# Appendix

A. Teacher Notes (Connections to National Science Standards, Biology & Chemistry topics)

B. Reference to National Science Standards

C. Content Supplement for Teachers: Chemical Bonds and Forces: A Review

D. Student Self-Quiz with Answers

A Project Funded by a NIDA Science Education Drug Abuse Partnership Award

# APPENDIX A: Teacher Notes

| Module | National Science Standard Codes* | Biology Connections | Chemistry Connections |
|---|---|---|---|
| Acids, Bases, and Cocaine Addicts | CA1, CA21, CA24, CA25, CB20, CB22-25 CB30, CB33, CC10, CF13, CF60, AA1, AA2, AA3, AC2, AC4, AC5 | • membrane structure and transport mechanisms<br>• capillary function<br>• diffusion<br>• circulatory system and respiration<br>• blood-brain barrier | • ions and ionization<br>• weak acids/bases, equilibrium<br>• bond types – melting/boiling points of ionic vs. covalent<br>• polarity<br>• osmosis |
| Drug Testing: A Hair-Brained Idea! | CA1, CA23, CA24, CA25, CB20, CC53, CC63, CE10, CE11, CE12, CE13, CF21, CG11, AA1, AA2, AA3, AC2, AC4, AC5, AD1 | • kidney and liver function<br>• circulatory system<br>• cell structure and call types<br>• melanin formation<br>• enzymes<br>• membrane transport<br>• decision making (scientific and social) | • pH, weak acids/bases<br>• enzymes<br>• polymers<br>• polarity<br>• S bonds<br>• bond types – melting/boiling points of ionic vs covalent |
| How Do Drugs Damage Neurons? It's Radical! | CA1, CA21, CA24, CA25, CB12, CB13, CB20, CB32, CB34, CB5, CB6, CE23, CF11, CF12, CF13, CG20-23, AA1, AA2, AA3, AC2, AC4, AC5 | • neuron structure and function<br>• neurotransmitters, enzymes<br>• toxins<br>• free radicals, cell damage,<br>• Parkinson's, Alzheimer's disease | • redox, free radicals<br>• enzymes<br>• electrochemistry<br>• radiation and cellular damage<br>• Fenton reaction |
| Military Pharmacology: It Takes Nerves | CA1, CA23, CA24, CA25, CB20, CB22, CB24, CB30, CB32, CB33, CB34, CB5, CB6, CE10, CE11, CE12, CE13, CF11, CF12, CF13, CF14, CG11, CG21, AA1, AA2, AA3, AC2, AC4, AC5 | • toxins,<br>• peripheral nervous system (SNS, PSNS)<br>• respiration system<br>• enzymes | • hydrolysis<br>• reversible-irreversible reactions<br>• enzymes<br>• gas behavior |
| Why do Plants Make Drugs for Humans | CA23, CA24, CB10, CB20, CB22-25, CB33-34, CC10, CC14, CC53, CC60, CC63, CF10, CF12, AA13, AC4, AD1-4 | • angiosperm classification<br>• plant cell structure<br>• membrane transport<br>• enzymes, receptors, neurotransmitters | • bonding types<br>• solubility, weak acids/bases,<br>• catalysts<br>• origins of chemicals |
| Steroids and Athletes: Genes Work Overtime! | CA10, CA24, CB22, CB23, CB25, CB30, CB34, CC10, CC12, CC13, CC53, CD32, CE13, CE14, CE20, CF10, CF12, CF14, CF61, AB11, AB14, AC2, AC4, AE1 | • types of muscles, cell structure<br>• steroids: synthesis, function<br>• membrane transport systems<br>• DNA, RNA, gene transcription<br>• liver & kidney function<br>• addiction vs physiologic dependence. | • non-polar and polar bond types<br>• steroid structure<br>• hydrophobic and lipophilic compounds<br>• DNA and the chemical structure of base pairs. |

* See Appendix B for code descriptions. Opportunities for demonstrating Teaching Standards are provided in each module, so they are not listed here. Teachers may integrate the Teaching Standards into their own style and management plan.

# APPENDIX B

## National Science Standards

The following coding is used to abbreviate the National Standards that pertain to the modules and your lesson planning. The coding "C" represents Content Standards, "A" represents Assessment Standards, and "T" represents Teaching Standards. The standards appear in the order as they occur in the National Science Standards publications. The coding is our own, but you may see it used by other organizations.

**SCIENCE CONTENT STANDARDS (C)**

## Science as Inquiry

**CONTENT STANDARD A: As a result of activities in grades 9-12, all students should develop**

**CA1**. Abilities necessary to do scientific inquiry

**CA2**. Understandings about scientific inquiry

**CA21**. Design and conduct scientific investigation
**CA22**. Use technology and mathematics to improve investigations and communications
**CA23**. Formulate and revise scientific explanations and models using logic and evidence
**CA24**. Recognize and analyze alternative explanations and models
**CA25**. Communicate and defend a scientific argument
**CA26**. Understand about scientific inquiry

## Physical Science

**CONTENT STANDARD B: As a result of their activities in grades 9-12, all students should develop an understanding of**

**CB1.** Structure of atoms
**CB2**. Structure and properties of matter
**CB3.** Chemical reactions
**CB4**. Motions and forces
**CB5**. Conservation of energy and increase in disorder
**CB6.** Interactions of energy and matter

**CB1:** ***STRUCTURE OF ATOMS***

**CB10.** Matter is made of minute particles called atoms, and atoms are composed of even smaller components. These components have measurable properties, such as mass and electrical charge. Each atom has a positively charged nucleus surrounded by

negatively charged electrons. The electric force between the nucleus and electrons holds the atom together.

**CB11.** The atom's nucleus is composed of protons and neutrons, which are much more massive than electrons. When an element has atoms that differ in the number of neutrons, these atoms are called different isotopes of the element.

**CB12.** The nuclear forces that hold the nucleus of an atom together, at nuclear distances, are usually stronger than the electric forces that would make it fly apart. Nuclear reactions convert a fraction of the mass of interacting particles into energy, and they can release much greater amounts of energy than atomic interactions. Fission is the splitting of a large nucleus into smaller pieces. Fusion is the joining of two nuclei at extremely high temperature and pressure, and it is the process responsible for the energy of the sun and other stars.

**CB13.** Radioactive isotopes are unstable and undergo spontaneous nuclear reactions, emitting particles and/or wavelike radiation. The decay of any one nucleus cannot be predicted, but a large group of identical nuclei decay at a predictable rate. This predictability can be used to estimate the age of materials that contain radioactive isotopes.

## CB2: *STRUCTURE AND PROPERTIES OF MATTER*

**CB20.** Atoms interact with one another by transferring or sharing electrons that are furthest from the nucleus. These outer electrons govern the chemical properties of the element.

**CB21.** An element is composed of a single type of atom. When elements are listed in order according to the number of protons (called the atomic number), repeating patterns of physical and chemical properties identify families of elements with similar properties. This "Periodic Table" is a consequence of the repeating pattern of outermost electrons and their permitted energies.

**CB 22.** Bonds between atoms are created when electrons are paired up by being transferred or shared. A substance composed of a single kind of atom is called an element. The atoms may be bonded together into molecules or crystalline solids. A compound is formed when two or more kinds of atoms bind together chemically.

**CB23.** The physical properties of compounds reflect the nature of the interactions among its molecules. These interactions are determined by the structure of the molecule, including the constituent atoms and the distances and angles between them.

**CB24.** Solids, liquids, and gases differ in the distances and angles between molecules or atoms and therefore in the energy that binds them together. In solids the structure is nearly rigid; in liquids molecules or atoms move around each other but do not move apart; and in gases molecules or atoms move almost independently of each other and are mostly far apart.

**CB25.** Carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures, including synthetic polymers, oils, and the large molecules essential to life.

### CB3: *CHEMICAL REACTIONS*

**CB30.** Chemical reactions occur all around us, for example in health care, cooking, cosmetics, and automobiles. Complex chemical reactions involving carbon-based molecules take place constantly in every cell in our bodies.

**CB31.** Chemical reactions may release or consume energy. Some reactions such as the burning of fossil fuels release large amounts of energy by losing heat and by emitting light. Light can initiate many chemical reactions such as photosynthesis and the evolution of urban smog.

**CB32.** A large number of important reactions involves the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, or atoms. In other reactions, chemical bonds are broken by heat or light to form very reactive radicals with electrons ready to form new bonds. Radical reactions control many processes such as the presence of ozone and greenhouse gases in the atmosphere, burning and processing of fossil fuels, the formation of polymers, and explosions.

**CB33.** Chemical reactions can take place in time periods ranging from the few femtoseconds ($10^{-15}$ seconds) required for an atom to move a fraction of a chemical bond distance to geologic time scales of billions of years. Reaction rates depend on how often the reacting atoms and molecules encounter one another, on the temperature, and on the properties--including shape--of the reacting species.

**CB34.** Catalysts, such as metal surfaces, accelerate chemical reactions. Protein molecules called enzymes catalyze chemical reactions in living systems.

## Life Science

**CONTENT STANDARD C: As a result of their activities in grades 9-12, all students should develop an understanding of**

**CC1.** The cell
**CC2.** Molecular basis of heredity
**CC3.** Biological evolution
**CC4.** Interdependence of organisms
**CC5.** Matter, energy, and organization in living systems
**CC6.** Behavior of organisms

## CC1: *THE CELL*

**CC10.** Cells have particular structures that underlie their functions. A membrane that separates it from the outside world surrounds every cell. Inside the cell is a concentrated mixture of thousands of different molecules which form a variety of specialized structures that carry out such cell functions as energy production, transport of molecules, waste disposal, synthesis of new molecules, and the storage of genetic material.

**CC11.** Most cell functions involve chemical reactions. Food molecules taken into cells react to provide the chemical constituents needed to synthesize other molecules. Both breakdown and synthesis are made possible by a large set of protein catalysts, called enzymes. The breakdown of some of the food molecules enables the cell to store energy in specific chemicals that are used to carry out the many functions of the cell.

**CC12.** Cells store and use information to guide their functions. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires.

**CC13.** Cell functions are regulated. Regulation occurs both through changes in the activity of the functions performed by proteins and through the selective expression of individual genes. This regulation allows cells to respond to their environment and to control and coordinate cell growth and division.

**CC14.** Plant cells contain chloroplasts, the site of photosynthesis. Plants and many microorganisms use solar energy to combine molecules of carbon dioxide and water into complex, energy rich organic compounds and release oxygen to the environment. This process of photosynthesis provides a vital connection between the sun and the energy needs of living systems.

**CC15.** Cells can differentiate, and complex multicellular organisms are formed as a highly organized arrangement of differentiated cells. In the development of these multicellular organisms, the progeny from a single cell form an embryo in which the cells multiply and differentiate to form the many specialized cells, tissues and organs that comprise the final organism. This differentiation is regulated through the expression of different genes.

## CC5: *MATTER, ENERGY, AND ORGANIZATION IN LIVING SYSTEMS*

**CC50.** All matter tends toward more disorganized states. Living systems require a continuous input of energy to maintain their chemical and physical organizations. With death, and the cessation of energy input, living systems rapidly disintegrate.

**CC51.** The energy for life primarily derives from the sun. Plants capture energy by absorbing light and using it to form strong (covalent) chemical bonds between the atoms of carbon-containing (organic) molecules. These molecules can be used to

assemble larger molecules with biological activity (including proteins, DNA, sugars, and fats). In addition, the energy stored in bonds between the atoms (chemical energy) can be used as sources of energy for life processes.

**CC52.** The chemical bonds of food molecules contain energy. Energy is released when the bonds of food molecules are broken and new compounds with lower energy bonds are formed. Cells usually store this energy temporarily in phosphate bonds of a small high-energy compound called ATP.

**CC53.** The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.

**CC54.** The distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials.

**CC55.** As matter and energy flows through different levels of organization of living systems--cells, organs, organisms, communities--and between living systems and the physical environment, chemical elements are recombined in different ways. Each recombination results in storage and dissipation of energy into the environment as heat. Matter and energy are conserved in each change.

## CC6: *THE BEHAVIOR OF ORGANISMS*

**CC60.** Multicellular animals have nervous systems that generate behavior. Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules. In sense organs, specialized cells detect light, sound, and specific chemicals and enable animals to monitor what is going on in the world around them.

**CC61.** Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.

**CC62.** Like other aspects of an organism's biology, behaviors have evolved through natural selection. Behaviors often have an adaptive logic when viewed in terms of evolutionary principles.

**CC63.** Behavioral biology has implications for humans, as it provides links to psychology, sociology, and anthropology.

## Science and Technology

**CONTENT STANDARD E: As a result of activities in grades 9-12, all students should develop**

**CE1.** Abilities of technological design
**CE2.** Understandings about science and technology

### CE1: *ABILITIES OF TECHNOLOGICAL DESIGN*

**CE10. IDENTIFY A PROBLEM OR DESIGN AN OPPORTUNITY.** Students should be able to identify new problems or needs and to change and improve current technological designs.

**CE11. PROPOSE DESIGNS AND CHOOSE BETWEEN ALTERNATIVE SOLUTIONS.** Students should demonstrate thoughtful planning for a piece of technology or technique. Students should be introduced to the roles of models and simulations in these processes.

**CE12. IMPLEMENT A PROPOSED SOLUTION.** A variety of skills can be needed in proposing a solution depending on the type of technology that is involved. The construction of artifacts can require the skills of cutting, shaping, treating, and joining common materials--such as wood, metal, plastics, and textiles. Solutions can also be implemented using computer software.

**CE13. EVALUATE THE SOLUTION AND ITS CONSEQUENCES.** Students should test any solution against the needs and criteria it was designed to meet. At this stage, new criteria not originally considered may be reviewed.

**CE14. COMMUNICATE THE PROBLEM, PROCESS, AND SOLUTION.** Students should present their results to students, teachers, and others in a variety of ways, such as orally, in writing, and in other forms--including models, diagrams, and demonstrations.

### CE2: *UNDERSTANDINGS ABOUT SCIENCE AND TECHNOLOGY*

**CE20.** Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations. Many scientific investigations require the contributions of individuals from different disciplines, including engineering. New disciplines of science, such as geophysics and biochemistry often emerge at the interface of two older disciplines.

**CE21.** Science often advances with the introduction of new technologies. Solving technological problems often results in new scientific knowledge. New technologies often extend the current levels of scientific understanding and introduce new areas of research.

**CE22.** Creativity, imagination, and a good knowledge base are all required in the work of science and engineering.

**CE23.** Science and technology are pursued for different purposes. Scientific inquiry is driven by the desire to understand the natural world, and technological design is driven by the need to meet human needs and solve human problems. Technology, by its nature, has a more direct effect on society than science because its purpose is to solve human problems, help humans adapt, and fulfill human aspirations. Technological solutions may create new problems. Science, by its nature, answers questions that may or may not directly influence humans. Sometimes scientific advances challenge people's beliefs and practical explanations concerning various aspects of the world.

**CE24.** Technological knowledge is often not made public because of patents and the financial potential of the idea or invention. Scientific knowledge is made public through presentations at professional meetings and publications in scientific journals.

## Science in Personal and Social Perspectives

**CONTENT STANDARD F: As a result of activities in grades 9-12, all students should develop understanding of**

**CF1.** Personal and community health
**CF2**. Population growth
**CF3.** Natural resources
**CF4.** Environmental quality
**CF5.** Natural and human-induced hazards
**CF6**. Science and technology in local, national, and global challenges

### CF1: *PERSONAL AND COMMUNITY HEALTH*

**CF10.** Hazards and the potential for accidents exist. Regardless of the environment, the possibility of injury, illness, disability, or death may be present. Humans have a variety of mechanisms--sensory, motor, emotional, social, and technological--that can reduce and modify hazards.

**CF11.** The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease-producing organism. Many diseases can be prevented, controlled, or cured. Some diseases, such as cancer, result from specific body dysfunctions and cannot be transmitted.

**CF12.** Personal choice concerning fitness and health involves multiple factors. Personal goals, peer and social pressures, ethnic and religious beliefs, and understanding of biological consequences can all influence decisions about health practices.

**CF13.** Substances may modify an individual's mood and behavior. The modification may be beneficial or detrimental depending on the motives, type of substance, duration

of use, pattern of use, level of influence, and short- and long-term effects. Students should understand that drugs can result in physical dependence and can increase the risk of injury, accidents, and death.

**CF14.** Selection of foods and eating patterns determine nutritional balance. Nutritional balance has a direct effect on growth and development and personal well-being. Personal and social factors--such as habits, family income, ethnic heritage, body size, advertising, and peer pressure--influence nutritional choices.

**CF15.** Families serve basic health needs, especially for young children. Regardless of the family structure, individuals have families that involve a variety of physical, mental, and social relationships that influence the maintenance and improvement of health.

**CF16.** Sexuality is basic to the physical, mental, and social development of humans. Students should understand that human sexuality involves biological functions, psychological motives, and cultural, ethnic, religious, and technological influences. Sex is a basic and powerful force that has consequences to individuals' health and to society. Students should understand various methods of controlling the reproduction process and that each method has a different type of effectiveness and different health and social consequences.

**CF6:** ***SCIENCE AND TECHNOLOGY IN LOCAL, NATIONAL, AND GLOBAL CHALLENGES***

**CF60.** Science and technology are essential social enterprises, but alone they can only indicate what can happen, not what should happen. The latter involves human decisions about the use of knowledge.

**CF61.** Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science- and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges.

**CF62.** Social issues and challenges can affect progress in science and technology. Funding priorities for specific health problems serve as examples of ways that social issues influence science and technology.

**CF63.** Individuals and society must decide on proposals involving new research and the introduction of new technologies into society. Decisions involve assessment of alternatives, risks, costs, and benefits and consideration of who benefits and who suffers, who pays and gains, and what the risks are and who bears them. Students should understand the appropriateness and value of basic questions--"What can happen?"--"What are the odds?"--and "How do scientists and engineers know what will happen?"

**CF64.** Humans have a major effect on other species. For example, the influence of humans on other organisms occurs through land use--which decreases space available to

other species--and pollution--which changes the chemical composition of air, soil, and water.

## History and Nature of Science

**CONTENT STANDARD G: As a result of activities in grades 9-12, all students should develop understanding of**

**CG1.** Science as a human endeavor
**CG2.** Nature of scientific knowledge
**CG3.** Historical perspectives

### CG1: *SCIENCE AS A HUMAN ENDEAVOR*

**CG10.** Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science or engineering can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific question or technological problem. Pursuing science as a career or as a hobby can be both fascinating and intellectually rewarding.

**CG11.** Scientists have ethical traditions. Scientists value peer review, truthful reporting about the methods and outcomes of investigations, and making public the results of work. Violations of such norms do occur, but their peers censure scientists responsible for such violations.

**CG12.** Scientists are influenced by societal, cultural, and personal beliefs and ways of viewing the world. Science is not separate from society but rather science is a part of society.

### CG2: *NATURE OF SCIENTIFIC KNOWLEDGE*

**CG20.** Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism, as scientists strive for the best possible explanations about the natural world.

**CG21.** Scientific explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied. They should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public. Explanations on how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific.

**CG22.** Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. The core ideas of science such as the conservation of energy or the laws of motion have been subjected to a wide variety of confirmations and are therefore unlikely to change in the areas in which they have been tested. In areas where data or understanding are incomplete, such as the details of human evolution or questions surrounding global warming, new data may well lead to changes in current ideas or resolve current conflicts. In situations where information is still fragmentary, it is normal for scientific ideas to be incomplete, but this is also where the opportunity for making advances may be greatest.

**ASSESSMENT STANDARDS (A)**

PEP Modules are designed to follow the National Science Standards Guidelines for Assessment. There are several opportunities for assessment within each module. These include, 1) the student handout questions at the beginning of each module, 2) assessment strategies associated with the student activities section, and 3) a set of student self-quiz questions (with answers) associated with each module.

**ASSESSMENT STANDARD A: Assessments must be consistent with the decisions they are designed to inform.**

**AA1.** Assessments are deliberately designed.

**AA2.** Assessments have explicitly stated purposes.

**AA3.** The relationship between the decisions and the data is clear.

**AA4.** Assessment procedures are internally consistent.

**ASSESSMENT STANDARD B: Achievement and opportunity to learn science must be assessed.**

**AB1.** Achievement data collected focus on the science content that is most important for students to learn.

**AB2.** Opportunity-to-learn data collected focus on the most powerful indicators.

**AB3.** Equal attention must be given to the assessment of opportunity to learn and to the assessment of student achievement.

**AB1: ACHIEVEMENT DATA COLLECTED FOCUS ON THE SCIENCE CONTENT THAT IS MOST IMPORTANT FOR STUDENTS TO LEARN.** The content standards define the science all students will come to understand. They portray the outcomes of science education as rich and varied, encompassing

**AB11.** The ability to inquire.

**AB12.** Knowing and understanding scientific facts, concepts, principles, laws, and theories.

**AB13.** The ability to reason scientifically.

**AB14**. The ability to use science to make personal decisions and to take positions on societal issues.

**AB15**. The ability to communicate effectively about science.

**ASSESSMENT STANDARD C: The technical quality of the data collected is well matched to the decisions and actions taken on the basis of their interpretation.**

**AC1.** The feature that is claimed to be measured is actually measured.

**AC2.** Assessment tasks are authentic.

**AC3.** An individual student's performance is similar on two or more tasks that claim to measure the same aspect of student achievement.

**AC4.** Students have adequate opportunity to demonstrate their achievements.

**AC5.** Assessment tasks and methods of presenting them provide data that are sufficiently stable to lead to the same decisions if used at different times.

**ASSESSMENT STANDARD D: Assessment practices must be fair.**

**AD1.** Assessment tasks must be reviewed for the use of stereotypes, for assumptions that reflect the perspectives or experiences of a particular group, for language that might be offensive to a particular group, and for other features that might distract students from the intended task.

**AD2.** Large-scale assessments must use statistical techniques to identify potential bias among subgroups.

**AD3.** Assessment tasks must be appropriately modified to accommodate the needs of students with physical disabilities, learning disabilities, or limited English proficiency.

**AD4.** Assessment tasks must be set in a variety of contexts, be engaging to students with different interests and experiences, and must not assume the perspective or experience of a particular gender, racial, or ethnic group.

**ASSESSMENT STANDARD E: The inferences made from assessments about student achievement and opportunity to learn must be sound.**

**AE1**. When making inferences from assessment data about student achievement and opportunity to learn science, explicit reference needs to be made to the assumptions on which the inferences are based.

## SCIENCE TEACHING STANDARDS (T)

### TEACHING STANDARD A: Teachers of science plan an inquiry-based science program for their students. In doing this, teachers

**TA1.** Develop a framework of yearlong and short-term goals for students.

**TA2**. Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students.

**TA3**. Select teaching and assessment strategies that support the development of student understanding and nurture a community of science learners.

**TA4**. Work together as colleagues within and across disciplines and grade levels.

### TEACHING STANDARD B: Teachers of science guide and facilitate learning. In doing this, teachers

**TB1.** Focus and support inquiries while interacting with students.

**TB2.** Orchestrate discourse among students about scientific ideas.

**TB3.** Challenge students to accept and share responsibility for their own learning.

**TB4.** Recognize and respond to student diversity and encourage all students to participate fully in science learning.

**TB5.** Encourage and model the skills of scientific inquiry, as well as the curiosity, openness to new ideas and data, and skepticism that characterize science.

### TEACHING STANDARD C: Teachers of science engage in ongoing assessment of their teaching and of student learning. In doing this, teachers

**TC1.** Use multiple methods and systematically gather data about student understanding and ability.

**TC2.** Analyze assessment data to guide teaching.

**TC3.** Guide students in self-assessment.

**TC4.** Use student data, observations of teaching, and interactions with colleagues to reflect on and improve teaching practice.

**TC5.** Use student data, observations of teaching, and interactions with colleagues to report student achievement and opportunities to learn to students, teachers, parents, policy makers, and the general public.

**TEACHING STANDARD D: Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science. In doing this, teachers**

**TD1.** Structure the time available so that students are able to engage in extended investigations.

**TD2.** Create a setting for student work that is flexible and supportive of science inquiry.

**TD3.** Ensure a safe working environment.

**TD4.** Make the available science tools, materials, media, and technological resources accessible to students.

**TD5.** Identify and use resources outside the school.

**TD6.** Engage students in designing the learning environment.

**TEACHING STANDARD E: Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning. In doing this, teachers**

**TE1.** Display and demand respect for the diverse ideas, skills, and experiences of all students.

**TE2.** Enable students to have a significant voice in decisions about the content and context of their work and require students to take responsibility for the learning of all members of the community.

**TE4.** Nurture collaboration among students.

**TE5.** Structure and facilitate ongoing formal and informal discussion based on a shared understanding of rules of scientific discourse.

**TE6.** Model and emphasize the skills, attitudes, and values of scientific inquiry.

**TEACHING STANDARD F: Teachers of science actively participate in the ongoing planning and development of the school science program. In doing this, teachers**

**TF1.** Plan and develop the school science program.

**TF2.** Participate in decisions concerning the allocation of time and other resources to the science program.

**TF3.** Participate fully in planning and implementing professional growth and development strategies for themselves and their colleagues.

# APPENDIX C

## Chemical Bonds and Forces: A Review

### Intramolecular Bonds

Intramolecular bonds are the bonds that hold atoms to atoms and make compounds. There are 3 types of intramolecular bonds: covalent, ionic, and metallic.

**Covalent Bond:** a bond in which a pair or pairs of electrons is shared by two atoms.

- Molecular compounds refer to covalently-bonded species, generally of low molecular mass.
- Macromolecular compounds are high molecular mass compounds that are covalently-bonded and linear, branched, or cross linked.
- Network: compounds in which each atom is covalently-bonded to all its nearest neighbors so that the entire crystal is one molecule.

**Ionic Bond:** a bond that holds atoms together in a compound; the electrostatic attraction between charged ions. Ionic compounds are formed between atoms that differ significantly in electronegativity. The electron(s) involved in bonding is (are) transferred from the less electronegative to the more electronegative atom(s) forming ions.

**Metallic Bond:** a bond resulting from the attraction between positive ions and surrounding mobile electrons.

### Intermolecular forces

Intermolecular forces are the forces that attract molecules or particles to like or unlike molecules or particles. Typically, these *forces* between molecules form much weaker *bonds* than those bonds that form compounds. Intermolecular forces are described below. They are grouped into 3 subcategories based on the type of intramolecular bonds that form a compound:

- Ionic compounds exhibit electrostatic intermolecular forces that form strong bonds with other ionic species.
- Covalent compounds exhibit van der Waals intermolecular forces that form bonds of various strengths with other covalent compounds. The three types of van der Waals forces include: 1) dispersion (weak), 2) dipole-dipole (medium), and 3) hydrogen (strong).

- Ion-dipole bonds (ionic species to covalent molecules) are formed between ions and polar molecules. These compounds typically form medium to strong bonds.

There are five kinds of intermolecular forces described below; the bond strengths described range from strongest to weakest (the latter 3 are examples of van der Waals forces). Please remember that this comparison is relative to other *intermolecular* attractions and not to covalent or ionic bond strength; there are numerous exceptions that are not provided here.

- **Electrostatic:** attractive forces between ions of opposite charge; e.g., NaCl bonded to another NaCl to form a crystal of salt.

- **Ion-Dipole:** forces of attraction between a cation/anion and the solvent molecules when dissolved in water or other polar molecules; e.g., NaCl dissolving in $H_2O$ to form $Na^+$ and $Cl^-$ surrounded by water molecules.

- **Hydrogen Bond:** a special type of dipole-dipole interaction between the hydrogen atom in a polar bond like O-H or N-H and the electronegative atoms, N, O, or F. These are much stronger forces of attraction than other dipole-dipole forces. When H, a very small atom, is bonded to other very small atoms with high electronegativity, they form a strong attraction to other similar atoms. Only N, O, and F form hydrogen bonds. Water molecules also form hydrogen bonds with other water molecules.

- **Dipole-Dipole:** forces of attraction between polar molecules. For example, one molecule of $H_2O$ is attracted to another $H_2O$ molecule because $H_2O$ is a polar molecule. Water is called the universal solvent because many ionic and covalent compounds will dissolve in it.

- **Dispersion (London forces):** attractive forces that arise between temporary dipoles and induced dipoles in atoms or molecules; e.g., $I_2$ bonded to $I_2$ to form liquid or solid iodine. The larger the molecule, the stronger the dispersion force.

# APPENDIX D

## Self-Quiz for Module 1

Think of a biological membranes as an oreo cookie. It is a lipid bilayer with 2 parts—the outer (or chocolate cookie part) is _____ and the inner part (or the creamy part) is _____. (fill in the blanks)

1. hydrophilic, hydrophilic
2. lipophilic, hydrophilic
3. hydrophilic, hydrophobic
4. hydrophobic, amphoteric

Answers:

1. You're half right! The outer parts of the plasma membrane, or lipid bilayer, are hydrophilic or water-loving because that end of the fatty acid is polar. The inner part of the fatty acid contains the carbon chain, which is non-polar, or hydrophobic (water-fearing).

2. Sorry, you got it backwards. The outer parts of the plasma membrane, or lipid bilayer, are hydrophilic or water-loving because that end of the fatty acid is polar. The inner part of the fatty acid contains the carbon chain, which is non-polar, hydrophobic (water-fearing) or lipophilic (lipid-loving).

3. Terrific! The outer parts of the plasma membrane, or lipid bilayer, are hydrophilic or water-loving the that end of the fatty acid is polar. The inner part of the fatty acid contains the carbon chain, which is non-polar, or hydrophobic (water-fearing).

4. Sorry! The outer parts of the plasma membrane, or lipid bilayer, are hydrophilic or water-loving because that end of the fatty acid is polar. The inner part of the fatty acid contains the carbon chain, which is non-polar, or hydrophobic (water-fearing).

Certain drugs cannot get into the brain very easily because of the presence of a "blood-brain barrier". Lipophilic drugs like cocaine penetrate this protective barrier rather quickly, but charged compounds cannot. This is because the blood-brain barrier consists of:

1. Tightly packed capillary epithelial cells
2. Tightly packed capillary endothelial cells
3. Mucosal cell membranes
4. Very small sacs known as alveoli

Answers:

1. Sorry, that is incorrect. Epithelial cells are a type of skin cell. Capillaries in the brain contain tightly packed endothelial cells that prevent polar compounds from diffusing across the membrane into the brain (the "blood-brain barrier").

2. Good answer! Capillaries in the brain contain tightly packed endothelial cells that prevent polar compounds from diffusing across the membrane into the brain (the "blood-brain barrier"). Lipophilic compounds diffuse easily across the capillaries.

3. Sorry, that is incorrect. Mucosal cell membranes are a type of epithelial cell that secretes mucous (such as in the lining of the gut or the nose). Capillaries in the brain contain tightly packed endothelial cells that prevent polar compounds from diffusing across the membrane into the brain (the "blood-brain barrier"). Lipophilic compounds diffuse easily across the capillaries.

4. Sorry, that is incorrect. Alveoli are special cells present in the lungs for the exchange of gases. Capillaries in the brain contain tightly packed endothelial cells that prevent polar compounds from diffusing across the membrane into the brain (the "blood-brain barrier"). Lipophilic compounds diffuse easily across the capillaries.

Research into the fields of drug abuse, pharmacology, and psychology indicates that the period of time between the introduction of a drug into the body and its ability to produce euphoria or pleasure is important in the abuse potential of that drug. A user is more likely to continue cocaine use after:

1. Snorting the drug
2. Ingesting the drug orally
3. Smoking the crack form of the drug

Answers:

1. Wrong answer. When snorted, cocaine must diffuse through mucosal cells lining the nasal passages into nearby capillaries, which allow its absorption into the blood stream rather quickly. However, the drug must then travel within the venous system to the heart, then to the lungs, and then back to the heart for distribution throughout the body, including the brain.

2. Wrong answer. Very little cocaine gets absorbed from the gut into the bloodstream because much of it is actually metabolized there. Only mild effects are produced and they occur very slowly, decreasing the abuse potential of this form of cocaine.

3. Bravo! Because smoking crack allows the drug to enter the bloodstream almost instantly, the high is produced within seconds. The cocaine only needs to return to

the heart from the lungs and then goes straight to the brain. Furthermore, cocaine leaves the brain very quickly after smoking stops, encouraging the user to repeat the process.

Cocaine is a molecule composed of C, H, O, and N atoms. In solution, the drug exists in two forms in an equilibrium: the free base and the acid salt; the pH of the environment determines the predominant form. The route of administration of cocaine depends on whether it is in the free base or acid salt form. The ionized or polar form (the salt) of cocaine can be administered into the body in which of the following manners?

1. Snorted and smoked
2. Snorted, injected, and smoked
3. Injected and smoked
4. Snorted and injected

Answers:

1. You are partly right. The hydrochloride salt form of cocaine readily dissolves in solution, allowing the drug to be snorted or injected. However, the salt forms of weak bases like cocaine are destroyed by the high temperatures needed to make them volatile, so they cannot be smoked.

2. You got 2 out of 3 right! The hydrochloride salt form of cocaine readily dissolves in solution, allowing the drug to be snorted or injected. However, the salt forms of weak bases like cocaine are destroyed by the high temperatures needed to make them volatile, so they cannot be smoked.

3. You are partly right. The hydrochloride salt form of cocaine readily dissolves in solution, allowing the drug to be snorted or injected. However, the salt forms of weak bases like cocaine are destroyed by the high temperatures needed to make them volatile, so they cannot be smoked.

4. You're right! The hydrochloride salt form of cocaine readily dissolves in solution, allowing the drug to be snorted or injected.

Drugs can be introduced into the body on the venous side or the arterial side of the circulatory system. Which side of the circulatory system does cocaine reach first, if it is snorted or smoked?

1. arterial, venous
2. arterial, arterial
3. venous, arterial
4. venous, venous

Answers:

1. Guess again. Any drug that enters the circulation via capillaries outside the lungs will flow into the veins. After snorting cocaine, it enters capillaries in the nasal passages, then travels to the veins, which bring it to the right side of the heart. In contrast, smoked cocaine enters capillaries in the lungs, that contain oxygenated blood, which returns to the left side of the heart, to be pumped through the arterial system throughout the body.

2. Guess again. Any drug that enters the circulation via capillaries outside the lungs will flow into the veins. After snorting cocaine, it enters capillaries in the nasal passages, then travels to the veins, which bring it to the right side of the heart. In contrast, smoked cocaine enters capillaries in the lungs, that contain oxygenated blood, which returns to the left side of the heart, to be pumped through the arterial system throughout the body.

3. Terrific! Any drug that enters the circulation via capillaries outside the lungs will flow into the veins. After snorting cocaine, it enters capillaries in the nasal passages, then travels to the veins, which bring it to the right side of the heart. In contrast, smoked cocaine enters capillaries in the lungs, that contain oxygenated blood, which returns to the left side of the heart, to be pumped through the arterial system throughout the body.

4. Guess again. Any drug that enters the circulation via capillaries outside the lungs will flow into the veins. After snorting cocaine, it enters capillaries in the nasal passages, then travels to the veins, which bring it to the right side of the heart. In contrast, smoked cocaine enters capillaries in the lungs, that contain oxygenated blood, which returns to the left side of the heart, to be pumped through the arterial system throughout the body.

## Self-Quiz for Module 2

In this module, you learned that hair color might affect the outcome of drug testing. A dark-haired man and a blonde man use cocaine one night at the same time. Upon drug testing one month later, the dark-haired man is denied employment while the blonde man is hired. This happens because the dark-haired man:

1. Has more keratin in his hair follicles
2. Has less keratin in his hair follicles
3. Has more melanin in his hair follicles
4. Has less melanin in his hair follicles

Answers:

1. Try again. Keratin, a fibrous protein, is responsible for the strength and structure of hair. Melanin, a polymer, provides the pigment that gives hair color. Darker hair contains more melanin than lighter colored hair. Melanin, which is acidic, binds to weak bases such as cocaine. Therefore, the more melanin present, the more binding of cocaine.

2. Try again. Keratin, a fibrous protein, is responsible for the strength and structure of hair. Melanin, a polymer, provides the pigment that gives hair color. Darker hair contains more melanin than lighter colored hair. Melanin, which is acidic, binds to weak bases such as cocaine. Therefore, the more melanin present, the more binding of cocaine.

3. Correct! Melanin, a polymer, provides the pigment that gives hair color. Darker hair contains more melanin than lighter colored hair. Melanin, which is acidic, binds to weak bases such as cocaine. Therefore, the more melanin present, the more binding of cocaine.

4. Try again. Melanin, a polymer, provides the pigment that gives hair color. Darker hair contains more melanin than lighter colored hair. Melanin, which is acidic, binds to weak bases such as cocaine. Therefore, the more melanin present, the more binding of cocaine.

Cocaine, a weak base, can be found in hair. Once in the bloodstream, cocaine can cross the capillary membranes to enter the hair follicle and bind to melanin. Its ability to bind to melanin, an acid, is because it can:

1. Remove a hydrogen ion, $H^+$, from the melanin
2. Remove a hydroxide ion, $OH^-$, from the melanin
3. Add a hydroxide ion, $OH^-$, to the melanin
4. Add a hydrogen ion, $H^+$, to the melanin

Answers:

1. Good answer! Cocaine, a weak base, accepts a hydrogen ion from melanin, and this causes the cocaine to become a charged molecule. Charged molecules are not able to cross back very easily into capillary membranes found near hair follicles.

2. Sorry, that is incorrect. Cocaine, a weak base, accepts a hydrogen ion from melanin, and this causes the cocaine to become a charged molecule. Charged molecules are not able to cross back very easily into capillary membranes found near hair follicles.

3. Sorry, try again. Cocaine, a weak base, accepts a hydrogen ion from melanin, and this causes the cocaine to become a charged molecule. Charged molecules are not able to cross back very easily into capillary membranes found near hair follicles.

4. Sorry, that is incorrect. Cocaine, a weak base, accepts a hydrogen ion from melanin, and this causes the cocaine to become a charged molecule. Charged molecules are not able to cross back very easily into capillary membranes found near hair follicles.

This module reminded you that drugs can enter the body in different ways. Drug addicts avoid using methods of administration that result in slow entry into the body or bloodstream because they need to feel the effect of the drug quickly. By which of the following forms of adminstration does a drug get into the bloodstream slowest?

1. Injection into a vein
2 Snorting it
3. Smoking it
4. Ingestion (by mouth)

Answers:

1. No. Injecting a drug directly into a vein is actually the quickest way to get it into the bloodstream. Once in the veins (deoxygenated blood), the drug travels to the right heart, goes to the lungs, and then the oxygenated blood returns to the left heart, where it is pumped through the arterial system to reach all tissues.

2. Incorrect. Snorting a drug allows the drug to enter the venous system somewhat rapidly, but more slowly than injecting it. Once in the veins (deoxygenated blood), the drug travels to the right heart, goes to the lungs, and then the oxygenated blood returns to the left heart, where it is pumped through the arterial system to reach all tissues.

3. Try again. Smoking is almost as fast as injection in order to get a drug into the blood. When crack is smoked, it moves easily from the lung tissue into arteries (with oxygenated blood) that go back to the left heart. Upon leaving the left heart via the aorta, the drug is pumped through the arterial system to reach all tissues.

4. You're right! A drug that is ingested travels from the gut to the liver first. A portion of the drug is metabolized (destroyed) as it passes through the liver. As it leaves the liver, the drug travels through the venous system to the right heart, then the lungs, and then back through the left heart, where it is pumped through the arterial system to reach all tissues. This takes extra time compared to all other forms of drug administration.

A drug test is given to a woman applying for a job. The interviewer tells her that traces of cocaine were found in her hair. She claims that she has not used any of the drug. She said it must be because she was near someone who was smoking crack. Upon further investigation, the interviewer believes her because:

1. Metabolites of cocaine were found in her hair shaft
2. She had a high level of melanin in her hair
3. There was no real pattern of cocaine binding to the hair

Answers:

1. Sorry, that isn't correct. If metabolites of cocaine were found in the woman's hair shaft, that would indicate that the drug had entered her bloodstream, it was metabolized and the metabolites entered the hair follicles. Thus, she must have used cocaine.

2. Sorry, try again. The amount of melanin in hair does dictate how much cocaine will bind to the hair; more melanin means more binding of cocaine. However, this would not answer the question of how the drug got into the person's hair.

3. Correct! When a person is exposed to smoke containing drugs like cocaine, heroin or nicotine, these lipophilic compounds can easily penetrate the hair shaft and bind to melanin. The length of hair that is exposed to the air during the exposure time will bind uniformly to the drug, producing no real pattern.

As discussed in this module, the bottom of the hair follicle contains a bulb with cells responsible for making hair. Higher up in the bulb, the hair is more highly organized into three layers of cells. The middle layer, or cortex, contains keratinocytes and melanocytes. What do these cells do?

1. Destroy keratin and melanin
2. Destroy carotene and melatonin
3. Make keratin and melanin
4. Make carotene and melatonin

Answers:

1. Sorry. Keratinocytes are cells that make keratin—they don't destroy it. This fibrous protein helps give the hair strength and structure. Melanocytes, also present in the cortex, produce melanin, which gives hair its color.

2. Not even close! Carotene (beta form) gives carrots the characteristic orange color and it acts as an anti-oxidant. Melatonin is a hormone produced in the pituitary gland that causes sleep.

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3. You're right! Keratinocytes are cells that make keratin. This fibrous protein helps give the hair strength and structure. Melanocytes, also present in the cortex, produce melanin, which gives hair its color.

4. Not even close! Carotene (beta form) gives carrots the characteristic orange color and it acts as an anti-oxidant. Melatonin is a hormone produced in the pituitary gland that causes sleep.

Hair color is explained in part by physics and chemistry. The color of one's hair is dependent upon the absorption and reflection of light (dictated by the presence of melanin). Which hair color is the result of the most amount of reflected light?

1. Blonde
2. Brown
3. Black

Answers:

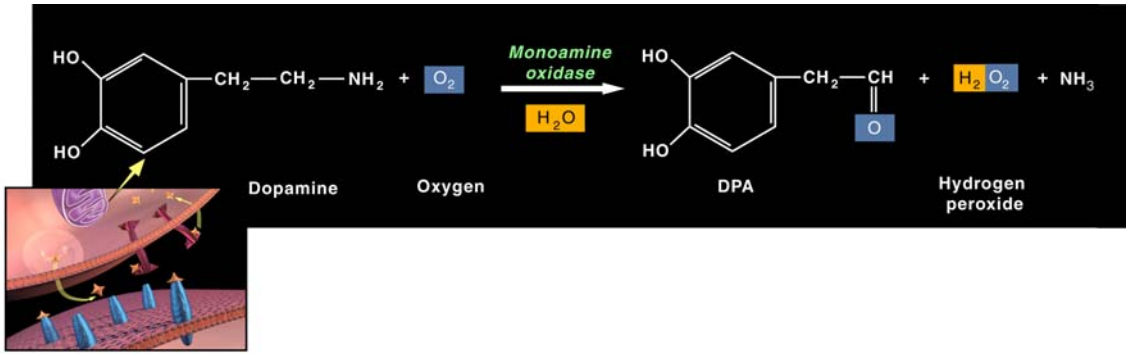
1. Hooray! Blonde hair contains little melanin; therefore, almost all of the light is reflected. The reflected light contains all parts of the visible color spectrum, producing the blonde or whiter color, visible to your eye.

2. Sorry, that's not right. When light hits brown hair, only some of the light is reflected; the rest is absorbed so the hair appears brown. Blonde hair contains little melanin; therefore, almost all of the light is reflected. The reflected light contains all parts of the visible color spectrum, producing the blonde or whiter color, visible to your eye.

3. Sorry, that's not right. Black hair has a lot of melanin, so it absorbs almost all light that hits it (and your eye doesn't detect any color). Conversely, blonde hair contains little melanin; therefore, almost all of the light is reflected. The reflected light contains all parts of the color visible spectrum, producing the blonde or whiter color, visible to your eye.

# Self-Quiz for Module 3

Consider the following reaction:




In this example, which of the following is oxidized and which is reduced?

1. Dopamine is oxidized, hydrogen peroxide is reduced
2. Dopamine is reduced, oxygen is oxidized
3. Dopamine is oxidized, oxygen is reduced
4. Dopamine is reduced, hydrogen peroxide is oxidized

Answers:

1. You are half-correct! Dopamine is oxidized by $O_2$; it donates an electron (associated with the H) from its $CH_2$ group to molecular oxygen ($O_2$). Hydrogen peroxide is formed by the reaction in the presence of $H_2O$.

2. Sorry, try again. Dopamine is oxidized by $O_2$; it donates an electron (associated with the H) from its $CH_2$ group to molecular oxygen ($O_2$). The $O_2$ is reduced because it accepts the electron from dopamine.

3. Hooray! Dopamine donates an electron (associated with the H) from its $CH_2$ group to molecular oxygen ($O_2$). The $O_2$ then becomes reduced.

4. Sorry, try again. Sorry, try again. Dopamine is oxidized by $O_2$; it donates an electron (associated with the H) from its $CH_2$ group to molecular oxygen ($O_2$). Hydrogen peroxide is formed by the reaction in the presence of $H_2O$.

In this module, you learned that the neurotransmitter dopamine is oxidized by molecular oxygen ($O_2$) with the help of an enzyme called monoamine oxidase. This means that the oxygen:

1. Donates a proton to dopamine
2. Accepts a proton from dopamine
3. Donates an electron to dopamine
4. Accepts an electron from dopamine

Answers:

1. Try again. When a compound is oxidized, it loses electrons and the species that causes the oxidation gains the electrons. With the aid of the enzyme, the $O_2$ tends to accept a single electron from dopamine.

2. Try again. When a compound is oxidized, it loses electrons and the species that causes the oxidation gains the electrons. With the aid of the enzyme, the $O_2$ tends to accept a single electron from dopamine.

3. Try again. When a compound is oxidized, it loses electrons and the species that causes the oxidation gains the electrons. With the aid of the enzyme, the $O_2$ tends to accept a single electron from dopamine.

4. Bravo! When a compound is oxidized, it loses electrons and the species that causes the oxidation gains the electrons. With the aid of the enzyme, the $O_2$ tends to accept a single electron from dopamine.

Methamphetamine, a central nervous system stimulant, causes increased alertness and agitation by causing:

1. Oxidation of dopamine
2. Rapid onset Parkinson's disease
3. Release of dopamine
4. Formation of free radicals

Answers:

1. Sorry, that is incorrect. Although methamphetamine causes oxidation of dopamine, it is unrelated to its actions as a stimulant.

2. Sorry, that is incorrect. Methamphetamine's ability to cause oxidation of dopamine may damage neurons, similar to the effects of Parkinson's disease.

3. Good answer! Methamphetamine, like amphetamine, causes the release of the neurotransmitter dopamine into the synaptic space. This is the basis for its stimulant activity.

4. No, try again. Methamphetamine causes oxidation of the neurotransmitter dopamine, which can lead to the generation of oxygen radicals. This action is unrelated to its actions as a stimulant, but it can damage neurons

When a drug user takes methamphetamine, it releases the neurotransmitter dopamine into the synaptic space. There, the dopamine is autooxidized by $O_2$, without the help of enzymes. In this case the autooxidation of dopamine results in the production of an unstable molecule called:

1. Hydrogen peroxide ($H_2O_2$)
2. Superoxide radical ($O_2^{\bullet-}$)
3. Ammonia ($NH_3$)
4. Oxygen

Answers:

1. Not quite. Hydrogen peroxide is produced when dopamine is oxidized with the help of the enzyme, monoamine oxidase. It is not formed by the autooxidation of dopamine.

2. You're right! When dopamine is autooxidized, $O_2$ gains an electron, providing it with an extra unpaired electron. This compound is a free radical known as superoxide and it has 13 electrons in its outer orbital making it very unstable.

3. Not quite. Ammonia is produced when dopamine is oxidized with the help of the enzyme, monoamine oxidase. It is not formed by the autooxidation of dopamine.

4. Wrong answer. Oxygen is required to oxidize dopamine—it is not generated by the oxidation of dopamine.

In this module you learned about some of the dangers of free radicals in the body. Free radicals oxidize lipids, proteins, and DNA, disorganizing their structure. Which of the following is a consequence of the oxidation of lipids in a cell membrane?

1. Water leaves the cells and causing them to shrink
2. The carbon chains in the lipids can get kinky causing the cell to become leaky
3. Disulfide bonds are formed

Answers:

4. Try again. Oxidation of membrane lipids by free radicals makes them kinky. This destroys the membrane structure and the membranes become leaky. Water enters the cell, causing it to swell and eventually burst.

5. Bravo! Oxidation of membrane lipids involves the loss of hydrogen atoms (and electrons) from the carbon chains. This alters their structure and the chains become shortened and kinky. The lipids no longer form a tight membrane barrier, so the cell becomes leaky.

6. Incorrect. Disulfide bonds are generated by the oxidation of proteins that contain sulfur-hydrogen molecules. The SH molecule loses a hydrogen atom (and electrons) to produce the double bond between two S atoms. This destroys the action of the protein so that the cell doesn't function properly.

As you have learned, oxygen radicals can produce a range of detrimental effects. One way in which our bodies reduce the damage caused by oxygen radicals is to:

1. increase release of dopamine
2. increase exposure to UV radiation
3. activate enzymes that scavenge oxygen radicals

Answers:

1. Sorry, that's not right. The presence of excess dopamine actually results in autooxidation of this compound, which produces more oxygen radicals.

2. Sorry, that's not right. UV radiation causes oxidative damage to cells and increases formation of oxygen radicals.

3. You're right! To keep the level of oxygen radicals low in our bodies, oxygen radicals are "scavenged" by enzymes to render them harmless. For example, superoxide radicals are reduced with the help of the enzyme superoxide dismutase to form hydrogen peroxide ($H_2O_2$), which is then detoxified by the enzyme catalase which converts it to water and $O_2$.

## Self-Quiz for Module 4

Hydrolysis of the neurotransmitter acetycholine is facilitated by the enzyme acetylcholinesterase. For hydrolysis of acetylcholine to occur, which of the following molecules is required?

1. choline
2. water
3. acetic acid
4. nerve gas

Answers:

1. Try again. Hydrolysis is a process that involves water. A molecule such as acetylcholine is cleaved into two parts by reacting with water. Water forms a bond between one of its H atoms and part of the molecule and it forms a bond between its OH group and the other part of the molecule, causing the molecule to split. Acetylcholine is split, forming choline and acetic acid.

2. Good answer! Hydrolysis is a process that involves water. A molecule such as acetylcholine is cleaved into two parts by reacting with water. Water forms a bond between one of its H atoms and part of the molecule and it forms a bond between its OH group and the other part of the molecule, causing the molecule to split. Acetylcholine is split, forming choline and acetic acid.

3. Try again. Hydrolysis is a process that involves water. A molecule such as acetylcholine is cleaved into two parts by reacting with water. Water forms a bond between one of its H atoms and part of the molecule and it forms a bond between its OH group and the other part of the molecule, causing the molecule to split. Acetylcholine is split, forming choline and acetic acid.

4. Try again. Hydrolysis is a process that involves water. A molecule such as acetylcholine is cleaved into two parts by reacting with water. Water forms a bond between one of its H atoms and part of the molecule and it forms a bond between its OH group and the other part of the molecule, causing the molecule to split. Acetylcholine is split, forming choline and acetic acid.

Like acetylcholine, nerve gas also binds to the enzyme acetycholinesterase but it is bound with a different kind of bond that prevents the breakdown of acetylcholine by the enzyme. What kind of bond is formed between nerve gas and acetylcholinesterase?

1. Covalent and reversible
2. Electrostatic and reversible
3. An irreversible hydrogen bond
4. Covalent and irreversible

Answers:

1. You are half correct. Nerve gases have a phosphorus group that is highly attracted to an OH group on the enzyme. The bond is so strong that, for most types of nerve gases, it can't be broken. This is called a covalent bond. Since the bond between the phosphorus atom of the nerve gas and the enzyme can't be broken (i.e., irreversible), the enzyme is no longer able to interact with acetylcholine.

2. Sorry! Nerve gases have a phosphorus group that is highly attracted to an OH group on the enzyme. The bond is so strong that, for most types of nerve gases, it can't be broken. This is called a covalent bond. Since the bond between the phosphorus atom of the nerve gas and the enzyme can't be broken (i.e., irreversible), the enzyme is no longer able to interact with acetylcholine. In contast, when acetylcholine binds to acetylcholinesterase, the bonds are electrostatic and reversible in nature.

3. Sorry, that is incorrect. Nerve gases have a phosphorus group that is highly attracted to an OH group on the enzyme. The bond is so strong that, for most types of nerve gases, it can't be broken. This is called a covalent bond. Since the bond between the phosphorus atom of the nerve gas and the enzyme can't be broken (i.e., irreversible), the enzyme is no longer able to interact with acetylcholine.

4. You're right! Nerve gases have a phosphorus group that is highly attracted to an OH group on the enzyme. The bond is so strong that, for most types of nerve gases, it can't be broken. This is called a covalent bond. Since the bond between the phosphorus atom of the nerve gas and the enzyme can't be broken (i.e., irreversible), the enzyme is no longer able to interact with acetylcholine.

In this module, you learned that the neurotransmitter acetylcholine can produce a variety of effects on the body. Acetylcholine produces all of the effects below except:

1. Bronchial constriction (inhibited breathing)
2. Lacrimation (tears)
3. Salivation
4. Constipation

Answers:

1. Not quite. Acetylcholine causes smooth muscle contractions, resulting in bronchial constriction. This is part of its action within the parasympathetic nervous system.

2. No, try again. Acetylcholine causes secretion, resulting in lacrimation or tearing. This is part of its action within the parasympathetic nervous system.

3. Sorry! Acetylcholine causes secretion from glands throughout the body, including the salivary gland. This is part of its action within the parasympathetic nervous system.

4. Bravo! Acetylcholine causes intestinal smooth muscle contractions, resulting in diarrhea and not constipation. This is part of its action within the parasympathetic nervous system.

One of the reasons that nerve gas is so poisonous is its ability to get into the human body quickly in many ways: absorption through the skin, inhalation into the lungs, and entrance through the eyes. Once in the body, the drug easily reaches the brain, diffusing readily through the brain's protective membrane (the blood-brain barrier). Which property of nerve gas allows for its rapid penetration into the brain?

1. Its phosphorus group
2. Its lipophilic (non-polar) nature
3. The fact that it is odorless

Answers:

1. Try again. The phosphorus group allows nerve gas to bind irreversibly to acetylcholinesterase, preventing it from hydrolyzing acetylcholine. The brain capillaries provide protection to the brain because the endothelial cells are packed tightly together. Therefore, only compounds that are highly lipophilic or non-polar, such as nerve gas, can enter the brain by diffusing through the capillary membranes. Lipophilic compounds also penetrate eyes and skin readily, passing easily through the lipid membranes of those tissues.

2. Correct! The brain capillaries provide protection to the brain because the endothelial cells are packed tightly together. Therefore, only compounds that are highly lipophilic or non-polar, such as nerve gas, can enter the brain by diffusing through the capillary membranes. Lipophilic compounds also penetrate eyes and skin readily, passing easily through the lipid membranes of those tissues.

3. Try again. While nerve gas is indeed odorless, this does not affect its ability to cross cell membranes. The brain capillaries provide protection to the brain because the endothelial cells are packed tightly together. Therefore, only compounds that are highly lipophilic or non-polar, such as nerve gas, can enter the brain by diffusing through the capillary membranes. Lipophilic compounds also penetrate eyes and skin readily, passing easily through the lipid membranes of those tissues.

The peripheral nervous system includes neurons that connect the brain and spinal cord to muscles, organs and skin to send sensory and motor information. Based on your knowledge of the nervous system, which branch of the peripheral nervous system is responsible for controlling voluntary movement?

1. The parasympathetic nervous system
2. The autonomic nervous system
3. The sympathetic nervous system
4. The somatic nervous system

Answers:

1. Sorry, try again. The parasympathetic nervous system is responsible for involuntary organ function. As part of the autonomic nervous system, the parasympathetic system is active all of the time.

2. No, try again. The autonomic nervous system includes only the parasympathetic and sympathetic branches. These branches of the peripheral nervous system help smooth muscles and other organs receive information from the brain and spinal cord to control mostly involuntary organ function.

3. Sorry, try again. The sympathetic nervous system is responsible for involuntary organ function. As part of the autonomic nervous system, the sympathetic system is activated during stressful situations.

4. Good answer! The somatic nervous system is responsible for controlling voluntary movement. Neurons arising in the spinal cord (motor nerves) connect to skeletal muscles, bringing information to the muscles to contract.

Nerve gases are extremely toxic; a small droplet can kill a person. They exist in both liquid and gaseous forms. Inside closed containers, the nerve gases are in liquid form. However, they when exposed to air, they:

1. Vaporize due to their very high vapor pressure
2. Vaporize due to their very low vapor pressure
3. Remain in the liquid state
4. Vaporize due to their dense nature

Answers:

1. Very good! The high vapor pressure of nerve gases causes them to vaporize upon contact with air. Additionally, since nerve gases are much more dense than air, they hover near the ground, where both humans and animals are more likely to be poisoned.

2. Sorry, that's not right. The high vapor pressure of nerve gases causes them to vaporize upon contact with air. Additionally, since nerve gases are much more dense than air, they hover near the ground, where both humans and animals are more likely to be poisoned.

3. Sorry, try again. The high vapor pressure of nerve gases causes them to vaporize upon contact with air. Additionally, since nerve gases are much more dense than air, they hover near the ground, where both humans and animals are more likely to be poisoned.

4. No, try again. The high vapor pressure of nerve gases causes them to vaporize upon contact with air. Additionally, since nerve gases are much more dense than air, they hover near the ground, where both humans and animals are more likely to be poisoned.

## Self-Quiz for Module 5

Alkaloids are found most commonly in the subclass of Angiosperms known as the dicots. Which of the following best describes the characteristics of a dicot?

1. embryos bearing one cotyledon, parallel-veined leaves, 3-petaled leaves, and scattered vascular bundles
2. embryos bearing one cotyledon, net-veined leaves, 4- or 5-petaled leaves, and vascular cylinders arranged in concentric rings
3. embryos bearing two cotelydons, parallel-veined leaves, 3-petaled leaves, and scattered vascular bundles
4. embryos bearing two cotyledons, net-veined leaves, 4- or 5-petaled leaves, and vascular cylinders arranged in concentric rings

Answers:

1. Sorry, this is incorrect – this answer describes the characteristics of a monocot, such as the wild yam that produces a steroid-like compound that is used as the starting material to make progesterone used in birth control pills.

2. Oops! Monocots have one cotyledon; the remaining characteristics describe a dicot.

3. Wrong. Although a dicot does have two cotyledons, the remaining characteristics describe a monocot.

4. You are correct! Dicots, such as the opium poppy, tomatoes, and the oak tree, have two cotyledons, net-veined leaves, 4- or 5-petaled leaves, and vascular cylinders arranged in concentric rings within the plant stem. Remember, it is the dicots that most commonly produce alkaloids.

When extracting alkaloids from plants (either chemically or by smoking), why does the extraction process usually require an alkaline environment?

1. It shifts the equilibrium of the alkaloid molecule to favor the polar, charged form.
2. It shifts the equilibrium of the alkaloid molecule to favor the non-polar, free base form.
3. It shifts the equilibrium of the alkaloid molecule to favor the polar, free base form.
4. It shifts the equilibrium of the alkaloid molecule to favor the non-polar, charged form.

Answers:

1. Sorry, you got it backwards. The polar, charged form of alkaloids exists inside the watery and acidic environment of the vacuole.

2. Good job – you are correct! Alkaloids exist predominantly in their polar or charged form inside the acidic environment of the vacuole. When the alkaloid is mixed in an

alkaline solution (or environment), the equilibrium shifts the other way, in favor of the free base, which is non-polar or uncharged.

3. Well, you're partly correct. When the alkaloid is mixed in an alkaline solution (or environment), the equilibrium shifts in favor of the free base, which is non-polar or uncharged.

4. You're partly correct. When the alkaloid is mixed in an alkaline solution (or environment), the equilibrium shifts in favor of the free base, which is non-polar or uncharged.

Tobacco companies add ammonium hydroxide to the tobacco as it is prepared in the production of cigarettes. Why do they do this?

1. It makes the inhaled smoke taste better.
2. It keeps nicotine from degrading.
3. It shifts nicotine into its more polar form, helping it to volatilize.
4. It shifts nicotine into its more non-polar form, helping it to volatilize.

Answers:

1. No, the tobacco companies add other compounds (like menthol) to make the smoke taste better.

2. Incorrect. Nicotine becomes degraded when it gets oxidized (especially if it is exposed to air).

3. You are partly correct. The base does help nicotine volatilize because it shifts it into its nonpolar form, which has a lower boiling point.

4. Great! Nicotine is an alkaloid, and addition of a base shifts the nicotine into its free base or nonpolar form, which has a lower boiling point. Thus it is easily volatilized.

Drugs have several targets with which they interact in the body to produce their effects. These targets include enzymes, receptors and transporters. They belong to the family of:

1. lipids
2. carbohydrates
3. proteins
4. nucleic acids

Answers:

1. Sorry. This isn't correct. Some lipids can interact with drugs, but these targets do not have the structure of lipids.

2. Incorrect. Some carbohydrates can interact with drugs, but the chemical structure of these targets is much larger than that of a carbohydrate.

3. Hooray! Yes, enzymes, receptors and transporters are all macromolecular structures called proteins.

4. Well, you're only right for the receptor. Actually, some nucleic acids in DNA can serve as a receptor for certain drugs. However, nucleic acids do not act as enzymes or chemical transporters.

Several forces enable the reversible binding of a charged drug to its receptor (or target). Which of the following describes the forces involved in 1) the initial attraction of a charged drug to its target and 2) the strengthening of the drug-target interaction?

1. electrostatic; hydrogen bonds
2. hydrogen bonds; van der Waals forces
3. van der Waals forces; electrostatic
4. electrostatic; covalent

Answers:

1. Great! The initial attraction between a charged drug and its target is electrostatic, pulling the molecules together. Hydrogen bonds, the strongest form of van der Waals forces, help to strengthen and stabilize the interaction between the drug and its target, especially at close range.

2. Sorry, this is not entirely correct. The initial attraction between a charged drug and its target is electrostatic, pulling the molecules together. Van der Waals forces (hydrogen and dipole-dipole) help to strengthen and stabilize the interaction between the drug and its target, especially at close range.

3. Sorry, this is backwards. The initial attraction between a charged drug and its target is electrostatic, pulling the molecules together. Van der Waals forces (hydrogen and dipole-dipole) help to strengthen and stabilize the interaction between the drug and its target, especially at close range.

4. You're partly right. The initial attraction between a charged drug and its target is electrostatic, pulling the molecules together. However, a covalent bond that might form by sharing a pair of electrons would prevent reversible binding between the drug and receptor.

# Self-Quiz for Module 6

In this module you learned about several types of steroid hormones that are made in the body. Which of the following steroid hormones is important in increasing muscle size?

1. cortisol
2. estrogen
3. testosterone
4. progesterone

Answers:

1. Not correct. Cortisol is one of the glucocorticoids that is synthesized in the adrenal gland. It actually causes muscle breakdown. The synthetic version, cortisone, is used as a powerful anti-inflammatory agent.

2. No, estrogen is a female sex steroid synthesized in the ovaries to help in the process of ovulation. It also helps maintain the mineral density in bones.

3. You are right. Testosterone is a male sex steroid synthesized in the testes to produce male sexual characteristics (androgen). It also can increase muscle size in exercising males and females (anabolic).

4. Sorry, this isn't right. Progesterone is a female sex steroid synthesized in the ovaries to help prepare the uterus for pregnancy (promotes endometrial cell differentiation).

Steroids are lipophilic molecules that must cross the cell membrane in order to bind to its receptor inside the cell. What form of membrane transport is used?

1. active transport
2. passive diffusion
3. facilitated diffusion
4. filtration

Answers:

1. Sorry, this isn't right. Active transport is a process that requires energy to move a substance against the concentration gradient. It involves the help of a protein carrier, or transporter.

2. Very good! The non-polar nature of steroids allows them to move easily with their concentration gradient into the cell. Their non-polar nature attracts them to the hydrophobic core of the membrane lipid bilayer and this helps the steroid to move in the direction of the cytoplasm. No energy is required.

3. Not correct. Facilitated diffusion also occurs with concentration gradient, but it requires a protein carrier to help. No energy is required, but the carriers can become saturated, limiting the transport. A good is example is the movement of the testosterone-androgen receptor complex into the nucleus, across the nuclear membrane.

4. No, sorry. Filtration is occurs when a solute moves through a pore in the membrane, with the concentration gradient. It is often aided by pressure. It is limited by the size of the compound and it does not require any energy.

Anabolic steroids increase the ability of DNA to make more muscle proteins. The protein synthesis is directed by 2 major processes. Which of the following describes the steps to protein synthesis?

1. translation, followed by transcription
2. translation, followed by transportation
3. transcription, followed by conscription
4. transcription, followed by translation

Answers

1. Sorry, you've got it backwards. Translation occurs second. It is the process of assembling a sequence of amino acids to form a protein using instructions brought by the mRNA to the ribosome. It takes place in the cytosol. Transcription occurs first. It is the process of generating a specific mRNA from the DNA template, with the help of several enzymes. It takes place in the nucleus.

2. Not correct. Translation occurs second. It is the process of assembling a sequence of amino acids to form a protein using instructions brought by the mRNA to the ribosome. It takes place in the cytosol. Transportation is the movement of a molecule from one site to another, or your ride from school back to your house.

3. You're half right. Transcription is the process of generating a specific mRNA from the DNA template, with the help of several enzymes. It takes place in the nucleus. Conscription is the process of recruitment or enlistment to be in the armed forces or maybe in the school play.

4. Yea, you got it right! Transcription is the process of generating a specific mRNA from the DNA template, with the help of several enzymes. It takes place in the nucleus. Translation is the process of assembling a sequence of amino acids to form a protein using instructions brought by the mRNA to the ribosome. It takes place in the cytosol.

There are several steps involved in muscle contraction. Which of the following sequences is correct?

1. Acetylcholine binds to a receptor on the muscle cell, activating DNA. DNA causes calcium to be released from the sarcoplasmic reticulum, causing the tendons to shorten.
2. Acetylcholine binds to a receptor on the muscle cell, calcium is released from the sarcoplasmic reticulum, sacromeres shorten due to the thin actin filaments sliding over the thick myosin filaments.
3. Acetylcholine binds to a receptor on the muscle cell, calcium is released from the sarcoplasmic reticulum, sacromeres shorten causing the thin actin filaments to twist around the thick myosin filaments.
4. Acetylcholine binds to a receptor on the tendons, calcium is released from the sarcoplasmic reticulum, the tendons pull on the sacromeres causing them to lengthen.

Answers:

1. Try again. DNA does not play a role in muscle contraction and tendons lengthen when a muscle contracts.

2. Great! Muscle contraction is initiated when acetylcholine binds to its receptor, triggering release of calcium from inside the muscle cell into the sarcoplasm. This causes the sliding of actin and myosin filaments to shorten the sarcomeres, contracting the muscle.

3. Not quite. Shortening of the sarcomeres results from the sliding of actin filaments over the myosin filaments.

4. Not correct. Shortening of the sarcomeres results from the sliding of actin filaments over the myosin filaments. The contraction pulls on the tendons.

The production of hormones in our bodies is under the control of positive and negative feedback. This keeps levels of hormones in the normal range. However, hormone production changes when we take drugs that bind to the hormone receptors. What will happen to the athlete who takes anabolic steroids over a long period of time?

1. his testes will stop making testosterone
2. his testes will increase the production of testosterone
3. his hypothalamus will increase production of gonadotropin releasing hormone
4. his pituitary will increase production of LH and FSH

Answers:

1. You are right. The high amount of anabolic steroid in the blood signals the hypothalamus (i.e., binds to androgen receptors there) in the brain to stop producing gonadotropin releasing hormone. This stops the pituitary gland from making LH and FSH. These hormones signal the testes to make testosterone—without them, no testosterone is synthesized.

2. No, the opposite happens. The high amount of anabolic steroid in the blood signals the hypothalamus in the brain to stop producing gonadotropin releasing hormone. This stops the pituitary gland from making LH and FSH. These hormones signal the testes to make testosterone—without them, no testosterone is synthesized.

3. No, the opposite happens. The high amount of anabolic steroid in the blood signals the hypothalamus in the brain to stop producing gonadotropin releasing hormone.

4. No, the opposite happens. The high amount of anabolic steroid in the blood signals the hypothalamus in the brain to stop producing gonadotropin releasing hormone. This stops the pituitary gland from making LH and FSH.

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