

**Turfgrass Culture, ORH3222C Section 7982
and Grad. – Res. And Develop. in Turfgrass Sci. HOS6523 Section
5819**

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Natural Sciences Review

Science is currently viewed to be the system of acquiring knowledge by the scientific method and the body of knowledge thus acquired. Science as we know it is thus generally the same as what was called “natural science” based on rigorous and experimental methods, in contrast to social science which was based largely on observation and interpretation *a posteriori*, that is, after the fact, and in contrast to formal sciences such as mathematics and logic. All areas of science may be rigorous and systematic; however only natural science has the highest level of confidence and ability to formally test hypotheses in some instances relatively free of bias and subjectivity.

Since the advent of behavioral sociology, subjects such as economics and sociology have become more truly scientific in their approach. Also, natural sciences rely heavily on mathematics in measurements and interpretations, including the area of applied mathematics called statistics.

Science, or the natural sciences, includes two general areas, physical sciences (items 1 to 4, below) and biology

1. Physics – matter and motion including energy, mass, force, motion, charge, and gravity, including the nucleus and subatomic particles, radiation, classical mechanics, electricity, the electromagnetic spectrum, and atoms and elements
2. Chemistry – matter as substances, including compositions and transformations of matter involving the other shell of electrons, compounds, and molecules and compounds
3. Earth sciences – geology, oceanography, climate, meteorology, soil science
4. Astronomy – stars, planets, origins of the universe
5. Biology – the study of living organisms including genetics

Science can be contrasted to engineering and technology, which are considered applications of science, engineering fields including design and testing, and technology, the most fundamental level of technique and management. Thus a scientist would measure the physics and biology of cutting a grass leaf blade, an engineer would study the kinetics of turf clippings discharge and would design a better rotary mower, and a technician would cut the grass.

Plant sciences including agronomy, horticulture, and forestry, are not entirely science but

include a range of activities from science (e.g., physiology and genetics) to engineering (e.g., crop production and plant breeding) to technology (farming and nursery crop production).

Science including physical sciences cannot be considered except in the context of the scientific method and the scientific paper. The scientific method is the gathering of evidence through observation and experimentation and the testing of hypotheses. A scientific paper is the first report of a significant scientific findings that have been peer reviewed and are accessible either physically in a publication in libraries or electronically, involving repeatable methods and hypotheses that are falsifiable, that is, can be disproved.

1. Physics

For now students showed understand the following terminology related mainly to the electromagnetic spectrum:

absorbance

advective

conduction

convection

heat

heat of condensation

heat of vaporization (evaporation)

infrared

light

photosynthetically active radiation (PAR)

radiation

reflection

reradiation

specific heat

transmission

ultraviolet

2. Chemistry

Chemistry is a science of matter dealing with composition, structure, properties, and transformations of matter as we commonly know it, that is, the substance of physical objects that we can sense directly around us such as liquids, solids, and gases. One way to define matter is, “anything that occupies space and has mass.” Matter as we know it is composed of particles called atoms which cannot be easily created or destroyed and it is the

relations of different kinds of atoms that are the main area of chemistry.

In contrast to chemistry, physics is a more fundamental science of matter dealing with the nature of matter, and force, motion, and energy, and all kinds of matter not just atoms but particles smaller than atoms, and kinds of matter that do not form objects or substances as we commonly know them.

Thus while chemistry and physics both deal with aspects of matter and energy, chemistry deals more with the external relationships of and between material substances, while physics deals more with what's under the dashboard.

Atoms, elements, molecules, and compounds

The atom is a particle that is the basic unit of substances, and it is the smallest unit into which a substance can be subdivided. An atom is a generally stable particle which consists of a positively charged dense central nucleus containing at least one proton and sometimes one or more neutrons, around which is a negatively charged cloud of electrons. The element is a type of element, determined by the number of protons in the nucleus of the atom, which vary from one for the smallest type of atom, hydrogen, to 92 for the largest and heaviest naturally occurring element, uranium. The atomic number of hydrogen is 1 and that of uranium is 92.

Even though the number of protons is the same for all atoms of an element, the number of neutrons can vary within certain numbers. For example, hydrogen naturally has either zero or one neutron. The simple hydrogen called has only one proton in the nucleus and has the atomic weight of approximately 1. Since the neutron weighs about the same as a proton, the type of hydrogen with one proton and one neutron has an atomic weight of 2. These two forms are called "isotopes" hydrogen-1 and hydrogen-2 and they are commonly designated with a superscript, ^1H and ^2H . Two common isotopes of uranium include uranium-238 or ^{238}U and uranium-235 or ^{235}U from atomic bombs are made.

A molecule is a particle that is formed from atoms of two different elements, for example, hydrogen oxide or H_2O is water. Molecules can also be homonuclear diatomic molecules such as the normal occurring forms of hydrogen, oxygen, and nitrogen, H_2 , O_2 , and N_2 and all the halogens, e.g., Cl_2 . Ozone, O_3 , is a homonuclear triatomic form, and large homonuclear molecules exist for sulfur, e.g., and S_8 , and carbon, C_{60} , also known as buckminsterfullerene.

A compound is a material formed of molecules. Generally ionic substances, e.g., sodium chloride, NaCl , do not exist in a true molecular state but exist as a positively charged cation for sodium, Na^+ and a negatively charged anion for chlorine, or Cl^- . This is ionic bonding involving the exchange of one or more electrons from an electropositive element such as sodium to an electronegative element such as chlorine.

Chemical changes involve change of substance through the interaction of reactants which may be atoms and molecules and the production of products which may be atoms and molecules, and the release (exothermic) or absorption (endothermic) of energy. Even an exothermic reaction may require activation energy, that is, the energy "to push the rock down the hill."

under conditions of high or low pH.

The covalent bond

Molecules can have strong bonds between the atoms in the form of covalent bonds, which involve an exchange of electrons. Many strong compounds involve carbon or C as the basic chain, usually with hydrogen (H), the hydrocarbons, and oxygen (O) including sugars and other carbohydrates, and often nitrogen (N), e.g., the amino acids.

Organic molecules

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The hydrocarbon series called the alkanes starts with methane, chemical formula CH_4 and goes up ethane, C_2H_6 , propane, butane, pentane, hexane, heptane, oxane, etc. They can be branched and have side groups, e.g., methyl for $-\text{CH}_3$. Alkenes have double bonds and alkynes have triple bonds.

Hydrocarbon derivatives

Alcohols, aldehydes, carboxylic acids, ketones, ethers, amines, and amino acids are more complex. Sugars have a ring.

Aromatic hydrocarbons

The benzene ring is very stable and consists of a single 6-carbon ring and six hydrogen atoms, formula C_6H_6 and a double ring is naphthalene, and the triple ring is anthracene. These are the building blocks of many pesticides. When these rings are added onto with functional groups, they are numbered clockwise from the top, so the number 1 position is in the “12:00” position, the number 2 position is in the “2:00 position, and the number 3 position is in “4:00” position.

Functional groups

The covalent bond (sharing of electrons) makes organic molecules relatively strong. There are single, double, and triple bonds that can occur between two carbon atoms. Rings such as the benzene ring (represented by the phenyl functional group) tend to be very stable. An herbicide has a basic structure with variable functional groups. The atoms of an herbicide molecule are primarily H, C, O, and N.

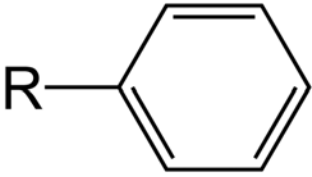
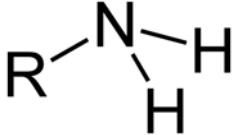
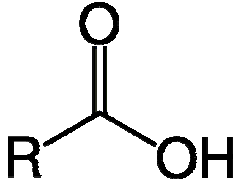
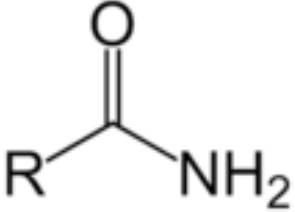
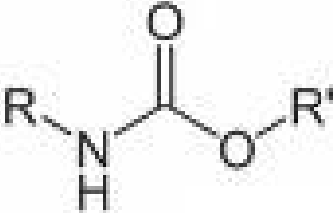
Isomers and stereoisomers

An isomer is a variation of a chemical molecule with the same formula and different arrangement. A stereoisomer is a variation with the same arrangement but different chirality or handedness so that one form looks like the other in the mirror. The two forms of a chiral molecule are called enantiomers.

Chemical characteristics

Common chemical characteristics are color, solubility, pH, odor, boiling point, corrosivity, carcinogenicity, LD_{50} , specific gravity, miscibility, reactivity, and physical state.

Functional groups, their base molecules, and structure

Base molecule	Functional group	Illustration
benzene	phenyl	
methane	methyl	$R-CH_3$
primary amine, e.g., ammonia	amino	
carboxylic acids, e.g. formic acid or methanoic acid	carboxyl	
formamide	amide	
carbamic acid	carbamate	

Brief history of chemistry

German chemists who were later joined by other nations advanced organic chemistry from the early 1800s and the early products included explosives, chemical warfare, fertilizers, dyes, plastics, and ultimately in 1943, pesticides in the form of the herbicide 2,4-D. (Other chemicals were used previously, such as copper salts for selective weed control in cereals in the late 1800s.) The age of “better living through chemistry” (a motto of Dupont) eventually shifted to a more responsible approach after the publication of Rachel Carson’s *Silent Spring* in 1962, showing the concerns about the effects on birds of the insecticide DDT, and the birth of the Environmental Protection Agency under the Nixon administration in 1970.

In 2008, herbicides are enormously important in commercial weed control, however some of the downsides, besides environmental concerns, are the large carbon footprint of petrochemical pesticides and the development of herbicide-resistant weed populations.

The basic concepts and terminology of herbicides include absorption (into the plant), translocation (through the plant), and metabolism (in the plant). Herbicides may be selective or nonselective, systemic and translocated or non-systemic and contact, soil-applied or foliage-applied, preemergence (kills seedlings after they germinate and before they emerge from the soil) or postemergence. There are also fumigants, gaseous herbicides or pesticides that usually allow nothing to survive. Herbicides are classified in 40 to 50 families.

3. Earth sciences

For now students showed understand the following terminology related mainly to the meteorology:

boundary layer

dew

humidity

relative humidity

turbulence

wind

4. Astronomy

The main relationship of astronomy to turfgrass is relationship of the earth’s orbit to climate.

5. Biology

For now students showed understand the following terminology related mainly to the plant function and organelles:

carbohydrate

chloroplast

chromosome

deep-root feeding

etiolation

evaporation

evapotranspiration

exudation

floral initiation

guttation

light compensation point

mitochondrion

nucleus

photosynthesis

resistance vs. tolerance vs. avoidance

respiration

shade

stomate

thermoperiodism

transpiration

transpiration stream