I. INTRODUCTION

A. Toxicology is concerned with the chemical and physical properties of _______________ substances, their physiological effects on living organisms and methods for their analysis.

1. A poison may be regarded as any substance which, when taken in sufficient quantity, will cause ill health or _______________
   a. "Sufficient quantity" is the ingestion of large amounts of a substance over an extended period of time.
   b. "All substances are _______________; there is none which is not a poison. The right _______________ differentiates a poison from a remedy."

2. Most poisons don't cause visible changes in the body - neither in a living person nor during an _______________.
   a. Most poisons work their mischief within the cells of the body and leave behind no visible _______________.
   b. As a result, the medical examiner doesn't often see visible evidence of _______________ during an autopsy or on slides from body tissues that he or she prepares for viewing under the microscope.
   c. The medical examiner collects _______________ and tissues from the body that the toxicologist analyzes for the presence or absence of toxins.

3. The science of toxicology has expanded to include a wide range of interests, including:
   a. the evaluation of the risks involved in the use of pharmaceuticals, ________________, and food additives.
   b. the study of occupational poisoning, exposure to environmental pollution.
   c. the effects of _______________.
   d. and, biological and chemical _______________.

B. The forensic toxicologist is concerned primarily with the detection and estimation of poisons in _______________ and body fluids obtained at autopsy or, occasionally, in blood, urine, or _______________ material obtained from a living person.

1. The forensic toxicologist _______________ the results as to the physiological and/or behavioral effects of the poison upon the person from whom the sample was obtained.

2. In the case of tissues collected at autopsy, the _______________ results may reveal that the decedent died from poisoning.

C. The complete investigation of the cause or causes of sudden death rests with the medical examiner, ________________, or pathologist.

1. The success or failure in arriving at the correct conclusion frequently depends upon the combined efforts of the pathologist and the _______________ toxicologist.

2. Most drugs and poisons do not produce characteristic or observable lesions in body tissues, and their presence can be demonstrated only by _______________ methods of isolation and identification.
D. In instances where death is not due to poisoning, the forensic toxicologist can often provide valuable evidence concerning the circumstances surrounding a ________________.
1. The detection of alcohol, narcotics, hallucinogens, or other drugs may substantiate the testimony of witnesses as to the aggressive, incoherent, or irrational behavior of the decedent at the time of a ________________ incident.
   a. Negative toxicology findings may dispel stories of the decedent’s ________________ use.
2. In the case of epileptics, negative or low drug concentrations may indicate the decedent was not taking his medication in the prescribed manner and as a result experienced a fatal ________________.

II. DEATHS INVESTIGATED BY TOXICOLOGISTS

A. Deaths resulting from accidental poisoning.
1. Most accidental poisonings occur in the home and often involve ________________.
2. Children, due to their innate curiosity and adventurous nature, may gain access to and ingest prescription drugs, ________________, pesticides, and household cleaners.
3. Accidental poisoning in adults most often occurs because a product is mislabeled, usually because someone placed it in a container other than its ________________ one.
4. Accidental poisonings may occur in industry due to carelessness or mishaps which expose workers to ________________ substances.

B. Deaths resulting from drug abuse.
1. Drug abuse is the non-medical use of drugs or other chemicals for the purpose of changing mood or inducing ________________, is the source of many poisonings.
   a. Abuse may involve the use of illicit drugs such as:
      (1) ________________ or phencyclidine;
      (2) the use of restricted or controlled drugs such as ________________, barbiturates, and amphetamine;
      (3) the use of chemicals in a manner contrary to their intended purpose - such as inhaling solvents and aerosol products.
   b. The "drug ________________" that began in the mid-1960s, deaths due to illicit drug use are still the most common fatal poisonings investigated by toxicologists today.
2. Drug abuse may also include the excessive use of legal substances, such as ________________ and prescription drugs.
   a. Significant blood alcohol levels have been found at autopsy in 35% of all persons committing suicide and in 50% of all ________________ victims.
   b. Many people die each year due to pathologic conditions directly attributed to or complications arising from the consumption of alcohol.
   c. Numerous accidental deaths occur from the concurrent ________________ of potent prescriptions drugs and alcohol.

C. Deaths resulting from suicidal poisoning.
1. Suicide is a common manner of death in cases of ________________.
   a. In all types of cases involving ________________, about twice as many men successfully commit suicide as women.
   b. In suicide cases involving ________________, twice as many women attempt to commit suicide with poison as men.
2. The most ________________ suicidal agent used is carbon monoxide.
   a. Allowing a car motor to run in a closed garage is the usual method used by those who commit suicide with carbon monoxide.
3. Cyanide and __________________________ may be occasionally used as suicidal agents but most deaths result from prescription drugs. 
   a. Most suicidal poisonings involve multiple drug ingestion; 
      (1) usually three to ______________________ different drugs are ingested at one time.
4. By analyzing the gastric and bowel contents, blood, urine, and the major ________________________ of the body, the toxicologist can determine the minimum quantity of the poison ingested.

D. Deaths attributed to homicidal poisoning.
1. Determining that a person died as the result of homicidal poisoning is often the most difficult type of investigation for law enforcement officers and ______________________ experts.
   a. Homicidal poisonings occur most often at home, meaning that the killer usually knows about the victim's habits and has access to the victim's food, ________, and medications.
   b. General evidence of poisoning is obtained from:
      (1) a knowledge of the ______________________ displayed by the decedent before death,
      (2) the postmortem examination of the body by the pathologist, and
      (3) the isolation and identification of the poison by the _________.
   c. Requirements for successful prosecution of a suspect:
      (1) law enforcement officers must establish that the perpetrator had _______________ to a supply of the poison,
      (2) that the suspect was aware of the ___________________ effects of the poison, and
      (3) that the suspect had opportunity to administer the poison to the decedent.
2. The pathologist can recognize the effects of certain poisons at autopsy.
   a. Strong acids and alkalis may cause extensive ________________ around the mouth or the surface of the body, with severe destruction of the internal __________.
   b. Metallic poisons may cause intensive damage to the gastrointestinal tract, liver, and kidneys.
   c. Phosphorus, chlorinated hydrocarbons, and poisonous ______________________ cause gross fatty degeneration of the liver.
3. Most poisons do not produce observable changes in body ______________________; 
   a. In many instances of poisoning, the value of the pathologist's examination of the body is:
      (1) establishing that death was not due to ________________ causes,
      (2) not due to traumatic injury, and
      (3) there is no evidence for cause of death except from possible _________________.
4. In most cases, toxicological analysis produces evidence for murder by poison.

III. TOXICOLOGICAL INVESTIGATION OF A DEATH INVOLVING POISON

A. Obtaining the case history and suitable specimens
1. The toxicologist must be aware of the age, sex, ______________________, medical history, and occupation of the decedent, as well as;
   a. any treatments administered before death,
b. the gross _____________________ findings, drugs available to the decedent, and
c. the time interval between the onset of symptoms and ____________________________.

2. In an average year, the toxicology laboratory of a medical examiner's office will perform analyses on tissues for such diverse poisons as:
   a. prescription drugs (analgesics, antidepressants, ______________________, tranquilizers),
   b. drugs of abuse (hallucinogens, ____________________, stimulants),
   c. commercial products (antifreeze, aerosol products, insecticides, rubbing compounds, weed killers), and gases (carbon monoxide, ____________________).

3. The collection of specimens for toxicological analysis is usually performed by the pathologist during the ____________________.
   a. Specimens from numerous body fluids and organs are necessary as drugs and poisons display varying affinities for the body __________________________.

4. In collecting the specimens, the pathologist ________________________ each container with the:
   a. date and time of autopsy,
   b. the name of the __________________________,
   c. the ____________________________ of the sample, and
   d. the signature of the pathologist.

5. The toxicologist, when receiving the specimens, gives the pathologist a written ___________________ and stores the specimens in a locked refrigerator until analysis.
   a. This procedure provides an adequate ______________________ of custody for the specimens.
   b. Maintaining a chain of custody enables the toxicologist to introduce his results into any __________________________ procedures arising from the case.

B. The toxicological analysis of specimens collected.
1. Prior to analysis the toxicologist must consider several factors:
   a. the _____________________________ of specimen available,
   b. the ____________________________ of the poison sought, and
   c. the possible biotransformation of the poison.

2. Working with a limited amount of specimen requires the toxicologist to devise an analytical approach which will allow the detection of the __________________________ number of compounds.
   a. In cases involving oral administration of the poison, the gastrointestinal contents are analyzed first, because large amounts of residual __________________________ poison may be present.
   b. The ____________________________ are the major organ of excretion for most poisons and high concentrations of toxicants are often present in urine, therefore the urine is usually analyzed next.
   c. Drugs or poisons absorbed from the gastrointestinal tract, are first carried to the __________________________; therefore, the first analysis of an internal organ is conducted on the liver.
   d. If a specific poison is suspected or known to be involved in a death, the toxicologist will usually chose to analyze those tissues and __________________________ in which the poison concentrates first.

3. Biotransformation is a term used to denote the ____________________________ by the body of a foreign chemical to a structurally different chemical.
   a. The new compound is called a ______________________.
b. Biotransformation of a drug or poison usually results in formation of a physiologically inactive substance which is more readily excreted from the body than the parent compound.
   (1) Evidence of heroin use is indicated by the presence its metabolite – ________________________.

4. The toxicologist must begin the ____________________ or toxicological analysis as soon after death as possible.
   a. Natural processes may destroy a poison initially present at death.
   b. Natural decomposition may produce substances or compounds with chemical or physical properties similar to those of commonly encountered poisons.

IV. COLLECTING SAMPLES

A. Toxins rarely leave behind visible _______________________, so finding a toxin and enough evidence to determine that it was the cause of death involves several specialized _______________________ and a variety of bodily tissues and fluids.
   1. The best places to get samples for testing are the locations where chemicals enter the body, where chemicals concentrate within the body, and along the routes of _________________________.
      a. Blood, stomach contents, and tissues around injection sites may possess high concentrations of the drug.
         (1) Analyses of _______________________, brain, and other tissues can reveal where a drug or its metabolites accumulated.
      b. Urine testing can indicate where the drug and its metabolites are concentrated for __________________________ elimination.

B. Potential sources of illicit toxins include the following.
   1. Blood: Blood by far is the toxicologist's most useful substance.
      a. With modern toxicological techniques, essentially any drug and its _______________ metabolites can be found in the blood.
      b. Blood examination tells the toxicologist what was going on in the __________________________ at the time of death.
      c. Concentrations of medicines and drugs within the blood correlate well with levels of intoxication and levels that are potentially __________________________.
   2. Urine: Because kidneys are situated along one of the body's major drug and toxin elimination _______________________, toxicologists can often find such substances in greater concentrations in the urine than in the blood.
      a. The correlation between urine concentration of a drug and its effects in the body has _______________________.
         (1) The urine level may reveal that the drug had been in the blood at some earlier time, but it can't determine whether the drug was exerting any effect on the individual at the time it was _______________________.
         (2) If someone drank a great deal of water, the urine and any chemicals it contains become more diluted than they for someone who hasn't consumed large quantities of _______________________.
   3. Stomach contents: Doctors remove the stomach contents of survivors of drug ingestions by way of a _______________________ tube, which typically passes through the nose and into the stomach.
a. The contents are then washed from the stomach and tested for the presence of drugs or _________________.
b. Obtaining stomach contents is critical in cases where investigators suspect poison or drug ingestion.

4. Liver: The liver is closely involved in drug and __________________________ metabolism (destruction).
a. Testing liver tissue and the bile (excreted by the liver and required for the digestion of food) it produces, often a drug or its metabolites.
b. Many drugs, particularly ________________, tend to concentrate in the liver and can be measured in these tissues even when blood tests show no _______________ of them.
c. The liver may reflect levels of a drug during the hours before death, and the ________________ may indicate what drugs were in the system during the past three to four days.
(1) Neither test is very accurate.

5. Vitreous humor: Vitreous humor is the liquid in the _________________.
a. It is fairly resistant to putrefaction (decay), and in severely decomposed corpses, it may be the only remaining _______________.
b. It is a water-like fluid that will allow water-soluble chemicals to dissolve in it.

6. Hair: Hair absorbs certain heavy-metal (arsenic, lead, and others) ________________
a. Hair has the unique ability of providing an intoxication ________________ for many of these substances.

7. Insects: Toxicologists may test insects that ________________ on corpses for drugs in cases of severely decomposed bodies.
a. Certain drugs tend to concentrate in the tissues of these ________________ and they may supply information about whether a drug was present in the deceased.

V. UNDERSTANDING THE TESTING PROCEDURES

A. An understanding of the circumstances surrounding a death is of utmost importance for determining ________________ and ________________ it happened.
1. Clues at the scene often point toward a particular drug or poison.
   a. Finding a young girl on her bed at home with an empty ________________ bottle at her side would lead to one avenue of testing.
   b. Finding a long-term addict in an alley with fresh ________________ marks would point to another path.
2. The more clues that the circumstances of the death can supply, the narrower the ________________ of possibilities the toxicologist must consider.

B. When testing for drugs, toxins, or poisons, the toxicologist typically follows a ________________-tiered approach:
1. Presumptive tests are used for ________________ screening and typically are easier and cheaper to perform.
   a. When negative, they indicate that the ________________ or toxin in question isn't present, and the toxicologist doesn't need to perform further testing for it.
   b. When positive, the results indicate that a particular substance may be present.
   c. In general, these tests are more sensitive but less specific than confirmatory tests and are unlikely to give ________________ negatives.
2. Confirmatory tests are used only after ________________ tests find the possible presence of a drug or toxin.
   a. They are more expensive and time-consuming.
b. They establish the ________________ of the specific drug present.

C. Common toxicological screening, or presumptive testing, include the following:

1. Color tests are chemical tests in which a reagent (chemical solution) is added to the substance (usually blood, urine, or ________________) being tested.
   a. A color change occurs whenever the suspected ________________ is present.
   b. The color change results from a chemical reaction between the drug and the reagent.
      (1) Produces a new compound that imparts a specific color to the _________________.
      (2) Tests are cheap, easy, quick, and determine if a specific chemical or class of chemicals is present in the material being _________________.

2. Immunoassays involve an antigen-antibody reaction. The substance being sought is the antigen, and the testing reagent is the _________________.
   a. An antibody reacts only with antigens that it recognizes and ignores all others.
   b. In this test, the toxicologist adds an ________________ that can specifically identify the suspected substance to the sample.
      (1) For example, if blood is to be tested for ________________, the toxicologist adds an antibody specific to amphetamines to a sample of the blood.
      (2) A reaction gives him a positive result.

3. Thin-layer chromatography is an inexpensive screening test that presumptively identifies hundreds of _________________ at once.
   a. It is a process that separates compounds according to how far they move through an absorbent material (usually a silica gel) when combined with a _________________.
   b. The compounds are then identified by comparing their respective movements with the movements of known standards.
   c. This test uses a ________________ reaction that further identifies the compound.

4. Gas chromatography is a method of separating compounds according to their respective sizes, ________________, and chemical properties.
   a. Gas chromatography can identify the class of an unknown or suspected chemical but can't give its exact _________________.
   b. It is useful as a screening tool because it separates the components of a chemical _________________ for later confirmatory testing.

5. Ultraviolet spectroscopy takes advantage of the fact that different compounds ________________ or reflect light in differing amounts and at varying wavelengths.
   a. When exposed to ultraviolet light; compounds or classes of compounds absorb ultraviolet light more strongly at specific _________________ and less so at other wavelengths.
   b. The magnitude of the ________________ absorption at the wavelength of maximum absorption indicates the concentration of the suspected drug or chemical in the sample.

VI. CONFIRMING THE RESULTS

A. A good confirmatory test is sensitive and specific, recognizes the chemical in question, and can identify it to the _________________ of all others.
1. After a chemical has undergone a screening test and the toxicologist has established a presumptive identity, a confirmatory test can accurately determine the identity of the unknown substance.

2. The most important confirmatory test used by the toxicologist is spectrometry.
   a. When the toxicologist compares the mass spectrums of unknown and known substances, the identity of the unknown sample comes to.
   b. In the forensic toxicology laboratory, spectrometry is usually used in combination with gas chromatography.
      (1) Gas chromatography separates the test sample into components, and mass spectrometry each of those components.

3. Infrared spectroscopy also determines the chemical fingerprint of the substance being tested but exposes the substance to light instead of electrons.
   a. When exposed to infrared light, each compound transmits, and reflects the light in its own unique pattern.
   b. These unique patterns determine which compounds are present and identify the substance being tested.

VII. INTERPRETING THE RESULTS

A. After testing has revealed the presence and concentration of a chemical substance, the toxicologist now must what the results mean.

1. The toxicologist must evaluate each of the drugs present, identifying of administration, and determine whether concentrations that are present played a role in the subject's behavior or death.
   a. Based on these findings, the toxicologist decides whether a drug may have caused the victim to lose control of a car or exhibit violent or behavior, for example, and whether a drug caused or contributed to the victim's death.
   b. The route of entry of a toxin is extremely important.
      (1) If a drug was into a person who had no means of injecting it or into a site that makes self-administration unlikely, homicide may be a stronger consideration.

2. The concentration of the drug or poison is greatest at the where it's administered. For example:
   a. Ingested toxins show up in the stomach, or liver.
   b. Inhaled gases are concentrated in the.
   c. Toxins that are injected intramuscularly linger in the tissues around the injection site.
   d. Drugs injected into are slowly picked up by the blood and transported throughout the body.
   e. Drugs that are given intravenously bypass the stomach and, entering the bloodstream directly.
   f. Finding a large amount of a toxin in the victim's stomach doesn't necessarily mean that the drug was the cause of death;
      (1) it may not yet have been absorbed into the and distributed to the body.
(2) The level of the drug in the blood is more important than the concentration of the drug in the __________________________ contents.

3. After determining a blood level of a certain chemical, the toxicologist assigns the __________________________ for one of these four broad categories:
   a. _____________________: This level is the one that is expected in the general population under normal circumstances.
   b. Therapeutic: This is the level that your doctor wants you to reach when you’re taking a prescription medication.
   c. _____________________: A toxic level is one that may cause harm - nausea, vomiting, or a drastic change in the heart's rhythm, for example - or death.
   d. _____________________: This is the level at which the drug in question consistently causes death.

4. Everyone reacts to chemicals and toxins differently.
   a. Much of this variance relates to age, ________________, body size and weight, genetics, and nutritional and health status.
   b. A young and healthy individual usually tolerates more of a given drug than someone who is old, thin, and ______________.
   c. Drug addicts commonly ingest or inject doses of cocaine or _______________ that would kill the uninitiated in minutes.

5. Toxicologists must consider these factors when assessing whether a given level of a drug is toxic or lethal and whether it contributed to the subject's behavior or ______________.

B. At times, toxicologists are called upon to determine whether a poisoning is __________________________ (quick but intense) or chronic (drawn out in small doses).
1. A good example is arsenic poisoning.
   a. Arsenic can kill when it's given in a single large dose or when it's given in repeated _______________________ doses during the course of weeks or months.
   b. Determining whether the poisoning was acute or __________________ may be extremely important.
      (1) The suspect list for an acute poisoning may be long.
      (2) The suspect list for a chronic poisoning would include only those who had long-term ________________ with the victim.
         (a) A family member, a caretaker, or a family cook may qualify.

2. Toxicologists use the victim's _______________________ to determine whether a poisoning was acute or chronic.
   a. Hair analysis not only reveals exposure to arsenic but also provides a ______________________ of the exposure.
      (1) Arsenic, for example, is deposited in the cells of the hair follicles in proportion to the blood level of the arsenic at the time the __________________________ was produced.
      (2) As hair grows, hair follicle cells undergo changes and are incorporated into the growing hair __________________ .
      (3) The toxicologist can cut the hair into short segments and then measure the _______________________ levels of each.
         (a) This reveals a timeline of the victim's exposure to arsenic.
VIII. THE TOXICOLOGIST AS EXPERT WITNESS

A. The forensic toxicologist is often called on to testify in court as to his or her __________________________ findings and their interpretation.

1. Although few toxicologists have medical _____________________, they are frequently permitted to state in court the effects of drugs or poisons on the human body.
   a. When questioned as to his analytical findings, the toxicologist must first establish that he has maintained a proper __________________________ of custody of all specimens analyzed.

2. The written __________________________ of custody establishes that all specimens received were stored in a manner which prevented unauthorized persons from tampering with the specimens.

3. The toxicologist must be completely familiar with the principles, procedures, and __________________________ of all tests which he performed.
   a. His interpretation must reflect a knowledge of the professional __________________________, as well as his own experience with similar cases.
   b. The toxicologist may disagree with other experts in the field, but all his conclusions must be based on sound scientific or __________________________ knowledge.

B. As an expert witness the forensic toxicologist must present all testimony with honesty and __________________________.

1. If he does not know the correct answer to a question, he should state that he does not know.

2. No one knows all things about any given field of medical or __________________________ endeavor.
   a. A successful testimony in court may further the ends of justice; or at worst, it may serve as an __________________________ experience.