



## Chapter 1: Essay

# Science Denialism *Did we really land on the Moon?*

Common knowledge is that about half a century ago, astronauts landed and walked upon the Moon. This was the culmination of NASA's programs of the 1960s in the context of the "space race" between competing countries—the United States and the then-Soviet Union. The Soviets were the first to launch an orbiting satellite and the first to send a person into space. The Americans, not wanting to be out-done at the height of the Cold War, set the lofty goal of being the first nation to land a human on the Moon. It was a daunting mission performed in an age before advanced computers. Mistakes were made and, tragically but unsurprisingly, astronauts lost their lives. But success was achieved when Neil Armstrong first stepped foot on the Moon on July 20, 1969. It was undeniably one of the greatest achievements in human history. Reaching the Moon was an illustration of what can be accomplished when people work together with reason, creativity, a sense of purpose, and, importantly, an understanding of the rules of nature.

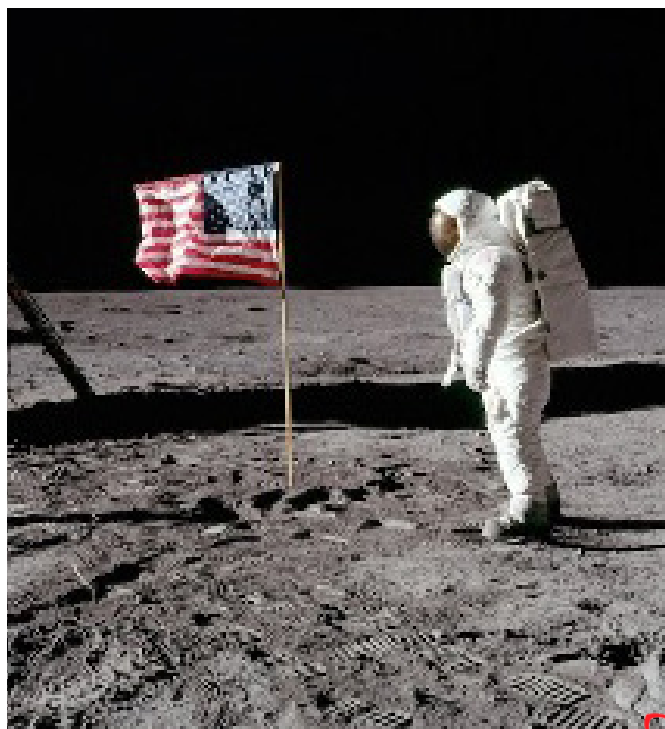
Figure A. Accompanying Armstrong was astronaut Buzz Aldrin, who honors the American flag. The flag is held up against the Moon's gravity by a stick across the top. The waves in the flag resulted not from wind (there is no wind on the Moon) but from how they had to twist the pole into the lunar soil so that it would remain standing.

However, not everyone believed or believes that a human walked on the Moon. Thirty years after the landings, a Gallup poll indicated about 6% of Americans believed the lunar missions were staged in a studio, with the help of prominent film makers. This belief has grown with the rise of social media where voices of no authority can receive much attention and even credibility. Young people today were born many years after the lunar missions. Because they

weren't there to see the dramatic events unfold, they are perhaps more susceptible to conspiracy theories about the lunar missions.

So, did we really land astronauts on the Moon? And more generally, how can truth versus falsehood be determined in today's world, where just about anyone can say just about anything through a broad array of media channels that do little fact-checking? These are big questions to ponder. However, today as in ancient times, **logic supported by verifiable evidence** provides a reliable path to the truth. Think of this recipe for truth-finding in terms of your own life, as well as on the world stage. Let's practice by applying logic and evidence to assess whether the lunar landing actually occurred. Consider the following:

1. With today's space telescopes we can see the lunar landing sites, as shown in Figure B.



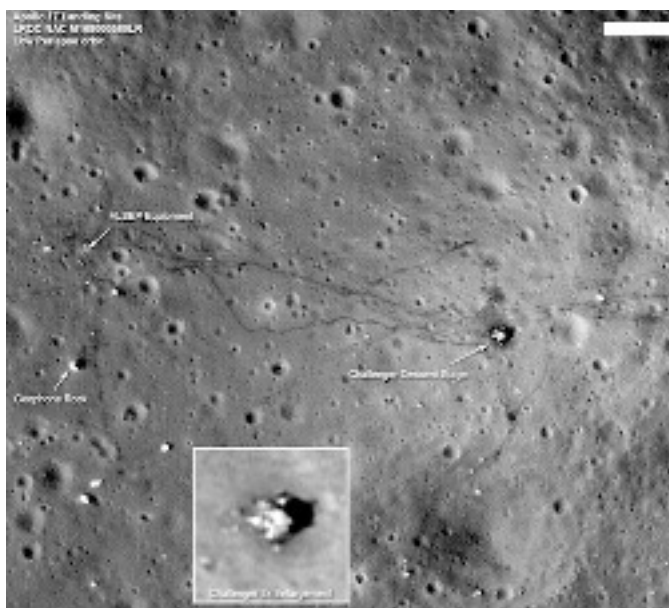


Figure B. The Apollo 17 landing site recently photographed by the Lunar Reconnaissance Orbiter. Lunar rover and astronaut foot trails are evident.

2. The Apollo astronauts brought back some 842 pounds of Moon rocks that have been studied (and authenticated) by scientists around the world.

3. The Soviets tracked the progress of our spacecrafts as they traveled to the Moon and back. Given the nature of the space race, it would be most unlikely the Soviets would have been willing to go along pretending that the Americans successfully beat them to the Moon.

4. The astronauts left reflectors on the surface of the Moon. Scientists today routinely reflect laser light off these reflectors to aid measurement of the Moon's distance and for other experiments.

5. If NASA were faking it, why did they continue going back to the Moon six more times, from Apollo 11 in 1969 to Apollo 17 in 1972? With each mission, they would be increasing the chances of error and their forgery revealed.

6. In the late 1960s, there were no modern computers and certainly no CGI to create fantastic computer-generated scenes as in today's movies. Science is a mode of inquiry and a body of knowledge built upon rational thinking and experimental evidence. Does reasoning and all the evidence support the claim that Neil Armstrong and Buzz Aldrin walked on the Moon? How can you defend your opinion? If you use logic and evidence, then you are thinking in a scientific manner.

Some people might reject science because they don't understand the details. The remedy for this would be more education, which puts the person in a position to accept or reject an argument based on the merits. But you need not be an expert. Even basic knowledge can go a long way to helping you understand the big picture. Furthermore, basic knowledge helps to cement your trust in those who are bonafide experts. From this foundation, there's value in any disagreement you might have with a particular conclusion. Why? Because your disagreement is made from understanding, not ignorance.

There can be an emotional motivation behind denying scientific information. This often occurs when scientific findings carry implications for public policy that are distressing or distasteful. It's analogous to what might happen with your dentist. If your dentist tells you that you need a root canal, you may not want to believe her evidence and reasoning. You are emotionally motivated to deny the report. So, you go for a second opinion, and perhaps a third—which is quite reasonable. You are gathering data to evaluate. But at a certain point, if all of the credible dentists you visit are in consensus about your diagnosis, you will be wise to set your emotions and short-term preferences aside, and try to understand the science of what is happening to your tooth.

Think of a less wise approach: You interview 10,000 dentists until you find one who declares no root canal is needed. You then heed the advice that no root canal is needed. Further, you praise and elevate that dentist's credentials because finally you found someone who knows how to listen to your underlying needs. You convince yourself there are always two sides to a story. You think of yourself as a crafty renegade for bucking a system that's clearly corrupt and self-interested. What you would be doing here is known as "cherry-picking" the evidence. Cherry picking evidence means that you only consider evidence supporting your case, no matter how outlying that evidence is. Cherry-picking evidence is a common way to deny the validity of scientific claims.

As we know, science sometimes reveals facts that are not welcome. More serious than a rotten tooth, is the case of climate change. Is climate change



Figure C. Planet Earth as seen from the Apollo 11 mission while in low orbit around the Moon.



a real threat? If so, how do we respond? How much easier it would be if anthropogenic climate change were not an actual threat to the biosphere. We could keep using fossil fuels, keep cutting down forests to build roads and raise livestock, and otherwise maintain our modern, resource-consuming lifestyles. It can be quite tempting to ignore the science outright without even understanding it—to deny it—because it is threatening and emotionally disturbing.

Denying the lunar landing makes for a juicy conspiracy theory—one that some might find entertaining, shocking, or fun to think about—like a scary movie. Hopefully, the scientific reasoning and evidence presented above regarding the Apollo missions helps to put this juicy conspiracy theory to rest. Just as we must leave the theater after a scary movie in order to function in the real world, we ultimately need to leave unfounded conspiracy theories behind and devote ourselves to understanding the real world—for our impact upon it is immense. The physical world, knowable to a large extent through science, offers *real* rewards, joys, sustenance, and plenty of hazards too. The human population is booming like never before. This means we are taxing the environment that sustains us like never before. Can we ultimately use what we learn from science to address our modern challenges and to accomplish great things? If we've been to the Moon and back, then the answer is a resounding yes.

#### CONCEPT CHECK

Why are long term problems, like over-population, easier to deny than short term problems, like a sewage spill?

**CHECK YOUR ANSWER** It's common for people today to think short term. I'm hungry. I want to buy that car. Wow, that sewage stinks. These problems are focused, relatively easy to address, and solving them provides immediate gratification. A problem that develops over a longer time scale, such as too many people in too small a space—overpopulation—is more difficult to grasp, especially if you live in a sparsely populated area. Addressing long-term problems requires a focus on the future and commitment to a sustainable way of life. This is a greater challenge.



#### FOR YOUR INFORMATION

**Skepticism:** Unsubstantiated claims hold no value.

**Denialism:** Substantiated claims hold no value.

