Introduction

Science is based on three principles. These principles establish the framework and limits of science. And they’re very straightforward. The first principle is called common perception, and it means we share the same senses. From that idea, it follows that all people are likely to agree when making the same observation. Easy enough, right? The second principle is called uniformity of time and space. It means, in part, that the laws of nature observable on Earth are the same everywhere in the universe (uniformity of space). In addition, it means that those laws have always been, and will always be, the way they are now (uniformity of time). That’s not too bad either, I think. The last principle is called natural causation, and it means that you’re not allowed to invoke any “unknowable force” as the cause of things. Obviously, these principles limit what science can address—the tasks it can be expected to perform well. For example, science is not an effective approach to art or ethics or religion.

Science is a great approach to solving problems. It can answer questions that haven’t been answered before. Science provides a means for anyone to perform original research. In fact, many scientists are involved with research directly—running experiments and making observations. Although individually these scientists are engaged in many separate fields of science (e.g., astronomy, biology, chemistry, physics), collectively they’re doing just two types or broad categories of research—basic and applied.

Basic research expands the knowledge base in a field of science. It may become the basis for a major theory or entire industry (e.g., DNA/genetic engineering), or it may simply occupy disc or library space until the end of time without application. It is, by its nature, difficult to predict the fate of basic research, and its significance is occasionally unknown for years (e.g.,
Mendel's work in genetics). Basic research is usually performed in universities or non-profit research institutes, and it is usually funded by charitable or governmental grants. Basic research benefits us indirectly, since it is the foundation of all applied research.

Applied research is intended to improve a product or service—or even to create a new product or service. Scientists employed in private industry—at least here in America—usually perform applied research. Sometimes private industries form partnerships with government labs to perform this research. By its nature, applied research is industrial and is directed towards economic growth through direct profits. Applied research brings direct, measurable benefit as it continues to expand our economy.

But how is this research performed? What is the method by which scientists solve problems? At its simplest, the scientific method begins by making observations, then proposing explanations, and finally testing those explanations.

**Discussion**

The scientific method is the most common tool of science. I suppose you could say it's the way many scientists do their jobs. Although some books may differ, I prefer to think of the method as following these six steps:

1. **Observation**
   To me, observation means looking at things. According to many texts, before a scientist develops a hypothesis about anything, that individual notices something that sparks his or her imagination.

2. **Questioning**
   It's the spark of imagination. Maybe a good example is that “huh?” feeling you have when you see something that interests (or surprises or baffles) you, but you don't understand it. Sometimes I call this wonderment, but I don't mean to imply awe—just interested curiosity.

3. **Library Search**
   You want to find out if someone already knows the answer to the question that’s on your mind (see step 2). Some people call it “literature search.” You might begin your search by calling colleagues who work in the area that concerns you and go from there. Often published journal articles lead to other articles, and you learn as you go.

4. **Hypothesis**
   This may have been in the back of your mind from the start, or at least during the first step (above). Your hypothesis is your educated guess about the answer to the question that occurred to you as you made your observation. Since it's an educated guess, I listed it after library search.
5. Experiment/Test
In many experiments, two groups are observed: an experimental group and a control group. Ideally, the two groups are identical except for a single factor. That factor is called the variable factor, and it should be the only difference between the two groups.

In a laboratory setting, it is often possible to maintain good control of many things that might affect your results, including the variable factor. Outside of the lab, it’s not possible to control things as well as in the lab, and statistical evaluation of experimental data becomes critically important.

The design of experiments is critical and not often easy. The basic idea of your experiment is that you want to predict what should result under certain circumstances if your educated guess (hypothesis) is correct. A well-designed experiment will test that prediction. For an experiment to be designed well, it must have good verifiability (ability to show that your idea is true when it is true) as well as good falsifiability (ability to show that your idea is false when it is false). You do not need to know specifically how to design experiments to pass this course, but you should be aware of the need for falsifiability and verifiability.

Some experiments involve detailed lab procedures, precise instruments and planned control of variables. Other experiments are simply quantitative observations and might be better described as tests. Astronomy is a science in which many experiments are essentially what I have just described as tests.

6. Conclusion
This means that you reject or you do not reject the hypothesis. Regardless of the conclusion reached, additional investigations may be performed to gather more evidence regarding the hypothesis.

I suppose it’s great if the experimental observations (the experimental data) are so conclusive that all rational people will know whether to reject or not reject the hypothesis, just by looking at the data. But rejecting or not rejecting a hypothesis is often based on a statistical analysis of experimental data, and with statistical analysis, you’ll have some known uncertainty about your decision. The uncertainty is frequently called error, but it does not imply a mistake or deliberate flaw. Error, in this use, expresses how certain you are in the truth (or correctness) of your decision.

A good example of known uncertainty (error) is found with polling results. Those results are often presented this way:

40% favor the proposition; 60% are against it, with an uncertainty of plus or minus 3%.

That 6% range of uncertainty (error) is an example of known uncertainty, and its size depends on many things, including the size of the sample. All else being equal, a large sample is usually better than a small sample.