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ORIGINAL ARTICLE

Animation as a visual bridge between science and society

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Abstract: Scientific knowledge has always depended on images, especially when it addresses phenomena that escape direct sensory perception. This introduction sketches the privileged yet problematic role of animation in figuring the "invisible" within contemporary science communication, pointing out some connected epistemological and ethical questions. In fact, the increasing visual coherence, realism, and interactivity of animated models can obscure the constructed nature of scientific models, encouraging audiences to read them as direct depictions rather than as mediated arguments. The present special issue of Mutual Images Journal is related to the Marie Skłodowska-Curie project FICTA SciO – Figuring the Invisible (2023–2025), which investigated conventions and tactics of animation for science outreach while advocating transparency as a core communicative value. The introduction outlines the conceptual stakes of the project and presents the seven contributions as complementary inquiries into how animation shapes scientific understanding, visibility, and public trust within contemporary visual culture.

Keywords: scientific animation; invisibility; science communication; visual epistemology; useful animation; modelling and simulation; immersive media; animated documentary

1. Science, animation, and the "invisible": a necessary dilemma

From early anatomical drawings to contemporary data-driven simulations, visualisation has always been a constitutive element of scientific epistemic practices. This longstanding entente between images and science acquired a thought-provoking pre-eminence when scientific inquiry addresses entities and processes that cannot be accessed through direct sensory perception, as in the case of objects that are too small, too distant, too fast, too slow, or too abstract to be seen, heard, or otherwise experienced without technological mediation. In such cases, visualisation does not merely illustrate knowledge; it actively participates in creating a scientific paradigm.

In this context, animation has a key role. Unlike photography or live-action recording, animation does not need to foreground optical indexicality. As such, it is a privileged expressive tool to visualise anything that is inferred from data evidence, by bringing it to a sensorial and temporal scale fit to human fruition. Such scale adaptation in time and space is a first step towards interactive possibilities, for outreach purposes, but also to test, refine, and imaginatively explore theoretical models. Animation invites the creation of an «image-as-process», and not just of an image which documents a process of scientific relevance, inviting the end user to manipulate it. In the contemporary age, animated digital images for science «are meant to be *used*, cut, correlated, rotated, colored» (Daston & Galison 2007: 383).

Well before that, from the 1910s onward, film animation became consistently involved in the media history of science (Curtis, 2021). More recent scholarship has proposed the umbrella term "useful animation" to describe a wider field of research, thereby moving beyond an exclusive focus on cinema and documentary (Curtis 2015: 23–27; Curtis & Lue, 2018; Cook, Cowan, & Curtis, 2023). Such a perspective acknowledges the pervasiveness of animation in the contemporary media landscape (Buchan, 2013), encompassing thus also museum installations, videogames, graphical user interfaces, data visualisation, virtual reality, and scientific modelling environments.

This expanded range of animation makes it even more urgent to inquire a decisive side of its scientific use: its persuasive power. When scientific animations present models with a high degree of visual coherence, realism, and aesthetic polish, they can facilitate engagement and comprehension while also obscuring the constructed and interpretive character of the images themselves. Viewers are rarely informed about what elements of an image are grounded in empirical data, and what instead derives from inference, or what has been introduced for narrative, metaphorical, or didactic reasons.

This problem has already been addressed from multiple perspectives within animation studies and documentary theory. A key point is that animation does not intend to replace photographic evidence, but it reorganises the conditions under which evidence is read. Animation can stage memory, hypothesis, and embodied experience while still demanding to be taken as "about the world" (Honess Roe, 2013: 7-11). In animated science outreach, this becomes not an option but a foundation, because the representations of entities "invisible" to our common sense (from subatomic particles to black holes, and even to extinct life forms) need to be understood as a reflection of real scientific research. Banner and Ostherr (2015) have noted that digital animation can create persuasive new worlds out of research, but may also claim a problematic neutrality, smoothing over the contexts and conventions behind scientific representation.

The transparency problem reflects a deeper semiotic and phenomenological mismatch between scientific objects and human-scale perception. The animated model does not merely illustrate an entity; as argued before, it acts as a perceptual substitute that satisfies the demand for visibility while concealing the scientific and artistic mediations through which the entity becomes knowable. Mitchell's notion of "image science" is relevant here, since it posits that scientific knowledge circulates through heterogeneous image forms (may them be diagrams, equations, models, metaphors, simulations) rather than through pictures alone (Mitchell, 2015: 21-29). Animation for public outreach inherits the potential and unavoidable shortcomings of all this heterogeneous image ecology and merges them into a unified audiovisual surface, masking the multifaceted

epistemological dilemmas of scientific imagery behind the phenomenological authority of a view.

José van Dijck's critique of the "realist paradigm" touches this point by noting that in much contemporary science documentary, animated reconstructions often borrow the visual rhetoric of factual television or commercial spectacle in order to render immediate presence and immersion (van Dijck, 2006; see also Campbell, 2016: 37–41). The issue is intensified by the use of photorealistic digital imagery and by immersive or interactive interfaces, which encourage audiences to feel that they are not simply watching a model but participating in a scientific reality firsthand.

Such staging of scientific animated models, inviting to approach the audiovisual experience as unquestionably true and immediate, contrasts with the philosophical frame of the scientific method. Scientific hypotheses must remain open to falsification (Popper, 2005), and scientific paradigms remain historically contingent, vulnerable to crisis and revision (Kuhn, 2012). Yet, outreach imagery is often slow to register epistemic instability; it tends instead to repeat familiar iconographies because they are communicatively efficient, culturally sedimented, and visually gratifying. Merleau-Ponty's reflections on the visible and the invisible might also be pertinent here: when science gains access to domains not naturally given to human perception, knowledge requires not only more powerful instruments but also more inventiveness about how to mediate what cannot simply be seen (Merleau-Ponty, 1968: 16). Animation answers that need, but its answer should not be mistaken for transparent access.

A telling example is provided by the visual culture of black holes, one of the most recognisable cases in which animated iconography has shaped public expectations in advance of public evidence. The gravitational well, the luminous vortex, and more recently the asymmetrical accretion ring all circulate as if they were straightforward depictions. Yet, as discussions surrounding the Event Horizon Telescope image of M87* demonstrated, even the most authoritative images of black holes are not transparent photographs but complex products of data acquisition, processing, inference, and trained judgement (Daston & Galison, 2007; Davelaar et al., 2018). This does not make them false; it makes them interpretable. Their communicative value depends on how clearly that interpretive status is conveyed.

The present special issue of Mutual Images Journal emerges from the dilemma binding together scientific objectivity and animated representation, and the need to address it through a sustained interdisciplinary dialogue. Rather than proposing a unified model or a prescriptive framework, the issue maps a field of practices and problems, highlighting recurring strategies, tensions, and politics.

2. FICTA SciO: a research framework

This issue was conceived in the context of the Global Marie Skłodowska-Curie Action FICTA SciO – Figuring the Invisible: Conventions and Tactics of Animation for Science Outreach (2023–2025), of which it represents one of the project's intellectual and dissemination outcomes. FICTA SciO was designed to address the structural problem in contemporary science communication described above: animated visualisations of invisible scientific entities circulate widely, yet they are rarely accompanied by guidance that would enable audiences to read them critically and appreciate the interpretive labour embedded in the image.

FICTA SciO addressed this issue by cataloguing animated models of invisible phenomena, analysing their visual conventions and communicative

tactics, and promoting transparency as a core value of science outreach, asking how scientific images can remain persuasive without disguising their own conditions of production.

The project's theoretical background draws on animation studies, documentary theory, visual epistemology, media archaeology, and philosophy of perception. It engages with the historical shift from "truth-to-nature" and mechanical objectivity toward "trained judgment" identified by Daston and Galison (2007), with the broader understanding of animation as a pervasive time-based form of synthetic expression (Buchan, 2013; Russett, 2004), and with the phenomenological tenet that scientific visibility always entails approximation and mediation.

3. The Figuring the Invisible conference

The core of this special issue derives from the international FICTA SciO conference "Figuring the Invisible: The Role of Animation in the Communication of Scientific Knowledge," held at the Lucerne University of Applied Sciences and Arts (HSLU) in December 2023. It was chaired by prof. Tina Ohnmacht, prof. Jürgen Haas, and the guest editor and author of this introduction.

Conceived as a meeting point for scholars, artists, animators, scientists, and educators working at the intersection of visual culture and scientific knowledge, the conference balanced theoretical reflection, practice-based research, and case studies. Its programme ranged from astrophysics to medicine, from data visualisation to school education, and from immersive environments to the politics of synthetic imagery. This plurality tried to acknowledge the shifting and transdisciplinary status of the problem, which does not strictly pertain to inaccessible scales or the abstract nature of data, but also to bodily processes, social stigma, or technologically opaque image production.

Several contributions included in this issue originated as conference papers and were subsequently expanded, revised, and peer-reviewed for publication. What unites them is a shared concern with animation's role as a mediator between scientific abstraction and human experience, and with the responsibilities that accompany this mediating function.

4. Scope and structure of the issue

This issue extends the traditional disciplinary focus of Mutual Images Journal, which has historically concentrated on visual cultures in East Asia and transnational image flows. In doing so, it situates scientific images as cultural objects. The shift is less a departure than an expansion: it acknowledges that scientific visuality, too, belongs to the domain of image culture and must be studied as such.

The seven essays collected here approach the problem of the invisible from complementary angles. Together, they show that animation is not a single solution to scientific communication, but a flexible repertoire of audiovisual techniques and rhetorics whose applications and implications draw a complex artistic and ethical landscape.

5. Overview of the contributions

The issue opens with Emma Harper, Hannes Rall, Sabrina Wong, and Gray Hodgkinson's discussion of visualizing medical knowledge through animation. Their case study (*A Choice for Life*, a gamified VR experience focused on diabetes management) makes visible a physiological and statistical problem (diet, metabolism, risk) through embodied interaction. The authors frame VR's relevance through the notions of immersion and

presence, drawing on established accounts of how virtual environments can heighten experiential engagement. Their work is situated in relation to prior diabetes-focused VR initiatives. A major focus is the detailed articulation of design tensions, facing questions such as how to simplify without trivialising; how to sustain a serious topic without alienating users; how to structure nutritional data so that it becomes actionable rather than overwhelming; and how participatory feedback reshapes representational decisions across iterations. The paper exemplifies a shift from showing scientific content as *information* to staging it as *experience*. This resonates with broader discussions on how immersive media reframes the relationship between viewer and image. It also foregrounds a core ethical issue: when an experience is designed to persuade users toward healthier choices, transparency about simplification and modelling is not optional. The case of this VR experience demonstrates how representation, affect, and agency can be engineered together.

A medical topic is also at the core of Vincenzo Maselli's essay, which addresses a different dimension of invisibility: the social one produced by stigma. Focusing on animated campaigns related to HIV and AIDS, Maselli analyses how specific graphic languages and narrative strategies are employed to make a stigmatized condition visible without reinforcing fear or prejudice. The paper follows Roberto Bernocchi's typology of social communication styles (sentimental, reassuring, dramatic, accusatory, transgressive, humorous, paternalistic, informative) originally developed to describe awareness campaigns. By applying this grid to a corpus of animated HIV/AIDS-related artefacts identified through organisational archives and bibliographic reconstructions, Maselli discusses the recurrence or rarity of certain visual styles, advancing that transgressive or overtly denouncing tones are uncommon, in favour of perceived friendliness and accessibility, to reduce defensive reactions and to foster empowerment rather than confrontation, even when the topic is structurally political. In this instance, representational "accuracy" is essentially complemented by representational care.

Laurence Arcadias, Robin Corbet, and Emma Booth's article on Astro-Animation turns to cosmological invisibility. By presenting multiple perspectives (those of a scientist, an animator, and a student) the authors show how animation mediates between astronomical data and public imagination. Three intertwined projects are discussed: an astro-animation class in collaboration with NASA astronomers; a STEAM-oriented exhibition concept designed to reach teenagers, including underrepresented communities; and an animation strategy that foregrounds scientists' hand gestures as a bridge between abstract concepts and embodied expression. By treating gesture as both cognitive extension and communicative device, the authors align with research on how hand movements support scientific reasoning and explanation, while also reactivating a long-standing topic in animation studies, pertaining to the hand as a theme and iconography, as well as the origin of indexical traces of making. The "invisible" universe is figured not only through cosmic imagery but through the visible labour of explanation itself. Their account of workshops and surveys frames "science anxiety" as a barrier to learning, and motivates the use of playful, hands-on animation activities to reduce intimidation and build curiosity. This resonates with a broader body of work on informal science learning and the role of creative practice in fostering engagement.

The theme of animation practice and epistemic mediation is further explored in Martina Fröschl's reflection on immersive scientific visualisation. Drawing on the work of the Science Visualization Lab in Vienna, Fröschl examines how animation and visual effects translate scientific data into experiential environments. The "hidden worlds" describe

an institutional practice oriented toward rendering microscopic and otherwise inaccessible phenomena tangible through high-resolution imaging data and visual metaphors. Fröschl embeds the Lab's work within longer genealogies of scientific visual culture, from early modern microscopy and its emblematic atlases to contemporary documentary and exhibition formats. The point is not to claim continuity as identity, but to show that visualisation has always combined epistemic aspiration with aesthetic choice. Fröschl also engages the question of objectivity versus subjectivity, emphasising that imaging processes inevitably involve interpretive decisions (thresholds, colour, emphasis), and that integrity depends on how these decisions are managed and communicated. So, immersive and interactive strategies (projection mapping, AR, installation) become ways to reconfigure audiences from observers into participants.

Lorenzi and Vallese offer a further insight into the artistic and conceptual choices behind the creation of scientific animation. Instead of focusing on a single scientific domain, they examine how visual languages circulate across contexts (art historical iconographies, exhibition design, scientific outreach, and immersive media) and how these languages shape what kinds of scientific "invisibility" can be made perceptible. By placing stylised animation (*Pulsars*) alongside a realistic science-fiction VR application (*Nucleosynthesis VR Experience*), the discourse develops a discussion of different rhetorical resources. Stylisation plays a key role by clarifying structure, foregrounding process, and inviting metaphorical reasoning, while realism counterbalances this by providing a feeling of plausibility and embodied scale. The authors' attention to Venetian bas-reliefs and archaeoastronomical iconographies meaningfully underscores that the visualisation of the cosmos has always been mediated by cultural form.

Another practice-based approach is examined in Rachel Landers's article on animated hybrid documentary for children, a collaborative project between scientists and creative practitioners aimed at visualizing microscopic life forms for audiences aged 10–12 . The project connects representational strategy to public engagement goals. The "tiny, invisible things" at stake, that is to say micro-organisms, are scientifically consequential yet culturally marginal because they remain unseen and unnamed in everyday experience. Landers proposes that hybrid documentary, by combining scientific imaging with animated transformation and authorial voice, can produce narratives that connect microscopic phenomena to identity, curiosity, and social imagination, making microscopic science perceptible and making scientific participation imaginable for audiences historically positioned as outsiders. Transparency and interpretive guidance remain central, but so does the question of *for whom* an image is designed and what social futures it implies.

Lawson's essay functions as a critical coda to the issue, questioning the very concept of image and its computable incarnations, that make the threshold between evidentiary recording and synthetic production no longer perceptually stable. The argument proceeds from a technical grounding in digitisation toward the epistemic crisis posed by the capacity of machine learning to generate plausible audiovisual artefacts. Lawson treats this as a political and philosophical problem of truth and potential totalitarian control, not because the technology is inherently malign, but because the contemporary speed needs of mass communication systems undermine the slower infrastructures of verification. From the standpoint of this issue, Lawson's contribution reframes "invisibility" yet again. The scientific referents of a certain image might be inaccessible, but the *operations* producing images render the final media opaque, concealing labour and provenance. In this context, the call for transparency already

advanced by some of the previous essays becomes again urgent, but also more difficult. However, Lawson does not declare that images will merely disappear. The inherent warning, instead, is that images may lose their evidentiary privilege, unless new visual literacies and practices are established. It is an implicit call for a new audiovisual education, aligned with the technology and epistemology of the contemporary digital image.

6. Perspectives and future directions

Several questions or reflections might arise from this minimal, tentative map of the negotiation between scientific accuracy, aesthetic form, and ethical responsibility.

First, more fine-grained vocabularies for distinguishing the nature and purpose of animated scientific images might be beneficial. Familiar binaries such as objective/subjective, scientific/artistic, or documentary/fiction are too blunt for the rhetorics of contemporary media. Animated science communication might need to integrate a lexicon or a jargon that sensibly addresses animated images, circumventing any lingering moral implication pertaining to the true/false dichotomy.

Then, any evaluation of animated scientific imagery is context-sensitive. The same representational strategy can be responsible in one setting and misleading in another. A stylised metaphor may be the most effective solution for school education while being inadequate in a documentary framed as authoritative evidence; a photorealistic simulation may support intuitive comprehension while also concealing uncertainty if presented without annotation or contextualisation. The decisive question is therefore not whether an image is accurate in the abstract, but accurate for what use, for which audience, and with what communicated limits.

Further study is needed on the production pipelines of scientific animation and on their epistemological and political effects. Images do not emerge fully formed from scientific data. To study them means examining not only the final artefact but also the infrastructures and decisions that authorize certain visual solutions while excluding others.

Audience literacy also emerges as a central variable. Science outreach animation can certainly foster interpretive competence, but such competence cannot be assumed in advance. It is crucial to understand how different viewers recognize, or fail to recognize, the status of a model, and how annotation, framing, or stylistic choice may support more reflective forms of reception. In this respect, the pedagogical function of science animation extends beyond explanation toward the cultivation of critical visual habits.

Finally, and expanding the previous point, an important need evidenced by the authors of this issue is to acknowledge and decode the social distribution of visibility. Invisibility is also a political condition: it encompasses stigma, marginalisation, and who is invited to receive and understand science outreach. The ethics of "figuring the invisible" therefore includes not only truthful depiction of phenomena, but also the responsibility to avoid reproducing the exclusions that keep certain bodies, experiences, and communities unseen.

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