2001 odysseys through space-time: (uncon)science in the cinema?

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The text looks at the image of science as shown by cinema, from a dual perspective: on the one hand, it presents the (bad) treatment of scientists and their laboratories, a source of the (un)popular view of science and its creators; and, on the other hand, a small collection of examples that illustrate the uses and abuses of scientific knowledge in cinematographic discourse.

Keywords
Science, scientists, physics, cinema, science fiction, scientific popularisation.

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> "Science fiction is not only good fun but it also serves a serious purpose, that of expanding the human imagination. [...] Today's science fiction is often tomorrow's science fact. To confine our attention to terrestrial matters would be to limit the human spirit."
>
> (Stephen W. Hawking, 1995)

1. By way of introduction

We live in a time of constant changes and, naturally, also of contradictions. In a society that defines itself as technologically advanced, in which broad sectors of the population enjoy inventions that have become everyday (from the mobile phone to GPS, including laptops and all kinds of domestic appliances), nonetheless irrationality and a lack of scientific culture have still not been expelled. The dizzying scientific and technical progress our society has experienced (or suffered!) in the last fifty years has not left much time for this to be assimilated. At no other time have so many changes come together in such a short period of time; changes that come in such quick succession that, whether we like it or not, we are forced to live with them and familiarise ourselves with them. Today it is not only essential to learn but also to be ready to learn how to learn. As the astronomer and science populariser Carl Sagan used to say, getting used to change is the key to survival for our civilisation and even for humanity itself.

Immersed in their daily routines, most citizens look on as science and technology get further and further from their understanding. Growing specialisation, the jargon used, as well as the very characteristics of research complicate even further the possibilities of building bridges between scientists (people who *do* science) and society (those who *receive*, in the short or long-term, the practical applications

of this science). Science is perceived as a veritable ivory tower that provides shelter for a few privileged souls (scientists), often not very used to the fact that elements alien to their *closed circle* can access it. Getting close to science requires effort and many scientists are not willing to waste valuable time by popularising this knowledge. The ground is therefore ready for the appearance of all kinds of irrational attitudes. In spite of all this, however, it must be said that the flame of interest in scientific issues is still alight, in spite of the small number of volunteers willing to carry the torch.

Although the accusing finger points inexorably at the scientist, in general academic and governmental authorities invest little effort to improving the stifling level of knowledge of the average citizen in scientific and technical fields. And not only citizens! The media themselves are stuffed with incorrect ideas and incomprehensible errors that denote a clear lack of specific training in these areas. So, the newspaper *El Punt* published the following news item on 8 August 1996: "Scientists from the United States find remains that indicate there might have been life on Mars, by analysing a meteorite that fell to Earth 13,000 million years ago". At the very least a surprising statement, considering that the age of the Earth is estimated at around 4,550 million years! In another medium, *Las Noticias*, this curious news item also appeared (2006): "A team made up of 73 astronauts from 12 countries has discovered a planet similar to Earth at a distance of around 20,000 million light years, close to the centre of the Milky Way. […] The most fantastic thing about this piece of news is the distance: to reach the planet OGLE-2005-BLG-390 you would have to travel for 20,000 million years at the speed of light (300,000 kilometres per second). It's a bit far". We must disagree: the most fantastic thing about this news item is the writer's incapacity to realise that 20,000 million light years is a greater distance than the dimensions of the known universe! It is, indeed, "a bit far". Someone, without much of an idea, decided to add six zeros to the real distance of 20,000 light years... Even in the evening news programme of the first television channel we could hear, in March 2005 and regarding one of the largest meteorites in Europe exhibited in a museum in León: "the carbon 14 tests have proved that it is made of iron". Perhaps we should remember that the carbon 14 test determines the proportion of carbon 14 of a sample and, possibly, dates it. Unfortunately, we will never be able to find out whether the meteorite contains iron by using this analytical technique...

Science, seen as a body of knowledge but also as a method of getting closer to the world that surrounds us, is possibly one of the most important facets to which part of humanity has dedicated itself throughout history. Not knowing who Shakespeare, Cervantes or Beethoven were is, without any doubt, synonymous with outright illiteracy. Paradoxically, the same protectors of these standards of culture do not consider names such as James Watt, Gregory Mendel or Carl Friedrich Gauss to be important, just to give some examples. Science is the heritage of humanity and our duty as *priests of this religion* is to communicate science and to get society involved in its advances.

2. Bad, mad or dangerous? Scientists on film

Neither has the image, a little sinister, of science and scientists shown to us by the cinema, helped to redirect this rejection or undervaluation of science. In fact, in the popular imaginary scientists are usually presented in an undeniably masculine key: men, therefore, either middle aged or elderly, flat personalities, almost of cardboard, obsessed with the search for knowledge (which often leads to veritable environmental chaos), closer to the status of villains than heroes, preferably recluses in remote, isolated laboratories and constantly dressed in a way not very suited to their activity, with immaculate white coats. As a contrast, they are usually located in the midst of veritable Technicolor laboratories, with neon lights (more typical of a disco than of a real research laboratory), test tubes that distil green, blue or red liquids, flasks with a whole range of smoking fluids, microscopes and, if the budget allows, other instruments of various characteristics with a whiff of technology.

The stereotypes that the cinema, like other narrative media, have set up around the figure of the scientist have been amply analysed in various publications [see, for example, the exceptional book *From Faust to Strangelove* (1995), by Roslynn D. Haynes]. In this section, therefore, we will leave to one side the classic *alchemists, absent-minded professors, romantic scientists, idealists* and other archetypes to focus on the more or less contemporary image of

the scientist (and his environment) as shown by contemporary cinema. We will start with the costume, the object of curious if not stifling situations in the cinema. To the eyes of the 21st century, attitudes such as those shown by the star of the film *The Giant Spider Invasion* (B. Rebane, 1957) seem to be quite out of place. In the film, a NASA researcher goes to an astronomic observatory to interview a colleague and puts himself in the most ridiculous of situations by not accepting the evidence in front of him (possibly brought about by a huge number of chauvinist traditions rooted in his subconscious): the woman dressed in a white coat who is handling an enormous telescope is not a daughter or wife or sister but the person he has come to see! Yet another example of the obsessive tendency in film to relate, unequivocally, the wearers of white coats with the role of scientist, in spite of the mental blindness shown by the star. In contemporary cinema, however, the iconographic white coat is starting to lose its followers (in accordance with reality). Films such as *Hulk* (A. Lee, 2003) support this new trend: in the opinion of the film's director, it was preferable to dress the stars in naturally coloured practical clothes and with the bohemian touch so characteristic of San Francisco, where the action takes place. Why would a scientist need a white coat while sitting in front of a computer screen?

The last few decades have also seen scientists mutate from their almost exclusive condition as a lone wolf, a veritable sniper ready to go and fight and do their own research (war?), to one forming part of a research team. So, on Nublar Island, close to Costa Rica, a select team of scientists are working on the complex (not to say crazy) task of cloning dinosaurs with fossil DNA, filling in the holes in the chains with frog DNA (*sic*). Long ago are the times when, in the cinema, such an extraordinary project could be tackled by a scientist alone, in the midst of a toy laboratory, where the modest equipment available seemed to be taken straight out of a "bargain store" ... On the other hand, the laboratory of *Jurassic Park* (S. Spielberg, 1993) constructs a veritable ode to modernity, with latest generation computers, virtual reality monitors, ergonomically designed furniture, incubators, microscopes, refrigeration chambers for embryos... The complex has, however, a kind of white room from where the growth of the dinosaur eggs is controlled. A room where, nonetheless, the brilliant palaeontologist Dr. Grant and other guests on the inaugural tour access in their hiking boots, without hesitation... A similar structure, based on teamwork, also appears in *Hollow Man* (P. Verhoeven, 2000), a film that is also notable for the extensive technological equipment of its laboratories. The team, made up of three women (one African American) and four men, in an unusual proportion of genders, are "some of the best experts in the country". Curiously, all appear to be around 30 to 35 years old, an age that is more appropriate for a promising scientist than one classifiable already as an authority in his or her field.

In all, contemporary cinema commits quite a few casting errors in its characterisation of scientists, combining elderly wise people, something compatible to a certain degree with the presumed prestige and experience of the person, and comparatively too young (and preferably blond!) females for similar tasks. A paradigm of this curious custom is Dr. Christmas Jones in *The World is not Enough* (M. Apted, 1999), an nuclear physicist who is an expert in dismantling military nuclear installations but only 30 years of age...

Figure 1. *The World is not Enough*

Source: *The World is not enough*, Metro-Goldwyn-Mayer.

* Dr. Christmas Jones, in the film *The World is not Enough* (1999), the "most improbable nuclear physicist of all history" according to some film critics. Of her (rather meagre) costume, dangerous for working in a military installation with nuclear weapons (for various reasons!), the only thing saved is an (also) miniscule radiation counter, as usually carried by physicists and technicians in similar places with a high risk of radiation. A costume, in any case, more suitable for going camping...

3. Science or fiction? Science in science fiction films

Like a modern Prometheus, we scientists should take on the challenge of stealing the fire of knowledge from the gods to give it to humans. There are many different ways to achieve this goal. In this section, we will illustrate how science fiction on film (without forgetting or underestimating other aspects, such as comics or literary science fiction) can become a veritable Trojan Horse, capable of infiltrating scientific knowledge beyond the frontiers of irrationality and ignorance.

The Earth and the winds of (climate) change

A planet in rotation, our dear Earth, over a background of stars is the beginning of the futurist film *Waterworld* (K. Reynolds, 1995), the story of a "predicted flood"... The narrator's voice in off gives us the background while, in a spectacular image, the earth's surface becomes totally covered by water: "The future. The polar ice caps have melted, covering the Earth with water. Those who survived have adapted to a new world."

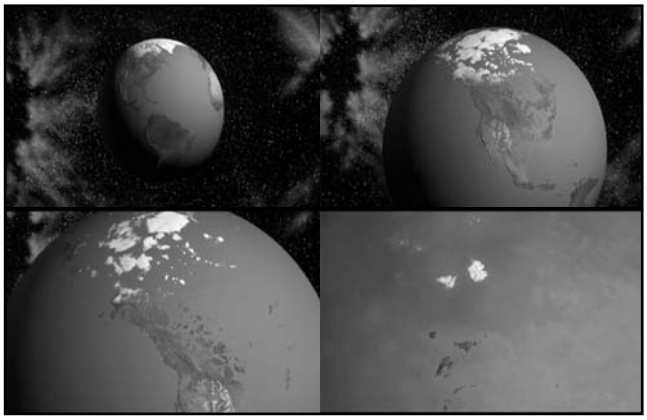
Just as the day breaks, under a multicolour symphony and on a particularly paradisiacal, cloud-free morning, a small boat is sailing the seas, defiant. Its pilot, the bold sailor (Kevin Costner), survivor of a decimated humanity, is steering his trimaran across this infinite sea towards Atoll, a city in the midst of the sea, a veritable commercial centre of an Earth in complete decadence.

Waterworld is an interesting reflection on the future of our planet. The depletion of the ozone layer, growing levels of pollution and the rising trend in global temperatures of the planet are some of the aspects of this climate change, a veritable nightmare of the 21st century. Together with other effects, global warming questions the very stability of the large masses of polar ice. Even so, you don't even need to have finished your secondary schooling to realise that, although the melting of the ice caps would be catastrophic, it would obviously not lead to an Earth completed covered by water. It is estimated that the Earth's ice content (concentrated in places such as Greenland and the South Pole) totals around twenty thousand billion tonnes. A considerable mass, undoubtedly, and one which, if melted, would have devastating effects on coastal towns although, unlike what is suggested by the film, there would still be a lot of the Earth uncovered. In fact, the equivalent of this ice in liquid water would lead to an increase in sea levels of less than... 20 metres! Goodbye film! Skyscrapers, mountains and a large portion of the continents would mock the initial image of the film, where the whole Earth (whole!) is literally submerged underwater. In fact, in the film, the probability of finding a simple rock is so remote that, two hundred years after the catastrophe, the existence of a mythical "dry Earth" has become a legend.

Simple arguments based on the Archimedes principle allow us to reduce this estimate even further: a mass of ice that is loose (an iceberg, for example) does not increase the water level when it melts.

On the other hand, the effects noted in *A.I. Artificial Intelligence* (S. Spielberg, 2001) seem at least somewhat more realistic. In one of the spectacular scenes the film presents us, a small helicopter is flying over a decrepit New York, in another time a vibrant, multiracial metropolis. Partially covered by water, all that remains of the formerly emblematic Statue of Liberty is its right arm, carrying the torch that rises up, phantasmagorical, in the midst of the turbid waters. Inaugurated in 1886, the Statue of Liberty (a

Figure 2. ***Waterworld***



Source: *Waterworld*, Universal Pictures, 1995.

* An Earth completely covered by the waters from the polar ice caps melting (or the effects of climate change amplified by the creative minds of Hollywood scriptwriters). Images which more than one farmer in times of extreme drought will dream about... From the film *Waterworld* (1995).

gift from the French government, whose structural design was by Gustave Eiffel himself), is 46.5 metres high (93 if we count the pedestal), a significant height. The view presented by the film, with the arm of the Statue visible above the water, in spite of being a little exaggerated, is much more in line with reality than the not very propitious predictions of *Waterworld*...

From star wars to galactic encounters

"A long time ago, in a galaxy far, far away..." a science fiction film, *Star Wars* (G. Lucas, 1977), catapulted Luke Skywalker, Han Solo and princess Leia to veritable legends of the genre. In the different films that go to make up the saga, the object of absolute veneration by legions of fans of the genre (the sacred *gospel* according to Saint —George— Lucas?), we can note the little rigour with which the script-writers tackle the displacement of the spacecraft, gravity and the battles themselves that have the void as their bloody setting. Perhaps aiming for stardom, a bold translator decided to extend one of the already improbable star wars to an even more unsustainable confrontation between galaxies, as the title in Spanish suggests ("La Guerra de las Galaxias" or war of the galaxies)…

In one of the liveliest scenes of *The Empire Fights Back* (I. Kershner, 1980), a squadron of imperial TIE fighters is frenetically pursuing the rebel ship *Millennium Falcon*. Han Solo, its intrepid pilot, tries to avoid the enemy ring by making daring manoeuvres and dodging the crossfire of the laser batteries. Loops, twists and turns and complex acrobatics compensate his futile attempts to connect the impulse system that should launch them (faster than the speed of light!) through the sinuous corridors of hyperspace. Meanwhile, a large number of lasers are hitting the energy shield of the Falcon. The rebels are awaiting their fatal destiny with resignation. Everything is lost... or almost. Facing a small probability of survival (1 in 3,721, according to the faithful android C3PO), Han plunges the *Millennium Falcon* into an asteroid field...

Asteroids, bodies of varying sizes, with typical dimensions from scales less than a centimetre up to 1,000 km in diameter, are relics from the formation of a planetary system. These aggregates, made up of the same nebula in which stars and planets are shaped, do not possess enough mass to generate, alone, an asteroid belt (in a short time, on an astronomical scale, the various fragments would disperse, if it were not for the presence of a central Sun). However, in the only asteroid belt known to date, the one between the orbits of Mars and Jupiter, in our solar system, the average distance between its components is considerable. In fact, it is estimated that the probability of a collision between two asteroids of 10 km radius in this belt is once every 10 million years! Far removed from the frenetic image of the film that is more reminiscent of a walk along Portaferrissa road in Barcelona, the night before the Epiphany[1] than the ordered chaos of an asteroid belt.

This is not the only badly treated aspect in this scene that, without doubt, could pass into the annals of cinematography for its large number of scientific errors (more than a dozen contained in a fragment of one and a half minutes!). The characteristic noise of the crafts' impulse engines (a sound that, in the film, manages to be transported by a vacuum), the generation of gravity in a spaceship (even in repose!), the perception of the trajectory taken by the lasers (moving at a much slower speed than light and clearly visible in the film), the acrobatics resembling airplane flight or the very presence of a monumental worm that is about to swallow the *Millennium Falcon* and its crew, in a place as little frequented as an asteroid belt. How has the worm got there? Is it logical to find a predator isolated in an environment lacking in prey? Perhaps its diet is limited to intrepid but unfortunate travellers.... What a sybarite!

Errors of *little gravity*?

As illustrated in the film *The Empire Fights Back*, a widespread practice in cinematographic science fiction (as well as on television) is the systematic absence of any effect produced by a change in gravity. Globalisation, it seems, has also affected gravitational pull! It doesn't matter if we're walking on a star of neutrons, inside a spaceship that's adrift or on a small asteroid. In Hollywood, at least, the *American*

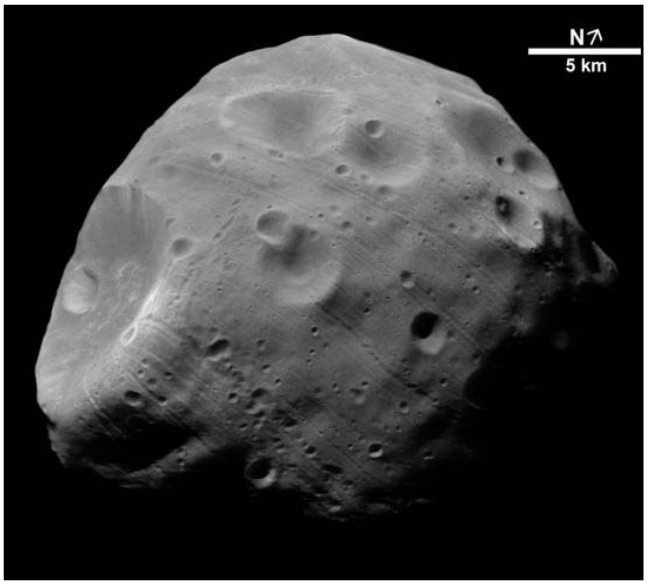
1 Translator's note: Portaferrissa road is in the centre of Barcelona and is often very busy, especially the night before January 6th (Epiphany), the day when the Three Kings bring children gifts.

way of life seems to have turned its back on the laws of physics...

For a human, as surprising as a habitat with extreme gravity may be (with the exception of Bruce Willis, capable of *accelerating at 9.5 g for 11 minutes* in the film *Armageddon* (M. Bay, 1988)), a conventional human would not withstand acceleration of more than a few terrestrial gravities or a world with little gravity (a scene, however, that is ideal for performing a thousand and one acrobatics). The small escape velocity of some minor bodies in the solar system has provided curious plots for various narrations and films of the genre. So the astronauts on a rescue mission in the B movie *Queen of Blood* (C. Harrington, 1966) experience an unexpected odyssey that takes them to the surface of Phobos, one of the two miniscule Martian satellites (with a radius of only 13 km!). In a memorable scene, two astronauts decide to invoke the goddess of fortune to tackle an uncomfortable situation: the discovery of a living alien inside a spaceship that has crashed into the Martian satellite. They decide to toss for who will leave the rescue craft (and who will remain on board). Perhaps we should ask the scriptwriter why two astronauts are sent in a two-seater rescue craft! Are they unlikely to find anyone living in the place of the accident? And, if not, why bother to send a rescue craft at all? In spite of this, it would be even better to ask the scriptwriter about the method employed to resolve the problem: making use of a *lucky dollar*, one of the astronauts tosses the coin into the "air" (a doubtful expression in a world without an atmosphere, like Phobos), leaving their destiny in the hands of fate.

The gravity on the surface of Phobos is insignificant. Its value can be estimated based on its average radius and its density: the gravitational pull would be 2,300 times less than that of Earth. On Earth, you need to toss a coin at around 3 metres a second for it to go 40 cm (a similar distance to that seen in the film). Under the ridiculous escape velocity on Phobos (only 10 metres per second, compared with 11,200 metres per second for the Earth), the coin would reach an altitude of almost 1 km (with the spaceship's roof permitting!), which we would call a *notable launch*... The astronauts, for their part, would have to be patient and wait more than twenty minutes for the small object to fall, and all three would die, given that, according to the film, the maximum time they have to connect to the mother ship is only 16 minutes! It is therefore evident that a minimal knowledge of physics can save lives, even on Phobos...

Figure 3. Fobos



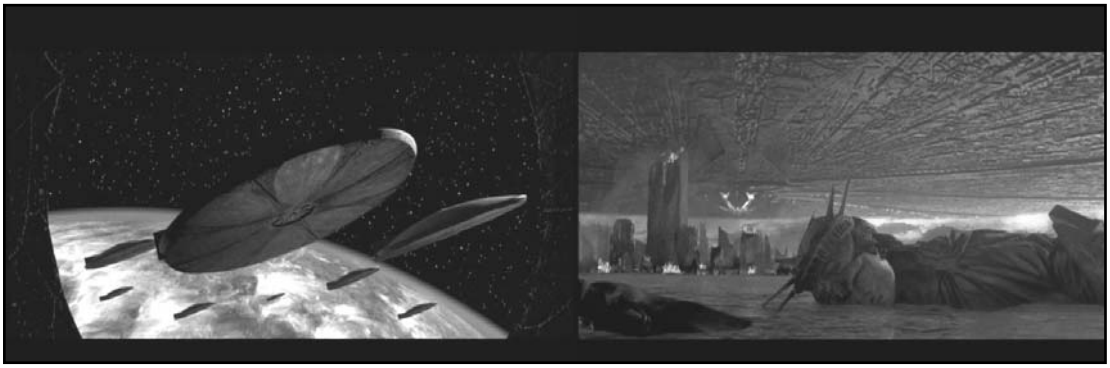
Source: ESA/DLR/FU Berlin (G. Neukum)

* High resolution photography of the small Martian moon Phobos, taken by the probe *Mars Express* (ESA) in 2004, from approximately 200 km distance. To the left of the image you can see the huge impact crater Stickney.

The day of independence (from the laws of physics)

Science fiction has been prodigious in covering extraterrestrial invasions. A recent example of this recurring (and at the same time fruitless) alien invasion has been the box office success *Independence Day* (R. Emmerich, 1996), yet another recreation of the perils that come from outer space. The film starts with the images of a colossal spaceship crossing interstellar space on its way to Earth. Its powerful engines seem to announce the arrival to the solar system with a symphony of terror: an intense acoustic vibration (there we are again!) which is capable of wiping out the footprints left behind on the lunar surface by the Apollo XI astronauts. A spectacular image, without any kind of doubt, although from a physics point of view it makes you think about the price for the cinema ticket: so clearly announced by the advertising poster for the film *Alien*, "in space, no-one can hear you scream"... Sound, a mechanical wave that

Figure 4. ***Independence Day***



Source: *Independence Day*, 20th Century Fox.

* The alien invasion of *Independence Day* (1996). Flying saucers of 25 km in diameter (left-hand photo) could hardly withstand the inexorable tidal forces in their extreme approach to a large number of terrestrial cities.

requires a medium of propagation such as air or water, cannot be transmitted through empty space. So, in the absence of an atmosphere, the moon becomes a world of impenetrable silence.

It could be argued, and not without reason, that the presence of a spaceship as shown by the film, with the mass of one third of the lunar mass and a radius of 550 km (data from the film), could exercise significant gravitational disturbance on our satellite: the so-called *tidal forces*. The earthquakes and slides produced by these disturbances could lead to intense vibrations that would reach the surface (and would have a lot more success in erasing the footprints left almost four decades ago by Neil Armstrong and Edwin Aldrin on the Moon). Are we witnessing a team of scriptwriters from Hollywood with solid knowledge of physics and who respect how the subject should be treated? Perhaps, although other huge errors seem to suggest the opposite. Otherwise, how can we justify the presumed origin of the aliens: "they come from a world 90,000 million light years from Earth", i.e. from a planet that is beyond the limits of the known universe (and probably beyond the limits of the universe itself!).

In the odyssey that takes them to the solar system, the alien ship must have ignored millions and millions of galaxies, stuffed with an infinity of planetary systems. Does the Earth deserve such an honour? The duration of the journey isn't a serious problem for the scriptwriters either, who seem to have ignored the fact that, in order to complete their improbable mission, even travelling at the improbable speed of light, they would need a period five times longer than the age of the universe itself …

These small but at the same time representative examples highlight the little care taken by cinema with the world of science (although it has occasionally been aided by scientific advisors!). Something that not very surprising, however. It is evident that the ultimate function of the cinema, seen as a spectacle, is to entertain the masses, not to popularise science. But the patent asymmetry in the treatment of humanities and sciences raises juicy questions: might we forgive, indulgently, a scriptwriter who places George Washington at the time of the Roman Empire, or who states that Miguel de Cervantes was from Venezuela? However, the function of the cinema is not to inform! But, why would we consider these examples as veritable affronts to culture while the most basic scientific aspects are systematically ignored and violated? The fear of the box office and the desire for commercial success seem to have led cinema more towards unconsciousness than towards science. Truly a pity. We have wasted the only chance to get our money's worth, enjoying not only the show and entertainment but at the same time a few healthy drops of the elixir of knowledge...

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