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## CHAPTER 9

# North American World's Fairs and the Reinvention of the Science Museum in the 1960s

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*While it is an established fact* that world's fairs played a key role in the establishment of science museums during the nineteenth century, this perspective is largely absent during the twentieth century, especially the postwar period. However, this is more due to a lack of interest in the history and impact of world's fairs during the twentieth century than to a lost connection between the popular forms of science and technology displayed at fairs and those in museums. In order to uncover these connections, I focus in this chapter on two diametrically opposed reinventions of what usually is

called a “science museum”—both of which occurred in the United States in the 1960s—and try to place them into the context of the North American world's fairs of that decade.

The Smithsonian Institution's Museum of History and Technology in Washington, D.C., revived the traditional museum of historical artifacts, in which the objects are meticulously and systematically arranged into one visiting tour. However, in its conception as a museum of history *and* technology (rather than *of*), objects of science and technology were meant to be contextualized within a larger historical narrative. Along the museum's trajectory—which involved its renaming to the National Museum of American History—it was ultimately drawn into the “science wars” of the 1990s, thereby pushing its way to the fore of museum discussions.<sup>1</sup>

The Exploratorium in San Francisco, in contrast, did not develop as a place where historical artifacts could be found, despite following “a rationale for a science museum.”<sup>2</sup> Rather, it was seen as the model for what is now widely identified as a “science center”—a place for hands-on experiences of scientific phenomena, a playground of exploration with few, if any, rules or tour recommendations, and as site where science and art can connect, however loosely.<sup>3</sup> Whether it was intentional or not, as those involved would say, the “science center” became an ideal presentation of science that could be politically instrumentalized while easily evading tedious problems of social implications, the environment, or military application. In this way, science centers opened a window for a more uplifting “public understanding of science”—to use an old phrase that had been remobilized in the 1980s—foregoing more critical approaches.<sup>4</sup>

I argue that the apparently contradictory developments of the “science museum” as an institution can be understood only within the context of the history of world’s fairs in North America at that time. After the rather late, postwar resumption of the world’s fair model in Brussels in 1958, the expos in Seattle (1962), New York (1964–1965) and Montreal (1967) not only defined the state of the art of display in this field, but also shaped visitor expectations toward permanent science and technology display in museums through ambitious exhibits.

I proceed in four steps: After a short introduction into the postwar setting, during which few new museums or large fairs were erected before 1958, I first focus on the immense efforts undertaken for the U.S. Science Exhibit of the 1962 Seattle expo, and demonstrate how it anticipated display concepts now associated firmly with later institutions. Second, I discuss the rather awkward simultaneity of the 1964 New York World’s Fair, whose Hall of Science was transformed into a permanent institution, and the opening of the Museum of History and Technology in Washington, D.C., which marked the positive ending to a long struggle to establish such a museum in the U.S. capital. While the former was dominated by big corporations, the latter pursued a much more historical and academic approach. Third, I address the developments between 1964 and 1969, sketching the prehistory of the Exploratorium and its “rationale” and relating it to the contemporaneous 1967 International and Universal Exposition, or Expo 67, in Montreal.<sup>5</sup> Lastly, I put into perspective the Exploratorium and its initial program, which—though soon dismissed—had more likeness to the display approaches in museums and world’s fairs. This section concludes with reflections on how the history of a long-term development of interactive exhibits differs from the rather local and audience-dependent reinventions of different kinds of science museums.

## Bringing the World’s Fair Model into the Atomic and Space Age

It is widely held that world expositions were a phenomenon of the nineteenth century, culminating in the Paris fairs in 1889 or 1900 (the fairs in Chicago and St. Louis were other notable events in 1893 and 1904, respectively) and extending until World War I. However, there have been

two renaissance periods of this type of spectacle that have not been given the same historical attention so far: the first was in the 1930s, particularly on the eve of the Second World War, and the second took place in the 1960s, during the period of time referred to as the Space Age. After plans for an international exposition in Tokyo in 1940 and Rome's "E42" in 1942 were canceled, it would take until 1958 for a postwar world's fair to take place in Brussels.<sup>6</sup>

While the war took a toll on some of the leading science museums hit by bombs, such as those in Munich and Paris, or blighted by years of neglect, like that in London, the demand for scientific heritage in Europe survived virtually unscathed. As the special *Diesel* exhibit at the Deutsches Museum in 1947 showed, presented even before the museum was reopened in 1948, the idea of the science museum was very much alive.<sup>7</sup> This was confirmed again with the London Science Museum's exhibit on *Chemical Progress* in the same year.<sup>8</sup> While Italy could boast the opening of a new museum in 1953, the Leonardo da Vinci National Museum of Science and Technology in Milan had a concept that was more compatible with plans from the 1930s and 1940s.<sup>9</sup> In the United States, the New York Museum of Science and Industry had excelled with its interactive and "progressive" exhibits, but these were supplanted first by industrial and, during the war, by military displays. Thus, wrecked by war and war ideology, the museum died quietly in 1951.<sup>10</sup>

Science exhibits became a key part of events to raise the spirit of nations. For example, the 1951 Festival of Britain, which—like the British Empire Exhibition of 1924—used the model of a world's fair, but adapted it to serve the self-assurance of empire and nation, respectively.<sup>11</sup> The festival became a "golden opportunity" because it brought a new building for the Science Museum, which served as the key place to promote the atomic theme of the fair.<sup>12</sup> Similarly, the All-Union Agricultural Exhibition, which had been reopened in Moscow in 1954, was rebranded as an industrial exhibition two years later and became the Exhibition of the Achievements of the People's Economy in 1959.<sup>13</sup> The world's fair model had been adapted once again, only this time for the Soviet world. Clearly, the exhibition raised the spirits of the Soviet peoples, but its Pavilion of Atomic Energy in particular also had the effect of sparking international competition in Atomic Age exhibits. Most popular among the artifacts was a working 100-kW nuclear reactor of swimming-pool type, which was demonstrated to the visitors from 1956 on.<sup>14</sup>

When the United States wanted to counter this idea for the promotion of nuclear energy at the Brussels Expo 58 with a U.S. reactor, it displayed a dwarf copy with the feeble power of 1 watt in a section of the International Hall of Science that was accessible only to qualified scientists and hence visited by a very small fraction of fairgoers. (Originally, it was planned to power the entire event, with the first Belgian 11.5-MW nuclear plant to be built on the fairgrounds, but a worried King Baudouin in his nearby palace ultimately nixed the idea.)<sup>15</sup>

The United States also had underperformed in other areas in competition with its Cold War rival at the time of the Khrushchev Thaw. Newspaper reports and historians' judgments on the American performance at the Expo 58 appear rather mixed. They cite as detrimental factors the long struggles against underfunding, an aura of complacency, an exhibit conceived by the MIT on *Unfinished Work*—which was supposed to present the problem-solving capabilities of American

democracy, but at the same time acknowledged the social problems of race and urban blight—and even the use of the U.S. presence for espionage activities. In any case, it was difficult for the Americans to counter the hard-selling approach of the Soviets. Like most western countries, the United States was still playing the tune of the peaceful atom and the advantages of democracy, while the Soviet pavilion combined a monumental Lenin with *Sputnik* I and II, including their notorious *beep-beep-beep*. Taken together with a model of a future solar-powered space station, the Soviet exhibits significantly shifted the field of competition and at the same time drew attention to new sorts of artifacts: satellites, rockets, and space modules.<sup>16</sup> There had been no time to counteract the *Sputnik* shock at the Brussels Expo, but something had to be done to reclaim U.S. scientific preeminence.

## The United States Science Exhibit at the Seattle World's Fair 1962

In mid-October 1957, a few days after the Soviets launched the first *Sputnik*, the Josiah Macy Jr. Foundation's Frank Fremont-Smith, Chief of the Office of Science at U.S. Department of Defense Orr Reynolds, and Associate Director of the National Science Foundation James Mitchell met in Washington, D.C., and agreed that something such as an international science fair was badly needed to demonstrate the many areas in which U.S. science was preeminent and awaken the American public to the significance of the general scientific effort and the importance of supporting it.<sup>17</sup> This was the starting point for a world's fair that put science—"rather than its massive technology"—at the center like no other before or after.<sup>18</sup> The *Sputnik*-induced project was discussed in wider and wider scientific circles, and eventually more than 300 scientists collaborated with the U.S. Department of Commerce on a U.S. Science Exhibit, for which the federal government appropriated about \$10 million. Only several months after planning had started, it became apparent that the opportunity of Seattle's thematically rather unfocused and delayed bid for a world's fair could be seized, and so the U.S. Science Exhibit along with the Space Needle became the core attractions of the 1962 world's fair.<sup>19</sup>

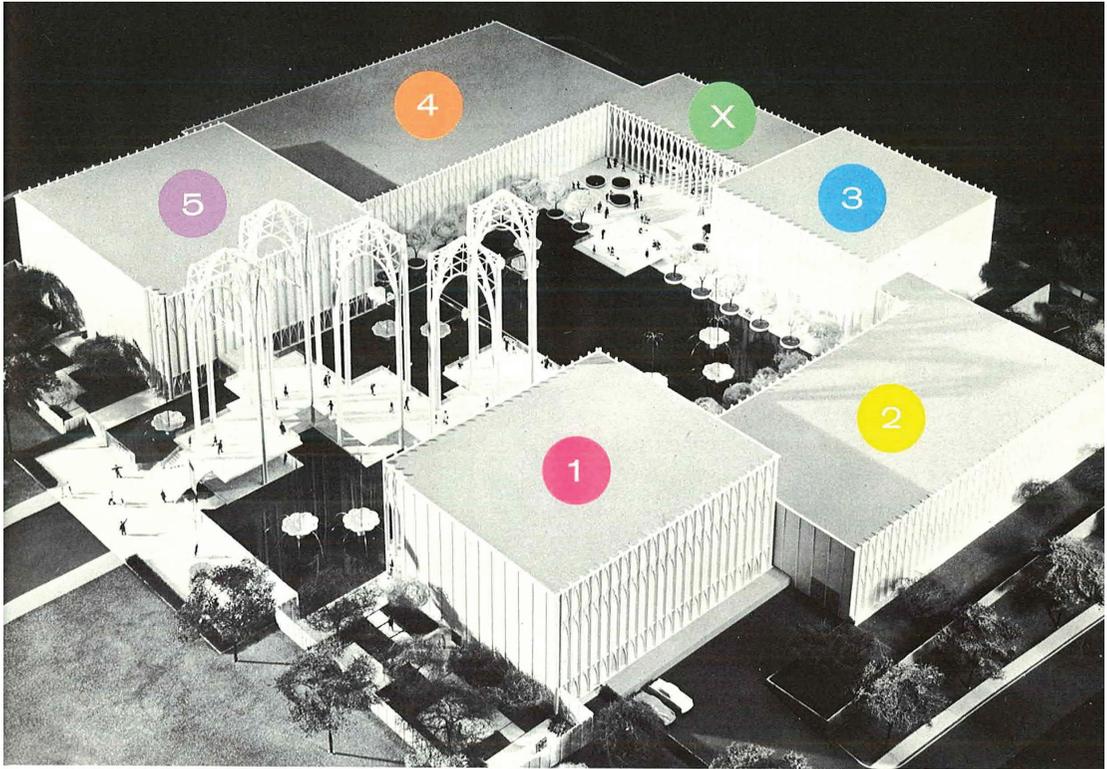
For Seattle—the city of Boeing Corporation, a leading airplane and rocketry company that was now also supporting the international event with \$2 million—the Expo stimulated city modernization, brought in cultural institutions, and diversified Seattle's commercial range beyond aerospace. However, neither the initial theme of the "World of Century 21," a typical future-oriented display of technological prowess, nor the "World of Commerce and Industry," the more traditional trade show part, let alone the "Worlds" of entertainment or art, defined the expo of 1962. Rather it was the "World of Science," which was visited by more than 6 million people, or 70% of all those entering the fairground.<sup>20</sup>

The "storyline" of the Science Exhibit was conceived to be "a radical departure from all science and technology exhibits in the past." Already its size of six acres, housed in five huge buildings, "not only dwarfed similar exhibits in other fairs, but there are relatively few museums in the world with this much space devoted to science," let alone "contemporary science." In contrast to

other exhibits and museums, a novel approach had been adopted: As “an adventure of the mind” and “man’s effort to understand the universe,” it needed to be more than a pleasing compilation of interesting objects. In any case, it had to be neither “a glamorization of science,” nor “a parade ground for products” for industry, thus alluding to criticism, which had been raised towards the largely corporate-driven expos in Chicago and New York in the 1930s. Now it was an “effort to display the innate beauty and joy of science rather than its complex discoveries,” as in this way it could become “the most powerful and important social force in the world.”<sup>21</sup>

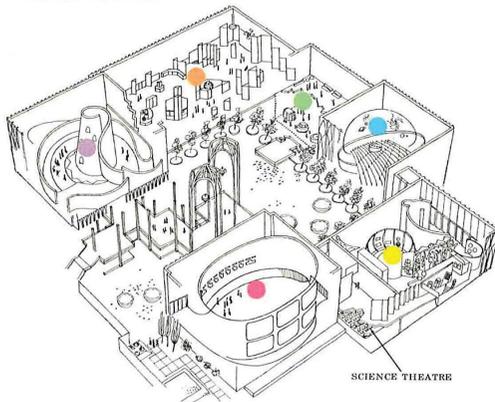
As *Science* reported after the fair, the approach had worked: “[P]lanners of the United States science exhibit risked a display that was essentially science without technology, and they appear to have made a popular success of it,” which was all the more remarkable because in Brussels “some of the exhibits had gone over the heads of the fairgoers.”<sup>22</sup> The latter, however, was a euphemism; in the report of a science adviser to the U.S. secretary of state, the exhibit was described more devastatingly as “too technical for any but the most highly trained scientists.”<sup>23</sup> Seattle’s U.S. Science Exhibit should do better, for one by providing a carefully crafted storyline unfolded in six areas, which I will only briefly sketch out. Another decisive element of the exhibit’s success, upon which I will focus in more detail, were its artefacts and “edufacts”—that is, non-authentic and non-historical objects, which elucidate scientific phenomena often in a hands-on way.

In Area 1 (Figure 1) the visitor first saw a 13-minute state-of-the-art immersive film presentation that was created by Charles and Ray Eames and portrayed the scientist at work, claiming that “a laboratory can be anywhere that a scientist is drawn to look.” Thus, it stressed a general human interest and faculty, while in the end summarizing that “[S]cience is essentially an artistic or philosophical enterprise carried on for its own sake. In this it is more akin to play than work.” And this play was meant to solve “a system of interlocking puzzles,” assuming they are solvable and fair.<sup>24</sup> Area 2 was mainly historical and arranged in such a way that the visitor followed a defined path. It started with a large section on false perceptions of the senses of sight, hearing, and touch—for example, “Touching concentric loops of warm and cool pipe convey a burning sensation” (Figure 2, on the left). The section then turned to the techniques of precision measurement and subsequently opened a museum-like display of artifacts, mostly historical replicas and some loans from the Smithsonian that dealt with electromagnetism, atomic-molecular research, genetics, and astronomy. By combining historical objects with three-dimensional scale models and a number of panels and charts, the exhibit emulated—or rather updated—contemporary forms of display, such as those found in the major science museums. However, there were only a few “audience-operable devices,” such as an exhibit demonstrating the charge-to-mass ratio of electrons.<sup>25</sup> More than an update of the contemporary planetarium shows was the Boeing-sponsored Space Age planetarium, or *Spacarium*, which simultaneously beamed 750 “passengers” into outer space. With the help of astronomers and space scientists, “the production as true a representation as possible of the stars, planets and other astral phenomena” was attempted in Area 3.<sup>26</sup>



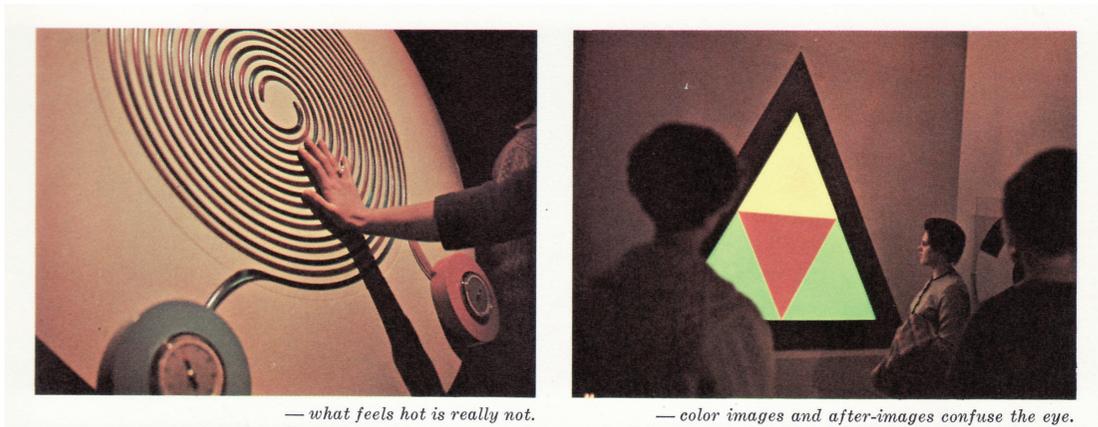
## GUIDE TO THE UNITED STATES SCIENCE EXHIBIT

Colored numbers indicate the preferred sequence in which the exhibits should be seen and are keyed to corresponding sections of this book. The Junior Laboratory of Science is for children from eight to sixteen years of age.



- 1 *The House of Science*
- 2 *The Development of Science*
- 3 *U.S.-Boeing Spacearium*
- X *Junior Laboratory of Science*
- 4 *The Methods of Science*
- 5 *The Horizons of Science*

**Figure 1.** U.S. Science Exhibit at the Seattle World's Fair 1962, bird's-eye view of a plan of the site and interior of the buildings. From U.S. Department of Commerce, ed. *Souvenir Guide Book: United States Science Exhibit. World's Fair in Seattle 1962* (Seattle: Craftsman Press, 1962), 7.



**Figure 2.** Hands-on and visual perception exhibits in Area 2 of the U.S. Science Exhibit. On the left, a “touch-deception exhibit” with a double spiral of hot and cold tubes, and on the right a color projection that demonstrates the fallibility of human vision. From U.S. Department of Commerce, ed., *Souvenir Guide Book: United States Science Exhibit. World’s Fair in Seattle 1962* (Seattle: Craftsman Press, 1962), 13.

Returning from both the future and history, Area 4 on “the methods of science” aimed to show the visitor “how scientists do their work” and to present 27 supposedly “random samples of present day research which is still going on,” each of them addressing a question that would provide the exhibit’s main headings. Doing good science was all about asking the right question, “one that goes to the heart of the problem—and can be answered with the tools and information at the scientist’s disposal.” The planners stopped short of presenting current research, but they hired 40 carefully selected, scientifically trained and attractive young women as “science demonstrators,” who were dressed in uniforms and consistently styled. Their assignment was to explain, for example, a working satellite-tracking station or topics such as atomic structure or nuclear energy to a large crowd of visitors without entering into politically laden terrain: The satellite exhibit was simply determining the exact shape of the earth, while atomic and crystal structures were unrelated to negative uses, as was the production of energy by nuclear fusion and photoelectric cells. Further demonstrations from the life and behavioral sciences included the process of preparing tissue for examination under the electron microscope, how pigeons learn to peck according to the colors and patterns presented to them, and the filial imprinting of chickens. A special part of the building was reserved for The Modern Laboratory, where standard lab techniques were demonstrated “live,” including the handling of radioactive cobalt-60 to inhibit bread mold; the stimulation of horseshoe crabs’ optical nerves, which could then be monitored on an oscilloscope; or the operation of a Soxhlet extractor to isolate special ingredients from plants. In this modern look-the-scientist-over-the-shoulder laboratory, some gifted female demonstrators engaged in individual research that “bordered on original work.”<sup>27</sup>

This approach to exhibiting scientific work and the real materiality of the lab with an attractive and placid (female) face may be traced back to the Palais de la découverte in Paris, which introduced the demonstration of scientific practice into the museum in the 1930s. Even more spectacular than this part of the exhibit, however, was likely Area X, also named Junior

Laboratory of Science, which can be understood as the postwar version of the London Science Museum's Children's Gallery from around the same time.

While initial plans for a children's area were dismissed at an early stage, they were revived in spring of 1961, leaving just 10 months available for the realization of what became probably the first participatory and hands-on science center. Somewhat ironic for an exhibit that in all other aspects apparently eschewed every link with war and destruction, the children's area was housed in the fallout shelter previously required by the Office for Civil Defense. Just as Area 4 presented the methods of science with 27 general quests for knowledge and demonstrators taught visitors about modern research, the Junior Lab had 27 audience-participation exhibits that invited visitors to individually "observe and draw conclusions," since here one "should *learn* but not be *taught*." Initially, this approach of knowledge acquisition was meant for adults as well, as "science can be learned . . . from climbing trees, blowing soap bubbles, or *doing* things." The Junior Lab planned for the 8- to 16-year-olds was, in fact, so popular with adults that children hardly made it to the buttons and handles of the interactive exhibits; after two weeks all adults except the teachers were banned. However, an attentive observer may have sensed the opportunity that such a place would offer to a broader audience, or as the final report—in which the costs, use, and effectiveness of the exhibits were meticulously recorded (Figure 3)—put it: "While it may not have educated the children to the extent first hoped for, the Junior Laboratory of Science demonstrated that the potential for exhibits of this kind is almost limitless. It showed what is possible and pointed new paths."<sup>28</sup>

The finale for all Science Exhibit visitors was Area 5, a multimedia apotheosis about the universality of science and its kinship with art. Conveyed through a darkened room by a moving floor, the visitors were presented a highly immersive "best-of" experience composed of film, dioramas, models, images, and so forth from other parts of the exhibit. These were often mysteriously arranged behind louvres and combined with a voice coming from above, which predicted new discoveries, longer life for all, control of nature, moon rockets, and reactors everywhere, but most important of all, "the delight of knowing the common laws that govern things." Like art, science explores the essence of things and connects with the humanities and philosophy.<sup>29</sup>

In this way, the entire U.S. Science Exhibit stressed the universality of science and almost completely omitted the reference to scientific rivalry and technological competition so obvious in the fields of nuclear threats and space exploration. Only after visitors had left the peaceful "World of Science," could they proceed to "NASA's first major attempt to tell graphically the story of the United States' space program." Located two blocks away from the Science Exhibit, the NASA exhibit featured "models and mock-ups" of satellites successfully launched, and of rockets in miniature, and included John Glenn's Mercury capsule, *Friendship 7*, used during the first American space orbit, which as the guide mentioned, had been succeeded a few months earlier by Shepard's first American but suborbital flight. However, the attempt to celebrate the Space Age as an age of exploring new frontiers and developing new technologies for a better life, without dealing with the ongoing space race between the Soviet Union and the United States, was put to a test.

## JUNIOR LABORATORY OF SCIENCE

### Summary of Cost, Use, and Effectiveness of Exhibits

	Original cost	6-month maintenance	Time in operation	Popularity at any instant	Educational effect
	<i>Dollars</i>	<i>Estimated dollars</i>	<i>Estimated percent</i>	<i>Estimated percent</i>	<i>Estimated percent</i>
1 Linear Accelerator.....	10,303	450	95	4.0	40
2 Hartl Disk.....	5,184	40	100	1.3	100
3 Low Friction Carts.....	10,000	510	15	0.0	50
4 Pinball Scattering.....	9,000	570	70	8.6	60
5 Weight on Other Worlds.....	11,417	275	60	2.8	30
6 Bernoulli Effect.....	6,800	525	95	2.3	50
7 How a Telescope Works.....	13,388	150	95	4.0	60
8 Measuring Distances in Space.....	11,131	730	65	4.5	60
9 Crystal Growth.....	4,294	505	95	1.6	90
10 Microscopes.....	8,952	555	85	5.6	90
11 Pond Water Micro-organisms.....	2,196	650	85	0.0	80
12 Gyroscope Effect.....	4,474	200	70	11.8	70
13 Audio-Visual Stethoscope.....	15,132	515	50	3.7	90
14 Electromagnetism.....	4,800	82	95	2.4	50
15 Probability Checkerboard.....	5,216	50	100	5.0	40
16 Electrolysis of Water.....	3,093	140	85	1.3	80
17 Paper Chromatography.....	10,000	100	80	3.4	80
18 Photosynthesis.....	2,640	30	30	1.5	20
19 Ant Colonies.....	15,820	690	100	3.7	60
20 Gravity Well.....	42,000	710	70	11.0	70
21 Speech Stopper.....	8,500	300	95	4.8	40
22 Vacuum Phenomena.....	10,100	400	50	3.4	90
23 Peep Shows.....	7,415	600	35	5.4	60
24 Ripple Tanks.....	20,788	560	70	4.2	90
25 Electric Fish.....	4,566	550	20	0.6	30
26 How We Hear.....	8,500	250	95	2.7	80
27 Rain Forest Mural.....	2,800	10	100	0.0	40

Figure 3. List of the 27 hands-on exhibits at the Junior Laboratory of Science at the 1962 Seattle World's Fair. Each exhibit was evaluated in regard to building and maintenance costs as well as availability, popularity, and educational effect. From U.S. Department of Commerce, ed. United States Science Exhibit. Seattle World's Fair. Final Report (Washington, D.C.: U.S. Department of Commerce, 1962), 41.

A public relations crisis occurred when Russian cosmonauts visited the NASA exhibit with much press fanfare, while the American organizers were still waiting for Glenn and Werner von Braun to meet the challenge of human spaceflight.<sup>30</sup>

When the U.S. Science Exhibit, along with the entire world's fair, was closed on 21 October, the Science Center opened the next day. It heeded the University of Washington's proposal, developed during the fair, that it should not be a "hold-over attraction" but a "National Living Science Center." Some parts of the U. S. Science Exhibit would remain open through 1963, but thereafter objects were gathered in one building devoted to "learning equipment" for students. Rather than becoming a national institution, the outlook was more that of a regional science education institution, mainly addressing schools. In a way, it was the first "science center," since its education coordinator Dixy Lee Ray argued that rather than a museum, it should be a place

to “amuse, beguile, stimulate, inspire, inform,” mainly the regional residents or students, about the “essence as well as the aims and methods of science.” This was, however, achieved in a modest way, and after a few years of constant struggle for survival, the museum became more traditional.<sup>31</sup> The Pacific Science Center did not become a “Smithsonian of the Northwest,” but rather fell somewhat under the radar of national and international discussions about new science museums. Instead of capitalizing on the novel approach of the Junior Laboratory of Science, it turned to exhibits from NASA’s space program and focused in particular on the history and environment of the Puget Sound region, including a reproduction of a Native American village and public lectures about environmental pollution.<sup>32</sup>

## Washington and New York, 1964

According to *Science*, Seattle’s world’s fair had become “both the ideal and the standard for science exhibits,” but New Yorkers had to “try a different tack” for their presentation of science and technology at the 1964–1965 New York World’s Fair. From the outset, its Hall of Science was to become a permanent museum to fill a gap that other projects had just started to tackle. However, the reuse of Flushing Meadows, the site of the 1939–1940 world’s fair, led to critical speculation whether “anything more than a trade show for science-based exhibitors” would emerge.<sup>33</sup> In fact, both the Hall of Science and the U.S. Space Park were located in one corner of the Transportation Area, while the others were occupied by a journey from prehistory to Space Age (created by Ford with the help of Walt Disney); General Motors’s *Futurama II*, in which visitors looked at the world by driving through the city of the future (thus updating a similar 1939 *Futurama I*, which depicted its concept of a city and highway landscape from 1960); and the *Auto Thrill Show*. In this way, large corporations presented their visions of the future use of science and technology to visitors, who were strapped into moving seats or cars that would ensure that carefully prepared immersive shows as *The Miracle of Life* or *Magic Skyway* could not be sidestepped.<sup>34</sup>

Like a quarter of a century before, a strong commercial orientation and consumer culture of entertainment characterized the New York fair, which had a much larger visitor reservoir and a less important role for the city than its precursor on the West Coast. As for science, however, New York could in no way compete with the Seattle exhibit, as it lacked both federal funds and a universal attitude. As the Hall of Science was meant to make clear, science has made the “highest form of a *free* society” possible in the United States; “in the great war of ideas . . . our greatest defensive weapons are not atomic and hydrogen bombs but the mind of man functioning in an environment of intellectual and spiritual freedom.” Wasn’t it primarily “scientists from the free western democracies” who made the fundamental discoveries? Evoking the linear model, wherein basic scientific research would almost automatically lead to rich technical applications, the fair’s top science adviser, William L. Laurence, connected pure scientific work, modern technological might, and political spin into one line of reasoning perfectly fitting the commercial nature of the entire event.<sup>35</sup> Consequently, when a preliminary report on the post-fair use was composed in January 1965, the main part of the future museum was a Hall of Discoveries and

Inventions that included engineering, communication, transportation, and space technology as “physical sciences”—thereby omitting most of the fundamental sciences—and “life sciences,” mostly understood as addressing medical questions.

From the review of exhibits to be kept in the Hall of Science after the fair, it suffices to name a few by their sponsors: Martin Marietta Corporation (*Rendezvous in Space* and *National Orbital Space Station*), Abbott Laboratories (*The Chemical Man*), Upjohn Company (*The Brain in Action*) and others had exhibits in the Hall of Science during the fair; these were then supplemented with exhibits from Bell Laboratories, Eastman Kodak, General Electric, Ford, General Motors, and more from other pavilions. For children, there was also a play area on the list: the Atomic Energy Commission’s *Atomsville U.S.A* which had allowed children to simulate the discovery of uranium on a world map by means of hidden buttons, manipulate radioactive material with mechanical hands, use Geiger counters, or handle a reactor while their parents observed them via closed-circuit television. (The adults also could find out more about “the science of survival” at the Office for Civilian Defense Exhibit, which, however, was not retained).<sup>36</sup>

The term “science center” was occasionally used by planners and administrators for what was eventually to become the permanent New York Hall of Science after the fair ended in the fall of 1965. However, this apparently pointed to the status the organizers of the Hall of Science hoped it would attain, namely that of the Lincoln Center, Metropolitan Museum, or National Museum of Natural History.<sup>37</sup> No reference was made to the Pacific Science Center or the Smithsonian’s Museum of History and Technology (MHT), which opened its doors in January 1964. The new museum in Washington, D.C., was similar to New York’s Hall of Science in terms of their modern architecture, but inside, the presentation could hardly have been more different.<sup>38</sup> While the expo created an immersive and captivating experience with spectacular renderings of the *Futurama*, sci-fi underwater cities or space capsules, visitors in the MHT mostly could not tell whether they were in a museum of technology from the beginning of the century or in postwar America. If not for a few contemporary objects such as a satellite or a fusion reactor, he or she probably would not have seen much difference (Figure 4). After a long history of collecting artifacts dating back to the 1880s and some unsuccessful attempts to create a dedicated technology museum in the 1920s and 1940s the new galleries continued to tell the story of technological progress in connection to American civilization by featuring period settings that focused heavily on agriculture, the railroad, and oil machinery.

Having been appropriated by Congress in 1955, the MHT was a hybrid from the onset, “for under one roof it combines the history and technology of a nation,” which was symbolized by the Foucault pendulum swinging in front of the Star-Spangled Banner, an icon of the American nation. For the press, the MHT characterized itself as “an exposition illustrating the cultural and technological development of our nation,” and according to its research agenda, it was part of a new Smithsonian that “aspired to nothing less than the reinvention . . . as a great university.”<sup>39</sup> In any case, it is hard to see in what way the new Washington, D.C., museum and the New York Hall of Science interacted. Although it was claimed on the occasion of the 50th

anniversary of the MHT that both institutions served a patriotic agenda and that New York's *Futurama* and the like "challenged MHT's new staff of designers to create equally exciting historical displays," such displays did not make it into the "illustrated tour" that was published in 1968 (see Figure 4).<sup>40</sup>

## Diverging Paths of Science Museums

The history of science and technology display at world's fairs and the efforts to establish new museums of science were closely linked, but not in a simple way. The immense momentum of the U.S. Science Exhibit had not pushed the Pacific Science Center to the front of the discussions on science display or museum development, nor did the hundreds of scientists involved in the preparations transfer its approach, or "tack," to other projects. While the Smithsonian had its secretary, Leonard Carmichael, on the Seattle planning board and provided a number of historical exhibits for the fair—which one of its designers, Robert B. Widder, judged "[o]ne of the finest displays ever conceived"—reports on the fair and post-fair Hall of Science do not mention any use of the "nation's attic," the undisputed repository of cultural as well as scientific and technological heritage in America.<sup>41</sup> Whether or not the designers at MHT took up the challenge from New York, the underlying commercial and showman nature had no place in the Smithsonian Institution. While it was suggested that the permanent exhibit in New York should have actors playing great scientists and inventors—"demonstrating each major discovery or invention made by them, [so this] would make such presentations not only highly instructive, but highly dramatic and entertaining as well"<sup>42</sup>—in Seattle, the general and everyday practices of science were on display. In Washington, D.C., however, it was not only the history of the nation that should be included, but also the manifestation of a new and confident history of science, which defined the approach. In 1954, Robert P. Multhauf was the first academically trained historian of science to join the Smithsonian. He recruited a number of others with the goal of "making the MHT one of the centers of history of science and technology in the United States." The editing of the journals *Isis* and *Technology and Culture* and the opening of the Smithsonian Institution Archives in 1967 propelled the museum to the crest of a new wave of social and cultural history of science and technology with a rich production of eminent scholars. The 28 curators of the new museum were "historians," not "educators," and the aim was to create a "research atmosphere." MHT's planners did not consult with those of the New York Hall of Science but instead traveled in droves to Europe, in particular to Munich.<sup>43</sup>

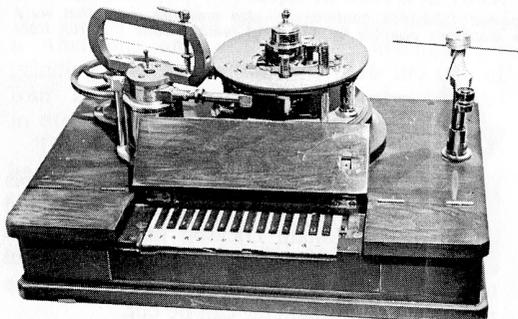
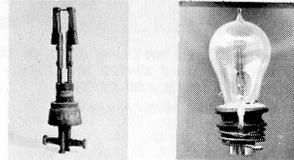
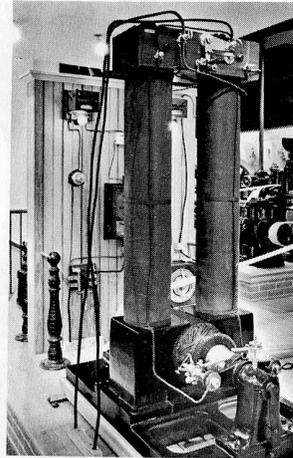
The great differences in the representation of the nature, uses and, in particular, artifacts of science explain why New York's approach to the world's fair would not resonate well with that of the museum in the capital, where collecting, traditional documentary research, and new social and cultural history corresponded to a rather serious and substantial presentation of scientific heritage, aiming more at the educated and interested than at those to be educated and interested. Eventually, the Smithsonian's approach proved to be more viable, since efforts to transform the New York Hall of Science into a permanent institution in 1966 were judged to be

tions satellites represented the entire first generation of satellite techniques and devices.

A section on electrical science, soon to be opened, will include 18th-century electrostatic machines, Joseph Henry's 19th-century electromagnetic apparatus, and 20th-century maser experimental equipment produced by Townes and others.

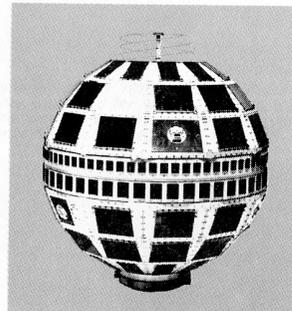
A third section, dealing with the history of communications, will include some of Bell's experimental telephones, Armstrong's early radio equipment, and recent developments in radar and radio astronomy.

*Edison lighting dynamo and switchboard of the 1880s; and two early lamps — a low-voltage incandescent lamp (at left) invented by Moses Farmer in 1878, and Edison's commercial lamp of 1881.*

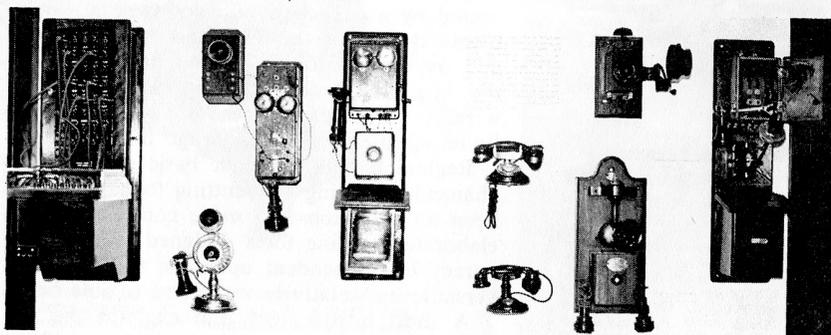


*Printing telegraph invented by Royal E. House of Rockingham, Vermont, in 1852.*

*Intercontinental relaying of microwave signals has been made possible by use of communication satellites. Telstar I, identical to the one shown here, was launched in 1962.*



*A display of early commercial telephones.*



**Figure 4.** Page 101 from the electricity section of the catalog *Exhibits in the Museum of History and Technology*, which shows the wide variety of artifacts that were displayed. From National Museum of History and Technology, ed., *Exhibits in the Museum of History and Technology: An Illustrated Tour* (Washington, D.C.: Smithsonian Institution Press, 1968), 101.

“a tired version” of the fair, “unworkable,” and “an acoustical nightmare,” and in the 1970s “got stuck in the Flashing Meadows mud.”<sup>44</sup> Although it took until the 1990s for the MHT to open its own “Hands-on Science Center” and to hear the “call of stories,”<sup>45</sup> it was nevertheless the Smithsonian Institution that set the course for the future of the science center as we know and historicize it today. This is true at least under the premise that it was the Exploratorium that became the key engine of the science center movement and that its driver was Frank Oppenheimer, J. Robert’s experimental brother.

## Toward a New “Rationale” for the Science Museum

After a decade of being blacklisted by Joseph McCarthy, Frank Oppenheimer returned to academia in 1957 as an educator in the West, first to high schools, where his students soon won prizes at regional science fairs, and then to the University of Colorado. There he developed the idea of making experiments available to lower-division physics students much in the same way books were accessible in a library.<sup>46</sup> While there is no evidence directly linking Seattle’s 1962 World’s Fair to Oppenheimer’s hands-on educational interests when he taught in Colorado, it appears that, in addition to his 1965 Guggenheim fellowship—which took him to Europe, where he studied its science museums—it was the Smithsonian Institution’s Conference on Museums and Education at the University of Vermont in August 1966 that was the decisive step toward what he would later term a new “rationale” for a science museum.<sup>47</sup>

Initially scheduled to talk about school curriculum reform, Oppenheimer in fact expanded on “The Role of Science Museums” and was one of the most active discussants of the conference. This conference laid the foundation for his “Proposal for a Palace of Science and Art” in San Francisco, which was drafted in July 1967 and published a year later as “A Rationale for a Science Museum.”<sup>48</sup> With the aim of creating a model for a science museum in medium-sized cities, he referred to his own experiences with the university’s demonstration laboratory and the regional science fairs in Colorado, as well as the elaborate demonstrations at the Palais de la découverte, which were its hallmark. He recalled what he had seen during his Guggenheim year abroad: boys who were searching for push-buttons in the Science Museum’s coal mine in London and the hands-on teacher training courses of the Deutsches Museum. Considering these examples, Oppenheimer first suggested, among other things, that science demonstration should become a profession and that personnel would be needed to “continually” redesign apparatus, not only in order to withstand wear and tear but also “on the basis of the museum experience.” Then, however, he went on with a general critique of the push-button exhibits and other too-constrained display techniques. After observing the random button-pushing by children and adults alike, who often walked away without observing the full demonstration, he recognized the problems: lack of observer control, lack of stimulation during the demonstration process, and poor textual explanation. He wrote, “It is almost impossible to learn how anything works unless one can repeat each step in its operation at will; furthermore, it is usually necessary to make small changes which impair its operation. . . . detailed control of apparatus does not necessarily preclude remote control,

although wherever possible it is more instructive to hold and manipulate the items directly in one's hand."<sup>49</sup>

While these were some key elements of the Exploratorium model, Oppenheimer's approach was still firmly rooted in "terms of the traditional science museum but a little more out in the open."<sup>50</sup> However, things became less traditional in the lecture "Gawk or Think?" by Michael V. Butler, especially during the discussions. As a physics curator and teacher of the Cranbrook Educational Community in Michigan, Butler was involved in the creation and evaluation of the 1962 U.S. Science Exhibit and was now discussing an object-based approach inspired by Seattle's Junior Laboratory, which made it appear as the stellar example of successful museum learning.<sup>51</sup> Even "busloads of tough city tenth graders" did not wreck the exhibit against all odds; rather "[a]fter ten or fifteen minutes of bedlam, the noise dropped off and the people began to concentrate . . . the children had just found the satisfaction that goes with learning." Like Oppenheimer before, he argued that such new science exhibits need a machine shop for designing and redesigning, but he went on to stress a more emotional and sensory approach: museum exhibits should "involve handling, hearing, or smelling as well as seeing; that involves puzzlement, with its inevitable consequence: thinking."<sup>52</sup>

Oppenheimer presented himself as "a non-museum person" who had realized how "terribly important" museums are as they "lay before one all the things that people take or have taken seriously" and that are not "fake." He also advocated for the complementary role of museums and schools that have to narrow things down. In the discussion following Oppenheimer's presentation, Albert Parr, the renowned director of natural history museums at Yale and in New York pointed out the inconsistency: "a science museum will achieve its most 'authentic,' scientifically exact effects with exhibits which are . . . 90 percent fake" because the idea or effect "prevails over the object." Parr also tried to escape the question of (historical) artifacts and whether they are already "the message" by claiming that the art museum is about objects and the science museum about ideas, for it presents the principles of nature. The editor of the conference volume, however, praised Oppenheimer for his plea not to divide art and science; what "both art and science do is to teach one to beware of one's surroundings . . . to pay attention to things that one has learned to ignore," what the stars in the sky or even complementary descriptions of reality in physics can be. Playing the card of atomic—or rather quantum—physics, which revolutionized the understanding of reality, and criticizing the narrow discussion of this topic in schools and curriculum reform projects, Oppenheimer suggested that both art, such as poetry or music, and science offer ways to understand aspects of the world "far away from the tactile, ordinary experience."<sup>53</sup>

Despite inconsistencies, Oppenheimer's views apparently dominated the whole discussion, with Albert Parr initially taking on the task of advocacy and reconciliation, then later criticism: "Too many museums are scared of finding out how wrong they have been." As frustrating as the different approaches of educators, researchers, and curators towards museum practice and education in often underfunded institutions may have been, it is surprising that out of the seven participants from the Smithsonian (of a total of around 40), no one appeared in the

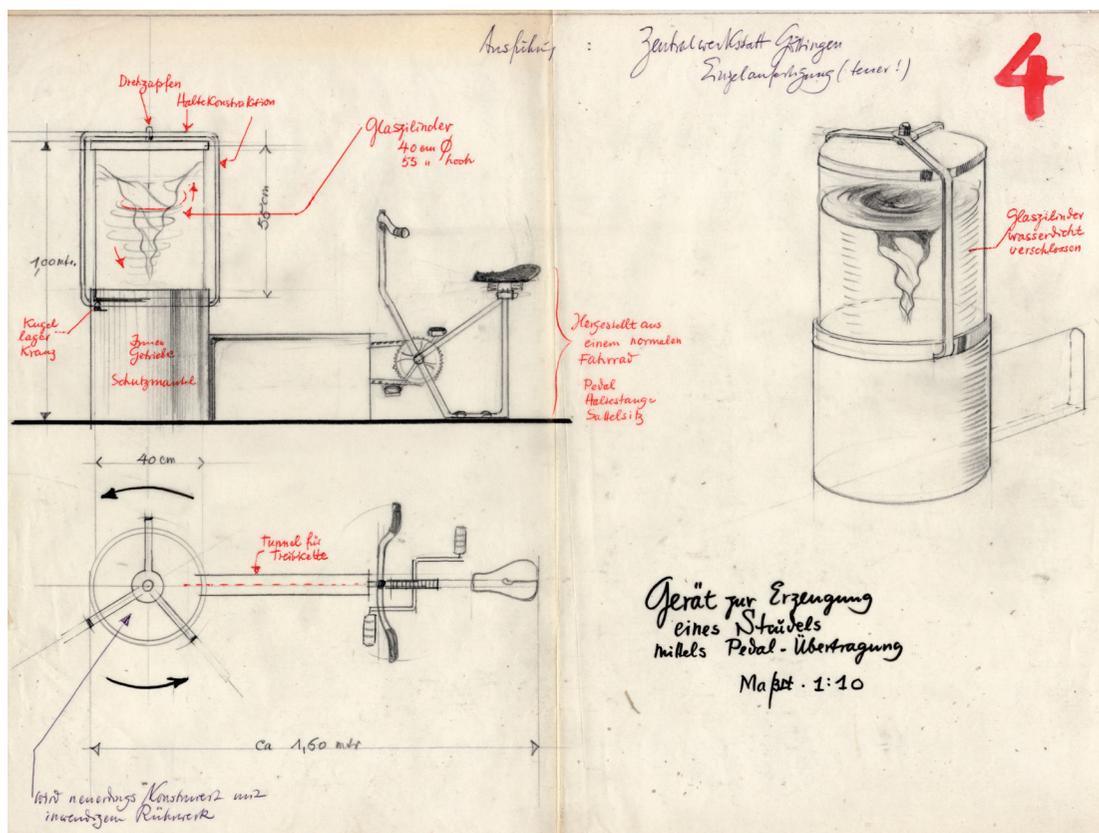
documentation of the discussions. Charles Blitzer, the new director of education, had organized the conference; Secretary S. Dillon Ripley provided the introduction; the eminent Frank Taylor, who served all his life for the Smithsonian and eventually became founding director of the MHT, had just chaired a session; while still others were panelists for the discussion of individual presentations. Over the six days of the conference, however, there must have been much undocumented exchange, which gave Oppenheimer the opportunity for the first time to interact with seasoned museum professionals like Parr, Taylor, or Alma Wittlin, and to discuss current projects such as the “self-instruction demonstration exhibits” developed for the Lawrence Hall of Science at University of California, Berkeley, with Hans Weltin.<sup>54</sup> The Lawrence Hall of Science was initially conceived as a museum, but when it opened in 1968, it was more of a center for curriculum study and a teaching laboratory and thus did not seize the opportunity to establish itself as a science center.<sup>55</sup>

After the conference three notable things happened: Blitzer from the Smithsonian invited Oppenheimer to help plan a Mid-America Center in Arkansas, an offer which he declined; his attempt to join the staff of the Lawrence Hall of Science was turned down; and his own concept for a Palace of Arts and Science in San Francisco went far beyond what he had presented in Vermont.<sup>56</sup> Parr wrote Oppenheimer that his new proposal for a “museum of science and technology” was “excellent” and suggested publishing its first sections in *The Curator*. Oppenheimer did so under the title “A Rationale for a Science Museum,” which became a charter of science centers in 1968 and has been cited hundreds of times since.<sup>57</sup>

Key to the proposal became something that Oppenheimer remembered emerging “when the perception theme occurred to me.” One may wonder about different sources for his insight to focus on the human senses and the very processes of perception as a good basis for a novel kind of science museum.<sup>58</sup> The topic of perception and sensory experience was raised by Michael Butler at the conference in Vermont but was not deepened; it was also present to a certain extent in some perception exhibits at Seattle’s world fair (see Figures 2 and 3). Furthermore, the approach of teaching science through perception and play was also present at Expo 67 in Montreal—though not as a part of the U.S. pavilion, which dramatically showcased the American space program in a translucent Buckminster Fuller sphere, but this was displayed in a small gallery of the German Pavilion.<sup>59</sup>

## The Exploratorium Revolution in Perspective

At Expo 67, Hugo Kükelhaus, a carpenter, educator, and a kind of natural philosopher, presented a selection of objects for Germany that allowed visitors to experience the laws of nature through play. With the support of chemist Otto Hahn and help from the central workshop of the Max Planck Society for the Advancement of Science, Kükelhaus had “. . . designed a collection of 32 devices, which demonstrate important phenomena of motion, the principles of the lever and of falling bodies, oscillations, flow patterns in water and smoke, the laws of sound, the conditions of perception like seeing, hearing, smelling in such a way that a child can handle them in bodily play.”<sup>60</sup> His Strudelgerät (Figure 5), a machine that produces a vortex in water, may be a good



**Figure 5.** Plans drawn by Hugo Kükelhaus for a “Strudelgerät,” or water vortex machine, displayed at Montreal’s Expo 67 and for the custom-made building by the Göttingen Zentralwerkstatt of the Max Planck Society. Hugo Kükelhaus Papers, Stadtarchiv Soest. Courtesy of Barbara Vogel-Kükelhaus

example that satisfies all requirements Butler, Oppenheimer and others had put forward for educative science exhibits; it may even have conceptually outshone later “vortex machines” in the Exploratorium. It is reported that, as in Seattle, “also and especially adults felt invited” to operate the objects, though most of the gear did not withstand the crush of users.<sup>61</sup>

Those interested in Kükelhaus have tried to describe him as a trailblazer for the science center, but a direct connection to Oppenheimer has not yet been established.<sup>62</sup> What appears to be a puzzle, I would argue, is more of a deception due to a singular perspective—like some of the optical illusions that entertain us in science centers. To this end, and to conclude this discussion on the interrelationship of world’s fairs and museum history in the 1960s, I suggest that the history and evolution of display techniques should be neither reduced nor too narrowly related to successful institutional development, which is often labeled by main protagonists and too often judged only in hindsight.

Two observations appear particularly revealing. First, by using the rich visual material available from the 1962 U.S. Science Exhibit, one can easily illustrate all the essential display innovations for which the Exploratorium stands: from phenomena of color, tactile sensations (see Figure 2), and optical delusions to animal behavior (with horseshoe crabs in Seattle and grasshoppers in

San Francisco). Similarly, some of Kükelhaus's examples of *naturkundliches Spiel-Werk* (natural historic playthings) for Expo 67 can be rediscovered later in the Palace for Art and Science, as the Exploratorium was called initially. Clearly, the main fields of playful science were already identified, and many display techniques were not completely new.

Second, the Exploratorium of 1969 was intended to be a kind of museum, and initially it was also realized in much more of a traditional museum mode than its later archetypical science center nature would suggest. The *San Francisco Chronicle* reported in May 1969 that "SF 'Exploratorium' Gets Big League Help" and that NASA had just decided to make it "the permanent home for a major series of Space Agency exhibits" with "dozens of full-scale models, mock-ups and working examples of satellites and rockets." In addition, the "historic Smithsonian Institution in Washington, world-famed as a museum of technology . . . [had] agreed to ship out a large group of permanent exhibits."<sup>63</sup> Three months later the paper reported that "California's oldest glider" as well as "a diorama and bone castings of a prehistoric animal" would also be on display.<sup>64</sup> All this appears to be in line with a 1968 document on "The Initial Program for the Palace of Arts and Science." The Exploratorium was to be opened at the same time as the moon landing, which would be projected on large screens and complemented by "detailed charts and information about the mission." Space and accelerator exhibits, which represent the largest and smallest domains of the universe, were to "form the heart of the initial program." As Oppenheimer's concept documents explained, in general, the "museum" should present both "demonstrations" and "historical displays." In this way, the early Exploratorium was not what most people may think it was in view of its later archetypical status. For Oppenheimer the initial program meant an intermediary step "not necessarily based on the envisaged rationale," which called for "developing demonstrations that elucidate the mechanisms of human perception." Time and funds were needed to achieve this; hence, in a way, the visitors were attracted by the first exhibits but they were also misled about the project.<sup>65</sup>

It might look like the Exploratorium was on a way to becoming the Smithsonian of the West, uniting the American science museum, as epitomized by the Museum of History and Technology, with the participatory, hands-on innovations of the U.S. Science Exhibit of the 1962 world's fair, but it was not. Clearly, a detailed and multifaceted early history of the Exploratorium, which involved a number of negotiation processes between multiple institutions and actors on the demarcation of the (visitor and funding) terrain as well as several conceptual adjustments, still needed to be written. For example, the temporary exhibit *Cybernetic Serendipity*, which came to the United States from the London Institute for Contemporary Art in late 1969, had a great impact on the development of the Exploratorium with its exhibits that lived in some new realm between art and science and were supposed to allow the visitor to "push, pull, whistle, blow and yell at a gallery full of tame wonders which look as if they've come straight out of a Science Museum of the year 2000."<sup>66</sup>

However, concerning the general development of hands-on and participatory exhibits and its display techniques, which are nowadays closely associated with the science center, it was a

question of choice and implementation rather than one of unprecedented invention or individual ingenuity. As Alison Griffiths has convincingly argued, the history of expository media is a “back to the (interactive) future”—meaning that a closer historical investigation shows that the interactive display technique emerged to large extent along with the science museum and concurrent world’s fairs throughout the nineteenth century.<sup>67</sup> It is hence not surprising that standard exhibits of science centers, such as the Bernoulli blower, wave machines, the gyroscope, optical illusions, Chladni patterns, or silent bells in a vacuum, can be traced back to the *Exploratorium Cookbook* (a publication that explained how to build the interactive exhibits of the Exploratorium), to the major science museums in the first half of the century and further back to the early science exhibits for the bourgeois audiences in 1890s Berlin or 1830s London.<sup>68</sup>

From this wider perspective, it turns out that the reinvention of the science museum in the 1960s—including the Museum of History and Technology and the Exploratorium—cannot be reduced to the presence or absence of new display techniques or novel ways of contextualizing historical artifacts. Rather, this development must be explained as the deliberate mobilization of methods of visualization and narrative strategies that can be applied both to artifacts and “edu-facts” and that have a track record in earlier museums, fairs, and shows.

Apart from the local conditions that determined visitor reservoirs, the single most important factor for the success of new science exhibits may have been to meet the demands and expectations of the audience. Here the interrelationship between world’s fairs and museums likely becomes most crucial, as it was to a great extent the visits by multiple millions to the expos that defined visitor expectations, particularly for science and technology museums.

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44. Samuel, *End of Innocence*, 193ff.
45. Henson "'Objects of Curious Research,'" S267, references, footnote 51.
46. NSF Proposal "Request for Funds for the Establishing a Student Participation Demonstration-Experiment Laboratory," 1 December 1961, Frank Oppenheimer Papers, Bancroft Library, Berkeley, MSS 98/136; F. Oppenheimer and M. Correll, "A Library of Experiments," *American Journal of Physics* 32 (1964): 220–225.
47. I cannot detail at this point further influences and persons like the Colorado colleague David Hawkins, physicist and philosopher interested in childhood learning, who suggested Oppenheimer for the Conference; F. Oppenheimer and C. Weiner, "Oral History Interview with Frank Oppenheimer, 1973 February 9 and May 21," <http://www.aip.org/history-programs/niels-bohr-library/oral-histories/4807-1> (accessed 4 May 2017), 25.
48. Oppenheimer, "Proposal for a Palace of Science and Art," Exploratorium Records, Bancroft Library, University of California, Berkeley, MSS 87/148c, carton 5:1 (July 1967).
49. E. Larrabee, ed., *Museums and Education* (Washington, D.C.: Smithsonian Institution Press, 1968), 175.
50. Oppenheimer and Weiner, "Oral History Interview," 27.
51. Butler wrote a report on the Junior Science Laboratory, which appears to have been the basis for the *Final Report*.
52. Larrabee, *Museums and Education*, 187–188.
53. Larrabee, *Museums and Education*, 213–215.
54. H. White, H. Weltin, M. Gould, and R. Rice, "Quantitative Demonstration Exhibits and a New Low-Cost Physics Laboratory," *American Journal of Physics* 34 (1966): 660.
55. Initially conceived as a major science museum, the Lawrence Hall turned to curriculum development and teacher training. It also developed teaching machines. The interesting connections between Seattle's Junior Scientific Laboratory and the developing concept of the Lawrence Hall cannot be covered here. See H. E. White, "The Lawrence Hall of Science," *The Physics Teacher* 3 (1965): 256–262.
56. H. S. Hein, *The Exploratorium: The Museum as Laboratory* (Washington, D.C.: Smithsonian Institution Press, 1990), 15; Oppenheimer and Weiner, "Oral History Interview," 25; Oppenheimer, "Proposal for a Palace of Science and Art."
57. Albert Parr to Frank Oppenheimer, 2 Feb and 24 Mar 1968. Frank Oppenheimer Papers, Bancroft Library, University of California, Berkeley, Mss. 98/136, 1:36.
58. C. Weiner, "Oral History Interview," 27. At the beginning of 1967, perception exhibits were not yet a focus of Oppenheimer and were only mentioned in passing in a letter discussing exhibits and demonstrations for a future science museum, Frank Oppenheimer to Jerrold Zacharias, 6 Jan 1967, Bancroft Library Berkeley, Mss. 98/136, 1:36.
59. R. Kenneally and J. Sloan, eds., *Expo 67: Not Just a Souvenir* (Toronto: University of Toronto Press, 2010). Another, however, rather distant elaboration on the perception theme was due to Richard Gregory in Britain, who presented his view in the 1967 Royal Institution Christmas Lectures "The Intelligent Eye" broadcast on BBC, cp. A. Barry, "On Interactivity: Consumers, Citizens and Culture," in *Politics of Display: Museums, Science, Culture*, ed. S. Macdonald (London: Routledge, 1998), 89f.
60. H. Kükelhaus, "Über das Erleben von Naturgesetzen im Spiel," *Physikalische Blätter* 24 (1968): 25.
61. J. Münch, "Erfahrungsfeld zur Entfaltung der Sinne," in *Neue Ausstellungsgestaltung 1900–2000*, ed. A. Müller and F. Möhlmann (Stuttgart: av Edition, 2011), 160.
62. Hildegard Viereg, for example, claims that the ideas of Kükelhaus directly led to the development of the Science Center, of which the Exploratorium was the first. Viereg, *Museumswissenschaften. Eine Einführung* (UTB, 2006), 22.
63. D. Perlman, "S.F. 'Exploratorium' Gets Big League Help." *San Francisco Chronicle*, 16 May 1969.
64. *San Francisco Chronicle*, "'Exploratorium' Taking Shape," 25 August 1969.

65. F. Oppenheimer. "The Initial Program for the Palace of Arts and Science" ca. 1968, and "The Content of the Museum" 1968, BANC MSS 87/148c, 5:4 and 5:2, respectively. Because Oppenheimer's museum concept had changed significantly between 1966 and 1969, and the "perception theme" has not been seized upon from the beginning, I would like to stress not so much a coherent "vision" of Oppenheimer but rather follow the contingent developments and acknowledge the apparent inconsistencies that determined the Exploratorium's history. In this I differ to some extent from H. S. Hein, *Exploratorium*, and K. A. Rader, "Hands on Science Centers as Anticollections? The Origins and Implications of the Exploratorium Exhibits Model," in *Challenging Collections: Approaches to the Heritage of Recent Science and Technology*, ed. A. Boyle and J.-G. Hagmann (Washington, D.C.: Smithsonian Institution Scholarly Press, 2017), 198–213.
66. Publicity for the London exhibition, cited in M. Fernández, "Detached from HiStory: Jasia Reichardt and Cybernetic Serendipity," *Art Journal* 67, 3 (2008), 6–23, on 13. For a short discussion of the role of the exhibition for the Exploratorium from the perspective of media studies, see M. Henning, *Museums, Media and Cultural Theory* (Maidenhead: Open University Press, 2006), 87ff.
67. A. Griffiths, *Shivers Down Your Spine: Cinema, Museums, and the Immersive View* (New York: Columbia University Press, 2008), ch. 5, 159–194.
68. See, for example, R. Bruman, *Exploratorium Cookbook I: A Construction Manual for Exploratorium Exhibits* (San Francisco: Exploratorium, 1975); Deutsches Museum, ed., *Amtlicher Führer durch die Sammlungen* (München: Deutsches Museum, 1925); M. W. Meyer, *Illustrierter Leitfaden der Astronomie, Physik und Mikroskopie in Form eines Führers durch die Urania zu Berlin* (Berlin: Paetel 1892); R. Altick, *The Shows of London* (Cambridge: Belknap Press, 1978), ch. 27, 375–389.

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