The British Journal for the History of Science (2025), 1–22
doi:10.1017/S0007087425101118

RESEARCH ARTICLE

Between education and entertainment: animation, science communication, and the Bell System Science Series

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Abstract

Finding the right balance between education and entertainment in science communication has always been a challenge. This essay argues that this balance has often been framed in terms of the correct proportion and use of animation and live-action footage in popular-science media. Clarifying the assumptions behind a century of concerns about animation and science, this historical case study examines the advisory board's complaints about animation in the Bell System Science Series, which aired in the United States between 1956 and 1964. AT&T interrupted the series mid-stream by switching the creative team from Frank Capra and his production company to Owen Crump at Warner Bros. Studio. Capra's use of animation in the series featured prominently in this decision. The historical record – as well as Capra's and Crump's different aesthetic choices about animation – tells us much about the board's objections and how they were resolved in production. This essay examines the differences between the two parts of the series to uncover a course correction steered primarily by the scientific advisory board, which reveals a sometimes-fraught relationship between live-action footage and animation in science education that persists even today.

Comprising nine hour-long episodes aired irregularly in the United States between 1956 and 1964, the Bell System Science Series was a landmark event in the history of science communication and television. Sponsored by American Telephone and Telegraph (AT&T), each episode focused on a different scientific topic thoroughly vetted for accuracy and clarity by prominent advisers. All episodes were produced by top names in the film-making industry and crafted to the highest Hollywood standards. The breadth of the series' reach was remarkable: the broadcasts themselves were highly rated, pulling in tens of millions of viewers, but then films of the episodes were also made widely available to schools and colleges, reaching an even greater share of the viewership, perhaps into the hundreds of millions – in terms of innovation, production value and size of audience, only the science episodes for *Walt Disney's Disneyland* (ABC, 1954–8) can compare.[1] The Bell series shared with the Disney episodes something else: an extensive use of animation to convey scientific ideas. Indeed, while animation had been used for science education since the 1910s, the popularity, quality and prestige of both series surely cemented the now-prominent role of animation in science communication.

[1] 'Man in space' (9 March 1955), 'Man and the Moon' (28 December 1955), 'Our friend the atom' (23 January 1957) and 'Mars and beyond' (4 December 1957).

Yet the use of animation in the Bell series raised concerns with its own scientific advisory board, prompting AT&T to change the creative teams halfway through the series partly in response to these complaints. Hollywood legend Frank Capra produced the first four episodes: *Our Mr. Sun* (on solar phenomena, aired on CBS on 19 November 1956), *Hemo the Magnificent* (on circulation and the blood, 20 March 1957, CBS), *The Strange Case of the Cosmic Rays* (on cosmic radiation, 25 October 1957, NBC), and *The Unchained Goddess* (on weather, 12 February 1958, NBC). The next four were produced by journeyman director and documentarian Owen Crump at Warner Bros. Studio: *Gateways to the Mind: The Story of the Human Senses* (23 October 1958, NBC), *The Alphabet Conspiracy* (on linguistics, 26 January 1959, NBC), *The Thread of Life* (on genetics, 9 December 1960, NBC), and *About Time* (on time, 5 February 1962, NBC).[2] There were many reasons for the switch, including budget issues, schedule concerns and creative differences, but the use of animation changed enough between the two sets of episodes in the series to indicate that it was also a serious source of contention.

With this series, we have two types of evidence pointing to the scientific community's concerns about the use of animation in public outreach. First, we have the advisory board's written communication to Capra about the animation, as well as the reactions of preview audiences and television critics, which corroborate the board's complaints. Second, we have the difference in the use of animation between the two halves of the series, indicating a course correction under the direction of the board. This series, then, offers a uniquely clear case of the role of animation in the balance between education and entertainment, a balance that the scientific community continues to seek. Animation has been a prominent mode of representation for popular-science films but has often been the scapegoat for failures to achieve this balance.[3]

The Bell series advisory board likewise blamed animation as 'too elementary', meaning that, even for a series that was to have the widest possible appeal, its animated approach to science in their eyes simplified its subject too much and even diminished its seriousness. Capra's persistent use of personification – portraying concepts as cartoon characters – was the primary culprit here, but also the nature of the interaction between live-action film and animated characters. The board also pushed back against the habit of using animation when live-action footage would have worked as well. In their view, the perceived overuse of animation took time away from live-action demonstrations of scientific concepts and experiments, as well as from scientists presenting their research in live-action footage. Animation, then, threatened the legitimacy of science communication by being associated with the trivial or infantile, and, perhaps more seriously, by offering a secondary or diminished image, one that paled in comparison to the evidentiary and rhetorical weight of the photographic image. For the board, the use of animation in the Capra episodes pushed the educational series too much toward entertainment.

These were not new complaints, as Kirsten Ostherr has shown about the Rockefeller Foundation's use of animation in *Unhooking the Hookworm* (1920).[4] On one hand, the animated sections of the *Hookworm* film had broad appeal, solving the problem of holding the

[2] Disney Studios produced the final entry, *The Restless Sea* (on oceanography, aired 24 January 1964) before AT&T pulled the plug on the series. The original version of *The Restless Sea* is not available, so this essay will focus on the first eight films of the series.

[3] See, for example, K. Pickering, 'Another Walt Disney experiment', *Health Education Journal* (March 1955) 13(1), pp. 78–80; Sylvie Bissonnette, 'Scalar travel documentaries: animating the limits of the body and life', *Animation: An Interdisciplinary Journal* (2014) 9(2), pp. 138–58; and Vincent Campbell, *Science, Entertainment and Television Documentary*, London: Palgrave Macmillan, 2016.

[4] Kirsten Ostherr, 'Cinema as universal language of health education: translating science in *Unhooking the Hookworm* (1920)', in Nancy Anderson and Michael R. Dietrich (eds.), *The Educated Eye: Visual Culture and Pedagogy in the Life Sciences*, Lebanon, NH: Dartmouth College Press, 2012, pp. 121–40. See also Ostherr, *Medical Visions: Producing the Patient through Film, Television, and Imaging Technologies*, Oxford and New York: Oxford University Press, 2013,

https://doi.org/10.1017/S0007087425101118 Published online by Cambridge University Press

lay audience's attention, unlike the live-action sections. On the other hand, the foundation and its advisers had an unshakeable faith in 'documentary realism' as the basis for effective visual pedagogy: the idea that the photographic image's ability to capture the detail and particulars of an individual instance gave it evidentiary (hence educational) power.[5] This gave the live-action sections a rhetorical weight with the Rockefeller advisers that animation lacked, especially considering animation's association with studio cartoons. The foundation could not solve this conundrum and eventually threw up its hands by assigning its public-health films to Disney Studios and its 100 per cent animation approach, sacrificing the perceived realism of live-action educational film for broad accessibility.

What emerges from this history is a practitioner theory of animation: a shared set of assumptions about the material limits, potential and appropriate use of animation by those who use it. The assumptions about animation in popular-science programming held by the Rockefeller Foundation advisers and the Bell series advisory board amounted to a theory of the medium (or mode of representation, if you prefer), especially in terms of its perceived opposite medium or mode: live-action film. For this reason, we can use 'intermediality' as a method or lens through which we can better understand the *interaction* between modes of representation (such as animation, live-action film or television) in science communication. Practitioners often borrow conventions or grammars from one medium while working in another, which is where intermediality is most useful as an analytical concept or historical method.[6] This borrowing pinpoints the useful overlap or shared affordance between modes, such as camera movement in live-action film and the construction of 'camera movement' in animation. We can also see these presumed specificities and shared affordances in the way science communicators stage interactions between modes: how they use diagrams in relation to photographic images or how they mix animation and live-action footage in popular-science films, for example. The Bell series presents a unique opportunity in this regard as well: the narratives of the individual programmes were often based on the interaction between different modes, in this case animation and live-action film. But this staged interaction, in which characters from each mode literally talk to each other, was mediated by a third mode: television. That is, the series borrowed conventions from both science television and children's television programming to frame this interaction. This intermedial exchange, in the eyes of the advisory board, also tipped the series' balance from education to entertainment.

Ultimately, this historical case study can clarify the assumptions behind a century of complaints about the use of animation in science communication. If the balance between education and entertainment remains a problem to be solved in science communication, this essay argues that the balance has often been coded as one between live-action footage and animation, especially how each should be apportioned in popular-science media. Even as we enter an era of pervasive animation, when assumptions about the relative value of graphic and photographic modes are perhaps fading or blurring together, the question of this balance still lingers. This case study seeks to emphasize the importance of this balance – between live action and animation, between education and entertainment – for the history of animation in science communication.

We will approach the Bell series from three directions. First, the essay will summarize the historical record: correspondence between Capra and the scientific advisory board mostly concerned questions of accuracy, but the board's unease about Capra's choices regarding

pp. 28–47. Ostherr's work on animation and science communication is seminal. See also hers 'International animation aesthetics at the WHO: *To Your Health* (1956) and the global film corpus', in Christian Bonah, David Cantor and Anja Laukötter (eds.), *Health Education Films in the Twentieth Century*, Rochester, NY: University of Rochester Press, 2018, pp. 279–302.

[5] Ostherr, 'Cinema as universal language of health education', op. cit. (4), p. 134.

[6] See Tim Boon's contribution to this issue.

https://doi.org/10.1017/S0007087425101118 Published online by Cambridge University Press

the balance of education and entertainment also made itself known in these letters and replies. Second, it will clarify and sharpen these concerns by examining the typical functions of animation in science films of the time, whether for expert or lay audiences: to make visual metaphors, to depict change or process, to simplify or abstract and to depict the imperceptible. These functions expressed theoretical beliefs about animation's potential but also acted as implicit guardrails for the proper use of animation in science communication; misuse or overuse of one or more functions seemed to raise eyebrows. If the historical section outlines the sometimes vague concerns of the board, the theoretical section better articulates the problems they saw with animation. Finally, the essay will describe the producers' solutions to the problems by comparing and analysing the episodes of the two halves of the series directly. Capra's and Crump's different aesthetic choices about staging, the use of animation and the interaction among animated sequences, live-action footage and televisual tropes in the episodes tell us much about the board's concerns and how they were resolved in production. These film-making choices bear on the typical functions of animation as well as on the historical balance between science education and entertainment. Indeed, the approach to animation changed most in the series, suggesting that it was the most volatile ingredient, the proper proportion of which was constantly under debate and revision.

A history of the Bell System Science Series

All episodes of the Bell series share some common features: an avatar of the scientific community, called 'Dr Research' and played by award-winning television educator Frank C. Baxter throughout the series, interacts with an onstage audience to explain the topic. In the Capra episodes, Dr Research collaborates with a character named 'Mr Fiction Writer', representing the imaginative approach to understanding. The idea was that 'education through entertainment', which was something of the series motto, requires input from both the scientific and the creative communities. The audience depicted in the episodes varied from mythological beings or fictional characters to actors playing ordinary folk. Each episode alternated between these interactions and live-action footage or animation that demonstrated the idea or phenomenon under discussion. Typically, a member of the onstage audience would ask a question, which Dr Research or Mr Fiction Writer would explain using props, animated clips, photographs or live-action footage of the phenomenon or of significant moments in the history of its discovery. Indeed, to explain the topic at hand, the history of the science was just as important as features of the phenomenon itself.

By the time AT&T began considering a science television series in 1951, the company had a tradition of public-service programming in *The Bell Telephone Hour* (NBC, 1940–58), a radio series that featured classical and Broadway music. Meanwhile, science programming on television had grown in the post-war era as shows such as *Johns Hopkins Science Review* (1948–55), *Zoo Parade* (NBC, 1950–7) with Marlin Perkins, or *Watch Mr. Wizard* (NBC, 1951–65) with Don Herbert blazed a trail of entertaining, durable and popular series in an era when science could find a spot on the uncrowded television schedule with relative ease.[7] Public-service programming was good for public relations, of course – associating a trademark with pleasant entertainment has a long history – but AT&T also sought to remind its audience of its position as a leader in corporate science. As Frank Capra recalled in his autobiography, Cleo F. Craig, board chairman of AT&T, 'insists that since science is what his company

[7] Marcel C. LaFollette, 'A survey of science content in U.S. television broadcasting, 1940s through 1950s: the exploratory years', *Science Communication* (2002) 24(1), pp. 34–71. See also LaFollette, *Science on American Television: A History*, Chicago: University of Chicago Press, 2012.

https://doi.org/10.1017/S0007087425101118 Published online by Cambridge University Press

is selling, science is what the Bell System should sponsor'.[8] According to AT&T's annual report, producing a science series would 'show in a dramatic and entertaining way how scientists are working to help mankind toward better and more useful living' and 'stimulate interest in science among young people. The country needs more scientists'.[9] But the goal was not merely altruistic; from the start AT&T invested considerable resources in this series to make clear Bell's leadership in both science television programming and corporate science. In the autumn of 1951, AT&T engaged its advertising agency, N.W. Ayer and Son, to produce the series.[10] Ayer began producing live sports programmes for television in the late 1940s for some of its clients and then children's programming in 1950 with *Big Top*, a one-hour live circus show produced for Sealtest Dairy, so it was ready and eager to lead the project.

Ayer assigned Donald Jones of their Radio–Television division to the project.[11] His background as a Hollywood screenwriter put him in a good position to find and evaluate talent on the creative side.[12] His targets also signalled AT&T's aspirations. During 1951 and 1952, Jones reached out to prominent scientists who were among the top names in their field, including Robert Millikan and Margaret Mead, many of whom agreed to be consultants.[13] He also approached Hollywood producers for their interest in such a series. That AT&T focused on Hollywood for their series rather than talent experienced in television production tells us that they were interested in a different kind of production value that would express their leadership in the field. Capra's name kept coming up in conversations because of his well-known interest in scientific topics; he had graduated with a degree in chemical engineering from Caltech before going into film-making. His success in Hollywood spoke for itself: five Oscars for his feature films and an Academy Award, Legion of Merit and the Distinguished Service Medal for his documentaries. With that kind of background, he seemed like the perfect fit when Jones approached him in early 1952. Capra was at a point in his career when such opportunities were fewer, and in 1950 he had completed an as-yet-unfunded scenario showcasing Millikan's work on cosmic rays, so he was enthusiastic about the Bell opportunity for a variety of reasons.[14]

Capra signed an agreement with Ayer in September 1952.[15] Initially, Ayer expected Capra to produce thirteen shows at an estimated budget of $175,000 to $250,000 per episode, beginning production in December 1952 with the first broadcast in autumn 1953, continuing at four-week intervals thereafter.[16] The budget seems low and the production schedule ambitious for the cinematic production values they were hoping to achieve. In comparison, Disney's 'Man in space' episode for the *Disneyland* series, which had a similar mix of live action and animation in its approach to science communication, cost around $300,000 and spent almost a year in production before its March 1955 broadcast.[17] The Capra episodes eventually cost around $400,000, which was not outrageous (Disney's third installment in its

[8] Frank Capra, *The Name above the Title: An Autobiography*, New York: Da Capo, 1997, p. 440.

[9] AT&T Annual Report 1956, p. 40, quoted in Eric Smoodin, *Regarding Frank Capra: Audience, Celebrity, and American Film Studies, 1930–1960*, Durham, NC: Duke University Press, 2005, p. 234.

[10] William E. Haesche Jr, 'Our new science TV series performs a public service', *Bell Telephone Magazine* (1957) 36(1), pp. 6–7.

[11] Haesche, op. cit. (10), p. 9.

[12] James Gilbert, *Redeeming Culture: American Religion in an Age of Science*, Chicago and London: University of Chicago Press, 1997, p. 202.

[13] Gilbert, op. cit. (12), p. 203.

[14] Joseph McBride, *Frank Capra: The Catastrophe of Success*, New York: Simon and Schuster, 1992, p. 613.

[15] Haesche, op. cit. (10), pp. 8–9.

[16] 'Capra signed for AT&T series', *Broadcasting* (20 October 1952) 43(16), p. 74.

[17] David R. Smith, 'They're following our script: Walt Disney's trip to Tomorrowland', *Future* (May 1978) 2, pp. 54–63.

https://doi.org/10.1017/S0007087425101118 Published online by Cambridge University Press

series, 'Mars and beyond', broadcast in December 1957, cost $450,000), and the price did not go down when Ayer moved the series to Warner Bros.; *Gateways to the Mind*, for example, cost approximately $400,000 as well.[18] The contracts were continually revised to accommodate new production timelines, but the Ayer and Capra relationship was dogged by the disparity between their expectations. Capra often asked for more money for the productions but met resistance. Shamus Culhane, whose company produced the animation for three of the Capra episodes, recalled that Capra 'might just as well have asked for a pound of bone marrow from each chairman of the board' when he requested more funds.[19] Even though AT&T's revenue rose by over $500 million in 1956, $31.5 million of which came from television technology contracts, shareholders still grumbled about the amount of money AT&T, a monopoly at the time, was spending on advertising, especially on this series.[20] So the drive to keep costs within budget came not only from unrealistic expectations but also from external pressure.

Animation was the primary culprit for the cost and schedule overruns. Studio-quality animation takes a lot of time and money, something the sponsors (or even Capra) might not have known initially. They also might not have expected that so much of the footage for the episodes would be devoted to animation when they drafted the first contract, well before Capra had prepared the first scenario and storyboard. At between $160,000 and $180,000 per episode, animation alone accounted for nearly half of the production budget. Ayer knew it would be expensive, because Jones gathered bids for *Our Mr. Sun* from three animation studios in April 1953, one of which came in as high as $182,000.[21] But Capra also added to the final cost, because animators had to redo work after he made corrections or changed his mind. By the final instalment, *Unchained Goddess*, Capra, the animators, Ayer and AT&T were all visibly frustrated with each other. Capra complained in June 1957 that AT&T's cost concerns were forcing him to leave already-scripted animation out of an episode, noting that the cost overruns were not this time attributable to his production company: 'The committed animation ... is being done *without* any supervision from us, since Culhane stated it was mostly our supervision which increased costs above their estimates.'[22] Capra noted, rather obstinately, 'If the ledger and time clock could have replaced creative talent they would have done so long ago. There is no guaranteed method known to keep a creative effort on a conveyer belt.'[23] But that was also Capra's final, petulant swipe at his overlords, because by this time (May–June 1957) AT&T had already announced that they were washing their hands of the Capra situation and giving the rest of the series to Warner Bros.[24] If cost and schedule were among the primary reasons for AT&T's dissatisfaction, Capra's approach to animation was largely to blame.

To be fair, balancing entertainment and science – perhaps the fundamental issue in science communication for public outreach – has always been a challenge, even for as accomplished and invested a film-maker as Capra. He articulated it well, if oddly, in response to the advisory board's comments on *Cosmic Rays* in 1956:

[18] McBride, op. cit. (14), p. 616; Smith, op. cit. (17), p. 63; 'Bell System Science Series', *Broadcasting* (3 November 1958) 55(18), p. 15.

[19] Shamus Culhane, *Talking Animals and Other People*, New York: St Martin's Press, 1986, p. 367.

[20] 'AT&T ad budget rapped at stockholder meeting', *Broadcasting* (22 April 1957) 52(16), p. 32.

[21] 'Comments by animation producers on *Our Mr. Sun*', 1 April 1953, folder: *Our Mr. Sun* comments on script April–June 1953, Box 19, Frank Capra Collection, Reid Cinema Archives, Wesleyan University, Middletown, CT, USA (subsequently Reid Cinema Archives).

[22] Frank Capra to James Hanna, 14 June 1957, *Unchained Goddess*: Correspondence 1957, Box 26, Reid Cinema Archives, original emphasis.

[23] Frank Capra to James Hanna, op. cit. (22).

[24] 'Four WB tinters for Bell Telephone', *Variety*, 5 June 1957, p. 27.

> The marriage of science and entertainment is a 'mixed' marriage with many problems. If entertainment wears the pants, science may take a beating, and vice versa. So we must squarely face the facts that:
>
> 1) with bad entertainment we've got no audience; and
> 2) with bad science we fall short of the objective.[25]

If Capra had to contend with AT&T and Ayer's concerns about cost and schedule, he had also to deal with the advisory board's understanding of this balance between science and entertainment. Early in the process, Jones commissioned prominent subject experts to comment on drafts of the scripts. Bell and Capra were deeply committed to getting the science correct, and the vast bulk of the comments on the scripts through the years focused on scientific accuracy. There were moments when entertainment might trump accuracy – a demonstration on-screen might end up taking too long, for example – but these moments were rare and, as Capra once reasonably noted, 'I believe this will be 98% accurate, and in the interest of avoiding dullness, and making a complicated point readily understandable, I plead for 2% leeway.'[26] The experts gladly gave him that leeway, as they readily saw the value of, and compromises required for, engaging science programming.[27]

But the experts were also an audience who had their own views about the nature of this balance, especially when Capra's approach threatened their sense of the profession. From 1953 to 1957, Ayer employed between two and four subject experts for each film plus two standing consultants – Ralph Bown, former research director of Bell Labs, and Warren Weaver of the Rockefeller Foundation and president of the American Association for the Advancement of Science – who also offered general comments on the scripts. But as tensions over the tone of the episodes grew, Ayer and Jones must have felt that they needed more voices in their discussions with Capra, because they created a larger scientific advisory board in early 1956.[28] AT&T and Bell Labs had considerable clout among the scientific community – Bown and Weaver were among the giants of post-war big science – so the advisory board included top scholars from various fields: George Beadle (Nobel Prize-winning geneticist), Farrington Daniels (Priestley Medal-winning chemist), Maurice Ewing (William Bowie Medal-winning geophysicist), and George R. Harrison (Medal of Freedom-winning physicist) were just some of the prominent names on this board.[29] Bown and Weaver served as chairman and vice chairman respectively, and did most of the heavy lifting, but all board members contributed as audience members when they screened rough cuts of the four episodes in September 1956. While many of them had read and commented on the scripts throughout the pre-production process since 1953, only a couple of them had seen *Our Mr. Sun*, and none had seen the rest. Two issues stood out in their responses: Capra's pronounced religious emphasis in the series, and the perceived imbalance between education and entertainment, often represented by animation.

Historian James Gilbert has already covered the religious aspect of the Capra episodes, but one exchange from this screening encapsulates the tension that hung over the Ayer–Capra relationship from the beginning.[30] Jones summarized the comments of the

[25] Frank Capra to Ralph Bown, 15 October 1956, p. 1, *Strange Case of the Cosmic Rays*: Scientific Comments, 1956 October 3, Box 25, Reid Cinema Archives.

[26] Frank Capra to Ralph Bown, op. cit. (25), p. 4.

[27] For a larger history of this negotiation and of the role of science consultants in feature film production see David Kirby, *Lab Coats in Hollywood: Science, Scientists, and Cinema*, Cambridge, MA: MIT Press, 2013.

[28] Gilbert, op. cit. (12), p. 211.

[29] John Z. Bowers, dean of the University of Wisconsin School of Medicine; Paul R. Burkholder, Sloan–Kettering Institute microbiologist; Clyde Kluckhohn, Harvard anthropologist; and John R. Pierce, Bell Labs electrical engineer, rounded out the board, which was in place until the end of the series in 1964.

[30] Gilbert, op. cit. (12), pp. 199–233.

https://doi.org/10.1017/S0007087425101118 Published online by Cambridge University Press

board on each of the episodes, religion being the overriding concern for all of them: 'After the showing to the scientific advisory board of all four programs there was discussion at some length of the strong religious flavor of many parts of the program', Jones wrote to Capra.[31] For example, Capra included a tagline for the series that 'grate[d] on the majority of the group': 'Science: the art of discovering what God created'. Instead, they offered an alternate tagline, 'Science: man's effort to understand nature's laws', which was eventually used for the series.[32] Capra was vehement:

> Forget it. If Advisory Board does not see the impact and salutary implication of saying they are studying God's work, then they are missing an important bet ... And if they are not studying God's work, whose creation are they studying? What does 'nature' mean – chaos or God? If it's chaos, can it make laws?[33]

Clearly, the board and Capra saw the world differently. Even though Capra relented in the same letter ('I'll not belabor the point. The Advisory Board doesn't like it, so it's out ... The suggested substitute phrase ... carries no wallop. Better we use nothing'), this was only the final volley in a long, exhausting battle that Jones, Ayer and the advisory board no longer wanted to wage.[34] Even though he made his views clear from the start, Capra's insistence on mixing science and religion was eventually another deal-breaker for the series.

Capra's approach to animation was also a problem – not just for Ayer in terms of resources but also for the board in terms of the balance between education and entertainment. Animation did not raise the board's hackles in the way that Capra's blunt religious asides did, but they had concerns that the animation came at the expense of live-action film, perhaps even marginalizing the science as represented by Dr Research. One part of the report read, 'There was considerable discussion on the scientific content, some scientists feeling that it was low, was too elementary and did not contain enough real demonstrations as distinct from animation.'[35] Animation, it appeared, was not keeping to its usual role. Instead, the board felt that Capra relied too heavily on animation to convey ideas that might have been communicated using demonstrations or other live-action means.

Additionally, the conventional view of animation as 'kid stuff' adds to the board's objection that the episodes were 'too elementary.' This complaint was shared by others, from the surveys given at audience previews of *Our Mr. Sun* to the reviews of the shows after broadcast. One reviewer called it 'sugar coating', but the sentiment was common among consultants and the board.[36] One consultant was rather direct in his condescension: 'In conclusion may I make a personal plea for you and your advisory group to try and hold down "animation" to a minimum. I decry the modern tendency, in the name of vague "expediency" to abandon reality for someone's interpretation of reality in "Mickey Mouse" form.'[37] Another wrote to Capra about the use of animation, 'I am, I must confess, a bit surprised that you who are closer to the problem of interesting the mass public than I am consider that it is

[31] 'General comments from the scientific standpoint', 3 October 1956, *Unchained Goddess*: Correspondence 1955–56, Box 26, Reid Cinema Archives.

[32] 'Comments on *The Strange Case of the Cosmic Rays* from a scientific standpoint', 3 October 1956, op. cit. (25).

[33] Frank Capra to Ralph Bown, op. cit. (25), p. 2.

[34] Frank Capra to Ralph Bown, op. cit. (25), p. 3.

[35] 'Comments on *Hemo*', 3 October 1956, *Hemo the Magnificent*: Comments 1956 Oct. 3, Box 23, Reid Cinema Archives.

[36] Jack Gould, 'TV: story of weather: Capra's Unchained Goddess is keyed below the adult viewer's level', *New York Times*, 13 February 1958, p. 59.

[37] Paul A. Nicoll to Maurice Visscher, 20 January 1955, *Hemo the Magnificent*: Correspondence 1955 Jan.–Mar., Box 23, Reid Cinema Archives.

https://doi.org/10.1017/S0007087425101118 Published online by Cambridge University Press

necessary to go to such lengths to attract the interest of the high school-level mind.'[38] While not all the scientists were as concerned about animation as they were with religious references, most felt that the animation crowded out the science.[39] Some viewers and scientists liked the animation, however, so the mixed reactions left Capra's approach untouched. As he sardonically replied to them all, 'Like the poor, these contrasting viewpoints will always be with us.'[40]

After Capra's departure in June 1957, the production of the series moved to Warner Bros., where Owen Crump took charge. The Warner Bros. series attenuated or eliminated the religious references, but the concerns of most of the board about Capra's approach to animation would also be addressed in the Warner Bros. episodes. Indeed, the most striking difference between the Capra and Crump episodes is the use of animation to convey scientific concepts, which might lead us to conclude that animation was the greater challenge to the proper balance between education and entertainment. In the eyes of the board and of AT&T, animation was certainly an accepted mode of representation for science programming. But it evidently did not stay in its lanes: it exceeded its scope budgetarily and creatively, in that the use of animation went beyond what was considered appropriate, especially, according to the board, the complaint that the animation was 'too elementary', the damning association with children's entertainment, and the animation's displacement of opportunities for live-action footage. Yet all these issues would have been apparent upon agreeing to use animation in the first place. So what exactly was the nature of the board's complaints? To articulate and clarify the implicit boundaries that such complaints draw, it would be worthwhile to examine a statement from the time about the proper functions of animation in education – that is, a practitioner's theory of animation.

The functions of animation in science communication

An essay from the era gives us a baseline from which to gauge the Bell series and the board's objections. In 1946, John Hubley and Zachary Schwartz, part of the team that founded United Productions of America (UPA), an animation studio that grew out of industry discontent with Disney's dominance in the field, wrote something of a manifesto about the potential for animation in training and education.[41] Prompted by their experience creating animation for wartime needs, they extolled the promise of animation for communication beyond its usual uses in entertainment cartoons. Communication via animation, they claimed, could convey ideas quickly and efficiently, visualizing 'areas of life and thought which photography was incapable of showing'.[42] They pointed especially to three functions specific to animation: (1) its ability to 'combine ideas' or its facility with making symbols and rendering metaphors, (2) its ability to compress time and to depict, through continuous change, a process quickly and dynamically, and (3) its ability to create abstractions, presenting not the specific instance, as in photography, but a general idea. To these I would add one other important function implied in their essay: (4) animation's ease at depicting what cannot be seen, whether the very small or the very large, a hypothetical situation or a theory. The Bell series employed all these functions using a variety of techniques, of course, but, more importantly, Hubley and Schwartz's division of labour between animation and photography (or live-action film) also articulated common assumptions about the proper

[38] Maurice Visscher to Frank Capra, 29 March 1955, *Hemo the Magnificent*: Correspondence 1955 Jan.–Mar., Box 23, Reid Cinema Archives.

[39] 'General comments from the scientific standpoint', op. cit. (31).

[40] Capra's response to 'Comments on *Hemo*', op. cit. (35), p. 8.

[41] John Hubley and Zachary Schwartz, 'Animation learns a new language', *Hollywood Quarterly* (July 1946) 1(4), pp. 360–3.

[42] Hubley and Schwartz, op. cit. (41), p. 361.

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role of animation in science film. Their theory of animation was therefore also a theory of appropriate use, as many theories of medium specificity are.[43] Their functions for animation could be considered its guardrails; examining each function in detail can clarify the implicit lines that Capra's animation crossed.

First, Hubley and Schwartz speak of animation's ability to 'combine ideas: such as a human face on a locomotive, an animal in a tuxedo, a skeleton with a cloak and scythe, etc.'[44] At first glance, this formulation appears to describe the anthropomorphism so common in Hollywood studio cartoons, about which Hubley and Schwartz's essay complains.[45] But a human face on a locomotive could have rich metaphorical implications: it could depict a combination or overlap of mechanical and human features, such as steam power and motivation or mechanical repetition and perseverance. The power of this personification emerges from its balance between the two sides of the metaphor: train and human. Anthropomorphism occurs when all the features of one side of the metaphorical comparison (e.g. human-ness) take over, leaving no room for the others (e.g. train-ness). In the Bell series, there are many interesting and useful analogies, such as the comparison between the brain and a television control room in *Gateways to the Mind*. But there are also many personifications without much metaphorical resonance, such as the obstinate Mr Sun, or Hemo the Magnificent, a rather boastful symbol of blood. These characters are anthropomorphic, because their traits have more in common with human foibles than with conventional traits of the object they depict. Personification is a useful function, but if overused or abused as anthropomorphism, it raises eyebrows.

Second, Hubley and Schwartz note that animation can compress a lengthy process into a single moment or a series of moments, which, like personification, is a kind of condensation.[46] One can do this with time-lapse cinematography, too, which can dramatically depict, say, the growth of a plant in a few minutes. Animation can mimic the regularity of time-lapse, or it can condense the same process into a second. Furthermore, animation can combine this compression of time with the metaphorical function discussed above, emphasizing the productive and insightful relationship between animated metamorphosis and change or process. Such a transformation can be a signal to compare two unlike things to better understand their relationship. Change is always a transformation of some sort, an invitation to compare before and after, and animation is well suited to depicting change as a transformation and prompting a comparison that encourages learning.

Third, they note animation's ability to generalize: 'a drawing's range of expression, its area of vision, is wider than that of a photograph, since the camera records but a particular aspect of reality in a single perspective from a fixed position. In short, while the film records what we *see*, the drawing can record what we *know*'.[47] We may add that a photograph captures a specific object at a specific moment in time; it is a depiction of the resolutely individual instance – *this* thing in *this* place at *this* moment ('what we *see*'). A drawing, however, is not bound to space and time in the same way and hence can depict the general idea or a theory of the object depicted ('what we *know*'). Drawn animation provides this same potential for abstraction, but it also moves, which gives it an experiential dimension. A line drawing lacks the detail of a photograph, which is precisely its strength, but this can also be its weakness: it can be too simple. To match the rhetorical weight of photographs or live

[43] On medium specificity see Noël Carroll, 'Forget the medium!', in Carroll, *Engaging the Moving Image*, New Haven and London: Yale University Press, 2003, pp. 1–9.

[44] Hubley and Schwartz, op. cit. (41), p. 361.

[45] See also John Hubley, 'Beyond pigs and bunnies: the new animator's art', *American Scholar* (Spring 1975) 44(2), pp. 213–23.

[46] For an enlightening discussion of condensation in educational animation see Dan Bashara, *Cartoon Vision: UPA Animation and Postwar Aesthetics*, Oakland: University of California Press, 2019, pp. 115–63.

[47] Hubley and Schwartz, op. cit. (41), p. 361, original emphasis.

action, an animated sequence must display signs of disciplinary learning. In animation this can be done in a variety of ways, from the seriousness and density of the voice-over narration to the complexity of the animation itself. The advisory board's objection to Capra's use of animation in this regard was that it was 'too elementary'. They recognized the value of animation for abstraction and even its appeal in balancing education and entertainment, but they disagreed with the narrative and design choices that simplified the science too much.

One final function is so common that it is mildly surprising that Hubley and Schwartz did not mention it explicitly: animation's ability to visualize the imperceptible. 'Imperceptible', however, covers a lot of ground: it refers not only to that which is beyond the limits of human perception (atoms, for example), or that which is perceptible only to the scientific imagination (say, a theory), but also those phenomena or situations that are technically perceptible, but not easily depicted by other means, especially photography. This distinction – between that which can and that which cannot be photographed – is central to many common assumptions and biases about animation in science. Most science films that incorporated animation, whether for lay or expert audiences, had an implicit rule of thumb: if it could be photographed, it should be, and animation should play only a supplemental role. Animation was confined to a restricted role in relation to the photographic image, which has become the visual expression of 'evidence'. The power of animation to visualize beyond the camera's capabilities is both incredibly useful and controversial in that its visualizations can go beyond what is known and depict theory as if it were fact. Historically, the scientific community has often been anxious about illustrations that depict for a lay audience the unseen, because the very act of drawing the unseen gives it form and materiality that it may not have.[48] It has usually been posed as '*we* know this is theory, but *our lay audience* might not', which highlights the role illustrations and animation have played in the power dynamic between elite and popular scientific cultures. Hence conventions for the use of animation in science films have often hewed to this dynamic by keeping animation in a role supplementary to live action.

In the Bell series, this dynamic played out in the discussion of the relative time given to animation versus the time on-screen given to live demonstrations. Indeed, Hubley and Schwartz's theory of animation helps to clarify the scientific advisory board's concerns and place them in a larger history and context of animation for educational and science films. The board had not read the Hubley and Schwartz essay, of course; the essay should be considered an articulation of already-established but unspoken assumptions about animation in education. The board held to these tacit rules of thumb in their objections to Capra's approach. In the next section, we shall see how the board and the producers attempted to rein in Capra's use of animation.

Comparing the episodes

At first glance, the Bell series scientific advisory board's complaints seem specific to Capra's handling of the series. But the essay by Hubley and Schwartz indicates that these concerns echoed across the larger literature on animation's educational potential. The objection that the animation was 'too elementary' points to Capra's over-reliance on anthropomorphic

[48] See G. Nigel Gilbert and Michael Mulkay, *Opening Pandora's Box: A Sociological Analysis of Scientists' Discourse*, Cambridge: Cambridge University Press, 1984; Alberto Cambrosio, Daniel Jacobi and Peter Keating, 'Ehrlich's "beautiful pictures" and the controversial beginnings of immunological imagery', *Isis* (December 1993) 84(4), pp. 662–99.

https://doi.org/10.1017/S0007087425101118 Published online by Cambridge University Press

characters and approaches to abstraction that strayed from conventional scientific illustration toward caricature. The charge that animation displaced live-action demonstration points to the function of 'depicting the imperceptible', which includes an unwritten rule that what can be photographed should be, unless it is impractical or unhelpful. Finally, the implication that Capra's use of animation recalled too clearly its association with children's entertainment can be seen in the way Capra borrowed conventions from children's television.

We can see these objections, then, in terms of the intermedial interactions among animation, live-action film and television (as well as, to a certain extent, scientific illustration), and Hubley and Schwartz's four functions as a theory of medium specificity that also implies guidelines for appropriate use. Accordingly, the second half of the series was a course correction to keep its intermedial interactions within these guardrails. These rules of thumb were assumed and practised, however; they were not as explicitly stated as in Hubley and Schwartz's essay. The board's objections were a gut reaction to how animation behaved in the Capra episodes, and a feeling about how it should behave. This section therefore analyses the key differences between the two halves of the series to find the producers' solutions to the problem that Capra's episodes presented. Those solutions bear on the way animation (1) was incorporated into the setting of each of the episodes and the conventions of scientist–audience interaction, (2) was employed to convey metaphors and to personify concepts and (3) was used in relation to live-action footage.

Staging the interaction

All four of the Capra episodes follow the same conceit: as we tune in, the characters are still making the very programme we are watching, a backstage motif that appears to be a winking concession to the commercial imperative in science programming on television to 'put on a show'. Indeed, the last line of the narrated credits of each entry proudly claims 'public education through entertainment' as the main purpose of the series. The Capra series personifies the proper balance of education and entertainment as a collaboration between its two main characters, Dr Research (played consistently by Frank C. Baxter) and Mr Fiction Writer (played by Eddie Albert in *Our Mr. Sun* and Richard Carlson thereafter).[49] The set for the episodes resembles a sound stage decorated with assorted laboratory equipment, models, globes, books and journals; desks strewn with papers; framed pictures of scientists and iconic scientific imagery; and other trappings of scientific inquiry – an intellectual man cave of sorts. Reels of film and a Movieola sometimes peek through the clutter, too: important props that highlight the significance of two large movie screens on either side of the set. On the left is Dr Research's screen, dedicated to scientific imagery. On the right is Mr Fiction's screen, dedicated to the imagination (Figures 1 and 2). The primary purpose of Dr Research's screen is to illustrate some point about the science he is trying to explain, which may involve live-action footage, animated figures, animated personification of phenomena and theories or the animated re-enactment of historical events. Animation is not used sparingly on this screen. However, there is a strong contrast between the kinds of illustrations on the science screen and what is shown on the other screen. In all four Capra episodes, the imagination screen primarily depicts the (animated) characters – Mr Sun and Father Time, Hemo the Magnificent and his companions, Edgar Allen Poe and the other puppet judges of *Cosmic Rays*, and Meteora and her minions – with which the two main

[49] The characters are never called these names in the aired programmes, but they are the names given to them in the scripts.

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Figure 1. Dr Research's screen for science from *Our Mr. Sun*.

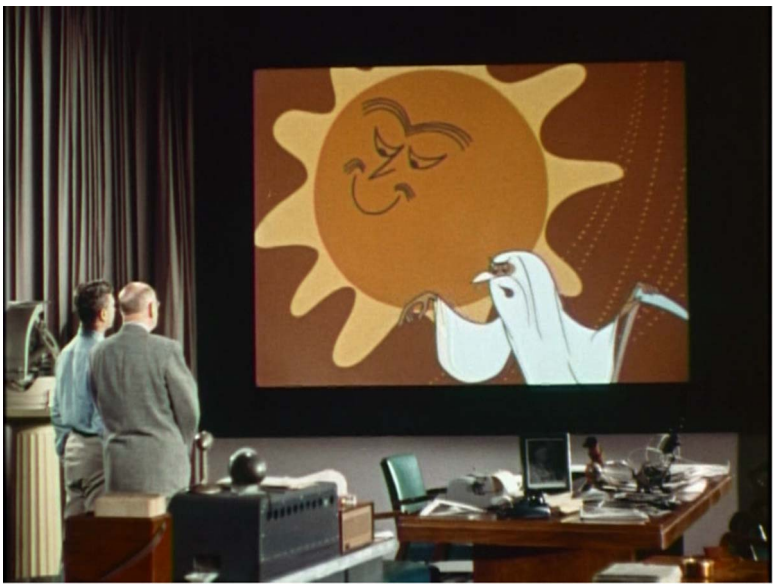

Figure 2. Mr Fiction's screen for imagination from *Our Mr. Sun*.

characters interact. Dr Research's screen, on the other hand, functions as educational technology: he uses his microphone to speak to 'Jim' to call up a clip to illustrate a point, just as a teacher might ask a backstage technician for the next slide. Mr Fiction's screen, however, functions more as an interactive technology, a window onto another world in which its inhabitants can also see and talk with the two protagonists in real time.

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Of course, this dream of interactivity is as old as the idea of television itself, and closed-circuit systems, which enabled televisual interaction, were being used at this moment for scientific and medical training and inquiry.[50] Interactivity was a common convention of science programming on television, manifesting itself usually as indirect address: explaining not to the viewer directly, but to someone on set. The panel of scientists on the *Johns Hopkins Science Review*, for example, would address the television audience directly, while Don Herbert in *Watch Mr. Wizard* would explain his experiments to a young person who came to visit each week, thereby addressing the television audience indirectly. The narrative motivation of shows like *Watch Mr. Wizard* resided in the alternation of question and answer, which guided the direction of the programme from a query to a demonstration of a principle. This alternation, of course, depended on an interaction between the questioners (or the surrogate audience) and those, like Mr Wizard, who answered the questions. This interaction was so common that it was taken for granted and featured in shows that were both live and pre-recorded.

Capra's innovation, however, was to have the explainers interact with cartoon characters (or puppets in the case of *Cosmic Rays*) instead of live-action humans. As far as I can tell, no other show of any type featured this kind of interaction. In the history of animation, there were many instances of live-action–animation interaction, from the Koko the Clown series (Fleischer, 1919–29), to Gene Kelly dancing with Jerry Mouse in *Anchors Aweigh* (MGM, 1945), to *Mary Poppins* (Disney, 1964), to *Who Framed Roger Rabbit* (Touchstone, 1988). All these instances, however, concern the incursion of animated characters into the live-action realm or vice versa. That is not what happens in the Capra series. Instead, the live-action and animated characters stay on their side of the frame and discuss the issue at hand from the safety of their separate realms. This is different from the use of animation in, say, the Disney science shows, which simply alternated between live-action explanation and animated illustration without direct interaction between the two realms.

The kind of interaction in the Capra series recalls not science shows, but children's programming of the day, especially a show such as *Kukla, Fran, and Ollie* (1947–57), which featured puppets interacting with a human host (Figure 3). What is the difference between a live-action interaction between adults and children and one between adults and puppets? The answer is not that the puppets are fictional – the human characters are, too. It is that the puppets are of a different order, one of fantasy rather than reality. They evoke a realm of possibilities different to the world outside the frame, a realm of imaginative play, which allows such avatars narrative agency: a child playing with its dolls is also a child with whom its dolls are playing – and suggesting what to do next. A child's questions to Mr Wizard guide the science show narrative, too, but to give such agency to a cartoon character evokes the conventions of children's television programming more than those of science television. For the Bell series board, that might have been a step too far.

Specifically, in each of the episodes the animated character is sceptical of the science or of humanity's ability to understand the object of study. The drama of each show – the narrative motivation – is whether Dr Research and Mr Fiction can persuade the characters of the value of scientific inquiry. In a way, the cartoon characters stand in for a potentially sceptical audience that Capra imagines must be convinced, an assumption that keeps science on its heels the entire series – and gives narrative agency to the cartoons. In fact, Mr Sun, Hemo and Meteora are not just sceptical; they are downright anti-science, which puts science in the awkward position of justifying itself to cartoon characters.

This disadvantage reaches a crescendo by the time of *The Unchained Goddess*, which features Meteora, cartoon goddess of the weather. She is smitten by Dr Research and, at one

[50] Doron Galili, *Seeing by Electricity: The Emergence of Television, 1878–1939*, Durham, NC: Duke University Press, 2020; V.K. Zworkin, E.G. Ramberg and L.E. Flory, *Television in Science and Industry*, New York: John Wiley & Sons, 1958.

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Figures 3 and 4. Children's television at the time sometimes staged similar interactions between humans and imaginary beings. Compare Figure 2 to Figure 3, a still from *Kula, Fran, and Ollie* (1947–57), and to Figure 4, which depicts human-to-human interaction in *Gateways to the Mind* later in the series.

point, envisions him as a romantic mate in a toga more suited to her mythological status. She even proposes to him at the end of the programme. Just after he turns down her proposal, Fiction asks him, 'Hey Doc, you said it couldn't storm tonight, didn't you?' and then opens a curtain to reveal rain and wind through the window. Meteora and her fellow beings get the last laugh as Fiction says to a visibly embarrassed Research, 'Doc, I think

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your isobars have slipped.' The belly laughs of the cartoon characters at the expense of Dr Research even annoyed viewers at the preview:

> An excellent show, good opening. Too much of the cartoons. Great camera work, especially the cloud time-lapse shots. Baxter is a great character ... The ending could definitely be altered. The movie shows how science is disproving superstitions, and at the end Baxter (science) is made a fool of, many ways it could be changed for the better.[51]

Other viewers – and the scientific advisory board – agreed: Capra's use of animation, written into the very design of the set, disparaged science and scientists. We should be quick to note that one does not come away with the general impression that Capra hated scientists. The episodes are excited about science and eager to extol scientific accomplishments. In fact, Mr Fiction passionately defends science to the sceptical beings in *Hemo*. The staging in the Capra episodes, however, positions science and scientists with more humility than in the Crump episodes. Capra's insistence that religion should occupy equal ground – and the decision to divide the set into two sides, science and imagination – meant that scientific endeavour had to share the stage with prayer and art, two other ways in which humanity seeks understanding. Alone, this humbler position of science would probably have been tolerated. But combined with the other aspects of the staging in relation to animation, humility edged toward humiliation, which raised eyebrows on the board. Capra's set design and choice to indirectly address the audience via interaction with cartoon characters had unfortunate implications that seemed to reach their logical conclusion in *The Unchained Goddess*, the ending of which may or may not have been an expression of his frustrations with the advisory board – the ending of his contract was surely a sign of their frustration with him.

In the Crump series, science is central and does not need to jockey for position among these options. Capra's aesthetic choices might have sprung from presumptions about a *sceptical* audience that needed to be *persuaded* about science. Crump approached the same choices differently, assuming instead an *interested* audience that wanted to *learn*. We can see this difference in the staging of the Warner Bros. episodes. For the Crump series, set designs changed with every episode: a Hollywood sound stage in *Gateways*, a little girl's home and then a Wonderland-like setting in *The Alphabet Conspiracy*, a lecture hall in *The Thread of Life* and 'Planet Q' in *About Time*. Interaction was also key to the Crump series, but Crump hewed more closely to the conventions of science television. In keeping with the televisual theme, *Thread* even stages this interactivity as a conversation between Dr Research and audience members via a fantasized version of closed-circuit screens. But whether he addressed his interlocutors televisually or in person (Figure 4), Dr Research always interacted with human characters; Crump jettisoned interaction with cartoon characters right away.

This is not to say that the Crump series had no place for cartoonishness. There was plenty of animation, and *Alphabet Conspiracy* features Jabberwock and the Mad Hatter, played expansively by Hans Conried, so caricature was not out of the question. But the attitude of Dr Research's audience has changed dramatically. All the interlocutors are now respectful and curious – curiosity instead of scepticism is the guiding principle of the interactions in the Crump episodes, and this is also a convention of science television programming. Only the Mad Hatter is anti-science, but Dr Research's main interlocutor in the film is the Alice-in-Wonderland-like character, who eagerly asks questions about the science. Dr

[51] Comments by Gus King, 18 December 1957, *Unchained Goddess*: Correspondence 1957, Box 26, Reid Cinema Archives.

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Research's mission in the Bell series – to answer questions and explain – did not change from one episode to the next. Baxter's avuncular approach to the role, which he honed after years of award-winning work on early educational television, is steady throughout.[52] But explaining the science to a group of animated mythological beings is qualitatively different to hanging out with the boys on a sound stage, even for an expert educator like Baxter. Crump made it easier on Baxter, Dr Research and the advisory board by eliminating that disadvantage and keeping animation on a tighter leash.

Personification

Capra's decision to personify the objects of study – the sun, blood, the weather – for his episodes was not out of character for his series, which often employed this technique. Animation's ability to combine ideas in a visual metaphor or to encapsulate one idea in a personification is, as we saw above, crucial to bringing difficult concepts closer to layperson understanding. Like time-lapse or high-speed cinematography, which bring phenomena from temporal orders beyond human perception in line with our own, animation's ability to personify helps to make complex ideas, such as the special theory of relativity in *About Time*, or phenomena, such as the circulatory system in *Hemo*, recognizable for the layperson. However, this technique or function must be employed consistently and clearly if it is to present insightful analogies. It must aid the explanation, not get in its way. This is not the case for much of the animation in the Capra episodes, which idiosyncratically and inconsistently use personifications in sometimes inexplicable ways. *Hemo*, for example, has some excellent analogies and personifications, such as the vision of the heart as an antechamber with little 'muscle men' pushing doors open and closed while 'foremen' control the tempo. But, later, other personifications come into play, sometimes bewilderingly, such as the comparison between American colonial settlers and early cell life, where 'groups of these cells came together to live as colonies', or unnecessarily, as when Dr Research remarks, 'If you squeeze the human body as you would a sponge' you would get mostly seawater, and we see personified sponges being squeezed. The film is devoured by comparisons to the point where even one of the animated personifications in *Hemo* complains about another character supposedly helping with the explanation: 'coal, motors, ashcans – he drives us crazy around here' with his analogies. The most baffling instance comes in *Cosmic Rays*, which frames scientific puzzlement about cosmic radiation as a detective story that, inexplicably, puts radiation in the role of a gang of bank robbers and cosmic rays as a 'phantom thief' who escapes detection (Figure 5). While the analogy is followed throughout the film, its relation to the science grows ever more perplexing: if the heat of suns strips atoms of their electrons before sending them off as positrons and other particles, what makes these positrons 'thieves'? What, exactly, do they steal? Why are these particles likened to Fagin from *Oliver Twist* and other particles as 'henchmen'? Capra's often murky metaphors obscure the scientific explanations.

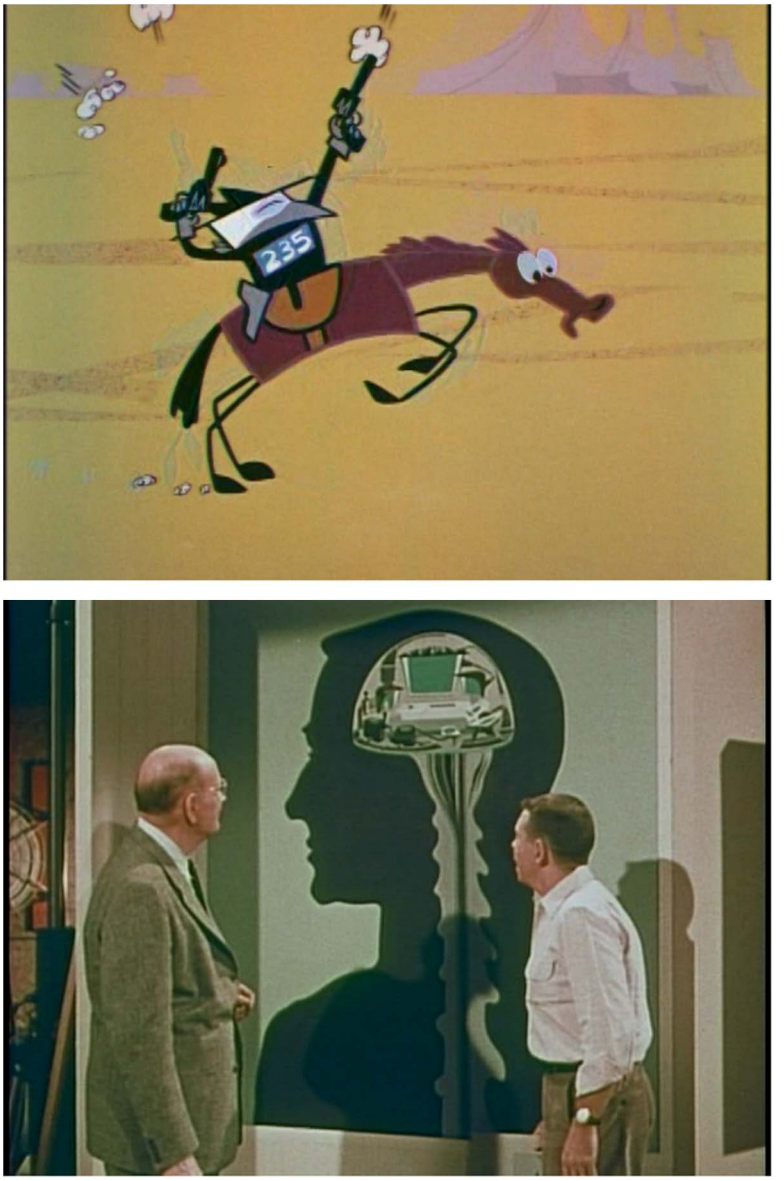
These analogies eluded the board's concerns on *Cosmic Rays*, however, which focused instead on questions of accuracy and status, specifically asking about scenes in which the writer offered scientific interpretations that the board thought best left to Dr Research.[53] The 'detective story' approach to the topic might have come from Bruno Rossi, one of the scientific specialists consulting on the script, whose narrative sketch of the scientific community's interest in cosmic rays had an element of mystery in it.[54] Capra expanded on that

[52] For more on Baxter see Jacob Smith, 'Dr. Frank C. Baxter, titan of US educational television', *Screen* (Summer 2014) 55(2), pp. 189–203.

[53] 'Comments on *The Strange Case of the Cosmic Rays* from a scientific standpoint', 3 October 1956, op. cit. (25).

[54] Bruno Rossi to Donald Jones, 13 September 1954, *Strange Case of the Cosmic Rays*: Correspondence, 1954 Sept. 13, Box 26, Reid Cinema Archives.

https://doi.org/10.1017/S0007087425101118 Published online by Cambridge University Press



Figures 5 and 6. Compare Capra's over-reliance on caricatured personification (here a cosmic ray as a 'phantom bandit' in *Cosmic Rays*) to similar personifications in *Gateways*, inspired by conceptual scientific illustration.

sense of mystery in his notes, emphasizing detective work and Sherlock Holmes as a guiding muse.[55] Capra's translation of this trope into a series of analogies about cosmic rays as bank robbers apparently did not bother the board, but it bothered the preview audience (of Ayer employees), who complained that 'the device of the detective story seemed far-fetched and pulled in by the heels' and was 'too coy and "cute" to carry the type of information in such length', or that the film was confusing and 'covered a lot territory' that 'would be better if

[55] Frank Capra, 'Notes – Cosmic Rays', 25 September 1954, in *Strange Case of the Cosmic Rays*, op. cit. (25).

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less thoroughly covered but in simpler terms'.[56] Print reviews of the film after its October 1957 broadcast were even more impatient, especially now that Sputnik had emerged on the horizon. John Crosby, television critic for the *New York Herald Tribune*, spoke for most of his brethren when he charged that the programme 'has simplified matters to the point where they are twice as confusing as a straight science lecture would be' and that Capra's approach 'is so cute and arch and coy that it will only drive away the intelligent people who might be genuinely interested'.[57] These complaints matched opinions of those on the board who thought that Capra's approach was 'too elementary' and that the use of animation got in the way of the science. By this time, Ayer had already decided to go in a different direction: the Crump episodes dialled back the use of personification and proliferation of analogies considerably.

Most notably, the Crump episodes used personification and analogies much less often than the Capra series. Personification is still a common technique for at least an episode or two, but the third episode, *Thread of Life*, had no personification at all, its use of animation confined largely to abstraction and depicting change. The other episodes use personification sparingly and always consistent with a visual theme or overriding metaphor for the series. For example, *Gateways* is set on a Hollywood sound stage, the technology of which serves as the thematic frame for the exploration of the different senses: sight and cameras, hearing and sound recording, props and set designs to explore touch, taste, smell and optical illusions. The animation mostly avoids elaborate analogies in favour of moving illustrations of Dr Research's lecture. When it needs a metaphor, it adopts the approach of conceptual scientific illustration, in line with the technological theme, such as a vision of the brain as a television control room (Figure 6).[58] Furthermore, the use of animation is discussed candidly with Research, the process of conceptualizing the metaphor broken down and explained to the audience, just as the camera and sound recorder are explained. The Animator and Research concede that 'trying to draw a character that represents a sense' is 'a pretty tough assignment', but the Animator walks Research through the process and shows sketches of his ideas about the personification metaphor, noting that his choice of a Hermes- or Mercury-like character was grounded in features of the senses: 'quick, responsive'. So the episode is at pains to demonstrate that the personification is rooted in already established conventions of scientific illustration and linked to what we know about the science. When Research notes that 'it's not the easiest thing in the world to look in on the actions and workings of a living human brain', the Animator replies, 'Maybe that's where the animator has an advantage: he can invent one.' He then shows more sketches: 'Here's just a few of the hundreds of sketches that we waded through trying to make our drawings agree with your facts.' Animation, in the Crump episodes, is beholden to the science, not the other way around.

Animation and live-action film

Animation is keenly aware of its proper role in the Crump episodes – or what the board and Ayer perceived its proper role to be. Throughout the Crump series, animation comes at the bidding of the live-action characters, doing what it is directly asked to do. For example, Dr Research says in *About Time*, 'It's fun to conjecture what *would* happen' if the theory of relativity held, and the accompanying animated sequence re-enacts that wonder. Animation

[56] 'Cosmic Ray comments – N.W. Ayer Employees – Philadelphia – 6/8/55 – 2:00 to 3:00 P.M.' *Strange Case of the Cosmic Rays*: audience surveys, 1955 June 8, Box 26, Reid Cinema Archives.

[57] John Crosby, 'The kindergarten approach', *New York Herald Tribune*, 30 October 1957, p. A1.

[58] On conceptual illustration see Michael Sappol, *Body Modern: Fritz Kahn, Scientific Illustration, and the Homuncular Subject*, Minneapolis: University of Minnesota Press, 2017.

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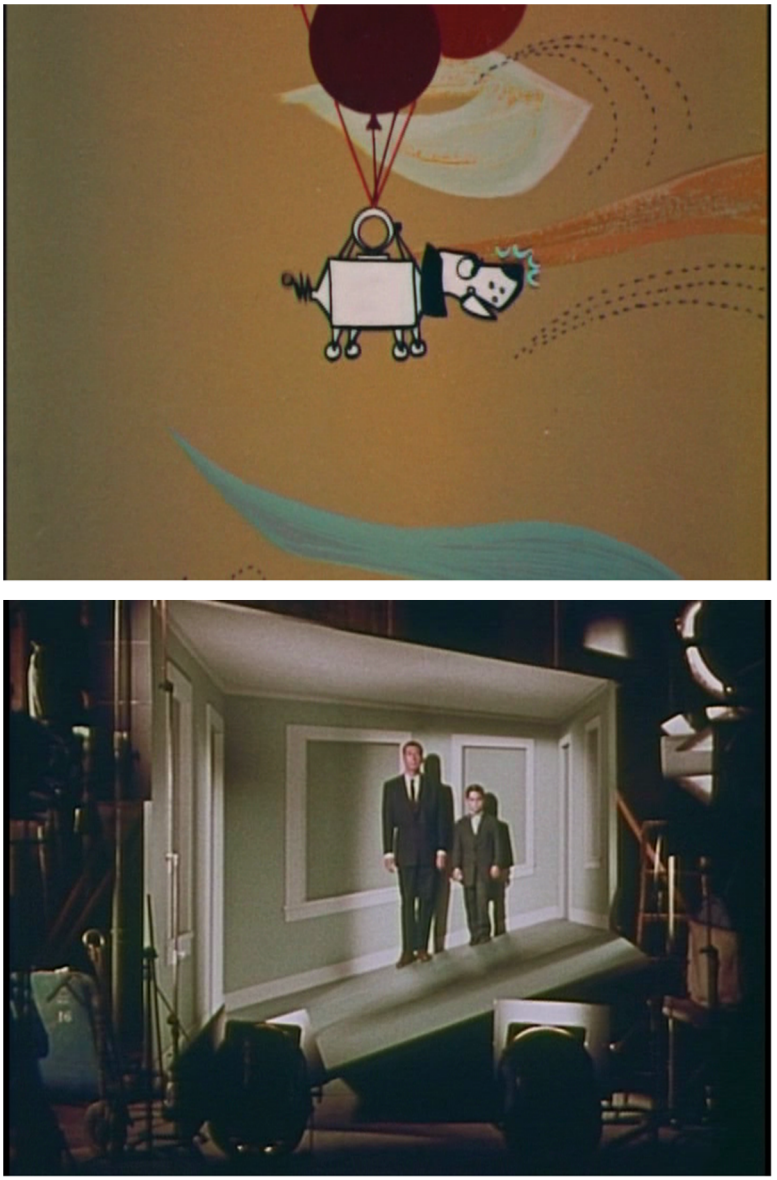
in the Crump episodes has no narrative agency. Compare this to a moment in Capra's *Unchained Goddess*, when the animated character Thor interrupts Research's demonstration on lightning, demanding to have a say about the topic. True, he and his fellow beings are all bluster, and the live-action characters are never really taken aback, but there is a pattern of animation usurping live action in the Capra episodes. In the same episode, Research uncharacteristically explains a finer point using jargon, which prompts animated Professor Coriolis to take over to explain it in layperson's terms. In *Cosmic Rays*, Research demonstrates an electroscope, designed to measure cosmic rays, holding it in his hands and taking it apart. Mr Fiction says, 'it's kind of an automatic mechanical bloodhound', leading to an animation picturing the device as it transforms into a bloodhound (Figure 7). The animated simile overtakes the interest in the actual mechanical device. Unnecessary uses of animation such as this raised concerns among the board, which was worried that the amount of animation left little room for live-action demonstrations.[59] If a demonstration were needed, as in the explanation of the Coriolis effect in *Unchained Goddess*, it was almost always accomplished via animation in the Capra episodes.

For the science educator, live demonstrations were the gold standard, the default approach to conveying lessons to a lay audience, usually one's students. Given a choice between an animated demonstration and a live-action film of a demonstration, the Bell series advisory board preferred the latter. This was in keeping with commonly held views on the appropriate use of animation in science television. One manual from the era celebrated television's ability to visualize science, naming all types of potential visual aids, but then immediately declared, 'Obviously, the first search for visual material should be made in the laboratory of the scientist who is to give the program.'[60] One should look first to live demonstration and its artefacts. Later, the book conceded that motion pictures and photographs of such artefacts are fine, but charts, drawings and animated cartoons 'should be used sparingly and only when all other visual methods fail'.[61] The bias against the figural was not limited to the Bell advisory board.

The Crump episodes, by contrast, are eager to show live-action experiments or demonstrations, as in the illustration of optical effects on the sound stage of *Gateways* (Figure 8) or the use of radiation to date the age of the Earth in *About Time*. These demonstrations also feature prominent scientists – psychologist Hadley Cantril and geologist Gerald J. Wasserberg respectively – telling about their research in their own words. Indeed, the Crump series gave many prominent researchers, most notably neurologist Wilder Penfield and physicist Richard Feynman, opportunities to explain the significance of their work to the topic at hand. While the Capra episodes would often picture and name important scientists in its history or explanation of the subject, it did not give them screen time to address the audience directly. The staging of live-action interaction also reveals clashing ideals about the proper balance of education and entertainment. All parties were concerned about getting the science right and making it appealing to the audience, but Capra's vision of 'edutainment' presumed an audience for whom science competed with other cultural forces, such as religion and entertainment. For Capra, animation functioned as a bridge between these disparate realms, a mode that could convey myth, imagination and science at once. But such a heavy rhetorical load relied on animation and threatened to crowd out other modes of depicting science, especially live action. Crump, in line with the board's vision, placed live-action scientists and demonstrations front and centre of the educational mission, which also points to a desire to protect science's authority in the face of representational forms, like animation, that potentially abstracted and diminished that authority.

[59] 'Comments on *Hemo*', 3 October 1956, op. cit. (35).
[60] Lynn Poole, *Science via Television*, Baltimore, MD: Johns Hopkins University Press, 1950, p. 46.
[61] Poole, op. cit. (60), p. 50.

https://doi.org/10.1017/S0007087425101118 Published online by Cambridge University Press



Figures 7 and 8. The Capra episodes offered some live demonstrations, but too often used animation to depict an artefact or a principle (Figure 7, from *Cosmic Rays*), while the Crump series opted first for live-action demonstrations (Figure 8, from *Gateways*).

In this way, the rhetorical power of scientific authority was closely associated with the rhetorical power and evidential authority of photography.

Conclusion

In an era when animation is used almost without a second thought for scientific videos of all sorts – from research, to training, to outreach – a case study from mid-century seems

https://doi.org/10.1017/S0007087425101118 Published online by Cambridge University Press

perhaps only of historical interest. Yet the use of animation, especially in the form of photo-realistic computer-generated imagery (CGI), is still controversial. The debates about the threat of CGI to documentary realism have not diminished with the ubiquity of special effects and animation – quite the opposite, in fact.[62] The case of the Bell System Science Series demonstrates that animation and the figural have often put the chummy relationship between photographic images and scientific authority at risk, and that the present-day discussion about this risk is not merely a consequence of CGI's aspiration to realism, but the result of a long-standing dichotomy between these modes of representation. The balance between education and entertainment has always been difficult (if not impossible) to achieve; when that balance has been perceived as furthest from ideal, animation has often been the scapegoat. The Bell series case shows that animation's historical rivalry with live action is at least part of the reason why.

Intermediality helps to clarify other reasons for the board's concern about Capra's staging of the episodes. Specifically, the interaction between different modes of representation – here, animation, live-action film and television – pointed to limits of appropriate use. Capra's borrowing of conventions from children's television – the direct interaction between human and imaginative realms – further blurred boundaries between live action and animation, or between education and entertainment, that seemed to set off alarms among the scientific advisory board and critics. Their assumptions about how animation should be used in this setting amounted to a theory of the medium: its strengths, its weaknesses and how it can be best applied. These assumptions are deeply ingrained, going back to debates about the proper use of shading in scientific illustration, for example.[63] The concern has always been about the gap between what the scientist knows to be theoretical and what the audience might perceive, and how the image responsibly conveys or not the limits of knowledge. But it has also been about the relationship between knowledge and spectacle: the responsibility of communicating scientific understanding to a lay audience, the value of spectacle for that task, and the danger it presents to the legitimacy of science and scientists. Animation's potential marriage of scientific illustration with the experiential aspect of moving images makes it a tempting solution to the challenge of science communication. But the Bell System Science Series (and many similar cases) demonstrates that animation has also presented many potential pitfalls – it has always been perceived as a volatile ingredient to be handled carefully. To counter this history and these debates in a post-photographic era, we need a theory of animation in science that sees it as a partner to the photographic, and articulates the equal and vital role it plays in the production of knowledge.[64]

Acknowledgements. The author wishes to thank Tom Gunning for bringing this series to his attention, and Alla Gadassik, Tim Boon, Jean-Baptiste Gouyon and the anonymous reviewers for their astute comments on an earlier version of this article.

[62] See, for example, the discussion of *Walking with Dinosaurs* and similar series in Campbell, op. cit. (3), pp. 36–51.
[63] See Cambrosio, Jacobi and Keating, op. cit. (48).
[64] A tentative first step in this task is Scott Curtis, 'Animated images in a media history of science,' *Journal of Cinema and Media Studies* (Fall 2021) 61(1), pp. 147–52.

Cite this article: Curtis Scott, 'Between education and entertainment: animation, science communication, and the Bell System Science Series', *The British Journal for the History of Science* (2025), 1–22. https://doi.org/10.1017/S0007087425101118