What are the steps involved in the research process (scientific method)

We hear about the scientific method every day. Middle and high school students learn about it in science class and use it in research competitions. Advertisers use it to support claims about products ranging from vacuum cleaners to vitamins. And Hollywood portrays it by showing scientists with clipboards and lab coats standing behind microscopes and flasks filled with bubbling liquids.So why does the scientific method remain such a mystery to so many people? One reason has to do with the name itself. The word "method" implies that there is some sacred formula locked in a vault -- a formula available to highly trained scientists and no one else. This is absolutely untrue. The scientific method is something all of us use all of the time. In fact, engaging in the basic activities that make up the scientific method -- being curious, asking questions, seeking answers -- is a natural part of being human.In this article, we'll demystify the scientific method by breaking it down to its basic parts.We'll explore how the scientific method can be used to solve everyday problems, but we'll also explain why it is so fundamentally critical to the physical and natural sciences. We'll also examine a few examples of how the method has been applied to make landmark discoveries and support groundbreaking theories. But let's start with a basic definition.Ask a group of people to define "science," and you'll get a lot of different answers. Some will tell you it's a really difficult class wedged between social studies and math. Others will tell you it's a dusty book filled with Latin terms that no one can pronounce. And still others will say it's a useless collection of facts, figures and formulas. Unfortunately, most dictionaries don't shed any significant light on the subject. Here's a typical definition:Science is the intellectual and practical activity encompassing the structure and behavior of the physical and natural world through observation and experimentation [source: Oxford American Dictionary].Sounds difficult, right? Not if we break this long-winded definition into its most important parts. By doing so, we'll achieve two things: First, we'll support the argument that science isn't mysterious or unattainable. Second, we'll demonstrate that the method of science is really no different than science itself. Let's break down the definition of science.Part 1Science is practical. Although science sometimes involves learning from textbooks or professors in lecture halls, its primary activity is discovery. Discovery is an active, hands-on process, not something done by scholars isolated from the world in ivory towers. It is both a search for information and a quest to explain how information fits together in meaningful ways. And it almost always seeks answers to very practical questions: How does human activity affect global warming? Why are honeybee populations suddenly declining in North America? What enables birds to migrate such long distances? How do black holes form?Part 2Science is based on observation. Scientists use all of their senses to gather information about the world around them. Sometimes they gather this information directly, with no intervening tool or apparatus. Other times they use a piece of equipment, such as a telescope or microscope, to gather information indirectly. Either way, scientists will write down what they see, hear and feel. These recorded observations are called data.Part 3Data can reveal the structure of something. This is quantitative data, which describes an object numerically. The following are examples of quantitative data:The body temperature of a ruby-throated hummingbird is 40.5°C (105°F).The speed of light is 299,792,458 meters per second (670,635,729 mph).The diameter of Jupiter is 142,984 kilometers (88,846 miles).The length of a blue whale is 30.5 meters (100 feet).Notice that quantitative data consist of a number followed by a unit. The unit is a standardized way to measure a certain dimension or quantity. For example, the foot is a unit of length. So is the meter. In science, the International System (SI) of units, the modern form of the metric system, is the global standard.Part 4Data can also reveal behavior. This is qualitative data, which are written descriptions about an object or organism. John James Audubon, the 19th-century naturalist, ornithologist and painter, is famous for the qualitative observations he made about bird behavior, such as this one:Generally, scientists collect both quantitative and qualitative data, which contribute equally to the body of knowledge associated with a certain topic. In other words, quantitative data is not more important or more valuable because it is based on precise measurements [source: Audubon].Next we'll learn about science as a systematic, intellectual pursuit. As more proof that there is no one way to "do" science, different sources describe the steps of the scientific method in different ways. Some list three steps, some four and some five. Fundamentally, however, they incorporate the same concepts and principles.For our purposes, we're going to say that there are five key steps in the method.Step 1: Make an ObservationAlmost all scientific inquiry begins with an observation that piques curiosity or raises a question. For example, when Charles Darwin (1809-1882) visited the Galapagos Islands (located in the Pacific Ocean, 950 kilometers west of Ecuador, he observed several species of finches, each uniquely adapted to a very specific habitat. In particular, the beaks of the finches were quite variable and seemed to play important roles in how the birds obtained food. These birds captivated Darwin. He wanted to understand the forces that allowed so many different varieties of finch to coexist successfully in such a small geographic area. His observations caused him to wonder, and his wonderment led him to ask a question that could be tested.Step 2: Ask a QuestionThe purpose of the question is to narrow the focus of the inquiry, to identify the problem in specific terms. The question Darwin might have asked after seeing so many different finches was something like this: What caused the diversification of finches on the Galapagos Islands?Here are some other scientific questions:What causes the roots of a plant to grow downward and the stem to grow upward?What brand of mouthwash kills the most germs?Which car body shape reduces air resistance most effectively?What causes coral bleaching?Does green tea reduce the effects of oxidation?What type of building material absorbs the most sound?Coming up with scientific questions isn't difficult and doesn't require training as a scientist. If you've ever been curious about something, if you've ever wanted to know what caused something to happen, then you've probably already asked a question that could launch a scientific investigation.Step 3: Formulate a HypothesisThe great thing about a question is that it yearns for an answer, and the next step in the scientific method is to suggest a possible answer in the form of a hypothesis. A hypothesis is often defined as an educated guess because it is almost always informed by what you already know about a topic. For example, if you wanted to study the air-resistance problem stated above, you might already have an intuitive sense that a car shaped like a bird would reduce air resistance more effectively than a car shaped like a box. You could use that intuition to help formulate your hypothesis.Generally, a hypothesis is stated as an "if ... then" statement. In making such a statement, scientists engage in deductive reasoning, which is the opposite of inductive reasoning. Deduction requires movement in logic from the general to the specific. Here's an example: If a car's body profile is related to the amount of air resistance it produces (general statement), then a car designed like the body of a bird will be more aerodynamic and reduce air resistance more than a car designed like a box (specific statement).Notice that there are two important qualities about a hypothesis expressed as an "if ... then" statement. First, it is testable; an experiment could be set up to test the validity of the statement. Second, it is falsifiable; an experiment could be devised that might reveal that such an idea is not true. If these two qualities are not met, then the question being asked cannot be addressed using the scientific method. What does it mean to conduct research? What are the distinct stages of the research process? What are the requirements of modern scientific research? How do you analyze a scientific article? This course will teach you to conduct research in accordance with scientific methodology. You'll learn to analyze scientific articles in engineering and science subjects, and how to conduct scientific experiments. The course will help to develop the core skill of a scientist, giving you the research tools to succeed. The course material is well-suited for anyone interested in the problems of uncovering knowledge and science; giving you a methodology for the achievement of educational and scientific activities. This course is for anyone who has ever said, “Science is interesting.” It will appeal to those who want to learn the processes behind modern scientific research.Institution: UrFUxSubject: ScienceLevel: IntermediatePrerequisites: Introduction to Philosophy Fundamentals of physics Language: EnglishVideo Transcript: English Understand the fundamental problems of science Ability to analyze scientific articles How to properly conduct scientific research and experiments Week 1: The philosophical aspects of scientific activity Introduction to the Philosophy of Science. What is a "scientific theory"? The structure of a scientific theory. The methodology used to obtain scientific knowledge. Requirements to achieve scientific results. Week 2: Theory and practice of scientific research What is research? Ph.D. requirements. Research planning. Research question. Modes inquiry. Induction and deduction in your research project. Week 3: Philosophical principles of research Ontology and epistemology. Objectivity and subjectivity. Causation and correlation in your research project. Week 4: Research process Literature review. Research questions and hypothesis. The structure of paper and plan investigation. Research impact. Week 5: Methodology of experiment in engineering studies The purpose and structure of the experiment. Planning. Analysis of the results.