# The Gravity of Cartoon Physics; or, Schrödinger's Coyote

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## Abstract

When Wile E. coyote goes off a cliff, instead of falling in a parabolic arc, he comes to a halt in mid-air, hangs there until he realizes that he is no longer on solid ground, then falls. Many critics and, indeed, the creators of the cartoons themselves, describe this as "cartoon physics," which breaks the rules that appear to govern the real world, but several principles of modern physics are in fact depicted here. He is both falling and not falling; when he is able to observe his situation, the laws of quantum physics catch up with him. This, and the principle of relativity, govern the apparent paradoxes of the cartoon world. Although the coyote was, according to his creators, conceived as a parody of a modern scientist and played for laughs, he illustrates several paradoxes of modern science and the unease with which these are widely viewed. These cartoon physics have become a meme that has developed in later animated cartoons and live-action science fiction films, and is now even a part of modern-day science textbooks.

## 1 Introduction

It is often said that science fiction is a genre that has recently moved from the fringe to the mainstream, but a strong argument can be made that it has always been in the mainstream, or at least close to it, considering the canonical authors, including Jonathan Swift, Mary Shelley, H.G. Wells, Robert Louis Stevenson and Margaret Atwood, who have written works with scientific themes. Many of these themes and characters have made it into the popular lexicon as archetypes and memes, like Frankenstein's monster and the mad scientist who created him. The Floating Island in *Gulliver's Travels* (Swift 1726) is a parody of the scientific establishment of the time, and throughout the genre's history parody has developed side-by-side with more serious treatments.

Modern science fiction novels and films make use of these fictional conventions, and, since these fictions are based to a large extent on extant scientific principles, they often reflect popular perceptions of current scientific research and discoveries. The makers of the popular Warner Brothers road runner cartoon series, which began in 1949 and continues to be produced today, parodied these conventions of science and scientists in their creation of Wile E. coyote, who is

constantly frustrated in his attempts to catch the road runner with an array of flawed high-tech equipment. Director Chuck Jones claimed his cartoons flout scientific conventions, but ironically, their paradoxical visual depictions of accepted principles actually illustrate many of the scientific discoveries of the twentieth century. In this paper I will show how some of these scientific principles, such as relativity and quantum physics, are addressed both in these animated cartoons and in later live action parodies of science fiction, such as the film *The Adventures of Buckaroo Banzai Across the Eighth Dimension* (Richter 1984). Several astute critics have pointed out that this comic flouting of conventions reveals deeply-held anxieties about the direction our technologydriven society is taking. As Istvan Csicsery-Ronay jr. says, "SF [Science Fiction]
[…] became a barometer for social anxieties about future shock" (CsicseryRonay 2015, 31).

## 2 The Icons of Science Fiction

The conventions of science fiction are enumerated in a list of the "items and icons" of science fiction perceived by "the common reader" in Ursula Le Guin's Introduction to *The Norton Book of Science Fiction.* They include the future

> 'futuristic' science, technology, weaponry,
> cities, etc. spaceships, space voyages time
> machines, time travel other worlds alien
> beings monsters robots mutants
>
> parapsychology
> mad scientists (Le Guin 1993, 1999, 22)

All of these topics have appeared in science fiction novels, stories and films, as well as animated cartoons, including several Warner Brothers Bugs Bunny cartoons featuring Marvin the Martian and Frankenstein's monster (Avery et al. 1937–1964), time travel in The Wayback Machine in the Peabody and Sherman segments of *The Adventures of Rocky and Bullwinkle* (Ward and Scott 1959–1964), the future in *The Jetsons* (Hanna and Barbera 1962–1963), and all of these, plus mad scientists, in *Dexter's Laboratory* (Tartakovsky 1996–2003).[1]

[1] I focus here on a discussion of animated cartoons, but there is a long history of science themes in newspaper and comic book cartoons as well, such as Gary Larson's *Far Side.* See Higdon (Higdon 1994).

Science fiction of the mid-twentieth century, particularly the subgenre known as "hard" science fiction, focused as much on technological advances of the time as it did on speculation about the future. Three aspects of twentieth-century scientific discoveries in particular stand out in the Warner Brothers' road runner cartoons: the effect of gravity on coyotes; the ability of roadrunners to go through solid matter; and Wile E. coyote as the archetype of the "mad scientist."[2] The coyote is enamoured of the technology featured in contemporary science fiction, such as rockets, seductive gadgets, brand-names, and ever more potent weaponry. Gwyneth Jones describes how these items encapsulate the themes of early twentieth-century science fiction, partly in response to the visual imagery featured on the covers of pulp science fiction magazines:

> In its literary version, the genre had quickly developed a number of signature and easily visualized memes, those rockets and other vehicles for space flight, robots, aliens and alien realms, and a variety of gadgets and gadgeteers signifying a world of technological change. All of these would also become key visual attractions of the form, thanks, in part, to those alluring, four-color covers of the many pulp magazines that helped breathe life into early SF. (Jones 2003, 124)

The bright covers of those science fiction magazines were the precursors of an explosion of science fiction themes in animated cartoons, linking cartoons to science fiction literature.

Increased popular awareness of scientific developments in turn paved the way for popular acceptance of and demand for more technological development. As physicist Lawrence Krauss shows in *The Physics of Star Trek*, technologies that not too long ago were firmly considered to be solely in the realm of the imagination have now become commonplace in our lives (Krauss 2007). Jones confirms this:

> In the twenty-first century, the other-worldly, sacred status of many of the genre's classic icons is rapidly changing. rockets and space stations remain marginal to most people's lives, but hand-held global communicators (their eerie resemblance to the Star trek version owing

[2] The first two of these recurring themes in the cartoons can be viewed as metaphoric responses to the apparent paradoxes in recent scientific discoveries; the third reflects a comic version of the public perception of science. Stephen r. Gould (not the famous paleobiologist Stephen jay Gould) notes that "new looney toon analysis reveals that these, seemingly nonsensical, phenomena can be described by logical laws similar to those in our world. Nonsensical events are by no means limited to the Looniverse. Laws that govern our own Universe often seem contrary to common sense" (Gould 1993).

> more to ergonomics than SF prescience) have passed into the mundane. cyborgs, virtual environments, genetically engineered plants, animals and even humans, artificial intelligence, cataclysmic climate change, mindreading machines, quantum computing – it seems as if almost every wild, innovative, SF plot device has been annexed by the everyday. (Jones 2003, 172–73)

Krauss canvassed his colleagues and found that many of them had been fans of the *Star Trek* series in their youth, and attributed their lifelong interest in scientific research to this early influence. Science and science fiction thus could be said to have a symbiotic relationship; scientific discoveries transform into urban myth, and from there into the repetitive narrative of the cartoon, where iterative action takes over the comforting role that prayer used to command. The very predictability serves to disperse future shock.

## 3 Cartoon Logic and the Suspension of Normal Rules

Popular cartoons are generally humorous, depending on sight (and occasionally sound) gags that upend viewers' expectations. In many cases this "cartoon logic" goes hand-in-hand with special effects to create "other" environments, particularly when depicting environments in space and on other planets and when satirizing science and "technocracy." Mark O'Donnell formulated a set of rules of cartoon Physics that summarise this logic:

> I: Any body suspended in space will remain in space until made aware of its situation.
>
> II: Any body in motion will tend to remain in motion until solid matter intervenes suddenly. III: Any body passing through solid matter will leave a perforation conforming to its perimeter.
>
> IV: The time required for an object to fall twenty stories is greater than or equal to the time it takes for whoever knocked it off the ledge to spiral down twenty flights to attempt to capture it unbroken.
>
> V: All principles of gravity are negated by fear.
>
> VII: certain bodies can pass through solid walls painted to resemble tunnel entrances; others cannot.
>
> VIII: Any violent rearrangement of feline matter is impermanent.
>
> IX: Everything falls faster than an anvil. (O'Donnell 1980)

J.P. Telotte explains how and why animators applied this kind of logic:

> One type simply dissolves that narrative frame, so that the entire film seems to operate according to a dream logic that makes maximum use of animation's properties of exaggeration and transformation. It does so by exploiting the cartoon's fundamental plasticity, capitalizing on its entertaining capacity for taking viewers away from the real or the expected, and centering its action in a world governed by the sort of "gravity-defying tricks" and visual surprises that, Esther Leslie suggests, "were the essence of cartooning" in its early days. (Telotte 2017, 32)

This variant on "dream logic" appears in many animated cartoons, such as those produced by the Warner Brothers studios, as well as in live-action films, supplemented with special effects, to create visual humour based on incongruity. Other animators and studios, such as Disney, make use of a different, more realistic, style:

> In contrast, another approach follows what Leslie terms a "realist injunction" of the sort that would eventually become associated with Disney-style animation of the later 1930s – a style in which "gravity" and other laws actually play a kind of normalizing role, as characters squash, stretch, rebound from, and anticipate movements, and as events are more naturalistically motivated and depicted. (Telotte 2017, 32)[3]

Disney's animators do, however, make use of surrealistic animation tricks and surprises when it suits their purposes, as in both the supernatural and scientific sections of *Fantasia* (Walt Disney Productions 1940).

This was a movement parallel to the development of perspective in renaissance painting, where a scientific discovery facilitated the medium's ever closer approximation of mimesis: realism. cartoon logic revises this mimetic agenda, however, and instigates a disruption of realism, using the tools and skills that could reproduce the real to offer a counter-realism instead. Animated films of the 1920s and 30s used special effects and visual metaphors to create an imagined space impossible to depict with the effects available to live-action directors of the time; animators, in contrast, were able to draw anything that they could imagine. In live-action films, as the technology developed, various special effects were used to depict this imagined space, such as the stop-motion animation techniques of eminent visual effects designer ray Harryhausen, as well as makeup and

[3] It is both ironic and fitting that the Warner Bros. cartoons that create humour by satirizing science do so by inverting the laws of physics, while Disney's productions, which for the most part are updated retellings of traditional fairy tales and fantasies, rely on a realistic style.

prosthetics (Pierson 2002, 71). Modern directors are able to create similar effects using CGI, but some filmmakers go beyond using them to create realistic-looking effects, instead applying them to emulate cartoon logic, bringing the relation between live action and animation full circle. This is a case where technological advances in filmmaking led to new ways of seeing.

More recently, similar techniques have been used to create an aura of realism in video games using algorithms called "physics engines":

> to keep the game's action consistent with players' physical intuitions, the game's physics engine calculates all the relevant interactions. But to make the action also outlandishly cartoony, the computer plays loose with some of the numbers used in its engine. For instance, it assigns cars the elasticity of balloons and makes hammers as heavy as anvils. When a hammer blow hits a car, the vehicle temporarily squashes flat – cartoon fashion – and then springs back again. Overweight harpoons hit like missiles, powerful enough to penetrate steel. It's all in the parameters of the equations. For game developers and filmmakers who know how to manipulate such representations of physical reality, even the immutable laws of physics can give wings to their fancy. (Weiss 2002)

In essence, the programmers use one physics engine to emulate realistic responses to Newtonian forces, and another to modify these responses in order to create incongruity for the sake of humour. This incongruity won't work unless the audience can perceive it; therefore, cartoon makers and game designers needed to reference the common-sense physics of the everyday, while aligning their violations with esoteric science knowledge. cartoons such as road runner, like video games, thus have two audience levels, like parables of old.

The techniques of animation, both analogue and digital, closely reflect the literary and visual techniques developed by science fiction authors and filmmakers when they created a genre of fiction that is, in Darko Suvin's estimation, a "literature of cognitive estrangement" (Suvin 1972, 372), "whose main formal device is an imaginative framework alternative to the author's empirical environment" (375). In cartoons, at least of the comic kind, this alternative universe is a place where actions have different outcomes from those we expect in day-to-day life, but at the same time are largely preordained. Although we don't want the coyote to go hungry, we would prefer not to have the road runner killed. The liminality of this world, where the laws of nature appear to function somewhere in between those of realism and fantasy, is central to the kind of wish-fulfilment urge that keeps

the coyote returning to the Acme catalogue time after time, when all his experience should tell him their gadgets won't work. Wile E. coyote is preordained to fail and the road runner to succeed, not because of the rules of fairy-tale, fantasy or tragedy ethics, but because of director Chuck Jones's rules.[4]

In the imaginary world of the road runner cartoons, like any created world of science fiction or fantasy, the author still follows a set of internal rules that create a feeling of consistency for the viewer. Science fiction follows the rules of naturalism, often projected into the future, but in this case, the present. Here, the science fiction elements work for two purposes, humour and satire. The rules of Animation conform to the same requirement for internal consistency that govern science fiction and fantasy. As Csicsery-Ronay argues, science fiction animation simultaneously respects and defies the audience's knowledge of real physics (such as the knowledge that coyotes cannot really defy gravity). The appeal in thus visually breaking the rules that we know bind us he calls "lyrical physics" (Csicsery-Ronay 2015, 37); when he says "ultimately it is all about gravity," he is correct. We all know, or sometimes wish to believe, that rules can be broken, except for this one.

Gwyneth Jones argues, however, for an intertextual dimension to the use of cartoon special effects, as she outlines a kind of "arms race" between the print and visual arts:

> At the same time, the most visual of popular print fiction genres is challenged by ever more rapid developments in the entertainment media. Gone are the days when the B-movies could not hope to provide the same spectacular special effects, eye-kicks and entrancing false realities that could be created by the reader's and the writer's inner eye. But an icon is meaning as well as spectacle, and there is a logic to the icons of sf that will always recall the reader of these signs to the printed page, and verbal rather than visual argument. (Jones 2003, 173)

Animators had to develop new techniques to express new ideas and to encompass the new experiences the twentieth century brought to most people; physicist Werner Heisenberg notes that scientists in the twentieth century similarly had to develop new mathematical and physical techniques to adequately describe new developments in scientific discovery because of the impossibility of expressing new ideas in old language (Heisenberg 1959, 106, 123). The "logic" described by Gwyneth Jones is that of common-sense expectations frustrated by the

[4] 1. The road runner cannot harm the coyote except by going “meep, meep.”

2. No outside force can harm the coyote – only his own ineptitude or the failure of Acme products. trains and trucks were the exception from time to time.

3. The coyote could stop anytime – if he were not a fanatic.

4. No dialogue ever, except “meep, meep” and yowling in pain.

5. The road runner must stay on the road – for no other reason than that he’s a roadrunner.

6. All action must be confined to the natural environment of the two characters – the southwest American desert.

7. All tools, weapons, or mechanical conveniences must be obtained from the Acme corporation. 8. Whenever possible, make gravity the coyote’s greatest enemy.

9. The coyote is always more humiliated than harmed by his failures. 10. The audience’s sympathy must remain with the coyote.

11. The coyote is not allowed to catch or eat the road runner. (Jones 1999) incomprehensible complexities of a changing world, the frustration felt by everyone who has ever been confronted with the intractable refusal of a machine to work as it is supposed to. Her reminder that in cases like this we revert to “verbal rather than visual argument” in order to decipher the icon recalls one of Ursula Le Guin’s categories of science fiction tropes, the “literalization of metaphor” (Le Guin and Attebery 1993, 30): when the coyote fails spectacularly, either the “ground drops out from under him” or he “hits the wall.” **4 Gravity and The Observer Effect; or, Schrödinger’s Coyote**

In cartoons, the normal logic of everyday life is suspended: characters careen into solid objects and pick themselves up without a scratch; the road runner can run through the side of a mountain if it has a picture of a tunnel painted on it; Wile E. coyote sometimes appears to defy the law of gravity (if only temporarily) when he goes over a cliff. Among Chuck Jones’s rules for logical consistency in the series is rule 8: “Whenever possible, make gravity the coyote’s greatest enemy” (Jones 1999, Kindle Locations 2344–46). Jones explains: “tex [Avery], more than any other director, was fascinated by the limitless possible extensions of the medium. He simply ignored all the physical laws of the universe, with, perhaps,

an occasional nod to the law of gravity" (Jones 1999, Kindle Locations 1000–1002).[4]

On a closer look, while gravity appears to be the one constant in the Warner Bros. cartoons, even when it works the effects are unpredictable. Avery and Jones may have ignored the laws as they knew them, but developments in twentieth-century theoretical physics seem to corroborate their far-fetched vision. While Wile E. coyote does sometimes appear to defy gravity in the commonplace world of classic Newtonian physics, gravity works on him as it appears to do on quantum and relativistic levels; the rules are bent but not broken. Sometimes, when the coyote falls, his trajectory takes the form of a parabolic arc, as we would normally expect.

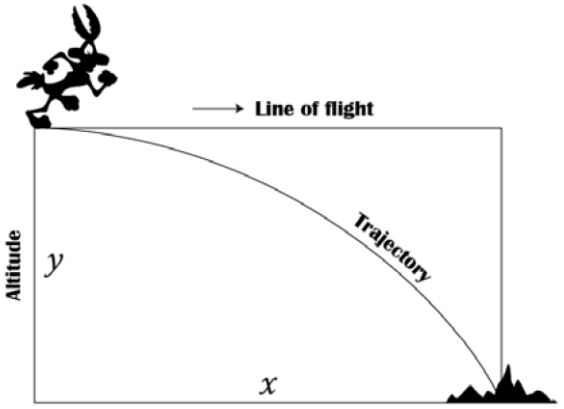


**Figure 1.** Falling coyote (canis ballisticus) obeying Newtonian rules of Gravity. Illustration by
Matic Ačko.[5]

At other times, after he goes over a cliff, he hangs suspended in mid-air until he realises that he is no longer on solid ground. This turns out to be an illustration of the paradoxical "observer effect": gravity has no effect on him until he becomes aware of it. This is a visual parody of the observer effect which, as explained by Heisenberg, marks a profound change in the way we see the world: "[I]t is in quantum theory that the most fundamental changes with respect to the

[4] Avery was Jones's predecessor as director of Warner Bros. cartoons.

[5] His trajectory can be calculated using simplified versions of the equations proposed by Edwin Wilson (1920):$xx$
Horizontal distance $xx = vv_{xx}{}^{1}tt$ ; Vertical distance $yy = vv_{yyyy}tt - {}^{1}{}_{2}ggtt^{2}$ ; Where $x$ is the horizontal component, $y$ is the vertical component, $g$ is gravitational acceleration, $v$ is initial speed, $v_x$ is the horizontal component of the initial speed, and $v_{y0}$ is the initial vertical component of the initial speed.

concept of reality have taken place" (Heisenberg 1959, 33). In certain extreme cases, such as the observation of sub-atomic particles, the very act of observation affects the observed process:

> Of course, the introduction of the observer must not be misunderstood to imply that some kind of subjective features are to be brought into the description of nature. The observer has, rather, only the function of registering decisions, i.e., processes in space and time, and *it does not matter whether the observer is an apparatus or a human being*; but the registration, i.e., the transition from the 'possible' to the 'actual,' is absolutely necessary here and cannot be omitted from the interpretation of quantum theory. (121)

At this moment, the shot, in which we see him horizontally, ends, and in the next shot the camera, still at the same level above the ground, is now pointed downwards as we watch him falling away from us to the canyon floor far below. In some cartoons, his fall is accompanied by a realistic whistling sound emulating the familiar Doppler effect, whereby the sound of an object moving away from us has a descending pitch; in others, we hear a symbolic pennywhistle version of the sound (see the Appendix, which lists different variations of the effect of gravity as they appear in road runner cartoons).

Several scientific principles are depicted here. First, as the coyote goes over the edge, he loses traction, and air resistance brings his motion to a halt. Second, gravity takes hold and he falls.[6] Here, however, his behaviour appears to be governed by the Uncertainty Principle: is he falling, or is he not falling? The coyote is both falling and not falling; he has been quantized. It is only when he is able to observe his situation, to which he was oblivious in his quest to catch the road runner, that the laws of physics catch up to him. When he realises that he must fall, his potentiality turns into movement.[7] Suvin attributes this kind of logic to the realm of fantasy: "The stock fairy-tale accessory […] evades the empirical law of physical gravity – as the hero evades social gravity – by imagining its

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[6] Under the laws of classic Newtonian physics, gravity would take effect immediately the moment he was no longer on solid ground, and he would be subject to the law as described in the equations

$$F_g = mg, \sum F = ma, F_g = ma, mg = ma, A = g,$$ where $F_g$ is the gravitational force, $m$ is the mass of the object, $g$ is the gravitational acceleration, $\sum F$ stands for the sum of the forces acting on the object and $a$ is the acceleration of the object.

[7] The Uncertainty Principle, formulated in 1927, is expressed in the function $\sigma_x \sigma_p \geq \frac{\hbar}{2}$ where $\sigma_x$ is the standard deviation of position, $\sigma_p$ is the standard deviation of momentum and $\hbar$ is the reduced Planck-constant, $h / (2\pi)$. In quantum theory, radiation, such as light, is emitted, transmitted, and absorbed in discrete energy packets, or quanta, determined by the frequency of the radiation and the value of Planck's constant ($6.62607004 \times 10^{-34}$ joule·second).

opposite. The wish-fulfilling element is its strength and weakness […] Anything is possible in a fairy tale, because a fairy tale is manifestly impossible" (Suvin 1972, 375). Suvin draws a hard line between science fiction and fantasy: for him, science fiction depicts what is possible, given current knowledge of nature, while fantasy crosses over into the impossible and the supernatural. Other science fiction writers and critics, such as Le Guin, have a less rigid view; our definition of what is "possible" is constantly changing. The coyote's act of observing gravity has an effect on the location and time of its effect on the object (himself), thus illustrating the principle of infinite regression in physics: "no interpretation of the quantum theory can avoid a measurement problem involving the observer" (Rosenblum and Kuttner 2002, 1273). Charles Seife argues in "Physics Enters the twilight Zone" that the strange predictions of modern quantum and relativity science predict a "multiverse," where anything and everything is possible (Seife 2004). trying to come to terms with the apparent logical paradoxes described by twentieth-century scientific discovery gives rise to a feeling of the absurd.

Another strange effect predicted by modern physics appears in some of the cartoons in which, immediately after the coyote realises that he is about to fall, his body stretches; his feet begin to fall first, and he is momentarily elongated until his head catches up. This is an illustration of the tidal effect, described by physicist Stephen Hawking, when an object becomes subjected to an intense gravitational field, such as that close to a black hole. Nigel Calder dubbed this phenomenon "Spaghettification" (Calder 1979, 143; Hawking 1998).[8]

These strange predictions of modern theories of the physical laws of the universe are similar in both method and intent to the way science fiction transforms the familiar world: "Science fiction uses the techniques of both mimetic representation and also quasi-mimetic but counterfactual deviations from the established ideological world-picture to create a critical distance from it" (Csicsery-Ronay 2015, 31). Ironically, although the cartoonists and animators of the mid-twentieth century may have thought that they were merely lampooning the eccentricities of the "boffins," they anticipated some of the real scientific discoveries of the century. In summary, cartoons and other science fiction parodies illustrate one of the philosophical paradoxes described by eminent twentieth-century theoretical physicist john Wheeler: "no phenomenon is a

[8] In keeping with physics' concept of symmetry, there is a similar symmetry in the effect of gravity on Wile E. coyote: in some cartoons, gravity stretches him; in others, he is compressed when he falls and hits the ground, or is hit by a falling object; in "Wild about Hurry" (1959) and "to Beep or Not to Beep" (1963) this takes the form of "concertinafication," complete with squeeze-box sound effects.

phenomenon until it is an observed phenomenon" (Wheeler 1978, 14); this, as the coyote often observes, even includes gravity.

## 5 Multidimensionality

Many road runner cartoons show the road runner doing something that seems impossible, such as when he goes through solid matter. The coyote despairs of catching the faster road runner in a race, so he decides to create a trap by painting a tunnel on the side of a mountain. to his surprise, the road runner runs straight through the "tunnel"; to his double surprise, the coyote crashes into the mountainside when he tries to follow, a comic pratfall both surprising and expected.

Wile E. coyote also crashes when he falls over a cliff. After several long seconds, the falling shot ends, and in the next shot, now at canyon floor ground level, we see a third example of a twentieth-century physics paradox: instead of the splattered remains we would expect in a common-sense Newtonian world, the coyote has gone through solid matter, leaving a coyote shaped hole in the ground from which he emerges dazed but otherwise unharmed. The coyote's penetrating power defies the normal rules of biology, but it does correspond metaphorically to the laws of physics, if his inability to learn from his mistakes is a measure of his density.

Viewers have seen these gags so many times that we have come to expect them; the impossible has been normalized. Over time, we have become accustomed to the idea that nothing is impossible. Scientists constructed a similar paradigm shift in the mid-twentieth century. Einstein's Theory of relativity (1905, 1915) predicted that nothing could escape the force of gravity. The extreme case would be an object passing through the event horizon of a black hole, where gravity is so strong that the escape velocity exceeds the speed of light. Any object or information that fell in could never get out. Stephen Hawking, however, combined relativity with quantum theory to show that it could: in quantum theory, pairs of subatomic particles can appear out of empty space, drawing on the potential energy present throughout all space. A particle and an anti-particle can appear, exist for a very short time, then annihilate each other, thus preserving the matter and energy balance of the universe (Hawking 1975). If, however, such a pair appears near the event horizon of a black hole, one particle might fall through the event horizon while the other moves off in a different direction. Thus, in effect, matter/energy can escape the gravitational pull of a black hole (which, given enough time, could "evaporate"). The coyote metaphorically emulates this

gravity defying particle when he hits the canyon floor and disappears into a hole in the ground, only to reappear momentarily, dazed but otherwise unharmed, having defied both death and gravity (and, incidentally, enacting mythical cyclical rebirths, like Adonis (see Frye 1957, 158)).

The road runner's ability to go through mountains unscathed is similar to the behaviour of another kind of sub-atomic particle. He behaves like an alpha particle in the Geiger-Marsden experiment (also known as the Rutherford Gold Foil Experiment).

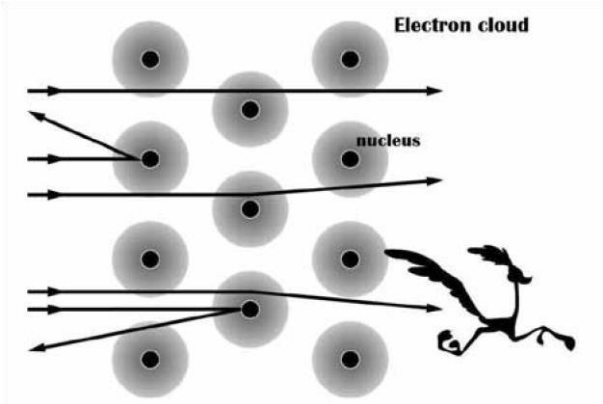


**Figure 2.** road runner (*Avem energeticus*) penetrates solid matter. Illustration by Matic Ačko.

The same principle is one of the central themes of *The Adventures of Buckaroo Banzai Across the Eighth Dimension* (Richter 1984), a live-action film that uses cartoon logic and physics in a parody of older science fiction films.[9] Buckaroo's interdimensional car can go through the side of a mountain, as the road runner can and Wile E. coyote cannot (Buckaroo is an analogue of the road runner, and his antagonist, Lord john Whorfin, who steals his oscillation overthruster to try to get back to the 8th dimension, is a version of the coyote). In the film, Banzai explains at a press conference that he can go through solid matter because the

[9] W.D. richter and Earl Mac rauch's 1984 film begins with an experiment in which Buckaroo manages to go through a mountainside in his car, which is equipped with an "oscillation overthruster," analogous to rutherford's alpha particle beam generator, confirming the rutherford theory on a macroscopic scale. While in this alternate dimension, however, he finds evidence of life, and deduces that our world has been invaded by red Lectroids, aliens from another dimension, criminals who had been banished from their own world. Their attempt to return home is opposed by their own people, who threaten to destroy the Earth unless Buckaroo can stop them, which he eventually does. As special effects technologies developed, live-action films borrowed many of the visual images of cartoons. In *Buckaroo Banzai*, the red Lectroid space pod makes a sound like that of the jetsons' flying car (Hanna and Barbera 1962–63); there is also a sight gag like Wile E. coyote's delayed reaction when falling off a cliff, as the pod drops off the bottom edge of the screen only to rise into the frame again

atoms that make up matter are mostly empty space, recalling the model described by the experiments of Rutherford, Geiger and Marsden (Rutherford 1911).[11]

The revolutionary concepts of relativity and Quantum Physics have forced us to redefine the way we think about the world we live in, but fortunately, we had Wile E. coyote and the road runner to help us get used to the new ideas.

## 6 Technocracy, Mad Scientists, and Metamorphoses

The common public perception of lapses from "common sense" in the discoveries described by scientists and parodied in films and cartoons are symptoms of a widespread scepticism about technological progress. This phenomenon is not a new one. Jonathan Swift described the same thing in Book IV of *Gulliver's Travels* (1726) with his satire on the "Projectors" (Kiernan 1971). Swift was critical of Newton and the royal Academy; he believed that Newtonian science was both useless and immoral, since in his view mathematics was "irrelevant to the human predicament" (Treadwell 1975). Pat rogers asserts that Swift's satire was mainly aimed at engineering projects of his time (rogers 1975, 261), while other commentators note a political element in his satire on science: "the 'Flying Island' is an image not only of arbitrary, 'high-flying' political power, but also of officially patronized technological lunacy" (Worth 1991, 355).

A few decades after Swift, Samuel Johnson described how disappointment with the promises of contemporary science and technology continued in the mideighteenth century:

> When the Philosophers of the last age were first congregated into the royal Society, great expectations were raised of the sudden progress of useful arts; the time was supposed to be near when engines should turn by a perpetual motion, and health be secured by the universal medicine; when learning should be facilitated by a real character, and commerce extended by ships which could reach their ports in defiance of the tempest.
>
> But improvement is naturally slow. The society met and parted without any visible diminution of the miseries of life. The [gout] and [stone] were still painful, the ground that was not ploughed brought no harvest, and neither oranges nor grapes would grow upon the Hawthorn. At last, those who were disappointed began to be angry; those likewise who hated innovation were glad to gain an opportunity of ridiculing men who had

depreciated, perhaps with too much arrogance, the knowledge of antiquity. (Johnson 1759)

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when Buckaroo and Black Lectroid john Parker figure out how to work it (by jump-starting it with a car battery). The red Lectroids also move in uncanny ways; villain Lord john Whorfin's henchman john Bigbouté side-punches a bystander using the same movement used by Sam Sheepdog in an homage to the 1953 Warner Bros. cartoon "Don't Give Up the Sheep."

[11] Rutherford's team bombarded a sheet of gold foil with alpha particles (helium nuclei), and discovered that 7,999 out of 8,000 particles went through the foil unimpeded, thus demonstrating that what appears to be solid matter is in fact mostly empty space. By measuring the angle of deflection of the remaining particle, the "gold foil" experiment established the size of a gold nucleus with the formula $r_{\min} = \frac{1}{4\pi\varepsilon_0}\frac{2q_1q_2}{mv^2} = 270 \text{ fm}$ where $r_{\min}$ is the radius of the atom, $\mathcal{E}_0$ is the dielectric constant in a vacuum, $q_1$ are $q_2$ the values of electric charges of the particle being fired and the target particle, $m$ is the mass, and $v$ is the velocity of the particle fired; 1 fm = $10^{-15}$ meters.

Douglas Lane Patey summarises this theme of Swift's in terms still current in criticism of twentieth-century science:

> We all know what Swift finds wrong with the natural philosophers of Lagado. Gulliver witnesses experiments that serve no practical human use, or that would do harm by inverting the uses of nature (breeding sheep without wool); in seeking to reverse the order of nature (extracting sunshine from cucumbers, returning excrement to its original food), Lagadan projects are utopian – the external equivalent, we might say, of the failure to know one's self. (Patey 1991, 817)

While Swift and Johnson criticized The royal Society in the context of satires mainly focused on politics, economics and morality, later movements in literature brought an examination of scientific ideas into other realms of popular fiction: "literary naturalism was a remarkably important step along the road to the Golden Age [of science fiction]. Strongly influenced by post-Darwinian developments in the biological sciences and intrigued by emergent theories of human nature in the late nineteenth century, the literary naturalists were central figures in the merging of scientific thought and fictional narrative" (Link and Canavan 2015, 8).

Like science fiction in prose and film, in addition to illustrating some of the paradoxes explored by twentieth-century physics, animated cartoons also explore one of the cultural dimensions of modern society, the simultaneous attraction to and fear of technocracy. The coyote's addiction to Acme products results in his becoming an archetypal mad scientist seeking "technocratic" solutions to his problems.[10] After World War II, cartoon aliens, Martians, mad scientists, out-of-control robots and malfunctioning, rube Goldbergian machines were "tropes for […] cold War anxieties" (Telotte 2017, 116), as the same images in pre-war political and animated cartoons were for Depression-era anxieties.

Nigel Calder explains this dual perception of scientists by the general public; on the one hand, "physics made a noise in the world. But the abiding reason for its special status was that it posed the deepest question to nature" (Calder 1979, 14). While for many people, these are important activities, to others they can seem esoteric and disconnected from reality, so that "The public nevertheless formed illusions about the physicists. There are two versions of the scientist in popular culture: the mad one and the saintly one" (99–100).[11] Both of these visions reflect a widening gap between scientific knowledge and popular understanding, and a fear and distrust of the specialisation and esoteric expertise that appear to be rapidly supplanting traditional knowledge, traditions and institutions. "Unappreciative of the passion for understanding which drove them in their work more compellingly than any taskmaster, outsiders substituted the image of the mad scientist, impelled by a lust for power over nature and man" (14). This image of the mad scientist, the descendant of Swift's "Projectors," is repeated and confirmed in countless stories, novels, films and cartoons. The modern archetype is Colin Clive's portrayal of Dr. Frankenstein in James Whale's 1933 film (Whale 1931), masterfully parodied by Gene Wilder in Mel Brooks' *Young Frankenstein* (Brooks 1974). An important aspect of the mad scientist trope is his foreignness, not only figuratively in his unswerving devotion to his goal, but literally in his place of origin. Although Wile E. coyote is silent,[12] his spiritual cartoon successor, Dexter, "speaks with a Russian accent. Dexter considers himself a very

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[10] In this respect he resembles Mr. toad in *The Wind in the Willows,* who refuses to accept the arguments of his friends who try to persuade him to give up his addiction to motorcars: "I faithfully promise that the very first motor-car I see, pooppoop! Off I go in it!" (Grahame 1913, 149).

[11] constance Clark notes that one of the models for the visual portion of the modern stereotype of the scientist comes from a famous photograph of the bearded charles Darwin: "Darwin's iconic image quickly came to stand as shorthand for evolution in late nineteenth-century cartoons" (Clark 2009, 573). In the twentieth century, photographs of the elderly Einstein with his streaming white hair became a symbol of the saintly scientist.

[12] The coyote is mute in the road runner cartoons, although he often communicates by holding up a sign, and he can read. When he appears in cartoons with Bugs Bunny, such as "Operation rabbit" (1952), he speaks in a posh English accent, voiced by Mel Blanc.

serious scientist, and all well-known scientists have accents" (Adams 2001). [13] Christine Cavanaugh, the voice of Dexter in the cartoons (Tartakovsky 1996–2003), explains that his accent and manner are conscious affectations meant to invoke the stereotype; Dexter, it seems, is playing the role of mad scientist: he has "an affectation, some kind of accent, we're not quite sure. A small Peter Lorre, but not. Perhaps he's Latino, perhaps he's French. He's a scientist; he knows he needs some kind of accent" (Moore 1996). Scientists, in pop culture, are modelled on strange geniuses, foreign in many ways, such as Einstein, Edward teller, Leo Szilard, Werner von Braun, and their fictional counterparts, Prospero, Victor Frankenstein, Doctor Strangelove (modelled on von Braun) (Starr 2012, 100).[14] These prominent scientists had European accents, since many of them, including Einstein, teller and Von Braun, came to the United States, either fleeing the Nazi regime or liberated from it.

Mad scientists look, as well as sound, foreign. Animators, borrowing the visual symbolism of films, drew their mad scientists with several iconic features: white lab coats, beards, goatees, hunched backs, dark, staring eyes, all of them denoting madness. Overall, these stereotypical depictions are symbolic of a deep-seated existential anxiety about threats from transformation and change.[15]

*The Adventures of Buckaroo Banzai* uses these same conventions, as do the *Dexter* and Warner Bros. cartoons, as well as countless other science fiction film villains, in their portrayal of the mad scientist. The villainous Dr. Emilio Lizardo has a mad scientist foreign accent and a scuttling walk like a cartoon character. Lizardo is a hybrid or composite character, like The Fly (Langelaan 1957, Neumann 1958, Cronenberg 1986); he was caught between two dimensions and is an amalgam of the human scientist Lizardo (who was based on Hungarian scientist Leo Szilard) and the reptilian red Lectroid Lord John Whorfin.[16] He has

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[13] Dexter's creator, Genndy Tartakovsky, explains the influence of Warner Brothers' cartoons on his own: "they were made for adults and were shown before theatrical movies. They were still cartoons, so they had to be childlike, to a degree: slapsticky, Three Stooges, physical humor. A good cartoon is always good on two or three levels: surface physical comedy, some intellectual stuff – like Warner Brothers cartoons' pop-culture jokes, gas-rationing jokes during the war – and then the overall character appeal" (Adams 2001).

[14] Part of the late astronomer and cosmologist Stephen Hawking's popularity was based on his disability, wheelchair and artificial voice, which gave him an otherworldly appeal.

[15] A real-life example of a "mad scientist" from the era of the Warner Brothers cartoons appears in a *Time* magazine article about russian scientist Vladimir Demnikhov, who transplanted a puppy's head onto an adult dog; the resulting hybrid lived for 38 days (1955).

[16] Like Doctor Jekyll and Mr. Hyde, The Fly, and countless other cartoon, comic and movie characters, he has been given a split personality by his own botched experiment, thus embodying the dual nature of the scientist described by Calder.

an Italian accent, while the other red Lectroids (villainous aliens) have American accents and the Black Lectroids (good aliens) have Jamaican accents. John Lithgow, who played Whorfin/Lizardo

> was not sure about the character, but Richter convinced him by 'claiming what a real feast for an actor this wonderful Jekyll and Hyde character was,' the actor said. Lithgow told an interviewer, 'I have had roles where I came very close to going over the top. […] But this role is completely over the top. It makes the role in *Twilight Zone* seem like a model of restraint. I do it in a wild, red fright wig and rotten false teeth with a thick Italian accent. It's wild.' For Lizardo's accent, Lithgow spent time with an Italian tailor at MGM and recorded his voice […] Lithgow said of his character, 'playing Lizardo felt like playing the madman in *The Cabinet of Dr. Caligari*.' (Editors)

In addition to the accent, Lithgow worked on conveying an aura of alienness with his movements: he changed his walk to that of an "old crab, and because my alien metabolism is supposed to be messed up." Lizardo's henchmen, the red Lectroids, similarly use unusual movements, like cartoon characters, such as john Bigbouté's sideways punch, to denote their alienness, even when disguised as humans.[17]

More than just the scientist's appearance, their pattern of behaviour also fixes them as "mad."[18] As Calder notes, it is the fixation on the goal that many people are unable to identify with: Wile E. coyote's increasingly desperate and futile attempts to catch the road runner with Acme gizmos, Lizardo's attempts to steal Banzai's Oscillation Overthruster (which he needs in order for his ship to cross dimensions), Marvin the Martian's Illudium pu-36 Explosive Space Modulator, with which he plans to destroy the Earth.[19] In each case, the character's fixation on their immediate goal blinds him or her to the big picture and ends in defeat.

The origins and development of the mad scientist stereotype in the popular culture of the early twentieth century can be traced from rube Goldberg, through Boob McNutt and Professor Lucifer Gorgonzola Butts, to the anthropomorphic coyote

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[17] These symbolic movements are similar to another kind of symbolic shorthand, the postures in stereotypical illustrations of evolution: "The iconographic motifs denoting evolution – especially primates, 'cavemen,' and the linear evolutionary sequence, have become fixed in a cartoon lexicon. The jokes work because viewers recognize the pattern" (Clark 2009, 572).

[18] Mad scientists can be female too, like Sarah Polley's character Elsa Kast, a modern-day Dr. Frankenstein in Vincenzo Natali's *Splice* (Natali 2009).

[19] Marvin is also an Acme customer, with a similar level of customer satisfaction.

who carries business cards introducing himself as "Wile E. coyote, Super Genius." The devices he is able to buy from the Acme company seem to support that boast, as they demonstrate his fascination with mechanical engineering; however, "for all of his failed plots at capturing the road runner, his rube Goldberg devices that work only when they want to, or his inability to reckon with such basic laws of nature as gravity, the coyote is not really "a dunce," just "more often unlucky than stupid" (Telotte 2017, 118). In the cartoons, the initial goal of catching the road runner becomes less important for both the coyote and the audience than the next absurd scheme he hatches with the help of mail-order contraptions from the Acme corporation.[20] In this he becomes a metaphoric representative of a post-war society that devoutly believes in technological advance as a solution to all its problems, even those caused by technology. This fixation on immediate, rather than long-term, goals can be seen as the cause of many of the problems that plague our modern industrial society. The headlong rush to develop new technological fixes is widely perceived as ultimately shortsighted and destructive, and the theme of an entire genre of works based on the *Frankenstein* (Shelley 1818) story.

North American viewers in the 1950s saw a series of mock-informative broadcasts that parody mid-twentieth-century educational films:

> Farm of tomorrow relies almost entirely on such strange juxtapositions, as it catalogues the sort of hybrid wonders that the new "science" of farm cross-breeding will bring, including an ostrich-chicken to provide larger drumsticks, a kangaroo-cow that will keep its milk in a handy pouch, and a banana-duck whose feathers can be peeled off more easily. […] [A]ll of these films are simply formulaic gag reels, set within a postwar science consciousness, but nonetheless revealing a shift in cultural attitudes. For they all frame their forecast developments not quite as marvels but – especially in the Avery films – as increasingly absurd variations on a theme, as rhetorical pieces in a scheme that, with a hint of rube Goldberg influence, actually puts the often-heralded accomplishments of science and technology into question. (Telotte 2017, 117–18)

What was considered comical and far-fetched in the 1950s and 60s, however, prefigures the genetic modification and cloning experiments of the 1990s that resulted in such famous creations Dolly the Sheep and a white lab mouse with a

[20] Acme (meaning "apex" or "pinnacle") is an analogue for the Sears corporation, whose mail-order catalogue allowed residents in remote locations across the continent (including canada) to purchase a multitude of items for delivery by post. today's equivalent is clearly amazon.com; a recent online search (March 30, 2018) turned up giant magnets, giant

human ear growing out of its back (cao et al. 1997). The absurdity of these creations earns them a place in the tabloids and talk shows, which often distort or ignore the science behind them. This trope of transformation is, like Swift's example of the Projectors and Dr. Johnson's critique of science in the eighteenth century, a long-established one.

Ovid's *Metamorphoses* and Mary Shelley's short story "The transformation" (Shelley 1831), provide supernatural explanations, while classic novels such as Stephenson's *Strange Case of Dr. Jekyll and Mr. Hyde* (Stevenson 1886) provide a scientific take on the story. The transformers comics and films use a cartoon meme when the transformers metamorphose. In most science fiction stories and

slingshots, jet packs and flamethrowers; there are no jet-powered roller skates, but an enterprising coyote could buy electric-powered rocketskates™. The cartoons never revealed how he paid for all these purchases.

films, it is humans who metamorphose, but in this series, as in 1930s cartoons, it is the machines that change:

> Like the live-action silent comedies that were so popular during the 1910s and 1920s, the cartoon's gag emphasis made great capital from that modernist spirit of "overturning" the status quo, even as it frequently centered those gags around different forms of "transformation". […] (Telotte 2017, 19).

## 7 Conclusion

In his pursuit of the unattainable, Wile E. has become a modern-day icon, a twentieth-century Don coyote. His quest to master a force of nature with technology puts him squarely at the centre of an enduring dilemma and debate. It is this theme that, in addition to the production quality and humour of the "Golden Age" cartoons, accounts for his enduring popularity.

As Heisenberg notes, new ideas require new language to describe them, and the animator's art in the early twentieth century was an ideal medium to express new mind- and rule-bending concepts. As relativity and quantum theory challenged long-established perceptions of reality, visual imagery and symbolism were used by scientists such as Einstein, with his thought-experiments (1905, 1915), and Richard Feynman, with his diagrams (1949), to bring about a paradigm shift in the way we describe and understand the world. Popular filmmakers used the same principles to bring these concepts, and debates, to a wide audience:

"cartoons have not always been included in discussions of the visual cultures of science, but they should be: they respond to, and can shape, public understandings of science in important ways" (Clark 2009, 573).

There has always been a duality in popular attitudes towards science and learning, from excitement and admiration for those brave enough to "boldly go where no one has gone before" to fear of unknown realms, such as "in space, noone can hear you scream." As Clark notes, "public controversies about science are useful to historians of science. They also add new inflections to the visual language of popular science iconography" (576).

Depictions of currents trends and ideas in science fiction in novels, short stories and film were and are important for bringing these concepts to a wider audience, but in the first half of the twentieth century, science fiction was still less widely consumed than it has become today. Science fiction films such as *The Day the Earth Stood Still* (Wise 1951), *Godzilla* (Honda 1954) and *Attack of the Fifty Foot Woman* (Hertz 1958), were low-budget B-movies, compared to their modern counterparts. The cartoon parodies of science fiction in works by Warner Brothers, Disney, Hanna-Barbera and others helped bring these ideas to the mainstream by making ideas presented in works of more traditional science fiction genres more familiar and less threatening.

While animated cartoons use techniques of parody and satire to elicit laughs from their audiences by poking fun at what many people consider nonsensical, they also have the effect of familiarizing people with new ideas, and as such are used for educational as well as entertainment purposes. In the 1950s, animated cartoons were used to teach science. Visual imagery makes complex concepts easier for visually-literate people to grasp, as in the Bell scientific film series from the 1950s, which included animated segments which functioned "'by weaving together live scenes, fantasy, traceries of diagrams, animated cartoon characters, puppets, and – above all – humorous illustrative parables, metaphors, similes, and analogies, we reduced the complex to the simple, the eternal to the everyday'" (Telotte 2017, 123).[21]

Nowadays, in addition to their widespread use as parodies, cartoons are often used to teach in standard textbooks. "Hip-Hop Physics" (Hayes 2009) uses analogies from cartoons to model and understand physical problems. Modern

[21] A series of eight films, the first four directed by Frank Capra, *Our Mr. Sun* (1956), *Hemo the Magnificent* (1957), *The Strange Case of the Cosmic Rays* (1957), *The Unchained Goddess* (1958) and the second four by Owen crump, *Gateways to the Mind* (1958), *The Alphabet Conspiracy* (1959), *The Thread of Life* (1960) and *About Time* (1962).

textbooks use cartoons and animated graphics to teach science concepts; for example, when teaching the effect of air resistance on an object in free fall, Grubelnik et al. found that elementary school students find it easier to understand concepts of math and physics when they use computer graphics to help visualise examples from their experience (Grubelnik et al. 2018).

Thus, Wile E. coyote went from comic foil to an Everyman of the twentieth century. In trying to adapt himself to a challenging nature with the use of flawed and overhyped technology, his inevitable pratfalls and defeats, tempered with his determination, gave audiences something to both laugh at and admire. His difficulty with the seemingly arbitrary laws of nature reflects our difficulty in comprehending a world whose rules seem to be changing around us, while at the same time his determination to succeed by repeating the tactics that have always failed him give an educational, as well as an entertaining, dimension.

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**Appendix A – Chronological Use of Effects in a Selection of Road Runner Cartoons**[22] Jones, Chuck, dir. 1949. "Fast and Furry-ous." U.S.A.: Warner Bros. Pictures.

First Wile E. coyote cartoon; painted tunnel on mountainside.

—, dir. 1952. "Operation rabbit" (with Bugs Bunny). U.S.A.: Warner Bros. Pictures.

First use of "Wile E. coyote, Genius."

—, dir. 1952. "Going! Going! Gosh!" U.S.A.: Warner Bros. Pictures.

Bows and arrows; catapults; glue; grease; rockets; hand grenades; painted picture trap in front of chasm → Gravity Observer effect; Acme Street cleaner's Wagon + 500lb anvil + Excelsior Electric Fan + weather balloon.

—, dir. 1953. "Zipping Along." U.S.A.: Warner Bros. Pictures.

Hand grenade; Acme Giant Kite Kit + bomb; Acme Bird Seed + Ace Steel Shot + giant magnet; Standard Gravity (parabolic arc); spaghettification; Acme Nitroglycerin. —, dir. 1953. "Don't Give Up the Sheep" (featuring ralph Wolf and Sam Sheepdog). U.S.A.: Warner Bros. Pictures.

Sam gives ralph the same sideways punch that john Bigbouté gives the hunter in *Buckaroo Banzai*. ralph is a coyote in wolf's clothing.

—, dir. 1954 "Stop! Look! And Hasten!" U.S.A.: Warner Bros. Pictures.

Acme Bird Seed; Acme Leg Muscle Vitamins.

—, dir. 1955. "Guided Muscle." U.S.A.: Warner Bros. Pictures.

Bow and arrow; slingshot; cannon; TNT; Acme Grease; home-made tar-and-feather machine.

—, dir. 1955. "ready, Set, Zoom!" U.S.A.: Warner Bros. Pictures.

Acme Glue + dynamite + standard gravity (parabolic arc); second time–parabolic arc; catapults; dynamite; Acme Outboard Motor + jim-dandy Wagon + washtub + roller skates = Gravity Observer Effect (coyote only falls when he realises he is in thin air) + spaghettification); rocket; Acme Female roadrunner costume.

—, dir. 1956. "There They Go-Go-Go!" U.S.A.: Warner Bros. Pictures.

Gravity Observer Effect 3x; dynamite; rocket.

—, dir. 1956. "Gee Whiz-z-z-z-z-z-z." U.S.A.: Warner Bros. Pictures.

Acme triple-Strength Battleship Steel Plate Armor – the road runner goes right through it (and the coyote too); Acme Bat-Man Outfit; Acme Giant rubber Band. coyote goes through the ground. And through a mountainside. reversal of the sight gag where the road runner goes through painted mountainside and the coyote can't. In this one, the road runner goes through the painted barrier

[22] This selection includes cartoons produced at the Warner Bros. cartoons Inc. studios, which closed in 1963.

in “real” life, and the coyote follows into the fictional painted scene and over the painted cliff edge; Acme handlebars + Acme jet motor → Gravity Observer Effect.

—, dir. 1957. “Zoom and Bored.” U.S.A.: Warner Bros. Pictures.

Gravity Observer Effect 2x; electric road drill; dynamite; Acme Bumble Bees; falling anvil; catapult; Ahab Harpoon Gun

—, dir. 1957. “Scrambled Aches.” U.S.A.: Warner Bros. Pictures.

coyote falls over cliff, climbs out of hole at the bottom 2x + spaghettification + Acme Dehydrated Boulders.

—, dir. 1958. “Hook, Line and Stinker.” U.S.A.: Warner Bros. Pictures.

Dynamite; Acme Bird Seed; rube Goldberg machine.

—, dir. 1958. “Hip-Hip-Hurry!” U.S.A.: Warner Bros. Pictures.

Hand grenades; dynamite; speedboat; Acme Mouse Snare + Acme Hi-speed tonic (contains vitamins r, P & M).

—, dir. 1958. “Whoa, Be-Gone!” U.S.A.: Warner Bros. Pictures.

Gravity Observer Effect and spaghettification; Acme giant rubber band; Acme Do-it-yourself tornado Kit.

—, dir. 1959. “Wild About Hurry.” U.S.A.: Warner Bros. Pictures.

rocket; concertinafication; Acme Giant rubber Band; invoice from Acme Shopping center (for rocket sled, track and accessories); Acme Bird Seed + Acme Iron Pellets; magnet + roller skate + hand grenade; Acme Indestructo Steel Ball.

—, dir. 1960. “Hopalong casualty.” U.S.A.: Warner Bros. Pictures.

Dynamite; Acme christmas Packaging Machine; Acme Earthquake Pills; gravity parabolic arc.

—, dir. 1960. “Fastest with the Mostest.” U.S.A.: Warner Bros. Pictures.

Standard Gravity: first time the coyote falls over a cliff and his trajectory is a parabolic arc. Second time: Observer Effect and spaghettification. More spaghettification later. At the end, Wile E. coyote holds up a sign that reads “I wouldn’t mind, except that he defies the law of gravity!” Then, road runner holds up a sign that says “Sure – but I never studied law!” —, dir. 1961. “Lickety-Splat.” U.S.A.: Warner Bros. Pictures.

Spaghettification 4x + Gravity Observer Effect; roller skis; bow & arrow; dynamite darts + balloon; boomerang; falling anvil.

—, dir. 1961. “Beep Prepared.” U.S.A.: Warner Bros. Pictures.

Gravity Observer Effect; concertinafication; portable hole; Acme Iron Bird Seed + giant magnet; Acme Little Giant Do-it-yourself rocket Sled Kit.

—, dir. 1961. “Zip ‘n’ Snort.” U.S.A.: Warner Bros. Pictures.

Gravity Observer Effect; Acme Iron Pellets + giant magnet; standard gravity parabolic arc; Acme Axle Grease (Guaranteed Slippery).

—, dir. 1962. “Zoom at the top.” U.S.A.: Warner Bros. Pictures.

concertinafication; Gravity Observer Effect; Acme Bird Seed; Acme Instant Icicle Maker; Acme Boomerang + Iron Glue.

—, dir. 1963. “to Beep or Not to Beep.” U.S.A.: Warner Bros. Pictures.

Gravity Observer Effect; concertinafication (including concertina sound effect); wrecking ball; catapult.

—, dir. 1964. “War and Pieces.” U.S.A.: Warner Bros. Pictures.

Hand grenades; electric eye; Acme Invisible Paint; rocket.