iwerks, Walt Disney's first partner and an early animation cartoonist. Later Ub Iwerks worked both on animation and theme park attractions for the Disney Company.

1999). The world audience was estimated at 62 million, approximately 2.5 percent of the conventional film audience. In 1997, the 112 United States installations were categorized into three types of venue. The nonprofits group (64 percent or 72) was made up of science and history museums (50), air and space museums (12), aquariums (4), zoos (4), convention centres (1), and botanical gardens (1). The attractions group (22 percent or 25) was made up of tourist attractions (15), attraction parks (7), and natural wonders (3). The entertainment group (13 percent or 15) was made up of malls and cinema "multiplexes" (12), and casinos (3). While the entertainment sector appears to be a quickly growing market area (by 2001 it was probably larger than the non-profit group), giant-screen films are still shown at many museums and science centres around the world.

Science museums, as one of the primary venues for seeing giant-screen productions and certainly the largest sector until recently, have helped ensure that much film content is science related, indeed, the vast majority of giant-screen films currently available are science documentaries, focusing particularly on natural history and space science topics. However, new technologies are enabling conventional films to be transposed to the giant screen, opening the possibility of large format feature films.

Films at ASC are shown in repertory (two or three films shown at five or six different times of the day) and from 1997-2000 included, To be an Astronaut, Cosmic Voyage, The Living Sea, Wolves, Whales, Alaska: Spirit of the Wild, Solar Max, Everest, Lost Worlds: Life in the Balance, The Great American West, and Super Speedway.

Funding for the making of giant-screen films comes from private industry, private foundations, science museums themselves,[8] and the National Science Foundation's Informal Science Education (ISE) funding stream.[9] Hyman Field, former head of NSF's ISE and its Science Literacy Section, is quoted as saying of giant-screen films, "People will go to an IMAX film who won't turn on a science show on television. They'll go because it's a more exciting medium" (Anon 1997). NSF funds this form of

[8] ASC was a part-sponsor of *Super Speedway*.
[9] In 2001, the appropriation was nearly $36 million to support film, television, radio series, and museum exhibitions and programs.

filmmaking, believing that it is particularly compelling and attractive to non-scientifically literate audiences. Surprisingly, large-screen films have never been the subject of a major evaluation to ascertain whether they indeed do foster NSF's avowed reason for sponsoring them, which is, "fostering widespread science literacy."

While giant-screen films developed from entertainment rides in expos and theme parks into NSF-backed science documentaries screened at museums, they are still strongly entertainment experiences designed to attract large audiences and revenues. At ASC, films are not selected and booked by education staff, but by members of the marketing department. Tickets are offered to those visiting ASC's exhibits as an extra charge and some museums even have facilities for separate ticketing and entrance (for example, the Denver Museum of Natural History and the Museum of Natural History, New York). Often then, giant-screen films do not enhance or augment the host institutions exhibit-based offerings, but are viewed as essentially separate, revenue producing endeavours. ASC's not-for-profit Iwerks theatre competes with other commercial IMAX giant-screen venues in the state: One at a local shopping Mall and one close to an entrance to the Grand Canyon National Park.[10]

At ASC, giant-screen films are viewed by 31 percent of those visiting the centre.[11] While this is a lower percentage than those going to planetarium shows (42 percent), everyone who goes to a film buys a ticket, unlike the planetarium, where up to half the audience is made up of members for whom there is no charge. The result is that in the first four years, over 500,000 visitors paid to see a film at ASC. On the other hand, giant-screen films, like planetariums, require a considerable investment in expensive equipment, a purpose-built facility (at ASC, a structure some six stories high and over 6,900 square feet or 641 square metres), and trained staff. Many science museums are now opting to house simulator rides, using some of the same technologies, but without the considerable capital investment. The question remains for those that do make this investment: How and what do they add to the museum experience? Sheila Grinell suggested that among the things to seriously consider in weighing the pros and cons of

[10] An IMAX theater in nearby Scottsdale closed in 1998, but several new giant-screen theatres have been proposed for other Arizona malls and themed attractions.
[11] This figure is based on the first four years of ticket sales (April 1997–March 2001).

operating a giant-screen facility is their use of space, the quality of their scientific content, the financial precariousness of the industry, competition from commercial theatres, and the development of alternative immersion technologies.

Several different technologies create and project giant-screen films. Indeed, they can only be shown on proprietary large format equipment, but they do share a number of basic characteristics. Special cameras and film record images up to ten times larger than the conventional 35mm frame and three times larger than the standard 70mm frame. The films are shown in specially designed theatres, often using steeply raked decks, projecting on to screens that may be flat or domed and that are up to eight-stories high. The pre-announcement at ASC welcomes visitors to the theatre, "Where the experience is second only to being there." A sign in the waiting area provides the following description:

> Science and entertainment come together on giant-screen in the Irene P. Flinn Theater. The Iwerks Theater System puts viewers "into the picture" with spectacular images and sound projected by a 7,000 watt Xenon gas projection lamp on a 50 foot-high by 67-foot wide screen. The theater's audio system is a seven-channel, 16,000-watt digital audio system, capable of reproducing a full-range of audio sound with uncompromising clarity and tonal quality. The 285-seat theater is one of the Center's showcase attractions, featuring exclusive screening of large-format (70mm) films.

Here the equipment and technology is celebrated as if it were an exhibit. It is also the only place at ASC where label text makes overt reference to "science and entertainment come together." It also refers to the whole Iwerks theatre installation in language usually associated with theme parks, that is, as a "showcase attraction."

All this technology, according to its proponents, creates a radically different experience compared with conventional film. The filmmaker Ben Shedd has made the strongest case for the educational benefits of giant-screen films and their inclusion in science-technology museums. His observations are worth quoting at length:

> Giant cinema screens are unique to film formats. They are as distant from small screen filmmaking as still photography is from the movies. In giant-screen cinema, we are dealing with moving images so large that we do not see the

> edges of the screen. Taking away all the grounding reference points of the frame changes everything in our perception of these films.
>
> ... this means that perceptually the action of the giant-screen film has moved from the screen to the audience. This imagined movement is a result of the fact that the screen is so large it extends beyond our peripheral vision, giving us images which are not contained or contextualized or scaled by a frame.... This gives a wonderful opportunity for making educational events, as giant-screen movies can create virtual first person experiences rather than second hand events. We as audience members don't just watch others go somewhere; we fly there ourselves, or dive underwater or grow and shrink into other scales of matter.
>
> In accounting for the sensation of movement, the filmic experience has moved from passive, from being held in a frame, to active, to becoming the engulfing reality with the audience present within the filmic events. In frameless film the audience becomes the main character in the film (Shedd 1993-1997).[12]

Shedd makes several claims in this passage: "Frameless film" creates a unique experience; indeed, it creates an "event," because the perception of action has moved from the screen to the audience, thereby producing "first person" experiences that are active rather than passive. Although giant-screen uniqueness is now challenged by "small screen" simulator technologies that also employ a full-screen effect, Shedd is arguing that the simulated appearance of movement amounts to active participation. Like the planetarium, the body is tricked by the lack of frame into believing the movement of the camera is real and personal. The ubiquitous shot from a helicopter as the camera shoots over a cliff edge, mountain range, or along a river is the standard form the "sensation of movement" takes in large format films. Although the body does, indeed, perceive motion, this is far from the active participation of real involvement that Shedd suggests. While one can concede that the *camera* in giant-screen films does often take the first-person perspective, the *viewer* does not have active involvement so much as a passive absorption into the screen's totalizing experience. It is important, nevertheless, not to confuse such forms of representation with self-generated perceptions without carefully examining what is at stake for both the producer of representation and its subject.

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[12] Shedd's website does not provide specific dates for individual items and articles reproduced, but only the inclusive dates of 1993-7.

The notion is taken up by Anne Friedberg in her examination of modernity and the "panoptic gaze" (the scrutiny of the observer) and the "virtual gaze" (the scrutiny by the observed) (Friedberg 1998). She makes several important points about technologies that developed well before large format screens that help place modern technologies in a broader perspective. Absorption into the "frameless frame" could be considered an extension of the panoptic view of power relations developed by Foucault (Foucault 1979a; Gordon 1980), but Friedberg reminds us, around the same time as the invention of the panoptican (1791) came the panorama (1792) and the diorama (1823), devices not of confinement but transportation. Indeed, the modern large format film does seem to be more in the tradition of the spectacles of the panorama and diorama than the panopticon and its regulatory control. The metaphor or illusion of travel and transportation is but one feature the new and old technologies have in common. Another is that the diorama and the large format film provide to audiences, "The pleasure of immersion in a world not present" (Friedberg 1998: 261). Friedberg points to a paradox of these early forms that seems equally applicable to the giant-screen experience:

> The panorama and its successor, the diorama, offered news forms of mobility to its viewer. But a paradox here must be emphasized: as the "mobility" of the eyes became more "virtual".... the observer became ever more immobile, passive ready to receive the constructions of a virtual reality placed in front of his or her unmoving head (Friedberg 1998: 261).

These considerations show that interest in virtual realities has a much longer history than we are normally aware of. Geoffrey Batchen suggested that it was around 1800, when many new technologies of representation were invented (and one can add, the science of optics was first being explored (page 58):

> ... that there came about a dissolution of the boundaries between observer and observed, subject and object, self and other, virtual and actual, representational and real – the very dissolution that some want to claim is peculiar to a newly emergent and postmodern VR (Batchen 1998: 276).

The result is that the giant-screen film appears to offer new spectacle to audiences, but ones firmly in a museum tradition of virtual-reality technologies going back some hundreds of years, which are themselves implicated in the politics of social control, disciplining of the body, and its fleeting escape. These technologies are, thus, both coercive and escapist. The social and political implications are discussed more fully below, but it is clear these new technologies raise important questions about how science and technology are represented as sources of authority and control, explicitly and implicitly, through the communicative technologies of museums.

6.3 Science Demonstrations

Science demonstrations are a staple of science centres and yet are difficult to typify, because they are presented in a variety of settings, delivered by a variety of personnel, on a variety of topics, to a variety of audiences. They are presented in exhibition galleries on mobile carts, on tabletops in exhibit areas, and in especially built and equipped theatres. Some centres refer to the activities described below as "live demonstrations," emphasizing the person-to-person nature of the experience. Scientists, actors, and educators, who may be volunteers or paid staff, may all deliver science centre demonstrations. Demonstrations are usually related to the themes of exhibit galleries or individual exhibits, although special demonstrations are also created for temporary exhibits or brought to centres by occasional visiting experts.

Science centres have included science demonstrations from their inception. This may be considered a contradiction of their emphasis on direct, personal contact with science phenomena, but according to Hilde Hein's account of the Exploratorium, "It is done wherever hazards or security problems exist" (Hein 1990: 89). While this is certainly a practical explanation for some demonstrations, particularly those involving materials like lasers, static electricity, and liquid nitrogen, the science demonstration has much deeper historical roots (see section 3.1.3, page 57). Willem Hackmann, for example, writes of the original Ashmolean museum of the seventeenth century as "the first of the science centers," containing not only its museum of, "specimens from all creation, as in Noah's Ark," but also a lecture gallery, and a laboratory (Hackmann 1992: 89). The museum and its public science demonstrations predate the teaching of science at Oxford, reiterating the historical shifts in the relationship of museums and science: where once museums were primary sites for practical science, they are now increasingly sites that merely represent science created elsewhere. Nevertheless, the public demonstration of science persists.

At ASC, demonstrations are not pre-selected and paid for separately by visitors like a planetarium or film presentation, but encountered as a free-choice opportunity in a gallery. The Center has three special demonstration theatres located in the Freeman gallery, the All About You gallery, and in the World Around You gallery. In addition, liquid nitrogen demonstrations are given from a mobile cart in the Fab Lab gallery. The times of these free, 15-20 minute demonstrations are posted in ASC's lobby, but most audiences gather spontaneously from among those circulating in the gallery areas close by when the shows are announced on the public address system. Seating accommodates audiences of approximately 40 per show and the Center features between four and six shows per day. Approximately 20 percent of visitors see a demonstration during their visit.

The Center trains its staff of gallery educators and volunteers to present one or more of a repertory of approximately 15 different demonstrations of which 9 or 10 are rotated at any time. In the period October-December of 2000, for instance, the following demonstrations were presented: Astronauts on the Job, Blood Lab, Dissection: Optics of the Eye (discussed below), Learning Lasers, Liquid Nitrogen and Space Exploration, Living in Space (discussed below), Mineral ID, Mystery Planet, Radio Communications, and Static Electricity.

6.3.1 Dissection: Optics of the Eye

The first demonstration for consideration is Dissection: Optics of the Eye. This demonstration is a science centre classic and one that is featured in many other science centres.[13] The Exploratorium, for instance, has presented cow eyeball dissections almost daily for over thirty years and many other institutions, including ASC, have developed their own version of a similar script. It is also a school staple, usually

[13] A version of the "standard" script is included on the Exploratorium's website.

performed for and by sixth grade students (who are approximately 11 years of age) as part of biology courses. According to Hein's account of the demonstration at the Exploratorium:

> Visitors stand by, at first repelled by the operation, as the explainers themselves were before they learned how to perform it. But they soon forget their distaste and succumb to wonder (Hein 1990: 99).

Hein's hyperbole aside, the repulsion factor is certainly part of the attraction for many younger visitors. "Distaste" mixed with "wonder" places the presentation in the realm of spectacle, in the dramatic and striking meaning of this visual term. The first incision is often greeted by audience groans. The demonstration is performed on a table in front of the audience and details of the dissection are simultaneously displayed on a video screen behind the demonstrators on either side of a chart of the human eye's physiology (figure 6.2).

At ASC, those who perform this and other science activities in the galleries are called "demonstrators," rather than the more common "explainers." According to Laura Martin, Vice-President for Education and Research at the Center, this is a purposeful naming to refer more directly to their role of *demonstrating* science, rather than *explaining* it. Despite this, the script of the cow eyeball dissection contains both elements, involving as it does the naming and showing of some eleven parts of the eye as the dissection progresses, with brief explanations of their function. Before the dissection proper, the demonstrator with the help of an audience volunteer demonstrates that a double convex lens (the same as the lens of the human eye) produces a reversed image.

Figure 6.2: Optic of the Eye demonstration

The demonstration begins with this counter intuitive suggestion that we see everything upside down and that our brain somehow reverses the images our brain receives through the inverting lenses of our eyes. The script does not provide an explanation, although demonstrators often spontaneously add that our brain "Turns the image around." This activity functions to involve the audience directly by using a volunteer, by making a direct connection between the cow's eye and human vision, and by using the standard device of showing something counter intuitive, which, therefore, needs explanation. The script[14] proceeds, via their representative volunteer, by directly dealing with the audience's likely squeamishness about touching an eyeball:

> Now X, as long as I have you up here, I need you to put this glove on and go over to the sink to get the eyeball in the bag and bring it back over here. How many people have ever touched an eyeball? How many people have ever touched their own eyeball before? That counts. If you are interested you can come up at the end of the show and put a glove on to touch this eyeball as X is about to do. OK X I need you to get the eyeball out of the bag, and put it on the tray. Excellent.

[14] These excerpts come from ASC's written script, the steps of which demonstrators are expected to follow, using their own language when they are confident to do so.

The demonstrator then performs the dissection of the eye, making comparisons to the human eye along the way, and referring to the appropriately labelled chart (see figure 6.2). As the dissection takes place, the demonstrator introduces and briefly explains the function of the eye's major components: eye muscles, sclera, cornea, aqueous humour, pupil, iris, lens, vitreous humour, retina, tupetum, blind spot, and optic nerve. In less than ten minutes, the dissection is complete. Descriptions of the eye's components contain a substantial amount of information delivered in short summaries, for example:

> The back of the eye contains the retina, which detects the image focused by the cornea and lens. The retina is made up of a thin layer of photoreceptor cells. These cells respond to light, and send visual messages to your brain. There are two kinds of photoreceptor cells: rods and cones. Rods are responsible for contrast – lightness and darkness, while cones are responsible for color vision. Since cows are colorblind, this retina has no cones.

It is unlikely that the audience remembers much of the detailed description, unless they have already covered it in a school biology course. The aim, however, is not to inform so much as to demonstrate the natural classification of the components that comes from having performed an orderly and methodical dissection. More significantly, it is dissection being witnessed and normalized as an ordinary scientific procedure that is demonstrated. For many children this is something of a rite-of-passage in formal science education. The demonstrator plays the role of a dispassionate and expert scientist. The dissection is both the embodiment of knowledge gained through empirical discovery and a ritual enactment of doing what scientists do. As Hein suggests, the demonstrators are in the same "repelled" state as the witnessing public until they learn and are socialised to the activity. At the end of the dissection the audience should have overcome this feeling too, albeit vicariously. The test comes when they are invited up to the dissecting table to demonstrate the result:

> I've given you a basic idea of how vision works, so that's it for the dissection. Now, if you'd like, you can come up and view the eyeball first hand, and even touch and hold it. Please form a line to the left of the table.

Lines do form. The demonstration, which at one level is one of the most straightforward performed in science centres, has considerable symbolic significance that forms part of its appeal and, perhaps, also part of its repulsion.

6.3.2 Living in Space

The second demonstration for consideration is also performed in a large number of science centres, but was created much more recently as part of a series of demonstrations and other activities in a national project called Star Station One (figure 6.3). As the demonstrators who introduce the Living in Space demonstration explain to their audiences:

> ... today we're going to explore a little bit about what it would be like to live on the International Space Station, in orbit around the Earth. This show is one in a series that we are doing over the next few years as the International Space Station is gradually assembled. Over 60 other science centers all over the United States are doing these shows and we will continue to add more new shows as the station grows.[15]

The Living in Space demonstration, performed regularly at ASC in 2000, was the fourth in a planned series of some 17 and as many as 10,000 visitors saw the demonstration during the year. Other components of the Star Station One program include ISS models, mock-ups, and exhibits; educational outreach materials; workshops and training; revenue generating products; and an evaluation and assessment program. NASA (who supplied materials and information) and the Boeing Company (who financed the initial project) began the program 1998 as a joint venture. Additional funding was and is supplied by "sponsors and contributors," among them some of the 500 companies in the United States receiving ISS contracts. Staff from ASC was sent to the Houston Space Center for training in 1998 on the program's objectives and to see performances of the first few demonstrations developed by the Bishop Museum in Hawaii, including Living in Space.

[15] The national program provides a basic script and its props to each centre. Excerpts here come from the rewritten version created by ASC's Education Department staff.

Figure 6.3: Living in Space demonstration at California Science Center[16]

The basic scientific concept treated in the Living in Space demonstration was microgravity. The meaning of microgravity was not explained in the demonstration for the script dealt only with its effects and not the basic principles and causes. The third demonstration in the series, Astronauts on the Job, did explain microgravity, but only a small minority of visitors were likely to see both demonstrations. In contrast to the dissection demonstration, Living in Space used very little technical language or specialist vocabulary. The following description was used, for example, to describe the effects of microgravity on the human body, using a balloon as an analogy to a person:

> One of the most immediate and noticeable effects in the microgravity environment is that all the fluids in your body shift around and redistribute themselves. To illustrate this I'm going to use this liquid-filled balloon to simulate a person. Here on earth, if our bodies did nothing to counteract it, the force of gravity would pull all the fluid in our bodies down to our feet – like this

[16] Photograph from Star Station One website.

> (*squeeze balloon*). Fortunately though our bodies are pretty good at counteracting this effect and our muscles help us to squeeze all the fluids back up out of our legs into the rest of our body and keep all the fluids evenly distributed – like this (*squeeze balloon again*).

Other activities follow in the course of the demonstration, each using a simple model or analogy to illustrate their point. For example, the second activity involved a volunteer pressing down on a model of a spine to simulate the effects of gravity and microgravity on the spine's spongy discs, illustrating how astronauts grow in space.

The third activity was about space motion sickness. Another volunteer, with the entire audience following along, was asked to stand on one foot with their eyes open and then with their eyes closed. When extra difficulty was experienced with eyes closed, the demonstrator remarked: "The information from your inner ear isn't enough for you to balance. You need extra information from your eyes to help you adjust your position and maintain your balance." Unfortunately, this is exactly the opposite of the actual experience in space, where there is information from their eyes, but not the inner ear. The effect is similar – balance is disturbed – but the cause is not the same. The point of the activity appears to be less to do with accurately simulating the phenomenon as creating an enjoyable group activity in which audiences can identify with how astronauts feel.

The fourth activity was even less directly related to an actual experience in space. The topic was introduced as follows: "Astronauts often experience feelings of disorientation when they are first up in space living in microgravity." The next volunteer was invited to wear goggles that shift vision five degrees to the left and then asked by the demonstrator to shake hands and catch and throw a beanbag (see figure 6.3). The volunteer could only accomplish these tasks with great difficulty, which invariably caused laughter in the audience, but was used only to illustrate the point that, "The astronaut can feel the same kind of disorientation in space." It was not made clear in the demonstration if astronauts actually experienced this disorientation (that is, a measurable shift in visual perception) and, if so, why. Again, the point does not appear to be directed to explanation, but imaginative identification with astronauts' sensations.

The final activity made identification with the plight of the astronaut graphic. The demonstrator asked, "What do you think is the most common question astronauts get asked about living in space? Right ... How do you go to the bathroom?" The activity involved sitting down on a simulated microgravity toilet using a green bull's-eye fastened to a volunteer's behind so that the target could be lined up with the hole in the toilet seat. This participatory comedy theatre formed the show's finale. The show ends thus:

> Let's give X a round of applause for volunteering to try this. Thanks X, you can go back to your seat now. OK, well that's the end of my Living in Space show – thank you all for coming along. I'll be here if you have any questions, and I hope you have a great time for the rest of your visit to the Arizona Science Center.

If the goals of the cow eyeball dissection are to legitimate a particular form of science activity and knowledge, the goals of the Living in Space demonstration are much more social and political. The web site of the Bishop Museum, the organization that wrote and produced this demonstration,[17] provides a detailed account of the program's intentions as the following excerpts show:

> While NASA, Boeing and our International Space teams are hard at work for many years planning and building the International Space Station, the vast majority of the public has little, if any, personal understanding of the program. The taxpayers, who are currently funding the entire cost of the project, should have full and easy access to the International Space Station progress. Star Station One will help provide it![18]
>
> The whole purpose of the program is to connect the International Space Station with those who are paying for it and to inspire our young people to seek their dreams through solid preparation in schools.
>
> Museums and science centers comprise the "informal science education" system and are the primary mechanism for Star Station One.

These materials also describe the program's implementation strategy:

[17] Future demonstrations will be produced by the Challenger Learning Center organization.
[18] These quotations are from various web pages accessible through the official Star Station One site (Bishop Museum 1998).

> Workshops and training sessions for participating science center and museum staff are essential to ensure the Star Station One program is effectively implemented throughout the country. An initial 3-day workshop hosted by the Star Station One program was held in Houston prior to the first element launch of the International Space Station. Representatives from the selected 60 core Star Station One partner institutions were thoroughly indoctrinated in the International Space Station subjects and the Star Station One program.

This suggests a strategy of using institutions that are, in its own language, "[a] non-threatening and trusting place for average citizens and families to seek information..." in order to reach as many citizens as possible. This can be interpreted in a number of ways: from a propaganda exercise by vested interest (NASA and Boeing among them) to leverage long-term support for the huge public investment in the ISS or simply an honest attempt to inform the public about the program so that they can make "... informed judgments and decisions about their future."

These examples show that demonstrations treat the content of science quite differently: the dissection demonstration is the public showing of standard biological lab procedures using, in the phrase of the public announcement "a real cow eyeball," whereas the space demonstration relies heavily (and by necessity) on enactment through analogy and simulation. Both, though, are forms of theatre each in its own way presenting and promoting a particular form of scientific endeavour. The audience, as audience, receives a packaged and scripted message about the truth and value of science.

6.4 Legitimation through Presentations

Public science presentations have a long history. As already mentioned, Stephen Shapin and Simon Schaffer, for example, examined the role of public and collective witnessing of scientific "matters of fact" in Robert Boyle's development of experimental method in the seventeenth century (Shapin and Schaffer 1985). They describe the public witnessing of controlled demonstrations, such as Boyle's air pump, in the "open laboratory" as an essential part of the creation of scientific facts using objects and apparatus. Despite postmodernist and feminist critique of what counted as "public" and "open" some three hundred years ago (Haraway 1997), the importance of public witnessing clings to the science demonstration in museums to this day.

Unlike public yet mainly individual interaction with science exhibits, the contemporary science demonstration is public and collective. The eyeball dissection performed thousands of times per year in science museums across the country by demonstrators (or explainers) unfailingly reveals the eye's inner structure and function to a public assembled together to witness the objectivity of scientific method through findings revealed, literally, on a table of knowledge. The public animal dissection is simultaneously an educational experience and an instantiation of the "facts" it displays. The audience collectively verifies the truth the demonstrator "shows and tells." The science demonstration is, thus, more than the public rerunning of an old experiment, it is a ritual enactment.

The audience understands that the demonstrator is a stand-in for the experimental scientist and yet, as they found at the Franklin Institute's Cutting Edge gallery, "Many visitors expect the demonstrators to be expert in whatever field they are demonstrating..." (Wagner 1997: 155). This is an understandable problem for the demonstration demands not merely a showing of what is in nature, but an explaining of it too. Museums, as we have seen above, have included educational lectures on scientific topics since at least the seventeenth century. By the late nineteenth century, science lectures and demonstrations in the U.S. were a very popular and important part of many museum's offerings, fulfilling the role of educating a public while simultaneously creating that public (Harris 1981). The America Museum of Natural History, for instance, found that by 1887 the hall it hired for lectures and demonstrations, with a seating capacity of over a thousand, was regularly filled beyond capacity (Dallett 1987: 8). During this period, public lectures were a main conduit of informative exchange between professional scientists, interested amateurs, and some of the broader general public. At a time when exhibits were not well interpreted by today's standards, the divisions between professional and amateur scientists were not so institutionalized, and other "edutainment" attractions were not so well established as they are today, it is not surprising that public science demonstrations, often in the form of lantern-slides, were so popular.

The social and political meaning of science shows has changed over times as new technologies of knowing developed and as the very notion of the public altered. In our own period, the comparatively high degree of internalized self-regulation, assuming Foucault is correct, means museum visitors may be allowed a high degree of apparent free-choice and first-hand experience without the watchful and disapproving eye of external authority. Indeed, this "free choice" opportunity has been taken as an indicator of our political freedom rather than our social constraint (see Barry's comments on the Explorartorium, 1998: 112). There are dangers in this new, democratized museum, however, for as Eilean Hooper Greenhill suggests, "... newly pleasurable technologies of discipline and control have evolved to soften the contradictions and disguise the inequalities" (Hooper-Greenhill 1992: 214). Each form of science show uses distinct technologies and teaching devices. The science demonstration itself, as described above, comes in many forms, but usually in the science centre context involves an audience for whom the truths of science or values of science are shown and legitimated by a person manipulating various devices and props. These enactments are a form of theatre and, it has been noted, theatrical performance can make science memorable (Arnold 1996; Farmelo 1992; Kavanagh 1989). It is also a setting in which powerful arguments can be made about science. In the two demonstration examples examined above, for example, the argument is made that animal dissection is a legitimate and normal activity of science and that the ISS deserves public support.

While there are many opportunities for participation as an audience and as a volunteer in the show's scripts (and thereby implicit assent to its message), there are few opportunities for dissent. Some members of the public do question demonstrators after the performance, but this is not part of the public's collective activity. Similarly in the planetarium show, the audience can choose to opt to follow a different scenario by voting, but this is little more than the choice to change channel when watching television – less choice, because only the most popular choice is taken. The giant-screen movie offers the least amount of choice and the highest degree of immersion. Clearly, these experiences, "... can have the function, in the apparently democratised environment of the museum marketplace, of soothing, of silencing, of quieting questions, of closing minds" (Hooper-Greenhill 1992: 214).

A counter argument to this pessimistic outlook comes from those working in popular rather than high culture (museum) studies. We saw above that some visitors evade the intended meanings of exhibits (page 144) and it is also likely to be true of science shows, even given their relatively controlled setting. Surveys of planetarium audiences regularly included a minority of comments on the "unbalanced" way the shows exclude a religious understanding. The following, for instance, were among comments on a planetarium show about the development and demise of the dinosaurs of the Jurassic period (Arizona Science Center 2001b):

> I thought it would say something about when God created the heavens and the earth.
>
> The Bible makes more sense.
>
> I don't agree with the evolutionary methods.

The purpose of these shows at the most mundane level is to offer enjoyable breaks from the more directly involving and, arguably, cognitively demanding exhibitry. Each show is a spectacle presented to a relatively passive and powerless audience, but the role of the human presenter or mediator is different in each case. In the demonstration, the demonstrator is a surrogate scientist. This is also the case with planetarium shows, but the presenter has the additional responsibility of also mediating between the audience and the authority of technology. In the giant-screen theatre, direct human mediation is replaced entirely by the voice of the narrator and the "presence" of the immersive experience, although the films often feature a scientist as a main character who's work the camera follows on a journey of discovery.

Planetarium and giant-screen theatre presentations move beyond the presence of real phenomena and real witness (even if the presenters are only actor-surrogates with props in a larger drama) to simulations that offer the virtual experiences of immersion, movement, and "being there." The extra dimension these technologies provide is captured by the phrase "the technological sublime," in which experiences linked to technology have transcendent significance. David Nye describes the history of the social role of the sublime in the United States, which includes the grandeur of the "natural sublime" (Niagara falls, Grand Canyon, for example) and the development of the technological sublime with growth of railroads, bridges, skyscrapers, factories, electrification, the atom bomb, Apollo XI, and newer simulation technologies like IMAX films (Nye 1994). Nye explains the social and political significance of these technologies, which deepens the analysis provided by Bukatman:

> There is an American penchant for thinking of the sublime as a consciousness that can stand apart from the world and project its will upon it ... Those operating within this logic embrace the reconstruction of the life-world by machinery, experience the dislocations and perceptual disorientations caused by this reconstruction in terms of awe and wonder, and, in their excitement, feel insulated from immediate danger. New technologies become self-justifying parts of a national destiny, just as the natural sublime once undergirded the rhetoric of manifest destiny. Fundamental changes in the landscape paradoxically seem part of the inevitable process in harmony with nature (Nye 1994: 282).

Nye examines the simulations and attractions of World's Fairs (particularly the 1939 fair) and IMAX films (particularly the Arizona installation close to the entrance to the Grand Canyon, which only shows films of the Grand Canyon) and describes them disparagingly as a new "consumer sublime" where the visitor purchases "new sensations of empowerment" (Nye 1994: 287). The sense of empowerment is also one that applies to the planetarium and giant-screen films generally, which through new technological means simulates the experience of nature (terrestrial and extra-terrestrial) and reinforces the power of humans *over* nature. It goes beyond the perception of a process in harmony with nature to one where, as Nye puts it, "The assumption of human omnipotence has become so common that the natural world seems an extension of ourselves, rather than vice versa" (Nye 1994: 289).

Science Centers, according to this argument, cannot be thought of as in any simple way "democratized museums" of unmediated free-choice learning. The forms in which science is presented and the technologies that are used to do so carry in themselves a powerful argument about the ability of science to reveal and control nature, quite apart from the actual scientific content they present. In addition, these various forms of show-based interpretation are implicated in what is arguably one of the central issues of museology: the role of power and authority in the modern museum.

It is argued here that the science demonstration is a continuation of the expert educating an uninformed citizenry, as in the disciplinary museum of nineteenth century, and that the new technologies of the planetarium and giant-screen film are expressions of the power of science to control nature, wrapped in the reassuring cloak of the sublime. The power of the shows to present and legitimate such arguments goes almost unnoticed as its audiences and its creators reinforce each other's notions of the democratized museum, providing the public a science that is both fun and educational.

7. Implications and Conclusions

This chapter returns to some of the themes introduced in chapter 1, beginning with a reconsideration of the diversity or motley of the science centre experience and the type of institution this forms. This is discussed in terms of a series of tensions that are found in science centres, their models of science, and the popular legitimacy they claim. The issue of legitimacy is examined through the trust that exists between the science centre and its public and the science centre and its funders. It is argued that science centres can claim a certain form of social legitimacy, but that it is subject to renegotiation as "boundary conditions" alter and the wider society changes.

7.1 The Motley of Science Centres

The science centre is motley. The term is not meant pejoratively, but rather complimentary to a variegation in form and function that enables it to thrive in so many environments. It is an institution within the museum community, but has considered itself and has been considered by others as a new type of museum with a novel and influential approach to visitor engagement. It is an institution within the education community, but sees itself promoting a new pedagogy in a freer atmosphere than the traditional approach to teaching science and science learning. It is an institution in the leisure industry; one among many forms of public entertainment in an entertainment-saturated world, but considers itself able to combine fun and learning in a distinctive, compelling, and popular way. It is an institution with significant local economic, social, and cultural impact, yet is dedicated to promulgating the universal principles of science. In a single institution it combines the four elements that Pine and Gilmore discern in compelling experiences (page 78): education, entertainment, aesthetics, and escapism (Pine II and Gilmore 1999). It even attempts to represent at least two formulations of science: what might be called the "everyone a scientist" model and the notion that science is the product of specialist knowledge and skills (Rowe 2001) (page 150). It is, indeed, an institution with diverse goals and aspirations and can be viewed from multiple perspectives.

An attempt has been made here to acknowledge this motley; to take to heart the "Just So" story of the elephant and the blind men who each felt a different part of the animal and from that experience assumed knowledge of the whole living thing. Any narrow interpretation of such a complex creature as an elephant or a science centre is likely to perpetrate what may be called the fallacy of metonymy; where one aspect is taken as the totality. As suggested in chapter 1 (page 23), the science education movement has done something similar to understandings of the science centre. The literature of science centres, both pro and con, has tended to accept this part-for-the whole understanding at face value and examine them as exclusively informal or free-choice sites for science education, employing inquiry-based or investigative learning; a sort of school without rules. This is understandable. After all, the average science centre is full of purpose-built devices intended to embody and instruct its mainly young visitors in the basic principles of science. The fact that these devices are not presented through artifacts and that the principles they embody are universal, reinforces the notion that they break with the traditional museum to focus exclusively on educational goals. Viewed more broadly, however, while the content of science centres may claim to transcend time and place, their form does not. Interactivity and hands-on as presentational modes are historically and socially formed; so too are the particular principles chosen for inclusion. In addition, educational goals are not their only purpose and not the only way to interpret and assess their success.

Viewed as broader products of history and society, it turns out that a large number of the experiences found in contemporary science centres have significant historical antecedents, which were only relatively recently gathered together in this new institutional setting (see page 57). As recreations illustrating timeless truths, they are often divorced from their past and the social meanings they had. Both the science and its mode of presentation are by in large offered as if they have no social, historical, and, therefore, no cultural meaning. In so doing, this new ahistorical and asocial interpretation goes virtually unnoticed. The notion of science carried by such ellipsis is fundamental, however, to an understanding of its institutional form. Unfortunately, a literature of the broader cultural and historical meaning of science centres and the cultural meaning of the experiences they offer hardly exists.

If science centres are, indeed, motley, then, there are inevitable tensions resulting from the various directions in which these institutions are drawn. The result is that science centres seek legitimacy through a number of other institutions, while at the same time trying to develop their own distinctive claim to authority. This chapter aims to offer some general conclusions about the overall legitimacy of science centres and examine some of the unresolved tensions that arise in light of the analysis offered in previous chapters.

7.2 The Legitimacy of Science Centres

Ernest Gellner's notion of legitimacy was introduced earlier as a convenient and relatively neutral way to examine science centre authority and Jean-Francois Lyotard's notion of dual legitimacy provided an understanding of the reciprocal and mutually reinforcing nature of the institution and the message it carries (see section 2.1, page 32ff). These broad, theoretical notions of legitimacy become specifically grounded when Bourdieu's notion of cultural capital is used to examine the legitimacy of cultural organisations (Bourdieu 1984, 1986; Bourdieu and Passeron 1990) and his account may be used to compare and contrast social capital as it applies to the legitimacy of science centres.

In his formulation, cultural capital conveys legitimacy through two main institutions of significance to science centres: educational institutions and those that regulate taste, such as museums. Like economic capital, cultural capital is convertible and reproducible as social and economic power. For example, the formal educational system creates a market in cultural capital by converting it into certificates of competence (like PhDs), which can then be used as currency in the job market. The institutions of taste – Bourdieu's example is the taste sanctioned and manifest in art museums – are based on appeals to the aesthetic, which are fundamentally arbitrary and interiorised as a sense of cultivated pleasure through the process of socialisation.

> ... children from cultivated families who accompany their parents on their visits to museums or special exhibitions in some way borrow from them their disposition to cultural practice for the time it takes them to acquire in turn their

> own disposition to practice which will give rise to a practice which is both arbitrary and initially arbitrarily imposed (Bourdieu and Darbel 1991: 109).

In Bourdieu's account, leaving aside the enigma of how privilege developed in the first place, both the educational system and the cultural system function to legitimate existing social privilege. The process masks or suppresses awareness of the way taste is learned by particular social groups, creating the "... illusion of a cultivated nature predating any education" (1991: 109). It becomes hidden, forgotten, or denied, thereby creating a "myth of innate taste." What may work to explain the legitimating role of traditional (classical) art museums, as major sources of cultural capital in bourgeois society, does not work so neatly for science centres. The reasons for this include the popular appeal of science centres and the social meaning of science in our society.

Cultural capital for Bourdieu comes in three forms: embodied in individual dispositions and tastes (a type of "habitus"); objectified in cultural goods, such as valued works of art; or, as mentioned above, institutionalised in the form of academic credentials. Something similar takes place in science centres, but the results are both ambivalent and varied. They are ambivalent, for while science centres do aim to influence attitudes, build skills, provide knowledge, etc., they are not embodied in or manifest through the "cultivated" dispositions Bourdieu refers to, nor do they involve the bestowing of credentials. They are varied, because different supporters and different users of the institution create and use their cultural capital in different ways.

While the science education gains that might result from a visit to a science centre are socially valued, knowledge of science and a positive attitude towards it are not a distinctive badge of taste. This is something known at least since C.P. Snow's lament over society's "two cultures" (Snow 1959). The result is that the cultural capital created and used by its supporters as visitors and sponsors of the museum institution is somewhat ameliorated by the relatively low status of science knowledge in general and experience with interactive science (in museums without precious objects) in particular.

Things have not changed much since Snow described how scientific ignorance is more socially acceptable than cultural ignorance. BJ Freeman remarked on the difficulty of raising funds for ASC among Phoenix's philanthropic community, particularly before the new building opened, even though some leading families and institutions generously supported the Center (page 70). Indeed, ASC has received munificent and consistent support from local foundations, businesses, and individuals and their names are featured (often personified) throughout the centre (Dorrance, Freeman, Toyota, American West, etcetera) and as underwriters for exhibitions (Arizona Republic, Arizona Public Service, etcetera). In the place of taste and distinction, sponsors support the Center's educational mission and, as discussed below (page 197), their own interests. The educational role of the Center is, therefore, a key element in its legitimation, but as argued above, like other science centres, ASC is ambivalent about this, because of the negative associations of science education as formal and dull.

On the one hand, science centres are not formal science education credentialing organisations and are quite critical of formal science education institutions that are.[1] Their insistence on free-choice learning is predicated on being open to all regardless of existing skill or, more importantly, existing status or credentials. They eschew assessment; reflecting Oppenheimer's much quoted comment, "No one ever flunked a museum" (quoted in Semper, 1990). On the other hand, they are keen to show their educational efficacy and relevancy for a technologically and scientifically advanced society in need of future science workers and a scientifically literate citizenry. Pressure is on them to show that their exhibits and programmes are related to state and national educational standards and they are keen to impart their skills with inquiry-based learning to schoolteachers who are interested.

Similar to the interests of sponsors, the social dispositions of the broader public, resulting from a visit to a science centre, do not create or reinforce the sense of social distinction that is associated with the contemplation of the aesthetic in the traditional art museum. The public does, however, see the experience as a positive social activity and one that is both enjoyable and educational. Again, the importance of education as a legitimating principle is significant.

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[1] Examples would be the negative connotations used in science centre slogans to contrast the science centre experience with school science (see page 109).

In contrast to Bourdieu's notion of the social capital of aesthetic goods, the science of science centres is not easily formed into tangible goods, such as works of art, which can be collected and owned by connoisseurs. Its closest approximation is in the science toys sold in science centre shops, but their ownership confers no social status and is generally seen as merely the possession of amusements. This is a necessary consequence of the subject matter, that is, art is a commodity that someone has made, whereas scientific principles are universal and are embodied in ways that do not lead to high status cultural objectification. "Cutting edge" devices from labs are not for personal possession, consumption, or contemplation. The grey computer boxes of modern scientific inscription, in particular, hardly compare aesthetically with much sought-after and collected historic scientific instruments (L'E Turner 1998).

In conclusion, science centres do produce cultural capital, however, not in the same way and with the same social functions as that produced for the socially elite Bourdieu was concerned with. Bourdieu's interest is in showing how certain social groups (the privileged) use cultural commodities, including museums, to underpin their position and differentiate themselves from the rest of society. According to Bourdieu:

> In order for culture to fulfil its function of legitimating inherited privilege, it is necessary and sufficient that the link between culture and education, at once obvious and hidden, should be forgotten or denied (Bourdieu and Darbel 1991: 111).

For the science centre to gain legitimation it is necessary and sufficient that the link between science and education be remembered and affirmed, hence, the centrality of education in the treatment of science centres in the scholarly literature. Modern science centres – and other museums too as access to museums broadens (Sandell 2002) – do not legitimate themselves by socialising and recruiting participants to a sense of social distinction or unconsciously affirm their privileges as natural. The science centre is more socially open and broad than this. Its message is not meant for an especially privileged social group – quite the reverse. It is a message for those who are not skilled in or practitioners of science. It generally assumes its participants are outsiders to scientific practice. In the "we are all scientists" part of its message, it attempts to engage non-scientists in an awareness of the basic principles that explain the world that surrounds them. In the "science as specialist knowledge" part of its message, it attempts to give non-scientists a sense of and appreciation for professional scientists' accomplishments in research and technology. This has been taken by some commentators to reflect a democratic ethos that is specifically linked to interactivity. As Andrew Barry put it:

> ... interactives have functioned as a kind of solution to the various problems that have emerged around the relations between science and the public. At the Exploratorium, for example, interactives were conceived as a way of disseminating a sense of scientific experimentation to the wider public. In turn, the capacity to be an experimenter was taken to be equivalent to democratic empowerment (Barry 1998: 112).

This chain of reasoning may be questioned. It has been argued throughout this thesis that experimentation in science centres is quite abstract, attenuated, and highly controlled and that the centres operate at three levels of abstraction (page 10). Even if this were not the case, interactivity hardly amounts to democratic empowerment. Feedback within the loop of a cybernetic device is a most abstract model of empowerment and, because of the highly circumscribed orbit of even the most loosely controlling exhibit, may also be seen to be quite the opposite of democratic freedom. It was precisely for this reason that the notions of de Certeau (1984) and Fiske (1989) were used as a way to examine how visitors can make their own meanings from those on offer "officially" (page 144).

It was argued above that much of the science centre message manifests itself as a ritualistic witnessing or embodiment of the truths of science (section 5.2.2, page 152). Its legitimation, therefore, is not located in the self-understanding of a particular social group, but in the broader activities and enactments of all visiting non-scientists. In this sense, science centres are part of popular culture, promoting a "popular aesthetic." This is why at various points throughout this thesis examinations were made of science-technology centres' broad public appeal, the links between science centres and mass media, and the characteristics of their general visitors (particularly chapter 4, page 86ff). John Storey, following closely Bourdieu's account in Distinction (Bourdieu 1984), contrasts the elite aesthetic of the art museum with the popular aesthetic:

> At the pinnacle of the hierarchy of taste is the "pure" aesthetic gaze – a historical invention – with its emphasis on form over function. The "popular aesthetic" reverses this emphasis, subordinating form to function. Accordingly, popular culture is about performance, high culture is about contemplation; high culture is about representation, popular culture is about what is represented (Storey 1998: 210).

This is a change of emphasis only, so while performance, function, and representation are emphasised in the science centre through hands-on activity and interactivity where devices represent scientific functions, their underlying form or principles for contemplation are also important and constitute "higher" educational goals. This dichotomy of form/function corresponds to other dichotomies, such as, surface/depth, education/entertainment that are discussed below as typical tensions within the science centre movement (page 200ff).

The science centre movement, even though it operates as part of the museum community, according to this analysis does not have elite cultural legitimacy, but it does have popular cultural legitimacy. This is manifest most directly in the large percentage of the public that visit their local science centre yearly. Science centres are not trafficking in taste here, but trafficking in experience. The science centre provides an apparently neutral environment to safely contact and experience the scientific realm without being judged by it.[2] The authority of science is never called into question by science centres, but there are no sanctions or social consequences for any visitor who does so as part of their "personal meaning making." The science centre experience viewed as a leisure time cultural can, thus, be seen to have social significance in terms of personal meanings, pleasures, and identities, although its separation from ordinary life suggests this is less significant than for other forms of popular culture (see page 215). The science centre experience is legitimated by the fact that people come to it, spend time and money on it, take part in it in social groups, talk and think about it later, and choose to do it again.

Science centres are actively engaged in attempting to broaden what Bourdieu called the "cultural competences" of its visitors on science issues. The fundamental question

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[2] However, the correction of naïve notions found in much of Minda Borun's work at the Franklin Institute is just such a form of judgment (Borun et al 1993).

remains: do these competences provide a real or tangible utility or are they merely in operation for the duration of a visit to the escapist spectacle of science celebration? It is only if the experience has real social consequences that it can be said to operate as a form of cultural capital that can be used by its visitors.

Science centres provide a series of experiences that the chapters above have elucidated and analysed. They introduce the public to scientific understanding and new technologies, although the long-term effect on whether they actually encourage children to stick with or take up science is unknown. They directly support and promote a positive view of science. They directly promote education through interaction, although much of their experience concerns the viewing and witnessing of scientific truth. They directly promote an ahistorical and asocial model of science and, indirectly, they contribute to their locality, culturally and economically.

It is important to understand that the science centre experience circulates as a commodity in both a cultural economy and a financial economy. ASC is a non-profit institution, so it can be assumed that its budget equals the cost of creating and providing its experience: approximately $5-6 million a year. Most of this is raised directly from those seeking its offerings (around 60 percent), with the balance invested by other institutions – business, government, foundations, philanthropists – in support of the Centre's mission and their own. A way of viewing both the use and support given to science centres is through the notion of trust.

Anthony Giddens suggested that personal and institutional trust is a central feature of late modernity (Giddens 1990, 1991), an argument that was taken up and elaborated by Roger Silverstone (1994) in his study of social meaning of television. In the science centre case, trust can be seen as characteristic of its visitors. They know and expect that their experience will be safe mixture of fun and education that everyone can take part in as a social group. It provides a space in which people (principally families and school groups) can interact with each other for a sustained period via stimulating exhibits and a variety of performances. As a result, somewhere between 8 and 10 percent of the entire local population visits ASC each year,[3] in 2002 over 13,000 families were members (estimated at around 52,000 individuals), and the Center was the recipient of two publicly voted bonds to build and extend the facility. Continuing trust is shown through visitor surveys at ASC that report a consistently high approval rating for its offerings. Such support is also attractive to other institutions. Individual schools and school districts, for example, bring over 120,000 school children to the centre each year and hundreds of local teachers take part in its professional development programmes.

This significant user support is attractive to other institutions that either approve of ASC's message and/or see a vehicle to also promote their own. As described above, the City of Phoenix invested some $30 million in making ASC part of its downtown redevelopment scheme (page 71); local companies, local and national foundations, and local and national philanthropic organisations and individuals invested millions more in permanent exhibits, temporary exhibits, and educational programmes. The national government also supports ASC by awarding grants through federal agencies such as the National Science Foundation, the Institute for Museum and Library Services, and so on. According to Chevy Humphrey, this support is predicated on trust that the Centre will deliver a message its supporters can count on. When asked about how involved sponsors are in the content of a possible temporary exhibit, she commented:

> I don't feel they really look at the content. I think they look at the return on investment and the packages we offer: Jurassic Park, everyone knows Jurassic Park; Titanic, everyone knows Titanic; Aliens believing – Carl Sagan brought that out. They trust that the Science Center will promote [the exhibition] and believe what we bring to the table in travelling shows. They feel we're very credible and we have a strong relationship with them and so they trust us.

In pursuing this trust strategy, the Center finds itself subject to issues similar to those confronting art museums that have taken the "blockbuster" approach. Victoria Alexander warns of the external dangers:

> Museums mount exhibitions, all of which cost money. Museums are highly dependent on concentrated sources of funds for exhibitions. In order to maintain

[3] This a broad estimate based on the population of Maricopa County in the Phoenix area, the average number of visits per year per visitor, the average number of out of state visitors, and the average number of total visitors.

> such funding, museums conform to the demands of those who supply resources – for example, they mount shows that conform to funder preferences (Alexander 2000: 179).

Alexander points out that "... funders do not force a museum to mount any particular type of exhibition," it is much more to do with the "credibility" the institution builds with supporters who can rely on the fact that they do not need to be concerned with content (Alexander 2000: 180). As Alexander explains it, the museum has a portfolio of the types of exhibition it is willing to mount and the funder has a portfolio of the types of exhibit it is willing to support. The exhibition the public sees is the overlap of their mutual interests. This applies not only to large-scale temporary exhibitions, but also to the sponsorship of permanent exhibits. This gives the sponsor (whether it is government or a private concern) considerable control. The public through market research and sales analysis does wield some authority over which offerings it prefers, but it does not have a direct say in those offerings. At best, the public may be polled on which of several choices an institution believes its sponsors may back. In its free-choice setting, this amounts to little more than consumer choice among a set determined by other criteria. It is no surprise; the science of science centres does not characteristically deal with controversial issues or offer up exhibits that could be considered to bite the (increasingly corporate) hand that feeds it. The power of the sponsor, however, is not a coordinated or unified exercise of power for each sponsor has its own agenda, as does each branch of government. While taken together such power is hegemonic, it is distributed locally in diverse ways among diverse groups and individuals who often compete with each other.

The diversity of user preferences and the diversity of sponsor agendas provide much of the motley that is the modern science centre and the institutional base of its discursive practice. Within this, the freedom of the user to determine meaning is quite narrow, but it does exist and was discussed above as the possibility of alternative or resistant readings (or not visiting at all). The image of science centre visitors roaming through exhibits, incorporating some intended meanings, missing others, and creating new ones of their own along the way is reminiscent of de Certeau's much quoted notion of "secondary production," where, "Readers are travellers; they move across lands belonging to someone else, like nomads poaching their way across the field they did not write" (quoted in, Storey 1998: 214).

The public's involvement is the basis for there being a connection between the science centre's and the funder's interests. Both want to attract a public to attend and enjoy the chosen exhibitions, albeit for possibly different reasons. On the one hand, the public benefits by being presented with exhibition experiences it would not be able to have otherwise. On the other hand, this process is not likely to produce the most challenging exhibitions or, necessarily, those most central to the institution's core mission. Instead, the trust strategy suggests that certain science issues or ways of dealing with them are unlikely to arise.

Conversely, it could be argued that the introduction of controversial topics is not in itself a betrayal of the trust between the institution and the public, particularly if an exhibition were to foster the goals of the Public Understanding of Science movement, that is, to foster science literacy, however that may be defined (see section 1.2.3, page 23ff). Indeed, the betrayal would be more likely between the funders and the institution than with the public, for the public would receive the fulfilment of their trust. Nevertheless, as discussed above, the sponsor's trust relationship with the institution is operative before the public's and hence the public generally does not have the opportunity to receive such benefits. The result is a form of cultural hegemony that goes largely unnoticed and unchallenged, because it is based on sets of interconnecting and hierarchically structured trust relations, precisely the way Foucault saw the distribution of power operating, almost invisibly and without overt struggle.[4]

In practice, in order to appeal to as wide an audience as possible, the public is often led by popular fiction into scientific fact. For example, ASC used the marketing of Batman to encourage visits to an exhibition on bats (page 109). Such a strategy runs the risk of subordinating the strictly science message to popular cultural forms and the interests of

[4] A view discussed by Jurgen Habermas suggests that even if a scientifically literate public were the result, its role in matters of science and technology is at best one of "...acclimation rather than public discussion," because the voter in representative democracies has no direct role in decision-making on science-relate issues, which is made by those that govern, informed by their expert advisors (Habermas 1971: 67ff).

the entertainment industry of which science centres are a somewhat tangential partner. An attendant danger is that the science of temporary exhibitions is likely to be secondary to the popular, usually fictional, appeal of its subject. It is highly unlikely to deal with issues of central importance to the professional scientific community, challenge the conventional notions of that community's authority, or deal with topics of important social and ethical weight. To say this is to simply describe discursive formations and struggles for power that operates through and in contemporary science centres. Given all the pressures, the resulting message about science is likely to be celebratory, comforting, and reassuring.

7.3 Tensions of Science Centres and their Model of Science

The discussion in the section above dealt mainly with the status of the science centre as an institution, while the following discussion will focus mainly on the model of science that science centres promote. This distinction is made only for the purposes of exposition. A model of double legitimation was introduced earlier (section 2.1, page 32), suggesting that a reciprocal relationship obtained, where the status of the "legislator" or mediator of science legitimated the science presented, while at the same time the science presented legitimated the mediator. This is clearly the case here; the science of science centres is central to its authority and its authority gives weight to the science it promotes. In the legitimating process, the message and messenger are ultimately inseparable.

As described above, science centres are involved with a variety of other institutions each of which affects both the message and the messenger, resulting in a set of tensions that can be treated as a series of dichotomies, each pole of which is pulling the centre in a particular direction. The following list shows just some of those that operate at ASC and other science centres:

Underlying principle ... Surface phenomena
Learning/education ... Fun/entertainment
Reality ... Appearance

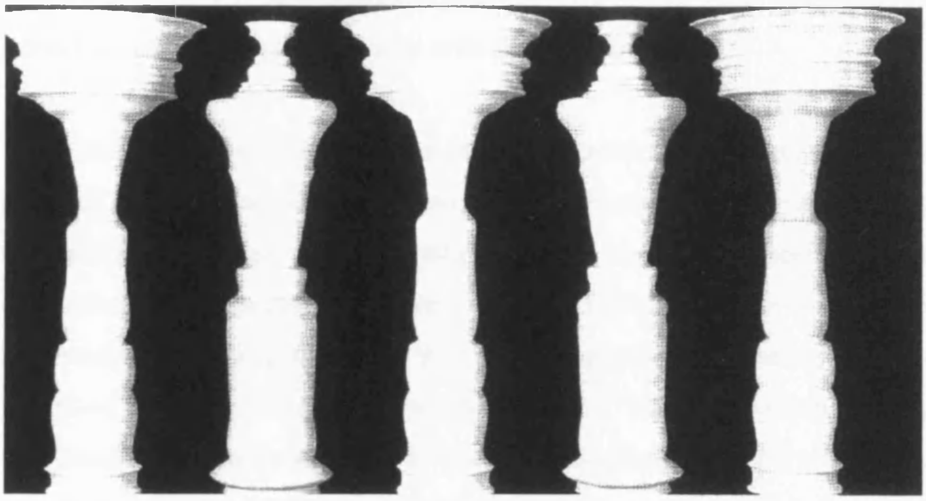
Universal principle ... Particular instance
Certainty of science ... Doubt of experience
Inside/depth ... Outside/surface
Rationality ... Empiricism
Universal truth ... Constructed meaning
Knowledge ... Appreciation
Thinking ... Embodying
Aha! ... Wow!

These form a set of binary opposites, which might be found to cross-cut in certain circumstances, but, by-in-large, those on the left hand-side belong together as do those on the right. The elements are linked to each other in a chain of preference. The deconstructionist's usual analysis of binary opposites alerts us to the fact that one member of each pair is invariably privileged and the other marginalised. This can be seen in the literature that criticises science centres (Bradburne 1998a; Hughes 2001; Karpf 2002; Kavanagh 1989), which usually takes them to task for offering their public the triviality of the right hand side when they should be offering them the significance of the left. Take James Bradburne's comments as an example:

> The dominant model in which science centres "vulgarise" knowledge to make it palatable to the masses, or sugar-coat science with gratuitous hands-on interaction to arouse visitor curiosity, is rarely if ever questioned (Bradburne 1998b: 120).

The implications of whether science centres fail to engage the right-hand side of these dichotomies will be explored below through a detailed consideration of the first two: "underlying principle – surface phenomenon" and "learning/education – fun/entertainment." What can be stated in anticipation is that science centres make a concerted effort to engage both sides. However, another valuable lesson from deconstructionism is that the honouring of both sides of a binary opposite is extremely difficult. Perhaps not coincidentally, this can be illustrated by the figure-ground illusion that is found at the entrance to the Exploratorium (figure 7.1):

Figure 7.1: The figure-ground illusion at the Exploratorium entrance



The visitor sees either a series of columns or a set of human figures, but not both, because our perceptual apparatus assumes one or other is in the foreground while the other is in the background. That is exactly the issue with any binary opposite. There is no way to foreground both sides simultaneously. To take Derrida's advice, the best we can do if we want to see things non-hierarchically (without choosing which element to privilege) is to engage in the free-play of non-stable meanings. This is what science centres attempt to do. The tensions this creates and the efforts to accommodate both aspects may be seen in the following examples.

7.3.1 Surface and Depth

A recurring constellation of ideas found in science centres, which owes much to earlier conceptions of science concern the "Underlying principle ... Surface phenomena" dichotomy. It manifests itself in many forms at ASC: truth is somehow hidden, things aren't what they appear to be, our senses may easily be fooled, perception and its underlying reality are different. Therefore, even though empiricism is the road to knowledge, immediate surface experience may be untrustworthy. Examples of this included the murals and exhibit at the entrance to the All About You gallery discussed above (section 5.1.1, page 120) and many other exhibits found in science centres, particularly those that deal directly with human perception.

These exhibits use a metaphorical model of scientific knowledge, where truth is the result of rationally based abstractions and simplifications, necessary to see the regularities, principles, and laws that govern and underpin the seemingly teeming chaos of (surface) phenomena. The move is from the novelty or error of sense perception and misperception to the discovery of the underlying principles that explain perception and, therefore, the error. This is followed by a kind of "re-seeing" when the empirical phenomenon is newly understood. There is a double-joy for the visitor here: first, the peculiarity, counter-intuitiveness, and sheer oddness of the initial phenomenon is fun to experience, but so too is the intellectual satisfaction of understanding when the anomaly is explained or discovered.

A similar model of scientific discovery can be found fully articulated in the late seventeenth century when the significance of empiricism and critiques of rationalism were first being debated. Roy Porter quotes Robert Hooke's Micrographia, where Hooke describes the new scientific method:

> Begin with Hands and Eyes, and to proceed on through the Memory, to be continued by the Reason; nor is it to stop there, but to come about to the Hands and Eyes again, and so, by a continual passage round from one Faculty to another (quoted in, Porter 2000: 149).

This anticipates by many centuries the feedback loops and interactive mechanism that are built into science centre exhibits. In modern museological terms, the illusory yet tantalizing surface appearance provides the power of attraction, but discovery of the underlying or hidden principle provides the ultimate holding power and key to understanding. This aspect is stressed in Durant and MacDonald's characterisation of science centres as concentrating on the underlying rational principles of science. This view, however, tends to marginalise the other necessary element, that is, the insistence on empiricism as the means to their discovery. Extra elements added over time to

Hooke's empiricism include the spatial metaphor of surface and depth and the notion that first appearances are often deceptive and that truth is discovered in the move between levels and back again. The move is finally embodied in the cybernetic feedback loop so influential in interactive exhibit design (page 63).

Surface/depth, illusion/reality, empiricism/rationalism pairings are found both in the history of science and in the history of museums and, therefore, it is no surprise to find it a basic device (in the sense of a stratagem) in science centres. The most compelling account of as it applies to the history of science is found in Rosalind Williams' Notes on the Underground (1990). She describes a metaphorical model of understanding that equates depth with truth, gained through the process of digging down into the phenomenon to be explained:

> In history, economics, psychology, and linguistics – in the widest possible range of disciplines – the process of excavation has become the dominant metaphor for truth seeking (Williams 1990: 46).

Science centres take up this metaphor for two reasons: first, it has been part of the basic characterisation of the operation of science for generations; second, the process of unearthing can be built into science exhibits such that visitors do not merely see, but actually embody this process of scientific discovery. Williams describes the symbolism of the model in the scientific discoveries of the eighteenth and nineteenth centuries:

> The assumptions that truth is found by digging, and thus the deeper we go the closer we come to absolute truth, have become part of the air we breathe. In this respect, scientific inquiry retains an aura of the mythological, since the heroic quest for scientific truth has the pattern of a descent into the underworld. If we shift from the metaphorical to the literal level, we still find mythological overtones to the scientific enterprise. Two centuries of scientific excavation after Bacon's death revealed a past of gigantic reptiles, buried cities, fabulous treasures, and apelike humans (Williams 1990: 49).

The metaphorical model of the hidden depths of truth is ubiquitous in our own time and can now be found in virtually any account of science. For example, Martin Curd and J. A. Cover wrote in their Philosophy of Science reader:

> The fundamental point of [scientific] theorizing [is] to discover deep, hidden truths about the underlying causes of events, regardless of whether these causes can be directly observed (Curd and Cover 1998: 1050).

Jacob Bronowski, in a more popular account of science, wrote as a summary to his historical chapters:

> We have now crossed the tangled and uneven fields of science at several places. More than this, we have at critical points mined below the surface for the solid strata on which it rests (Bronowski 1967: 102).

Science centre exhibits embody this metaphor of discovery of the underlying truth based on the model, if not the direct methods, of nineteenth century palaeontology, archaeology, geology, and anthropology. At the same time, the incorporation of this metaphor in exhibits plays an important inspirational role in science centres. In a point made at the end of the Williams' quote above, she writes:

> As Huxley noted, this is the stuff dreams are made of. Both in its process and in its results, then, both in the enterprise of digging into the subterranean spaces and what it has found there, modern science acts in an enchanted world (Williams 1990: 49).

Although she does not pursue the thought, it is clearly meant to suggest that post-Enlightenment science does not inevitably lead to a "disenchantment of the world" as Max Weber suggested, but perhaps, when the inspirational metaphors are in place, its opposite, re-enchantment. For science centres this is crucial. If visitors can be taken on such a journey of discovery, alienation from science may be replaced by enchantment with science. The devices science centres create and the experiences they offer their visitors are meant not to reduce phenomena to the cold truths of rationality, but to reinvigorate the scientific process with the mythological and heroic elements of Williams' journey. It is no surprise that science centre rhetoric, as examined in ASC's publicity materials (section 4.3.2, page 104) and the PlanetQuest 2000 planetarium script (section 6.1, page 158), are full of the familiar museum troupes of travel, discovery, and adventure. It is also not surprising that Laura Martin should comment:

> If you think of the science center personified – and I remember we were doing that with our market research, which also happened before we opened – they thought about a young Indiana Jones as the person that should be communicated.

This re-enchantment of the world is found particularly in exhibit-guided activity that leads to the discovery of a scientific principle. One may rightly describe such exhibits as "Devices of wonder"[5] and they include such staples of science centre exhibits as distorting mirrors, zoetropes, pinhole cameras, microscopes, telescopes and other lenses, miscellaneous visual illusions, Ames' rooms, immersion in giant-screen films and planetarium shows, counter-intuitive Bernoulli blowers, and many other exhibits and murals, such as those discussed above.

This move from the challenge of surface variability to inner understanding is repeated again and again at ASC. For example, a family quiz show called Call That Bluff, which has run in the Center's planetarium, periodically, since 1997, involves science experts, where only one of the experts tells the truth, explaining phenomena to a non-expert audience. The audience votes for the one they think is telling the truth, thus, literally calling the bluff. The premise requires that phenomena may be plausibly explained in more than one way, but that science experts possess this knowledge and can reveal it. Once the truth is revealed, the expert is asked to elaborate, thus, reinforcing the notions that science is about knowing truths that non-scientists could be fooled by. The surface-depth move is thus an analogy of the understandings of novices and experts. Another example that deals with the hidden nature of understanding is found in a large mural running the length of the wall of the third floor Fab Lab gallery (figure 7.2).

What at first sight appears to be a painting of a rocket blast-off and surrounding cloud formation turns out on closer inspection to contain over twenty hidden images (figure 7.3).

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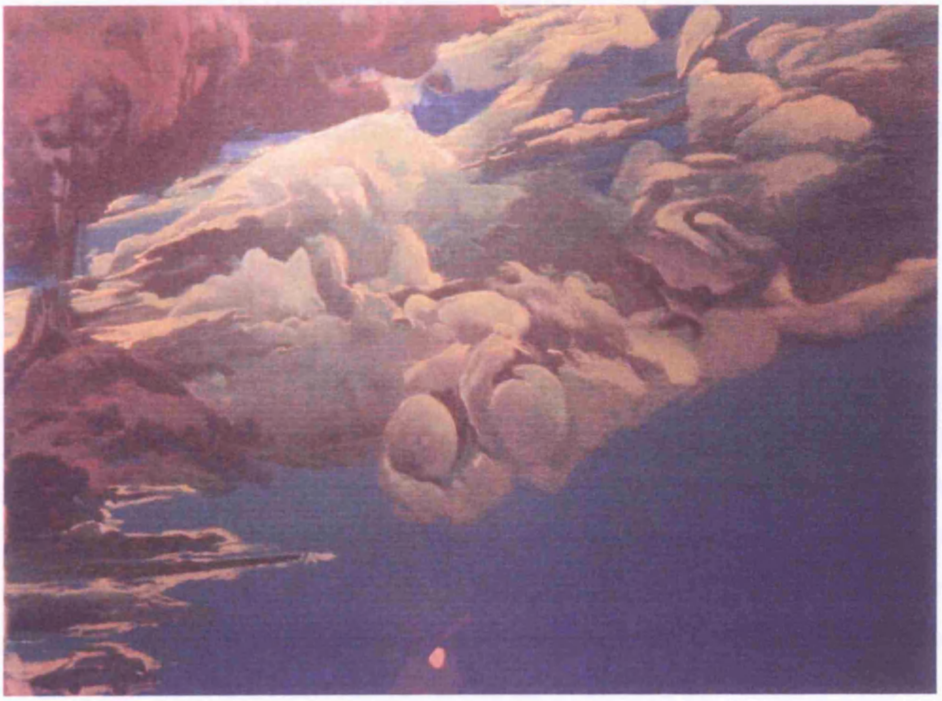
[5] To use the title of an exhibition at the J. Paul Getty museum exploring the history of "magical technologies and artful instruments" from the sixteenth century to today (Stafford and Terpak 2001).

Figure 7.2 Fab Lab gallery mural

Figure 7:3 Fab Lab gallery mural (detail)



When science centre exhibits function according to this model, its designers hope that the initial effect leads to deeper understanding. Activity-based experience and cognitive understanding are, therefore, conjoined elements of the successful science centre experience. With only the surface experience, the visitor is provided with wonder, but not the underlying explanation and understanding. The criticism is that the experience is superficial. With only explanation and no opportunity for empirical exploration, science becomes merely the didactic explication of abstract facts, laws, and principles. There is no experience, only abstraction. Williams' model (page 204), can be seen as a central metaphor of scientific discovery that science centres aim to replicate for their visitors, whereby these two elements are combined.

7.3.2 Education/Learning and Fun/Entertainment

Examples of exhibits that traverse this surface/depth dichotomous journey are often those that exemplify much of the "fun" of science centre experience. Undoubtedly, entertainment is a major motivator in science centres and yet the concepts of entertainment and pleasure are undertheorized in museums, at least in comparison with concepts of learning and education. When the issue is discussed at all it is often quickly subsumed as part of the "learning-orientated entertainment experience" in which the exploration and examination of learning is privileged, even when learning is given a broad definition (Falk and Dierking 2000: 71-74; Moussouri 1997).

Entertainment is discussed positively in terms of how it helps educate or negatively in terms of how it offers a superficial view of science, but not usually as a valued activity in its own right. The conclusion that fun and learning are simply aspects of a complex educational experience does not mean, however, the details of how and where pleasure is derived in science centres is not worth considering separately. After all, sciences centre marketers (chapter 4) and exhibit designers (chapter 5) make considerable efforts to promote and provide experiences that are pleasurable and, in the case of planetarium shows and giant screen films, overtly escapist (chapter 6).

The relationship of fun and learning is a research challenge for students of informal settings. This thesis has given more consideration to the comparatively neglected entertainment aspects than the strictly educational, which may give a false impression of the range of ASC's awareness of educational issues. At the Center, educational programmes are chosen, developed, and usually presented by staff of the Department of Education and Research.[6] They include science classes for children and families, school outreach science programs, teacher professional development courses and curricula using inquiry-based theory and techniques, children's summer and overnight camps, gallery-based science demonstrations and tabletop activities, and a wide variety of special programmes, including quiz shows, lectures by science experts, annual science festivals (such as Engineering Day, Video Game Festival, and so on), and programmes delivered through community-based partner organizations.

The approach taken in classes led by the Center's educational staff can be seen as an example of ASC's general educational approach. In short descriptions included in the spring 2000 edition of Elements (ASC's newsletter), for example, a series of 90-minute classes on the senses were offered to preschool children (those three to five years old). The "blurb" for the class "The Nose Knows" described it thus: "Explore the science behind your nose as we explore the sense of smell and taste. Mix natural fragrances and invent a new smell." Children's classes (for those five to eight and those nine to twelve years of age) included one linked to the theme of the temporary Aliens ... Are we alone? exhibition: "Invent an Alien: Learn about the physical geology and climate of other planets and then design a model of a living creature that might be able to live in such an extreme environment." One of the family classes (designed for teams of one adult and one child), also linked to the Aliens exhibition, was "Robot explorers: Use LEGO technology to design a vehicle that can navigate the terrain and sustain the extreme environments found on other planets." Each of these descriptions clearly links a hands-on activity to general scientific topics.

This move from the concrete activity to a general understanding exemplifies how each class offered at the Center was firmly rooted in its approach to inquiry-based learning

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[6] Where the author is employed.

and the empirical/rational dichotomy mentioned above. At the same time, these classes were all designed as informal and entertaining experiences.

Laura Martin, ASC's Vice-President for Education and Research, is a highly regarded and well-published researcher on informal science education (Martin 1990, 1996a, b; Martin et al. 1995) and classes developed by her staff were structured according to her interpretation of Vygotsky's approach to learning (1978). This approach is called the Investigative-Colloquium Model (I-CM). I-CM was originally developed by Brenda Lansdown (1971) and adapted by the Bank Street College of Education, New York. A central feature of the theory is that hands-on activity alone is not considered sufficient to produce generalisable learning, for participants in learning activities must also have the opportunity to represent what they have experienced in a mental model of some type and gain practice in applying that model to novel situations. This is quite difficult to achieve in the gallery setting, although, repeated experiences with several themed exhibits and having conversations with staff and others in a family or school group certainly facilitate the ability to generalise from experience. The 90-minute classes were designed specifically to provide the novelty and experience required through experimentation and exploration of selected science topics. The class setting provided a much longer opportunity to explore a single topic than is normally available in the museum setting, but with a similar informality to that provided in the rest of the Center.

Martin explained the contextual issue of the Center, applying her understanding of the "informal" to the science centre experience as a whole:

> I wouldn't use [the distinction between] "formal" and "informal" – non-school and school perhaps – because we <u>are</u> formal. We are engineered as a science center, as a learning environment, whether we choose to say that or not. We're not just out on the street, haphazard. Free choice, yes, you can browse, although with some exhibits you can't, you have to go step-by-step, stage one, stage two. But the non-judgmental thing is one of the overriding things – there's no test.

Clearly, while the museum can be thought of as free choice, it is far from unstructured. The contrast is made with school culture and its extrinsic motivators. The real difference is that science centres need to provide intrinsic motivators. Entertainment is a powerful intrinsic motivator, particularly with novices.

The I-CM theory requires that carefully selected materials, information, and examples of thinking processes must be created to teach participants how to question the natural world in order to build a scientific understanding of it. Martin describes what she sees as the particular challenge of science education with those who generally visit science centres and who may feel alienated or excluded from science:

> I think science is a particularly difficult educational challenge for a couple of reasons: because there is a body of knowledge that's outside the thinker, the learner. It has been sanctified or validated. That [knowledge] needs to get transmitted. That's hard.... Science doesn't start from scratch. If everyone had to recapitulate phylogeny, we wouldn't be moving ahead. So, we don't do that. So the question always comes down to, how do you bring people along without them feeling oppressed? How do you meet them where they're at and respect what they do think and then correct it? That's a huge challenge.

What is often perceived as mere entertainment, in the case of a public alienated and afraid of science, may be more an educational strategy that tries to avoid making novice participants feel "oppressed." This also sounds at first like the "half-constructivist" approach of science centres mentioned in chapter 1 (page 22), teaching a version of scientific realism (Bhaskar 1998) in that scientific knowledge is seen to be "outside the thinker." However, as she goes on to explain, there is no need to settle the philosophical issue of the status of scientific knowledge in order to adopt a psychological theory of how best that "knowledge" can be learned:

> Whether there's truth out there – there is a body of knowledge that is treated as truth – I don't know. It works as an explanation for the time being, until something better comes along. It's also the one our culture tells you you need to know. I think it's particularly difficult for science for all sorts of historical reasons, as opposed to some of the more interpretative disciplines – history and literature and things like that – where you can kind of make your own sense of what these elements add up to and it's OK, but science is hard, because there are rights and wrongs.
>
> The better educator would understand the logic of the visitor and then try to speak to that. Try to get them to understand the logic of the scientist either by bringing them along or by challenging or surprising them.

Science, then, is "outside " socially and culturally, rather than philosophically. Or rather, the philosophical question does not need to be answered, because society simply treats certain things as true that need to be learned as part of scientific literacy. The final epistemological status of science is irrelevant, given this more pragmatic approach, in which the child or adult visitor is assumed to be on the outside of scientific understanding or alienated from it. This understanding is available to scientific experts and their educator surrogates in the Center. Not only are the public not scientifically literate and probably scared of science, they are also likely to have understandings that need to be corrected, according to the so-called naïve notions of science approach associated with Minda Borun.[7] The task is to place them in engaging, engineered environments that result in discoveries that participants are then able to articulate for themselves in other contexts. In a sense, the focus shifts from the mind of the learner to the socially engineered environments that visitors are placed in. The environment the science centre uses is acknowledged as the "edu-tainment" one that is often criticised as being anathema to learning. Martin describes its characteristics:

> It is a safe, exciting environment. People like novelty and they like a certain degree of surprise and they like to feel connected. What I guess I'm saying is there are different environments in our museum that do that in different ways. One does it by immersing you in a beautiful scene. Another one by nestling you in a cosy dark space that's safe. Another one is a fun, stimulating, but not too monumental thing where you can explore and not feel stupid or judged. Where you can go where you want to go to. Where you know things are positive. You know that all the exhibits are smiling as you. And then you get the feeling that the whole environment or the whole institution cares about what you care about, which is understanding the world. It's a positive view of life.

This view synthesises the extreme poles of the entertainment-education dichotomy into a unified psychological process. Her particular Vygotskian inspired sociocultural theory may have differences with other learning theories applied to the non-school setting of the museum (see, Dierking 1992a; Dierking 1992b; Hooper-Greenhill and Moussouri 2002), but most agree that entertainment and pleasure are integral to education and learning when no extrinsic motivations are at work. Within a supportive environment, the pleasures of novelty and surprise form the building blocks of learning.

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[7] For a criticism of this approach see (Feher 1993) and footnote two above, page195.

Pleasure is generally accepted as a necessary psychological component of learning, but is not so well accepted and integrated into social theory. There is a certain suspicion, particularly among Marxist-inspired thinking, that pleasure is used as a tool by the powerful to spread its ideology – Bradburne's "sugar-coated science." This has been a large part of the theoretical debate on the meaning and use of pleasure in media studies (Kellner 1995). More recently, however, the notion of pleasure has increasingly been contrasted to the ideological. In some social theories, pleasure is seen as an act of resistance and not (as in most learning theories) as an act of compliance (Fiske 1996: 216).

Other theories propose that at least our "physical pleasures are our own" (Turner 1990: 110), suggesting here is a small island (of the body) free from ideological onslaught. However, as discussed throughout this thesis (and fundamental to Foucault's philosophy), the body is a contested realm in science centres and a central domain of the exercise of power relations. The various experiences the science centre offers directly impinge on the body and its sensations, from interactivity with purpose built devices, hands-on manipulation of phenomena, to the simulation of movement and immersion in the planetarium and giant screen theatre. In these spaces, we can perhaps see elements of all three social theories of pleasure. One, the body is manipulated to feel certain pleasurable sensations so that ideas of science can be directly expressed by or "inscribed" on the visitor's body. Two, the visitor can provide themselves with alternative pleasurable rewards and outcomes, often contrary to those intended by the centre.[8] Three, the choices people make among these experiences and the variable degree to which they actively engage in the experiences on offer suggests they are still, in part at least, their own masters.

The promise of fun and pleasure that is so much a part of science centres' self-image (see section 4.3.2, page 104) is also central to their criticism. For example, the theory that pleasure is an ideological tool in science centres is strongly articulated by Patrick Hughes:

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[8] A number of such exhibits were observed as part of a review process and the results reported by the author at the 2001 ASTC Annual Conference (Toon and Brower 2001).

> Science centres have proved very popular with visitors, not least because many represent science within discourse of fun and spectacle and promote themselves as sites where science equals entertainment. Indeed, at many science centres, science is totemic – emblematic of the good fortune of contemporary societies – and critical appraisal is effectively taboo. The effect is that visitors are prevented from acquiring science literacy – the critical resources required to evaluate discourse of science representations of science and scientific reports, in order to hold scientists to account (Hughes 2001: 1).

While some of this is true – science centres do deal in fun and spectacle and critical appraisal is uncommon – it is not clear that it is the fun and/or spectacle that suppress it. In and of itself fun does not preclude critical appraisal; indeed, it is the stock-in-trade of satire, parody, and debunking.[9] The taboo against critical appraisal is found in the whole discursive formation of science centres and their relationship to other institutions and interests, including educational institutions, government, business interests, and other sponsors. A broader issue raised by Hughes' comments is to question the basic goal of science centres and whether they prevent or promote science literacy, however that may be defined; in a sense do they fulfil the trust placed in them?

7.4 Fulfilling the Trust: Embodying Science

Whether the science centre fulfils its trust depends upon the role and responsibilities the evaluators mentioned in Chapter 1 consider it ought to have (page 32). In the discussion above, it has was judged a success or failure in terms of whether it falls more characteristically on one side or other of the listed dichotomies (page 200). The majority of scholarly studies assume that the judgment is determined heavily by its ultimate ability to deliver in the left-hand column (even if the importance of the right-hand column is acknowledged). This may be viewed narrowly as the ability of visitors to learn science skills and knowledge or more broadly that they become scientifically literate citizens. In so far as the right-hand column's attributes are acknowledged, they are viewed as impediments to the left-hand side or justified only if the ultimately deliver on the left-hand side. Therefore, while Bradburne and Hughes may feel that the science centre entertainment and spectacle prohibit cognitive gains, others see them as a

[9] The Aliens ... Are We Alone? exhibition, for example, debunked belief in visiting extraterrestrials.

necessary means to achieve them. For example, John Gilbert and Susan Stocklmayer take Bradburne's criticisms to heart and suggest a "personal awareness of science and technology" (PAST) model that conceptualises entertainment as merely preliminary to education:

> The model does permit the "peaceful co-existence" of educational and entertainment purposes in the construction of interactive exhibits.... exhibit designers must be reconciled to an apparent redundancy of many of the exhibits in respect of any single visitor, and that, whilst entertainment is immediate, education may be longer term (Gilbert and Stocklmayer 2001: 48).

Despite acknowledging the role of entertainment, for Gilbert and Stocklmayer, interactive exhibits are ultimately only justified by their educational efficacy. Something similar is found in Martin's comments. Such views seem to underplay the significance of the right-hand side of the column and yet again privilege those on the left.

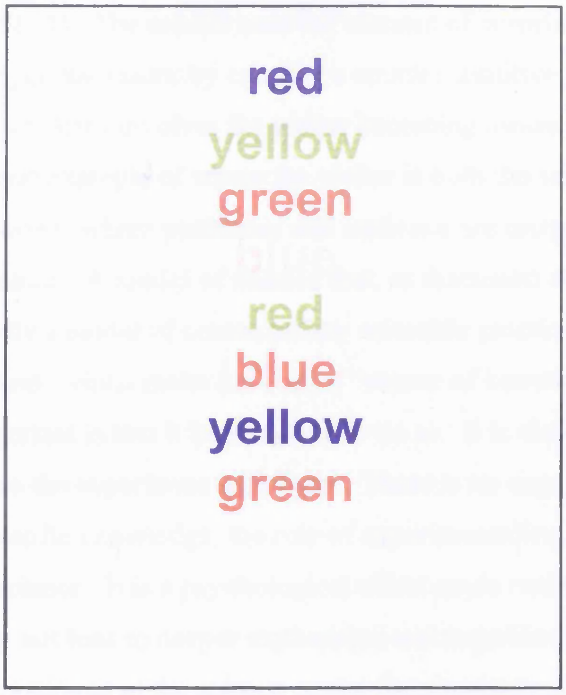
To re-emphasise the non-cognitive role, entertainment and spectacle turn science centres into theatres or carnivals for science. As a theatre of science, they can be seen as spaces in which visitors play ritualised scientists for the brief periods they are there. It is ritualised play and so does not need to model too closely the actual world of science practice. It involves its visitors in a symbolic enactment of science activity in a special zone, a place set aside, which is where neither ordinary life or science as professional practice normally takes place. As a form of street theatre, it is carnival like, involving participants simultaneously in performance, observation, reflection, and celebration. In this ritualised and liminal safe-space, normal social roles are reversed or combined. Those normally excluded from science become supposed scientists. Visitors' subjectivity and objectivity merge in the cybernetic feedback loop of experience.
All of this is temporary, lasting only as long as the visit. Like much else in popular culture, it can be taken as a way of temporarily letting off steam, while returning everything back to where it began. It is, thus, politically relatively conservative, for the science centre can do all of this while simultaneously reinforcing rather conventional views of science. One of its most significant contributions is that, as mentioned several times in this study, in a science and technology dominated world, the direction and

control over which the public has little say, the science centre temporarily transfers control to its visitors as witnesses and enactors of general principles that are not caught up in issues of epistemology, ethics, or politics.

These conclusions have implications for points made earlier about science literacy and the public understanding of science (section 1.2.3, page 23ff) and the nature of audiences and the performative (section 4.4, page 112ff). If science centres are indeed spaces for the ritualized enactment of science rather than its understanding then they are unlikely to function as sites for debate on pressing public issues by an informed citizenry. They are much more likely to be places that reinforce and acclaim the legitimacy of the forces that produce hegemony. They could still claim to have social and political relevance, however, if the performative nature of this celebration formed significant elements of the public's sense of identity or community in the ways discussed by Nicholas Abercrombie and Brian Longhurst for the music scene or identification with sports teams (Abercrombie and Longhurst 1998: 161ff). This may be doubted for science centres principally because unlike the elements of popular culture they cite, the science centre experience does not embed itself in the quotidian.

Rather than describe what science centres do not do, a final example is given of what they do. Figure 7.4 shows the well-known Stroop Effect, which was named after James R. Stroop who published his findings in the *Journal of Experimental Psychology* in 1935 on the mental "interference" effect created by the psychological tasks he set his subjects. It was included as an exhibit in the Psychology: Understanding Ourselves/Understanding Each Other exhibition that was developed by the American Psychology Association and the Ontario Science Centre. The exhibition, made up of some 40 psychology exhibits, toured 13 cities from 1992 through 1996 before being displayed permanently at ASC. A smaller version of the exhibition still tours museums and science centres, called Psychology: It's More Than You Think! In addition, Stroop Effect exhibits in many forms and styles are featured in numerous science-technology centres, web sites, and psychology texts. The visitor at the ASC exhibit is instructed to not read the words, but say the colours they are printed in. The result is invariably difficulty in completing the task because of the mental interference created by both seeing both the colour of the word and the meaning of the word.

Figure 7:4 Stroop effect



Exhibits of the Stroop Effect exemplify many of the characteristics of the science centre experience. First, although the psychologist's name may be in the exhibit's title (it is not at ASC), it is unlikely that his name would be given in full or that it would include the details of his "discovery," when he performed his experiments, or what he was trying to achieve. It is also unlikely that the significance of his work for the history of psychology or the continuing debate over what causes the interference would be included (but see Bower 1992, May 9; MacLeod 1991). Indeed, the label text at ASC on the panel that resembles figure 7.4 begins with the title "Interference" and instructs the visitor as follows: "Don't read the words below. Just say the colors they're painted as fast as you can out loud. You're in for a surprise!" Accompanying text panels and a panel with reversed text (on the other side of the panel above) suggests other experiments to try, but no psychological explanation is provided. The important thing is to perform the activity as instructed in order to enact the effect.

While this exhibit is little more than a printed panel with instructions, it is highly interactive in the sense meant by Beetlestone, as quoted above (page 65), where he commented that, "In many of the best interactives, the action is all in the visitor's head" (1998: 7). The exhibit uses the element of surprise (even though it announces it) to intrigue the visitor by creating a counter-intuitive and unexpected experience. Engagement involves the visitor becoming aware of his or her own cognition. It is also a good example of where the visitor is both the subject of the experiment and its observer; where performer and audience are merged; where subjectivity and objectivity combine. A model of science that, as discussed above (section 5.2.2), Barry noted is hardly a model of contemporary scientific practice, but is characteristic of science centres, which make the body a "source of knowledge" (page 153).[10] What is most important is that it is enjoyable to do so. It is also enjoyable to see others try and to share the experience with them. There is no engagement here with the nature of scientific knowledge, the role of experimentalists, or the ethical or social consequences of science. It is a psychological effect made real by its enactment and which may or may not lead to deeper exploration and cognition (learning) as to why. Through embodiment in the science centre the phenomenon is affirmed, as is the authority of science to isolate it for experience and interpretation. This is, thus, an example of the ritualised dual legitimation of science and the science centre performed each time a body enacts the activity, or a mind thinks about it.

7.5 Boundary Issues

This thesis argues that a broader intellectual approach should be taken to understanding and interpreting science centres than found in most of the available literature. This amounts to arguing for a perspective that goes beyond the dominant educational point of view, to a place where educational arguments can be seen in context as part of science centres' discursive practices of legitimation. It should be noted, however, that these arguments are far from complete and as social values inevitably change and views of science and education alter, they may never be complete.

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[10] Barry footnotes Richard Gregory on this point, suggesting again the importance of Gregory's thinking in science centre exhibits.

Viewed as a contemporary snapshot, however, we can see the current debate unfolding on two fronts. First, as described at several points above, as educational institutions, science centres want to both align with and be distinguished from formal educational institutions. Second, they also want to simultaneously develop their own distinctive approach to a science-rich edu-tainment experience, one that has been described here as ritualistic and yet symbolically significant. These two trends appear to pull science centres in different directions. This constitutes an on-going argument about two distinct boundaries.

The first boundary can be characterised as an inner-boundary issue that boils down to whether informal or free choice science education, as it is found in science centres, subsumes formal science education, is distinct from it, or is ultimately the same.[11] It was suggested above (section 1.2.2, page 14) that this is as much an issue of cultural politics as it is a theoretical question and it is likely to continue to be important in both areas. The advantage of the broad perspective advocated here is the ability to examine such views without having to choose between them.

The second boundary can be characterised as an outer-boundary issue that boils down to whether or not all experience should be thought of as educational. The questions become: How far does the educational experience go? Are the emotional, entertainment and escapist elements, for instance, best seen as educational or something *sui generis*? On this issue, the broad perspective advocated here does not afford the same neutrality as that of the inner-boundary, for it is self-evident to the position argued for here that there are experiences at science centres better viewed as non-educational, yet culturally significant. The whole argument offered about the importance of the ritualised and embodied enactments of scientific truth is predicated on such a notion. This results in a curious consequence.

This thesis has investigated the various modes and means of legitimacy that ASC deploys, from its media messages, ephemeral printed material, and building, to its permanent exhibits and programmes. It is perhaps, therefore, ironic that the largely

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[11] This "debate" is the focus of a series of articles in the Informal Learning Review. (See, Ansbacher 2002; Dierking et al. 2002; Russell 2002).

under-researched and under-valued role of non-cognitive activity explored here is in the main absent from the discursive legitimating practices of science centres. Discussion of the cultural significance of such ritualised activity is hardly addressed by the science centre movement. Where it does gain some mention (in the scholarly literature), it is more likely to be as an example of what is wrong with science centres than as an example of how to deliver a meaningful (read educational) experience. Nevertheless, its omission in large measure proves the point about how legitimation functions for science centres. It is absent precisely because it has no institutional advocates and it has no advocates because it has no legitimating power for the institution. Its advocacy here comes from a rather marginal voice: a middle manager without direct programmatic responsibility.

One may speculate on the reasons why such a view has no more powerful advocates: thought is more culturally valued than symbolic acts; ritual activity is largely considered empty or meaningless; scholarship itself values cognition above action. Whatever the reason, a significant part of science centres' central experience goes virtually unnoticed and certainly under-appreciated and yet makes up much of its offerings, at least, according to the analysis offered above.

There are reasons to think that with changing circumstances the boundaries discussed here will become more contested and, therefore, the subject of greater scrutiny in the future. For example, on the inner-boundary there are likely to be increasing pressures on U.S. science centres by government, foundations, and philanthropic sponsors to deliver what are considered core educational outcomes: basically, science knowledge and skills that can be demonstrated through standardised testing. In Arizona for example, while student testing in science is not currently a state requirement, it will be in 2005. So while funders are likely to continue to support inquiry-based, constructivist learning advocated by science centres, they are less likely to be impressed by claims in the affective domain unless they are also accompanied by what Falk called "traditional learning" outcomes: basically, increased test scores. It is already the case that many science centres, including ASC, align their exhibits and programmes with national and state school-science educational standards and that most provide professional development programmes for teachers; the NSF-funded Teacher Institute at the

Exploratorium is a national model. It is likely that debate on the inner-boundary will become more heated as science centres compete with each other and the formal educational system for scarce education dollars based on their ability to produce quantifiable results.

On the outer-boundary, there are trends that suggest some science centres are also becoming more entertainment focused and theme park like in their programmatic offerings. New technologies developed by the IMAX Company in partnership with the Disney Corporation, for instance, have recently made Disney films available in large-screen format and a number of science centres are offering and marketing the showing of Disney's *Beauty and the Beast* and *The Lion King.*[12] This is a far cry from the large-screen science documentary, for so long associated with science centres and promoted by the National Science Foundation (page 167). Similarly, blockbuster exhibits like Titanic: The Artefact Exhibit have been presented at a number of science centres, including ASC, even though the exhibition has relatively little science content. More fundamentally, new immersive science centres have opened recently, such as Science City in Kansas City, Missouri, which its President described as a place that,

> ... extends the earlier models for museums and science centers by integrating key characteristics from theme parks, retail and theatre to create a new form of educational attraction (Ucko 1999: 5).

It is unclear which trend will predominate – the educational or the entertainment – or whether, like the other dichotomies discussed above, they will continue to somehow balance each other out.

7.6 Future Research

The research presented here is multi-theoretical, multi-methodic, and ranges over a wide area of academic disciplines. It is not surprising, therefore, that this research opens up a wide area of possible future research. For the sake of convenience, suggestions are grouped into six areas, although there are several overlaps among them.

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[12] General feature films like *Star Wars* are also about to be shown in large format versions.

Case studies. This study told the story of a particular institution in a particular time and location. Broad generalizations about science centres were made based on its findings. There is a need for similar case studies of science centres in other U.S. cities. This would allow direct comparison with this study and, thereby, test its general conclusions.

The science centre situation can also be compared and contrasted with claims to legitimation found in case studies of other types of museum. Those explored by Timothy W. Luke, for example – which include two case studies of Arizona science museums (The Arizona-Sonora Desert Museum and the Pima Air and Space Museum) – is a recently published example of how museums, "... shape collective values and social understanding" (Luke 2002: xiii).

As mentioned above, the majority of previous studies of science centres were undertaken in the U.S. and the generalizations of this study apply no further than North America (page 41). Case studies of science centres in other countries, plus cross-cultural studies, however, would reveal much about the relationship of science centres to national cultural settings and help place the interpretation of U.S. science centres in its particular socio-political context. There is a need for such studies; for while science centres are a rapidly growing worldwide phenomenon, nevertheless, ". . . science centers are also very much influenced by local resources, needs, and norms" (Pollock 2003: 1).

Historical studies. A major organizing principle of this thesis is that the science centre movement has a long and varied history that is not fully dealt with in the scholarly literature, particularly, when its history is seen as part of the popularization of science, including, but going beyond, the modern notion of the museum. Seen from this broader perspective, there is a need for general historical studies, building on the work of Barbara Stafford (Stafford and Terpak 2001; Stafford 1994) and others, of <u>informal</u> science education in its various manifestations: popular lectures and demonstrations, private science amusements and hobbies, and technology-based public amusements such as planetariums, giant screen films, and so on.

Much remains to be understood about the role of the science centre movement as a major form of science popularization. This study raised a number of questions it was not fully able to answer, even with the help of its key informants: How have the notions of hands-on and interactivity developed and changed over time? What is the history of the "basic suite" of exhibits found in science centres all over the world? How influenced by the school-based science reform movement were the pioneers of science centres and *vice versa*? While science centres generally eschew the historical approach to science, they clearly have an important cultural history of their own that remains significantly under researched.

Statistical studies. Among data presented here were a variety of statistics collected by ASTC and other national sources on science and technology visiting and involvement (see in particular, section 4.1., page 86). Unfortunately, not only is it difficult to extract science centre data from that of other types of member institutions, but also current data are largely institutionally focussed – on budgets, staffing, facility size, programs offered – rather than on who visits and what they learn (Association of Science-Technology Centers 1989, 1998, 2001). The demographic and outcome data that are reported are either in the form of small-scale or generic research reports (Association of Science-Technology Centers 1990, 1993, 1994) or the ubiquitous, yet relatively uninformative, statistic of annual attendance. Overall, little is known about the demographic characteristics and learning outcomes of visitors to ASTC member institutions. If science centres are important informal science learning institutions then it is important for statistically based studies to gather and provide broad evidence on who learns in science centres and in what ways.

Such studies would not need to reinvent the wheel for there is much consensus in the literature on the need for a broad-based definition of learning, particularly as it applies to the informal or free-choice learning sector of which science centres are a part (Falk and Dierking 2000, 2002; Hein 1998, 1999; Hooper-Greenhill 1991, 1999). In addition, the Research Centre for Museums and Galleries (RCMG) at the Department of Museum Studies at the University of Leicester has already developed a "toolkit" for tracking the outcomes and impact of learning where "individual learning strategies" are linked to reportable "generic learning outcomes" (Hooper-Greenhill 2002a, b). Such a tool kit used in science centres could provide the detailed evidence on learning that researchers, funders, and science centres themselves are keen to understand.

Methodological studies. The results of the multi-methodic approach adopted here were described above as bricolage (page 6). This approach was adopted in part to break free of the dominant ways in which science centres are studied and interpreted, that is, as places that model the practice of science, places for science learning, and places for the public understanding of science and the promotion of science literacy. The intended result was to disturb the taken-for-granted understandings of science centres in order to step back and see them afresh – a sort of defamiliarization or "making strange" (to borrow terms from literary theory). The approach was to use whatever seemed an appropriate method at any given point in the argument ("at hand"), including philosophical argument, statistical analysis, textual analysis, informant testimony, reflective practice, etc. While this did enable a variety of evidence to be presented, it also challenged the reader to see the connections between them and ran the risk of making a patchwork of juxtapositions that might not form a fully coherent and connected picture. Efforts were made to reflect on these issues (particularly, section 2.3, page 49), but further studies are needed that examine more fully the implications of adopting a multi-methodic approach.

Theoretical studies. This study attempted what was called "epistemological agnosticism" towards the claims of science and a discussion was introduced on the nature of the scholarly "sticking points" that make such "bracketing" a useful theoretical position (page 47ff). Something similar was attempted with other key theoretical terms, including among others "ideology" (substituting "legitimation" instead), "learning," and "embodiment." While certain problems are sidestepped by such theoretical neutrality, other difficulties and confusions arise because it is not possible, or desirable, to avoid using these terms (the word "learning" occurs over seventy times in the first chapter above) and, yet, in not stating a position one can easily be assumed. For instance, although it was argued that certain approaches to learning were criticized for carrying cultural politics too far, that "boundary issue" problems were likely for learning in the science centre context, and a non-learning "space" was needed that allowed "embodiment" to be seen clearly, no precise definition of learning was offered. It could easily be assumed from this that "embodiment" was defined as outside of a learning experience and that, therefore, the definition of learning implicit in this thesis restricted itself to the relatively narrow issues of knowledge and skills. To go back to the point made above, the aim was to be agnostic, however, the desire to make a place for embodiment may well have involved crossing an unintentional line that did thereby overly restrict the notion of learning. It can be acknowledged that the "embodiment" argument is compatible with certain broad notions of learning. The only defence is that the aim was not to advocate for such an understanding or decide the issue one-way or the other. Rather, it was to simply argue that visitors to science centres embodying the "truths of science" by their actions is an interesting phenomenon worthy of consideration in its own right. This would be the case whether or not it might also fall under a particular notion of learning. What this discussion suggests is that there is a place in future studies for the careful unpacking of the meaning of concepts. Many quite ordinary words, such as those mentioned above are employed in the study of museums in quite technical ways. One can hope that future philosophically-inspired studies may do for museum studies what Ian Hacking did for experimental science when he discussed the meaning of terms such as "experiment," "observation," "measurement," and "microscopes" (Hacking 1983).

Cultural studies. Science centres as active participants in the production of culture both affect and are affected by changes in society. This thesis left much of this social context unexamined and treated it rather as a given. It was written assuming the social context of pro-science optimism largely attributable to post-Second World War scientific and technological innovation and economic prosperity. New research is needed that examines the interface between social change and science centre messages about science and technology. Science centres in the United States developed during the Cold War period and prospered during an era of unprecedented material and technical domestic progress and peace. The science centre movement grew rapidly and adapted successfully along the way, contributing to the public's widespread faith in and support for scientific and technological advancement. Nevertheless, public responses to events such as September 11th, the recent Columbus space shuttle crash, and broader concerns over the environment and "advances" in biotechnology, genomics, and other science-related social and political issues suggest significant changes may be taking place in the public's attitude to science and technology. So far, attendance at science centres has not regained its pre September 11th level,[13] but more sensitive and appropriate measures are required to study changes in the social meaning of science in contemporary society and the role science centres have in creating and reflecting theses changes.

Perhaps Roger Silverstone's suggestion will come to pass and people in a time of increasing vulnerability and uncertainty will turn to the fantasy end of experience (page 13). Conversely, they may seek out a deeper understanding of the troubled world around them and be drawn to a deeper exploration, including that provided by science and mediated by science centres. They may even do both. Whatever the outcome, the science centre movement will try to respond. So far, the movement has steadfastly maintained its allegiance to a universal and abstract notion of science mediated to a public through enjoyable interactive encounters. It is not clear, however, if over the longer term such optimism can be sustained and seen as appropriate by its various publics. Thus, claims to legitimacy will continue to be made by science centres as science and the social world alter and it is to be hoped that future studies will track and interpret these changes.

[13] According to unpublished research reports compiled by ASTC for charter member organizations.

Appendix

The following table provides the name of each interviewee and their role at ASC that formed the focus of the interview,[14] the date of the interview, and the approximate length of interview.

Interviewee	Date	Approximate Length of interview
Sheila Grinell, (ASC Chief Executive Officer)	January 2001	2 hours
Grant Slinn (ASC Director of Exhibits)	September 2001	1 hour 45 mins
Chevy Humphrey (ASC Vice President of Marketing and Development)	October 2001	I hour
Laura Martin (ASC Vice President of Education and Research)	October 2001	1 hour 15 mins.
BJ Freeman (ASC Trustee)	March 2002	1 hour

The semi-structured interviews were recorded and later transcribed. All interviewees were questioned on their role and work for Arizona Science Center. Grinell and Slinn were also asked about their prior experience in and understanding of the science centre movement in North America. Chevy Humphrey was questioned on ASC's marketing strategies, particularly with regard to temporary exhibitions and fund raising. Laura Martin was questioned on her educational philosophy. BJ Freeman was questioned on her involvement with the Junior League of Phoenix and its efforts to open a science centre in the city.

Follow-up questions (not transcribed) were asked of all interviewees except BJ Freeman. Sheila Grinell gave a general follow-up interview (not transcribed) in January 2003.

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[14] At the time of interview, Grant Slinn was Director of Exhibits and Programs at Science World, Vancouver, Canada.

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