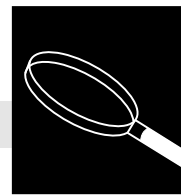


Topic Overview



CONTENT IN A NUTSHELL

The average life expectancy of U.S. citizens in 1990 was about 75 years, quite a contrast to a life expectancy of 68 in 1950 and of 60 in 1930. Chemistry and technology have played important roles in increasing the life expectancy and in improving the quality of life. Our increasing knowledge and understanding of the chemistry of biological processes and the discovery of therapeutic medical compounds (drugs) have contributed to the improvement of both mental and physical health and the quality and length of life.

A drug is a substance that can change a physical or psychological function in the body. Drugs may have both desirable therapeutic properties and undesirable side effects. Familiar substances like aspirin, antibiotics, alcohol, nicotine, *etc.*, are drugs. When should a specific drug be used? The media often try to help make that decision through advertising. Teenagers are highly susceptible to the advertised message, and sometimes the message is correct. You can get rid of a headache with aspirin (“I have occasional aches and pains, and, when I do, my friend Bufferin is there to help me.”), you can relieve an upset stomach with an antacid tablet (“Plop, plop! Fizz, fizz!”), and some first-aid ointments can help prevent infection and relieve pain (“Exclusive Formula! The three antibiotic ingredients widely recommended and used...plus an extra ingredient to relieve pain fast!”). Yet sometimes the properties of these substances may be independent of advertised claims.

On the other hand, the media message is often misleading. Some beer commercials, for example, try to lead people to believe that copious beer drinking can make one the life of the party and part of the in-crowd. This treatment of alcohol use is misleading and dishonest. Studies have shown that alcohol impairment does not make a person more gregarious and fun-loving, but rather leads to central nervous system depression and introversion. Indeed, government regulations now require truth in labeling, as the following typical warning on a whiskey label states: “...According to the Surgeon General, women should not drink alcoholic beverages during pregnancy because of the risk of birth defects; consumption of alcoholic beverages impairs your ability to drive a car or operate machinery, and may cause health problems...”

The purpose of this module is to inform students about the many positive uses of compounds used in medicine. These therapeutic drugs, some of which can be obtained over the counter, represent a variety of substances that help us cope with daily stress or disease. Yet, some of these substances (alcohol, tobacco, anabolic steroids) can be used illegally and abused. It is important that high school students understand the chemistry of drugs.

PLACE IN THE CURRICULUM

This module can be used as a supplement to an introductory organic chemistry module, or as the basis for enrichment through special projects and/or independent study.

CENTRAL CONCEPTS

1. The application of the principles of chemistry (and biology) to the introduction of new therapeutic agents is called medicinal chemistry. The medicinal chemist must have a knowledge of general and organic chemistry and biological sciences.

2. A therapeutic agent is often called a drug. A drug is any absorbed substance that changes any physical or psychological function in the body.
3. Physicians prescribe drugs to fight infection (antibiotics), reverse a disease process (heart stimulants), restore normal function (insulin), aid in diagnosis (radiopharmaceuticals), inhibit normal body processes (birth control pills), and maintain health (vitamins and vaccines).
4. Consumers use drugs to relieve common symptoms of discomfort (aspirin, cold remedies, antihistamines, antibiotics), to supplement the diet (vitamins), to enhance or inhibit normal body functions (sleeping pills, birth control pills, stimulants), *etc.*
5. Some people abuse drugs. Any drug can be abused, but the commonly abused drugs are alcohol, stimulants, depressants, opiates, tetrahydrocannabinol, nicotine, and anabolic steroids.
6. Drugs affect the living system, perform their action, and are eliminated from the body. Addiction, withdrawal, and tolerance are possible.
7. Drugs are known by brand names, generic names, and street names.
8. Drug sources are plants, animals, microorganisms, and laboratory synthesis.
9. Information about drugs can be obtained from the *Physician's Desk Reference* (PDR), *PDR for Nonprescription Drugs*, *The Merck Index*, and package label inserts.

1. Elementary biology
2. Brief introduction to organic chemistry (*e.g.*, nomenclature, identification of functional groups)

RELATED CONCEPTS

1. Manipulative laboratory skills involving the use of common glassware and hardware are needed to perform the activities in this module.

RELATED SKILLS

After completing their study of chemistry in medicine, students should be able to:

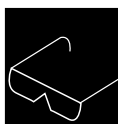
1. discuss a drug as any substance that will produce a change in the physical or psychological function of the body.
2. recognize medicinal chemistry as a link between chemistry and human biology.
3. differentiate between common drug terminology and scientific nomenclature.
4. state where to find information about drugs.
5. recognize that all drugs have positive and negative effects.
6. discuss the medicinal reasons and social reasons for drug usage.

PERFORMANCE OBJECTIVES

Concept/Skills Development



LABORATORY ACTIVITY: STUDENT VERSION

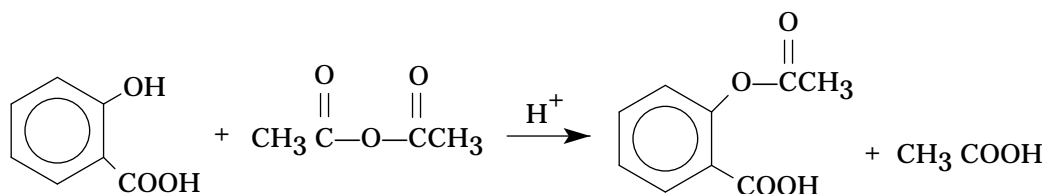


Activity 1: Synthesis of Aspirin

Introduction

In this laboratory activity you will synthesize aspirin, a derivative of salicylic acid. Salicylic acid and its derivatives are antipyretics. Such compounds lower the body temperature of a person with a fever. They have little effect if the body temperature is normal. Salicylates are also mild analgesics that relieve pain associated with headache, neuralgia, and rheumatism. Salicylic acid itself is not used for these purposes because it has an irritating effect on the stomach.

The most common salicylate used in medicine today is aspirin. In this activity, aspirin is prepared from salicylic acid and acetic anhydride.



When ingested, aspirin (acetylsalicylic acid) passes through the stomach largely unchanged. It is hydrolyzed in the intestinal tract liberating the active ingredient, salicylic acid.

In this laboratory synthesis, you will heat a mixture of salicylic acid and acetic anhydride with a trace of sulfuric acid as catalyst. Because aspirin is not very soluble in water, it can be isolated by addition of cold water to the reaction mixture followed by a gravity filtration.

Purpose

To synthesize aspirin from salicylic acid, test for the purity of the product obtained, and determine the number of aspirin tablets that can be obtained from your preparation.

Safety

1. Wear protective goggles throughout the laboratory activity.
2. Acetic anhydride is irritating in the liquid and vapor state. Avoid contact with skin and eyes. Rinse with water any body area that comes in contact with acetic anhydride.
3. Concentrated sulfuric acid is a powerful dehydrating agent; handle it carefully to avoid contact with skin and clothing.
4. Methanol is toxic; breathing its vapors and skin contact with methanol should be avoided.

Procedure

1. Set up a ring stand with a ring, wire gauze, and burner. The top of the burner should be about 12 cm below the ring and wire gauze. Place on the wire gauze a 400-mL beaker half-filled with water. Heat the water to boiling. This is your water bath. As you wait for the water to boil, go to the next step.

2. Weigh 2.0 g salicylic acid on weighing paper, and transfer the solid to a 125-mL Erlenmeyer flask.
3. Add 5 mL acetic anhydride from a 50-mL buret.
4. Add 5 drops concentrated sulfuric acid. (*CAUTION: Sulfuric acid is corrosive*) Stir the mixture.
5. Heat the flask in the boiling water bath for 10 min.
6. Remove the flask from the water bath, and carefully add 2 mL water from a 10-mL graduated cylinder. Swirl to mix the contents. Allow the flask to stand for 5 min.
7. Add 40 mL water from a graduated cylinder, and stir the solution until crystals begin to form.
8. Cool the flask in an ice-water mixture in a 400-mL beaker for 10 min to complete the crystallization.
9. Collect the product by gravity filtration using a 250-mL beaker to collect the filtrate. Wash the product twice with 5 mL cold water.
10. Let the aspirin dry until the next laboratory period.
11. Transfer the dried aspirin to a weighed piece of filter paper and weigh. Calculate the number of aspirin tablets you have prepared:

$$\# \text{ tablets} = \text{aspirin weight (in g)} \times \frac{15 \text{ grains aspirin}}{1 \text{ g aspirin}} \times \frac{1 \text{ tablet aspirin}}{5 \text{ grains aspirin}}$$
12. Calculate the percent yield of your aspirin from the formula below. The quantity in the denominator (2.5 g) represents the theoretical yield of aspirin based on the moles of salicylic acid and acetic anhydride used in the synthesis.

$$\% \text{ yield aspirin} = \frac{\text{weight aspirin}}{2.5 \text{ g}} \times 100$$
13. Determine the qualitative purity of your aspirin in the following manner. Place 1 mL methanol in each of three separate test-tubes. Add a few crystals of the following: Test-tube 1, salicylic acid; Test-tube 2, your prepared aspirin; and Test-tube 3, commercial aspirin, crushed. Add 1 drop of 1% iron(III) chloride solution to each test-tube. Observe the color in each tube. What can you conclude?
14. Extension: Determine the melting point of the aspirin as directed by your instructor.
15. Place the aspirin in a dry test-tube, label with your name(s), and give it to your teacher.
16. Thoroughly wash your hands before leaving the laboratory.

Data Analysis and Concept Development

1. Can the purity of the prepared aspirin be determined by the color test with the iron(III) chloride?
2. Can the purity of the prepared aspirin be determined by the melting point?
3. In Step 12, the quantity 2.5 g represents the theoretical yield of aspirin. Show the calculation leading to a theoretical yield of 2.5 g of aspirin. [*You must first determine the limiting reactant from the following data: Molar mass of salicylic acid = 138 g; molar mass of acetic anhydride = 102 g; density of acetic anhydride 1.08 g/mL.*]

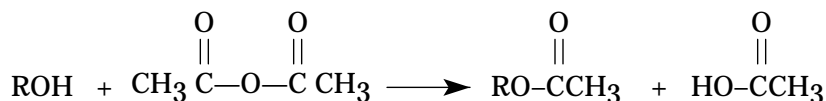


Implications and Applications

1. What steps do aspirin manufacturers have to take to make sure that their product is fit for human ingestion?
2. What other types of analgesics are on the market? How does their action compare with aspirin and why are these alternative drugs necessary?

Activity 1: Synthesis of Aspirin**Major Chemical Concept**

The synthesis of aspirin is known in organic chemistry as an esterification reaction. This is a substitution reaction in which an alcohol (the -OH group in salicylic acid) reacts with acetic anhydride to form an ester, aspirin.

**Level**

Honor chemistry students

Expected Student Background

None expected. The techniques illustrated here (synthesis, melting point determination) are not likely to have been previously encountered.

Time

The activity will take one 50-min period for the synthesis, an overnight drying step, and a second period for calculations, color tests, and melting point determination.

Safety

Read the *Safety Considerations* in the *Student Version*. The acetic anhydride, methanol and concentrated sulfuric acid should be handled with care. Dispensing the anhydride from a buret minimizes spills and possible body contact. Concentrated sulfuric acid should be dispensed from a small dropping bottle. The aspirin produced in this activity is not pure. It is often contaminated with salicylic acid, acetic acid, and/or sulfuric acid. Students should not taste their aspirin.

Materials (For 24 students working in pairs)**Nonconsumables**

12 Melting point devices (see *Possible Extensions*)

Mineral oil, 1 L

12 Thermometers (50-150 °C)

Capillary melting tubes

12 Funnels and supports

4 Burets, 50-mL

12 Erlenmeyer flasks, 250-mL

24 Beakers, 400-mL

12 Beakers, 250-mL

12 Graduated cylinders, 10-mL

12 Graduated cylinders, 50-mL

12 Flat-tipped spatulas or "rubber policemen"

12 Ring stands, rings and wire gauze

12 Stirring rods

**LABORATORY
ACTIVITY:
TEACHER
NOTES**



Consumables

- Salicylic acid, 24 g
- Acetic anhydride, 60 mL
- Concentrated sulfuric acid, 5 mL (in dropping bottles)
- Crushed ice
- Methanol, 50 mL
- Commercial aspirin sample
- 1% Iron(III) chloride, FeCl_3 , 100 mL (1 g FeCl_3 per 100 mL solution)

Advance Preparation

Fill the 50-mL buret with acetic anhydride. Prepare 1% iron(III) chloride solution in dropping bottles. Set out container of salicylic acid. Use of vacuum filtration, if available, will facilitate the filtration. Purchase commercial aspirin tablets, or obtain samples from the school health office. Set up mineral oil baths for melting point determination as shown in *Possible Extensions*.

Pre-Laboratory Discussion

1. Briefly explain the reaction type (substitution, esterification) and synthetic goal.
2. Caution students about reagent hazards.
3. Review the use of a buret for delivering a given volume of liquid.
4. Review technique of stirring versus swirling.
5. Review theoretical yield calculation.
6. Explain the concept in the iron(III) chloride test. Many phenols form colored coordination compounds with iron(III) ion, in which six molecules of a monohydric phenol are combined with one atom of iron in the form of a complex anion. Salicylic acid contains a phenolic -OH group and gives a positive test (turns purple) with iron(III) chloride. Complete reaction of salicylic acid with acetic anhydride substitutes an ester for the phenolic group. Therefore, aspirin uncontaminated with the salicylic acid starting material will give a negative test with Fe^{3+} . What can students conclude if their aspirin preparation turns purple? [*The preparation still has salicylic acid starting material present.*]
7. Explain how to obtain a melting point range (temperature at which solid first melts to the temperature at which solid is melted).

Teacher-Student Interaction

Walk around room during laboratory exercise emphasizing proper technique. Talk with students to ascertain if they understand activity. Help with yield calculations and melting point determination.

Anticipated Student Results

Typically students obtain a 60-70% yield. The product is often contaminated with salicylic acid. The result of the iron(III) chloride test is: salicylic acid (dark purple), prepared aspirin (dark purple), and commercial aspirin (light salmon). The melting point range is broad, *i.e.*, there is a large temperature range between first melting and complete melting of the sample. Typical values are between 128-137°C. Recrystallization of the aspirin would remove unreacted salicylic acid and narrow the melting point range.

Answers to Data Analysis and Concept Development

1. Yes. The prepared aspirin should not give a positive color test with the iron(III) chloride because salicylic acid, which gives the positive test, is absent.
2. Yes. The sharpness of the melting point is one of the best methods of determining purity of an organic solid. A broad melting point indicates the presence of impurities. In this case, the impurity is probably a trace of unreacted salicylic acid.
3. The number of moles of salicylic acid used is 0.014 mol $[2.0 \text{ g} \times \frac{1 \text{ mol}}{138 \text{ g}}]$.

The number of moles of acetic anhydride is 0.53 mol $[5.0 \text{ mL} \times 1.08 \frac{\text{g}}{\text{mL}} \times \frac{1 \text{ mol}}{102 \text{ g}}]$.

The theoretical amount of aspirin that can be obtained based on a balanced equation of 1 mol acetic anhydride to 1 mol of salicylic acid (the limiting reagent) is 2.5 g $[0.014 \text{ mol} \times \frac{180 \text{ g}}{1 \text{ mol}}]$.

Answers to Implications and Applications

1. Purification by recrystallization and testing for impurities by melting point determination and chromatography are necessary. Strict regulatory codes apply.
2. Other analgesics may be anti-inflammatory or antipyretic, but only aspirin is a "triple action" drug (fulfills all three functions). Aspirin is sometimes irritating to the digestive tract lining, so alternatives must be available for individuals affected by aspirin in this way.

Post-Laboratory Discussion

Review the experimental techniques, the experimental results and their significance.

Possible Extensions

1. Determine the purity of your aspirin by obtaining its melting point. Use the set-up shown in Figure 1. Crush about 50-100 mg of dry aspirin with a spatula against the walls of a 50-mL beaker. Thrust the open end of a melting point capillary tube into the powdered aspirin several times. Work the plug of solid material down to the tube's sealed end by dropping it 3-4 times into the open end of the 50-mL beaker used for crushing. The capillary tube should contain the amount of packed solid as shown in Figure 1.

Attach the capillary tube to the thermometer as shown in Figure 1. The rubber band can be a small section of rubber tubing of suitable diameter. Place the thermometer and tube in the 250-mL beaker oil bath. Heat the oil bath so that the temperature rises about 1-2 °C/min. Record as the melting point range the temperature at which the sample begins to melt and the temperature at which the sample is completely melted. The melting point of aspirin is about 135 °C. Discard the used melting point tubes in a waste glass container.

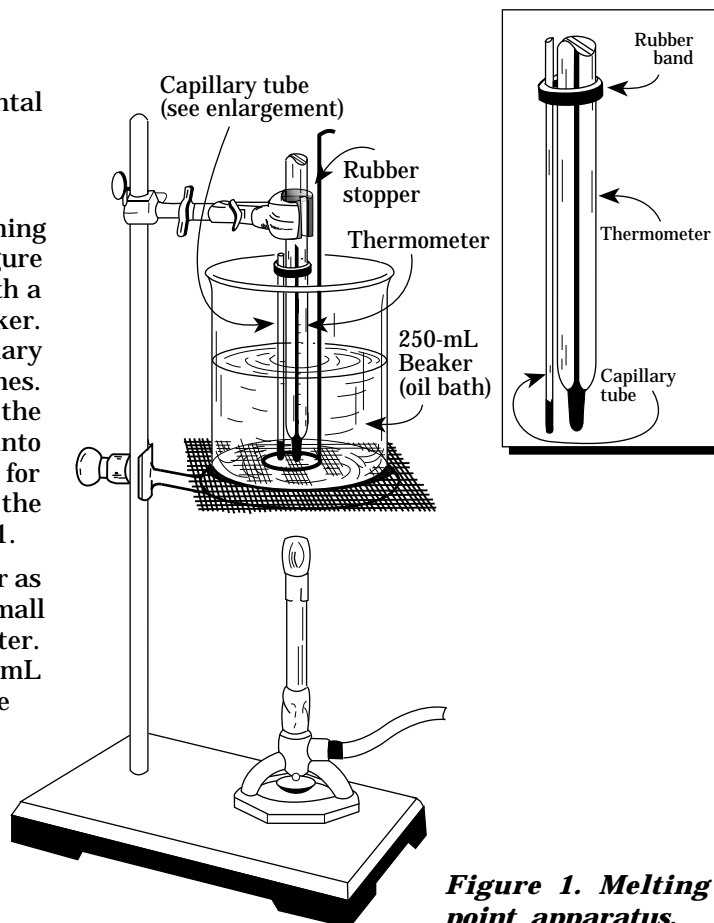
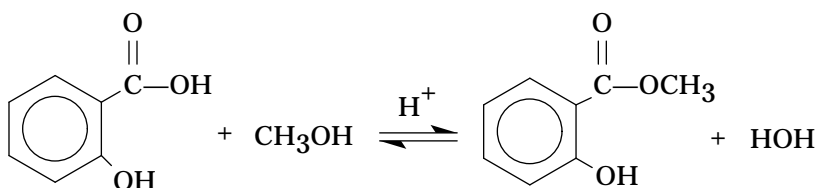


Figure 1. Melting point apparatus.



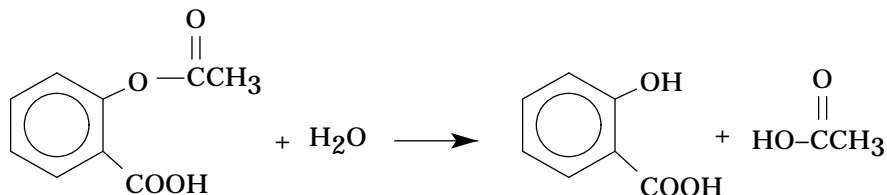
2. Synthesize methyl salicylate (oil of wintergreen) in a medium-sized test-tube from 0.5 g salicylic acid and 1 mL methanol. Stir the mixture, and add 3 drops of concentrated sulfuric acid. Heat the mixture in a water bath for 5 min. Remove the test-tube, cool it in a test-tube rack, and then add the contents to a 100-mL beaker containing 4-5 ice cubes. Waft the odor toward the nose. What commercial products contain oil of wintergreen? [*Wintergreen Life-Savers, Ben-Gay, etc.*]



3. Use a Spectronic 20 to determine the amount of salicylic acid in the laboratory-synthesized aspirin and in commercial aspirin. To prepare an aspirin solution, dissolve 0.05 g aspirin in 50 mL water. Prepare an iron(III) nitrate solution by dissolving 2 g iron(III) nitrate nonahydrate $[\text{Fe}(\text{NO}_3)_3 \cdot 9 \text{H}_2\text{O}]$ in 50 mL water and adding 0.5 mL concentrated nitric acid. To 1 mL aspirin solution add 5 mL iron(III) nitrate solution. Shake well for 5 min (a violet color should appear if salicylic acid is present). Measure the absorbance at 535–540 nm by placing the violet solution in the cell of a Spectronic 20 instrument after standardizing with distilled H_2O . *NOTE:* Old Spectronic 20's may still have their wavelength scales calibrated in $\text{m}\mu$ (millimicrons) but the accepted term for this unit is nanometers (nm). The absorbance is proportional to the concentration of salicylic acid in the sample. Compare your laboratory aspirin with several brands of commercial aspirin. [*The laboratory synthesized aspirin should have an absorbance >0.5 at 540 nm. The commercial aspirin has an absorbance of <0.2 at 540 nm. The commercial aspirin solution does not change to a violet color when mixed with the iron(III) nitrate solution.*]

Assessing Laboratory Learning

1. What are the most likely impurities present in the sample of aspirin you prepared? [*Unreacted salicylic acid, traces of acetic acid.*]
2. If aspirin sits for long periods of time, the odor of vinegar can be noticed in the container. A hydrolysis reaction occurs very slowly. Explain, using a chemical equation, the source of the vinegar, and the reason for the hydrolysis. [*Slow reaction with moisture in air can produce small amounts of vinegar.*]



3. A white powder was tested by a police chemist with iron(III) chloride solution. A purple color is seen. What conclusion was drawn by the police chemist? [*The white powder contained a phenolic compound, possibly salicylic acid.*]
4. Aspirin tablets are sold as containing 5 grains of aspirin. If 1 grain equals 65 mg, how many milligrams of aspirin does each tablet contain? [*325 mg*]

CAUTION: Use appropriate safety guidelines in performing demonstrations.

DEMONSTRATIONS

Demonstration 1: Reaction in a Breathalyzer

Purpose

The chemistry of some Breathalyzers involves the reduction of orange chromium(VI) to green chromium(III) by ethanol. In this activity, an orange solution of chromium(VI) is added to four quadrants of a Petri dish. Ethanol is then added to one quadrant until a color change occurs. Differing amounts of ethanol are added to the second and third quadrants, and the color changes are compared to each other and to the standard (control). (NOTE: Most Breathalyzers used by law enforcement agencies now utilize infrared analysis.)

Materials

- 4-Quadrant glass Petri dish (or four separate dishes arranged in a square)
- Overhead projector
- Stirring rod
- 3 Medicine droppers
- Paper towel
- Chromic acid reagent [add 6 g chromium(VI) oxide (CrO_3) to 12 mL concentrated sulfuric acid and stir until a smooth paste is obtained.
Cautiously dilute the paste with 40 mL distilled water, and stir until a clear orange solution is obtained. Cool to room temperature.]
- Ethanol, 45% [47 mL 95% ethanol ($\text{C}_2\text{H}_5\text{OH}$) per 100 mL solution]

Safety

Handle the chromic acid solution with care. It is a strong oxidizing agent, toxic by ingestion, and an alleged carcinogen. Follow proper disposal procedure (see *SourceBook Safety* section and your local requirements for disposal).

Procedure

1. Place the Petri dish on the overhead projector with the lamp on (or on a white sheet of paper on the desktop).
2. Add 15 drops chromic acid solution to each quadrant in the Petri dish. Add 15 drops distilled water to each quadrant and mix.
3. Keep Quadrant 1 as a control.
4. Add 1 drop 45% ethanol to Quadrant 2.
5. Add 2 drops 45% ethanol to Quadrant 3.
6. Add 3 drops 45% ethanol to Quadrant 4.
7. Compare the intensity of the green-brown color produced in each quadrant as a function of the amount of ethanol added. Make observations after 1-2 min. [Quadrant 2 contains a light colored precipitate; Quadrant 3, medium-dark; and Quadrant 4, a heavy dark precipitate. The increasing amount of precipitate indicates the increasing amount of ethanol oxidized.]



GROUP AND DISCUSSION ACTIVITIES

Key Questions

1. Is water a drug? [When given therapeutically to a dehydrated person, water can be considered a drug.]
2. Under what condition might aspirin not be considered a drug? [When taken by an anxious insomniac, aspirin would have no drug effect.]
3. Using the four names for a common drug given here, identify the generic name, the street name, the chemical name, and the brand name: blue birds, sodium pentobarbital, sodium 5-ethyl-5-(1-methylbutyl) barbiturate, Nembutal. [Generic name: sodium pentobarbital; street name: blue birds; chemical name: sodium 5-ethyl-5-(1-methylbutyl) barbiturate; brand name: Nembutal.]
4. A patient purchases a cough syrup consisting of 200 mL liquid. The label directs the patient to take 1 teaspoonful four times a day. How long will the prescription last if 1 teaspoon is equivalent to 5 mL? [10 days]
5. If the usual dose of a sulfa drug for a urinary tract infection is 2.00 g/kg body weight, how many grams of the drug should be given to a female if she weighs 120 lb (2.20 lb = 1 kg)? [109 g]
6. Examine the labels of three combination pain relievers (Bufferin, Excedrin, Vanquish, etc.). Make a list of the ingredients of each. Look up the medical uses, dosages, side effects, and toxicities of each in *The Merck Index*.

Counterintuitive Examples and Discrepant Events

1. “My tooth stopped hurting when I got to the dentist’s office” or “Doctor, I feel better just because you are here.” The anticipation of professional help is often reassuring to patients and provides support. It has much the same effect as a placebo. It is believed that certain natural body (endogenous) drugs (endorphins, adrenal hormones, and neurotransmitters) are released in this clinical and verbal approach.
2. Methanol (methyl alcohol) poisoning is treated by intravenous injection of ethanol (ethyl alcohol). Ethanol is oxidized more easily by the enzyme that catalyzes the oxidation of methanol in the body, and methanol is excreted unchanged in the urine. Enzyme oxidation of methanol yields formaldehyde and formic acid, both highly toxic substances. By saturating the system with ethanol, methanol cannot compete successfully for the enzyme and will be excreted largely unchanged.
3. More is better (a vitamin ad). Ingestion of large dosages of vitamins have been touted as being highly beneficial. Linus Pauling, twice winner of the Nobel Prize, advocates large daily doses of Vitamin C. While the beneficial effects of this practice remain in doubt, at least it should do no harm since Vitamin C is water soluble and will be quickly excreted. The fat-soluble vitamins, however, are not so quickly excreted and can end up in the body’s fat reserves. Thus, overdosages of fat-soluble vitamins (e.g., Vitamin A) have been documented in the medical literature and can lead to serious problems, even death.

Pictures in the Mind

1. TV Public Service message: “This is your brain (an egg); this is your brain on drugs (egg on a hot grill).”

2. TV Public Service message: "Before you get on drugs, you'd better know what you're jumping into (diver plunges into an empty swimming pool)."

Language of Chemistry

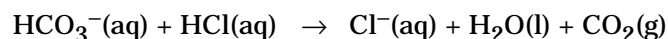
1. Classification of drugs.

TIPS FOR THE TEACHER

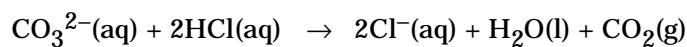
Designation	Examples	Description
Controlled substances		Substances whose sale, distribution, and possession is controlled by the Drug Enforcement Administration
Schedule 1	Heroin, LSD, mescaline	Abused drugs with no medical use
Schedule 2	Morphine, amphetamines	Abused drugs with medical uses
Schedule 3	Valium, phenobarbital	Prescription drugs that are often abused
Over-the-Counter (OTC)	Antacids, aspirin, cough medicines	Available to anyone
Prescription drugs	Antibiotics	Available only by prescription
Unregulated nonmedical drugs	Ethanol, caffeine, nicotine	Available in beverages, foods, or tobacco

Figure 2. Drug classifications.

2. Addiction, dependence, and tolerance are three terms used in describing the effects of some substances. **Addiction** is the continued need of a substance to function normally and to prevent the occurrence of withdrawal symptoms. **Dependence** is experience of withdrawal symptoms if use of the substance stops. **Tolerance** is the need for increasing amounts of a substance to experience the desired effect.
3. **Chemotherapy** is a planned attack on a disease using a specific chemical. Such substances have been designed to attack the disease center (not just relieve the symptoms), do their job and not harm healthy tissue. Substances have been prepared for that very purpose (see also Drug Design in *Links and Connections* section). Some chemotherapeutic agents and the disease they attack are: Salvarsan, syphilis; antibiotics, bacterial infections; radioactive iodine, thyroid cancer; and antimetabolites, some cancers. The possibility of side effects from the use of chemotherapy is a major problem.
4. An **antacid** is an alkaline substance that reacts with excess stomach acid (HCl). As shown in Figure 3, there are many varieties of over-the-counter (OTC) antacids. The most common antacid ingredients are sodium bicarbonate (NaHCO₃), calcium carbonate (CaCO₃), magnesium carbonate (MgCO₃), aluminum hydroxide (Al(OH)₃), and magnesium hydroxide (Mg(OH)₂). The carbonate antacids neutralize excess hydrochloric acid with the liberation of CO₂.



or





Product name	Antacid ingredients
Alka 2	CaCO ₃
Alka-Seltzer Blue ^a	NaHCO ₃ + Citric acid
Alka-Seltzer Gold	NaHCO ₃ + Citric acid
Amitone	CaCO ₃
Bisodol	NaHCO ₃ + MgCO ₃
Bisodol (low sodium)	Mg(OH) ₂ + CaCO ₃
Brioschi	NaHCO ₃ + Tartaric acid
Bromo-Seltzer ^b	NaHCO ₃ + Citric acid
Camalox	Mg(OH) ₂ + Al(OH) ₃ + CaCO ₃
Creamalin	Mg(OH) ₂ + Al(OH) ₃
Di-Gel ^c	Mg(OH) ₂ + Al(OH) ₃
Eno	Na Tartrate + Na Citrate
Gelusil ^c	Mg ₂ Si ₃ O ₈ + Al(OH) ₃
Maalox	Mg(OH) ₂ + Al(OH) ₃
Milk of Magnesia	Mg(OH) ₂
Mylanta ^c	Mg(OH) ₂ + Al(OH) ₃
Rolaids	NaAl(OH) ₂ CO ₃
Titrilac	CaCO ₃
Tums	CaCO ₃

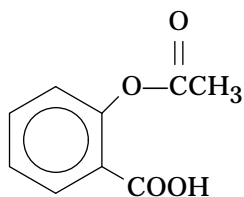
^aContains aspirin

^bContains acetaminophen

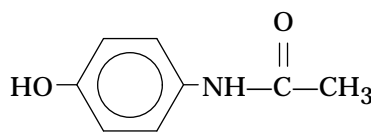
^cContains a silicone defoaming agent

Figure 3. Popular commercial antacid products.

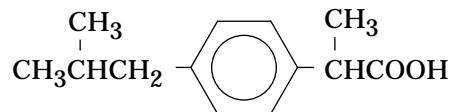
5. **Analgesics**(pain relievers) in common use today are aspirin, acetaminophen, and ibuprofen. All are available as over-the-counter (OTC) preparations. Of the three, aspirin is the only analgesic (reduces pain), antipyretic (reduces fever), and anti-inflammatory (reduces swelling). Acetaminophen is both an analgesic and antipyretic. Acetaminophen has been used as a combination pain reliever with codeine. Ibuprofen is an analgesic. The structure of each is shown below:



Acetylsalicylic acid
(aspirin)



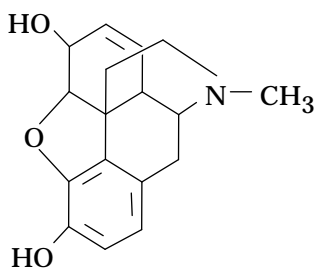
Acetaminophen



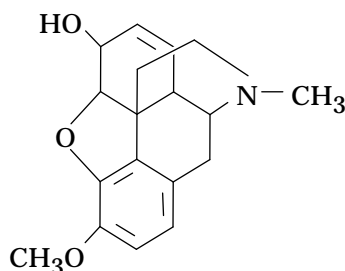
Ibuprofen

Typical doses of aspirin and acetaminophen are 325 mg and for ibuprofen, 200 mg. These drugs have drawbacks. Aspirin causes intestinal bleeding and may cause allergies. It has been implicated in Reye's syndrome, a life-threatening condition that may follow flu or chicken pox in children and teenagers. Acetaminophen is not useful to patients with arthritis, and it is toxic to the liver in large doses. Ibuprofen causes intestinal bleeding and impairs kidney function.

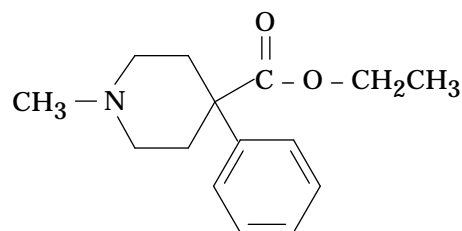
6. **Narcotic analgesics** are used to obtain higher levels of pain relief (*e.g.*, the pain associated with fractures, kidney stones, heart attack, gallstones) than can be achieved with the OTC aids. They produce stupor or insensibility as well as addiction and withdrawal symptoms and increasing tolerance. Narcotic analgesics include codeine, morphine, and meperidine (DemerolTM). Morphine is found naturally in the opium poppy. Codeine is made by methylating (substituting the CH₃- group for H-) morphine. Meperidine is a synthetic narcotic. The dose for pain relief of these analgesics is typically 5–120 mg.



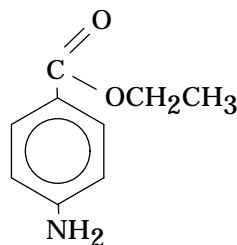
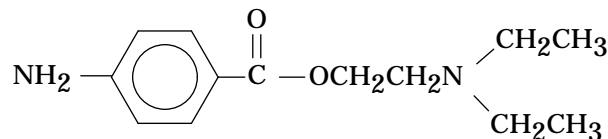
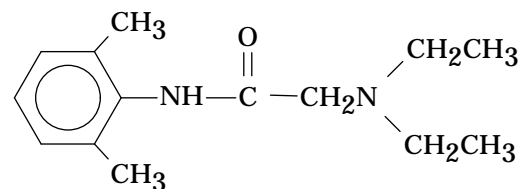
Morphine



Codeine


 Meperidine
Demerol®

7. **Combination pain relievers** contain aspirin and caffeine. Caffeine is a mild stimulant found in coffee, tea, and cola drinks. Evidence indicates that caffeine counteracts the action of aspirin. Thus combination pain relievers containing caffeine are less effective. Some combination pain relievers contain an antacid.
8. Colds are caused by viruses, and antibiotics are not effective against cold viruses. **Cold remedies** treat only the symptoms and may contain a cough suppressant, a nasal decongestant, and an antihistamine. The cough suppressant is either codeine or dextromethorphan. The antihistamine, usually diphenhydramine or chlorpheniramine, relieves allergy symptoms (sneezing, itchy eyes, and runny nose). The nasal decongestants are usually ephedrine and phenylephrine. These drugs have been found to be safe and effective when taken as directed, but antihistamines can cause drowsiness and are potentially hazardous to anyone who needs to be alert. Abuse of cold remedies can lead to addiction.
9. Some well-known combination remedies are shown in Figure 4.
10. **Local anesthetics** render one part of the body insensitive to pain. Benzocaine is available in some OTC preparations for localized surface pain and itching. Procaine and lidocaine are more potent and are used in dental repair or for minor surgery.


 Ethyl *p*-aminobenzoate
(Benzocaine)

 Procaine
(Novocain®)

 Lidocaine
(Xylocaine®)



Product name	INGREDIENTS				
	Analgesic	Antacid	Antihistamine	Decongestant	Other
Akka-Seltzer (Blue)	Aspirin	NaHCO ₃			Citric acid ^a
Alka-Seltzer Plus	Aspirin	NaHCO ₃	Chlorpheniramine	Phenylpropanolamine	Citric acid ^a
Allerest			Chlorpheniramine	Phenylpropanolamine	
Anacin	Aspirin				Caffeine
Arthritis Pain Formula	Aspirin	Al(OH) ₃ Mg(OH) ₂			
Bufferin	Aspirin	MgCO ₃ aluminum glycinate			
Comtrex	Acetaminophen		Chlorpheniramine	Pseudoephedrine	Dextromethorphan ^b
Contac			Chlorpheniramine	Phenylpropanolamine	Belladonna Alkaloids Caffeine
Cope	Aspirin	Al(OH) ₃ Mg(OH) ₂			
Coricidin	Aspirin		Chlorpheniramine		
Coricidin D	Aspirin		Chlorpheniramine	Phenylpropanolamine	
CoTylenol	Acetaminophen		Chlorpheniramine	Phenylpropanolamine	Dextromethorphan ^b
Day Care	Acetaminophen			Phenylpropanolamine	Dextromethorphan ^b Alcohol (7.5%)
Dristan	Aspirin		Chlorpheniramine	Phenylephrine	Caffeine
Empirin	Aspirin, Phenacetin				Caffeine
Excedrin	Aspirin, Salicylamide, Acetaminophen		Pyrilamine ^c		Caffeine
NyQuil	Acetaminophen		Doxylamine	Ephedrine	Dextromethorphan ^b , alcohol (25%)
Vanquish	Aspirin, Acetaminophen	Al(OH) ₃ Mg(OH) ₂			Caffeine ^b

^a Causes effervescent action.

^b Cough suppressant.

^c Found in Excedrin PM only.

Figure 4. Some well-known combination remedies.

- Antiseptics** are compounds that are applied to living tissue to kill microorganisms or to prevent their growth. Many are mild oxidizing agents and are effective because they oxidize bacterial cells (as well as human cells) or weaken cell walls so that the cell contents cannot be contained (see Figure 5).

Antiseptic	Concentration	Use
1. Hydrogen peroxide	3%	Topical antiseptic
2. Potassium permanganate	0.01–0.2%	Topical antiseptic, astringent
3. Benzoyl peroxide	5–10%	Acne ointments
4. Isopropyl alcohol	70%	Rubbing alcohol
5. Quaternary ammonium compounds	—	Surface-active agents
6. Iodophors (iodine + polyvinylpyrrolidone complex)	—	Restaurant glassware
7. Hexylresorcinol	—	Antiseptic

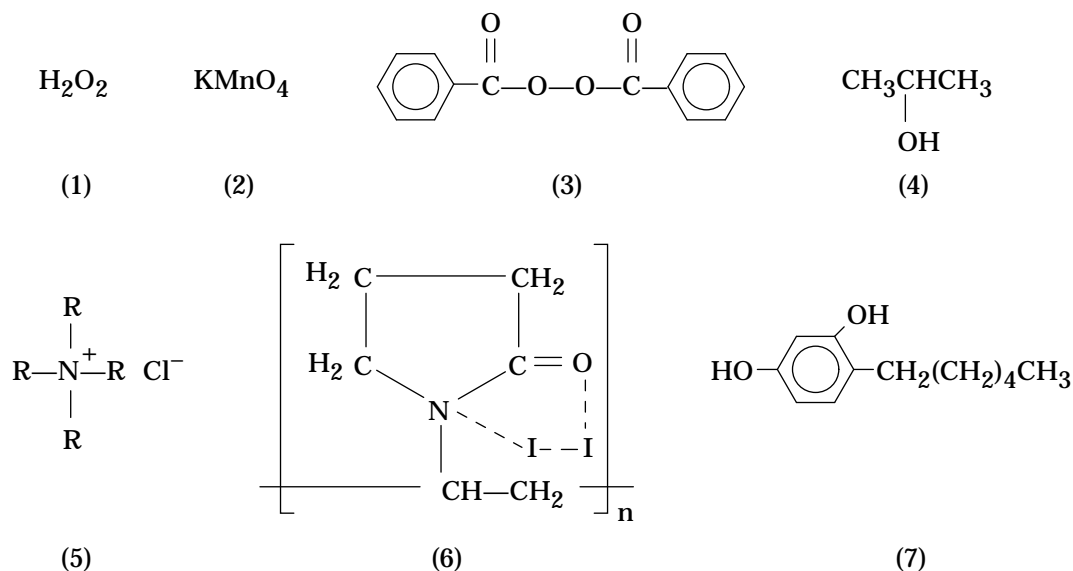
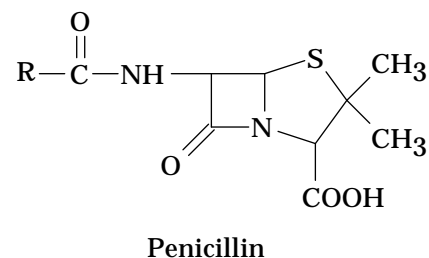


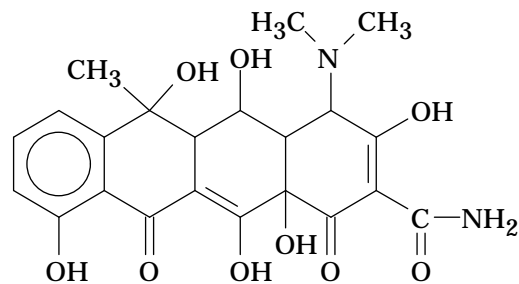
Figure 5. Some common antiseptics.

12. **Vitamins** are organic compounds required in small amounts in the diet because they cannot be synthesized by the body. Lack of proper amounts of vitamins in the diet can lead to vitamin-deficiency diseases. For example, Vitamin A deficiency leads to nightblindness (poor vision in dim light), Vitamin D deficiency lead to rickets (soft and poorly mineralized bones), and Vitamin K deficiency leads to hemorrhaging. Some vitamins are necessary in making certain coenzymes. For example, riboflavin is needed for flavin adenine dinucleotide (FAD), and niacin is needed for nicotinamide adenine dinucleotide (NAD). These particular coenzymes are involved in oxidation-reduction reactions. Megadoses of vitamins, unless prescribed by a physician, are dangerous.
13. **Antibiotics** are derived from molds or bacteria and inhibit the growth of other microorganisms. Discovered in 1941, penicillin is made by the mold *Penicillium notatum*. Many different penicillins exist, differing only in the structure of the R group in the general formula shown below. The nature of the R group determines whether or not the penicillin can be taken orally or by injection, and whether it causes diarrhea or an allergic reaction.





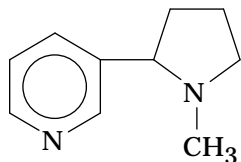
Tetracycline antibiotics get their name from their four-ring structure. First used in 1950, they are effective against a wide variety of microorganisms. Initially obtained from fungi, many tetracyclines are synthesized today. Terramycin is a typical example.



Terramycin

14. **Nicotine** and Smoking.

People smoke for enjoyment, to alleviate stress, or because they are addicted to nicotine. Yet nicotine, the active ingredient in tobacco, is toxic. It is lethal at doses of about 60 mg, and a typical cigar contains at least 120 mg. However, only about 10% of that amount is absorbed on inhaling the smoke, and over a relatively long period. A typical filter cigarette contains 20-30 mg of nicotine. Low doses of nicotine increase respiratory rate, stimulate an increased heart rate and blood flow, and constrict the arteries. Regular smokers exhibit a shortness of breath because CO and HCN formed in the combustion processes bind to hemoglobin, diminishing its ability to carry oxygen. At high doses, nicotine interferes with nerve impulse transmission. Tolerance can be developed for small amounts of nicotine along with a dependency.

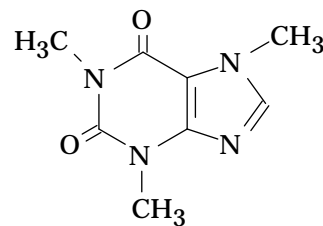


Nicotine

It is not just the nicotine in cigarettes that is harmful. Benzpyrene, found in tobacco smoke, is an extremely carcinogenic compound. Tobacco also contains β -naphthylamine, which causes bladder cancer.

Individuals chewing or dipping smokeless tobacco have a particularly dangerous habit. Smokeless tobacco causes tooth decay (it has a high sugar content), gum disease, and oral cancer. Nicotine levels in the blood of smokeless tobacco users is comparable to or greater than cigarette smokers.

15. **Caffeine** is found in tea, coffee, and cola drinks. Caffeine is an **alkaloid** (*i.e.*, can be extracted from its natural source by acid) and a stimulant. It causes an increased alertness, the ability to put off sleep, and an increased capacity for thinking, but coordination and timing may be adversely affected. It is the main ingredient in certain OTC products, such as No-Doz (100 mg caffeine per dose) and Vivarin (200 mg per dose). Caffeine users can develop tolerance and dependency. Coffee drinkers (90 mg/cup) will experience lethargy, headache, or nausea after abstaining for up to 15 hr. Cola drinkers (43 mg/can) and tea drinkers (50 mg/cup) can also experience these reactions.



Caffeine

16. **Ethanol** Alcohol is a term that describes a class of organic compounds with a hydroxy group ($-OH$) bonded to a carbon atom. It is also a term that the populace uses to identify liquors, beers and wines. The alcohol contained in these and other alcoholic beverages is ethanol (CH_3CH_2OH). Beer is usually 6% ethanol by volume; wines, 12%; and 80 proof whisky, 40%. (Proof = 2 x alcohol content by volume.) Ethanol is a mild depressant slowing down physical and mental activity in moderate amounts. In very large amounts, it produces unconsciousness or death. Although alcohol's effects vary among individuals, usual effects are summarized in Figure 6. The relationship applies to a 70 kg (154-lb male) who rapidly consumes 30-mL (1-oz) shots of 90-proof (45% ethanol) whiskey.

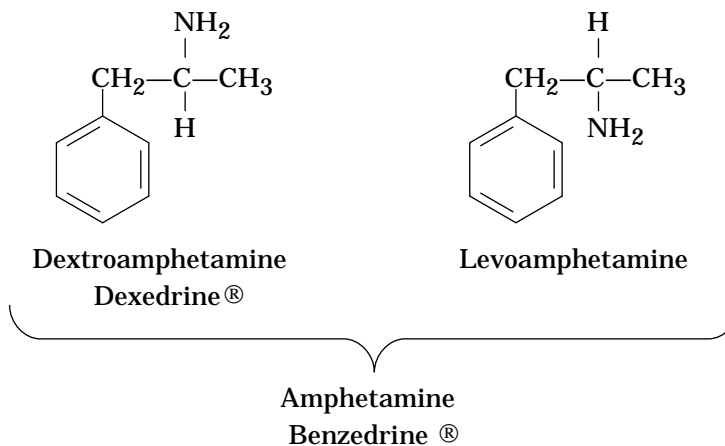
**Approximate Relationship between Drinks Consumed,
Blood-Alcohol Level (BAL), and Behavior**

Number of Drinks	BAL (Volume %)	Behavior
2	0.05	Mild sedation; tranquility
4	0.10	Lack of coordination
6	0.15	Obvious intoxication
10	0.30	Unconsciousness
20	0.50	Possible death

Figure 6. Effects of alcohol.

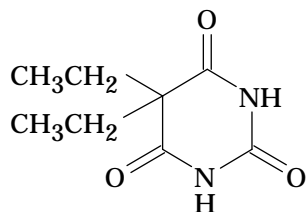
Ethyl alcohol is detoxified by a liver enzyme through an oxidation reaction. In individuals who develop tolerance for alcohol, increasing amounts of the enzyme build up in the liver enabling large amounts of alcohol to be detoxified.

17. Benzedrine is a mixture of two optical isomers of **amphetamine**. These two isomers differ in the way they rotate plane polarized light. These isomers occur because of the four different groups ($C_6H_5CH_2-$, NH_2- , CH_3- , and $H-$) around the central carbon atom. Dexedrine is the stronger stimulant of the two. Amphetamines are central nervous system stimulants that increase heart rate and blood pressure. They increase wakefulness, drive, and energy. They produce a temporary elevation of mood, usually followed by fatigue, irritability, and depression. Users often must take barbiturates to sleep. Amphetamines have been used for weight reduction and to relieve mild depression. In colloquial language, amphetamines are called "uppers."

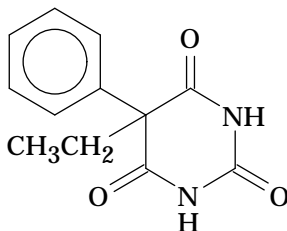




18. **Barbiturates** colloquially called “downers,” are used to produce mild sedation (a few milligrams) and to induce sleep (about 100 mg). They are the major ingredient in sleeping pills and can cause death in the case of an overdose. Barbiturates are addictive. Users generally develop a tolerance and require larger doses to obtain the desired degree of sedation. Structurally, barbiturates are amides. Barbiturates are particularly dangerous when used along with alcohol. Both substances are depressants, but when used together the sum of the effects is magnified (synergism). The structures of common barbiturates are given to the left.

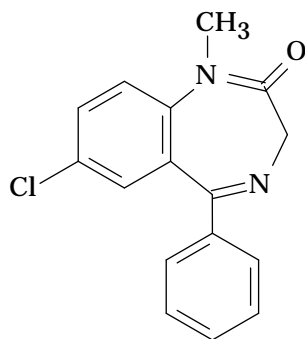


Barbital
Veronal®

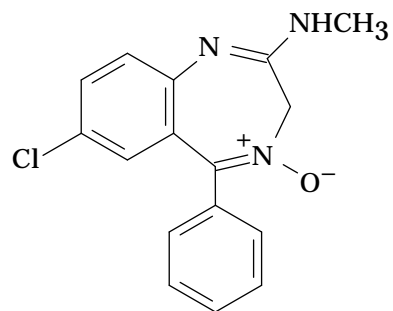


Phenobarbital
Luminal®

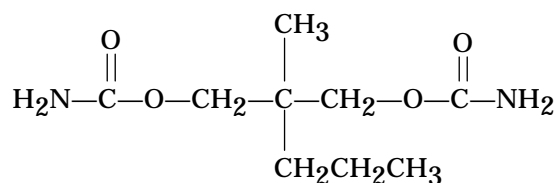
19. **Tranquilizers** are used to calm nerves and relieve tension. Cope, Vanquish, and Compoz are OTC drugs available to help individuals “cope” with problems and unwind. These products also contain aspirin and an antihistamine, which typically causes drowsiness. Tranquilizers are also available by prescription (for example, Equanil, Valium, and Librium). Many tranquilizers are addictive and attempts to stop using them have caused withdrawal symptoms. More potent tranquilizers (*e.g.*, thiorazine) are useful in treating severe forms of mental illness and schizophrenia. The structure of some common tranquilizers are given.



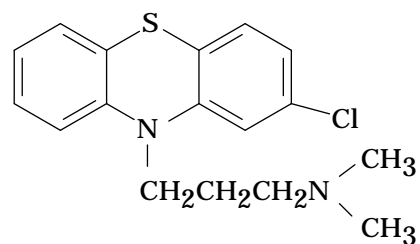
Diazepam
Valium®



Chlordiazepoxide
Librium®



Meprobamate
Miltown®, Equanil®



Chlorpromazine
Thorazine®
(as hydrochloride)

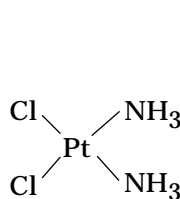
20. **Radiopharmaceuticals** Radioisotopes are used for therapy and diagnosis in medicine. As a diagnostic tool, they provide information about the type or extent of illness. The therapeutic use is intended to treat or cure a disease. Some examples are shown in Figure 7.

Isotope	Use
Barium-131	Detection of bone tumors
Cobalt-58	Determination of uptake of Vitamin B-12
Iodine-131	Detection of thyroid malfunction, treatment of thyroid cancer
Cobalt-60	Treatment of cancer
Radium-226	Treatment of cancer

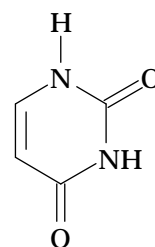
Figure 7. Some common radioisotopes and their uses.

Both diagnostic and therapeutic radioisotopes typically produce gamma radiation. In low doses, gamma radiation is less harmful to tissues than alpha or beta radiation. Although alpha and beta radiation produce more cell deaths per unit of exposure than gamma radiation, the penetrating power and ranges of alpha and beta radiation are very small. Gamma radiation penetrates tissues very effectively and, in high dosages, is very effective in causing cell death, particularly in rapidly multiplying cells. For this reason, gamma radiation is used for therapeutic purposes as well. Typically a beta emitter like cobalt-60 is used for cancer treatment. An atom of cobalt-60 transmutes to a highly excited atom of nickel-60, which emits two high-energy gamma rays in quick succession. These gamma rays have been found to be effective in the treatment of some types of cancer.

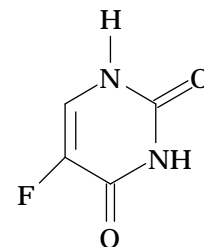
21. **Anticancer Drugs** Cancer is cell multiplication without restraint with invasion of nearby tissue. In addition to surgical removal of affected areas and irradiation to kill the cancer cells, cancers are treated by chemotherapy use of chemical substances to kill cancer cells. These substances include alkylating agents, cisplatin, and antimetabolites. Alkylating agents are organic compounds that transfer alkylating groups to nitrogen bases (usually guanine) in DNA. The presence of the alkyl group in guanine prevents DNA replication (and thus, cell division). Cisplatin also blocks DNA replication. Antimetabolites interfere with synthesis of a nucleotide necessary for DNA synthesis and therefore inhibit cell division. 5-Fluorouracil is an antimetabolite (see Drug Design in *Links and Connections* section). The use of these substances is based on the premise that cancer cells are undergoing rapid division and will be affected to a greater extent than healthy cells. In the long run, healthy cells suffer as well. Chemotherapy has provided an improvement in patient survival with some cancers, particularly breast, bladder, and colon cancer, and Hodgkin's disease.



Cisplatin



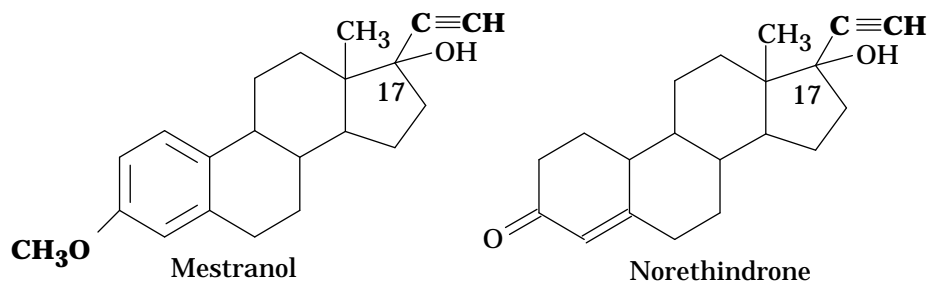
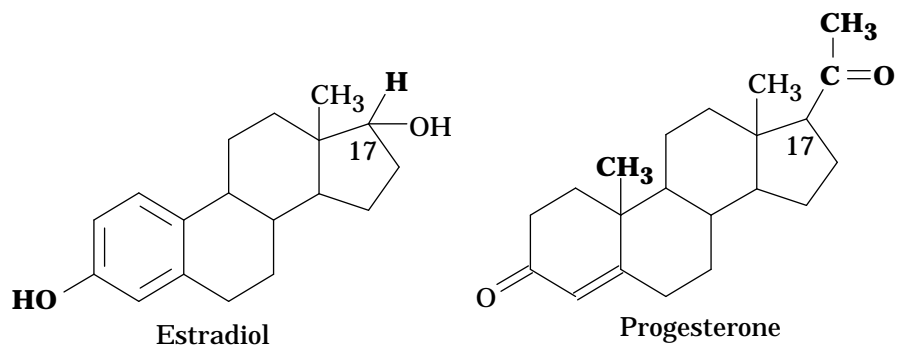
Uracil



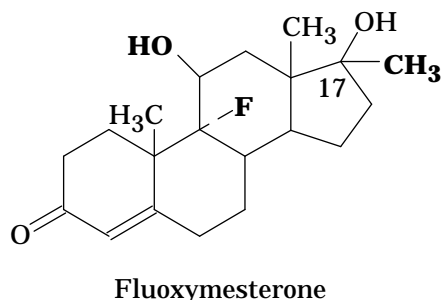
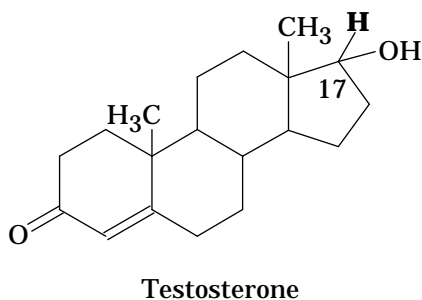
5-Fluorouracil



22. **Birth control pills** are steroids inhibiting ovulation and “convincing” the body that it is pregnant. If an egg is not released, females cannot become pregnant. The pill, a synthetic hormone-like substance, was first used in 1960. For most females the pill is safe, but some women experience undesirable side effects: hypertension, acne, and abnormal bleeding. A combination pill that contains both synthetic estrogen and progesterone is typically used. Notice the structural similarity of these synthetic compounds (mestranol and norethindrone) to the female sex hormones progesterone and estradiol. Substitution of the $-C\equiv CH$ group for a $-CH_3$ group at C-17 allows for a more effective drug (see *Drug Design in Links and Connections* section).



23. **Anabolic steroids** are synthetic derivatives of testosterone. These drugs are used in therapy to correct hormonal imbalance or to prevent withering of muscle in persons who are recovering from surgery or starvation. Healthy athletes use these drugs in doses 10 times the therapeutic dose to build muscle mass. When so used, a number of side effects are noticed including acne, baldness, enlargement of the breasts, and changes in sexual desire. In women, use of anabolic steroids produces facial hair, deepening of the voice, and changes in the menstrual cycle. Anabolic steroids are toxic to the liver. Notice the structural relationship between testosterone and fluoxymesterone,



a typical anabolic steroid. The presence of the $-CH_3$ group at C-17 is thought to slow the metabolism of the steroid in the liver and increases liver toxicity.

24. The following reference guide to some drugs that are subject to abuse is available from Council on Drug Abuse, 698 Weston Road, Toronto, Ontario, M6N 3R3; (416) 763-1491.

DRUG EFFECTS...the important effects are the ones that you don't feel.

What a drug does to the mind, body or both depends on much more than simply the drug the person is taking, including the following:

1. How big you are.
2. How old you are.
3. Your mood and emotions at the time you take it.
4. How much you take.
5. How strong the drug is.
6. How fast you take it.
7. How it gets into the body, (eating, smoking, *etc.*)
8. Your general physical condition.
9. What other drugs are in your body at the time.
10. What is already in your stomach.



ALCOHOL

EXAMPLES

Wine

Beer

Distilled Spirits (Rye, Scotch, Rum, Vodka and Liqueurs)

MAJOR DANGERS

Whatever the word “alcoholic” means, some people keep using alcohol even when it is killing them. Drinking impairs decision-making and control of muscles, leading to increased risks of car accidents, fighting, violence and suicide. Alcohol often makes people do things they know are wrong, or do not believe in. These problems can occur even when the drinker does not feel drunk. People may die from overdose if they drink too much too fast, or if they mix alcohol with other drugs such as sleeping pills. Overdose kills people by making them unconscious and then stopping their breathing. Any person, including a teenager, who drinks can develop alcoholism. Heavy alcohol use is likely to lead to problems at work, at school, and in the family. It can also result in bankruptcy, crime and foolish gambling. Some individuals have committed murder under the influence of alcohol. Alcohol can permanently damage the brain and the liver. It helps cause heart attacks, cancer of the throat or the stomach, and other diseases. Pregnant women should not drink alcoholic beverages without seeking advice from a physician.

CLASSIFICATION

Alcohol in any form is a depressant. A depressant slows everything down and can cause people to fall asleep, or stop breathing.

MEDICAL USES

There aren't many medical uses for alcohol. Ask your doctor for advice.

LEGAL OFFENSES

There are many: such as buying it from the wrong place, drinking under age, having it in the wrong place, being drunk in public and giving it to people who are too young to have it legally and so on. The law varies from one state to another.

SLANG NAMES

“Booze”

“Sauce”

“Juice”

SYMPTOMS and BEHAVIORS

Wine, beer, rye and all other alcoholic beverages have the same effect on your body, and what alcohol does depends on how much you drink, how big you are, how old you are and how fast you drink. You can have heartburn, vomiting and dizziness. Alcohol can take away some of the benefits of eating proper food. Alcohol effects include making people feel angry, uptight, or itching for a fight. With frequent drinking, tolerance develops, which means it takes more alcohol to produce the same effect. This is the main reason why some people drink a lot without showing signs of being drunk. However, such people are still impaired because the brain does not develop much tolerance.

HALLUCINOGENS (1)

EXAMPLES

LSD
DMT
DET
STP (DOM)
Psilocybin (“Magic Mushrooms”)
Mescaline
Peyote

MAJOR DANGERS

Hallucinogen users may see or hear things that aren’t there. Nobody can predict how long these effects will last. Users do not know what they will do or how they will feel when hallucinogens are used, even if used before. Users may think they cannot be hurt so they may try to stop a speeding car or step off a roof. Occasionally people have been known to kill themselves or other people while under the influence of these drugs. “Flashback” or “afterflash” can happen months after the last time users took the drug—this means that they go on a “trip” again without taking the drug again.

CLASSIFICATION

They can speed up the body’s workings and/or slow them down.

MEDICAL USES

None

LEGAL OFFENSES

Having it, selling it, having enough of it that the court thinks that you intended to sell it.

SLANG NAMES

“Acid”
“Blotters”
“Cids”
“Micro Dots”
“Shrooms”
“Window Panes”
“Double Domes”
“Orange Sunshine”

SYMPTOMS and BEHAVIORS

Nobody can predict what these drugs will do to users. Generally, however, users may seem very happy, very depressed, angry or terrified, restless, see things that are not there, talk to people who aren’t there; colors and shapes may change. Users may vomit, or get the shakes or start sweating. The difference between what is real and what is not may not be known.



HALLUCINOGENS (2)

EXAMPLES

Cannabis
Marijuana
Hashish
Hash oil
Marijuana oil

MAJOR DANGERS

Just before, during, and after feeling high, users usually cannot tell how far away something is or how fast it is coming. Usually users cannot tell if there is any crisis to react to. For both these reasons operating any kind of a machine can be very dangerous—including bikes, cars, punch presses, swings, sleds and skateboards. Marijuana cigarettes have been rated from 5 to 22 times worse for the lungs than tobacco. Regular users may be less able to fight off infections from viruses and bacteria. The chemicals from cannabis stay in the body for a long time. They may cause birth defects or interfere with sexual activity. Regular users often fail at their work or school; they lose interest in many things. Cannabis affects memory and limits the user's ability to concentrate. Most users take other drugs. They can do many things that they know are wrong or just not their way, such as stealing or lying. Tolerance develops with regular use, and the user needs more to get the same effect. The drug itself may not cause permanent brain damage, but it can permanently change your life, for example, by causing you to fail in school.

CLASSIFICATION

It can speed up the body's workings and slow them down. With high doses, it may work as a hallucinogen (user sees and hears things that are not there).

MEDICAL USES

No widely accepted uses.

LEGAL OFFENSES

Having it, selling it, having enough of it that the court thinks that you intended to sell it, sending it, lending it, offering to sell it.

SLANG NAMES

"Pot"
"Grass"
"Weed"
"Smoke"
"Hash"
"Honey Oil"
"Thai Stick"
"Colombian"
"Ganja"

SYMPTOMS and BEHAVIORS

Cannabis drugs can give users red eyes, severe coughs, and shortness of breath. Regular use in the long term can produce lung diseases like bronchitis, cancer, and emphysema (a lung disease that cannot be cured). When high, the user can be dreamy, talkative, or laugh a lot. Mood changes very rapidly and the user often cannot remember what happened a few minutes ago. If used often, the user may drop out of activities and become less interested in many things—including the future.

HALLUCINOGENS (3)

EXAMPLES

PCP (Phencyclidine)

MAJOR DANGERS

The people who sell this drug tell the customer that it is THC, LSD, or something else. Like most hallucinogens, this drug is unpredictable. What usually happens is users cannot feel pain, and this is dangerous. Users have died from accidental overdose or from getting into situations where they were killed in a fight. In some cases suicide can result. There is probably permanent brain damage from the use of PCP. It is especially dangerous, like most drugs, when mixed with any other drug. The other dangers are the same as those listed above for LSD.

CLASSIFICATION

It can speed up the body's workings and/or slow them down. It is an hallucinogen, which means that the user may see and hear things that aren't there.

MEDICAL USES

None

LEGAL OFFENSES

Having it, selling it, having enough of it that the court thinks that you intended to sell it, sending it, lending it, offering to sell it..

SLANG NAMES

"Hog"
"Dust"
"Angel Dust"

SYMPTOMS and BEHAVIORS

There is no telling how someone will react on PCP. It is known that blood pressure increases dramatically, and users can stay up for several days. PCP can act like alcohol, marijuana, LSD or all of these. Users are confused, see or hear things that are not there, and may have convulsions and can fall into a coma.



NARCOTICS

EXAMPLES

From Opium:

Heroin
Morphine
Codeine

Synthetic:

Methadone
Demerol
Percodan
Talwin

MAJOR DANGERS

Many users get quickly and severely addicted. The narcotic addict stops caring about self, work or other people. Those who use a needle can get infections, blood diseases, and AIDS. People can die from overdose: they stop breathing. Tolerance happens over time; that is, more and more of the drug is needed to get the same effect until at last there is no effect—the user takes it just to keep from getting sick. Most users are in poor health, mostly because they do not take care of themselves properly, and take physical risks.

CLASSIFICATION

Depressant. Narcotics slow everything down and can cause people to fall asleep, or stop breathing.

MEDICAL USES

Pain relief

LEGAL OFFENSES

Having it, selling it, or having enough of it that the court thinks that you intended to sell it, sending it, lending it, offering to sell it.

SLANG NAMES

Heroin:

“Smack”
“Junk”
“H”
“Horse”

Others:

“M”
“Percs”

SYMPTOMS and BEHAVIORS

Users “coast”—as in a dreamy half-awake state (usually followed by feeling very down). Users cannot control hands or legs or speech; appetite usually goes and often accidents occur. Urge for the drug is so strong that to get it, users may attack people they love, or steal. When addicts cannot get the drug, they vomit get watery eyes, runny nose, hot and cold flashes, muscular cramps, and diarrhea.

NICOTINE

EXAMPLES

Cigarettes
Cigars
Pipe Tobacco
Chewing Tobacco
Snuff
Smokeless Tobacco

MAJOR DANGERS

Users get addicted to it. Those who keep using it can get cancer of the lung, mouth, throat, or stomach; bronchitis and emphysema (a lung disease that takes a long time to kill), and eye problems. Nicotine is a major cause of heart attacks. Many die prematurely from the effects of smoking.

CLASSIFICATION

Nicotine speeds up the body's workings and slows them down.

MEDICAL USES

None

LEGAL OFFENSES

Under federal law, it is illegal to sell to persons under 18 years of age. There are many places where smoking is forbidden.

SLANG NAMES

"Coffin Nails"
"Cancer Sticks"
"Smokes"

SYMPTOMS and BEHAVIORS

Blood pressure goes up, heart rate is too fast, and if smokers use enough, they can get the shakes, have trouble breathing, and may develop kidney damage. Users usually emit an unpleasant odor.



ORGANIC SOLVENTS

EXAMPLES

Model Airplane Glue
Nail Polish Remover
Dry Cleaner Fluid
Gasoline
Paint Thinner
Lighter Fluid
Plastic Cement

MAJOR DANGERS

Chronic use causes damage to the brain, liver, and/or kidneys. Sniffing solvents can cause sudden death due to heart failure. The user may commit crimes, get into fights, and have accidents. Sometimes users die accidentally from choking or from suffocation. Other dangers are similar to those of cannabis or LSD, with the added risk of sudden death.

CLASSIFICATION

Depressants. These solvents slow everything down and can cause people to fall asleep, or to stop breathing.

MEDICAL USES

None

LEGAL OFFENSES

Not covered by law

SLANG NAMES

None

SYMPTOMS and BEHAVIORS

Users behave as if drunk and sometimes smell of solvents. Users get confused, cannot talk coherently and sometimes become very suspicious and/or violent. They may see and hear things that aren't there. They cannot control what their muscles do and often have a runny nose and watery eyes. Users may be grouchy, sleepy or become unconscious.

SEDATIVES AND HYPNOTICS

EXAMPLES

Sleeping Pills
Other Barbiturates

MAJOR DANGERS

Severe addiction can happen. Users cannot think coherently and lose muscle control. There can be damage to the liver and the brain. Users die from overdose either by the drug alone or by mixing it with some other drug, such as alcohol. It is dangerous to quit without a doctor's advice and supervision, partly because serious, sudden convulsions or seizures may occur.

CLASSIFICATION

Depressants. These substances slow everything down and can cause users to fall asleep, or to stop breathing.

MEDICAL USES

To treat insomnia, anxiety, nervous tension and epilepsy; they are also used in the treatment of mental disorders.

LEGAL OFFENSES

Selling it, or having enough of it that the court thinks that you intended to sell it, are crimes. It is also a crime to make or process any of these drugs.

SLANG NAMES

"Goofballs"
"Red Devils"
"Seckies"
"Tooies"
"Nemmies"
"Rainbows"
"Christmas Trees"
"Downers"
"Downs"
"Reds"

SYMPTOMS and BEHAVIORS

Users behave very much as if they were drunk. They usually have little energy and feel down much of the time. Pupils of the eyes may shrink to the size of pinpoints.



STIMULANTS (1)

EXAMPLES

Amphetamines (Speed or Uppers)
Benzedrine
Dexedrine
Methedrine
PMA
TMA
Phentermine

MAJOR DANGERS

Users of these drugs do not eat properly, cannot sleep properly, and often develop paranoia (they believe others are out “to get” them). They can get pneumonia, severe high blood pressure, or heart attacks and/or brain damage (for instance by a stroke). Sudden death may occur. These drugs reduce the appetite. Addiction happens fast and is very strong. Users take many foolish chances and often become violent because they cannot trust anyone. There is a tolerance effect, which means users must take more to get the same effect.

CLASSIFICATION

Stimulants. They speed up the body’s workings.

MEDICAL USES

To relieve mild depression and fatigue. To treat narcolepsy (a rare disease in which there is an uncontrolled desire to sleep). To treat hyperkinesis (overactive condition) in children.

LEGAL OFFENSES

Selling it, or having enough of it that the court thinks that you intended to sell it, are crimes. It is also a crime to make or process any of these drugs.

SLANG NAMES

For Pills and Capsules:

“Uppers”
“Ups”
“Pep Pills”
“Bennies”
“Beans”
“Dexies”
“Hearts”
“Peaches”

For Methamphetamines (usually injected):

“Speed”
“Crystal”
“Meth”

SYMPTOMS and BEHAVIORS

Pupils of the eyes get big. Users lose appetite, are talkative, grouchy and jumpy. Users get a bad complexion; the nose and mouth dry out. Users are either tired or overactive. If users take enough, they can believe things that aren’t true, get violent and can behave in many of the way described for LSD.

STIMULANTS (2)

EXAMPLES

Cocaine
Coca Leaves

MAJOR DANGERS

Cocaine is a very powerful stimulant and does all the things listed above for amphetamines, and is even more addictive. Sudden death may occur. Users get addicted to it and will use as much as can be found. Users will be confused, have memory problems, cannot think straight and often have dizzy spells.

CLASSIFICATION

Stimulant. It speeds up the body's workings.

MEDICAL USES

Local anesthetic (rare).

LEGAL OFFENSES

Having it, selling it, having enough of it that the court thinks that you intended to sell it, sending it, lending it, offering to sell it.

SLANG NAMES

"Snow"
"Coke"
"Nose Candy"

SYMPTOMS and BEHAVIORS

Much of the same as for speed and other uppers. While on the cocaine high, users wrongly think they can do anything, can make no mistakes. But judgment goes when on a high, and the high is so attractive users will go broke buying it. Often users steal and deal to pay for the habit.



STIMULANTS (3)

EXAMPLES

Crack (Crack is cocaine in a much stronger and smokable form)

MAJOR DANGERS

It does all that cocaine does, only faster and with more severe results.

CLASSIFICATION

Stimulant. It speeds up the body's workings.

MEDICAL USES

None

LEGAL OFFENSES

The same as cocaine.

SLANG NAMES

"Crack"

"Rock"

SYMPTOMS and BEHAVIORS

Crack brings addiction as fast as any drug, and much faster than most. Not only do users want the high again, but the down that follows is so bad it cannot be tolerated. The high and the down are barely 10 min apart, so crack users usually cannot think of anything but wanting the high again. Stealing is more unplanned than the cocaine user's—crack often leads to purse snatching and mugging.

TRANQUILIZERS

EXAMPLES

Miltown
Equanil
Valium
Librium
Serax
Ativan
Halcion

MAJOR DANGERS

Besides the real danger of strong addiction, users of these drugs may get to a point where there are memory problems and users just aren't as alert as they normally would be. These drugs cause driving impairment. As with any other depressant, tranquilizers become especially dangerous when mixed with any other drugs, often death by overdose happens because users mixed the tranquilizer with alcohol, sleeping pills or pain killers. As with the sedatives/hypnotics it is dangerous to get off tranquilizers without a doctor's advice and supervision.

CLASSIFICATION

Depressant. Tranquilizers can slow everything down and can cause people to fall asleep or to stop breathing.

MEDICAL USES

Psychiatrists and other doctors may prescribe tranquilizers to reduce severe anxiety or nervousness, often to enable a very anxious person to talk to a counselor. Doctors may also prescribe them for certain kinds of muscle problems.

LEGAL OFFENSES

Selling it, or having enough of it that the court thinks you intended to sell it, are crimes under the Food and Drugs Act. It is also a crime to make or process any of these drugs.

SLANG NAMES

"Downs"
"Tranks"

SYMPTOMS and BEHAVIORS

Tranquilizers work much like the sedatives and hypnotics listed above. Users may not see very well and may seem forgetful and confused; there can be dizziness or drowsiness. Sometimes users' speech is slurred and they may get a skin rash or have unexplained sweating.



Pattern Recognition

Drugs are not good or bad in themselves. They may be used properly or abused. Similarities in structural formulas of drugs cause similar physiological responses.

Common Student Misconceptions

1. **“Bufferin is twice as fast as aspirin. Bufferin helps prevent the stomach upset often caused by aspirin.”**The FDA investigated these advertising claims and did not find the claims to be true.
2. **“Chicken soup is the best cure for the common cold.”**There is no scientific evidence that chicken soup can cure the common cold. Plenty of liquids and rest, and 5-7 days of suffering are the best cures.
3. **“One of my friends took a drug once and got better.”**This statement is nonspecific and says nothing about drug effectiveness.
4. **“There is only one kind of alcohol.”**The “one kind of alcohol” typically thought of is ethanol or ethyl alcohol. Methyl alcohol and isopropyl alcohol are other alcohols.
5. **“More is better.”**This typically refers to minerals and vitamins that are needed by the body in small amounts. Taking megadoses of these substances can cause some unexpected problems. For example, too much vitamin D can cause pain in bones, nausea and diarrhea, and weight loss. Too much salt (NaCl) in the diet can cause elevated blood pressure in some individuals.
6. **“Walking across a field of poppies will put you to sleep.”**(From the Wizard of Oz.) When Dorothy and her friends in the Land of Oz walked across the poppy fields, they fell asleep. Although opium poppies contain morphine, a central nervous system depressant, walking through a poppy field will not cause one to fall asleep. The morphine must be extracted; *in situ* it is nonvolatile.
7. **“Antiseptic, antibiotic, analgesic, and anti-inflammatory mean the same thing.”**These terms do not mean the same thing and the distinction among them was described in this module.
8. **“Two extra strength aspirin are better than 3 regular aspirin.”**Three regular aspirin contain 975 mg (3 x 325 mg) of active ingredient. Two extra strength aspirin contain 1000 mg (2 x 500 mg) of active ingredient. The difference (25 mg) is not enough to make a significant difference.
9. **“Receiving a vaccine guarantees immunity.”**A vaccine is designed to cause a person to build a resistance to a viral infection (*e.g.*, mumps, polio). When given a vaccine, some individuals have developed serious cases of the disease that the vaccine is designed to alleviate.

Classroom Discussion

Classroom discussion is particularly important in this module. Suggested points for discussion are indicated below.

1. Why do people smoke or use drugs if we know that they are bad for you? (The discussion will avoid judgmental aspects and will address the social problem.)
2. How is the legal use of alcohol and cigarettes different from the illegal use of pleasure drugs?
3. To what extent is the use of anesthetics warranted in ordinary cuts and bruises, dentistry, and childbirth?
4. At what point in an illness should the decision to use or terminate chemotherapy occur?

For centuries, humans have eaten or chewed berries, bark, roots, and herbs to alleviate or cure sickness or disease. The origin of disease was unknown, and its treatment was coupled with magic and superstition. However, the scientific practice of medicine began in ancient Asiatic civilizations. The first known code of medical ethics was established in Sumer. The ancient practice of acupuncture and ideas about blood circulation suggest that the Chinese were familiar with anatomy, vascular systems, and the nervous system. In addition to introducing the Hippocratic oath, the Greeks advanced medical knowledge in anatomy and physiology, diet, and exercise. Through their sanitation facilities, the Romans improved public health. Medical knowledge began to decline during the Middle Ages in Europe, but Arab and Jewish physicians made some progress. For example, two Persians introduced opium for coughs and extracts of crocus seeds to treat gout. Both of these remedies are in use today.

The ancients knew that chewing willow tree (Genus: *Salix*) bark had an analgesic effect. Centuries later, the active ingredient was isolated from the willow bark and called salicylic acid in deference to its origin.

Jesuit missionaries introduced an important herbal remedy into Europe in the 17th century. This remedy was an extract of cinchona bark obtained from South American Indians. The extract was used by Indians against chills and fever and soon became a favorite anti-malarial medicine in Europe. The principal ingredient of cinchona bark is quinine. Also, in the 17th century, William Harvey demonstrated blood circulation and the heart as a pump. A major step toward diagnosing disease was made with the introduction of the compound microscope, making minute forms of life visible for the first time. The 18th century witnessed the introduction of vaccination by Edward Jenner.

Modern medicine had its birth in the 19th century with the development of the germ theory of disease, the use of anesthesia (Crawford Long, 1842), antiseptics in surgery (Joseph Lister, 1867), and a revival of public health measures and better sanitation. During the 20th century there has been an increased understanding of immunity, the endocrine system, and the importance of vitamins and nutrition, advances in surgery, organ transplants, and diagnostic techniques (CAT scan, MRI, etc.). Chemotherapy is an important development of the 20th century. Specific drugs have been discovered and designed to eliminate disease-causing microorganisms (antibiotics), to rectify a hormonal imbalance (insulin), and to arrest a cancerous growth (anticancer drugs).

The following are three interesting stories related to chemistry in medicine. The first two are taken from *Men of Medicine* by Katherine Shippen (1957). The last is from *Medical Heroes and Heretics* by Wayne Martin (1977).

Who Discovered Anesthesia?

In the eighteenth century, the English chemist Humphry Davy made dinitrogen oxide (N_2O , nitrous oxide, laughing gas), and observed that it prevented feeling physical pain. He thought it might be useful in surgery, but did nothing about it. It wasn't until the next century that a true anesthetic was made, although its discoverer has not yet been satisfactorily determined.

As towns sprang up in the West and South of the United States, people were entertained by showmen who featured laughing gas in their repertoire. At one of these laughing gas shows in December 1841, the Georgia physician Crawford Long observed its effects first-hand. Long was very popular with young people, and when his young friends asked him to prepare them some laughing gas, he told them he lacked the apparatus for making it but that he had a medicine called sulfuric ether that would do as well. He sometimes gave a few drops of this compound to nervous patients. Some of his friends tried inhaling sulfuric ether, others soon followed suit, and before long ether parties were being held all through the county. People affected

HISTORY: ON THE HUMAN SIDE



by the gas would throw themselves about hilariously, knocking against furniture, often falling down, bruising themselves, and scraping shins and elbows. Although the cuts and bruises were often considerable, the participants at the ether frolics never complained of them. They didn't even seem to notice that they had hurt themselves. Long correctly reasoned that the ether prevented their feeling pain.

Long decided to use the ether in an operation to remove two small tumors on the back of the neck of a young patient. He let the patient inhale some ether and, after the muscles completely relaxed, removed the tumor. Long recorded the surgery in his ledger, but did not report this first surgery under ether (1842) to a medical journal. Whatever the reason, it was a shock to him to read in a medical journal four years later that William Morton in Boston had administered a gas to a patient that made him insensible to pain.

Morton received much acclaim for his discovery and Long grew bitter over his neglect in reporting his own discovery. When he served in the Civil War, Long kept his ledger with the entry of his discovery with him. Upon his return home after the war, he placed the ledger in a trunk in the attic. His family never dared to speak of the discovery since the mention of it distressed Long too much.

Meanwhile, Morton received permission to demonstrate his ether in surgical operations before the great surgeons at Massachusetts General Hospital. The doctors were interested in seeing the preparation that diminished the sensibility to pain. Morton administered the drug to a patient who shuddered a little and then fell into a deep sleep. Morton removed a large tumor of the jaw, and the patient did not stir as the knife cut into his flesh. After regaining consciousness, the patient said the surgery hadn't hurt at all. Oliver Wendell Holmes, the poet and physician, suggested the word "anesthesia" to Morton in late 1846. According to Holmes, the term signified insensibility to touch.

Discovery of Penicillin

In 1914, Alexander Fleming, physician in the Royal Army Medical Corps, observed that many soldiers wounded in combat developed blood poisoning, pneumonia, or some other bacterial infection. Fleming knew there was need for an effective antiseptic to fight the infections, but none was available.

After the war, Fleming began to teach bacteriology at St. Mary's Hospital in London. He spent many hours in the laboratory searching for the microbe-destroying agent he had needed during the war. One day in 1928, he observed through his microscope that a mold fleck had settled on one culture plate of bacterial growth sitting next to an open window. At first he was annoyed that the mold had contaminated the plate. About to throw it away, he stopped and examined the plate again. The mold was being surrounded by a halo of watery fluid, and he surmised that something in the mold was destroying the microbes. He removed the mold and grew more of it. At first it was fuzzy white, then it turned green, spreading fronds that matted together in a thick mass. Fleming and his assistants continued to study the watery fluid secreted by the mold and found that it was effective against germs causing blood poisoning, sore throat, some types of pneumonia, but not typhoid fever or dysentery. It did not affect blood serum as he had feared it might, nor did it harm mice and rabbits. He concluded that it could be applied to the infected surface undiluted, and it was nonirritating and nontoxic. He named the new antiseptic penicillin, after the *penicillium* family to which the mold belonged.

In 1929, Fleming published a paper announcing the discovery of penicillin. The tiny amounts of penicillin that Fleming could make in the laboratory were not enough to treat a single patient, so his discovery did not arouse much interest. His paper lay forgotten on the library shelves for nearly 10 years until, in 1939, an Australian physician, Howard Florey, reread it and contacted Fleming. Fleming sent Florey some of the original mold, and from it Florey eventually isolated about a teaspoonful of

penicillin—enough to treat one case of infection. He soon had the opportunity to find out if it worked: as a last resort he administered the penicillin to a policeman with a severe case of blood poisoning. The penicillin combated the blood poisoning effectively as long as it continued to be administered, but the single teaspoonful was not enough. When the penicillin ran out, the blood poisoning returned, and the patient died. Florey knew that larger amounts of penicillin would have to be made on a commercial scale. Because England was involved in a war in 1941, Florey went to the United States where penicillin could be mass-produced. By 1943, it was being used to treat infected wounds of the armed forces. Since that time, many lives have been saved by this so-called “miracle drug.” Fleming and Florey shared the Nobel Prize for medicine in 1945 for their discovery.

Jonas Salk and the Polio Vaccine

In 1921, while vacationing on the Island of Campobello off the coast of Maine in New Brunswick (Canada), Franklin D. Roosevelt was stricken by paralytic polio and was crippled for life. In 1926, he established the nonprofit Warm Springs (Georgia) Foundation for treating polio victims. The March of Dimes program, which was associated with the foundation, amassed over \$500 million to help polio victims, designating some \$40 million to finance polio research. In this research endeavor, the conflict of heresy and established belief developed, yet both produced results. The heretic was Jonas Salk. His heresy was the use of a killed-virus vaccine.

In 1908, Karl Landsteiner (Austria) established that polio was caused by virus. By 1941, there were three general types of polio virus had been identified; it had also been determined that all strains of one type would immunize against strains of that type only. By 1952, it was known that polio virus circulated in the blood, and this fact proved to be its Achilles heel since a vaccine-produced antibody in the blood could protect against polio. Isabel Mountain prepared a killed vaccine using formaldehyde to inactivate the virus. She discovered that the killed-virus vaccine would produce a degree of immunity in a monkey without harm.

Given these bits and pieces, what was Jonas Salk's claim to fame? Salk put all the pieces needed for eradication of the disease together by acting quickly and with great precision. In 1947, Salk, then 33, was Research Professor of Bacteriology and Pathology at the University of Pittsburgh. He undertook a program of typing the approximately one hundred strains of polio virus that had been isolated. He became bored during the latter part of the three-year program and began to look ahead to develop a vaccine based on the knowledge available to him. The typing program confirmed that there were only three types of polio virus. In 1951, Salk made a killed-virus vaccine—by treating polio viruses with formaldehyde at 36 °C for 11–13 days. This killed-virus vaccine produced a high degree of immunity to all three types of polio in monkeys contrary to the belief at the time that a killed-virus vaccine could not mobilize antibodies. Salk continued to run tests to ensure that his vaccine was safe by repeatedly determining that the vaccine contained no live virus. He tested his vaccine in immune children (who had had a previous paralytic infection of polio). In all cases some increase in antibody production was noted. In 1953, confident of his vaccine, Salk tested himself, his family and about 400 volunteers in Pittsburgh. One year later the vaccinated subjects were retested and found to have the same high level of vaccine-induced antibodies. Children were vaccinated before the polio seasons of 1954 and 1955. The test showed the vaccine to be safe and effective.

The medical establishment, led by Albert Sabin, complained about the use of the killed-virus vaccine. Sabin claimed that if live virus remained in the vaccine and it were used, it would kill and cripple. Sabin and his colleagues felt that use of a weakened live-virus vaccine was preferable. Throughout his preparation of the killed-virus vaccine, Salk made every effort to ensure that no live virus was present. Yet unintentionally, Salk



hurt many feelings and stepped on many tender toes in the process. The ill will of the scientific community hurt Salk deeply, and he retreated into the seclusion of his laboratory at a time when the public wanted to give him a tickertape parade.

In 1955, a commercial laboratory carelessly produced and sold batches of Salk vaccine containing unkilld viruses. The defective vaccine caused 204 polio cases with 11 deaths and over 100 cases of paralysis. Albert Sabin and the establishment rallied with an attack of vigor and by 1956, the medical establishment had produced a weakened, live virus vaccine (the Sabin vaccine). In 1964, the Surgeon General stated there was only a small risk involved with the Sabin vaccine. He failed to mention that with the killed Salk vaccine, properly prepared, there was no risk at all. The Salk vaccine became passé. Today, the Sabin vaccine is preferred by physicians.

HUMOR: ON THE FUN SIDE

1. Word Search (see *Appendix* for master copy)

L R B Y G P L G J Y B B L T H J U
T V N V D O W S E N I E F F A C W
E L V I L T R W V H Q D E E N T I
S X R T U D H M D C X X F W A X Z
T C Z A L R I U D K K T Q T L R Z
O C M M U G T C X G B I I K G H P
S P G I W Y V X A S D I O R E T S
T E C N A R E L O T M Q E N S P N
E U O S A B G I G Z N Y P N I N F
R R E Y K U M R A M Z A R J C O J
O V E E R C X V O Z U P I I L A M
N Y G D I E T H A N O L G X O E H
E B T L G J I D Y E N F V T Z A L

Words about the concepts in this module can be obtained from the clues given. Find these words in the block of letters:

1. Substance that reacts with excess stomach acid.
2. Common name for a substance that changes a physical or psychological function in the body.
3. Need of increasing amounts of a substance to experience the same initial effects.
4. Acetaminophen, ibuprofen, or acetylsalicylic acid, for example.
5. Benzoyl peroxide is the active antiseptic ingredient in ___ ointments.
6. These organic compounds are required in small amounts in the diet.
7. Stimulant in cola and coffee.
8. Birth control drugs belong to this class of organic compounds.
9. The amount of this drug is determined in the Breathalyzer test.
10. Anabolic steroids are synthetic derivatives of this natural compound.

Answers: 1. ANTACID 2. DRUG 3. TOLERANCE 4. ANALGESIC 5. ACNE
6. VITAMINS 7. CAFFEINE 8. STEROIDS 9. ETHANOL 10. TESTOS-
TERONE

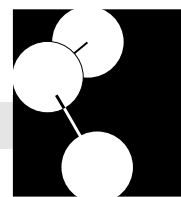
2. See cartoons at end of module.

1. The CHEM Study film "Molecular Structure and Health." Time-lapse photomicrography of laboratory demonstrations helps to identify the role of molecular structure in determining biological activity. Students will also see how the correlation of the structure and biological activity of sulfanilamide with a vitamin essential for bacterial growth leads to a more general presentation of the biochemical nature of growth. Color, 22 min. Available from Ward's Natural Science Establishment, Inc., 5100 West Henrietta Road, P.O. Box 92912, Rochester, NY 14692-9012, (716) 359-2509, (800) 962-2660; (716) 334-6174 FAX.
2. Software published by Project SERAPHIM, Department of Chemistry, University of Wisconsin-Madison, 1101 University Avenue, Madison, WI 53706-1396: (608) 263-2837 (voice) or (608) 262-0381 (FAX).
 - a. For the Apple II computer running on ProDOS: AR 702
 - b. For the Apple II computer: AP 701
3. Videodisc published by *JCE: Software*, a publication of the *Journal of Chemical Education*, Department of Chemistry, University of Wisconsin-Madison, 1101 University Avenue, Madison, WI 53706-1396: (608) 262-5153 (voice) or (608) 262-0381 (FAX).

"From an Amino Acid to a Peptide Chain," "The Alpha Helix," and "DNA Structure, Synthesis of Messenger RNA, Protein Synthesis," three chapters on *The World of Chemistry: Selected Demonstrations and Animations*: Disc II (double sided, 60 min.), Special Issue 4.

MEDIA

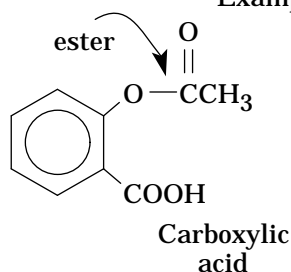
Links/Connections



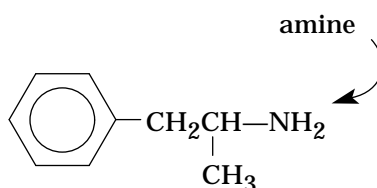
WITHIN CHEMISTRY

1. **Organic Functional Groups** Structurally, many drugs are carboxylic acids, alcohols, amines, esters, ethers, aldehydes, and/or ketones.

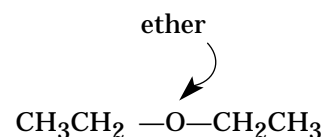
Examples are:



Aspirin
analgesic

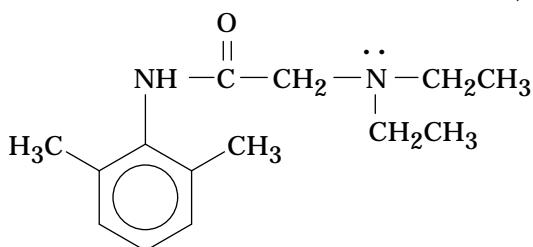


Amphetamine
stimulant

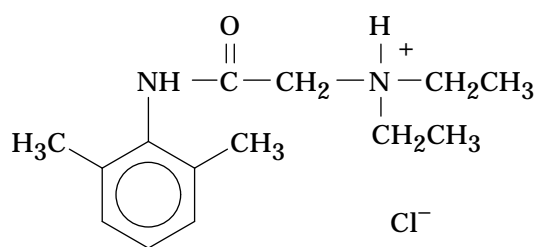


Diethylether
anesthetic

2. **Nomenclature** Several names can be used to specify a drug. Generic names are often used. The brand name (or trademark name) is the name adopted for use by the drug company that markets the drug. Each company chooses its own trade name. There is only one generic name for each drug, but there may be many brand names. For example, acetaminophen (generic name) is sold as Tylenol, Tempra, Datril, Liquiprin, and Trilium (brand names). Drugs are also referred to by street names (see Drug Reference Chart in *Tips for the Teacher* section).
3. **Acids and Bases** Pain sensation arises from a response of nerve endings to a change in pH of solutions around them. Neutralization of the solution in the tissues that is causing the irritation or pain relieves the pain. Certain organic functional groups are responsible for the acidic or basic properties of these substances. For example, lidocaine, a local anesthetic used by dentists, contains a basic amino group. To minimize the local irritation and discomfort when lidocaine is used, it is administered as a neutral salt solution.

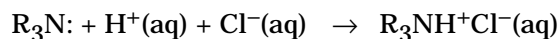


Lidocaine
(xylocaine)
with basic amino group

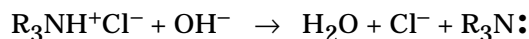


Lidocaine Hydrochloride
(xylocaine)
neutral

4. **Extraction** Many of the active ingredients in plants contain basic nitrogen atoms and can be extracted from the bulk of the plant material by dilute acid. Because these compounds behave similar to an alkali, they are referred to as alkaloids.

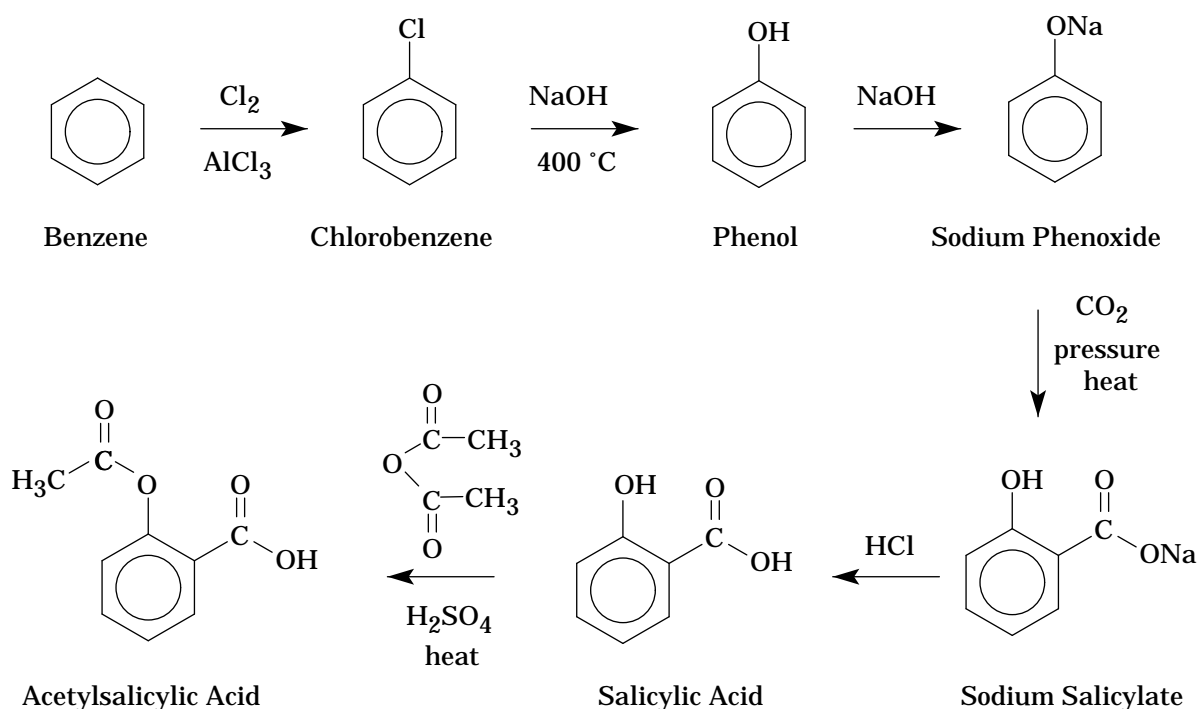


After extraction, free alkaloids can be regenerated by treatment with aqueous base.



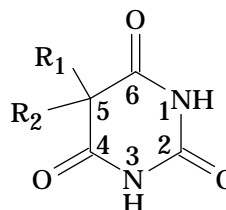
Cocaine, morphine, and atropine are obtained in this way.

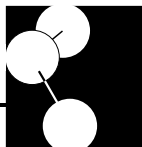
5. **Synthesis** Drugs that do not occur naturally in plants or animals must be synthesized in the laboratory. Many naturally occurring drugs are also synthesized to increase cost effectiveness and supply. Although salicylic acid is a good analgesic and antipyretic, it is sour and irritating when taken orally. Chemists modify the molecule's structure to remove this undesirable property while retaining the desirable medicinal property. Acetylsalicylic acid (aspirin) is prepared from salicylic acid by treatment with acetic anhydride (see *Activity 1*). Salicylic acid is made from benzene, which is obtained from coal tar.



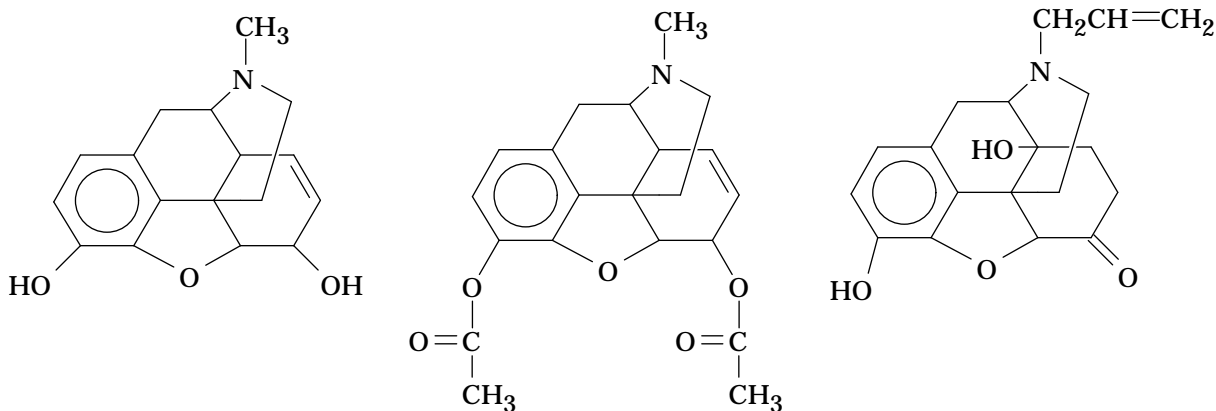
6. **Structure-Activity Relationships** Chemists have determined the structures of many naturally occurring biologically active compounds. Such information is useful in relating pharmacological action to chemical structure within a group of compounds with similar action.

Barbiturates contain the ring structure shown. Variation of the R groups at C-5 can modify the sedative-hypnotic action. For example, incorporating a phenyl group (C_6H_5-) yields a barbiturate that is less water soluble and more resistant to biodegradation and is therefore longer acting. Researchers can synthesize many different barbiturates and select those with the greatest promise.





The analgesic properties of morphine are due to the presence of hydroxy, ether, and amine groups that help bind it to the receptor site. Heroin is easily converted in the human body to morphine in an enzyme-catalyzed hydrolysis of the two ester ($\text{CH}_3\text{COO}-$) groups. Naloxone is a narcotic antagonist. By changing a hydroxy group to a ketone ($-\text{C}=\text{O}$), a methyl group to an allyl group ($-\text{CH}_2\text{CH}=\text{CH}_2$), introducing another hydroxy group, and by reducing a double bond, the drug still fits the opiate receptor sites in the brain but has lost all of its narcotic and respiratory depressant activity.

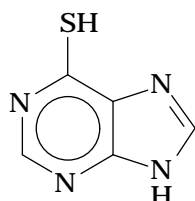


Morphine

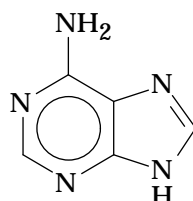
Heroin

Naloxone

In another example, cancer has been successfully treated using the structure-activity relationship. Mercaptopurine is similar to the real metabolite adenine. Rapidly growing cancer cells can mistake mercaptopurine for adenine. Mercaptopurine is an analog of hypoxanthine from which adenine is synthesized.



Mercaptopurine



Adenine

When this molecule is incorporated as a "useful" metabolite into cancer cells, cell growth is impeded. Mercaptopurine is called an **antimetabolite**. Although effective in cancer treatment, antimetabolites also harm normal cells.

7.

Stereochemistry

Benzedrine's active ingredient is the dextrorotatory form in a racemic mixture. Cisplatin is only an active chemotherapeutic in the *cis*-form. Transplatin has no therapeutic effect. These steric effects are a special case of structure-activity relationships.

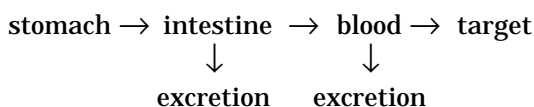
8. **Instrumentation and diagnosis** *Magnetic resonance imaging* (MRI) is a technology based on the same principle of operation as a nuclear magnetic resonance spectrometer used by chemists in structure determination (see *Instrumentation* module). The MRI scans the individual without exposing the patient to X-rays (as in CT scan) or gamma radiation (as in PET scan). In MRI, a low energy radiofrequency wave interacts with the hydrogen atoms in water molecules in soft tissue. The energy produced from this interaction is fed into computers that produce an image similar to that of CT and PET scans. MRI has proved to be useful for studying soft tissue (tumors, cancerous tissue, the pelvic area, prostate gland, and bladder). Use of this technique has improved the diagnosis of cancer in these soft tissues.

BETWEEN CHEMISTRY AND OTHER DISCIPLINES

1. **Botany.** Plants are an important source of drugs. Many of these drugs are legal, but some are drugs of abuse. Plants were used by early humans in religious rituals (peyote), medically (to treat diarrhea or worm infestation), and as poisons (Socrates' cup of hemlock tea that contained the active ingredient coniine). Examples of plant-source drugs in use today are shown here.

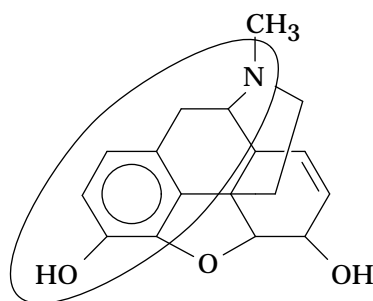
Drug	Plant source
Mescaline	Peyote cactus
Caffeine	Coffee arabica
Caffeine	Camellia thea
Cocaine	Erythroxyton coca
Marijuana	Cannabis sativa
Nicotine	Nicotiana rustica

2. **Pharmacology** When a drug is administered orally, it follows the pathway shown here:

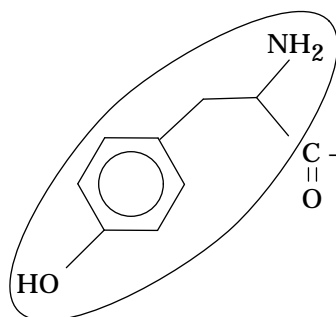


When a drug is administered by injection into fat or muscle tissue, the intestinal tract is not involved, and the drug finds its way into the blood stream and then to its target. The mechanisms by which some drugs function are summarized below:

- Analgesics and antipyretics** These drugs inhibit the synthesis of prostaglandins that are responsible for perception and a rise in body temperature.
- Local anesthetics** These drugs block nerve impulses to the brain.
- Morphine, codeine, and meperidine** Receptor sites in the brain accept naturally produced substances released as a response to pain (enkephalins). Morphine, codeine, and meperidine have structures that are similar to the enkephalins and can fit the brain's receptor sites. The better the fit, the better the analgesic action. Note the structural similarity (circled areas) in each structure, as shown.

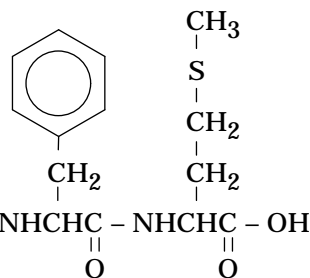


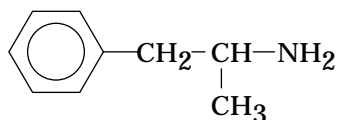
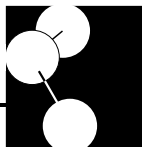
Morphine



An Enkephalin

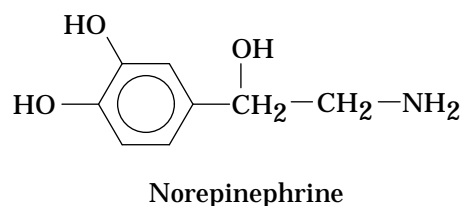
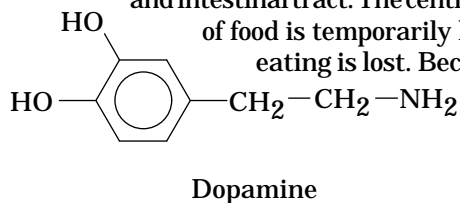
accept naturally produced substances released as a response to pain (enkephalins). Morphine, codeine, and meperidine have structures that are similar to the enkephalins and can fit the brain's receptor sites. The better the fit, the better the analgesic action. Note the structural similarity (circled areas) in each structure, as shown.





Amphetamine
(Benzedrine)

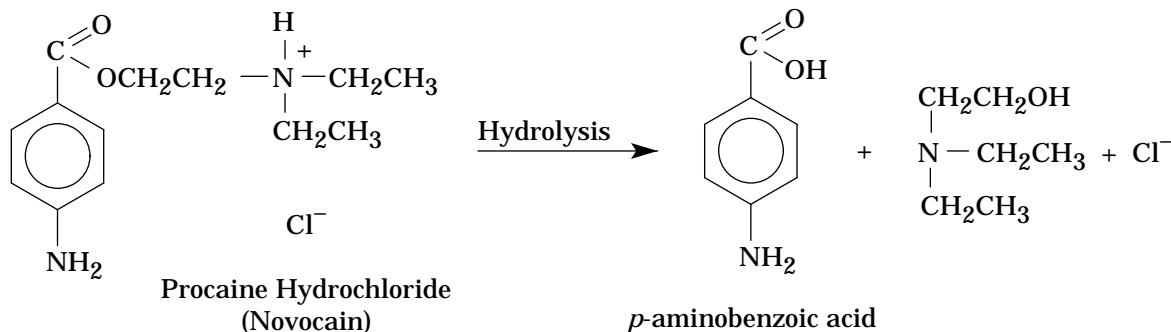
- d. **Amphetamines in weight control** An excited or angry person secretes extra dopamine and norepinephrine. These are then distributed to the brain and intestinal tract. The central nervous system is stimulated, and digestion of food is temporarily halted to the extent that interest in food and eating is lost. Because amphetamines are structurally similar to these two body chemicals, they produce the same kind of intestinal tract suppression.



- e. **Alcohol** A liver enzyme causes the oxidation of ethanol to acetaldehyde (CH_3CHO), then to acetic acid (CH_3COOH), and finally, to CO_2 . The "belch" associated with drinking beer is due to the buildup and release of carbon dioxide in the beer (see *Links and Connections within Chemistry* in the *Organic Chemistry* module for additional discussion of alcohol metabolism).

- f. **Alkylating agents** These agents transfer alkyl groups to guanine, a nitrogen base in DNA, blocking base pairing and preventing DNA replication. Healthy cells are harmed as well. (Alkylating agents are used in the treatment of cancer.)
- g. **Antimetabolites** These agents interfere with DNA synthesis by inhibiting the formation of thymine-containing nucleotides. (Antimetabolites are used in the treatment of cancer.)
- h. **Penicillins** Penicillins prevent cross-linking in the formation of bacterial cell walls. Human cells are of a different chemical composition and are not affected.
- i. **Birth control pills** The synthetic progesterone blocks the release of a hormone that stimulates the ovaries to release an egg. If an egg isn't released, pregnancy is impossible.

3. **Biochemistry** Nearly all the drugs we take are foreign to the body. The process by which the body accepts a drug, alters it chemically to eliminate the drug action, and then prepares it for excretion is called metabolism. The product of chemical breakdown of a drug is called a metabolite. Drug metabolism occurs primarily in the liver. The liver changes a drug chemically so that the metabolite is more soluble in the aqueous medium of the urine. Chemically, these processes involve hydrolysis, attachment to a normal body substance, oxidation, or salt formation. For example, the local anesthetic procaine (Novocain) is hydrolyzed to *p*-aminobenzoic acid, which has no anesthetic effect but, more importantly, is more water soluble than procaine.



4. **Genetics** In any population, there are individuals who are sensitive to a given drug and those who are resistant. The resistance is imparted by the genetic composition of the individual. Resistance to antibiotics by certain microorganisms is an example of this phenomenon. Broad spectrum antibiotics have been developed to encompass a greater number of the resistant population.

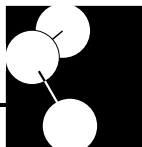
Community

Knowledgeable individuals: pharmacists, nurses, physicians, hospital directors, drug unit in a police department

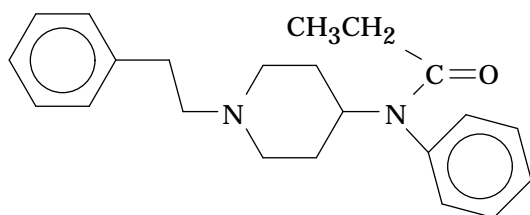
TO THE CONTEMPORARY WORLD

Societal (Science/Technology/Society; current events)

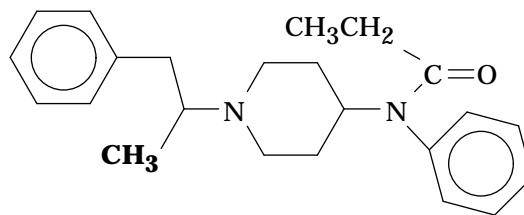
1. **Drug dependence** Dependence is a situation in which drug users develop reliance, either physical or psychological. Tolerance and withdrawal are not necessarily seen. For example, cocaine induces a psychological dependence, but does not induce the development of tolerance. (Addiction is a drug-induced change in the physical state of an individual characterized by a development of tolerance and withdrawal syndrome).
2. **Drug testing in Olympic games** Drug testing is an integral part of the Olympic Games. The International Olympic Committee uses instrumentation (primarily gas chromatography and mass spectroscopy) to detect drug use prior to an athlete's competition. The first four finishers plus one random competitor provide a urine sample within 1 hr of the competition's end. Drugs that have been banned include amphetamines, narcotics, analgesics, anabolic steroids, diuretics, and beta blockers. Athletes must be careful not to use cold medicines that contain ephedrine, pseudoephedrine, or phenylpropanolamine as these drugs could give false positive tests for amphetamines. Some anabolic steroids can be detected months after the last use; termination just before a competition will not normally avoid detection.
3. **Drug testing in the workplace** Reduced productivity due to alcohol and drug abuse costs the federal government and society in general billions of dollars each year. Drug use on the job can result in accidents, absenteeism, health problems, memory loss, turnovers, and loss of skills and coordination. Such problems have caused segments of government and private industry to institute drug testing. Alcohol and marijuana are drugs commonly abused, but amphetamines, barbiturates, cocaine, and opiates are also abused. If an individual is a government employee, the employer must have probable cause before the individual can be tested. Private employers have the right to demand drug tests at hiring time.
4. **Drug equivalence** Unless the physician has prohibited substitution of a generic drug for a brand name drug, pharmacists may substitute a less expensive generic drug. In many cases, generic name drugs cost one-fourth as much as their brand name equivalents. The concern for the consumer is the equivalency in effectiveness of the generic drug. Studies have shown that differences in absorption of brand name and generic drugs into the bloodstream are very small.



5. **Drug design versus designer drugs** Designer drugs are substances contrived in illegal laboratories to be chemical analogs of well-known controlled substances. Their slight difference in chemical structure renders them outside the jurisdiction of the law. Shown here is the structural relationship between the narcotic analgesic Fentanyl and its analog, α -methyl fentanyl.



Fentanyl

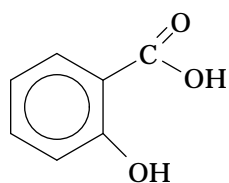


α -methylfentanyl

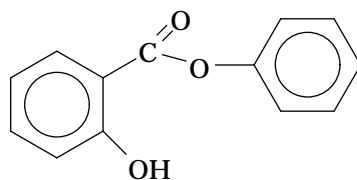
The minor structural change does not alter the fundamental analgesic nature, but α -methylfentanyl is a more powerful narcotic than Fentanyl. Many of today's designer drugs were synthesized years ago by legitimate medical researchers but rejected because of serious adverse effects.

Drug design, on the other hand, is the synthesis and study of legal substances to treat a particular disease or condition. Chemists have designed molecules to relieve headaches, cure infectious diseases, prevent conception, and kill cancer cells (see examples in *Tips for the Teacher* section).

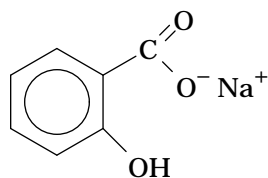
Salicylic acid, extracted from willow bark, was found to be useful in reducing fever and pain. However, it is sour and irritating when taken orally. Chemists sought to modify the structure of the molecule to remove this undesirable property while retaining and improving the desirable properties. The first modification was neutralization of the acid. The salt, sodium



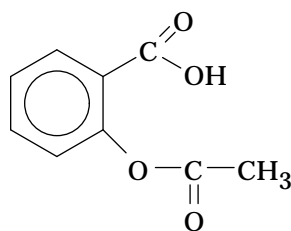
Salicylic Acid



Phenyl Salicylate
(salol)



Sodium Salicylate



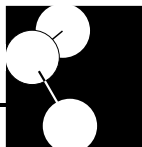
Acetylsalicylic Acid

salicylate, was less unpleasant to swallow, but it was highly irritating to the stomach lining. Phenylsalicylate, the next substitute, passed unchanged through the stomach. In the small intestine, it was hydrolyzed to the desired salicylic acid, but phenol that is rather toxic, was also formed. Acetyl salicylic acid (aspirin) was then introduced.

Thus a knowledge of the structure of drug molecules enables chemists to be more efficient when they design drugs. A knowledge of the structure of the drug molecule is not sufficient for an understanding of the molecular basis of the drug's action, however. It is also necessary for chemists to understand the structure of the molecules of the human body, of bacteria, and of viruses.

6. **Role of the Food and Drug Administration (FDA)** The FDA is responsible for approving the marketing of all new drugs sold in the U.S. The FDA also monitors drug use after approval. It can take up to ten years for a new drug to pass the rigorous program of safety and effectiveness for its intended use. First, evidence must show that the new drug has therapeutic activity in animals, that it shows promise for human use and that it appears to be safe for human testing. This is followed by human testing in patients with the disease and can involve thousands of patients to determine the drug's safety and effectiveness. Finally, the FDA examines all the evidence of safety and effectiveness and decides whether the drug will be approved for marketing. The FDA is very cautious so that people will be spared anguish and needless suffering.
7. **Drug interaction** The interaction of drugs with each other to heighten each drug's effect is called synergism. The effects can be helpful or harmful. Physicians have succeeded in prolonging the lives of some cancer patients with combinations of drugs. When the drugs are given in combination, lower doses of each drug can be used, and the harmful side effects of chemotherapy reduced. On the other hand, alcohol (a depressant) increases the action of many antihistamines and tranquilizers (depressants) resulting in a superdespondent, dangerous combination.
8. **Drug manufacture** Drug manufacture today is classified into five groups according to primary source. Plant extracts give alkaloids such as opium, quinine, atropine, and the precursors of steroid drugs. Animal extracts provide insulin and hormones. Vaccines and serums are prepared using biological sources. Fermentation is used for antibiotics such as penicillin, streptomycin, tetracycline, and steroid modification. Synthetic chemistry produces aspirin, tranquilizers, and antihistamines.
9. **Drug delivery** Drugs can be administered through one of the following routes: oral ingestion, inhalation, injection, body orifices, skin application, skin patch, implants, and microsponges. Most drugs are taken orally. They dissolve in the stomach acid and enter the blood stream by absorption from the stomach or intestine. Inhaled drugs are rapidly absorbed into the bloodstream. Nasal decongestant sprays work by shrinking the nasal membranes. Injection also provides a direct route to the bloodstream, eliminating the possibility of undesirable taste or destruction by digestive juices. Drugs can also be administered in the form of eye drops, eye inserts, under the tongue tablets, and rectal and vaginal inserts. Smokeless tobacco users get their nicotine by stuffing tobacco between the gum and the cheek. Medications can be applied to the skin as ointments or as aerosol sprays. Skin patches are worn on a convenient area of the body as the drug is slowly absorbed into the bloodstream. One such skin patch releases scopolamine to the bloodstream and provides prolonged protection from the nausea and vomiting of motion sickness.

Surgical implantation of a drug (pellet, reservoir, or pump) is another method of drug delivery. Contraceptive drugs have been implanted under the skin of a woman's upper arm. These implants, consisting of long, thin silicone rubber capsules that contain the drug, slowly release the contraceptive drug for about five years. Microsponges can be programmed to release drugs in response to pressure, time, or temperature changes. For example, a foot powder could release more antifungal drug with each step.

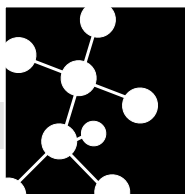


10. **Folk medicine** This type of medicine is part of the culture of a geographical people, such as the American Indians. Folk medicine deals with the emotional needs of the patient that may be related to the patient's bodily ailments. The Native American medicine man often involved a patient's family and tribe so that personal conflicts were resolved while the patient also recovered physically. The tribal members sometimes offered gifts to the patient, and sometimes the ritual involved a family member with whom the patient had quarreled.

Many practices of folk medicine are based on religion, superstition, or social customs. The medical (and religious) value of coca leaves was well recognized by the Incas. It was not until the 19th century that its analgesic property was recognized as due to cocaine. On the other hand, gold has no therapeutic value in the treatment of jaundice. The indigenous peoples of North America thought, erroneously, that "like cures like," and the color of gold matched that of the jaundiced person. With the various flora around them, they had a variety of remedies. They used foxglove as a remedy for fluid build-up in the legs resulting from heart failure. Today, the active ingredient in foxglove, digitalis, is a powerful cardiac drug. Native American medicines found their way into early folk practices of the white settlers. Unscrupulous peddlers claiming to have learned tribal formulas began to sell secret potions and elixirs. Many were nothing more than placebos and alcohol. Traveling road shows sold patent medicines such as Wigwam Tonic.

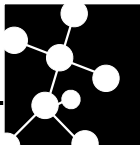
There are over 200 indigenous drugs used by the Native Americans. Some of the common native North American plants that were (or still are) used medically are bloodroot (causes vomiting), podophyllum (for warts), tobacco (for toothache), goldenseal (an astringent), and mint (for fevers). Folk medicine is still practiced on some reservations.

11. **Holistic medicine** Holistic medicine involves an understanding of the patient's whole situation. Emotional, spiritual, social lifestyle, and environmental factors are considered in the diagnosis and treatment of the disease. Many holistic approaches rely on psychology, and some practitioners emphasize muscular alignment through music, personal awakening, and physical manipulation. The importance of the mind in the treatment of physical ailments cannot be underestimated.
12. **Acupuncture** This Oriental practice has been shown to relieve the symptoms of certain ailments or diseases. While its mechanism is not understood, its effectiveness is thought to be based on stimulus of endorphin synthesis in the body.
13. Have you recently had a headache? In North America, about 40 million pounds of aspirin is consumed per year. Since the average dose of two tablets is 1.7×10^{-3} mol, the total amount consumed corresponds to 59 billion headaches. That's enough to give anyone a headache!
14. The nicotine in the smoke inhaled from a pack of 20 cigarettes ranges from 2.0 to 40 mg!



Extensions

1. Consider these possible topics for development and discussion: herbal medicines, antibiotics, anticancer drugs, AIDS, computer designed drugs, and drug toxicity.
2. Research and debate the importance of vaccinating children against common childhood diseases such as mumps, measles, and polio. [Hint: Consider objections on religious grounds, or vaccinating if the disease is eliminated.]
3. Prepare an oral presentation about the life and contribution of the following medical scientists: Louis Pasteur, Joseph Pawan, Hippocrates, Robert Koch, and Alexander Fleming.
4. The stamps of Rwanda commemorate the discovery of quinine. What is the plant shown on the 20^c stamp? What chemical laboratory equipment is shown on the 80^c stamp? What are the insects shown on the 1^F and 25^F stamps? How does the disease affect an individual as shown on stamp 3^F? What is the underlying disease documented on these stamps? Who are Joseph Pelletier and Joseph Caventou as portrayed on stamp 70^F?



150^eme ANNIVERSAIRE DE LA
J. AN NOTEN - 1970
DECOUVERTE DE LAQUININE
1820 - 1970
PAR PELLETTIER & CÆNTOU
CHINCHONA
20^C
REPUBLICQUE RWANDAISE



150^eme ANNIVERSAIRE DE LA
J. AN NOTEN - 1970
DECOUVERTE DE LAQUININE
1820 - 1970
PAR PELLETTIER & CÆNTOU
PHARMACIE
80^C
REPUBLICQUE RWANDAISE



150^eme ANNIVERSAIRE DE LA
J. AN NOTEN - 1970
DECOUVERTE DE LAQUININE
1820 - 1970
PAR PELLETTIER & CÆNTOU
ANOPHELE
1^F
REPUBLICQUE RWANDAISE



150^eme ANNIVERSAIRE DE LA
J. AN NOTEN - 1970
DECOUVERTE DE LAQUININE
1820 - 1970
PAR PELLETTIER & CÆNTOU
MALARIA
25^F
REPUBLICQUE RWANDAISE

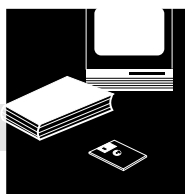


150^eme ANNIVERSAIRE DE LA
J. AN NOTEN - 1970
DECOUVERTE DE LAQUININE
1820 - 1970
PAR PELLETTIER & CÆNTOU
PAI
3^F
REPUBLICQUE RWANDAISE



150^eme ANNIVERSAIRE DE LA
J. AN NOTEN - 1970
DECOUVERTE DE LAQUININE
1820 - 1970
PAR PELLETTIER & CÆNTOU
LES PHARMACIENS
J. PELLETTIER
J.B. CÆNTOU
70^F
REPUBLICQUE RWANDAISE





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Module drafted by Philip Ogata, James Schreck, and Courtney Willis, the Colorado (North) team.

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A three-volume set dealing with a study of the chemical mode of action of a variety of medicinal compounds and their interactions with other substances.

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Chapters 22 and 23 provide information about chemical therapy and drugs.

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Chemistry and Medicine is the title of Chapter 15.

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A book for persons interested in examining high-use, high-abuse drugs in America, and the impact these drugs have on individuals and on society. The book can be used in health and drug education classes, public health courses, parent groups, and counselor training.

Martin, W. (1977). *Medical heroes and heretics*. Greenwich, CT: Devin-Adair.

This is the source (pp. 55–71) for “Jonas Salk and the Polio Vaccine.” This book and *Men and Medicine* below tell the story of bold adventures in medicine. Of particular interest is the types of individuals who got involved in medical discoveries, who can and have followed revolutionary lines of thought for the benefit of humans.

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A listing of chemicals including the trivial names, solubility, color, medical use, pharmacological activity, dose, and important or common side effects.

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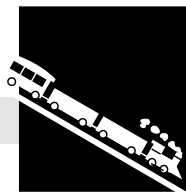
General interest book exploring the medical practices of non-Western cultures to establish a scientific basis for folk remedy successes. Explains why Western medical researchers look to folk medicine for new drugs, and looks at remedies from a variety of cultures and countries.

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This text describes the path of a drug from its formulation and entry into the human body, its distribution throughout the body, its interaction with active sites and its elimination.

Veenstra, T. (1993, September). Drinking and driving, *Chem 13 News*, p. 19.

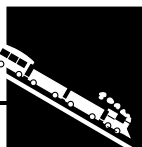
Appendix



- **Transparency Masters**
 1. Drug Classifications
 2. Word Search
- **Humor**

Drug Classifications

Designation	Examples	Description
Controlled substances		Substances whose sale, distribution, and possession is controlled by the Drug Enforcement Administration
Schedule 1	Heroin, LSD, mescaline	Abused drugs with no medical use
Schedule 2	Morphine, amphetamines	Abused drugs with medical uses
Schedule 3	Valium, phenobarbital	Prescription drugs that are often abused
Over-the-Counter (OTC)	Antacids, aspirin, cough medicines	Available to anyone
Prescription drugs	Antibiotics	Available only by prescription
Unregulated nonmedical drugs	Ethanol, caffeine, nicotine	Available in beverages, foods, or tobacco



Word Search

L R B Y G P L G J Y B B L T H J U
T V N V D O W S E N I E F F A C W
E L V I L T R W V H Q D E E N T I
S X R T U D H M D C X X F W A X Z
T C Z A L R I U D K K T Q T L R Z
O C M M U G T C X G B I I K G H P
S P G I W Y V X A S D I O R E T S
T E C N A R E L O T M Q E N S P N
E U O S A B G I G Z N Y P N I N F
R R E Y K U M R A M Z A R J C O J
O V E E R C X V O Z U P I I L A M
N Y G D I E T H A N O L G X O E H
E B T L G J I D Y E N F V T Z A L

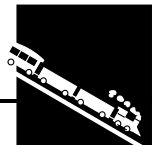
Words about the concepts in this module can be obtained from the clues given. Find these words in the block of letters:

1. Substance that reacts with excess stomach acid.
2. Common name for a substance that changes a physical or psychological function in the body.
3. Need of increasing amounts of a substance to experience the same initial effects.
4. Acetaminophen, ibuprofen, or acetylsalicylic acid, for example.
5. Benzoyl peroxide is the active antiseptic ingredient in ____ ointments.
6. These organic compounds are required in small amounts in the diet.
7. Stimulant in cola and coffee.
8. Birth control drugs belong to this class of organic compounds.
9. The amount of this drug is determined in the Breathalyzer test.
10. Anabolic steroids are synthetic derivatives of this natural compound.

Herman



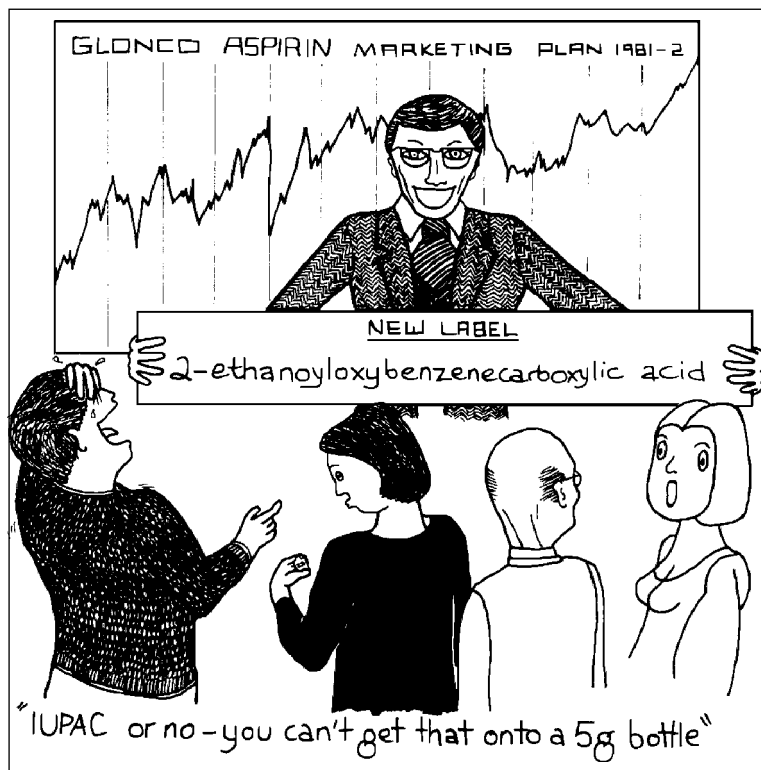
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TANK McNAMARA



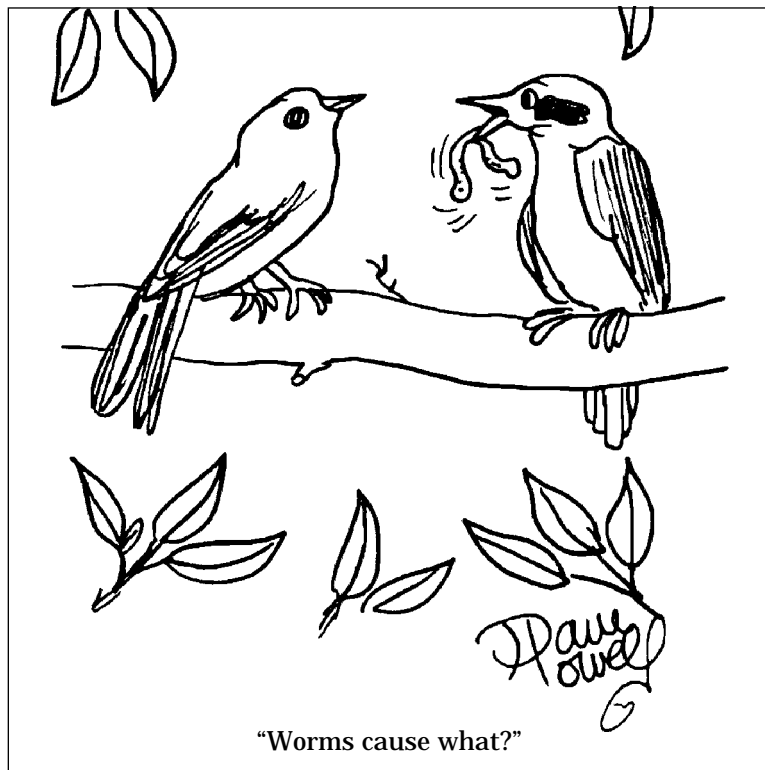
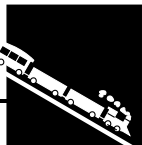
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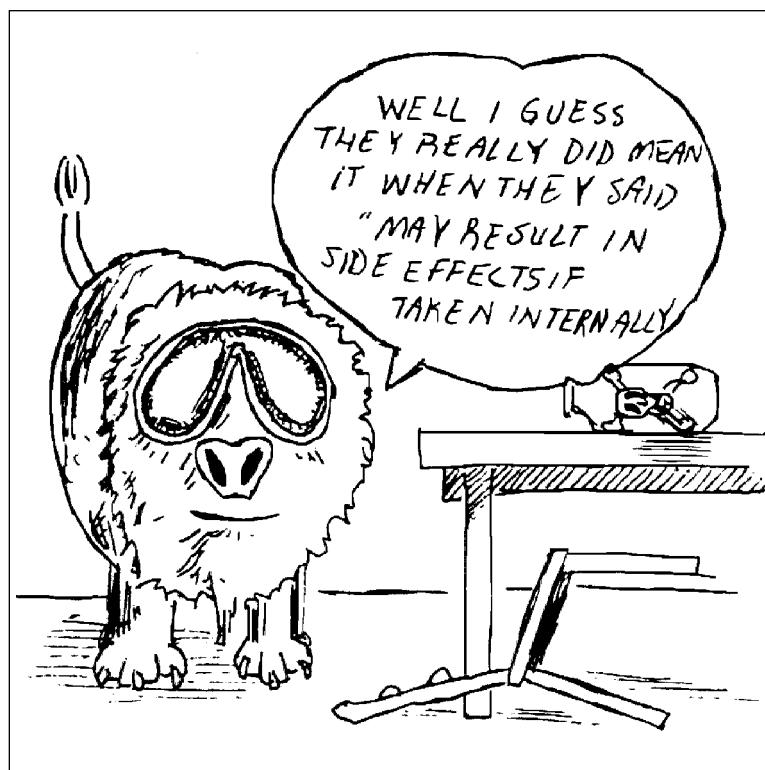
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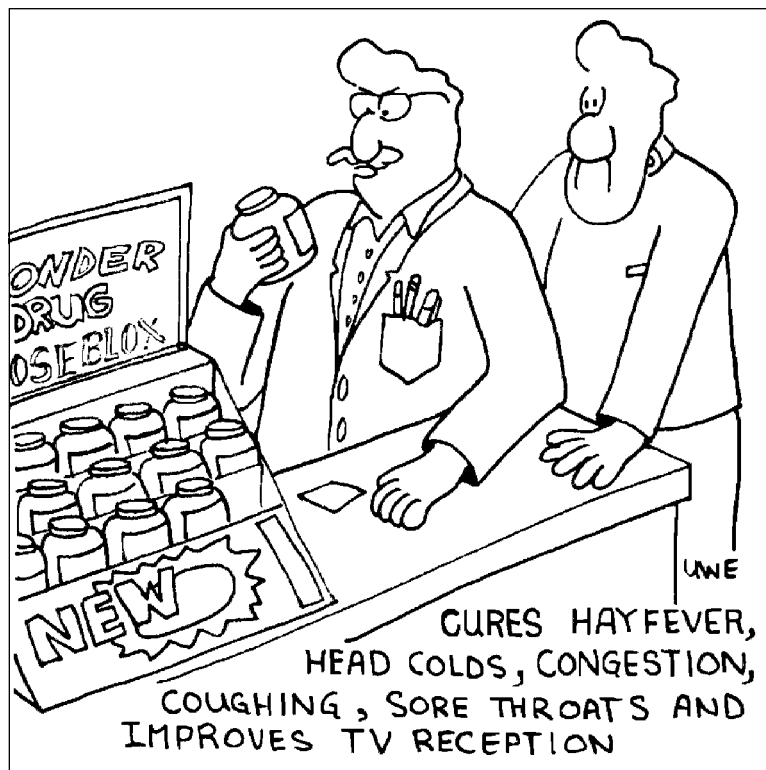
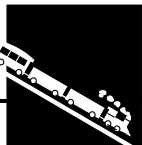
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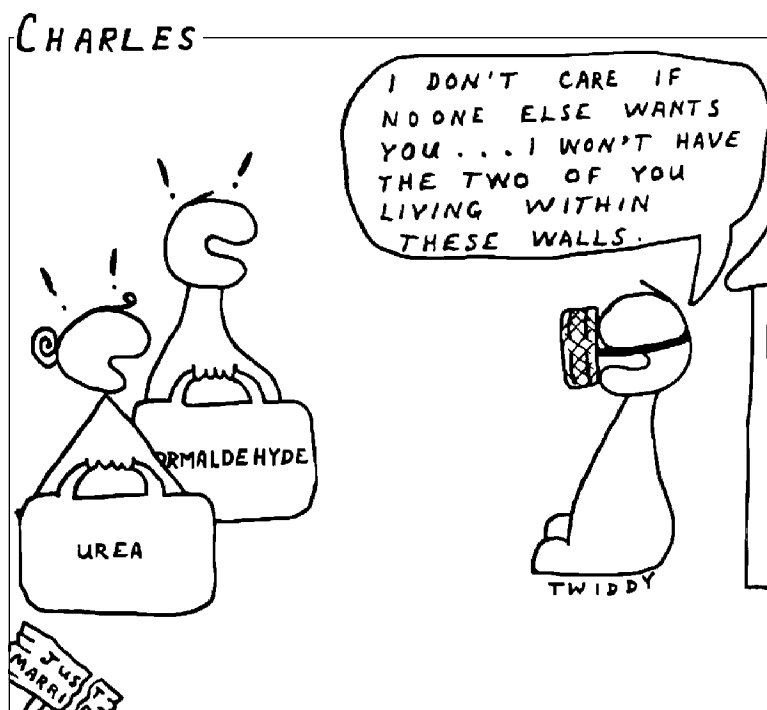
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