PRINCIPLES OF CLINICAL TOXICOLOGY

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Preface

Toxicology is one of the most rapidly developing sciences in the entire biomedical curriculum. It has evolved over recent years well beyond the boundaries that most authorities envisioned just a decade ago. Today, many students pursuing a degree in one of the health-related areas of the biomedical sciences study the principles of toxicology either in a freestanding format or as a component of their pharmacology sequence.

As is often the case in fields of rapid growth, the literature has not been able to keep up with the developments in toxicology. Specifically, there has not been a textbook written for the sole purpose of aiding the student who is pursuing the contemporary study of clinical toxicology as part of a baccalaureate degree. Although a wide variety of reference books, handbooks, guidelines, and individual articles from the literature is available, none of these presents a comprehensive treatment of the principles of toxicology. Realizing this deficiency we decided to accept the challenge and write an up-to-date toxicology volume.

This book serves a single purpose—to teach the *principles* of clinical toxicology. Principles are rules of action or reasons why certain procedures are undertaken; they are also the foundation of a science. This book adheres to its title in that it is neither a reference book nor a laboratory manual. Rather it is organized around the primary goal of explaining the fundamental principles of clinical toxicology. By understanding the basis for the events that occur and the reasons why a certain treatment is used or perhaps not used, we should then be able to approach any toxic emergency with few problems.

The book consists of two parts. The first part discusses household, occupational, and some common environmental poisons. The second part concentrates on drugs or chemicals that are used intentionally to cause some pharmacologic effect. We have chosen examples of classes of chemicals and drugs that are relatively common causes of poisoning. The uncommonly encountered substances are not included.

Specifically, chapters in this book include discussions of individual classes of toxic agents, their common sources and usual methods of intoxication, incidence and frequency of poisoning, mechanism(s) of action, and clinical signs and symptoms of poisoning, as well as reasons why these are occurring. Other cause-effect relationships are also presented. The management of poisoning is discussed from a descriptive standpoint. Laboratory findings also are included. A list of normal laboratory values comprises Appendix I.

Case studies have been carefully selected for each chapter to further illustrate and reinforce the text discussions of individual classes of poisons. Comments on these studies are presented when appropriate. Each chapter concludes with a list of review questions so that the reader may determine whether the basic concepts have been mastered.

It should be noted that differential diagnoses and prognoses of toxic events are not considered here. Unless otherwise specified, our approach assumes that an accurate diagnosis of the intoxication already has been made; from this point, we proceed to discuss what happens in these specific incidences. Except for a few cases, poisoning discussion is limited to acute exposure (e.g., a single toxic dose, or multiple subtoxic doses within a 24-hour period). The prognosis of any toxic event is highly variable and rarely predictable, unless a complete patient history is available and all of the possible ramifications of the poisoning event are known. Therefore, prognosis is discussed only with reference to making another relevant point.

We have applied a concept-oriented approach, in presenting the information in this text, that emphasizes basic principles and the reasons why things occur rather than merely presenting facts. Facts change often; basic principles remain constant. Furthermore, toxicology is a rapidly changing science. What is true and valid today may be outdated tomorrow.

Throughout this book we state that an event "may" occur, or that something "probably" happens. This is not meant to be elusive; the very nature of toxicology is that we still can only hypothesize regarding some of these areas. Likewise, numerous new methods for antidoting poisonings and new theories about poisoning are being evaluated. As these become known, they will be incorporated into future editions.

Principles of Clinical Toxicology is best utilized after completing courses in organic chemistry, biochemistry, physiology, and an introductory term of pharmacology. Each of these areas of knowledge contributes to clinical toxicology.

No single introductory text can serve as a sole authority. Therefore, we hope that you will continue your search for information using other literature sources. We hope this search will continue throughout your life.

T.A. Gossel
J.D. Bricker

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Most of all, we extend our very special thanks to all of our students, past and present, who have taught us much more than we could ever hope to teach them.

Toxicology in Perspective

1

INTRODUCTION TO TOXICOLOGY

An introductory chapter in any textbook should provide an overview of the topic and insight into subsequent chapters. We have attempted to do just that. Additionally, we have stressed the point on numerous occasions that toxicology should not be viewed as a free-standing science. Rather, it represents a compilation of many of the basic and clinical sciences, and has developed from input by hundreds of thousands of individuals over the years.

Toxicology, especially clinical toxicology, is still in its formative stages, however. As new concepts and procedures are developed and implemented into clinical practice, it seems that many of them are outmoded even before they have an opportunity to prove their value, as even newer concepts evolve.

But the one basic concept that does remain fairly constant is the premise that there are certain principles of toxicity which do not change. Principles are rules of action, or reasons why certain procedures are conducted. They are also the foundation of a science. We must always keep this in mind as we study toxicology.

Toxicology is not an easy word to define. The term is derived from Greek and Latin origins (L. *toxicum* = poison; Gr. *toxikom* = arrow poison; L. *logia* = science or study) and literally means a study of poisons on living organisms. Therefore, a toxicologist is a person who studies or works in the area of toxicology, but toxicology is not restricted to this narrow definition. Toxicologists do much more than simply work with poisons. In its broadest sense, toxicology traditionally involves all aspects of adverse effects of chemicals on biological systems. This includes their mechanisms of harmful effects and conditions under which these harmful effects occur, socioeconomic considerations, and legal ramifications.

HISTORICAL PERSPECTIVES

Toxicology in its present sense is a relatively new science, having developed over the years from an essence of observation to its current status as an analytical science. This development makes for exciting reading, but an in depth study is beyond the scope of this chapter. Interested students should consult Holmstedt and Liljestrand (5) or Casarett and Bruce (3) for specific details. There is one individual, however, who needs to be cited, for he, more than anyone else, certainly established toxicology as an absolute science.

The father of modern toxicology was Mathieu Joseph Bonaventura Orfila (1787–1853). Orfila was a Spaniard who served as attending physician to Louis XVIII of France, and taught at the University of Paris. During his early professional years, Orfila quickly realized the inadequacy of toxicology as a science, and consequently, in 1815, wrote the first book of general toxicology that was devoted to adverse effects of chemicals (11). Until that time, toxicology had been largely descriptive in nature, and it left wide gaps of information open for broad and often erroneous interpretation. Intuitive hunches often served as the sole basis for determining the cause of a poisoning incidence. Orfila, concerned with legal implications of poisoning, pointed out the importance of determining a chemical analysis to establish a definitive cause of poisoning. He then devised analytical procedures, many of which are still in use today, for detecting specific chemicals. It is reported that he sacrificed over 4,000 dogs to collect the data detailed in his book. Orfila's book established the basis for all future experimental and forensic toxicological evaluations and, subsequently, was translated into several languages. Orfila eventually followed up on his first book with numerous monographs that discussed, in detail, additional toxicologic information.

More than 165 years have elapsed since Orfila's book appeared. During that time, developments in toxicology were slowly evolving. The bulk of useful information related to modern toxicology only came about since the turn of this century, and most has developed exclusively within the past several decades. Perhaps the most exciting aspect is that the best is yet to come, for toxicology is still in its infancy.

As it developed over the years, toxicology has extracted many of the principles and techniques from many of the basic biological and chemical sciences. For example, Fig. 1 illustrates the progression of information the student of toxicology receives and the basic sciences on which toxicology is based. This is followed at another level by the specific subdisciplines within the science that have evolved over the years, and their specialty areas within those disciplines. We will briefly examine each of these disciplines, first to define the limits of each specialty, then to promote an appreciation of modern toxicology that has, by this point, developed into a very meaningful and necessary science.

DIVERSITY OF TOXICOLOGY

Occupational (industrial) toxicology has grown out of a need to protect the worker from poisonous substances and, in general, to make his working environment safe. The objective, obviously, is to prevent impairment of health of an individual while on the job.

It is the industrial toxicologist's job to define permissible levels (e.g., levels that are safe and do not produce adverse symptoms or disease) of exposure to chemicals as dusts, fumes, particles, etc. As a result of the need for this form of protection and control, the Occupational Safety and Health Act (OSHA) of 1970 was passed.

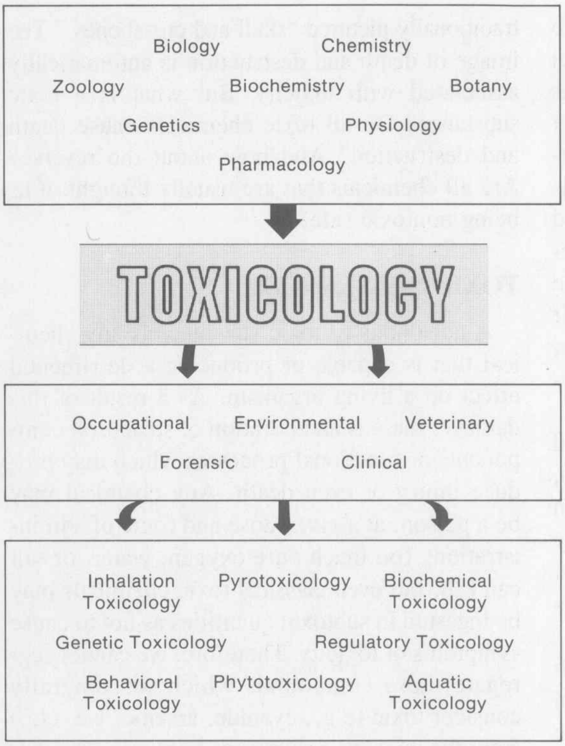

FIG. 1. The evolution of toxicology with its numerous applications.

Under the Secretary of Labor, OSHA was designed to assure that no employee will suffer diminished health, functional capacity, or limited life expectancy as a result of his work experience.

There are two agencies that are critical to the operation of OSHA. One of these is its sister agency, the National Institute for Occupational Safety and Health (NIOSH). This federal agency is charged with developing safety and health standards and is involved in the research aspect of occupational toxicology. It publishes *Criteria Documents* on specific chemicals which state pertinent toxicity and safety information concerning those particular chemicals. For example, NIOSH lists 8-hr exposure limits for chemicals, the immediate first-aid procedures to follow in case of skin or eye exposure, etc.

The other agency is the American Conference of Governmental Industrial Hygienists (ACGIH) which is devoted to setting safety standards for chemicals in the working environment. The research undertaken by this group results in useful data such as threshold limit values (TLV) and maximum allowable concentrations (MAC) of chemicals.

Environmental toxicology is a broad discipline of toxicology which encompasses the study of chemicals that are contaminants of food, water, soil, or the atmosphere.

It was Dr. Harvey Wiley, of the Food and Drug Administration (FDA), who first brought our attention to the problem of food additives (chemical preservatives and dyes), the deplorable conditions of the meat-packing industry, and the many "cure-all" claims for worthless medicines that, in many cases, probably were the cause of death (13). Today, specific information must be supplied to the FDA concerning the use of any substance, as a food additive, before it is released for production. A list of safe food additives is referred to as the GRAS list (Generally Recommended As Safe).

One of the classic incidents that first brought our attention to the problems of air pollution and its consequent toxic sequelae occurred in Donora, Pennsylvania, in 1948. As the result of a temperature inversion in this highly industrialized valley, expulsion into the atmosphere of several pollutants from zinc smelters and steel mills was hindered, and these chemical toxins were literally trapped within the air supply of the valley. This created a pocket of these potentially toxic materials. Consequently, individuals complained of nausea, vomiting, headache, and episodes of syncope. Similar events have occurred for other chemicals in other parts of the country. The most commonly encountered air pollutants are carbon monoxide, sulfur oxides, hydrocarbons, particulate matter, and the nitrogen oxides.

Environmental toxicology is also concerned with toxic substances that may enter the lakes, streams, rivers, and oceans. The most common problems dealt with in this aspect of toxicology are water-borne viruses and bacteria, waste heat from electrical plants, radioactive wastes, sewage eutrophication, and industrial pollutants.

Forensic toxicology is a discipline which combines analytical chemistry with essential toxicological principles in order to deal with the medicolegal aspects of the toxic effects of drugs and chemicals on man. The role of forensic toxicology is to aid in establishing cause-effect relationships between exposure to a drug or chemical and the toxic or lethal effects of the compound. In order to unequivocally confirm a cause-effect relationship, the forensic toxicologist relies on specific and highly sensitive analytical methods which can efficiently isolate, identify, and quantitate the toxic compound in question from biological fluids and tissues.

Clinical toxicology, as might be expected, is involved with the specific diseases caused by toxic substances and how they can be treated. Clinical toxicology encompasses the study of chemicals originating from any and all sources. It is concerned with all aspects of the interaction between these chemicals and people.

Veterinary toxicology is to animals what clinical toxicology is to humans.

TOXICITY: WHEN DOES IT START? WHEN DOES IT END?

When we think of the word *toxic*, or *toxicity*, the first image that often comes to mind is the traditionally-pictured "skull and crossbones." The image of death and destruction is automatically associated with toxicity. But what is a toxic substance? Do all toxic chemicals cause death and destruction? And how about the reverse? Are all chemicals that are usually thought of as being nontoxic safe?

TOXIC SUBSTANCES

A poisonous or toxic substance is any chemical that is capable of producing a detrimental effect on a living organism. As a result of this damage, there is an alteration of structural components or functional processes which may produce injury or even death. Any chemical may be a poison, at a given dose and route of administration. Too much pure oxygen, water, or salt can kill, but even classical toxic chemicals may be ingested in subtoxic quantities as not to cause symptoms of toxicity. Therefore, we cannot segregate those compounds which we generally consider toxic (e.g., cyanide, arsenic, lye, etc.) from the ones we assume are nontoxic. In other words, all chemicals must be assumed to be toxic, under the proper circumstances.

One point we must clarify is that many people consider poisoning to start the moment exposure occurs. While we concur that, in theory, this is true for cases where symptoms develop, it is an incorrect assumption for most toxic exposures. In reality, we are exposed to a wide variety of toxic substances each day from the food and water we ingest, and the air we breathe. We do not display toxic symptoms, so we are not actually poisoned. Thus, it is important to distinguish between poisoning from exposure or ingestion.

Toxicity Values

Another question commonly asked is, when is a chemical considered to be toxic? Or, how much of a substance has to be ingested to cause symptoms? Chemicals produce their toxic effects in a biological system whenever they reach a critical concentration in the target tissues. Toxicity is routinely expressed by the LD_{50} value, or the dose that represents the concentration of chemical required to produce death in 50% of the animals exposed to it. The LD_{50} value is used extensively to categorize the toxic dose of a chemical, and obtaining this value is generally the first experiment conducted on new chemicals.

LD_{50} determinations are plagued with variations, however. For example, species variation, inter-laboratory and intra-laboratory differences in values, and the fact that there is no standardized experimental protocol to calculate it are a few of the variables which make an LD_{50} value only an estimate. These values, then, are said to "estimate" the relative degree of toxicity for a given compound.

Table 1 illustrates the wide range of doses which induce lethal effects in animals. As can be seen from the table, some chemicals cause death in microgram quantities and are consequently expressed as being extremely toxic. On the other hand, other chemicals may be relatively harmless following doses in excess of several grams. Over the years, a toxicity rating scale has been used to provide a qualitative or "ball-park" figure describing the severity of the expected toxicity of a compound. Table 2 shows such a typical rating scale which lists the categories of toxicity based on their probable oral lethal dose in humans. Another use of an LD_{50} determination is to compare it with the ED_{50}, or median dose of a chemical that is therapeutically effective in 50% of the subjects receiving it. From this comparison, a therapeutic index or "margin of safety" for the chemical can be established.

TABLE 1. *Approximate LD_{50} of a selected variety of chemical agents*

Agent	Animal	Route	LD_{50} (mg/kg)
Ethyl alcohol	Mouse	Oral	10,000
Sodium choloride	Mouse	i.p.	4,000
Ferrous sulfate	Rat	Oral	1,500
Morphine sulfate	Rat	Oral	900
Phenobarbital, sodium	Rat	Oral	150
DDT	Rat	Oral	100
Picrotoxin	Rat	s.c.	5
Strychnine sulfate	Rat	i.p.	2
Nicotine	Rat	i.v.	1
d-Tubocurarine	Rat	i.v.	0.5
Hemicholinium-3	Rat	i.v.	0.2
Tetrodotoxin	Rat	i.v.	0.10
Dioxin	Guinea pig	i.v.	0.001
Botulinus toxin	Rat	i.v.	0.00001

Intraperitoneal = i.p.; intravenous = i.v.; subcutaneous = s.c.

From ref. 7.

TABLE 2. *Toxicity rating chart*

Rating	Dose	Probable oral lethal dose for average 150-pound adult
Practically nontoxic	>15 g/kg	More than 1 quart
Slightly toxic	5–15 g/kg	Between pint and quart
Moderately toxic	0.5–5 g/kg	Between ounce and pint
Very toxic	50–500 mg/kg	Between teaspoonful and ounce
Extremely toxic	5–50 mg/kg	Between 7 drops and teaspoonful
Super toxic	<5 mg/kg	A taste (<7 drops)

From ref. 4.

The therapeutic index (TI) is defined as the ratio of the LD_{50} to the ED_{50}. Figure 2 illustrates a hypothetical dose-response curve for the therapeutic effect and lethal effect of a given compound. Note that as the LD_{50} curve shifts to the left, the TI ratio becomes smaller and, thus, the compound has a reduced margin of safety (it is more toxic). An even more critical evaluation of a compound for its potential to produce toxicity relative to its margin of safety would be to calculate the ratio of the LD_1 to the ED_{99}.

With reference to Table 2, some compounds are considered relatively harmless because large quantities would need to be ingested prior to its toxic or lethal action. Table 3 shows that not all substances found around the home are toxic. These items are often involved in household poisonings and, unless massive quantities are ingested, there should be no serious toxic ef-

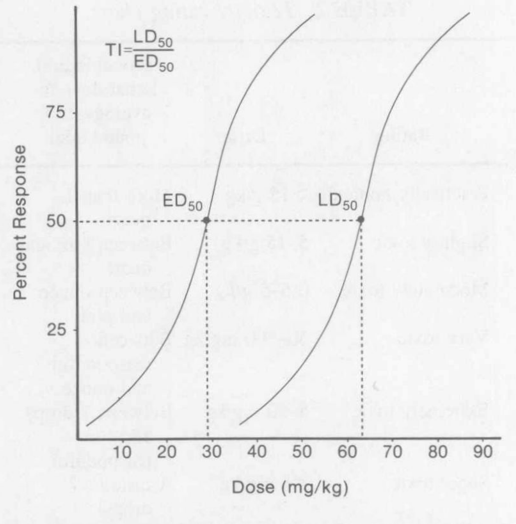

FIG. 2. A hypothetical dose response curve that illustrates the therapeutic effect (ED_{50}) and the lethal effect (LD_{50}) of a given chemical.

fects produced. Knowing when no antidotal treatment is needed is just as vital as knowing when treatment is required.

POISONING

Accidental and intentional poisonings are among the major causes of morbidity and mortality in the United States. The United States Consumer Product Safety Commission currently considers poisoning to be one of the leading causes of accidental death in children.

There is no way to accurately determine the exact extent of poisoning incidents. While it is reported that at least 5,000 to 10,000 Americans die from poisoning each year, there is currently no regulation that states these statistics must be gathered and documented. However, many people, including us, believe there is another group of victims, equal to in number or exceeding this 5,000 to 10,000 estimate, who die each year from unreported poisonings. These victims may have taken, for example, a medication which caused drowsiness while they were driving and caused a serious accident. The cause of death was reported as being an automobile accident, rather than as a poisoning event. Or, the victims may have been at work in a closed area with a gasoline engine running and inhaled a large quantity of carbon monoxide. If they left the area and shortly thereafter collapsed of an apparent "heart attack," and their blood was never checked for carbon monoxide, then death may be reported as due to natural causes rather than to acute carbon monoxide poisoning.

Several million more people may be poisoned each year, but because of life-saving first aid measures that are quickly instituted, they survive the ordeal. Because of their survival, or because their poisoning was not especially remarkable, the event was never reported. Consequently, these people are also not accounted for in the total annual figure that lists poisoning incidence.

So it can be seen that an accurate estimation of the actual number of poisonings that occur each year is not available.

Causes of Poisoning

The leading single cause of all poisonings in the United States today is plants (Table 4). This should not be surprising in light of the popularity in cultivating them for both inside and outside the home. Furthermore, many of them bear fruit or berries that are just too attractive and enticing for inquisitive children. Few people who cultivate plants actually understand the potentially toxic effects which may occur following their ingestion. Therefore, they fail to warn children of the danger, and they take no precautionary measures to avoid the poisoning.

On the more positive side, however, most plant ingestions do not cause severe toxicity, and simple supportive and palliative measures are all that are usually necessary. There are exceptions, of course, and some plants are deadly if ingested. Plant poisoning is discussed later, in Chapter 12.

Approximately 40% of all serious intoxications are caused by a variety of household products. Soaps, cleaners, and detergents lead the list, with petroleum-based products (e.g., furniture polish, lighter fluid, gasoline, etc.) following close behind.

Drugs account for the next class of poisoning causes, with aspirin still constituting the major

TABLE 3. *Partial listing of nontoxic substances*[a]

- Abrasives
- Antacids
- Antibiotics
- Baby product cosmetics
- Ballpoint pen inks
- Bathtub floating toys
- Battery (dry cell) (1/5 MLD of mercuric chloride)
- Bath oil (castor oil and perfume)
- Bleach (less than 5% sodium hypochlorite)
- Body conditioners
- Bubble bath soaps
- Calamine lotion
- Candles (beeswax or paraffin)
- Caps (toy pistol) (potassium chlorate)
- Chalk (calcium carbonate)
- Cigarettes or cigars (nicotine)
- Clay (modeling)
- Contraceptives
- Corticosteroids
- Cosmetics
- Crayons (marked A.P., C.P.)
- Dehumidifying packets (silica or charcoal)
- Detergents (phosphate type, anionic)
- Deodorants
- Deodorizers (spray and refrigerator)
- Elmer's Glue®
- Etch-A-Sketch®
- Eye makeup
- Fabric softeners
- Fertilizer (if no insecticides or herbicides added)
- Fish bowl additives
- Glues and pastes
- Golf ball (core may cause mechanical injury)
- Greases
- Hair products (dyes, sprays, tonics)
- Hand lotions and creams
- Hydrogen peroxide (medicinal 3%)
- Incense
- Indelible markers
- Ink (black, blue)
- Iodophil disinfectant
- Laxatives
- Lipstick
- Lubricant
- Lubricating oils
- Lysol® Brand disinfectant (not toilet bowl cleaner)
- Magic Markers®
- Makeup (eye, liquid facial)
- Matches
- Mineral oil
- Motor oil
- Newspaper
- Paint (indoor or latex)
- Pencil (lead-graphite, coloring)
- Perfumes
- Petroleum jelly
- Phenolphthalein laxatives (Ex-Lax®)
- Plants (250,000 of 300,000 plants identified are nontoxic. If dangerous plant identified, induce vomiting)
- Play-Doh®
- Polaroid® picture coating fluid
- Porous tip ink marking pens
- Prussian blue (Ferricyanide)
- Putty (Less than 2 oz)
- Rouge
- Rubber cement
- Sachets (essential oils, powder)
- Shampoos
- Shaving creams and lotions
- Shoe polish (most do not contain aniline dyes)
- Silly Putty® (99% silicones)
- Soap and soap products
- Spackles
- Spackling compound
- Suntan preparations
- Sweetening agents (saccharin, cyclamate)
- Teething rings (water sterility)
- Thermometers (mercury)
- Thyroid tablet 3 g
- Toilet water
- Tooth paste (with or without fluoride)
- Vaseline®
- Vitamins (with or without fluoride)
- Water colors
- Zinc oxide
- Zirconium oxide

[a]In the event that large quantities of any of these substances are ingested, an authoritative reference source should be consulted.

share of all drug-related poisonings. While aspirin toxicity was a leading cause of poisoning by all means in children under 5 years of age for many years, its incidence has decreased significantly during recent years. This is largely a result of the Poison Prevention Packaging Act of 1970 which required safety closures on all commercial packages of aspirin-containing products. Regardless of adverse publicity to the contrary, most people do not mind receiving medicines and household products in safety closure containers (2).

Other commonly encountered drugs that reportedly are leading causes of poisoning include vitamins and minerals (particularly products containing vitamins A and D, and iron), sleep-

TABLE 4. *Major causes of poisoning (1978)*

Plants
Soaps, detergents, cleaners
Antihistamines, cold medications
Perfume, cologne, toilet water
Vitamins, minerals
Asprin
Baby
Adult
Unspecified
Household disinfectants, deodorizers
Miscellaneous analgesics
Insecticides (excluding mothballs)
Miscellaneous internal medicines
Fingernail preparations
Miscellaneous external medicines
Liniments
Household bleach
Miscellaneous products
Cosmetic lotions, creams
Antiseptic medications
Psychopharmacologic agents
Cough medicines
Hormones
Glues, adhesives
Rodenticides
Internal antibiotics
Corrosive acids, alkalies
Paint

Modified from National Clearinghouse for poison Control Centers (10).

ing medications, antihistamines and cold remedies, and sedative and antidepressant medications.

It is also known that proper management of the poisoned patient saves lives. It is estimated that over three-fourths of all calls to Poison Control Centers can be handled adequately over the telephone, if sufficient, accurate information is given (8). All that is required is reassurance, not treatment. Since health professionals are readily accessible to most people, it is extremely important that they understand the basic principles of clinical toxicology, and understand how these principles apply to the poisoned patient.

Who Is Poisoned?

Statistics indicate that the majority of poisonings (approximately 75%) occur in children under the age of 5. Children over 5 years constitute the next group (approximately 15%), while adults comprise the remaining 10%. Although the number of poisonings in children under 5 is high, overall morbidity and mortality are remarkably low, except for certain classes of poisons which are invariably fatal (8).

The reasons why children under 5 years constitute the largest poisoning group are many and varied. No study of the basic principles of toxicology can be complete without mentioning what some of those causes are.

For example, a toddler's immediate environment includes all of those areas around the home about which adults are generally not concerned. Consequently, adults take few precautions to keep these areas secure and free from poisons. To illustrate, the area under the kitchen sink is out of immediate sight for most adults (Fig. 3). In order to view this area, an adult must stoop low, bend the knees, or actually sit on the floor. To a toddler, this area is in his direct line of sight and it affords him an entirely new world

FIG. 3. A curious child and his environment.

to conquer. Another example is the mothballs that may have fallen from the closet shelf into a dark corner on the closet floor. They are probably never seen by an adult, but are quickly detected by an inquisitive toddler who believes they are candy to be devoured.

Children are also curious and investigative. A closed cabinet door, or even a high shelf, quickly becomes a major challenge to the child to see what's behind that door or on top of that shelf. A youngster may readily open the door or stack books or boxes on top of one another to get to the shelf. Many cases have been recorded where youngsters have built elaborate raised platforms to gain access to the top of the bathroom sink which then allow fairly easy access to the medicine cabinet. In many instances, these were constructed in only a few minutes while the parent was out of sight.

Many household products are marketed in attractive packages or contain enchanting labels that are intended to catch the eye of potential purchasers. However, these same labels that depict pictures of merry spring flowers, dancing maidens, musical notes, or citrus fruits also readily catch the roving eye and inquisitiveness of a young child. The bright red berries on the evergreen shrubbery outside the house may appear to be the same as the red berries in last night's dessert, and into the mouth they go.

The natural tendency of most children is to place anything and everything into the mouth. The fact that it may bear no resemblance to food, and perhaps doesn't even taste good, is purely coincidental to a youngster.

A young child actually does not distinguish between good versus bad tastes. Every parent is aware that young children will often readily accept and consume foods at the dinner table without thinking about the taste or appearance, until older brother or sister "reminds" them that they are not supposed to like the taste of certain vegetables and other foods. Thus, taste discrimination is a trait that is learned later. For example, a mothball, which an adult would immediately spit out, may remain for a long time in a child's mouth, sufficient to allow a significant amount of the chemical to be absorbed.

Parents often foster a poisoning because they take medication in the presence of their children. The old adage of "If I see it, I can do it" is especially prevalent in young children. Other times, parents administer candy-flavored medications or multiple vitamin products to children enticing them to readily take the product because of its "delicious candy" flavor. Youngsters who cannot distinguish between right and wrong, and who find this same bottle or a different container or a parent's prenatal vitamins or iron tablets (Fig. 4) unattended later on, may swallow a lethal dose, simply because they were told it was candy and tastes good.

McCormick et al. (9) present an interesting summary of poisonings of infants during diaper changing. Of 138 cases of poisoning that occurred during this procedure, 19% of the infants were directly given the poisonous material to keep them occupied. The authors admitted this number was probably even greater than the number that was reported.

A brief look around most homes should convince anyone that poisons are often left in easy viewing and, thus, are readily accessible to the unsuspecting. For example, count the number of unlabeled containers around the home that are filled with some liquid or solid substance. Also, look where these items, or even other items that do have appropriate labels, are stored. They are often found in unlocked cabinets, suit-

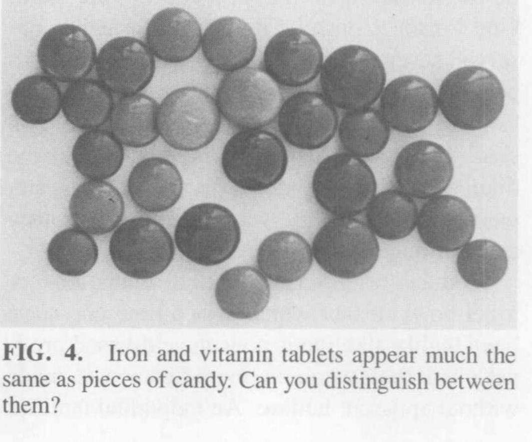

FIG. 4. Iron and vitamin tablets appear much the same as pieces of candy. Can you distinguish between them?

cases, on open shelves, in the bathroom corner, under the kitchen or bathroom sink, on the bedroom dresser or window ledge, on the workbench, etc. Too often an item that is normally kept in a secured area will be removed from that area for use, and then will remain within easy reach of some toddler's investigative fingers. It may even remain there for many days, weeks, or months until the user gets around to putting it away. Needless to say, poisoning takes only moments to happen.

Poisonings also occur because of the public's general unconcern or apathetic denial that a potential problem always exists. For example, cleaning aids, paint strippers and thinners, and other highly noxious products are used in nonvented areas. People work on an automobile, motorcycle, lawnmower, or other combustion engine left running in a closed garage, even though children are taught in grade school that this should not be done.

New products that may have been tested for their acute toxic potential are continually being introduced on the market. However, frequently, this toxic potential has not been tested over a period of time, or it has not been tested in persons of various ages, those with certain diseases, or when various diets are consumed. Also, many of these new products are extremely powerful, and the user may recall an older product that was similar but not exactly the same as the new product. If he uses it in the same manner as the older version, toxicity may occur.

Likewise, there is a wide variety of products on the market that exist in a concentrate form. One Poison Control Center reports it has observed severe burns occurring with alkali products whose pH was stated on the label as being "slightly alkaline" and, thus, seemingly safe on skin. However, this pH value referred to the diluted substance and not to the concentrate, whose pH in reality was in the dangerously caustic range.

Products often change their formulations. A toilet bowl cleaner which at one time may have been highly alkaline is now an acid-based product, and the switch in ingredients was made without apparent fanfare. An individual familiar with the older alkaline product may not even consider that the new product is completely different, especially since the name has not changed.

A common problem in acute poisonings occurs because the victim may not give the product's complete name. Therefore, the name is not descriptive of the constituents. For example, Clorox® is the name of a bleaching product that contains sodium hypochlorite. Clorox-2®, on the other hand, contains sodium perborate which must be antidoted differently than sodium hypochlorite. Drano® granules are sodium hydroxide, an alkali, and Drano® liquid drain cleaner is 1,1,1-trichloroethane, a moderately toxic hydrocarbon. So an important principle to remember is always make sure that the product name the victim states is actually descriptive of the ingredients.

A still more disturbing cause of poisoning exists because some products contain inaccurate or inappropriate antidoting information. Until recently, a salt solution to induce vomiting was considered appropriate to use for instances where emesis was indicated. However, it is now recognized that salt solutions may be more toxic than the actual poisoning event per se, and they have been the actual cause of some deaths (see Chapter 3). While labels on newly manufactured products no longer state that if the product is accidently swallowed, emesis should be induced with salt solution, many containers of these same products that were purchased 5 or 10 or even more years ago still exist around the home. The parent who is instructed by one of these older labels to administer a salt solution may be subjecting a poisoned victim to even more serious intoxication.

Consider another example of erroneous information (1). In this instance, a toddler swallowed a quantity of lye. First aid information on the label instructed that in case of ingestion, vinegar should be administered as an antidote. Vinegar was therefore given to the child with disastrous results. The mild acid actually increased the toxic effects of the lye due to an explosive exothermic (heat release) reaction which caused intense gastrointestinal damage that might not have occurred had the acid not been given.

While no one knows the exact extent of such inaccurate label information, it is thought to be extensive.

Where Poisonings Occur

Poisonings may occur anywhere, including around the home or workplace, at school, or on the road, and by any route of exposure. At home, most poisonings happen in the kitchen, followed by the bathroom, the bedroom, then all other sites together. It is not uncommon to hear a mother explain how her youngster got into some household cleaning agent found under the kitchen sink, or into a toilet cleaning aid, container of medicine from the bathroom, a medicine bottle, or cosmetic package in the bedroom. Likewise, reports are numerous which describe a person drinking a liquid from a soda bottle found in the garage that was apparently believed to be a palatable beverage but was subsequently shown to be gasoline, antifreeze, insecticide, or paint thinner. Even in the field, herbicides and insecticides serve as constant sources of poisoning through skin contact. The literature also abounds with reports of persons being intoxicated because they drank water which was transported in containers previously filled with insecticides or herbicides. Most accidental and suicidal poisonings occur through oral ingestion, while most industrial and agricultural toxicities follow pulmonary or dermal exposure (6).

Occasionally a farmer who is cleaning his liquid manure tanks is exposed to their toxic fumes (hydrogen sulfide), collapses, and dies after inhaling only a few breaths.

Another form of poisoning around the house can occur to anyone, but is especially prevalent to members of rural families during times of fertilizing the fields. In such incidences, application of liquid ammonia to the fields readily produces a cloud of ammonia gas which, if it carries across the field onto an adjoining plot where people are enjoying the evening on the patio, causes severe coughing, respiratory distress, and even death if enough is encountered.

At the place of employment, literally thousands of chemicals are present which may be accidentally ingested through contamination of food or water, or absorbed through the skin. Cases are documented whereby factory workers have taken certain chemicals home, apparently thinking they were nontoxic, but when used at home they caused serious toxicity.

In one instance, a family of three died when each of them ingested soup that had been seasoned with a lethal quantity of sodium nitrite. This was thought to have been placed in the salt container by a nonsuspecting father who brought it from his place of employment, apparently thinking it was table salt, sodium chloride.

An individual working in a ditch at a construction site around a busy highway, or in a tunnel, may become increasingly dizzy, lethargic, and ultimately unconscious, if the area where he is working becomes saturated with carbon monoxide from local traffic. Such poisoning encounters are fairly common around busy thoroughfares.

Schoolchildren, through negligence or perhaps even by mischievous intent, sometimes become careless with various chemicals from the chemistry laboratory, and these ultimately lead to some toxic episode. The fascination for metallic mercury has caused numerous reported toxicities, not through swallowing it, but by chronic inhalation of its vapors after being spilled on a living room carpet and dispersed into small globules with the vacuum cleaner.

Another example of reported unexpected toxic exposures resulted from aniline-containing products. These dyes are easily absorbed through the skin to cause methemoglobinemia. The route of exposure in these reports was from clothing stamped with laundry ink containing an aniline dye.

So it is easy to see that the potential for poisoning exists everywhere. Poisoning may result from chemicals in the air or water, from food because of residues or contamination, from medicines, or from other chemicals or poisonous products that are accidentally ingested.

When any one product or substance ingested by itself is not toxic per se, a combination of two or more different chemicals may be. For instance, we are all familiar with pharmacolog-