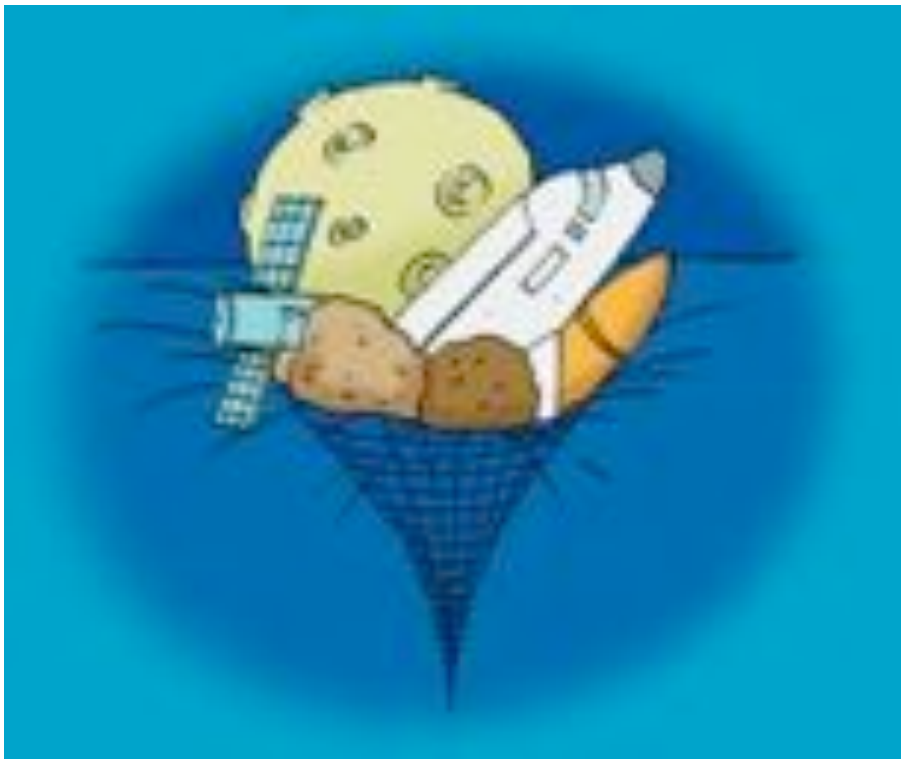
# Chapter 1

Misconceptions and Lies

*The opinion of 10,000 men is of no value if none of them know anything about the subject. - Marcus Aurelius*



# Misconceptions and Lies

*Left to right: Phil Plait (Mr. Bad Astronomy), crescent Moon and the Sun, the Great Wall of China, the Mars Face*

Everyone who has ever lived, has lived in the Universe. The Sun, the Moon, and the stars surround us. Yet few people take the time to look at the sky and fewer still take the time to think about what they see. As a result, much of what people "know" about the Universe around them is oversimplified, half-right, or just plain wrong. On top of that, there are people who are not afraid to spread the outright lie if they think they can profit from it. So, before taking a look at our Universe, maybe it's a good idea to look at some of these misconceptions, so they don't get in our way as we explore the Universe.

Dr. Phil Plaitt has made in his mission to expose astronomical misconceptions. Many of these bad ideas are taken from Phil Plaitt's book, *Bad Astronomy*. His website is also highly fascinating.

## STARS

### The North Star

You've probably been told somewhere along the line that the brightest star of the night-time sky is the North Star. You may even have told someone *else* that the North Star is the brightest star.If you have, don' feel bad, but unfortunately the North Star isn't the brightest star. It's not even the second or third brightest. It's about the 50th brightest! In fact, in a big city where there are lots of lights, the North Star can be a little difficult to pick out in the sky and most people are disap-

pointed when it is pointed out to them. Whereas the brightest stars in the sky are called *first-magnitude* stars, the North Star is a *second*-magnitude star.

Although it's not one of the brightest stars in the sky, it's still a very special star. What's special about it is that it stands directly above the Earth's North Pole. In fact, the real name of the North Star is **Polaris,** which is short for *Stella polaris,* Latin for the Star of the Pole. Since Polaris is above the North Pole, it can be seen all the time from anywhere in the Northern Hemisphere.

Wherever you are, it marks the direction north. Moreover, if you watch the sky all night long, you will see the stars moving in circles centered on Polaris. Polaris, alone of all the stars, stays in the same position in the sky all night long (and all day long, too).

The brightest star in the sky, apart from the Sun, is the Dog Star, Sirius. It is a star of the winter skies. Sirius is a Greek word that means "blazing" or "scorching." Sirius is 25 times brighter

than Polaris. Even in Los Angeles, you will have no trouble seeing Sirius.

*The constellation Orion (center) and Sirius (lower left), seen during the Orionid meteor shower.*

## Shooting Stars

Maybe you've seen a shooting star. It looks like a streak of light in the sky that lasts less than a second. It's different from a comet, which lasts for many weeks. Before we had electricity, people saw shooting stars or falling stars all the time. Today in modern cities only rarely do you see a shooting\ star bright enough to be seen, but it does happen.

The misconception is that shooting stars are stars that have fallen out of the sky. This is just a folk tradition. When you remember that stars are really just suns and that the Sun is a hundred times bigger than the Earth, you realize that it would not be a good day if a star were to fall to Earth!

The scientific name for a shooting star is a *meteor.* The word is of Greek origin and refers to something that happens in the air. *Meteorology*, the science of weather, comes from the same

word. What causes a meteor is not a star, which is very big, but a bit of dust, which is very small. There are dust grains flying all over the solar system. Many of them are debris from old comets. The dust grain itself is called a *meteoroid.* Meteoroids travel at high speeds—tens of thousands of miles per hour. When a meteoroid runs into the Earth, it hits the atmosphere at such a high speed that it compresses the air in front of it to the point where the air becomes hot enough to glow. The flash of light we see is nothing more than the hot air.

When the Earth crosses the path of a comet, the comet debris hitting the atmosphere creates an unusually large number of meteors, all of which seem to be coming from the same direction. Such an event is called a *meteor shower.* The Orionid meteors, for example, are cause by fragments of Comet Halley. Meteor showers always occur at about the same date every year. The Orionid meteors, for example, occur about October 20.

The meteoroid itself usually burns up in the atmosphere, maybe a hundred miles above the surface. Occasionally, a rock-sized meteoroid falls into the atmosphere. Such a large meteoroid has a chance of making it to the surface. If it does, it is now called a *meteorite.*

## Name a star after your girl friend

Now we come to an outright fraud. There are companies that, for a fee, will name a star after you or someone you choose. They advertise on radio, particularly during Christmas and Valentine's Day. They make it out to be a romantic gift for your girl friend or boy friend.

What you need to know is that these companies have no right to name a star after anyone. It's not that they're doing anything illegal, it's just that you have as much right to name a star after someone as they do. If you really want to name a star after your friend, just print out a certificate on your computer. It has as much validity as what you would get from the company.

The International Astronomical Union is the body officially charged with the task of naming celestial bodies. They don't, however, assign names to stars. A few stars, like Sirius, have traditional names that are universally recognized. Most stars, however, are identified by a number in a catalog. If you want to have something officially named after your girl friend or boy friend, you need to discover an asteroid. Asteroids can be named after anyone, or anything, you like—except

yourself. If you want to have something named after yourself, you need to discover a comet.

*Hind's Crimson Stor, one of the few stars named after a person—unofficially, of course. Its official name is R Leporis.*

## THE MOON

### The Moon comes out only at night

People associate the Sun with the day and the Moon with the night. The misconception is that the Moon is out *only* at night. It is certainly true that the Sun is out only during the day. But it is false logic to conclude that the Moon is out only at night.

The Moon goes around the Earth once a month. It goes around the sky in a path that takes it close to the Sun once a month. When the Moon is closest to the Sun in the sky, we say the Moon is **new**. You can't actually see the Moon when it is new, because the side of the Moon facing us is dark and the Moon is lost in the glare of the Sun.

The truth is that the Moon can be in the sky any time of the day or night, depending on where it is in the lunar cycle of phases. When the Moon is new, it rises at sunrise and sets at sunset. However, since you can't see the Moon when it is new, so no one realizes it's in the sky.

The full Moon is opposite the Sun in the sky. Because of this, the full Moon rises at sunset and sets at sunrise. That is to say, when the Moon is full, it's up all night long. The Moon is much

much brighter when it is full than at any other time, so the Moon is much more noticeable when it is full. Perhaps that is partly why people think the Moon is up all night long.

In other times of the lunar cycle, however, the Moon can be up during the daytime. From night to night, the time of moonrise is about an hour later. So, the day after the full Moon, the Moon rises about an hour after sunset. Two days later it rises two hours after sunset, and so on, until 14 or 15 days later it is rising at sunrise. By that time, it is new.

*Crescent moon (left), gibbous moon (center), full moon (right)*

## The phases of the Moon are caused by the Earth's shadow

When you look at the Moon, sometimes it is a slender crescent, sometimes it is full, and sometimes it is in-between. The changing appearance is called the Moon's **phase.** You've probably been told at one time or another that the part of the Moon that you can't see is covered by the Earth's shadow.

This is one of the most common misconceptions about the Moon. Like many misconceptions, it has a germ of truth to it. The germ of truth is that the Earth's shadow *can* fall on the Moon. However, this is an unusual event—a **lunar eclipse.** Lunar eclipses occur once every six months or so. They are not particularly rare, but they don't happen every night.

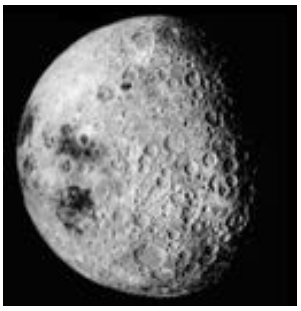
The truth is much simpler. The Moon doesn't give off any light of its own. It only reflects the Sun's light, just as you do when you are out in the Sun. One half of the Moon is in daylight and the other half is in darkness. The dark part of the Moon is simply the part that is experiencing night. As the Moon orbits around the Earth, sometimes we see mainly the nighttime part of the Moon and sometimes we see mainly the daytime part of the Moon. When we see all of the daytime side of the Moon, we say the Moon is full. When only the nighttime side of the Moon faces us, the Moon is new.

The nighttime side of the Moon is the part of the Moon that is in its own shadow. So you might say that the phases of the Moon are caused not by the Earth's shadow, but by the Moon's own shadow.

The nighttime side of the Moon isn't completely dark. It doesn't get light from the Sun, but it does get light from the Earth. This is the **Earthshine**. It is easily visible when the Moon is a slender crescent.

## The Dark Side of the Moon

As the Moon orbits around the Earth, one side of the Moon always faces the Earth, while the other side always faces away. The side that faces the Earth is the **near side.** The side that faces away is the **far side.** The misconception is that the far side is always dark, the infamous Dark Side of the Moon.



This is one of the most fascinating of all misconceptions. It's a psychological kind of thing. The mind reasons, if we can't see the far side of the Moon, it's dark to us. Why would nature bother to illuminate it if no one can see it?

Nature, of course, doesn't care that no one on Earth can see the far side of the Moon. What matters is whether the Sun can. And it can, provided the far side is facing the Sun. It does so for half the month.

If you were on the Moon, it would be like being on Earth, in that the Sun would rise and a little later it would set. Except that it would be a lot later. On the Moon, daytime last two weeks and nighttime lasts two weeks. This is true on both the near side and the far side of the Moon. So, half the time the far side is dark, but half the time it is bright.

## A "Blue Moon" is the second full moon in a calendar month.

The phrase "once in a blue moon" has been in the language for centuries. It's a joke—a funny way of saying "never," as in, "you'll get rich when the Moon turns blue."

Historically, there was no significance to the term "blue moon" among astronomers. But that hasn't stopped people from trying to find one. About 1980, an editor for the radio program *Stardate* read a story in an old *Sky and Telescope* story that mentioned the use of the phrase "blue moon" in a farmer's almanac to mean a fourth full moon in a quarter. Somehow, the editor interpreted this to mean that a "blue moon" is the second full moon in a month that has two full moons. This idea was announced on *Stardate,* picked up by the game *Trivial Pursuit,* and spread through pop culture, so that now you sometimes hear it on the evening news. Evidentally, this definition satisfies a lot of people who have been wondering what a "blue moon" is.

If a "blue moon" is the second full moon in a month, it is an event that is neither particularly rare nor particularly interesting. A full moon can occur on any day of the month. The time between full moons is 29 or 30 days. Therefore, in any month but February, if a full moon falls on the first day of the month, the next full moon can occur on the last day of the month. It is inevitable that this will happen every few years. Is that interesting? Maybe so, but the same thing can happen to new moons. Maybe a "blue moon" is the second *new* moon in a month. In any event, the second full moon that happens to fall in a calendar month doesn't look any different from any other full moon—there's nothing blue about it.

On rare occasions, however, a full moon occurs when there is fine ash in the air which gives the moon a bluish tint. I've only seen it once. That was, indeed, an event that was "once in a blue moon."

## The Moon landings were filmed in Burbank

Everybody loves a nice conspiracy theory. Conspiracy theories appeal to Americans' basic distrust of authority, which may not be an altogether bad thing. It is probably true that few conspiracy theories stand up under close scrutiny, but they are harmless for the most part.

Perhaps you've seen theTV show that claims the Moon landings were faked. If you don't know much about space, and weren't around yet in 1969, it probably sounds like they have some good arguments. For example, why is the flag waving in the wind if there is no air on the Moon? Well, the answer is that there was is stick inside the flag keeping it from sagging.

The fact of the matter is, the claim that the Moon landings were faked can only be considered absurd. The Apollo project involved tens of thousands of people. The idea that they all have kept this secret for forty years is incredible. The evidence that the astronauts landed on the Moon is much stronger than the evidence that George Washington was the first President.

The truth is that theApollo project was one of the great adventures in the history of exploration. It combined audacity, vision, technical expertise, and courage. The trip to the Moon was barely possible with the technology of the time. It was also very dangerous. You may have heard of the Apollo 13 mission, where there was an explosion in the spacecraft and the astronauts were very lucky to get home alive. And although no astronauts died while traveling to the Moon, three astronauts, Gus Grissom, Ed White, and Roger Chaffee, died at Cape Canaveral while testing the Apollo 1 spacecraft.

You may wonder why no one has gone to the Moon since 1972. There are several reasons. The reason for the Apollo program was to beat the Russians to the Moon, and after we did that, there wasn't the same motivation to keep going back. Additionally, there was a recession at the time and the federal tax revenue was down.

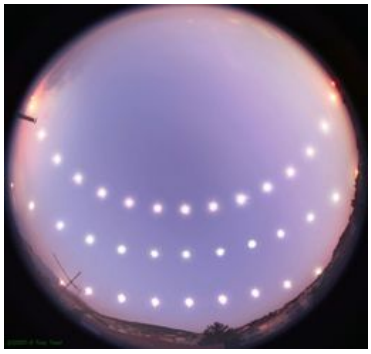
And finally, the Moon missions were risky. After Apollo 13, which was a close call, NASA was wary about risking lives unnecessarily. Consequently, the last few planned Apollo missions were canceled and we have yet to return to the Moon.

## THE SUN

### It's hot in summer because we're closer to the Sun

Here is another misconception that has a germ of truth to it. It is true that the Earth gets more heat from the Sun when it is closer to the Sun. It is also true that the distance between the Earth and the Sun varies over the course of the year. It is not true, however, that these facts explain the difference between summer and winter.

Consider this: if it were warmer because the Sun is closer, then the Southern Hemisphere should have summer at the same time as the Northern Hemisphere. But, as you are probably aware, the Southern Hemisphere has summer in January and winter in July. So there must be another explanation. Moreover, the Earth is actually closest to the Sun in January, when it is the dead of winter in the Northern Hemisphere.

*(Left) the Earth's orbit is nearly circular. (Right) The Sun's path in the sky in summer (top), spring and fall (middle), and winter (bottom)*

The fact is that the distance between the Earth and the Sun only varies about 3% over the course of the year. This is not enough to account for the difference between summer and winter. There is another factor involved. Because the Earth is tilted on its axis, the Sun is higher in the sky in summer and lower in the sky in winter. The Earth gets much more heat when the Sun is high in the sky. That is why it is hotter in summer than in winter.

## Solar Energy

Solar Energy is big in the news. As fossils fuels run out, (but not before changing the Earth's climate), we will be getting more and more of our energy from the Sun.

But what exactly *is* solar energy? Some say it's ultraviolet light. Some say it's "heat rays." Here's the secret the big energy companies don't want you to know: solar energy is *light.* It is light that heats the Earth.

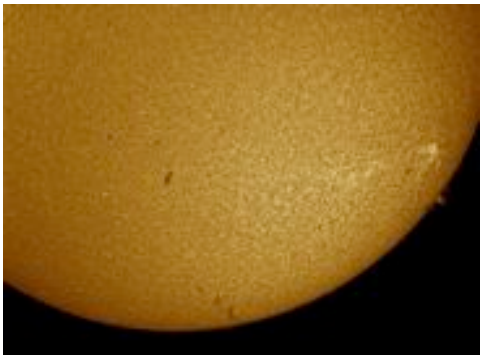
Actually, the Sun emits different kinds of light. In addition to light of all of the colors of the rainbow, from red to violet, the Sun gives off various forms of invisible light. One kind is ultra-violet light, which is more energetic than visible light. Another kind is *infrared light,* which has less energy than visible light. Much of the ultraviolet and infrared light is blocked by the atmosphere. The bulk of the energy that reaches the ground is ordinary visible light. This is no coincidence. Over time, life natuarally evolved eyes that are most sensitive to the kind of light that is most abundant.

## The Sun is burning.

Most people know that the Sun is not solid; it's a big ball of gas. It's also very hot—it's surface is at a temperature of about 6000° C or 11,000° F. It's easy to imagine that the Sun must be a big ball of fire—that the Sun is burning.

It's not. Burning is a chemical process. In a flame, inflammable compounds from the fuel are combining with the oxygen in the air. (Carbon dioxide is the end-product of this process.) It is

true that the Sun is made of an inflammable gas (hydrogen) and it also has a little oxygen. However, it turns out that the Sun is *too hot* for the hydrogen to burn. As you probably know, hydrogen combines with oxygen to form water. At the Sun's temperature, however, water molecules break up into hydrogen and oxygen atoms. It's so hot, the even the hydrogen and oxygen atoms start to break up, losing their electrons. In the interior of the Sun, the atoms have lost all of their electrons. A gas like this, where the electrons have lost their ions, is called a *plasma.* A plasma can't burn. It's too hot to burn!



The reason the Sun shines is simple. It shines because it is hot. Anything as hot as the Sun will shine brightly. Stars shine simply because they are hot.

The real question is, why don't stars cool off? That is a question that was a big mystery in astronomy for a long time. Today we understand that stars, including the Sun, don't cool off because energy is being released in the *center* of the star. The process that produces this energy is called *nuclear fusion.* Nuclear fusion takes place at truly unimaginable temperatures, temperatures of *millions* of degrees. The surface of a star is nowhere nearly hot enough for fusion. If ever we can figure out how to have a controlled fusion reaction on Earth, we will have all the energy we can possibly need—just from the hydrogen in seawater.

### The Sun will blow up when it dies

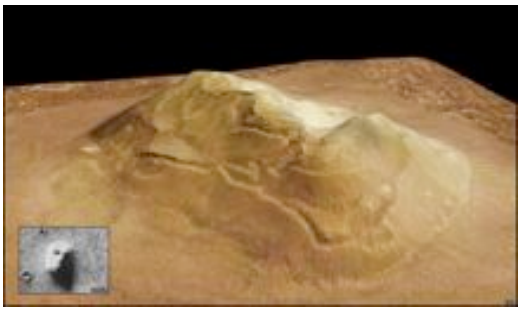
Some stars die a violent death. They literally explode. Such an exploding star as called a **supernova**. A supernova explosion is a really big thing. For a few weeks, the exploding star gives off as much light as billions of Suns. Supernovae have an important role to play in the history of the Universe, as we shall see.

The Sun, however, is not the kind of star that becomes a super-

nova. In fact, stars that go supernova are rare. Most stars, like the Sun, die more quietly. As we will see later, when the Sun grows old it will *slowly* expand until it is a hundred times larger than it is today—possibly large enough to engulf the Earth. Eventually it will throw off its outer layers, forming a beautiful **planetary nebula,** such as the Owl Nebula in the photograph. Exhausted of fuel, the core will contract to form a tiny, Earth-sized star called a **white dwarf.**

## THE PLANETS

### The Mars Face



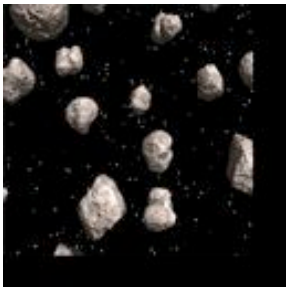
The Viking mission to Mars in the 1970s was spectacularly successful. (It was remarkable because most missions to Mars have been spectacular failures.) There were two Viking spacecraft, each of which consisted of a spacecraft that orbited Mars and a lander that descended to the surface. The two Viking landers were the first machines to make successful landings on another planet (other than the Moon).

Among the thousands of pictures of Mars sent back by the two orbiters was an image of a mountain which looked ever so much like a face. The picture was just an amusing curiosity until someone wrote a book explaining that the mountain was actually carved by the Martians to send us some kind of message. The book became a big success and led to a television special which is still floating around the cable channels. Adherents to this idea protested at JPL in Pasadena, claiming that NASA was covering up the truth.

Mars Global Surveyor, which went into orbit around Mars in 1997, returned to the "Face" with a superior camera and showed that the mountain is just a mountain. The real lesson of the Mars "Face" is that the human brain is an expert at recognizing faces. We can see faces in clouds, in inkblots, in mountains, in pieces of toast.

As for Mars, we have yet to find any evidence of intelligent life and the chances that we ever will are low. Mars is a harsh environment. The atmosphere is exceedingly thin; human beings would need to wear a spacesuit to stand on the surface. The temperature is below freezing. There is no oxygen in the air. There is no liquid water to be found. If there is life on Mars, it is probably microscopic bacteria living below the surface. Some people, disappointed that stories of little green Men on Mars are untrue, conclude that Mars is uninteresting. I think that it is the real Mars that is interesting, a world far stranger than science fiction, a landscape of enormous volanos, gigantic canyons, vast flood plains, and deep mystery. In the end, isn't the real Universe far more interesting than stories of aliens in flying saucers?

## The dangerous asteroid belt



You've seen it before: our hero, closely follow by the bad guys, drops into an asteroid belt and, dodging asteroids left and right, barely manages to get away. Exciting—but there is just one problem. The asteroids—at least in our asteroid belt—are really far apart. Like *millions* of miles apart. The fact of the matter is that if you were standing on an asteroid, you probably could not see even one other asteroid, the asteroids are so far apart.

The truth is that space is mostly empty space. Very empty. The planets and the asteroids are specks lost in the vastness of space. But that doesn't stop us from enjoying a good spaceship chase in a science fiction movie!

## There are 8 (formerly 9) planets

Recently there was a big controversy about whether Pluto was a planet, which culminated in the decision in 2006 of the IAU to re-classify Pluto as a "dwarf planet" rather than a planet. It was a curious declaration, in that something that is a "dwarf planet" would appear to be a kind of planet, and yet the intent was that Pluto should *not* be a planet. Go figure.

You might suppose that after all this time, astronomers would be able to tell a planet from a non-planet. It turns out, however, that there are dozens of plant-like bodies in the solar system. Moons are just planets that orbit around other planets. Asteroids are just small planets. Kuiper

Belt Objects (KBOs) are small planets that are in the fringes of the solar system (Pluto is a KBO.) The idea that there are only 8 or 9 planets is just a matter of habit, of tradition. If an object is small, you wouldn't call it a planet. The problem is that nobody can agree on how small can something be and still be considered a planet. The controversy is between those who think the number of official planets should be small and those who think it should be large. The fact of the matter is that there is no fundamental way of determining what is a planet and what is not. It's a matter of personal preference.

Moreover, the objects that are called "planets" are not all the same thing. Jupiter and the Earth, for example, are as different as night and day. Jupiter is a big ball of hydrogen gas. The Earth is a big rock with an iron core. The only thing they have in common is that they orbit the Sun. Some other race might well decide that Jupiter is a "planet" and the Earth is not.

The reality is that there are many more than 8 interesting and important worlds in the solar system. Our solar system is rich with many strange and exotic bodies, each unlike the others. It is simply on oversimplification to say there are only 8 (or 9) planets.

## THE UNIVERSE

### Black holes suck.

If there is anything everyone knows about black holes, it's that they spend their time going around and sucking up innocent planets. Right?

Guess what. Greatly exaggerated. The fact of the matter is that most black holes are rather small—only a few miles across. Obviously, it would be rather difficult for the Earth to fall into one. Indeed, it would be most unlikely that the Earth would ever run into one. It's really rather difficult to fall into a black hole. In order to do so, you have to aim right at the black hole, and because the black hole is small (compared with a star or planet), your aim would have to be

perfect. If a black hole were to come through the solar system and fly by the Earth, the Earth wouldn't be sucked into it, it would just be knocked out of its orbit. Which, to be honest, isn't so good, either.

It is true, that if you did succeed in falling into a black hole, it's a one-way journey. You wouldn't be able to come back. Real black holes are stranger than fiction. There are tears in the fabric of space and time. Perhaps they are portals to other universes. Most amazing of all, they are not science fiction. They are real.!

### The Universe started out as a pea.

The Universe is expanding. It started with a Big Bang and has been expanding ever since. The way the story is often told, the Universe started out very small. For some reason, everybody says it was the size of a pea. Not a lentil, or a lime bean, or a marble, or an orange pip. A pea.

There are two possibilities for the Universe. One is that the Universe started out small. Much smaller than a pea, smaller than a pinhead, smaller than an atom. In this case, the Universe today has a finite size, although very large.

The other possibility, perhaps more likely, is that the Universe today is infinite in size. If that is the case, the Universe has always been infinite. The Universe started out infinitely large, and has been getting larger ever since. Early on, the Universe was dense and hot, like one big sun. The expansion of the Universe has spread out the matter to the point that today the Universe is mostly empty space. At all times, however, there has been an infinite amount of space.

This is indeed a strange notion: that the Universe started out infinitely large, and is getting still larger. Isn't that much more interesting than a pea?

SCIENCE

## It's only a theory.

In common parlance, a "theory" is an unproven idea. The implication is that it's probably a wrong idea. We might poo-poo an idea my saying it's "only a theory," as thought it's bad to be a theory.

There is nothing more important to understand about science is that scientists use the word "theory" in a different way. To a scientist, a theory is a deep explanation of a natural phenomenon. A theory is powerful enought that it can make testable predictions about the outcome of experiments and observations. The development of theories is the end result of the scientific method. Theories are what make nature comprehensible.

In the course of scientific progress, several different theories may be worked out to explain a natural phenomenon. Eventually, all but one of the theories will be eliminated. Nevertheless, they are all theories. To a scientist, the word "theory" does not imply doubt. Some theories are known to be true, some have been discarded, and others we are still unsure about.

An example is the Theory of Evolution. From what you see in the media, you might suppose that the Theory of Evolution is still subject to doubt. The truth is that the debate about evolution among biologists was over a century ago. Just because it's called a "theory" doesn't mean that the evidence is lacking. Today, the Theory of Evolution is accepted by all biologists who are not religious fundamentalists. The Theory of Evolution is not going away. Like it or not, evolution is how Nature decided to put life on this planet. It's a wonderful story, a story of eons of time, of false starts and failed experiments, of dinosaurs and flying reptiles, of long periods of stasis and episodes of epic change, all culminating in the millions of species of animals and plants that make our world today the beautiful, amazing planet it is.