What is Chemistry?

At one time it was easy to define chemistry. The traditional definition goes something like this: Chemistry is the study of the nature, properties, and composition of matter, and how these undergo changes. That served as a perfectly adequate definition as late as the 1930s, when natural science (the systematic knowledge of nature) seemed quite clearly divisible into the physical and biological sciences, with the former being comprised of physics, chemistry, geology and astronomy and the latter consisting of botany and zoology. This classification is still used, but the emergence of important fields to study such as oceanography, paleobotany, meteorology, pharmacy and biochemistry, for example, have made it increasingly clear that the dividing lines between the sciences are no longer at all sharp. Chemistry, for instance, now overlaps so much with geology (thus we have geochemistry), astronomy (astrochemistry), and physics (physical and analytical chemistry) that it is probably impossible to devise a really good modern definition of chemistry, except, perhaps, to fall back on the operational definition: Chemistry is what chemists do!

Chemistry plays an important part in all of the other natural sciences, basic and applied. Plant growth and metabolism, the formation of igneous rocks, the role played by ozone in the atmosphere, the degradation of environmental pollutants, the properties of lunar soil, the medical action of drugs, establishment of forensic evidence: none of these can be understood without the knowledge and perspective provided by chemistry. Indeed, many people study chemistry so that they can apply it to their own particular field of interest. Of course, chemistry itself is the field of interest for many people, too. Many study chemistry not to apply it to another field, but simply to learn more about the physical world and the behavior of matter from a chemical viewpoint. Some simply like "what chemists do" and so decide to "do it" themselves.

Chemistry is a way of studying matter. What is matter? As is true with many of those words which are really basic to science, matter is hard to define. It is often said that matter is anything which has mass and occupies space. But then what are "mass" and "space"? Although we can define these, the process yields very little insight into what matter is. So let us just say that matter is anything which has real physical existence; in a word matter is just stuff. Iron, air, wool, gold, milk, aspirin, monkeys, rubber, and pizza - these are all matter. Some things which are not matter are heat, cold, colors, dreams, hopes, ideas, sunlight, beauty, fear, and x-rays. None of these is "stuff"; none is matter.

A sample of matter can be either a pure substance or a mixture. A pure substance has a fixed, characteristic composition an a fixed, definite set of properties. Pure substances are for example copper, salt, diamond, water, table sugar, oxygen, mercury, vitamin C, and ozone. A pure substance may be a single element, such as copper or oxygen, or a compound of two or more elements in a fixed ratio, such as salt (39.34 % sodium and 60.66 % chlorine) or table sugar (42.11 % carbon, 6.48 % hydrogen, and 51.41 % oxygen).

A mixture is a collection of pure substances simply mixed together. Its composition is variable, as are its properties. Examples of mixtures are milk, wood, concrete, saltwater, air, granite, motor oil, chocolate, and elephants.

A pure substance can be a solid, a liquid, or a gas; these are the three states of matter A solid maintains its volume and shape; a liquid, its volume only; and a gas, neither. Solids tend to be hard and unyielding; liquids maintain their volumes and flow to adopt the shapes of their containers. The ability to flow is called fluidity, and so gases and liquids are called fluids.

One of the goals of chemistry is to be able to describe the properties of matter in terms of its internal structure, the arrangement and interrelationship of its parts. This word, structure, sometimes refers to the physical arrangement of particles, such as atoms or molecules in space. At other times it is used to indicate some other arrangement, such as the arrangement of energy levels of an electron in an atom. The structure of matter determines its properties. Properties can be classed as either physical or chemical. A physical property of a substance can be characterized without specific reference to any other substance and usually describes the response of the substance to some external influence, such as heat, light, force, electricity, etc. Physical properties include boiling point, melting point, thermal (heat) conductivity, color, refractive index, viscosity, reflectivity, hardness, tensile strength, and electrical conductivity.

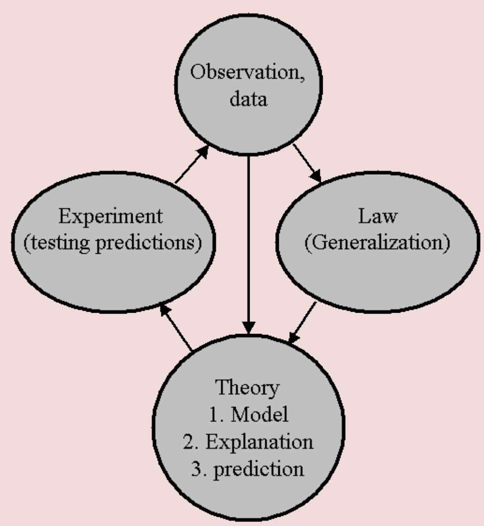
A chemical property, on the other hand, describes a chemical change: the interaction of one substance with another, or the change of one substance into another. Iron rusts in a moist environment, unrefrigerated milk turns sour, wood burns in air, photographs bleach when exposed to sunlight for a long time, dynamite explodes - each of these is a chemical property because each involves chemical change. During chemical changes, substances are actually changed into other substances. The simultaneous disappearance of some substances (called the reactants) and appearance of others (the products) is characteristic in chemical change (chemical reaction). Chemical changes are generally characterized by pronounced internal structural rearrangements.

Physical changes are not characterized by the transformation of one substance into another, but rather by the change of the form of a given substance. The bending of a piece of copper wire fails to change the property of copper into another substance; crushing a block of ice leaves only crushed ice; melting an iron nail yields a substance still called iron: These are all usually accepted as physical changes.

Properties of matter may also be categorized as either macroscopic or microscopic. A macroscopic property describes characteristics or behavior of a sample which is large enough to see, handle, manipulate, weigh, etc. A microscopic property describes the behavior of a much smaller sample of matter, an atom or molecule for instance. Macroscopic and microscopic properties are often different. A banana is yellow, but we do not use color to describe an atom. Some properties, on the other hand, can be either microscopic or macroscopic; mass is one of these.

Another word that is often used is system. A system is a portion of the universe which we wish to observe or consider. The size of the portion is usually small and a system may be a real one (in a test tube or flask, for example), or an imaginary one which this text is just referring to.

Viewed from an historical point of view, it is clear that scientific knowledge has been obtained and that therefore science has "advanced" in a series of fairly logical steps. On the other hand, counterparts to these steps are difficult to identify in the day-to-day professional activities of a scientist. The way in which science and in particular chemistry advances can be describes in terms of a series of cycles (see diagram). Observations and data (and laws) lead to the proposal of theories that, in turn, suggest predictions which can be tested by designing new experiments, and the whole process starts all over again.



John B. Russell, General Chemistry, McGraw-Hill International Book Company, 1980
http://chemweb.ucc.ie/what_is_chemistry.htm

How Would You Define Chemistry as a Science?

1 of 8 in Series: The Essentials of Chemistry Basics

Chemistry is a branch of science that studies the composition and properties of matter and the changes it undergoes. Chemistry is far more than a collection of facts and a body of knowledge. It's all about matter, which is anything that has mass and occupies space.

Matter is made up of either pure substances or mixtures of pure substances. The change from one substance into another is what chemists call a chemical change, or *chemical reaction*, and it's a big deal because when it occurs, a brand-new substance is created.

The general field of chemistry is so huge that it was originally subdivided into a number of different areas of specialization. But there's now a tremendous amount of overlap between the different areas of chemistry, just as there is among the various sciences.

Here are the traditional fields of chemistry:

- **Analytical chemistry:** This branch is highly involved in the analysis of substances. Chemists from this field of chemistry may be trying to find out what substances are in a mixture (qualitative analysis) or how much of a particular substance is present (quantitative analysis) in something. A lot of instrumentation is used in analytical chemistry.
- **Biochemistry:** This branch specializes in living organisms and systems. Biochemists study the chemical reactions that occur at the molecular level of an organism — the level where items are so small that people can't directly see them.

  Biochemists study processes such as digestion, metabolism, reproduction, respiration, and so on. Sometimes it's difficult to distinguish between a biochemist and a molecular biologist because they both study living systems at a microscopic level. However, a biochemist really concentrates more on the reactions that are occurring.
- **Biotechnology:** This is a relatively new area of science that is the application of biochemistry and biology, when creating or modifying genetic material or organisms for specific purposes. It's used in such areas as cloning and the creation of disease-resistant crops, and it has the potential for eliminating genetic diseases in the future.
- **Inorganic chemistry:** This branch is involved in the study of inorganic compounds such as salts. It includes the study of the structure and properties of these compounds. It also involves the study of the individual elements of the compounds. Inorganic chemists would probably say that it is the study of everything except carbon, which they leave to the organic chemists.

  So what are compounds and elements? Just more of the anatomy of matter. Matter is made up of either pure substances or mixtures of pure substances, and substances themselves are made up of either elements or compounds.
- **Organic chemistry:** This is the study of carbon and its compounds. It's probably the most organized of the areas of chemistry. There are millions of organic compounds, with thousands more discovered or created each year. Industries such as the polymer industry, the petrochemical industry, and the pharmaceutical industry depend on organic chemists.
- **Physical chemistry:** This branch figures out how and why a chemical system behaves as it does. Physical chemists study the physical properties and behavior of matter and try to develop models and theories that describe this behavior.

http://www.dummies.com/how-to/content/how-would-you-define-chemistry-as-a-science.html

What is chemistry?

Any freshman text will define chemistry as the science of matter and its changes. That's a safe but perhaps overly terse definition, considering that matter is anything with mass that occupies space.

Webster's Dictionary says the following:

chem·is·try *n., pl.* **-tries. 1.** the science that systematically studies the composition, properties, and activity of organic and inorganic substances and various elementary forms of matter. **2.** chemical properties, reactions, phenomena, etc.: *the chemistry of carbon*. **3. a.**sympathetic understanding; rapport. **b.** sexual attraction. **4.** the constituent elements of something; *the chemistry of love*. [1560-1600; earlier *chymistry*].

The first definition captures many of the essential ingredients of chemistry (although definitions 3 and 4 might make a more entertaining paper):

1. **Chemistry is a science.** There is only one sanctioned procedure for determining whether a statement about matter is really chemistry: the exhaustive, inefficient, but highly successful scientific method. Chemists often arrive at new results by nonscientific means (like luck or sheer creativity), but their work isn't chemistry unless it can be reproduced and verified scientifically.

2. **Chemistry is a systematic study**. Chemists have devised several good methods for solving problems and making observations. For example, analytical chemists often use *protocols* (thoroughly tested recipes) for determining the concentrations of substances in a sample. Chemists use well-defined techniques like spectroscopy and chromatography to study new or unknown substances.

3. **Chemistry is the study of the composition and properties of matter**. Chemistry answers questions like, "What kind of stuff is this sample made of? What does the sample look like on a molecular scale? How does the structure of the material determine its properties? How do the properties of the material change when I increase temperature, or pressure, or some other environmental variable?"

4. **Chemistry is the study of the reactivity of substances**. One material can be changed into another by a chemical reaction. A complex substance can by made from simpler ones. Chemical compounds can break down into simpler substances. Fuels burn, food cooks, leaves turn in the fall, cells grow, medicines cure. Chemistry is concerned with the essential processes that make these changes happen.

5. **Chemistry is the study of organic and inorganic substances**. Organic substances contain hydrogen combined with carbon; inorganic substances don't. It was once believed that organic compounds were exclusively produced by living things, but today chemists can synthesize many organic materials from inorganic ones. Carbon can link with itself and other atoms in many diverse ways, and its chemistry is far more complex than that of other elements. So while the organic/inorganic distinction is artificial, it's still useful.

6. **Chemistry is the study of connections between the everyday world and the molecular world.** Chemists use atoms and molecules to explain properties and behaviors of matter. For example, you can find molecular explanations for flavor and color changes.

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What Is Chemistry? - Definition

By Anne Marie Helmenstine, Ph.D.
Chemistry Expert

Question: What Is Chemistry?

Answer:

If you look 'chemistry' up in Webster's Dictionary, you'll see:
"chem·is·try n., pl. -tries. 1. the science that systematically studies the composition, properties, and activity of organic and inorganic substances and various elementary forms of matter. 2. chemical properties, reactions, phenomena, etc.: the chemistry of carbon. 3. a. sympathetic understanding; rapport. b. sexual attraction. 4. the constituent elements of something; the chemistry of love. [1560-1600; earlier chymistry]."

My glossary definition is short and sweet: Chemistry is the "scientific study of matter, its properties, and interactions with other matter and with energy".

An important point to remember is that chemistry is a science, which means its procedures are systematic and reproducible and its hypotheses are tested using the scientific method.

Chemists, scientists who study chemistry, examine the properties and composition of matter and the interactions between substances.

Chemistry is closely related to physics and to biology. Chemistry and physics both are physical sciences.

In fact, some texts define chemistry and physics exactly the same way.

As is true for other sciences, mathematics is an essential tool for the study of chemistry.

http://chemistry.about.com/cs/chemistry101/f/bldefinition.htm

Chemistry Is Everywhere

Everything you hear, see, smell, taste, and touch involves chemistry and chemicals (matter). And hearing, seeing, tasting, and touching all involve intricate series of chemical reactions and interactions in your body. With such an enormous range of topics, it is essential to know about chemistry at some level to understand the world around us.

In more formal terms chemistry is the study of matter and the changes it can undergo. Chemists sometimes refer to matter as ‘stuff’, and indeed so it is. Matter is anything that has mass and occupies space. Which is to say, anything you can touch or hold. Common usage might have us believe that ‘chemicals’ are just those substances in laboratories or something that is not a natural substance. Far from it, chemists believe that everything is made of chemicals.

Although there are countless types of matter all around us, this complexity is composed of various combinations of some 100 chemical elements. The names of some of these elements will be familiar to almost everyone. Elements such as hydrogen, chlorine, silver, and copper are part of our everyday knowledge. Far fewer people have heard of selenium or rubidium or hassium.

Nevertheless, all matter is composed of various combinations of these basic elements. The wonder of chemistry is that when these basic particles are combined, they make something new and unique. Consider the element sodium. It is a soft, silvery metal. It reacts violently with water, giving off hydrogen gas and enough heat to make the hydrogen explode. Nasty ‘stuff’. Also consider chlorine, a green gas when at room temperature. It is very caustic and choking, and is nasty enough that it was used as a horrible chemical gas weapon in the last century. So what kind of horrible mess is produced when sodium and chlorine are combined? Nothing more than sodium chloride, common table salt. Table salt does not explode in water or choke us; rather, it is a common additive for foods we eat every day.

And so it is with chemistry, understanding the basic properties of matter and learning how to predict and explain how they change when they react to form new substances is what chemistry and chemists are all about.

Chemistry is not limited to beakers and laboratories. It is all around us, and the better we know chemistry, the better we know our world.

http://www.acs.org/content/acs/en/education/whatischemistry/everywhere.html

What Is Chemistry?

By Mary Bagley, Live Science Contributor | May 30, 2014 01:18am ET

Chemistry is the study of matter, its properties, how and why substances combine or separate to form other substances, and how substances interact with energy. Many people think of chemists as being white-coated scientists mixing strange liquids in a laboratory, but the truth is we are all chemists.

Doctors, nurses and veterinarians must study chemistry, but understanding basic chemistry concepts is important for almost every profession. Chemistry is part of everything in our lives.

Every material in existence is made up of matter — even our own bodies. Chemistry is involved in everything we do, from growing and cooking food to cleaning our homes and bodies to launching a space shuttle. Chemistry is one of the physical sciences that help us to describe and explain our world.

Five branches

There are five main branches of chemistry, each of which has many areas of study.

Analytical chemistry uses qualitative and quantitative observation to identify and measure the physical and chemical properties of substances. In a sense, all chemistry is analytical.

Physical chemistry combines chemistry with physics. Physical chemists study how matter and energy interact. Thermodynamics and quantum mechanics are two of the important branches of physical chemistry.

Organic chemistry specifically studies compounds that contain the element carbon. Carbon has many unique properties that allow it to form complex chemical bonds and very large molecules. Organic chemistry is known as the “Chemistry of Life” because all of the molecules that make up living tissue have carbon as part of their makeup.

Inorganic chemistry studies materials such as metals and gases that do not have carbon as part of their makeup.

Biochemistry is the study of chemical processes that occur within living organisms.

Fields of study

Within these broad categories are countless fields of study, many of which have important effects on our daily life. Chemists improve many products, from the food we eat and the clothing we wear to the materials with which we build our homes. Chemistry helps to protect our environment and searches for new sources of energy.

Food chemistry

Food science deals with the three biological components of food — carbohydrates, lipids, and proteins. Carbohydrates are sugars and starches, the chemical fuels needed for our cells to function. Lipids are fats and oils and are essential parts of cell membranes and to lubricate and cushion organs within the body. Because fats have 2.25 times the energy per gram than either carbohydrates or proteins, many people try to limit their intake to avoid becoming overweight. Proteins are complex molecules composed of from 100 to 500 or more amino acids that are chained together and folded into three-dimensional shapes necessary for the structure and function of every cell. Our bodies can synthesize some of the amino acids; however eight of them, the essential amino acids, must be taken in as part of our food. Food scientists are also concerned with the inorganic components of food such as its water content, minerals, vitamins and enzymes.

Food chemists improve the quality, safety, storage, and taste of our food. Food chemists may work for private industry to develop new products or improve processing. They may also work for government agencies such as the Food and Drug Administration to inspect food products and handlers to protect us from contamination or harmful practices. Food chemists test products to supply information used for the nutrition labels or to determine how packaging and storage affects the safety and quality of the food. Flavorists work with chemicals to change the taste of food. Chemists may also work on other ways to improve sensory appeal, such as enhancing color, odor or texture.

Environmental chemistry

Environmental chemists study how chemicals interact with the natural environment. Environmental chemistry is an interdisciplinary study that involves both analytical chemistry and an understanding of environmental science. Environmental chemists must first understand the chemicals and chemical reactions present in natural processes in the soil water and air. Sampling and analysis can then determine if human activities have contaminated the environment or caused harmful reactions to affect it.

Water quality is an important area of environmental chemistry. “Pure” water does not exist in nature; it always has some minerals or other substance dissolved in it. Water quality chemists test rivers, lakes and ocean water for characteristics such as dissolved oxygen, salinity, turbidity, suspended sediments, and pH. Water destined for human consumption must be free of harmful contaminants and may be treated with additives like fluoride and chlorine to increase its safety.

Agricultural chemistry

Agricultural chemistry is concerned with the substances and chemical reactions that are involved with the production, protection and use of crops and livestock. It is a highly interdisciplinary field that relies on ties to many other sciences. Agricultural chemists may work with the Department of Agriculture, the Environmental Protection Agency, the Food and Drug Administration or for private industry. Agricultural chemists develop fertilizers, insecticides and herbicides necessary for large-scale crop production. They must also monitor how these products are used and their impacts on the environment. Nutritional supplements are developed to increase the productivity of meat and dairy herds.

Agricultural biotechnology is a fast-growing focus for many agricultural chemists. Genetically manipulating crops to be resistant to the herbicides used to control weeds in the fields requires detailed understanding of both the plants and the chemicals at the molecular level. Biochemists must understand genetics, chemistry and business needs to develop crops that are easier to transport or that have a longer shelf life.

Chemical engineering

Chemical engineers research and develop new materials or processes that involve chemical reactions. Chemical engineering combines a background in chemistry with engineering and economics concepts to solve technological problems. Chemical engineering jobs fall into two main groups: industrial applications and development of new products.

Industries require chemical engineers to devise new ways to make the manufacturing of their products easier and more cost effective. Chemical engineers are involved in designing and operating processing plants, develop safety procedures for handling dangerous materials, and supervise the manufacture of nearly every product we use. Chemical engineers work to develop new products and processes in every field from pharmaceuticals to fuels and computer components.

Geochemistry

Geochemists combine chemistry and geology to study the makeup and interaction between substances found in the Earth. Geochemists may spend more time in field studies than other types of chemists. Many work for the U.S. Geological Survey or the Environmental Protection Agency in determining how mining operations and waste can affect water quality and the environment. They may travel to remote abandoned mines to collect samples and perform rough field evaluations, and then follow a stream through its watershed to evaluate how contaminants are moving through the system. Petroleum geochemists are employed by oil and gas companies to help find new energy reserves. They may also work on pipelines and oil rigs to prevent chemical reactions that could cause explosions or spills.

http://www.livescience.com/45986-what-is-chemistry.html