

X-Men

There are certain movies where you must completely suspend your disbelief in order to enjoy the fantasy. In some of these, the fundamental premise requires that the principles of physics (and biology and chemistry) as we know them are completely dispensed with. X-Men are one of these movies.

THE SYNOPSIS: The film takes place in “the not too distant future” where a fearful public persecutes “mutants” with superpowers. The mutants split into two opposing camps. The first is led by the stately, dignified, and compassionate Dr. Charles Xavier, who is hopeful that mutants and humans can learn to live together in mutual respect and peace, while the disaffected and irritable prepared to destroy humanity to assure the ascendancy of the mutants.

NOTE: Because the main purpose of X-Men is completely implausible (after all, it is based on a comic book), we can't be upset by the lack of any adherence to physical reality. The idea that random mutations are somehow creating a race of “super-people” with incredible powers (while a lot of fun) is ridiculous and silly. As far as the physics goes, much of what happens is impossible to comment on because it's so far outside the realm of possibility that we wouldn't know where to begin. Nevertheless, we can point out some of the more obvious and specifically identifiable violations of major principles that run throughout this film. In this worksheet, we'll start with a character analysis of each character.

1. Magneto is an extremely powerful mutant who is somehow able to generate huge electromagnetic fields and therefore exert forces on any metallic objects in his vicinity.
 - a. Considering the fact that magnetic fields are produced by moving charges. How do you suppose Magneto accomplishes this huge magnetic field to move or crumple large objects like trains and bridges? Explain your theory. (Note: How would you devise a military weapon to do the same thing?)

- b. Even if you aligned every charged molecule in a human body, would it be possible of create this type of magnetic field? Explain.
- c. The amount of force that he applies must be incredible, and yet during one of these amazing feats we never see any physical effect on Magneto himself. Assuming that he can create force at-a-distance this large, is it possible to be unaffected while moving a bridge? Explain. (Note: Newton's 3rd Law: For every action there is an equal but opposite reaction. $F_{rxn} = -F_{axn}$ since, $F = ma$ in Newton's 2nd Law then $Ma = -mA$)
- d. Materials that form magnetic domains with magnetic fields pointing in the same direction are called "ferromagnetic". Many atoms in solids have a very weak magnetic interaction with their neighbors, so if placed in a strong external magnetic field, they will align in the direction of the field but will randomize again at room temperature once the field is removed. These materials (such as molecular oxygen, gaseous nitric oxide, and aluminum) are termed "paramagnetic." And there is a third class of materials in which, due to the nature of the interactions between adjacent atoms and the chemical ordering of the atoms, their atomic magnets (generated by electron orbits within the atoms) line up opposite an external magnetic field. If an external line magnetic field is applied to these materials and the field's North Pole points up, the atomic magnet's North Pole rotates to point down. These materials are called "diamagnetic," and they try to cancel out any external magnetic field. Gold and silver are diamagnetic. Water molecules are also diamagnetic. What type of magnetism do you think is the basis of Magneto's power? Explain.

- e. In moderate strength magnetic fields, the atoms in your body are not susceptible to being polarized. The diamagnetic interaction is weak, such that at room temperature, the normal vibrations of the atoms overwhelm the attempt to magnetically align them. In a very strong field, roughly two hundred thousand times greater than the Earth's magnetic field, the diamagnetic atoms in your body can be induced to all point in the same direction---opposite to the direction of the applied field. Just as two magnets repel if they are brought together so that their north poles are facing each other, the now magnetically polarized person will be repelled by the external magnetic field Magneto is creating---the very field that magnetically aligned the atoms in the first place. As Magneto increases the magnetic field he generates, the magnetic repulsion can become strong enough to counteract the downward pull of gravity. Assuming that Magneto can generate a large Magnetic field, would this explain his ability to levitate him and others? Explain. What would Magneto need to do to be able to fly around like Superman? [Note: The High Field Magnetic Laboratory at the University of Nijmegen in the Netherlands has amusing images on their website of floating frogs, grasshoppers, tomatoes and strawberries]
- f. There is another, easier method Magneto could use to threaten the stability of the world without menacing the existence of the Earth. It's a power he controls and has used in limited capacity. It's the awe-inspiring force of the electromagnetic pulse (EMP) bomb. It's a weapon that every nation in the world is trying to master at this very moment. Research the internet on this subject and reply with your opinion below: [Note: Can Magneto act like an EMP bomb? Can this make him as a powerful villain in itself?]
2. Dr. Jean Grey is "telekinetic" (she can move objects with her mind). As we understand physics, the only way she would be able to move (accelerate) masses this way is to apply a force to them.

- a. We will avoid the argument of what “telekinesis” could possibly be and just point out that when Jean tosses some large object across the room, would she also be tossed backwards in the opposite direction? Explain.

 - b. How is this similar argument that we have with Magneto?

 - c. Could Magneto have telekinesis, but interprets it as a magnetic force? How are they different?
3. Storm has the ability to change weather. She can form clouds, produce incredible wind storms, and rain lightning bolts down on her adversaries.
 - a. How is Storm’s ability to move atmospheric water around, similar to Jean Grey’s telekinesis, and Magneto’s magnetism?

 - b. The amount of energy involved in an average thunderstorm is on the order of a 20 kiloton nuclear bomb (around 10^{13} Joules). This is around 10 billion times the chemical energy required to run a marathon. With this in mind, who has the greatest power, Storm, Jean Grey or Magneto? Explain.

 - c. Do you suppose that Storm has some organ in her body that acts like a nuclear reactor to create large amounts of energy from small amounts of mass? Explain.

 - d. A physically plausible explanation for Storm’s ability to control the weather is that she is able to alter atmospheric temperature variations in space and time at will. The wind that allows Storm to fly is created by a temperature gradient

beneath her. Would Storm use her mutant power to make the region of air under her hotter or colder to enable her to fly? Explain.

- e. If Storm is indeed able to control the local temperature, then she can also vary the barometric pressure and humidity at will. It is not unreasonable that she would be able to cause localized rain or snowstorms, or even generate lightning strikes. However, would her ability to control the exact position of the strike be hampered? Why? Explain: {Hint: Lightning strikes is a charge build up between two locations of Positive and Negative)
4. Cyclops' optic blast power is permanently "stuck" in the "on" position. The only two ways he can dampen his optic blasts are by closing his eyes or by wearing a visor---- wraparound glasses or goggles made of ruby quartz. The ruby quartz diffused the optic energy and renders it harmless and undetectable. Cyclops can focus the width of his force blasts with his eyes. The depth of his eye-blasts is controlled by his visor's adjustable slit.
- a. The energy that comes out of Cyclops' eyes is unusual, to say the least. It generates no heat, no radiation and no electrical or magnetic fields. If they did, what would this do to Cyclops? [Note: There is no evidence suggesting that Cyclops' physiology is as impervious as an atomic energy plant's containment vessel. In fact, he is vulnerable to everything that a normal non-mutant human is.]
 - b. Although Cyclops' beam is visible, it doesn't seem to be part of the electromagnetic spectrum. If it was, what are some of the problems in using a high powered laser beam as a weapon? [Hint: Reflection and Heat] [Note: Lasers slowly cut through things with heat]

- c. Cyclops' beam can manipulate molecules and it has concussive shock power. Would you define Cyclops' power as a force, energy or both? Explain.
- d. Why can ruby quartz or eyelids stop Cyclops' optic blasts? However, these same optic blast blow holes through a ceiling.
- e. Does the ruby quartz in Cyclops' visor function like a pair or really powerful sunglasses? Explain. (Note: Quartz is a crystal, and some crystals can force light waves into two separate rays, oscillating on two separate planes.)
- f. How is Cyclops able to see past the energy always flowing from his eyes? (Note: Although the energy emits or reflects a red glow, it must allow normal light to pass through it.)
- g. Perhaps Cyclops's power is not energy but, in fact, matter---a stream of exotic particles, perhaps a particle beam of sorts. Roughly speaking, most matter is composed of atoms, which are composed of subatomic particles called electrons, protons, and neutrons. Most subatomic particles are composed of quantum particles called quarks labeled: up, charm, top, down, strange, and bottom. These quantum particles, which you could call sub-atomic particles, are glued together with "messenger particles," called gluons. If you strip away the electron "shells," of atoms, then a type of matter can be formed called plasma. Plasma is a stream of charged or uncharged particles. Is there a possibility that we're dealing with a directed form of Plasma? Explain clues in the movie.

5. Mystique is a shape-shifter who naturally looks blue. Mystique has a number of powers including: the ability to change skin color; the ability to shape-shift---that is change form; the ability to impersonate other voices; and the ability to rapidly grow her hair.
- a. Is there an example in nature where an animal has the ability to change their skin color to match their environment? If yes, give an example:

 - b. Through a combination of genetic manipulation to activate melanocytes (and possibly chromatophores), and the use of surface coatings, it is not unforeseeable that we could develop human chameleons. However, do you think that a skin-color change from a conscious decision might be a problem? How can you wire the body such that skin color responds to your thoughts? {Note: Research on the internet on how animals can do this}

 - c. Through the use of electronics and simple mimicry; do you think it might be possible to impersonate another person's voice in the near future? Explain.

 - d. Is it possible to foresee rapid hair growth through rapid protein synthesis? (Hint: Spider Webs). {Note: Research on the internet on how animals can do this}

 - e. Do you think that shape-shifting is possible? Is there an example of immediate shape-shifting in nature? If yes, give an example. [How can a human change its 3D shape?]

6. Toad is a member of Magneto's Brotherhood and possesses enhanced leaping capability and acrobatic speed, agility, dexterity, reflexes, coordination, balance, a sticky prehensile 13-foot (4.0 m) tongue, and the ability to spit acidic mucus that hardens almost instantly.
- Toad battles Storm, Cyclops, and Jean Grey all at once in the battle of the "Statue of Liberty". What does he do with Cyclops?
 - What does he do to Jean Grey as she stops him in mid-air?
 - Storm flies up and blows Toad out of the statue. He latches his tongue onto a support beam to stay alive. However, Storm strikes his tongue with a lightning bolt and electrocutes him. Since, electricity finds the shortest way to the ground, is Toad's main body electrocuted? Is Toad's main body electrocuted? Explain.
Is Toad's tongue electrocuted? Explain.

7. Wolverine is a mutant with a number of natural mutant powers and artificial improvements to his physiology. His primary mutant power was an accelerated healing ability that allowed him to regenerate damaged or destroyed areas of his body and cellular structure far beyond the capabilities of an ordinary human. He could regenerate organs such as missing eyes and large portions of flesh. Wolverine's natural mutant attributes stemmed from, at least partially, his accelerated healing factor. This "healing factor" also granted him virtual immunity to poisons, most drugs, toxins, and diseases, and limited immunity to the fatigue poisons generated by his own body.
- Would these unique regenerative qualities of his healing powers have an age suppression factor? Explain.

- Cell growth is dependent on protein synthesis, which is, in turn, dependent on ribosome synthesis. What are Ribosomes and why are they important to healing damaged tissue? (Hint: Use the Internet.)
- A wide variety of hormones play a major role in the stimulation of cell growth which is what causes healing. Steroids are one group that stimulates a certain type of cell growth---muscle cells in particular. Can

we assume that Wolverine must have hyped-up steroidal activity? What are enzymes and how are they related to cell growth? (Hint: Internet)

- iii) Wolverine's fast-healing factor would have to call upon a cocktail mix of hormones, enzymes, and other growth factors. Hormonal interactions and imbalances can create a wide range of behaviors. What Wolverine behaviors do you see in the movie that is explained by overstimulated hormonal functions?

- iv) Wolverine obviously relies a great deal upon adrenalin and the source of that is located in the adrenal glands on the upper inner surface of his kidneys. However, hypercorticism or Cushing's syndrome is an illness resulting for over activity of the adrenal cortex and often results in progressive weakness and muscle wasting. Does it appear that Wolverine suffers from hypercorticism? Explain

- v) Some of Wolverine's odd physical abilities could possibly be the result of hormonal imbalances. Consider, for example, the effect of too much estrogen on a human male: a distinct feminization of the features will usually occur, including the development of breasts and high-pitched voice. The reverse effects, hirsutism and muscle development, result when a human female receives too much testosterone. Most of us are familiar with the mood swings associated with both Pre-Menstrual Syndrome (PMS) and Post-Partum Depression, when hormonal imbalances can create physical and emotional problems. What hormone do you think Wolverine has problems with? Explain.

- b. Wolverine possessed superhumanly acute senses that were comparable to those possessed by certain animals.
- i) Wolverine was able to see objects with greater clarity and at much greater distances than an ordinary human. His sight was enhanced to the point that he could see with this same level of clarity in almost complete darkness. What animal has similar properties? Do you think Wolverine can see into the infrared and ultraviolet portions of the spectrum? What animals are able to do this?
 - ii) Wolverine's sense of hearing was enhanced in a similar manner, allowing him to hear sounds that humans could not. What animal has similar traits and what characteristics do they have that enables this? (Note: Some animals can sense subsonic and ultrasonic frequencies. This is due to shorter and longer hairs in the cochlea that vibrate to the shorter and longer waves of ultra- and sub-sonic frequencies, or perhaps special sensing organs in some animals)
 - iii) Wolverine was able to use his highly developed sense of smell to track targets by scent. He was able to track targets with an impressive degree of success, even if the scent had been eroded by natural factors such as weather conditions. What animal has these same super traits? Why? [Note: The nose collects odors and the molecules with scent are drawn to the hair-like cilia of receptors in the two olfactory mucosae (nose holes). These cilia stick out of the tops of neurons and into the mucosa, which is a thin layer of mucus on the surface of the cell. There are at least 10 cilia per neuron and they are located in the epitheliums. Each of the two epitheliums is only a few centimeters square but has about 5 million neurons, not to mention their supporting cells and stem cells. Conceivably, a **larger** epithelium would aid a higher odor detection rate.]
- c. One cannot talk about Wolverine without discussing the amazing metal alloy known as adamantium. It is best known for being the substance bonded to Wolverine's skeleton and bone claws. The metal is somehow liquefied, and then made to combine with his bones (and claws!) to create an almost invulnerable hero.

- i) In 2004, several groups succeeded in producing bulk amorphous steel. The Oak Ridge group refers to their product as “glassy steel”. Their material is non-magnetic at room temperature and is significantly stronger than conventional steel. An amorphous metal is a metallic material with a non-crystalline, disordered structure. The material is cooled at an incredibly rapid rate, locking the metal into a “glassy” state without giving crystals time to form. Would this help explain how a strong metal is somehow liquefied and then cooled into a superhard state?
- ii) The idea that metal can be bonded or combined with organic tissue is not as science-fictional as it sounds. For example, the mandibles of leaf-cutter ants and locusts are peppered with zinc, making them stronger and more durable. A new titanium foam developed by scientists at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials Research will now enable average human beings to embed their bones with the metallic substance, making them virtually indestructible. This alloy is already used in bone replacement but this new foam will allow for it to be used in many more people. It is virtually the only metal that isn’t rejected by the human defenses. [Note: Given the hardness of adamantium, it is conceivable that it would retain its stability and cohesion even when shaved to molecular thickness.] Do you think that the fictional alloy of adamantium might become possible? Do you think that an alloy of titanium might be a real world replacement? Explain.

8. The main X-Men aircraft is a jet called the Blackbird. This was one of the last jets designed by the Lockheed “Skunkworks” in the early 1970s and was designated the RS-150. The highly classified RS-150 was intended for the U.S. reconnaissance program but was never used. It was later designated the SR-71 and was code-named Oxcart during its development. It flies on a tremendous 65,000 lbs. of thrust at an altitude of 100,000+ feet at Mach 3.5 and has a range of four thousand miles. That’s four times faster and seven miles higher than the U-2. At this speed, how much time would it take to go coast to coast across the U.S.? (Estimate and use the internet for distance).

