DRAWING IT OUT: THE FORM AND FUNCTION OF ANIMATION

IN SCIENCE DOCUMENTARY FILM

by

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Animation offers many opportunities to filmmakers to deeply explore concepts and ideas in their films, sometimes with more resonance than live action footage. In science film, animation offers a particular strength in engaging audiences despite complicated and technical science subjects. This paper serves as an analysis of animation in science documentary, a survey of the history of animation in science film, an exploration of platform for these films, and a reflection on the production of my own short animated science documentary titled, “Transistors: Teeny Tech that Changed the World.”
INTRODUCTION

Communicating scientific ideas has been a part of film practice since the invention of the first motion picture camera. In the last century, film has become a crucial tool in the spreading of scientific ideas and popularizing a once mystifying subject. Many scientific concepts are beyond the realm of human vision, such as the far reaches of deep space or infinitely small quantum mechanics. Science documentaries have traditionally used animation as a tool to illustrate concepts that are impossible to record with live footage. Filmmakers who attempt to illustrate complex scientific subjects have an advantage in animation, and can use it to help their audience understand and learn. This paper will explore animation’s form and function in science film. I argue that animation offers several advantages to filmmakers in illustrating complex scientific ideas, and may even serve as a primary form of representation in science films.

I will also analyze films that I deem to be exemplary in science communication and animation, as a way to draw out best practices. Although this paper is by no means a comprehensive survey of all these types of films, it serves to show a context of animation in science film. I will conclude this historical survey with an analysis of animation in science film today, and discuss ideal platforms for these films. I will analyze some successful Internet science videos to outline why Internet distribution is an appropriate and successful vehicle for films that communicate science concepts through animation.

As a conclusion to my analysis of animation in documentary science film, I will examine my choices in creating a short animated science film titled “Transistors.” I will argue why my film’s specific subject is especially suited for animation, and discuss some
of the production of the film. As a conclusion to this discussion of my own production, I will explore the techniques I employed to create a science film specifically suited for Internet distribution.
HOW ANIMATION FUNCTIONS IN SCIENCE DOCUMENTARY FILM

Animation in science documentary functions in several ways, most often serving to further explain a complex concept or idea. To have a useful exploration of this and other functions of animation in science documentary, it is helpful to situate these types of films within the documentary genre. Theorists have debated the definition of documentary since the moment the term entered film studies. Animation, similarly, has many interpretations and definitions.

John Grierson, a Scottish filmmaker born in 1898, gave us one of the first definitions of documentary film as “the creative treatment of actuality” (13). This simple phrase still applies today, although each word in the phrase has an air of ambiguity. What is “creative” treatment? What is “actuality?” Grierson’s definition is attractive because it is equally applicable to a number of styles, from direct cinema films to highly stylized interviews and re-enactments. It also leaves plenty of room to include animated documentaries.

Contemporary film theorists like Bill Nichols and Trinh T. Minh-ha offer definitions for documentary that are even more ambiguous. Nichols argues in *Representing Reality* that “documentary as a concept or practice occupies no fixed territory” (*Representing Reality* 12). Nichols later argues, “every film is a documentary” (*Introduction to Documentary* 1). Minh-ha takes it a step further by asserting that “there is no such thing as documentary,” whether it defines a genre or a style (90). Nichols and Minh-ha both demonstrate that documentary is a term that has to be constructed much
like the films it defines. For science and informational films to fit into the documentary realm, these types of definitions are crucial.

Because this paper focuses specifically on science documentary film, I think it is necessary to offer a definition. For the purposes of this paper, science documentary films will mean documentary films that center around a scientific, mathematical, or medical subject matter, which attempt to educate the audience about that subject. It also makes sense here to acknowledge the use of the term “film” or “video” throughout this paper. For the sake of simplicity a “film” or “video” refers to an audiovisual work regardless of the physical form it takes.

Animation is also a complex term that can be difficult to define. Norman McLaren was an influential filmmaker and animator who worked with Grierson, and his work influenced animators for decades to come (Jordan, 2). McLaren described animation as “not the art of drawings that move, but rather the art of movements that are drawn” (Furniss 5). This definition, equally as broad as Grierson’s definition of documentary, lends itself to various applications. Maureen Furniss quotes Charles Solomon in Art in Motion: Animation Aesthetics, about the two key elements of animation, “the illusion of motion is created, rather than recorded,” and “the imaginary is recorded frame-by-frame” (5). Solomon’s factors are still fairly broad, and apply to traditional hand-drawn animation as well as computer-generated animation (Roe 4).

Bill Nichols first introduced his “modes” of documentary in Representing Reality to help create a language with which to study and theorize documentary (32-75). One way to define animated science documentary is to see how one might fit into these
modes. Nichols describes the “reflexive mode” as “self-conscious not only about form and style…but also about strategy, structure, conventions, expectations and effects” (Representing Reality 57). Sybil DelGaudio argues that documentary animations fit into the “reflexive mode…since animation itself acts as a form of ’metacommentary’ within a documentary” (192). She also argues that animation can portray “undocumentable” events, because a camera has not been present at an event or the event happened prior to the camera’s invention (DelGaudio 192). This is a common function of animation in science documentary film, where animation replaces an un-filmable or abstract scientific process.

Anabelle Honess Roe presents a more concrete definition of an animated documentary in her book Animated Documentary. She argues,

an audiovisual work (produced digitally, filmed, or scratched directly on celluloid) could be considered an animated documentary if it (i) has been recorded or created frame-by-frame; (ii) is about the world rather than a world wholly imagined by its creator; and (iii) has been presented as a documentary by its producers and/or received as a documentary by audiences, festivals or critics (4).

This definition makes room for these films to be included in documentary studies, and Animated Documentary is the only comprehensive analysis of animated documentary at the moment. She defends animation as a primary means in representing reality, while animation might at first seem to threaten the documentary project by destabilizing its claim to represent reality, I suggest that the opposite is the case. Animation, in part through its material differences from live-action film, shifts and broadens the limits of what and how we can show about reality by offering new or alternative ways of seeing the world (Roe 2).

Animation’s ability to show alternative ways of seeing is a key component to its success in science film. Animation can show a new way to interpret a scientific idea, or illustrate
a complicated concept in a simple way. Interestingly, Roe excludes science films from her study in *Animated Documentary*.

According to Roe, the animated documentary genre does not include “scientific” films, because they are “neither intended, nor received as documentaries” (Roe 4). However, according to Roe’s definition, films that are received and/or accepted as documentaries *are* included, so science films that are presented as documentaries *should* fit into her definition (Roe 4). As Paul Ward argues in his analysis of animation and documentary realism, “animation has long been used in informational and educational films that can clearly be included as part of the documentary category” (Ward, 82). Especially since Nichols’ and Minh-ha’s definitions of documentary are open enough to include science film, Roe’s exclusion of these films in her study must be a subjective decision on her part, and I argue that her definition and analysis still applies to science documentaries that rely heavily on animation.

Animation also has a practical purpose for filmmakers in many instances, especially for science films. In her article for the International Documentary Association, journalist Beige Adams argues,

Faced with a deficit of materials with which to reconstruct an event or illustrate the written word, the trend among documentarists has been to animate a short sequence within a feature. The impossibility of real-time filming, or the prohibitive costs…have also led directors to opt for a variety of animation techniques (“When Docs Get Graphic: Animation Meets Actuality”).

This is another common function of animation in many science documentaries, where animation serves as a last-resort to explain a complicated idea. Even if a science process or idea can be filmed, it may not be in the filmmaker’s budget or ability to get that
footage. However, instead of merely serving as a second-rate version of live footage, animation can do more than simply replace the un-recordable. Animation can be a primary tool in conveying information.

In science film, DelGaudio’s definition applies to using animation to illustrate mathematical or scientific concepts. Although a documentary could use footage of a person explaining a concept, an animation can be much more effective in engaging the audience and educating them. “Archival footage plus talking heads does not always equal historical truth,” argues Adams, and it also does not guarantee learning (“When Docs Get Graphic: Animation Meets Actuality”). In some cases, animation produces a more genuine learning experience than live action video.

An educational experiment study done in 2004 titled, “The Use of Video Demonstrations and Particulate Animation in General Chemistry,” investigated “whether video demonstrations or particulate animations helped the students’ conceptual understanding” of the material presented (Velázquez-Marcano et al. 1). What they found was that “students showed improvement after each [animated] visualization” (Velázquez-Marcano et al. 1). Although this is a scientific study in the effectiveness of animation for science education in the classroom, it applies to this discussion of science documentary film. This study offers credence that animation provides a more effective learning environment for the viewer than a talking head. Animation, here, provided a better visual learning experience than live action could.

Minh-ha’s definition negates the existence of documentary, and perhaps this is the only way to stay sane and have a productive conversation about animation and science
One definitive fact about documentaries is that they are created and constructed by filmmakers. Paul Ward applauds animation’s ability to bring this idea forward to more general audiences. Because “the viewer can be under no illusion that what they are looking at is, categorically, a construction, then this prompts them to consider the nature of that construction” (Ward 99). This makes more active and aware viewers out of everyone, and, perhaps, more attentive learners.

Animation has a clear function in science documentary, which is to illustrate complicated ideas. Most common reasons for using animation in science documentary are either because the event was impossible to film, or because the filmmaker didn’t have the funds to get the footage they need to illustrate an idea. This has been the case throughout the history of films and animations that concern scientific subjects. Through the following short historical survey, I hope to demonstrate the evolution and roots of this practice as a form of representation in science film.
There is a solid history of animation in documentary, dating back to 1918 with Windsor McKay’s *Sinking of the Lusitania* (Roe 6). Animation even pre-dates cinema, with nineteenth century optical inventions like phenakistoscopes, which were “full fledged animation devices” (Leskosky 1). Some of the earliest “films” were more like animations, like the work of Eadweard J. Muybridge, who studied the locomotion of animals and people with what we would call “stop-motion” animation today. Although Muybridge presented his photographs in *The Human Figure in Motion* as serial images on a page, if laid on top of each other and animated, they create the illusion of motion.

Since Muybridge, there have been many examples of animation to convey complex scientific ideas, and to list them all would be beyond the scope of this paper. The presence of animation as a filmic tool in explaining scientific ideas is present in several instances throughout film history. I have selected a few examples that show the potential that animation has in effective science education to establish a firm context for this practice.

“The Einstein Theory of Relativity” (1922)

An early example of animation in science documentary is a 1922 film created in Germany titled, “Die Grundlagen der Einsteinschen Relativitas-Theorie” or “The Einstein Theory of Relativity” directed by Hanns Walter Kornblum. Although the film itself no longer exists in its original form, a short version has survived, produced by American filmmakers Max and Dave Fleischer.
Science history scholar, Milena Wazeck, has written extensively about the film and how it came across to the public in the early twentieth century. In her article titled “The 1922 Einstein Film: Cinematic Innovation and Public Controversy,” she argues, “Kornblum’s film dared to present an abstract field of theoretical physics to the German public, and therefore ventured into entirely new thematic territory for educational films” (Wazeck, 167). She goes on to explain how Kornblum managed to illustrate the physical consequences that followed from Einstein’s theory of relativity, such as the behavior of a body moving at a speed approaching the speed of light, were obviously much more difficult [to visualize] (Wazeck, 167).

Kornblum resorted to animation to explain some of Einstein's concepts. For example, to explain relativity of space, an animation shows two ship captains on opposite sides of the earth "raise" their flags. However, as seen from space, one flag points up and another points down. This moment, and many others in the film represent the clear advantages of animation in illustrating complex concepts, and it was made almost one hundred years ago.

“A is for Atom” (1953)

About 30 years after “The Einstein Theory of Relativity,” Carl Urbano produced “A is for Atom” in 1953. This film is entirely animated, and presents what an atom is, how certain kinds of atoms release energy, the peacetime uses of atomic energy and the byproducts of nuclear fission. In 1953, it was impossible to film atomic processes with live action. Some aspects of this film could have been represented using live action, most notably the depictions of elements and atoms in everyday life and objects. Despite the
fact that he could have used live action for part of the film, Urbano consciously chose to make the film entirely animated. The strength of this decision is evident in the way that the main character, Mr. Atom, could “act-out” the concepts he was describing because he was an atom.

Also, the fact that this film was fully animated allowed the film to have a continuity of visual style to it that could allow for more complex and engaging content. Animation also allowed the potentially upsetting subject matter of atomic bombs to be easier to consume for some viewers.

“Powers of Ten” (1977)

Fast-forward another twenty or so years, and we get “Powers of Ten.” This 1977 film has a simple goal. Charles Eames and Ray Eames used animation to represent how powers of ten affect a square meter. The film documents the size differences between squares of one meter, and goes up by powers of ten, to the reaches of human understanding. The film is completely reliant on the animation that makes up the entirety of the visuals.

“Powers of Ten” is a prime example of just how powerful animation can be in conveying ideas. Seeing the world scale down and the stars begin to move past make the unfathomable numbers that the narrator describes have much more meaning. And, as the film goes towards the ends of the known universe, and conversely goes down to subatomic particles, the animation becomes quite a bit more abstract. Those extreme phenomena were obviously impossible to film with actual cameras, so animation makes
sense for those elements. However, having the rest of the film animated allowed the filmmakers to create a visual rhythm and structure to the piece that adds continuity to the whole viewing experience. The visual style of the film is instrumental in conveying its main concept, and animation provides the perfect tool to achieve that.

“The Story of Pi” (1989)

In 1989, Tom Apostol from the California Institute of Technology made a series titled *Project MATHEMATICS!* Apostol explains on the project’s website that the series of videos explores “basic topics in high school mathematics in ways that cannot be done at the chalkboard or in a textbook” (“Project Description”). Apostol claims that his choice to use animation “shows mathematics to be understandable, exciting, and eminently worthwhile” (“Project Description”).

One of the videos in the series entitled “The Story of Pi” stands out as an extraordinary example of animation as a tool for learning mathematics. In the film, animation illustrates the “method used by Archimedes” to estimate pi by “comparing the circumference of a circle with the perimeters of inscribed and circumscribed polygons” (Apostol “The Story of Pi”). The animation depicts a circle that segments into wedges. The wedges then assemble themselves into a rectangle, and as the wedges get infinitely small, the rectangle becomes clearer. This animation, paired with narration, explains how one uses pi to calculate the area of a circle. Instead of just telling the viewer how to use pi to make these calculations, Apostol *shows* this phenomenon in a visual proof through animation.
One of the most important elements of this collection of films is their ability to convey unfathomable concepts in simple and clean ways. In the examples from this short survey, animation serves as a filter of information, whether it’s the theory of relativity, atomic processes, or mathematical concepts. This historical survey shows the clear foundation that animation has as a tool in science documentaries.

This brief survey of films shows that animation has always been an effective from with which to convey complex information. Today, fully animated science films are more prevalent and have more recognition. This is in part thanks to the Internet as a platform for more specialized content.
Many science films use animation as one visual element among others, and some of my examples from history fall under this category. In my analysis of animation in science documentary today, I have decided to focus on films that are entirely animated. The following examples are by no means comprehensive, but offer a look into what is quickly becoming a sub-genre of science documentary. These examples and their success show how well this method is received by audiences today.

TED-Ed

TED-Ed is a pioneer in pursuing the combination of animation and educational content on the Internet. TED-Ed is a free educational website for teachers and learners, under its parent company TED.com, which hosts “talks” about various subjects. As described on the TED-Ed “About” page, their mission is to produce “carefully curated educational videos, many of which represent collaborations between talented educators and animators.” TED-Ed’s commitment to collaboration between animators and educators has produced hundreds of videos and they collectively have over a million subscribers on YouTube (TED-Ed YouTube Channel).

These short videos use animation not only to explain complicated topics, but also to celebrate a visual style that animation brings to the viewing experience. Their films often center around one central question, so despite their short length, they can delve fairly deep into their subjects. One such film titled, “The Chemistry of Cookies” takes a very simplified visual style, and uses it to break down the complexity of food science into
a short four and a half minutes. “The Chemistry of Cookies” has no music or sound effects, as with many other TED-Ed films. These films—or “lessons” as TED-Ed refers to them—are geared more towards an education experience rather than an entertainment experience (“About”). However, the animation brings alive the narration so much that it becomes a learning and entertainment experience.

AsapSCIENCE

The YouTube Channel entitled AsapSCIENCE also shows the growing popularity of animated science content. This group of videos produced by Mitchell Moffit and Gregory Brown, consistently have millions of views. Moffit and Brown use a very simple method of animation using a white board, and include the occasional prop or object that they animate with stop-motion. Each video deals with answering a science question from their pool of viewers, which allows each film to deal with a very specific subject. By crowd-sourcing their video topics, they engage with their audience and create content based on audience demand.

Kurz Gesagt – In a Nutshell

Another channel titled Kurz Gesagt - In a Nutshell packs a lot of technical information into a relatively short time in their videos. A lot of this has to do with their choice to fully animate their films. Their clean visual style simplifies their very complicated scientific subjects.
One of their animation techniques is to use visual comparisons and metaphor, such as in “Atoms as Big as Mountains,” where they explain what a neutron star is, and how it forms. In one sequence of the animation, they use their visual metaphor technique to compare the size of a neutron star to the size of Manhattan. The animation allows them to take a rather abstract concept and distill it into a simple visual comparison.

One common thread between the TED-Ed programs, AsapSCIENCE, and Kurz Gesagt is their platform. These films have had success because of their distribution on the Internet. What is it about the Internet that lends itself particularly well to science films, especially animated ones? The Internet has changed the way that people consume media, especially films, and science films directly benefit from this change, as I discuss below.

The Internet as an Ideal Platform for Animated Science Films

Many early theorists of film dreamed of what ways viewers could consume this new art form. “Since early in cinema history, ‘going to the movies’ has been an important and symbolic social act,” argues Kevin J. Corbett in his article titled “The Big Picture: Theatrical Moviegoing, Digital Television, and beyond the Substitution Effect” (19). In the age of Television, programs were only available during a specific day and time and people had to schedule their lives accordingly.

Although the Internet’s creation dates back as far as the mid twentieth century, the Internet really began to gain public popularity around the mid 1990’s. In 2005, the emergence of YouTube and other video streaming platforms soon after allowed anyone with an Internet connection to access video media. The recent emergence of mobile
devices and even more video streaming platforms has dramatically changed the landscape for video content consumption.

The Internet has become a diverse and hugely important platform for films, especially educational ones, and it is fast becoming an ideal platform for science programming. The reason for this is because of the concept of Web 2.0, a term given by theorists to describe a second generation of the World Wide Web that is focused on its ability to provide a space for people to collaborate and share information.

Tim O’Reilly, the founder and CEO of O’Reilly Media Inc, coined the concept of Web 2.0 in a conference with MediaLive International. O’Reilly argues in his article “What is Web 2.0,” that “there is an implicit ‘architecture of participation,’ a built-in ethic of cooperation, in which the service acts primarily as an intelligent broker, connecting the edges to each other and harnessing the power of the users themselves (2005).” Mary Samouelian, argues in her article “Embracing Web 2.0: Archives and the Newest Generation of Web Applications,” that Web 2.0 embraces collective intelligence and participation, and affords previously passive recipients of content the opportunity to engage with, combine, share, and ‘mash up’ information in new and imaginative ways. IBlog, wiki, podcasting, RSS (Really Simple Syndication) feed and collaborative tagging are all web 2.0 terms that are becoming more familiar to both online users and mainstream society. Social networking sites such as YouTube, Flickr, and Facebook allow users to contribute—not just view—content (43).

This phenomenon has expanded so much in the decade since Web 2.0 was first discussed in 2005, and it shows no signs of slowing down just yet. But what does the collaborative, participatory space that is Web 2.0 mean for science film?
AsapSCIENCE uses the power of Web 2.0 in their YouTube Channel, where they collect ideas for their videos from their online audience, a process known as “crowd sourcing.” If enough people show interest in a particular science question, the creators will make a video based on that. One of their most popular videos, “Which Came First - The Chicken or the Egg?” has over 16 million views. Overall, their channel reports over 3 million subscribers, and collectively their videos have over 350 million views (AsapSCIENCE YouTube Channel). Clearly, this shows how engaging and popular their method is in illustrating science.

Moffit and Brown’s harnessing of Web 2.0 by crowd sourcing video content engages their audience in an interactive way, which further adds to the effectiveness of their style. And the fact that they source their content from the viewers themselves offer the viewers a sense of agency in the process, which facilitates more of a productive discussion about the science content of the films. Web 2.0 opens up opportunities for dialogue between the filmmaker and the viewer, to a much greater extent than any other video platform.

Web 2.0 allows many outlets for discussion and debate on video content, in the comments below the video on most hosting sites, and through social media like Facebook. Kate Nash discusses Web 2.0 in the context of documentary film in “Clicking on the World: Documentary Representation and Interactivity.” Nash argues,

interactivity is often identified as the characteristic that distinguishes emerging forms of documentary from film and television, changing not only modes of engagement, but the form of the text itself (50).
The Internet certainly offers an interactive space that especially applies to films with science content, where viewers can either contribute science questions as with *AsapSCIENCE*, or respond to the content in discussion online, which can promote participatory learning.

Viewing content in a movie theater, which was once the only way to consume a film, is an immersive experience. Movie theaters are still huge providers of content, but when one is in a movie theater, it is rude to use a mobile device to gather more information about a film’s subject. With television, originally viewers could not pause or rewind the content. With DVRs, viewers can now pause and re-watch parts of a science program if they wish, but they must turn to another source if they want more information about the subject. The Internet platform is less formal than a movie theater and even less formal than television, and therefore can make complicated science topics seem more approachable to a viewer.

When a film is presented on the Internet, a viewer can also pause or re-watch a video to allow herself more time to digest an element or complex idea. However, unlike with a DVR, on the Internet a viewer can also look up a definition, find out more information, and start her own user-directed learning alongside the film on that same platform. Hosting sites like YouTube offer a space to add more interactivity through hyperlinks that pop up at certain times throughout a video to encourage a viewer to explore more or review a source.

With Web 2.0, Internet films also allow the viewer to join conversations about the film with others who are interested in its subject matter. She can continue to enrich her
experience of the film over time with these interactions. The last act of the traditional three-act structure of film can now happen after the film is over, when the viewer goes out to discover more about that subject.

Museums as a Venue for Animated Science Films

Although the Internet has distinct advantages for presenting this form, there is another venue that serves as a good platform for animated science films. This venue is the museum exhibit; where the film can function as an introduction to a topic for museum-goers who can then go on to direct their own learning through the exhibit. This has applications in various science museums, zoos, aquariums, and planetariums. Much like how a viewer can look up information on the Internet after viewing an online film, museum-goers can take the content they learned from a film and apply it to other parts of the exhibit. This offers the filmmaker possibilities where the film can refer to specific areas of the exhibit and encourage a viewer to then seek out those elements.

One example of this is with “Survival of the Sexiest” a group of animated films produced by Baker and Hill for the National Geographic Museum. The Museum featured this group of films throughout the Birds of Paradise exhibit in 2013. Each film is about 2 minutes long, fully animated, and quite humorous. The films discuss sexual selection and why birds of paradise look the way they do. The end of “Survival of the Sexiest Part 1” teases, “but have you ever wondered how it [sexual selection] works? Well, visit part two later in the exhibit to find out!” This sort of cliff-hanger at the end of each video encourages the viewer to seek out the next installment, and continue their learning.
Animated science films, although more common in recent years, offer a unique perspective on the science they present. These films thrive on the Internet, where they can address a specific audience who can supply the film content, as with AsapSCIENCE. The internet also allows films to contain lots of information packed into a short amount of time, because viewers can easily pause, re-watch, and augment their learning experience as needed. Museums also offer a similar venue for these types of films, where they can be presented within a context to encourage user-directed learning in an exhibit space. However, the Internet offers more opportunity to reach a larger audience who might not actively seek out content as museum-goers do.

Animated science films have a lot of potential to thrive as deliverers of complex and heavily scientific information in clean, digestible ways. As I embarked on my journey to create one of these films myself, I used the advantages of animation to explore a complex and technical science subject. I also used several techniques for specifically tailoring my film for presentation on the web.
PRODUCING A SHORT ANIMATED SCIENCE DOCUMENTARY FILM

I chose animation as the only visual form for my short film, “Transistors: Teeny Tech that Changed the World.” This decision is in part from my admiration of successful animated educational science films that I discussed earlier in this paper. This decision also stemmed directly from the particular subject of my film, the history and science of transistors.

_Animation as form in “Transistors” (2015)_

“Transistors” is a film about the unfathomably small components that make up our modern electronics. Although the first transistors were visible to the human eye, they are millions of times smaller today. Although it is physically possible to create live action footage of transistors, I chose to fully animate this film to allow me to access more creative ways of visualization. Although Sybil DelGaudio claims that animation can be used where live action is impossible, here I am making a conscious choice to use animation despite the ability to use live action.

As with “Powers of Ten,” there are elements of my film that I could easily do with live action, such as interviewing a physicist about how transistors work. However, I would still have needed to use some form of animation at some point. Transistors today are so small that they can only be seen with high-powered microscopes, so any live action that I would be able to get would be so abstract that it may have appeared to be animated anyway.
Animation does not take away from my film’s ability to convey facts and truth about my subject. A live action sequence in a documentary could be stylized and staged as a reenactment, as with Errol Morris’ *The Thin Blue Line*. Or, live action can bring an unrealistic sense of objectivity as in Frederick Wiseman’s *Primate*. It makes no sense to associate live action with truth and animation with fiction when put in the context of documentary practice, since all films are in some sense constructed, there is no method that holds more truth than another.

By making my film entirely animated, I was able to rely on a unity of style that was advantageous when illustrating complex concepts. A unified visual style to my film also helped to make it more cohesive as a short piece. By not switching between animation and live action, my audience has more time and energy focused on the content. I also must acknowledge here that creating the imagery for this film allowed me to explore the subject in an intimate way that I don’t know if I would have, otherwise. Actually drawing the scientific processes allowed me to understand them better and informed my writing of the narration.

Animation allowed me the freedom to create visual metaphors to underline complex science concepts. For example, in “Transistors,” I illustrate blowing up a transistor to the size of an apple, and how relatively a Smartphone would then be the size of the Earth. Taking a tip from the many animated science programs I outlined in this paper, I used metaphor to help the viewer fathom the unfathomable smallness of transistors mentioned in the narration.
“Transistors” is a film that I designed to be viewed on the Internet. Because of this, I have added various elements that take advantage of the platform. These elements help to take advantage of the interactive space of the Internet, and encourage the viewer to further their learning after they finish watching the film.

The first element that makes “Transistors” suited for online distribution is its length. At 8 minutes, this film does not ask a viewer to dedicate a long time to consume this content. The short length also makes the potentially technical and confusing subject of transistors into a digestible, manageable amount. Because of its short length, the film also addresses a very specific subject.

Specificity in subject is the second major factor that suits this film for Internet consumption. The success of TED-Ed, AsapSCIENCE, and Kurz Gesagt all point to the fact that science content no longer has to rely on feeling universally applicable to a general audience. By picking a very specific subject and packing that subject into a short film forces the filmmaker to deliver that information in a succinct manner. Specificity also allows the filmmaker to delve into a subject quickly and really explore it in a short amount of time. I applied this strategy with “Transistors,” and despite the fact that transistors involve complicated chemistry and physics concepts, I was able to distill that information into a digestible amount and deliver it in a short timeframe.

There are also several elements of “Transistors” that directly encourage the viewer to continue learning after watching the film. One of these elements is in the labels that pop up in the animation. At the beginning of the film, the two figures in the lab are
identified by labels as “John Bardeen” and “Walter Brattain.” The labels are only up for a few seconds, and then disappear. The narration does not further explain who these men were, but a viewer could pause the video and then look up those names and learn some of the fascinating drama that unfolded around these two men and the invention of the transistor. However, the viewer is not required to do this extra step in order to understand the film.

Another instance where “Transistors” encourages viewers to find out more is at the end of the film when the narrator mentions “quantum tunneling.” This piece of information is delivered as an almost offhand remark, and if the film had elaborated on it then it would have gotten very complicated very quickly. However, the offhand delivery of this fact encourages the viewer to then go on and find out more about quantum tunneling if they wish. With their already gained knowledge from the film, their user-directed learning about quantum tunneling would have context.

Much of my decision-making about the design of “Transistors” came from my intention for audiences to access the film on the Internet. Through its length, specificity in subject matter and use of animation, the film creates a space that encourages a viewer to continue their learning after the film is over. As a film designed to educate, to have a viewer then go on to find out more promotes user-directed learning and ultimately exposes the viewer to complicated science subject matter that they may not have otherwise sought out.
CONCLUSION

Animation offers many opportunities to filmmakers to deeply explore concepts and ideas in their films, sometimes with more resonance than live action footage. In science film, animation offers a particular strength in engaging audiences despite complicated and technical science subjects. Through my analysis of animated science documentary and survey of animation in science film throughout history and today, it becomes clear that animation is an extremely powerful part the filmmaking toolkit. Producing my own animated science documentary both affirmed and reinforced this idea, and I will likely revisit this technique in my future work.

Although animation isn’t a new technique in science film, the last decade has seen a huge increase in the animated science documentary. Although these films can be presented in a museum setting as well, the Internet provides an ideal outlet for these films. Due to the success of recent animated science films on the Internet, we will likely continue to see more of them in years to come.
REFERENCES CITED


