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CREATIVE STRATEGIES FOR SCIENTIFIC TV DOCUMENTARIES

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Abstract: *Documentary producers and filmmakers attempting to communicate science on television must overcome two barriers: first, the structural differences between the standards of scientific communication and those of audiovisual storytelling; and second, the fact that the scientific process is, simply put, quite hard to capture on film. In this article we analyze these barriers and describe successful strategies that practitioners have used over the years to overcome them.*

Keywords: *Science on television, documentary films, popularization, science communication, film techniques*

Resum: *Els cineastes i els productors de documentals que tracten de comunicar ciència a la televisió han de superar dues barreres: en primer lloc, les diferències estructurals entre els convenis de la comunicació científica i els de la narració audiovisual; i, en segon lloc, el fet que el procés científic és, simplement, molt difícil de capturar a la pantalla. En aquest article analitzem les barreres esmentades i descrivim les estratègies que els professionals han utilitzat al llarg dels anys per superar-les amb èxit.*

Paraules clau: *ciència a la televisió, documentals, divulgació, comunicació científica, tècniques cinematogràfiques*

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Three Logics of Communication

The basic source of information for any producer making a film on a scientific topic is, ultimately, a number of papers relating to the matter at hand.[2] Often the initial idea comes from a book or an article in a newspaper or a magazine, which will already have predigested some of these papers. But a good producer will read at least the most relevant papers related to the topic of the film.

The first hurdle that the producer needs to overcome derives from the fact that scientific papers are structured and written in a way (following a *logic*) that is as distant as it can possibly be from the logic of the medium for which the film is intended – that is, the logic of TV documentaries. Let's see what the main differences are. Scientific papers

- *a*) are written reports of several thousand words.
- *b*) target professional scientists.
- *c*) are written in an aseptic language, precise and emotionless.
- *d*) use a lot of data, acronyms and equations (high information density).
- *e*) use graphics as proof of the assertion(s) being made (statistics, microphotography). The graphics mostly convey raw or primary data.
- *f*) carry information allowing the replication of the experiments by other scientists wishing to confirm or to refute the author's findings.

The structure of a scientific paper is highly codified. It consists of a variation of a basic linear scheme that includes title, list of authors, authors' affiliations, abstract, precedents, processes and results, citations and methods. This standard has been refined over decades of scientific publishing and is actually compulsory if one wishes to see results or hypothesis published[3]. As a consequence, the universe of scientific journals is quite homogene-

2. A note on terminology: for the purposes of this article, the expressions "TV documentary", "documentary" and "film" mean an audiovisual work which

- a) is created with the main purpose of being shown on a television channel, either generalist (such as the BBC or PBS) or specialized (such as Discovery or National Geographic). This does not preclude other ways of dissemination (Internet, DVD, VOD…).
- b) runs usually between 30 to 60 minutes.
- c) is a stand-alone narrative, either as a one-off or as part of a series; as opposed to a news item or a magazine segment, which are part of a larger entity.
- d) aims for a long shelf life – in other words, is not directly influenced by the current events or news agenda, which might render its content obsolete in a matter of days or weeks.

The person(s) ultimately responsible for the creative task of making a scientific documentary are be referred to as "producer", "filmmaker" or "author", without distinction.

3. Anyone deviating from the standard will not be "heard" by the scientific community. This is one of the issues addressed in *The Man who unfolded a thousand hearts* (Dani Resines, 2007). This documentary tells the story of Paco Torrent Guasp, a

ous – very unlike the universe of television programming, in which TV documentaries exist.

Indeed, television offers a quite diverse and heterogeneous palette of programming, ranging from hard information (such as newscasts), to pure entertainment (such as music videos) including fiction, advertising, live events (sports) and many others. In this article we will argue that any programming offered on television can be located in a quadrangular, virtual "space" whose corners are occupied by 4 main "genres": news, fiction, entertainment and advertising (figure 1).

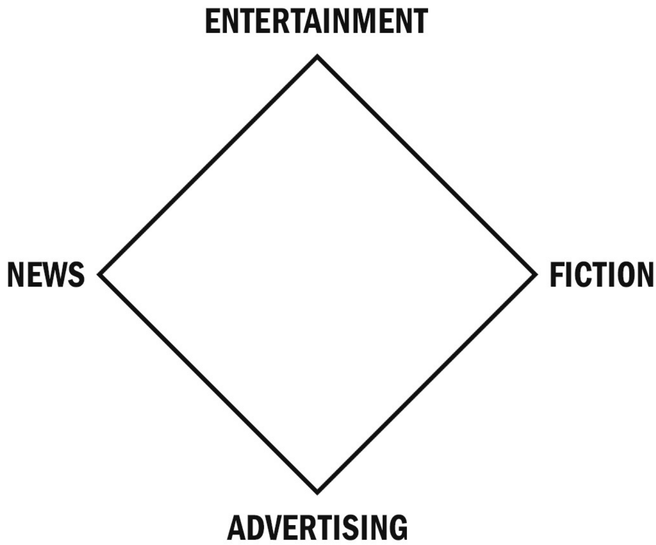

Figure 1.

Documentaries tend to sit in the News/Fiction axis[4] which has, in one end, the daily newscasts and the 24 hours news channels and, on the other end, series such as *Downton Abbey*, *Homeland* or *The big bang theory*, to name but a few current ones (figure 2). Current affairs shows – such as *Informe Semanal* (TVE), *Panorama* (BBC) or *60 Minutes* (CBS) – are a step removed from the News end, while films based on a true story (*The Monuments Men*, *The Wolf of Wall Street*, *Philomena* to mention but a few recent ones) are not pure fiction,

Spanish family doctor who in the 1980s solved the centuries old mystery of the heart's true anatomy, but whom nobody believed because he did not communicate his findings in the prescribed way. <http://vimeo.com/32674446>.

4. For the sake of clarity I am oversimplifying the issue – there is a degree of entertainment value in news and documentaries; and sometimes advertising (or propaganda) as well.

although they sit quite close to it. Documentaries occupy a fuzzy area in the center of the axis, because they juggle two logics: the logic of news and the logic of storytelling.

Figure 2.

Printed news

a) are written reports of several thousand words, although usually shorter than scientific papers
b) are targeted at the general public
c) are written in common language
d) use data and acronyms but no equations the information density is lower than in scientific papers
e) use graphics as illustrations of the concepts being discussed. The graphics are usually elaborate simplifications of the processes described in the scientific papers.

This is also mostly true for TV news, because often the weight of the information is carried by the reporter's narration, while the image track is just an illustration, generic or specific, of what's being reported.[5]

The "canonic" logic of news is, in essence, to pack as much information (facts) as possible in the given space or time. It uses the rule of the 5 Ws (an information, to be complete, must provide the answers to these questions: Who, What, When, Where, Why –some authors add "How") and follows the structure of the inverted pyramid (figure 3): the most relevant information always goes at the beginning of the news item and details are added further down, so the reader can leave the story at any point and will still have gotten the gist of it.[6]

5. Watch a newscast with the sound off: you will "get" the general topic being dealt with (the war in Syria, a meeting of the EU heads of State, the stock market) but you will not get the details (how many casualties, what is the outcome of the meeting, a new regulation is planned) because those are carried by the voiceover – or by captions, therefore in "print".

6. In the era of Internet and social media, printed news (the actual newspaper) has changed a lot and provides more analysis and context. But the basic tenet of journalism is still to offer new, timely information to the reader/viewer/customer.

Figure 3. The inverted pyramid

Although scientific documentaries are not news items, they share some of their logic, in the sense that docs, too, *must carry facts*. However, they need to sustain the attention of the viewer for a longer period of time – docs last 30 to 60 minutes, while a news item runs usually between a minute and a half and three minutes. And there's a reason for the brevity of news items on TV: the medium is very ill-suited to convey facts, because the mere piling up of fact after fact quickly saturates the viewer who, simply, disconnects.

So, how can producers convey the information and still keep the audience until the end of the show? By using the tools of storytelling. The problem is that the logic of storytelling is completely different from that of science papers or news reporting. It is the logic of *fiction*, be it a Greek tragedy, a Shakespearean comedy or the latest blockbuster action film. In spite of all their differences, they share an underlying structure that can be summarized as follows (figure 4): There is a world at peace, in equilibrium, where people go happily about their lives. Suddenly, something happens (*the inciting incident*) that breaks the balance and creates a tension, a conflict. The Protagonist (*the hero*) tries to solve the problem and fights the Antagonist (*the bad guy*). But things, instead of easing out, become more and more complicated and the dramatic tension rises until there is a final showdown between Protagonist and Antagonist (*the climax*) in which – usually – the hero wins over the bad guy. After that, the tension releases and equilibrium is restored. But something else has happened: the hero has changed along the way; (s)he has *evolved* as a character.

In other words, storytelling is about *emotional journeys unfolding over time*. As humans, we are brain wired to appreciate this sort of narrative, which provides an emotional rollercoaster from the comfort (and safety) of the living room, the cinema or your parent's lap. That's why children like to be told (or to watch) the same story again and again – they want to feel those emotions over and over.

Not only is the structure of storytelling quite different from that of scientific papers or news reports: its building blocks are of a totally different nature. Where papers and news are based on facts, stories are built from actions that their characters undertake (in the

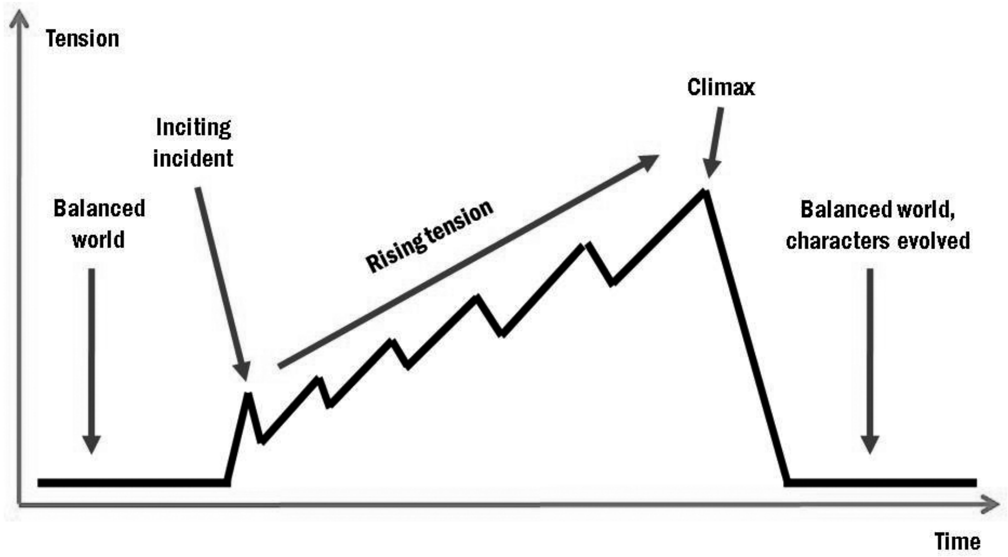

Figure 4. The classic structure of stories

Hollywood credo, a character reveals his personality through his actions, not through his words).

Film (and TV) is a very good medium for storytelling, because it is very well suited to convey emotions through the actions and words of the characters on the screen. Therefore, any science documentary producer finds his or herself in a bind: the nature of the message to convey is about facts (and abstract ideas) which work very poorly on the medium – which works best with actions and emotions. To make things worse, the scientific process is opaque to the camera.

Why science is hard to film

Documentary films are built with a combination of elements:

- Original shooting (actuality, interviews, reenactments)
- Archival footage and still images
- Scientific imagery produced by scientific instruments – telescope, microscope…
- Graphics and animations
- Narration
- Music
- Sound effects

In cinematic terms, the most powerful of these elements is, by far, actuality (the events happening in front of the camera as it is filming) –as long as what's happening in front of the camera involves the interaction of one or more characters between themselves or with the environment.[7]

Without any narration or interview, just with actuality (and editing) you have surely got most of what was going on in the scene. A group of people are in the desert, where a car has broken down (*the wheels don't turn, the doors don't close!*). It is a diverse group, they speak English and other languages. The owners of the car are three youngsters we see on camera and a fourth one behind it, who is filming. They do not know much about car mechanics and they just cannot believe their old Citroën can be repaired *then and there*. The others in the group, though, who clearly know about cars, are totally convinced it is feasible – and set out to actually do it. The method they use is most unconventional, but they succeed in repairing the car while the youngsters look on flabbergasted. One of the members of the group, whose face is covered by a scarf, acts as a sort of leader. We do not see his face at all, but we" get" his personality: he has a very British sense of humor and an unshakable faith in the power of a cup of tea.

The only things that you do not get from that sequence are factual details: Who are they, where are they and why? They are somewhere in the Sahara desert; they take part in the Plymouth-Banjul Challenge, a sort of anti-rally in which participants drive old cars from the UK to Gambia, where they are auctioned for charity; the youngsters are Catalan, and the rest of the group is a mix of Brits and Americans. These factual details, though, are pretty irrelevant for our understanding and enjoyment of the excerpt – which, by the way, follows closely the pattern of storytelling structure we have seen in figure 4. There is an incident (the car broke down); there is a protagonist (the guy with the scarf) and an antagonist (the lack of resources); there are unforeseen complications (the battery leaks and they have to start over again) and a climax (the car runs again); and the characters are transformed (the youngsters, who are secondary protagonists, learn that with determination, good humor and a cup of tea, no problem is insurmountable).

This sequence is very rich in action and interaction, but actuality works also in subtler circumstances. Take, for instance, one of many YouTube videos where we see a young kid, deaf, who hears for the first time thanks to a cochlear implant[8]. The expression on his face says it all – here, as the saying goes, an image is worth a thousand words.

These two examples show that the filming of actuality is very well suited to capture processes, interactions evolving over time. So it should also work to capture the scientific process –but it actually does not, due to the specific characteristics of the way science is carried out nowadays. In essence, the work of a scientist consists of

7. <http://vimeo.com/106685779> *This is not the Dakar*, by Pepe Rodríguez and Sheila Aguado (2007), produced by Media 3.14.

8. <https://www.youtube.com/watch?v=-GA9gEh1fLs>

a) Observing the world and finding an interesting set of data
b) Thinking about that data set
c) Coming up with a hypothesis
d) Devising and carrying out experiments to test the hypothesis
e) Thinking about the results of the test, coming to conclusions
f) Publishing the conclusions

The first step already poses a problem because *the tools that scientists use to observe the world are mostly opaque to the viewer*, be it a layperson or another scientist. Step into any lab and you will be surrounded by computers and by machines and devices which operate on the black box principle: something goes on inside them that we cannot see directly; the display is usually mediated by yet another computer, where results will appear as numbers or abstract graphics meaningful only to the initiated. If it is a biology lab, there will be microscopes, Petri dishes, shakers, centrifuges, maybe containers with liquid nitrogen, you name it. The people in the lab will be busy using all these tools and of course it is possible to film them, but that actuality will reveal practically nothing about what they are doing because the level of visual interaction is very low and the camera cannot see directly the effects of what the scientist is doing.[9] The visual appeal of molecular gastronomy – where cooking and science meet – is precisely that we can see what is happening to the food as it is being processed. If Ferran Adrià's miracles happened inside a closed pressure cooker, the discipline he founded would have a much lesser appeal to the general public, even if the results were the same.

The opacity problem not only appears when observing the world but also when carrying out the experiments[10], and for the same reasons. It is important to note here that the fact that an experiment is "legible" does not mean it becomes immediately meaningful to the lay observer. Science museums all around the world offer experiments and installations to their public which convey or illustrate basic scientific facts (maybe the most classic is Foucault's pendulum "showing" the rotation of the earth) but they must provide the relevant explanations as well for the public to take the lesson home.

Every generalization has its exceptions, and there are indeed branches of science which provide "good", meaningful actuality because they are not opaque to the camera. In general, sciences which focus on the behavior of humans or animals suffer a lesser degree of opacity, precisely because they observe interactions between the subjects and the environment. In

9. That is why TV shows that offer science as entertainment always select flashy experiments whose results are very visible and spectacular, be it explosions, billowing clouds of smoke or sudden changes in shape or structure of the materials.

10. This was not always the case. Until the nineteenth century, experiments were quite directly "legible" because scientists were still working, so to speak, at a macroscopic level. Only when they started working at the microscopic and atomic level did the tools become opaque to the outside observer.

the 1970s Michael Kirk-Smith and David Booth, researchers at the University of Birmingham, sprayed a male pheromone onto a chair in a dentist's office and then observed the reactions of men and women who were asked to enter the room. Women tended to sit on or close to the chair, while men sat at a distance away from it – and none sat on the chair itself. The visual recording of the experiment is perfectly legible and, once the viewer is told what's going on, can be even entertaining, as it is possible to turn the experiment into a guessing game: in which chair will the subject sit?[11]

However, most science today is opaque and, thus, filming scientists while observing nature or carrying out an experiment usually lends not very "good" actuality. What about that other very important part of their work – thinking? Here, the camera is largely useless: film does not capture the *thoughts* of a subject, only their facial expressions and body language. The act of (purposefully) thinking has been associated with stillness, as in Rodin's famous sculpture *The Thinker.* Indeed, there are scientists who like to sit in nearly absolute isolation when pondering a problem but there are also many others who go for walks or do any other sort of activity while their mind is working in "background" mode. But if we were to film them at those moments, the camera would just capture the image of a person walking, or gardening, or playing the piano, or riding a bike… We would still not *see* their thoughts.

At this point a reader might say: "The camera does not capture thoughts, but it certainly captures words. Another part of a scientist's work is discussing findings and results with colleagues while trying to find the explanation to the results, or while devising the experiments. That is a conversation between persons, and should work as actuality". Indeed, a conversation can have a lot of interaction and can be very engaging, thus providing good actuality… if the language is accessible to the viewer. And most often, when scientists are discussing a scientific topic because they are trying to reach some sort of conclusion (that is, when the conversation is relevant to them, as opposed to when they are playing for the camera and "explaining" the issue) they'll use a highly specialized language, full of specific terms, which can only be understood by a viewer trained in the same domain. A layperson is very likely going to be shut off from the conversation for lack of the required knowledge.

This happened in *The Dali Dimension*[12] (Susi Marquès, Eli Pons, Joan Úbeda, 2004), a film I produced which retraces the huge influence that science had in the life and work of Salvador Dalí – for him it was a source of inspiration and visual motifs which can be found up until his very last painting. The film's narrative structure is based on footage from a three-day seminar which took place in Dalí's museum in Figueres in 1985, where top-ranking

11. The film *La biochimie du coup de foudre* (Thierry Nolin, 1997, produced by Arte and Morgana Films), includes a visual record of the experiment, although it is not clear whether it's the actual experiment by Kirk-Smith and Booth or a reenactment of it.

12. <http://dalidimension.com/eng/synopsis.htm>

scientists met to discuss the role of chance in nature. It was a high-end physics debate which the painter, already very ill, followed via closed-circuit TV from a room in the building. Dalí was an avid reader of scientific literature and witnesses had told us that for him, listening to researchers was akin to enjoying music. Our initial intention was to include in the film a few segments of the actual talks and debates and we had a researcher listen to the full 18-hour recording of the proceedings to locate suitable excerpts. There was not a single passage that a common viewer would have understood –those were researchers addressing their peers and therefore not making any attempt to simplify the issues being discussed.[13] (We resorted to using music instead of the scientist's words). The only moment we could include was a confrontation between Ilya Prigogine (Nobel Prize in Chemistry in 1977) and René Thom (mathematician, winner of the Fields Medal in 1958) who clashed over their views on thermodynamics. For a few moments, they addressed each other in words (and body language) that anyone could understand – and that exchange gave rise to an anecdote that was evoked by some of the participants.

We have just seen three main reasons that make science hard to film as a process (in other words, that make science a poor provider of actuality[14]): the opacity of the tools, the fact that no camera can see the thoughts of a subject, and the barrier created by specialized scientific language. There is yet another reason, which has do to with time. As it happens, most scientific work takes a lot of time; planning, preparing, executing and validating an experiment is a long process.[15] In addition, nobody knows beforehand if the results will be successful or a failure, if at the end there will be a breakthrough or a disappointment.

These four reasons combined explain why the scientific process does not lend itself to be told on TV in the present time, in "making of" mode – as opposed to, say, the process that an athlete undergoes in preparing for a competition. The viewer can *see* the effect produced by repetitive training or by the introduction of a new technique or piece of equipment: the performance gets better and better, increasing the chances for the athlete to win the competition; which is to say, increasing the suspense for the viewer: will (s)he succeed? The same is valid for the creation of a theater play or choreography from first reading to opening night: we can witness the director's vision gradually taking shape through the movement, gestures and words of the performers. On the contrary, science on TV consists usually of the presentation of known facts (the laws of physics, a new view of the molecular mechanism of cancer), which were discovered as a result of a research process already completed –

13. The problem of language as a barrier is not exclusive of scientists, though: think of a conversation between car mechanics, computer experts or wine tasters – the same situation arises and the lingo of the trade leaves out the lay person.

14. Contrary to engineering and, by extension, technology, which consist in building something out of parts. That's a very visible process, be it building the world's tallest skyscraper or the smallest electronic device.

15. Fiction series with a scientific touch, such as *CSI*, have been criticized precisely for the liberties they take with the time involved in carrying out tasks such as DNA sequencing or other complex tests.

therefore as something that happened in the past and which is told to us from the present. (Or just as the presentation of facts, without any reference to how they were discovered). That is why there are no true, actual "eureka" moments in any scientific film: the camera is never there when the researcher has the epiphany that brings the key to the discovery. Whenever we see it, it is either a remembrance (the scientist evokes it in an interview[16]) or a reenactment.

The environment in which science documentaries are produced also plays a role in this state of affairs. TV executives have a strong aversion to incertitude and, given that time equals money, they very rarely – if ever – consider following an experiment or an investigation as a work in progress from beginning to end.

As a result of the inherent difficulties that science creates for filmmakers and the ecology of the TV environment, practically all scientific films are issue-driven and not character-driven – a film based on characters is necessarily based on actuality. With this in mind it is easy to understand the impact created by *Particle Fever*[17] (David Kaplan and Mark Levinson, 2013), a feature-length cinema documentary on the discovery of the Higgs boson at CERN which is an amazing exception to the rule – a film on particle physics which is entirely based on characters and their interactions, which the authors followed on and off for years. In my view, this film exists precisely because its financing did not come from the usual sources that pay for science on TV: broadcasters and foundations. Instead, it was mostly funded by private investors. Many of them were former physicists turned hedge fund managers in Wall Street who had made fortunes applying their mathematical skills to a different set of problems.

Creative strategies

The task facing any producer of scientific documentaries is how to convey the required data with a medium which is so ill-suited to this task, as we have seen before. The tension between the two extremes of the continuum "delivery of information-storytelling" (news-fiction in Figure 1) is acutely felt once the research phase is over and the time comes to write a narrative treatment, a script for the film. In over 30 years of experience, I have come to realize that there is an inversely proportional relation between the amount of data that a film can convey and its capacity to be told as a story. In other words: if one pushes the film from the "news/information" side towards the "fiction/storytelling" side, the film becomes more

16. Such a remembrance can be a powerful television moment. In the opening sequence of *Horizon: Fermat's Last Theorem* (written and produced by John Lynch, directed by Simon Singh, 1996, BBC) the mathematician Andrew Wiles, who had solved a problem that baffled minds for three centuries, sits at his desk reminiscing the moment when he "saw" the solution to the proof. Suddenly, his voice cracks as he says "Nothing I will do again will ever…" He's just realized that he has peaked, and that from now onwards his career will be in the shadow of the amazing work he did in the previous years.

17. <http://particlefever.com/>

satisfactory as a film, more "organic" and round as a story but, at the same time, there is less and less room for it to convey information (data).

At this stage, when the film is just text typed on a computer screen, another concern is that it must be able to capture and sustain an audience in an environment of hundreds of linear channels and a drowning number of online options, all competing for the attention of the viewer/user/consumer. Of course, science and knowledge in general have an intellectual appeal which can be quite powerful – but to count solely on it as a tool to engage the viewer may be over-optimistic and one may fall in the trap of preaching to the converted.

Over time, producers have used a number of strategies that seem to be efficient in reaching the elusive goal of being entertaining yet at the same time informative. The following are a few examples of these strategies, culled from my own experience and from some of the films I have seen throughout my career which have created on me an impression strong enough as to remember them years later.[18] This is a personal selection, there may be other recognizable strategies that I have not come across, or that I have not recognized, or that just did not interest me enough and therefore did not leave a lasting memory in my mind.

Make it relevant for the viewer

If viewers feel that the information being conveyed by the film is directly relevant to them, they are more likely to stay with it than if they feel the subject matter to be remote. The idea is to present the practical outcomes (present or future) of the science being discussed, and how they will affect every viewer as an individual and/or society as a whole. This approach works especially well with films focusing on medical, biological, environmental or engineering stories, because in principle it is possible to talk about practical outcomes. Thus, in a film focusing on the latest advances in the battle against cancer, or Alzheimer, it makes sense to introduce a patient whom we follow as he is using a new treatment over a few weeks. His evolution over this period will provide a storyline (beginning, middle, end) on which to graft the parts of the film dealing more directly with the science behind the treatment. It is harder to bring it close to the viewer if the films deals, for instance, with basic physics.

Anthropomorphize

Attributing human qualities to non-human entities has long been a way to bring a story closer to the reader. In certain kinds of film, this strategy also works. It is used quite regularly in wildlife films, where feelings are attributed to animals when discussing their behaviors. It also was quite popular in the 1950s in educational animated films such as *A is for Atom*[19] (1952) or *The light of your life*[20] (1949), film produced by General Electric.

18. When possible, I have obtained permission from the producers to include excerpts of the films as part of this article.

19. <https://www.youtube.com/watch?v=34tKkET_TFE>

20. <https://www.youtube.com/watch?v=FyEQnv1DYEo>

Build something

Any film is a linear narrative that is deployed over its running time. Ideally, something should happen during that time that carries the narrative forward to a satisfying conclusion. On the other hand, the information to be conveyed in a scientific film most often is not structured as a function of time. How to solve the conundrum? Imagine that you want to make a film about the science of metallurgy – or that you are *commissioned* to make such a film. On the face of it, it may sound like a flat proposition, without any traction to carry the film. But what if you followed the actual making of a metal artifact? That surely has a beginning (mining the ore), a middle (smelting the iron, shaping it) and an end (the finished product). So, one could follow the process – in which we can see the interactions, as it is a technological process- and now and then insert a short segment about the hard science of metals. Sounds like a good idea. So, what do we build: a teapot? Well, *that* does not have a lot of appeal, does it?

The producers of NOVA, the flagship science show on the US public television system, settled for a metallic object with a little bit more mystery and attraction. Secrets of the Samurai Sword[21] (produced by Doug Hamilton for NOVA; 2007) follows fifteen traditional Japanese craftsmen over nearly six months as they create a sword "capable of slicing through a row of warriors at one swoop". The choice is wise, not only because of the elaborate method of forging and the intricacies of metallurgy that can be explained throughout the process. The film also draws on the popular appeal of the katana, the samurais and, in general, of the Japanese classic traditions – which helps to draw viewers in and, possibly, to have them stay until the end.

Looking at "the science of X" where X is anything with popular appeal (the Titanic, sex, casinos, wine… you name it) is also a well-established strategy to sweeten the pill for the viewer, even if there is no construction involved (James Cameron nearly rebuilt the Titanic for his film, but he was not into science).

Use analogies and metaphors

Very often we resort to analogies and metaphors when trying to explain a scientific concept in a conversation or in writing. The same can be done with film, as shown by these two examples.

While raising funds for *The Dali Dimension* I approached commissioning editors from several broadcasters, both from the fields of the arts and the science, as the film actually sits between the two. I quickly realized that the people from the arts were a little bit anxious on hearing that the film would deal with particle physics, relativity or higher dimensions mathematics – they were afraid that the viewer would not understand these matters because they themselves were a little bit lost while talking to me. One particularly difficult hurdle in-

21. <http://www.pbs.org/wgbh/nova/ancient/secrets-samurai-sword.html>

volved the painting *Corpus Hipercubus*[22] (1954) where Dalí was consciously quoting a four-dimensional object (a hypercube) in connection to the divine nature of Jesus Christ. To make them understand the concept of a four-dimensional cube, I carried with me a bit of cardboard in the shape of a cross made out of six squares which I showed to them saying: "See, this is a two dimensional object, six flat squares. But if I fold it, it becomes a three-dimensional object, a cube. Now imagine that you have eight cubes forming a shape similar to a cross. In a world of four dimensions, which we cannot actually imagine but that we can intellectually conceive, you could fold those cubes into a four-dimensional cube – a hypercube. Well, Dalí painted eight cubes forming a cross –an unfolded hypercube". The fact that they saw me fold the cardboard as I was talking made them understand the concept and overcome their worries. It was such an effective tool that it found its way into the film.[23]

One of the best examples of the power of visual analogies and metaphors in a science film is, undoubtedly, *Death by Design* (directed by Peter Friedman and Jean-François Brunet, produced by Emmanuel Laurent, 1995). The film's subject matter is apoptosis, the mechanism of programmed cell death, which is fundamental to life. As usual, the filmmakers resort to using interviews and scientific imagery, in this case micro cinematography of all kind of cells doing all kind of cellular things. But the stroke of genius that turns a quite stale subject matter into a fascinating creative work is the use of ancient archival footage to build and sustain the metaphor of "cells as a society of individuals". The interviewees, all top-notch scientists in their field, gladly accept to use this comparison: an organism is like a society made of individuals, each cell is an individual in that society. And the filmmakers combine their statements[24] with the scientific imagery and with a carefully researched selection of bits of newsreels, slapstick comedies, even excerpts from Busby Berkeley films[25]. The combination of all these elements, plus a very carefully selected music score, creates a seductive atmosphere that captivates the viewer. Already in the opening credits[26] the analogy is made – the film begins with a montage of the trailer from the '50s science fiction film *It Came From Outer Space* which sets the tone – serious, meaningful content served in a highly unusual way.

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22. <http://www.salvador-dali.org/cataleg_raonat/resized_imatge.php?obra=681&imatge=1>

23. <http://vimeo.com/107064660>

24. Interviewing a scientist can be a very tough task because it is vital to have them talk in a way that will be understandable for an average viewer (a filmmaker should never overestimate the amount of information viewers have, nor underestimate their intelligence). Many scientists are just unable or unwilling to do that, usually because they fear that if they "dumb down" their discourse too much they will be criticized by other scientists. As a general rule, the scientists who speak better for the camera are those who have nothing to prove to themselves or to the world, because they have already succeeded (or because they do not care about outside criticism). And those are usually the ones at the top of their field.

25. <http://vimeo.com/107078904>

26. <http://vimeo.com/107078905>

Being literal

Instead of using analogies, sometimes producers resort to being actually literal, to putting on the screen exactly what the subject matter proposition is about. In 2010, the Japanese public broadcaster (NHK) and Al Jazeera Children's Channel introduced a series called *Discover Science*[27], aimed at a children's audience, aged between 7 and 11. In each episode, which lasts about 15 minutes, an experiment is carried out to demonstrate a law of nature. The twist is that the experiments are made on a large (actual) scale, and the program forfeits the use of any computer graphics. The episode called *Let's see the speed of sound*[28] is a very good example of the strategy. The aim of the program is to show that sound travels at about 340 meters per second. To do so, the producers organize a line of 86 people that covers 1,700 meters, each one holding a flag (the experiment is shot at a pier in a harbor). At one end of the line, a master of ceremonies produces several different sounds (with a horn, a trumpet, a pair of cymbals…). The participants, lined facing away from the MC, raise their flag when they hear the sound. The result is very effective because, when the sound is produced, the raising of the flags actually *makes visible* the progress of the sound wave along the pier[29]. The producers keep track of how long it takes for the last flag to be raised; then a simple division is made (space/time) and they come up with the figure of the actual speed of sound in that precise event and location.

The Plane Crash[30] (2012), another remarkable life-size experiment, was undertaken in 2012 by Dragonfly Film and TV, Discovery Channel, Channel 4 (UK) and ProSieben (Germany) for a 90-minute special in which a Boeing 727 passenger jet was crashed on purpose at the Sonora desert in the north of Mexico. The plane was fitted with cameras and sensors, and filled with state-of-the-art crash test dummies. The aim of the project was to provide actual data to a team of scientists in order to study the crashworthiness of the aircraft's airframe and cabin, examine the impact of crashes on the human body, and look for possible means of increasing passenger survivability. By crashing the plane, the producers also aimed to answer key questions - such as whether sitting at the front or the rear of the aircraft, wearing a seat belt, and using the brace position - can make the difference between life and death.

In that particular case the plane crashed nose first and the passengers in the front rows would have most likely died, while those in the back section would have escaped practically uninjured. However, in another accident configuration the results could have been oppo-

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27. <http://www.onscreenasia.com/article/swr-ur-ebs-and-astro-join-nhk-ned-jcc-s-discover-science/7668>

28. <www.br-online.de/jugend/izi/english/research/discuss_quality/discusses_quality_2010/_7-11%20non-%20fiction/Speed%20of%20Sound.pdf>

29. <https://www.youtube.com/watch?v=NPPgQcFUrXk>

30. <http://www.channel4.com/programmes/the-plane-crash>

site. This prompted some reviewers[31] to comment that the data gathered in the experiment was essentially a confirmation of what was already known (wearing a seat belt is safe; the brace position avoids injuries to the head).

Literality is also at the base of the concept for *The Human Footprint*[32] (2007), a film by Touch Productions for Channel 4 and National Geographic. The film aims at raising the viewer's awareness about the environmental cost that human action has on the planet. To do so, the filmmakers show several examples of the materials consumed over a lifetime by an average American (or Briton), embodied by a couple of lovely kids whom we see growing up into adulthood and old age[33]. The trick is that they do it by showing on camera the actual amount of that material – they line over 7,000 bricks of milk in front of the kid's house; they have the boy and the girl, now teenagers, swimming in a pool filled with all the gallons of beer an average person consumes over a lifetime or "bathing" in a bathtub filled with all 500-plus kilograms of red beans eaten with all those English breakfasts; they show the host wandering in a maze made with the thousands of newspapers read by an average US citizen; and so on. The trick works its magic on the viewer because it draws on the "wow" factor – a statistic is a cold number which may or not impress us; *seeing* the statistic embodied in actual size certainly catches the attention (although, some reviewers[34] thought, it wears out after a while).

Change of scale

The same effect of amazement that can be generated by being literal can be achieved by changing the scale of a given experiment or process. Usually this entails reducing the scale to make a microscopic process visible to the naked eye, but the reverse (enlarging the scale) can be useful to deal with astronomic distances, for instance.

One of the most creative examples of this strategy is *The Great Sperm Race*[35] (directed by Julian Jones, produced by Dan Chambers and Justine Kershaw; Blink Films and Cream Productions for Channel 4, National Geographic and Discovery Canada; 2009). The film tells a well-trodden story: human conception, namely the short period that elapses between intercourse and ejaculation until a sperm reaches and impregnates the egg. But the way the story is told makes the difference: to start with, it is framed as "natures' harshest competition", a race with 250 million participants but only one winner, with deadly traps waiting at every step. The film's narration focuses on all the perils and dangers a sperm must face in order to have a chance to be the winner and thus carry its genetic load onto a new genera-

31. <http://www.independent.co.uk/arts-entertainment/tv/reviews/last-nights-viewing-the-plane-crash-channel-4homefront-itv1-8208003.html>

32. <http://channel.nationalgeographic.com/channel/human-footprint/consumption-interactive.html>

33. Oftentimes a film will use a combination of strategies, in this case, literality and closeness to the viewer.

34. <http://www.nytimes.com/2008/04/12/arts/television/12foot.html?_r=1&>

35. <http://www.julianjonesdirector.co.uk/thegreatspermrace.html>

tion. On top of that, the producers change the scale and, in a wink and a nod to a Woody Allen classic[36], they have the millions of sperm represented by thousands of white-clad men and women who run like mad trough hills and valleys which represent the vagina and the uterus. This representational device is intercut with dramatized scenes with the couple involved, and segments of hard science with the usual combination of interviews with scientists and actuality shootings at labs and research centers.

Rebuild the past

As discussed previously, many scientific films tend to present known facts which were discovered as a result of a research process already closed, in other words as a story from the past, be it distant or recent.

A classical approach is the *biopic*, the biography of a scientist and his discoveries. This provides a narrative frame, usually chronological, which weaves together the events in the life of the scientist with the progress (and stalls) of his research until reaching the result for which he became famous –or was ignored, this being the reason for making the film in the first place.

For a biopic to succeed, though, two conditions must be met: the character has to be interesting (possibly with some sort of conflict in his life), and his discovery must be of a certain consequence. If the scientist is a bland, grey character who did not produce anything of relevance, there will be no way to make an interesting, engaging film out of his life story (except maybe a memento for the family).

There are many creative choices for a biopic, ranging from the straightforward documentary to the work of fiction, including feature films aimed at the cinema screen. British actor Benedict Cumberbatch has portrayed two of the best minds of the twentieth century, Alan Turing (*The Imitation Game*[37], directed by Morten Tyldum; The Weinstein Company, 2014) and Stephen Hawking (*Hawking*[38], directed by Philip Martin; BBC, 2004). The earlier is a "based on a true story" film (meaning more than a few liberties have been taken with the facts) while the latter is a TV movie produced as a collaboration between the BBC's Drama department and *Horizon*[39], the corporation's flagship science documentary strand –which, in principle, should guarantee that the facts have been better preserved than with Turing's film.

A different take on the reconstruction of the past is to chart the *timeline of a discovery*, which allows touching on the contributions of several researchers or scientists. *E=mc*[2] *Ein-*

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36. One of the sketches in *Everything you ever wanted to know about sex but were afraid to ask* (Woody Allen, 1972) works on the same scale-change device but for comic effect. The film actually focuses on the workings of the brain and the organism in general during a seduction process. The Great Sperm Race takes up from where Allen's film finishes – ejaculation.

37. <https://www.youtube.com/watch?v=S5CjKEFb-sM>

38. <http://www.bbc.co.uk/sn/tvradio/programmes/hawking/>

39. <http://www.bbc.co.uk/programmes/b006mgxf>

stein's Big Idea[40] (directed by Gary Johnstone; Darlow Smithson Productions for WGBH, Channel 4, Arte/France and NDR; 2005), a docudrama based on a book by David Bodanis, retraces the biography of the equation – that is how the terms of the equation (energy, mass, the speed of light) came to be discovered and understood, and how Einstein brought them together in his most famous equation. Besides Einstein and his contemporaries, the film includes characters such as Lavoisier, Faraday or Maxwell in a sweeping narrative that covers a great deal of the history of physics.

Director David Dugan chose a similar approach for *Absolute Zero*[41] (Windfall Films and Meridian Productions for BBC4, NOVA, ARTE; 2007), based on a book by Tom Shachtman. The story of the quest to reach the lowest temperature possible (zero Kelvin degrees) provides insight into the physics of matter and into the lives of some of the researchers who made the greatest advances in the field.

There's something about species[42] (directed by Denis Van Waerebeke; Ex Nihilo for ARTE, France 5, NHK; 2009) charts the story of evolution by retracing how scientists have tried to make sense of the diversity of life by providing a classification – in fact, telling the story (and meaning) of taxonomy.

A twist on the idea of the timeline consists in charting the contribution that an instrument or a technique has had on a given field of research. The central character of *Superfly*[43] (directed by Philip Smith, Oxford Film & TV, 2002) is *Drosophila melanogaster*, the fruit fly. Over the last hundred years, this small insect has been used to unlock many of the secrets of genetics (60 percent of our genes are the same as the fly's) because its very fast life cycle makes it possible to breed many generations over a short period of time and to find natural mutations. Using specialist photography and 3D animation the film retraces the main discoveries made through experiments involving the fly and portrays some of the current experiments being carried out, which include gay, drunk and violent flies, as well as mutants high on crack cocaine, all lovingly raised by a slightly obsessed breed of scientists past and present.

Conclusion

There are objective reasons that make science a particularly difficult subject matter for films. Directors and producers have devised strategies to overcome this problem by looking at ways to present science as a story, because scientific laws are abstract, but their discovery is the result of a quest for understanding whose central characters, the researchers, are flesh and blood human beings.

40. <http://www.pbs.org/wgbh/nova/physics/einstein-big-idea.html>
41. <http://www.pbs.org/wgbh/nova/zero/credits.html>
42. <http://www.cultureunplugged.com/play/6950/There-Is-Something-About-Species>
43. <http://www.bbc.co.uk/programmes/b0074n9h>