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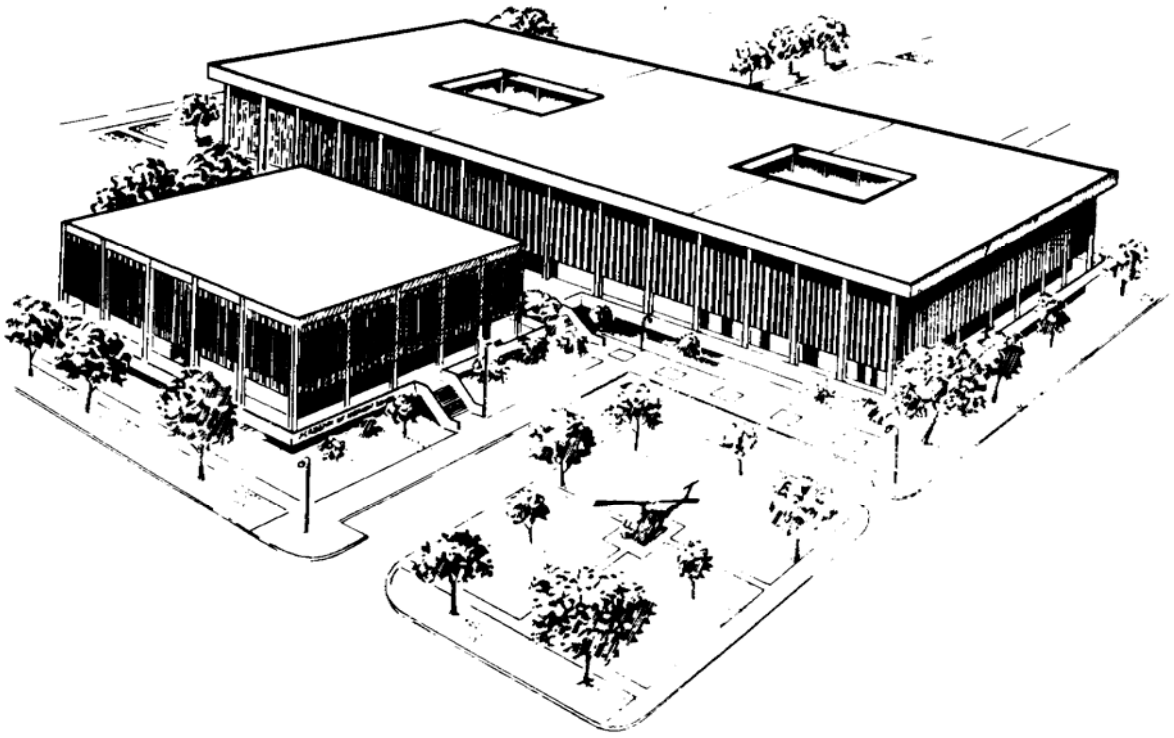

URINALYSIS

SUBCOURSE MD0852 **EDITION 200**

DEVELOPMENT

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The subject matter experts responsible for content accuracy of this edition were from the Department of Clinical Support Services, Academy of Health Science, ATTN: MCCS-HC, Fort Sam Houston, Texas 78234-6100.

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TABLE OF CONTENTS

CORRESPONDENCE COURSE OF THE
U.S. ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL

SUBCOURSE MD0852

URINALYSIS

INTRODUCTION

Due in part to the development of multiple reagent strips (dipstix) for urinalysis, more laboratory tests are now performed each year on urine than on any other body fluid. A typical urinalysis includes tests for glucose, protein, pH, ketone bodies, bilirubin, occult (unseen) blood, urobilinogen, and specific gravity and microscopic examination of urinary sediment. Many common abnormalities can be recognized by urine studies. Urine tests are the method of choice to monitor the treatment of diabetes.

Urine is an excretion product, but it is usually clean and sterile. Its chief components are urea, sodium chloride, and water. The stench of stale urine is largely due to the decomposition of urea to ammonia by bacteria. The odor of fresh urine is not unpleasant to most persons. Urine is not a significant source of infection. The disagreeable characteristics arising from decomposition can usually be avoided.

This subcourse will focus on the analysis of urine. The contents of the text will present and discuss the topics outlined above. However, you should remember that the subcourse is not intended to provide you with all that is known about urinalysis. For this reason, you should read other texts and journals, discuss the subcourse contents with your fellow workers and supervisors, and search other sources of knowledge to expand your knowledge of this important topic.

Subcourse Components:

This subcourse consists of three lessons. The lessons are as follows:

Lesson 1. The Collection and Preservation of Specimens; Macroscopic and Physical Examination of Urine.
Lesson 2. Chemical Measures.
Lesson 3. The Microscopic Examination of Urinary Sediment.

Study Suggestions:

Here are some suggestions that may be helpful to you in completing this subcourse:

Complete the subcourse lesson by lesson

Read and study each lesson carefully.

After completing each lesson, work the exercises at the end of the lesson, marking your answers in the lesson.

After completing each set of lesson exercises, compare your answers with those on the solution sheet which follows the exercises. If you have answered an exercise incorrectly, check the reference cited after the answer on the solution sheet to determine why your response was not the correct one.

As you successfully complete each lesson, go on to the next. When you have completed all of the lessons, complete the examination if you have enrolled in the correspondence course of subcourse. Mark your answers in the examination booklet; then transfer your responses to the examination answer sheet using a #2 pencil.

Mail the solution sheet to the Academy (along with the Student Comment Sheet if you have comments concerning the subcourse or examination) in the envelope provided with the examination booklet. Be sure that your name, rank, social security number, and return address are on all correspondence sent to the Academy. You will be notified by return mail of the examination results. Your grade on the exam will be your rating for the subcourse.

Credit Awarded:

To receive credit hours, you must be officially enrolled and complete an examination furnished by the Nonresident Instruction Section at Fort Sam Houston, Texas. Upon successful completion of the examination for this subcourse, you will be awarded 7 credit hours.

You can enroll by going to the web site http://atrrs.army.mil and enrolling under "Self Development" (School Code 555).

A listing of correspondence courses and subcourses available through the Nonresident Instruction Section is found in Chapter 4 of DA Pamphlet 350-59, Army Correspondence Course Program Catalog. The DA PAM is available at the following website: http://www.usapa.army.mil/pdffiles/p350-59.pdf.

LESSON ASSIGNMENT

LESSON 1	The Collection and Preservation of Specimens; Macroscopic and Physical Examination of Urine.
TEXT ASSIGNMENT	Paragraphs 1-1 through 1-15.
LESSON OBJECTIVES	After completing this lesson, you should be able to:

1-1. Select the statement that best describes the clinical importance of urinalysis.

1-2. Select the statement that best describes a type of specimen.

1-3. Select the statement that best contrasts the two special methods of urine collection.

1-4. Select the statement that best describes the means to preserve a urine sample.

1-5. Select the volume that is the median amount of urine produced by an average adult during a 24 hour period.

1-6. Select the definition that correctly describes the following terms: polyuria, oliguria, or anuria.

1-7. Select the substance(s)/conditions(s) which might cause urine to be a certain color.

1-8. Select the statement that best describes the macroscopic means of evaluating a urine sample.

SUGGESTION After studying the assignment, complete the exercises of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 1

THE COLLECTION AND PRESERVATION OF SPECIES; MACROSCOPIC AND PHYSICAL EXAMINATION OF URINE

Section I. COLLECTION AND PRESERVATION OF SPECIMENS

1-1. IMPORTANCE OF URINALYSIS

Purification of the circulating blood is crucial for the continuation of life. The urinary system is a group of organs that serves to remove from the blood nonvolatile waste products that cannot be removed through the respiratory system. The organ that has the major role in both filtration and reabsorption of necessary substances is the kidney. Consequently, urinalysis is an extremely valuable tool for demonstrating pathological conditions in the excretory system and as an index for the general metabolic condition of an individual. There are several different kinds of samples used in urinalysis.

1-2. RANDOM SPECIMEN

A random urine specimen is satisfactory for most qualitative tests and may be collected at any time. However, factors such as the type and amount of food consumed, and the performance of exercise must be considered when interpreting results. For example, an elevated urine sugar may be obtained after an exceedingly high carbohydrate meal. All random specimens should be freshly voided and delivered to the laboratory as quickly as possible. Urine is an excellent culture medium for many types of microorganisms. As bacterial growth and metabolism increase, decomposition of the urine proceeds rapidly. If a delay of several hours is unavoidable, the urine specimen should be kept in the refrigerator.

1-3. FIRST MORNING VOID

A first morning sample is collected when the patient rises in the morning. Only a clean container is necessary. Early morning specimens are used most frequently for analysis due to their day-to-day consistency. It is the most concentrated of the urine samples and is used for qualitative analysis. It is also essential for preventing false-negative pregnancy tests and for evaluating orthostatic proteinuria.

1-4. TWO-HOUR POSTPRANDIAL

This specimen is collected two hours after the patient has eaten a meal and requires only a clean container. The specimen is tested for glucose, and the results are used to monitor insulin therapy in patients with diabetes mellitus.

1-5. TWENTY-FOUR HOUR SPECIMEN

a. A 24-hour specimen is required in order to obtain significant results in the quantitative analyses. It is essential that a clean container and the proper preservative be used. The 24-hour specimen is made up of the total urinary output for a specific 24-hour period and to obtain an accurate timed specimen. It is necessary to begin the collection period with an empty bladder and end the collection period with an empty bladder. The procedure is as follows:

(1) Day one. First thing in the morning, the patient should void and discard that specimen, after which the remainder of urine is collected for the next 24-hours. The patient should be instructed to urinate into a separate urine collection cup and pour the contents into the 24-hour collection container (caused by the possibility of splashing preservative onto exposed skin).

(2) Day two. At the same time as the beginning of the first collection, the patient voids and adds this urine to previously collected urine.

(3) Storage. The patient should be advised to store partial collections at 4-6^{o}C and deliver the completed 24-hour urine collection to the laboratory as soon as possible after completion.

b. Upon arrival in the laboratory, the 24-hour specimen must be thoroughly mixed and the volume accurately measured and recorded. Only an aliquot is needed for testing, but the amount saved must be adequate to permit repeat or additional testing.

1-6. SPECIAL METHODS OF URINE COLLECTION

When bacteriological studies are to be done, special collection techniques may be necessary to avoid contamination of the specimen.

a. **Catheterization**. Catheterization is used for some bacteriological tests performed on urine. However, even the most careful sterile technique cannot entirely prevent contamination of the bladder and the upper urinary tract during the passage of the catheter. This method is not used very often as it causes the patient much discomfort.

b. **Midstream (Clean Catch) Specimen**. A midstream specimen is used more often than a specimen from catheterization. Although this method does not eliminate contamination as much as catheterization, it is satisfactory if it is carefully collected.

(1) With men, the glans penis should be adequately exposed and cleaned with soap or a mild antiseptic solution. The initial flow of urine should be allowed to escape, but the midstream urine should be collected in a sterile container.

(2) With women, the urethral opening should be plainly exposed and well cleaned with soapy cotton balls. The area should be thoroughly rinsed with sterile, water-saturated cotton balls. The female patient should void the first portion of urine forcibly and then allow the midstream portion of about 20 to 100 ml to be caught in a sterile container.

c. **Suprapubic Aspiration**. Urine may be collected by external introduction of a needle into the bladder. The bladder is sterile under normal conditions. This collection method provides a sample for bacterial culture free of extraneous contamination and may be used for cytological studies.

1-7. PRESERVATION

There is no substitute for a fresh urine specimen, and in all cases the analysis should be performed as soon as possible. A delay in analysis leads to a degeneration of the formed elements and decomposition of chemical constituents. Occasionally, however, the analysis has to be delayed, or a specimen must be shipped. When such situations occur, deterioration of the specimen may be inhibited by the use of some form of preservation. The methods most commonly employed for preservation are the following:

a. **Refrigeration**. The best general method of preservation up to 8 hours is refrigeration at 4-6ºC. Refrigerated specimens are warmed to room temperature before performing an analysis.

b. **Toluene (Toluol)**. If only the chemical contents of the urine are of interest, as with most 24-hour specimens, toluene may be used. Toluene merely lies on the surface of the urine, forming a thin layer and acting as a physical barrier to air and bacteria. However, anaerobic bacteria, if present, are not inhibited. To measure portions of the specimen, it is necessary either to remove the toluene or to pipet from below the surface.

c. **Formalin (10 percent)**. Ten percent formalin is an excellent preservative for the formed (microscopic) elements in urine. About 4 drops of formalin may be used for each 100 ml of urine. However, it interferes with some qualitative chemical tests, and it should not be used when the glucose concentration is to be determined.

d. **Boric Acid (0.8 percent)**. Boric acid is a satisfactory preservative for general purposes. It will not interfere with examinations for protein, sugar, or ketone bodies.

e. **Thymol (10 percent in Isopropanol)**. Thymol is another general purpose preservative. Approximately 10 ml of the prepared solution is used for each 24-hour collection.

f. **Chloroform**. Chloroform may be used as a preservative, but it interferes with some chemical tests and may cause cellular changes.

g. **Sodium Fluoride**. Sodium fluoride may be used as a preservative for urine samples when one is concerned with glucose. It inhibits tests for glucose on the reagent strip.

h. **Sodium Carbonate**. To preserve urobilinogen in urine requires special precautions. To assure alkalinity, a half-teaspoonful of sodium carbonate is placed in the specimen bottle before the urine is voided into the bottle.

i. **Strong Mineral Acids**. Analysis for amino acids, delta-aminolevulinic acid, and total nitrogen requires acidification with a strong mineral acid (for example, hydrochloric acid to pH 3.0).

Section II. MACROSCOPIC AND PHYSICAL EXAMINATION OF URINE

1-8. INTRODUCTION

Macroscopic analysis deals with those procedures or examinations, which are accomplished without the aid of a microscope. Included in this category are measurement of volume, color, appearance, pH, and specific gravity. Before performing microscopic or chemical tests on a urine specimen, a macroscopic examination is accomplished. As the metabolic waste products filtering into the kidneys are constantly changing in relation to body intake, so the urine is constantly changing with respect to volume, color, appearance, specific gravity, and pH. Therefore, an accurate description of these physical properties furnishes the physician and/or physician extender with valuable information regarding kidney function.

1-9. VOLUME

The total 24-hour volume of urine voided by the normal adult is influenced by food and fluid intake, temperature, exercise, seasonal change, and the use of diuretics such as caffeine. Nonetheless, a consistent normal range has been established. The average adult produces between 750 and 2,000 ml of urine during a 24-hour period, with a median of about 1,400 ml. Volume determination is a quantitative analysis and therefore, the 24-hour specimen is used. When the total volume of a urine specimen is to be measured, the smallest graduated cylinder that will hold the entire quantity should be used. The amount of liquid preservative that has been added is not included in the total volume measurement. It should be noted that the amount of urine excreted might fall above or below the normal range without the existence of a pathological condition. However, abnormalities can cause marked deviations in total urinary output, resulting in one of the three following conditions:

a. **Polyuria**. This term refers to an abnormal increase in the total volume of urine excreted (more than 2,000 ml/24-hours). Polyuria is associated with such pathological conditions as diabetes mellitus, diabetes insipidus, certain tumors of brain and spinal cord acromegaly, myxedema, and certain kidney diseases. The nonpathologic cause is usually increased fluid intake.

b. **Oliguria**. A reduction in the total volume of urine excreted is called oliguria (less than 200 ml/24-hours). This condition is associated with febrile states, excessive vomiting, severe diarrhea, or extreme dehydration. Nonpathological causes are decreased fluid intake and excessive sweating.

c. **Anuria**. This term literally means "no urine" and refers to a complete lack of urine excretion. It results from blockage of the kidneys or urinary tract, certain bacterial infections of the kidneys, and prolonged states of dehydration. There are not any tnonpathological causes.

1-10. COLOR

Urine color is another physical property that is evaluated in the routine urinalysis. The color of normal urine is caused by the presence of various pigments, which are collectively referred to as urochrome. The various shades of yellow in urine specimens vary with the intensity of the urochrome present; the intensity of the color also varies with the specific gravity. Urine can show a typical coloration because of pathological conditions and as a result of the ingestion of certain substances, including food pigments, dyes, drugs, and so forth. It is important that one note the exact color observed and indicate on the laboratory slip any changes that occur on standing. The physician determines the diagnostic significance of the observed color.

a. **Yellow**. Normal urine has a color of straw, yellow, or amber. Urines that are concentrated are usually amber; very dilute specimens may be almost colorless.

(1) In addition, a yellow color may be produced by the following substances:

(a) Cascara--a laxative.

(b) Phenacetin--to ease fever or pain.

(c) Food colors.

(d) Atabrine® (brand name)--an anti-malarial.

(e) Azulfidine® (brand name)

(2) A specimen that is a very pale yellow, greenish-yellow, or nearly colorless can be the result of several pathological conditions, specifically:

(a) Severe iron deficiency.

(b) Chronic kidney disease.

(c) Diabetes mellitus.

(d) Diabetes insipidus.

b. **Green and Blue-Green**. The blue-green color is frequently due to the mixture of the color blue with the yellow of the urine. The following can impart a green or blue-green color to the urine:

(1) Oral contraceptives.

(2) Bile pigment.

(3) Diagnex Blue® (brand name).

(4) Elavil® (brand name).

(5) Indican in large amounts.

(6) Vitamin B complex.

(7) Blue diaper syndrome.

(8) Evans blue.

(9) Methylene blue in kidney medication.

(10) Yeast concentrate.

(11) Pseudomonas toxemia.

(12) Increased serum copper concentrations.

c. **Brown and Black**. Brown-colored or black-colored urine can be produced by the following:

(1) Porphyrins.

(2) Bilirubin.

(3) Injectable iron compounds.

(4) Melanin pigment.

(5) Phenol poisoning.

(6) Alkapton bodies.

(7) Methemoglobin.

(8) Tertian malaria.

d. **Red, Pink, or Reddish-Orange**. Quite a few substances can give the urine a pink or reddish coloring. These substances include the following materials:

(1) Beets.

(2) Dilantin® (brand name).

(3) Food colors.

(4) Blood.

(5) Azo Gantrisin® (brand name).

(6) Senna in alkaline urines.

(7) Pyridium® (brand name).

(8) Porphyrin.

(9) Hemoglobin.

(10) Povan® (brand name).

(11) Rhubarb in alkaline urines.

(12) Phenolsulfophthalein.

(13) Myoglobin.

(14) Bromsulphalein.

(15) Chromogenic bacteria.

e. **Orange**. The following list of substances can give the urine an orange color:

(1) Senna.

(2) Rhubarb.

(3) Azo Gantrisin® (brand name).

(4) Carotene.

(5) Furoxone® (brand name).

(6) Riboflavin.

(7) Food colors.

(8) Santonin in acid urines.

(9) Pyridium.

NOTE: A highly concentrated urine resulting from fever, inadequate water intake, or excessive water loss may also appear orange in color.

1-11. GENERAL APPEARANCE OF THE URINE SAMPLE

The general appearance of a urine specimen should also be evaluated routinely. Normally, fresh urine is clear, but the specimen can also be hazy or cloudy. Freshly voided urine should be used, since, if allowed to stand, all samples become turbid due to bacterial contamination. This uniform turbidity does not disappear upon heating or acidification.

a. **Clear**. Normal, freshly voided urine is usually clear as it has no visible particles.

b. **Hazy**. When the sample contains a small amount of particles, it is designated as hazy. Normal urine specimens may have a hazy appearance. Haziness may be due to mucus, epithelial cells, or amorphous urates or phosphates. Amorphous urates can be removed from the urine specimen by gently heating the specimen in warm water or by gently heating the prepared microscope slide. These techniques cause the crystals to redissolve.

c. **Cloudy**. Moderate to large amounts of visible particles produce a cloudy urine. Cloudiness may be caused by crystallized mineral salts that have precipitated due to long standing, or to the increase of bacteria when urine is left standing at room temperature. Cloudiness may also result from pathological conditions that produce blood or pus. The bacteria resulting from acute infections may also produce a cloudy urine.

1-12. SPECIFIC GRAVITY

A good test of total kidney function is the determination of specific gravity. Such a determination will measure the kidney's ability to concentrate urine. Specific gravity is a comparison of the density of urine to the density of distilled water, which is regarded as 1.000. Generally, the greater the volume of urine excreted, the lower the specific gravity. There is considerable variation in the specific gravity range of 1.003 to 1.030. Pathological conditions often result in an elevated or decreased specific gravity. In pathological conditions, the range of urine specific gravity may be 1.001 to 1.060. The determination of specific gravity involves the use of the following two instruments:

a. **Standard Urinometer**. The equipment required for the determination of specific gravity includes the urinometer and glass cylinder. A new urinometer should always be checked prior to use. When calibrated using distilled water, this instrument should read 1.000 at the temperature specified by the manufacturer. If a large discrepancy is noted, the urinometer should be discarded. If the discrepancy is small, a correction factor may be used. In addition, if the temperature at which readings are taken differs from the manufacturer's specified temperature, a temperature correction of .001 should be added or subtracted for every three degrees above or below manufacturer's calibration temperature. (See figure 1-1 for an illustration of an urinometer.)

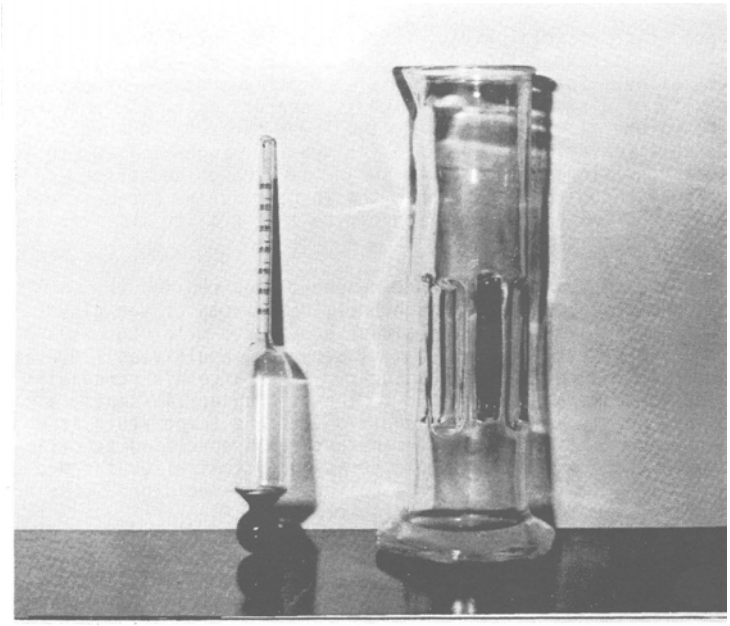


Figure 1-1. A urinometer.

b. **Refractometer (Total Solids Meter).** The refractometer is an optical instrument, which is based on the principle of light refraction. As the specific gravity of the urine increases, the degree of light refraction increases proportionally. The refraction is observed through an eyepiece, and results are obtained by noting where a shadow falls on the vertical graph. The actual measurement is the refractive index; however, the scales have been calibrated in terms of total solids (percent composition) for plasma or serum and in terms of specific gravity for urine. This instrument has several advantages: accuracy, simple operation, ability to obtain readings from a single drop of the specimen, lack of need to adjust for room and specimen temperature. However, it must be remembered that the readings of the total solids meter are specific for the two types of samples involved, plasma/serum and urine. Each scale is calibrated for one type of sample and is not a valid measurement of the other. To compensate for this situation, conversion tables are available. (See figure 1-2 for an illustration of a refractometer.)

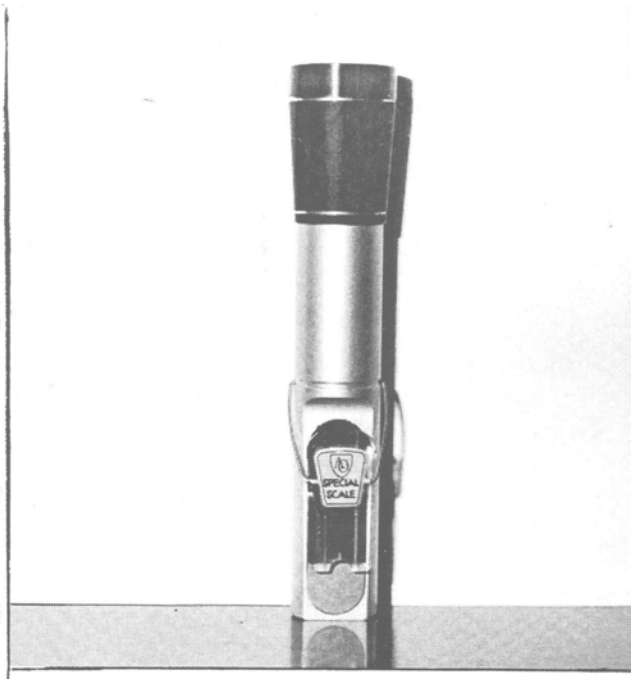


Figure 1-2. A refractometer.

1-13. pH

The determination of the pH of a specimen is part of a routine urinalysis. To be accurate, pH must be measured with fresh urine. Most specimens are acidic in their reaction, but fresh urine may be neutral or alkaline. The usual pH is about 6.0, with a reference range of 4.6 to 8.0. If urine specimens are allowed to stand at room temperature for long periods, they become increasingly alkaline because of the conversion of urea to ammonia by bacteria. This change in pH often causes adeterioration of many of the microscopic structures present in the urine and adversely affects a microscopic analysis. Therefore, if tests on a specimen are to be delayed, the specimen must be preserved. Changes in pH can be used to investigate the electrolyte balance of a patient as well as possible pathological conditions, such as acidosis or alkalosis.

a. **Significance of Acidity**. Urine with pH below 6.0 is considered to be acidic. Fresh urine is usually acidic and of little clinical significance; persistently acid urine occurs in some metabolic diseases. Formed elements usually remain well preserved if the urine specimen is acid.

b. **Significance of Alkalinity.** Urine with a pH above 6.5 is considered alkaline. When freshly voided urine is persistently alkaline, it may signify urinary infection, metabolic disorders, or the administration of certain drugs. There is an "alkaline tide" after meals, which is perfectly normal. In alkaline urine, the urinary sediment may be greatly modified by the dissolution of casts and lysis of red blood cells.

c. **pH Determination.**

(1) pH meter. For exact pH values, the pH meter should be used. However, since this instrument is rather complex, it is not used very often in urinalysis due to time limitations.

(2) pH paper. The pH of urine can be determined by the use of indicator paper such as pHydrion or nitrazine paper. The tip of the paper is dipped into the specimen or a drop may be placed on the paper. The resulting color is compared with the standard chart supplied with the paper. Nitrazine paper has a range of 4.5 to 7.5. The color varies from yellow at 4.5 to blue at 7.5.

(3) Reagent strips ("dipstix"). (See figure 1-3.) Some multiple reagent strips include a test region with the indicators methyl red and bromthymol blue. This combination of indicators gives a pH range from 5.0 to 8.5. The resulting colors range from orange to blue. Care should be taken to follow the directions supplied by the manufacturer. Excessive immersion time will wash the chemicals out of the test regions. This can affect the results of the readings on one or all of the test regions.

d. **Report.** The pH determination of a specimen is reported as the numerical value obtained or the relative degree of acidity or alkalinity depending upon the procedure used.

Figure 1-3. Reagent strips (dipstix).

1-14. ODOR.

Fresh urine from a healthy patient usually has a very slight aromatic odor, which is due to certain volatile constituents. After standing for a long time, the bacterial

decomposition of urea produces a characteristic odor of ammonia. The ingestion of certain foods (for example, asparagus) produces a characteristic odor.

1-15. FOAM

A slight amount of foam is formed when normal urine is shaken. This foam is white. The presence of bile pigments in the urine usually produces a yellow foam, but the presence of certain chemicals or drugs (for example, phenylazodiaminopyridine) will also produce a yellow foam. Excess urine protein (proteinuria) causes a marked increase in the foaming quality of urine.

Continue with Exercises

EXERCISES, LESSON 1

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise, by completing the incomplete statement, or by writing the answer in the space provided at the end of the exercise.

After you have completed all of the exercises, turn to "Solutions to Exercises " at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. What is the clinical significance of urinalysis?

   a. Urinalysis can provide useful information on the patient's ability to produce volatile wastes.

   b. Urinalysis provides a good indication of the overall metabolic condition of the patient.

   c. Urinalysis serves as a means of evaluating the patient's state of health in every major system in his body.

   d. Urinalysis can provide the physician with specific information about the patient's state of health.

2. Select the statement that best describes a two-hour postprandial urine sample.

   a. This type of sample tends to reveal abnormalities in the patient's metabolism.

   b. This type of sample is collected two hours after an initial urine sample has been collected from the patient.

   c. This type of sample must be collected in a sterile container.

   d. This type of sample must be mixed with an appropriate preservative.

3. Which statement best contrasts urine collection by the catheterization method and the midstream (clean catch) method?

   a. Catheterization is used more often than the midstream method to obtain urine specimens.

   b. The midstream method usually obtains specimens, which are sterile, while samples gathered by catheterization are usually contaminated.

   c. The urine collected by catheterization should be placed in a sterile container, while the urine collected by the midstream method should be collected in only a clean container.

   d. The midstream method is used more frequently than the catheterization method to collect urine.

4. Select the statement that best describes the preservation of urine by formalin (10 percent).

   a. This preservative is required when there is a need to preserve the urobilinogen in the sample.

   b. This preservative should not be used when the glucose concentration in the urine is to be determined.

   c. This preservative forms a thin layer on the top of the sample and acts as a physical barrier to air and bacteria.

   d. This preservative is required when the sample is to be analyzed for amino acids on total nitrogen.

5. Which of the following is the median amount of urine produced by an average adult during a 24-hour period?

   a. 1000 milliliters.

   b. 1250 milliliters.

   c. 1400 milliliters.

   d. 2000 milliliters.

6. Select the meaning of the term "oliguria."

   a. An abnormal increase in the urine output during a 24 hour period.

   b. A reduction in the volume of urine excreted.

   c. A complete lack of urine production.

   d. A reduction in the total volume of urine caused by diabetes mellitus and/or diabetes insipidus.

7. Anuria means:

   a. A complete lack of urine excretion.

   b An abnormal reduction in the volume of urine excreted.

   c. The production of urine which contains excessive numbers of negative ions.

   d. The production of excessively concentrated urine.

8. A patient's urine sample is orange. Which of the following substance(s) could produce such orange-colored urine? [Note: More than one response may be correct.]

   a. Bile pigment.

   b. Carotene.

   c. Pyridium.

   d. All the above.

9. A patient is very concerned because her urine is red. What substance could be the cause of such red-colored urine? [Note: More than one response may be correct.]

   a. Porphyrins.

   b. Pyridium.

   c. Melanin.

   d. All the above.

10. Which statement best describes the principle of the refractometer in the evaluation of urine specific gravity?

   a. Specific gravity compares the density of urine to the density of distilled water.

   b. This method is of little value in determining whether or not the patient has a pathological condition.

   c. Early morning urine samples should have a smaller specific gravity than samples taken in the afternoon.

   d. Little variation is seen in the specific gravity of random samples taken during the course of 24 hours.

11. Select the statement which best describes the evaluation of foam produced in urine.

   a. White foam is usually present in samples, which contain high levels of bile pigments.

   b. Proteinuria will produce a marked increase in the foaming quality of urine.

   c. Normal urine, even when shaken vigorously, should produce no foam.

   d. Yellow foam in urine is always a sign of a pathological condition in a patient.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 1

1. b (para 1-1)
2. a (para 1-4)
3. d (para 1-6)
4. b (para 1-7c)
5. c (para 1-9)
6. b (para 1-9b)
7. a (para 1-9c)
8. b
   c (para 1-10e)
9. a
   b (para 1-10 d, e)
10. a (para 1-12)
11. b (para 1-15)

End of Lesson 1

LESSON ASSIGNMENT

LESSON 2	Chemical Measures.
TEXT ASSIGNMENT	Paragraphs 2-1 through 2-11.
LESSON OBJECTIVES	After completing this lesson, you should be able to:

2-1. Identify the definition and usage of specific gravity in urinalysis.

2-2. Identify the definition and usage of pH in urinalysis.

2-3. Identify the importance of glucose in urinalysis.

2-4. Identify the importance of ketones in urinalysis.

2-5. Identify the importance of proteins in urinalysis.

2-6. Identify the importance of blood in urinalysis.

2-7. Identify the importance of bilirubin in urinalysis.

2-7. Identify the importance of bilirubin in urinalysis.

2-8. Identify the importance of nitrite in urinalysis.

SUGGESTION After studying the assignment, complete the exercises of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 2

CHEMICAL MEASUREMENTS

2-1. SPECIFIC GRAVITY

The specific gravity of urine indicates the relative proportions of dissolved solid components to the total volume of the specimen. It reflects the relative degree of concentration or dilution of the specimen. Knowledge of the specific gravity is needed in interpreting the results of most tests performed in routine urinalysis. Under appropriate and standardized conditions of fluid restriction or increased fluid intake, specific gravity measures the concentrating and diluting abilities of the kidney.

a. **Expected Values**. Specific gravity of urine may range from 1.003 to 1.030, but usually remains between 1.010 and 1.025. Specific gravity is highest in the first morning specimen, which is usually greater than 1.020. A specimen gravity of 1.025 or above in any random urine specimen indicates normal concentrating ability.

b. **Clinical Significance**.

(1) Low specific gravity.

(a) Diabetes insipidus, a disease caused by impaired functioning of the antidiuretic hormone (ADH), is the most obvious and severe example of the loss of effective concentrating ability. This disease is characterized by large volumes of urine with low specific gravity. Specific gravity in such cases usually ranges between 1.001 and 1.003.

(b) Low specific gravity may also occur in patients with glomerulonephritis, pyelonephritis, and various renal anomalies. In these cases, the kidney has lost its ability to concentrate the urine because of tubular damage.

(2) High specific gravity. Specific gravity is high in patients with adrenal insufficiency, hepatic disease, and congestive cardiac failure. It is elevated whenever there has been excessive loss of water, as with sweating, fever, vomiting, and diarrhea.

(3) Fixed specific gravity. Urine with a fixed low specific gravity (approximately 1.010) which varies little from specimen to specimen is known as isosthenuric. This condition is indicative of severe renal damage with disturbance of both the concentrating and diluting abilities of the kidney.

c. **Determination**.

(1) Specific gravity is a measurement that indicates the density of the urine. It is a number derived from the ratio of the weight of a given volume of urine to the weight of the same volume of water, under standardization conditions.

SPECIFIC GRAVITY =	**WEIGHT OF URINE** **WEIGHT OF WATER**

(2) Water has a specific gravity of 1.000. Since urine is a solution of minerals, salts, and organic compounds in water, the specific gravity is greater than 1.000. Specific gravity is a measure of the total solids in urine.

2-2. pH

The kidneys and the lungs are the two major organs that regulate the acid-base balance of the body. The lungs excrete carbon dioxide while the kidneys regulate excretion of the nonvolatile acids produced by the normal metabolic processes of the tissues. The acidity of urine is due primarily to acid phosphates, with only a minor portion contributed by organic acids such as pyruvic, lactic, and citric acids. These acids are excreted in the urine as salts, primarily sodium, potassium, calcium, and ammonium salts. The kidney regulates the selective excretion of the various cations in order to maintain normal acid-base balance. This is accomplished primarily through the reabsorption of a variable amount of sodium ion by the tubules and the tubular secretion of hydrogen and ammonium ions in exchange. Urine becomes increasingly acid as the amount of sodium retained by the body increases.

a. **Expected Values**. The pH of urine is a measure of its hydrogen ion concentration. A pH below 7 indicates acid urine. A pH above 7 indicates alkaline urine. Normal kidneys are capable of producing urine that can vary from a pH of 4.5 to slightly higher than 8.0. Freshly voided urine from patients not on special diets is acid and has a pH of about 6.0.

b. **Clinical Significance**.

(1) Acid urine. Acid urine with pH lower than 6.0 may be excreted by patients on high protein diets. Certain medications, such as ammonium chloride and mandelic acid, may also produce acid urines. Patients with acidosis and/or uncontrolled diabetes mellitus excrete urine containing large amounts of acid.

(2) Alkaline urine. Alkaline urine is frequently excreted after meals as a normal response to the secretion of HCl in the gastric juice. It also occurs in individuals consuming diets high in vegetables, milk, and other dairy products. Renal tubular acidosis is a specific disease of the kidneys in which the renal tubules are unable to adequately excrete hydrogen ions although severe systemic acidosis is present within the body. The urine pH of these patients usually remains approximately neutral and never falls below pH 6.0. Highly alkaline urines may represent either urinary tract infection or possible bacterial contamination of an old specimen with urea-splitting organisms.

(3) Renal stones. Renal stone formation significantly depends on the pH of urine. Phosphate and calcium carbonate stones develop in alkaline urine. Uric acid, cystine, and calcium oxalate stones precipitate in acid urine.

c. **Determination**. For routine analysis, urinary pH may be measured with reagent strips and a color chart. When more exact determinations are needed, a pH meter is used. The reagent strip is dipped into the urine specimen and the color change is compared to a standardized color chart on the bottle label that shows pH values 5 through 8.5.

2-3. GLUCOSE

Glucose is the sugar most commonly found in urine, although other sugars (such as lactose, fructose, galactose, and pentose) may also be found under certain conditions.

a. **Clinical Significance**.

(1) The presence of detectable amounts of glucose in urine is known as glycosuria. Glycosuria occurs whenever the blood glucose level exceeds the reabsorption capacity of the renal tubules (renal threshold); that is, when the glomerular filtrate contains more glucose than the tubules are able to reabsorb. The condition may be either benign or pathological, and the physician must distinguish between the two types.

(2) Diabetes mellitus, a pathological state, is the chief cause of glycosuria. This condition is associated with a marked elevation of blood glucose and usually an increase in urine volume.

b. **Determination**. There are various tests for glucose that can be applied to urine. Those most frequently used are of two types listed below.

(1) Enzymatic tests based on the action of glucose oxidase on glucose.

(2) Reduction tests based on the reduction of certain metal ions by glucose.

c. **Enzymatic Tests**.

(1) The enzymatic glucose oxidase tests for glucose, as applied to urine, are specified for glucose. In these tests, glucose oxidase catalyzes the oxidation of glucose to gluconic acid and hydrogen peroxide. The peroxide, in the presence of peroxidase, oxidizes an indicator that produces a color change. Other sugars, such as lactose, fructose, galactose, and pentose, are not substrates for glucose oxidase and, therefore, do not react with this test.

(2) CLINISTIX® Reagent Strip is another glucose test strip using the glucose oxidase principle. The results of this test are qualitative. Quantitation is only approximate because of the variable effect different urines may have on the color development. The glucose test strips will distinguish urines containing glucose only.

d. **Reduction Tests**.

(1) Metalic ions. The reduction of metallic ions such as Cu^{++} is nonspecific for glucose. This is because the reaction may be brought about by any reducing substance that may be present in the urine, such as creatinine, uric acid, ascorbic acid, or some other reducing sugar. The nonspecificity of the copper reduction test can be an advantage in that it will detect sugar other than glucose. It has a disadvantage in that it will detect reducing substances other than sugars.

(2) CLINITEST® Reagent Tablets. The copper reduction test has been greatly simplified by CLINITEST Reagent Tablets. When the tablet is added to a small test tube containing 10 drops of water and 5 drops of urine, it dissolves and produces carbon dioxide and heat. In the process, if a reducing substance such as glucose is present, the color changes from blue to orange, depending on the amount of sugar present. By comparing the color with a reference color chart, the amount of reducing substance in the urine can be estimated.

e. **Non-Glucose Reducing Sugars (Galactose)**.

(1) Galactose is found in the urine of infants afflicted with galactosemia. These children are deficient in the enzyme necessary for converting galactose into glucose. This is a severe condition, which can be treated by eliminating lactose and other sources of galactose from the diet. If not treated properly, the infant will rapidly deteriorate physically and mentally and early death will result. Galactose can be detected with CLINITEST.

(2) Some pediatricians will screen infants to detect for galactosemia by using CLINITEST and CLINISTIX® to detect the presence of non-glucose reducing substances (positive CLINITEST, negative CLINISTIX).

2-4. KETONES

Normally, the body completely metabolizes fats to carbon dioxide and water. Whenever there is inadequate carbohydrate in the diet or a defect in carbohydrate metabolism or absorption, the body metabolizes increasing amounts of fatty acids. When this increase is large, fatty acid utilization is incomplete. Intermediary products of fat metabolism appear in the blood and are excreted in the urine. These intermediary products are the three ketone bodies: acetoacetic acid (which is also called diacetic

acid), acetone, and beta-hydroxybutyric acid. They are derived from acetoacetic acid. All three ketone bodies are present in the urine of patients with ketonuria in the relative proportions of 20 percent acetoacetic acid, 2 percent acetone, and 78 percent beta-hydroxybutyric acid.

a. **Expected Values**. Normally there is no detectable amount of ketones in the urine.

b. **Clinical Significance**.

(1) Diabetes mellitus is the most important disorder in which ketonuria occurs. Diabetes mellitus is a disorder of glucose metabolism. In insulin-deficient diabetes, glucose metabolism is sufficiently impaired that fatty acids are utilized to meet the body's energy requirements. When this type of diabetes is untreated or inadequately treated, excessive amounts of fatty acids are metabolized. This results in the accumulation of ketone bodies in the blood (ketosis) that are excreted in urine (ketonuria). Progressive diabetic ketosis is the cause of diabetic acidosis, which can eventually lead to coma and even death. The term ketoacidosis is frequently used to designate the combined ketosis and acidosis of diabetes.

(2) Ketonuria also accompanies the restricted carbohydrate intake that occurs in association with fevers, anorexia, gastrointestinal disturbances, fasting, starvation, cyclic vomiting, pernicious vomiting of pregnancy, and cachexia.

c. **Determination**. In ketonuria, acetoacetic acid, acetone, and beta-hydroxybutyric acid are all excreted in the urine. Consequently, a general test procedure that indicates the presence of one of these components is usually satisfactory for the diagnosis of ketonuria.

(1) Nitroprusside reactions. The reagent strip method is the simplest technique for determination of ketonuria. The strip is dipped into fresh urine, tapped to remove excess urine, and compared to the color chart after exactly 15 seconds. The chart has six color blocks indicating negative, trace (5 mg/dL), small (15 mg/dL), moderate (40 mg/dL), or large (80 mg/dL) and (160 mg/dL) concentrations of ketone, and ranging in color from buff to lavender and maroon. The test is sensitive to acetoacetic acid. It does not react with beta-hydroxybutyric acid or acetone.

(2) ACETEST® reaction tablet. To detect acetone and acetoacetic acid:

(a) Place tablet on a clean surface, preferably a piece of white paper.

(b) Put one drop of urine (or serum, plasma, or whole blood) on the tablet.

(c) Compare urine ketone test results to color chart at 30 seconds.

2-5. PROTEINS

Approximately one-third of normal urinary protein is albumin. This albumin appears to be identical to serum albumin. The majority of normal proteins in the urine are globulins. A high molecular weight mucoprotein, the Tamm-Horsfall protein, occurs in normal urine quantities up to 2.5 mg/dL. In nephrosis, it may occur in higher concentrations. It is not found in plasma and is thought to originate in the kidneys.

a. **Expected Values**. Normally, between 40 and 80 mg of protein are excreted daily, but as much as 100 to 150 mg per day may be considered within normal limits. Since the average daily urine volume may range from 1,000 to 1,500 mL, the average normal concentration of protein in the urine varies from 2 to 8 mg/dL. This wide range of normal values is the result of biological variations and differences in the methods used for the determination of protein.

b. **Clinical Significance**.

(1) Proteinuria refers to an increased amount of protein in the urine and is one of the most important indicators of renal disease.

(2) Albumin constitutes between 60 percent and 90 percent of protein excreted in most disease states. The urine of patients with multiple myeloma contains increased amounts of a low molecular weight globulin (Bence Jones protein).

(3) Proteinuria depends on the precise nature of the clinical and pathological disorder and upon the severity of the specific disease. Proteinuria may be intermittent or continuous. Transient, intermittent proteinuria is usually caused by physiologic or functional conditions rather than by renal disorders.

2-6. PROTEINS IN URINE

a. **Proteinuria**.

(1) Marked proteinuria is characterized by the excretion of more than 4 gm per day. It is typical of the nephrotic syndrome, but also occurs in severe cases of glomerulonephritis, nephrosclerosis, amyloid disease, systemic lupus erythematosus, and severe venous congestion of the kidney produced by renal vain thrombosis, congestive heart failure, or constrictive pericarditis.

(2) Moderate proteinuria refers to the daily excretion of between 0.5 and 4 gm of protein. It is found in the vast majority of renal diseases, as well as all of the disorders listed above. It is also found in chronic glomerulonephritis, diabetic nephropathy, multiple myeloma, toxic nephropathy, preeclampsia, and inflammatory, malignant, degenerative, and irritative conditions of the lower urinary tract, including the presence of calculi.

(3) Minimal proteinuria is the excretion of less than 0.5 gm of protein per day. It is associated with chronic glomerulonephritis polycystic disease of the kidneys, renal tubular disorders, the healing phase of acute glomerulonephritis, latent or inactive stages of gloemerulonephritis, and various disorders of the lower urinary tract.

b. **Determination**. A number of simple, semiquantitative tests and more complex quantitative tests are available for the determination of all proteins in urine.

(1) Colorimetric reagent strip test.

(a) The colorimetric reagent strip test is based on the ability of proteins to alter the color of some acid-base indicators without altering the pH. In the presence of protein, the color will change to green and then to blue with increasing protein concentrations.

(b) Most multiple reagent strips contain an area for protein determination, along with test areas for other urinary constituents. Protein is determined simply by dipping the strip into well-mixed uncentrifuged urine and comparing the resultant color with the chart provided on the reagent strip bottle.

(2) Turbidimetric or precipitation test. The sulfosalicylic acid method is a simple method for semiquantitating protein concentration in terms of trace through four "plus" precipitation. The precipitation is read and interpreted as follows:

(a) Negative. No tubidity, or no increase in turbidity (approximately 5 mg/dL or less).

(b) Trace. Perceptible turbidity (approximately 20 mg/dL).

(c) 1+. Distinct turbidity, but no discrete granulation (approximately 50 mg/dL)

(d) 2+. Turbidity with granulation, but no flocculation (approximately 200 mg/dL).

(e) 3+. Turbidity with granulation and flocculation (approximately 500 mg/dL)

(f) 4+. Clumps of precipitated protein, or solid precipitate (approximately 1 g/dL or more).

c. **Sulfosalicylic Acid Method**.

(1) Place 3 mL centrifuged urine in a test tube.

(2) Add 3 mL of 3 percent sulfosalicylic acid.

(3) Mix thoroughly and estimate the amount of turbidity 10 minutes later.

2-7. BLOOD

Although protein in urine is the most important indication of renal dysfunction, the presence of blood in urine is also an indication of damage to the kidney or urinary tract. Blood may appear as intact red cells or as free hemoglobin. Usually, the presence of free hemoglobin indicates that the cells have ruptured because of the traumatic passage through the kidney and urinary tract to the bladder or because the cells have been exposed to dilute urine in the bladder, which has caused them to hemolyze. Free hemoglobin is excreted from the blood into the urine in special cases only, such as transfusion reactions.

NOTE: Hematuria is defined as the presence of red blood cells in urine. In contrast, hemoglobinuria is defined as the presence of free hemoglobin.

a. **Expected Values**. Normally, there is no detectable amount of occult blood present in urine, even with very sensitive chemical methods.

b. **Clinical Significance**. The presence of blood in urine, as indicated by a positive test for occult blood, most likely indicates bleeding in the urinary tract. This may occur in a variety of renal disorders, infectious disease, neoplasms, or trauma affecting any part of the urinary tract. Free hemoglobin is likely to be found in any of the above disorders. Free hemoglobin may also indicate transfusion reaction, hemolytic anemia, or paroxysmal hemoglobinuria. It may also appear in various poisonings or following severe burns. A positive chemical test without the presence of red cells may indicate myoglobinuria as a result of traumatic muscle injury.

c. **Determination**.

(1) The reagent strip method is the simplest and most direct test for the presence of blood in urine.

(2) The color of the strip is compared with a color chart 60 seconds after the strip is dipped into the urine.

2-8. BILIRUBIN

Bilirubin in the urine indicates the presence of hepatocellular disease or the presence of intrahepatic or extrahepatic biliary obstruction. It is an early sign of these disorders and, therefore, a useful diagnostic tool. Bilirubin is formed by the breakdown of hemoglobin in the reticuloendothelial cells of the spleen and bone marrow. It is linked to albumin in the bloodstream and transported to the liver. This albumin-bound form, which is also known as indirect bilirubin, is insoluble in water and does not appear in the urine. In the liver cells, it is separated from the albumin and conjugates with glucuronic acid to form water-soluble conjugated bilirubin, also know as direct bilirubin. The liver cells that form the conjugated bilirubin excrete it into the bile and it is then excreted into the intestinal tract through the bile duct. This conjugated bilirubin in the intestinal tract is converted by bacterial action to urobilinogen. Being water soluble, conjugated bilirubin can be excreted by the kidneys, although normally its level in the blood is not high enough to cause significant amounts to appear in the urine.

a. **Expected Values**. Biliruben present in urine is approximately 0.02 mg/dL, reflecting the normally low blood levels of conjugated bilirubin. This amount is not detected by routine qualitative or semiquantitative techniques.

b. **Clinical Significance**.

(1) Bilirubin excretion in the urine will reach significant levels in any disease process that increases the amount of conjugated bilirubin in the bloodstream. In some liver diseases due to infectious or hepatotoxic agents, liver cells are unable to excrete all of the conjugated bilirubin into the bile. Therefore, sufficient amounts are returned to the blood to elevate blood levels and cause significant bilirubinuria.

(2) In obstructive biliary tract disease, biliary stasis interferes with the normal excretion of conjugated bilirubin via the intestinal tract. This causes a buildup in the bloodstream with resulting bilirubinura. Since bilirubin may often appear in the urine before other signs of liver dysfunction (jaundice, clinical illness) are apparent, bilirubinuria is an important diagnostice sign of liver disease and a bilirubin test should be part of every routine urinalysis.

c. **Determination**.

(1) The bilirubin reagent area on multiple strips is the simplest test for the determination of bilirubin. The reagent strip is dipped into fresh, uncentrifuged urine, tapped to remove excess urine, and, after a 30-second wait, compared to the color chart on the reagent strip bottle.

(2) Reagent tablets and special absorbent test mats are a highly sensitive and convenient method for the determination of bilirubinuria. The procedure is:

(a) Place 10 drops of urine on one special test mat. If bilirubin is present in the specimen, it will be absorbed onto the mat surface.

(b) Place an ICTOTEST Reagent Tablet on the moistened area of the mat.

(c) Flow two drops of water over the tablet.

(d) When elevated amounts of biliruben are present in the urine specimen, a blue to purple color forms on the mat within 60 seconds. The rapidity of the formation of the color and the intensity of the color development are proportional to the amount of bilirubin in the urine.

2-9. UROBILINOGEN

Bacterial action in the intestinal tract converts the bilirubin to a group of compounds known as urobilinogen. It is estimated that as much as 50 percent of the urobilinogen formed in the intestines is reabsorbed into the portal circulation and re-excreted by the liver. Small amounts are normally excreted in the urine, but the major excretion is in the feces.

a. **Expected Values**. Normally, between 1 and 4 mg (1 to 4 Ehrlich units) of urobilinogen is excreted in urine in a 24-hour period. The concentration of urobilinogen in a random normal urine is 0.1 to 1.0 Ehrlich unit/dL (1 EU/dL $\simeq$ 1 mg/dL).

b. **Clinical Significance**.

(1) Urinary urobilinogen is increased by any condition that causes an increase in the production of bilirubin and by any disease that prevents the liver from normally removing the reabsorbed urobilinogen from the portal circulation. Urobilinogen is increased whenever there is excessive destruction of red blood cells as in hemolytic anemias, pernicious anemia, and malaria. It is increased also in infectious hepatitis, toxic hepatitis, portal cirrhosis, or congestive heart failure. Determination of urinary urobilinogen is a useful procedure in routine urinalysis since it serves as a guide in detecting and differentiating liver disease, hemolytic disease, and biliary obstruction. Sequential determination also assists in evaluating progress of the disease and response to management.

(2) Urinary urobilinogen is decreased or absent when normal amounts of biliruben are not excreted into the intestinal tract. This usually indicates partial or complete obstruction of the bile ducts such as may occur in cholelithiasis, severe inflammatory disease, or neoplastic disease. Also, during antibiotic therapy, suppression of normal intestinal flora may prevent conversion of bilirubin to urobilinogen, leading to an absence of urobilinogen in urine.

c. **Determination (Urobilinogen Reagent Area)**. The strip is dipped into fresh uncentrifuged urine collected without preservatives. It is then removed and, after exactly 60 seconds, the color reaction is compared to the color chart.

2-10. BACTERIURIA: NITRITE

The finding of significant numbers of bacteria by culture methods is considered indicative of a urinary tract infection, especially if the specimen is a clean-voided midstream sample collected under aseptic conditions in a sterile container that is immediately closed with a sterile cap. However, a positive test for nitrite on any random urine specimen always indicates bacteriuria.

NOTE: The preferable type of specimen for nitrite testing is first morning urine or urine that has incubated in the bladder for a minimum of four hours.

a. **Clinical Significance**.

(1) Bacteriuria is considered significant when microbiological laboratory findings show the presence of 100,000 (10^5) or more bacteria per mL of three separate urine specimens.

(2) Significant urinary tract infections may be present in patients who have experienced no symptoms. Despite an absence of symptoms, these infections are serious because they have the potential for causing severe kidney damage before the patient is aware of them. This condition is known as significant asymptomatic bacteriuria.

b. **Determination (Nitrite Test)**.

(1) The nitrite test is fast and inexpensive and it provides an indirect method for early detection of significant bacteriuria.

(2) The nitrite area of the reagent strips has to produce a pink color. Thus, a positive result from a nitrite test is an indication of significant bacteriuria. However, a negative test result should never be interpreted as indicating an absence an absence of bacteriuria.

2-11. BACTERIURIA: LEUKOCYTE ESTERASE

a. This test detects the esterase released from the white blood cells (neutrophils) in the urine. Usually the presence of a significant number of white blood cells (leukocytes) in the urine indicates bacteriuria or a urinary tract infection.

b. The detection of leukocyte esterase as an indication of bacteriuria is an indirect test for infection. Pyuria (the presence of white blood cells in urine in significant numbers) has long been an indication of the possibility of urinary tract infection.

Continue with Exercises

EXERCISES, LESSON 2

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise, by completing the incomplete statement, or by writing the answer in the space provided at the end of the exercise.

After you have completed all of the exercises, turn to "Solutions to Exercises " at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. The normal range of specific gravity in urine is:

   a. 0.950 to 1.050

   b. 1.000 to 1.200.

   c. 1.010 to 1.025

   d. 1.200 to 1.500

2. Diabetes insipidus is indicated by:

   a. Large volumes of urine with low specific gravity.

   b. Small volumes of urine with high specific gravity.

   c. Moderate volumes of urine with a fixed low specific gravity.

3. The pH of urine _____ as the amount of sodium maintained by the body increases.

   a. Increases.

   b. Decreases

4. A patient is on a high protein diet. You would expect the pH of his urine to be

   a. Neutral.

   b. More acid than normal.

   c. More alkaline than normal.

5. The enzymatic glucose oxidase tests, as applied to urine, _____ detect lactose, fructose, galactose, and pentose.

    a. Will.

    b. Will not.

6. The presence of keytones in the patient's urine may indicate diabetes meliltus.

    a. True.

    b. False.

7. The most likely cause of red blood cells in the urine is:

    a. Diabetes insipidus.

    b. Diabetes meliltus.

    c. Bleeding in the urinary tract.

    d. Hepatocellular disease.

8. Bilirubin excretion in the urine in significant levels usually indicates disease of the:

    a. Bladder.

    b. Intestines.

    c. Kidneys.

    d. Liver.

9. Which of the following is correct concerning a nitrite test for bacteriuria?

   a. A positive test result indicates significant bacteriuria. A negative test result should be interpreted as indicating an absence an absence of bacteriuria.

   b. A positive test result indicates significant bacteriuria. A negative test result, however, should not be interpreted as indicating an absence an absence of bacteriuria.

   c. A negative test result indicates significant bacteriuria. A positive test result should be interpreted as indicating an absence an absence of bacteriuria.

   d. A negative test result indicates significant bacteriuria. A positive test result, however, should not be interpreted as indicating an absence an absence of bacteriuria.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 2

1. c (para 2-1a)
2. a (para 2-1b(1)(a))
3. b (paras 2-2, 2-2a)
4. b (para 2-2b(1))
5. b (para 2-3c(1))
6. a (para 2-4b(1))
7. c (para 2-7b)
8. d (paras 2-8b(1), (2))
9. b (para 2-10b(2))

End of Lesson 2

LESSON ASSIGNMENT

LESSON 3 The Microscopic Examination of Urinary Sediment.

TEXT ASSIGNMENT Paragraphs 3-1 through 3-25.

LESSON OBJECTIVES After completing this lesson, you should be able to:

3-1. Select the statement that best describes the clinical importance of microscopic examination of urinary sediment.

3-2. Select the statement that best describes the basic technique that should be used to prepare the urine sample for microscopic examination.

3-3. Select the statement that best describes the use of the microscope in the microscopic examination of urine sediment.

3-4. Select the principal organized structure(s) found in urine sediment.

3-5. Select the statement that best describes the type of sediment or its clinical significance.

3-6. Select the type of sediment that best describes a description of sediment observed in the microscopic examination of a urine sample.

3-7. Select the name of the sediment, commonly found in urine, as shown in an illustration.

3-8. Select the statement that best describes the significance of the three-bottle urine sample in terms of sample collection.

3-9. Select the best definition of the term cast.

SUGGESTION After studying the assignment, complete them exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 3

THE MICROSCOPIC EXAMINATION OF URINARY SEDIMENT

Section I. PREPARATION AND ILLUMINATION

3-1. PREPARATION OF URINE SEDIMENT FOR EXAMINATION (UNSTAINED)

A properly performed microscopic examination of urinary sediment can provide valuable information that enables the physician to diagnose renal as well as other abnormalities. The importance of this procedure, which has been compared to a biopsy with respect to its significance, cannot be overemphasized. Thus it is crucial that the many structures occurring in urinary sediment be identified correctly and that the diagnostically significant elements be distinguished from extraneous substances.

3-2. BASIC TECHNIQUE

a. The urine sample should be examined macroscopically and checked for cloudiness, color, possible blood, and a syrupy consistency that may indicate mucus and casts. Such an examination can provide clues regarding the nature of the sediment.

b. The specimen should be thoroughly mixed to ensure proper dispersal of constituents. Twelve to 15 mL of the specimen is placed in a conical centrifuge tube and centrifuged at 1500 rpm (revolutions per minute) for 5 minutes.

c. The centrifuged tube is then inverted into a clean test tube. The supernatant urine is saved for chemical testing; the sediment that remains in the bottom of the tube is examined microscopically.

d. Next, the sediment is resuspended by "finger-flicking" the tube. Then, one drop of sediment is transferred to a clean, dry glass slide by a pipet or a dropper, and a cover slip is applied.

e. Next, the sediment is scanned by using the low power (10X) objective and is examined in detail by using the high power (43X) objective.

f. It should be noted that the appearance of the urine does not necessarily correlate with the results of a microscopic analysis. Clear, normal-appearing urine may often reveal abnormal elements of diagnostic importance upon microscopic examination. Urine that gives only slight sediment after centrifugation may contain important structures; on the other hand, cloudy urine that contains heavy sediment may not disclose any clinically significant elements.

3-3. ILLUMINATION OF MICROSCOPIC FIELD

a. **Light Intensity.** The technique for use of the microscope must be changed somewhat from ordinary practice due to the transparent nature of urine sediment. Since many of the structures to be examined are hyaline (semi-transparent) in nature, the light should be subdued for ordinary work. Before the structures can be seen and identified, the intensity of light must be reduced to a minimum. The light intensity is reduced by practically closing the iris diaphragm of the microscope.

b. **Scanning and Reporting**. The drop should be scanned under the low power objective and with moderate light. Low power is used because the low power objective covers a larger field and thus allows a more rapid scanning of the total preparation. Certain large structures such as parasite ova can be spotted using low power. Due to their large size, casts are also reported as the average number per low power fields. Smaller elements are reported in terms of average number per high field. When switching the objectives from low to high power, the condenser should be raised slightly to bring the light to its former intensity. Red blood cells, white blood cells, and epithelial cells are reported as the average number per high power field, counting 10 fields (for example, 15-19 rbc/HPF). If very few or very many cells are seen, descriptive adjectives are used, for example, "few," "occasional," "too numerous to count." Crystals should be reported when they are observed. However, an actual count is unnecessary; a report of the type of crystal and an indication of relative occurrence, such as "few," "many," "and so forth," is sufficient. If bacteria are seen in a fresh specimen, they are reported as present. Bacteria and epithelial cells are less significant in urine from females than in urine from males, but awareness and reporting of their presence in all specimens is a safe procedure.

3-4. COMMON SOURCES OF ERROR

a. **Delayed Analysis.** The urine must be examined while still fresh. As the nature of the sediment changes with the passage of time, the analysis should be performed within 2 hours after voiding. If immediate examination is not possible, the specimen should be refrigerated or preserved with formalin.

b. **Improper Illumination.** This is the most common error in the microscopic analysis of urine. As mentioned previously, subdued light is necessary so that hyaline semi-transparent structures are not obscured by intense illumination.

c. **Improper Placement of Sediment on Slide.** Placing drops of sediment from too many patients on the same slide is another frequent source of error. As a result, the drops tend to run together. In order to avoid this problem, a slide should not contain sediment from more than two patients.

d. **Dried Slide**. Another error is to attempt to identify objects in urine, which has dried on the slide. A valid examination is impossible if this occurs. Not only are the delicate organized structures distorted beyond recognition; however, there is a confusing deposit of urinary salts. After some experience, one can immediately recognize the urine has dried due to the peculiar refraction of the structures.

e**. Confusion Due to Artifacts.** Extraneous elements are also a common problem in accurate microscopic analysis. One must become totally familiar with the relevant elements so that extraneous structures are not confused with and reported as significant structures.

Section II. MICROSCOPIC EXAMINATION OF ORGANIZED SEDIMENT

3-5. INTRODUCTION

Urine sediment is divided into two groups, organized and unorganized. Organized structures, which are primarily body cells and their derivatives, may be found in small numbers in all urine specimens. However, if they are present in any appreciable amount, they are usually associated with a pathological condition. Catheterization of females may be required in rare cases to distinguish a pathological increase in the number of erythrocytes, leukocytes, and epithelial cells from an increase in these elements due to menstrual contamination. The principal organized structures in urine sediment are red blood cells, white blood cells, epithelial cells, and casts.

3-6. RED BLOOD CELLS (ERYTHROCYTES)

a. **Appearance.** The presence of large numbers of erythrocytes is pathological when contamination from menstrual discharge can be excluded. A few erythrocytes may be found in urine after exercise and are not considered pathologic. Red blood cells' appearance varies considerably depending on the reaction, specific gravity, age, and so forth, of the specimen. Erythrocytes may be confused with yeast cells, fat droplets, or oxalate crystals, and therefore, should be positively identified by examination under high-dry objective. Yeast cells have a doubly refractile border which simulates the doughnut appearance of a red blood cell. Urate crystals may be red or reddish-brown, but they are usually much darker in appearance than red blood cells.

(1) Intact red blood cells (figure 3-1). In fresh urine, erythrocytes appear as lightly pigmented biconcave disks of uniform size. They are about 7 to 8 microns in diameter. They may be intact and have the characteristic shiny surface with a blue-green tint. When blood is present in a large amount, it may impart a color to the urine.

(2) Crenated red blood cells (figure 3-2). Crenated red blood cells, or crushed cells, frequently have star-like shapes with margins displaying numerous sharp edges. This is due to the effect of osmotic pressure removing the internal red blood cell fluid and thus collapsing the cell. This type of cell is often encountered in concentrated urine due to its hypertonicity.

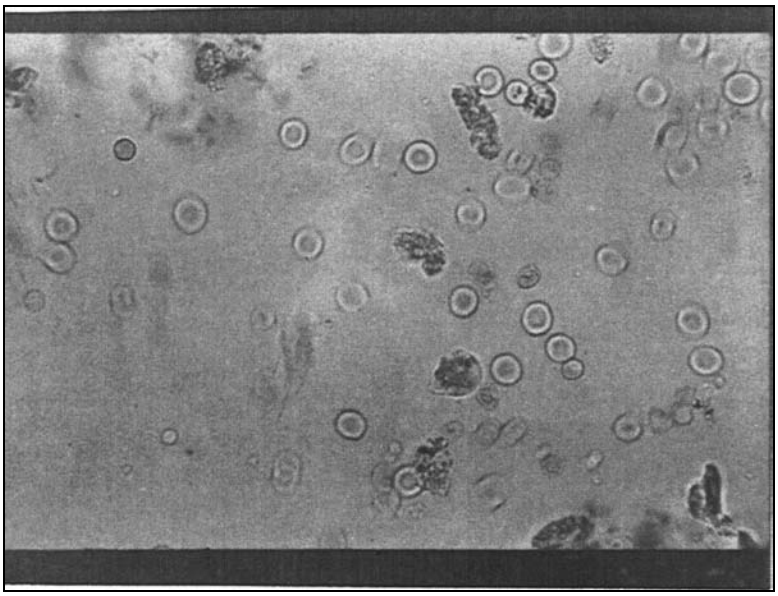


Figure 3-1. Red blood cells.

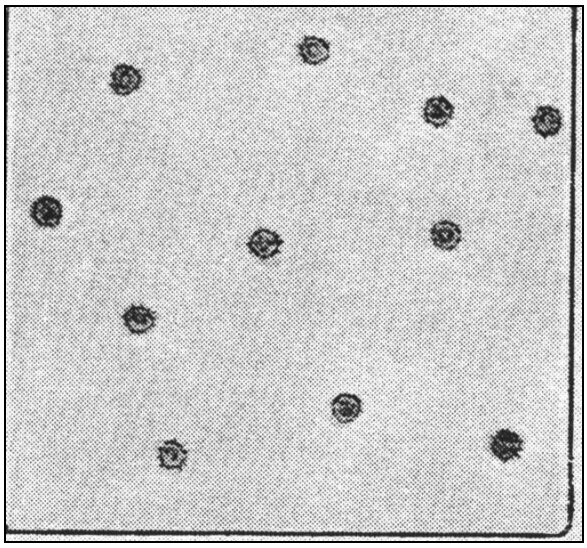


Figure 3-2. Crenated red blood cells.

(3) "Ghost" red blood cells (figure 3-3). In dilute urine specimens, the swollen ghost or shadow cell is frequently found. These cells have a larger than normal diameter. The swelling of these cells is caused by fluid flowing into the cell as a result of altered osmotic pressure. Ghost red blood cells are not always uniform in size and they may be circular or oval.

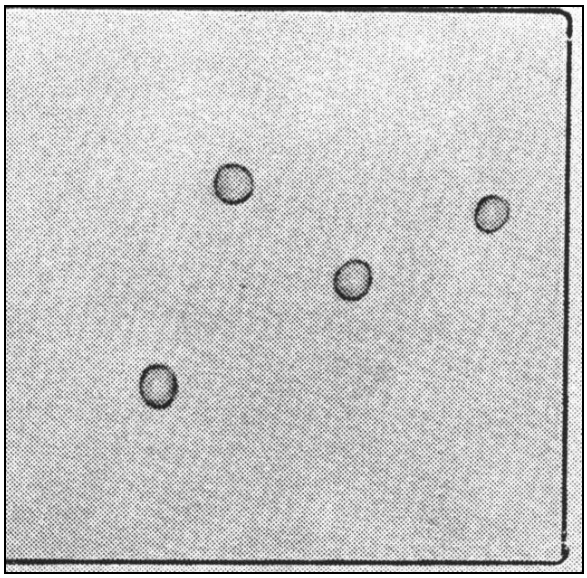


Figure 3-3. "Ghost" red blood cells.

b. **Blood in Urine**. Blood in the urine is a serious condition; however a few erythrocytes may be found in urine after strenuous exercise.

(1) Menstrual discharge. Blood in a urine specimen from a female may be due to contamination from menstrual discharge. However, it is not possible to determine whether all of the blood or only part of the blood is due to contamination with menstrual discharge. All blood in a urine specimen must be reported when it is detected.

(2) Kidneys. Blood from the kidneys or upper urinary tract is usually hazy, reddish, or smoky-brown in color.

(3) Lower urinary tract. If blood comes from the lower urinary tract, it is often a brighter red and is not so thoroughly mixed with urine. Fresh blood settles to the bottom more quickly, and small clots may be present.

c. **Three-Bottle Specimen**. A clue as to the site of the bleeding may sometimes be obtained by having the patient void three separate portions.

(1) First portion. If the blood is contained mainly in the first portion of the urine specimen, the bleeding point is probably in the urethra.

(2) Second portion. If blood is mixed uniformly in the second portion of the urine specimen, as well as in the first and third portions, the bleeding site is probably in the kidney or ureter.

(3) Third portion. If most of the blood is mainly in the last portion, the bleeding site is probably in the bladder.

d. **Alkaline Urine**. In alkaline urine, red blood cells are small in size or may be entirely disintegrated. To differentiate between erythrocytes and leukocytes, yeast cells, or contaminants, a drop of 10 percent acetic acid is added to the sediment. Red cells, if present, will dissolve while other structures remain unaffected.

e. **Associated Protein**. Urine that contains blood is always proteinaceous. A very small amount of blood may not be observed macroscopically. If large numbers of red blood cells are present, a positive protein will be obtained from the supernatant fluid of a centrifuged specimen.

3-7. WHITE BLOOD CELLS (LEUKOCYTES)

A few leukocytes are present in normal urine, particularly when much mucus is found. They are numerous only as a result of a pathological process. Catheterization or a "two-bottle test" may be required to distinguish urethral infection from infection of other parts of the genitourinary system. The two-bottle test is conducted in the manner of the three-bottle test described previously. However, only two portions of urine are obtained instead of three. If the greater portion of leukocytes is found in the first portion of the urine specimen, a urethral infection is indicated. If the greater portion of the leukocytes is found in the second portion, an infection involving some other part of the genitourinary system may be suspected. The presence of increased numbers of white blood cells or pus constitutes a condition called pyuria.

a. **Macroscopic Appearance**. When abundant, white blood cells form a white sediment resembling amorphous phosphates.

b. **Microscopic Appearance** (figure 3-4). Leukocytes are true cells with well developed nuclei. Most white blood cells are neutrophils and are stainable with neutral dyes. Under the microscope they appear as colorless granular spheres, about 10 to 15 microns in diameter, and larger than red blood cells most of the time. The granules are composed of normal neutrophilic granules and granular products of degeneration. Diluted acetic acid can dissolve the granules and thus allow the nuclear characteristics to be seen. In freshly voided urine, many white cells exhibit ameboid motion and assume irregular outlines.

c. **Alkaline Urine**. In alkaline urine, white blood cells are often swollen, very granular, and tend to adhere in clumps. The addition of a drop of 10 percent acetic acid not only allows differentiation from erythrocytes but brings the nuclei more clearly into view.

d. **Acid Urine**. In moderately acid urine, white blood cells are well preserved. In strongly acid urine, they may be shrunken and irregularly shaped, suggesting ameboid forms.

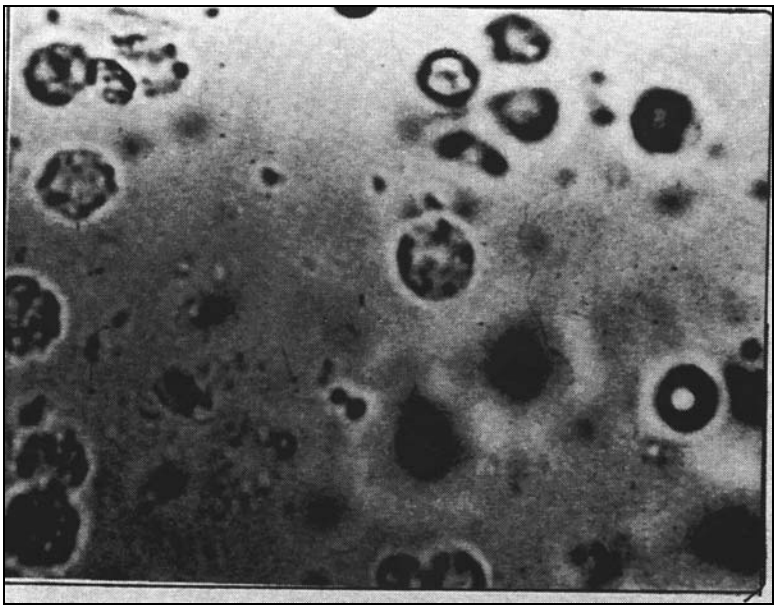


Figure 3-4. White blood cells (leukocytes).

e. **Decomposing Urine**. When the urine is decomposing, white blood cells are destroyed and converted into a gelatinous substance.

f. **Emphasizing the Nuclear Structure**. At times, the nuclei may be obscured or hidden by the granules. Nuclei may be brought clearly into view by running a little dilute acetic acid under the coverglass placed over the drop of urine before examining microscopically.

g. **Albumin**. When abundant, white blood cells add an appreciable amount of protein to the urine in the form of albumin. At times, it may be necessary to determine whether the albumin in a specimen is due solely to pus. It has been estimated that 80,000 to 100,000 white blood cells per cubic millimeter increase the albumin by about 0.1 percent. If a greater amount of albumin is present than can be accounted for by pus, the excess is probably derived from the kidney.

3-8. EPITHELIAL CELLS

a. **General Appearance.** A few cells from the epithelium of various parts of the urinary tract occur in every specimen of urine. A marked increase in the number of these cells indicates some pathological condition at the site of their origin. They may occur in "blocks," "clumps," or "sheets" of cells. One should be extremely cautious about making statements concerning the origin of any individual cell; only a pathologist can finally confirm the sites of origin of the cells. In addition, most cells are greatly altered from their original shape, and, due to degenerative changes, may be so granular that the nucleus cannot be seen. Many contain fat globules or glycogen vacuoles.

b. **Renal Tubular Cells** (figure 3-5). Renal epithelial cells are small, spherical, or polyhedral cells, about 20 microns in diameter. They are about the size of a white blood cell or slightly larger, colorless, and contain a large round nucleus. These cells may be binucleate or tetranucleate. Granules are usually present in the cytoplasm. These cells are believed to have their origin in the kidneys and come from the convoluted tubules and the loop of Henle. When they are polygonal in shape, dark in color, granular, and contain a rather large nucleus, they probably come from the renal tubules.

c. **Transitional Epithelial Cells** (figure 3-6). Transitional epithelial cells are much larger than the renal tubular cells. They are two to four times the diameter of white blood cells and may have various forms. Some can have a distinct round or oval nucleus; others may be pear-or spindle-shaped with tail-like projections. These are referred to as "caudate." Transitional cells have their origin in the posterior urethra, bladder, and ureters; the caudate variety originates in the neck of the bladder and the pelvis of the kidney.

d. **Squamous Epithelial Cells** (figure 3-7). The most common type of epithelial cell found in urine is the squamous variety. These are large, flat cells that usually have a small distinct nucleus. There may be occasional granules in the cytoplasm. Squamous cells are derived from the ureters, the superficial layers of the urethra and, rarely, from Bowman's capsule. In female patients, many large, squamous cells are frequently seen in the urine. These cells are from the vagina and labia and have no significance in renal disease except for the nuisance they cause by obscuring other elements of urinary sediment. When the number of squamous epithelial cells renders a valid examination impossible, catheterized urine should be obtained.

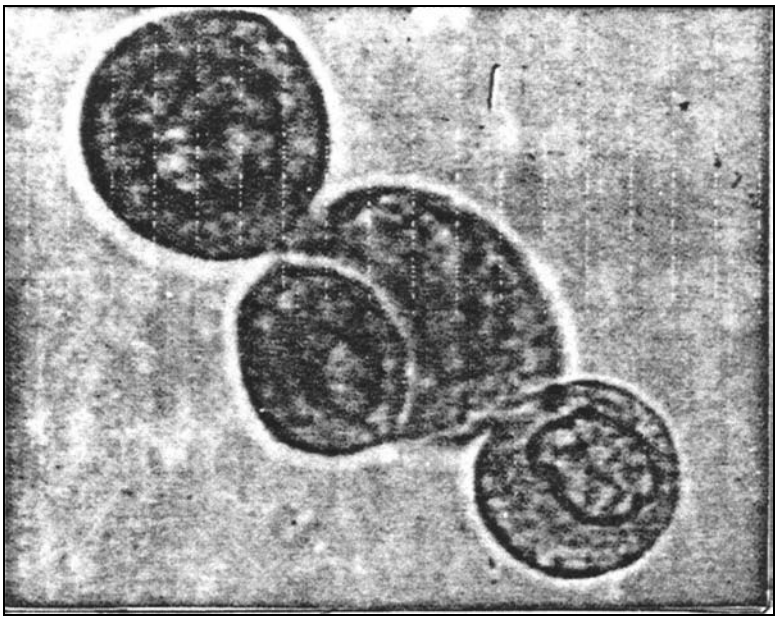


Figure 3-5. Renal tubular cells.

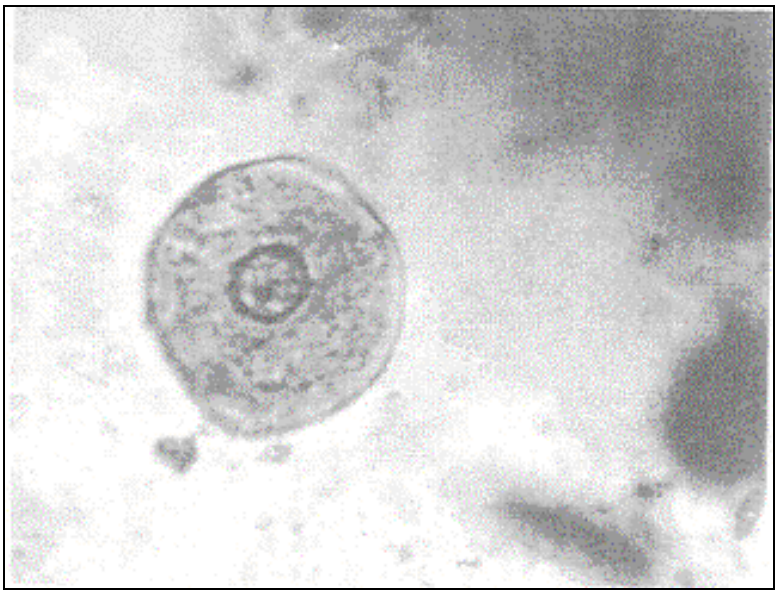


Figure 3-6. Transitional epithelial cells.

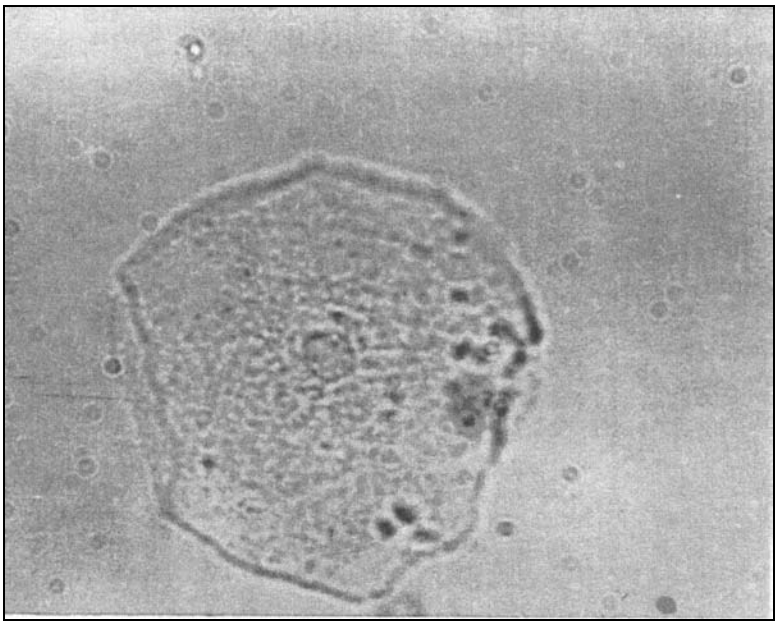


Figure 3-7. Squamous epithelial cells.

3-9. CASTS--GENERAL COMMENTS

a. **Significance.** Casts are proteinaceous products of the renal tubules, which act as molds for the casts. Casts, therefore, are tubular in shape and are a gelatinous impression of the kidney tubules. Their presence in the urine usually indicates some pathological change in the kidney, although the change may be slight or transitory. They are rarely found in the urinary sediment of normal individuals. Since casts are formed in and forced out of the renal tubules, they vary in shape and size according to the site of their origin. They may also differ in length, thickness, and consistency. A positive protein is often found when many casts are present.

b. **Formation.** Normal and occasionally abnormal plasma proteins constitute the source of the protein involved in cast formation. These proteins are not reabsorbed in the proximal convoluted tubules. In the distal convoluted tubules and the collecting ducts, acidification of the urine, and the relative concentration of solutes due to water reabsorption favor coagulation of protein. In addition, a marked decrease in urine flow and the presence of abnormal ionic or protein constituents encourage cast development. After formation, most casts are washed out of the tubules into the urine by increased hydrostatic pressure from behind, which causes the tubules to dilate around them. A simple way to visualize the formation and variety of these structures is to regard the process as a gel formation. This gelling process is similar to events that occur in the preparation of a gelatin dessert. When the proper temperature and concentration of gelatin are obtained in the solution, there is a sudden increase in viscosity. If sliced fruit has been added to the fluid mixture, the fruit fragments are included within the gelatinized mass. In much the same manner red blood cells, white blood cells, and epithelial cells become trapped in the gelatinized casts and thereby preserve a record of the tubular contents for examination in the urinary sediment.

c. **Identification.** If the urine is very dilute or alkaline, these casts dissolve. Therefore, it is imperative that the specimens be analyzed as soon as possible. Under the microscope, casts generally appear as clear, slightly refractive cylinders and are best recognized by using low power with dim light. However, all casts should be verified by using high power. Higher magnification is important in classifying casts as to type.

3-10. NONCELLULAR CASTS

a. **Hyaline Casts** (figure 3-8)**.** The simple hyaline cast is composed primarily of protein and has no inclusions. It is actually the basic material for all types of casts and is often referred to as a "hyaline matrix." Hyaline casts are colorless, homogenous, and semitransparent structures with cylindrical bodies that have parallel sides and rounded ends. The length of a hyaline cast varies. Generally it is straight, but occasionally may be slightly rounded or convoluted.

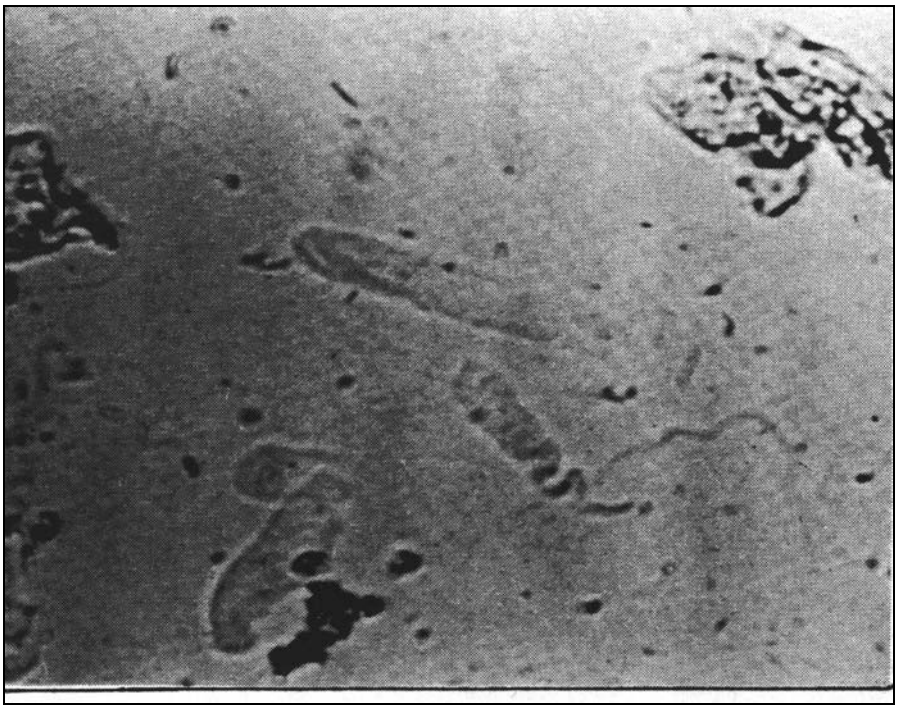


Figure 3-8. Simple hyaline casts.

(1) Diagnostic significance. Hyaline casts are the least significant of all casts. Small numbers appear after anesthesia, fever, or excessive exercise and in cases of renal congestion and irritation. However, as hyaline casts are associated with proteinuria, they can occur in virtually any kidney pathology.

(2) Microscopic identification. Since the refractive index of the surrounding medium is nearly identical with the refractive index of hyaline casts, such casts are almost invisible. They can only be seen in subdued light with the microscope condenser at its lowest adjustment.

b. **Granular Casts** (figure 3-9). Granular casts are about the same size as hyaline casts and are composed of common hyaline material in which numerous granules are embedded. This granular material consists of protein, disintegrated leukocytes or erythrocytes, fats, and degenerated epithelial cells. These casts appear in practically every type of kidney disorder. They are generally divided into two basic categories:

(1) Coarsely granular casts. If the epithelial cells or other materials do not become immediately incorporated within the hyaline material, they tend to degenerate into coarse granules. These granules then adhere to the casts, thereby forming coarsely granular casts. Since coarsely granular casts contain large granules, they are darker in color than finely granular casts. They can even be dark brown as a result of altered blood pigments.

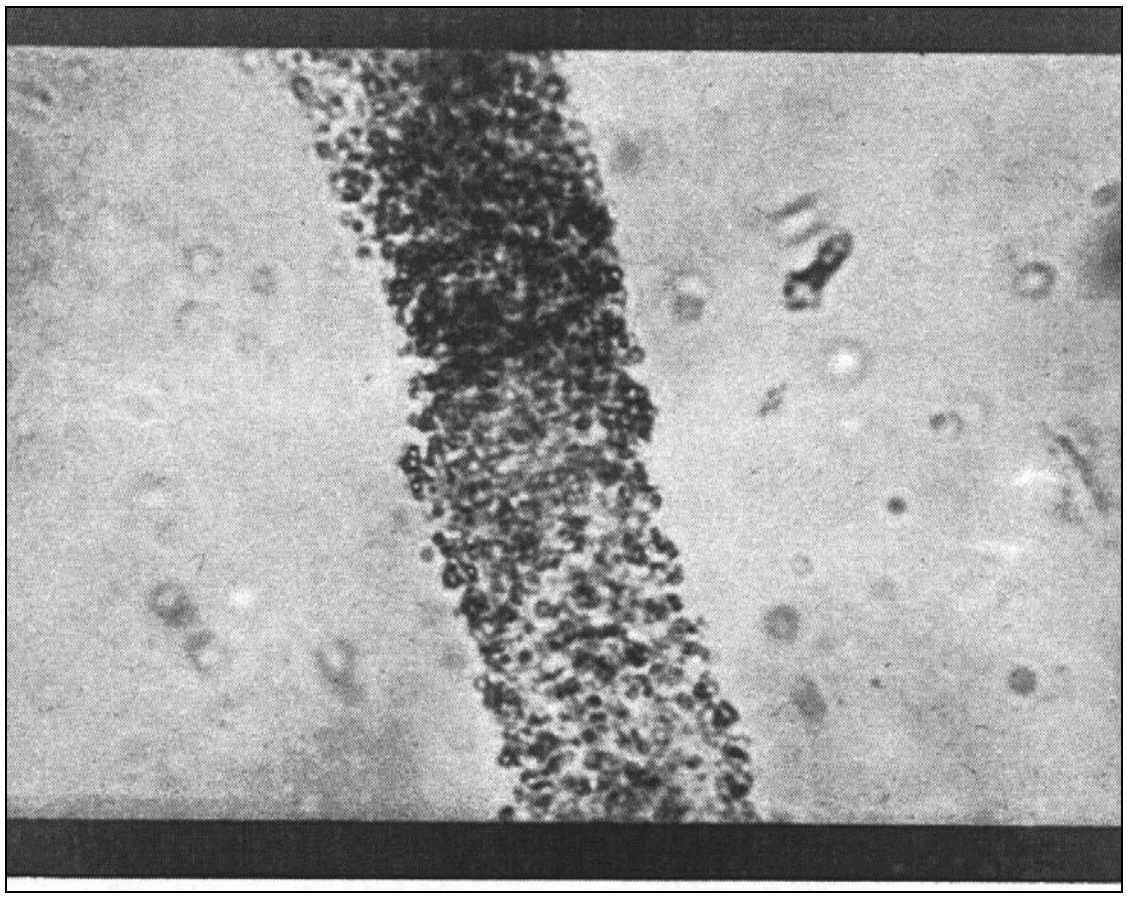


Figure 3-9. Granular casts.

(2) Finely granular casts. As the coarsely granular casts slowly pass on down the tubules, the cell degeneration continues until the granules are very fine. Thus, finely granular casts show a further degeneration of granules that have become much smaller in size than the coarse type. Since finely granular casts contain many minute granules, they are usually more opaque than simple hyaline casts. They are grey to pale yellow in color.

c. **Waxy Casts** (figure 3-10). Waxy casts, like hyaline casts, are homogenous. However, they are more opaque than hyaline casts and are a waxy yellow in color, resembling a structure made from paraffin. They tend to be short and broad with irregular broken ends. They can be distinguished from hyaline casts by a higher refractive index. Their size varies, and, at times, they may be extremely large and irregular. Waxy casts are considered to have remained in the tubules for a long time and represent the final stage in the deterioration of granular casts. They are indicative of localized oliguria or anuria and occur in cases of severe chronic renal disease.

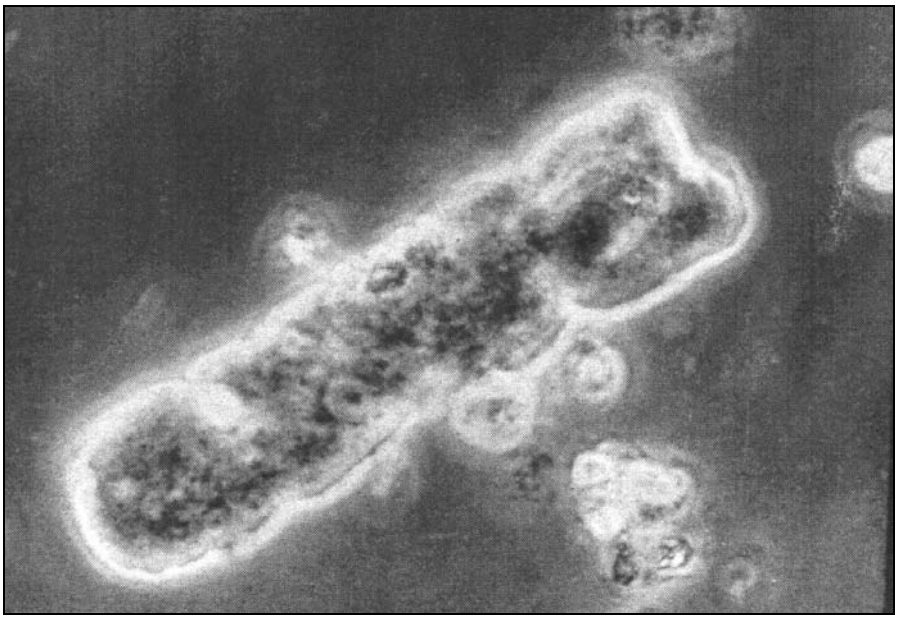


Figure 3-10. Waxy casts.

d. **Fatty Casts** (figure 3-11). The breakdown of the epithelial lining of the tubules may produce fat droplets instead of granules. These fat droplets are incorporated into the cast matrix to produce a fatty cast. Fatty casts are quite similar to waxy casts in appearance. However, the inclusion of the relatively large fat droplets makes them more refractile than either granular or waxy casts; they are lighter in color than waxy casts. Fatty casts are insoluble in acetic acid, but they are soluble in ether. They stain orange with Sudan III or black with osmic acid. Fatty casts are usually seen in degenerative tubular disease, associated with tubular deposition of fat and lipoid material.

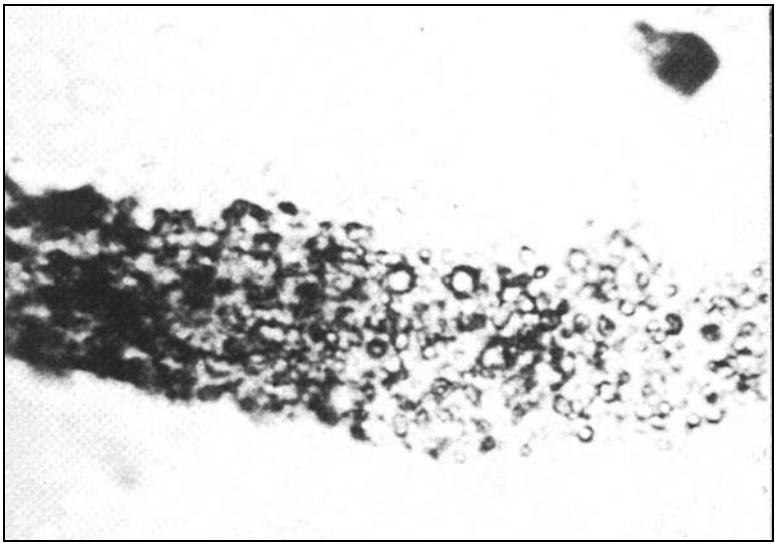


Figure 3-11. Fatty casts.

e. **Pigmented Casts**.

(1) Hemoglobin-pigmented casts (figure 3-12). Hemoglobin-pigmented casts are sometimes called true blood casts or fibrin clots. They contain hemoglobin from degenerated red blood cells. These casts are homogenous in texture with no perceptible cell margins; they are yellow to orange in color. The true blood cast must be distinguished from the hyaline red blood cell cast since they have different diagnostic implications. Some renal disorders increase the permeability of the glomerular membrane and, consequently, permit the passage of fibrinogen and numerous red blood cells into the glomerular filtrate. Such conditions can result in the formation of blood casts. The passage of fibrinogen through the glomerular membrane is significant because of the difference in the molecular size of serum globulin, serum albumin, and fibrinogen. As the fibrinogen molecule is larger than the albumin molecule, the passage of fibrinogen indicates a greater degree of glomerular damage than the passage of albumin.

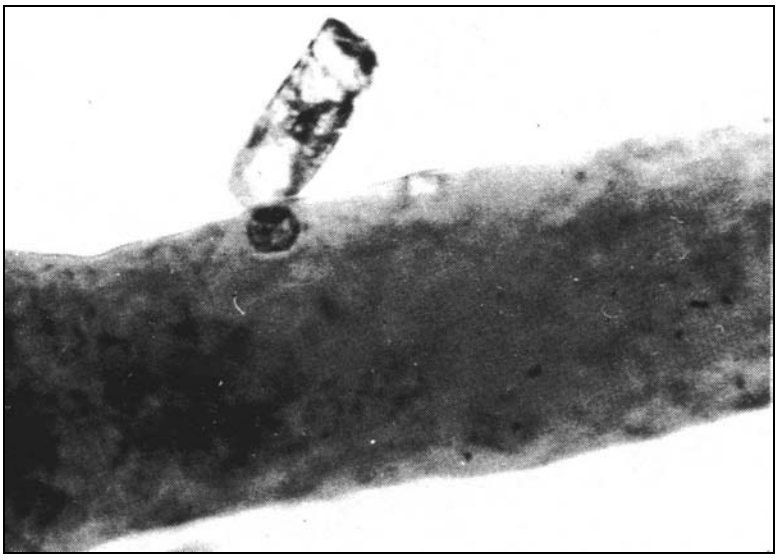


Figure 3-12. Hemoglobin casts.

(2) Myoglobin-pigmented casts. Myoglobin-pigmented casts are darker than hemoglobin-pigmented casts. The presence of myoglobin indicates muscular degeneration and glomerular damage.

(3) Bilirubin-pigmented casts. Casts pigmented with bilirubin are usually homogeneous and greenish-yellow in color. The presence of bilirubin provides microscopic evidence of liver disease.

3-11. CELLULAR CASTS

Cells can often adhere to a cast or become trapped within the cast matrix. When these entrapped cells are numerous, their names are used to designate the cast.

a. **White Blood Cell Casts** (figure 3-13). These casts are generally the same size and shape as hyaline casts, and are basically hyaline casts filled with leukocytes. An occasional white blood cell occurring within a cast has no serious implications; it is only when the casts are nearly or completely packed with leukocytes that they are designated as white blood cell casts. At times, it may be difficult to distinguish a white blood cell cast from a degenerated epithelial cell cast since the leukocytes have often degenerated and the details of the cell structure are not clear. White blood cell casts can be differentiated from epithelial casts by treating the cast with dilute acetic acid. This causes the nuclei of the leukocyte to become plainly visible. Identification is not difficult if the leukocytes are well preserved with visible nuclei and cell borders. White blood cell casts are a sign of intrinsic renal disease and are seen in suppurative diseases such as pyelonephritis and inflammatory conditions such as glomerulonephritis. If white blood cell casts are present, a bacteriological investigation of the urine is necessary.

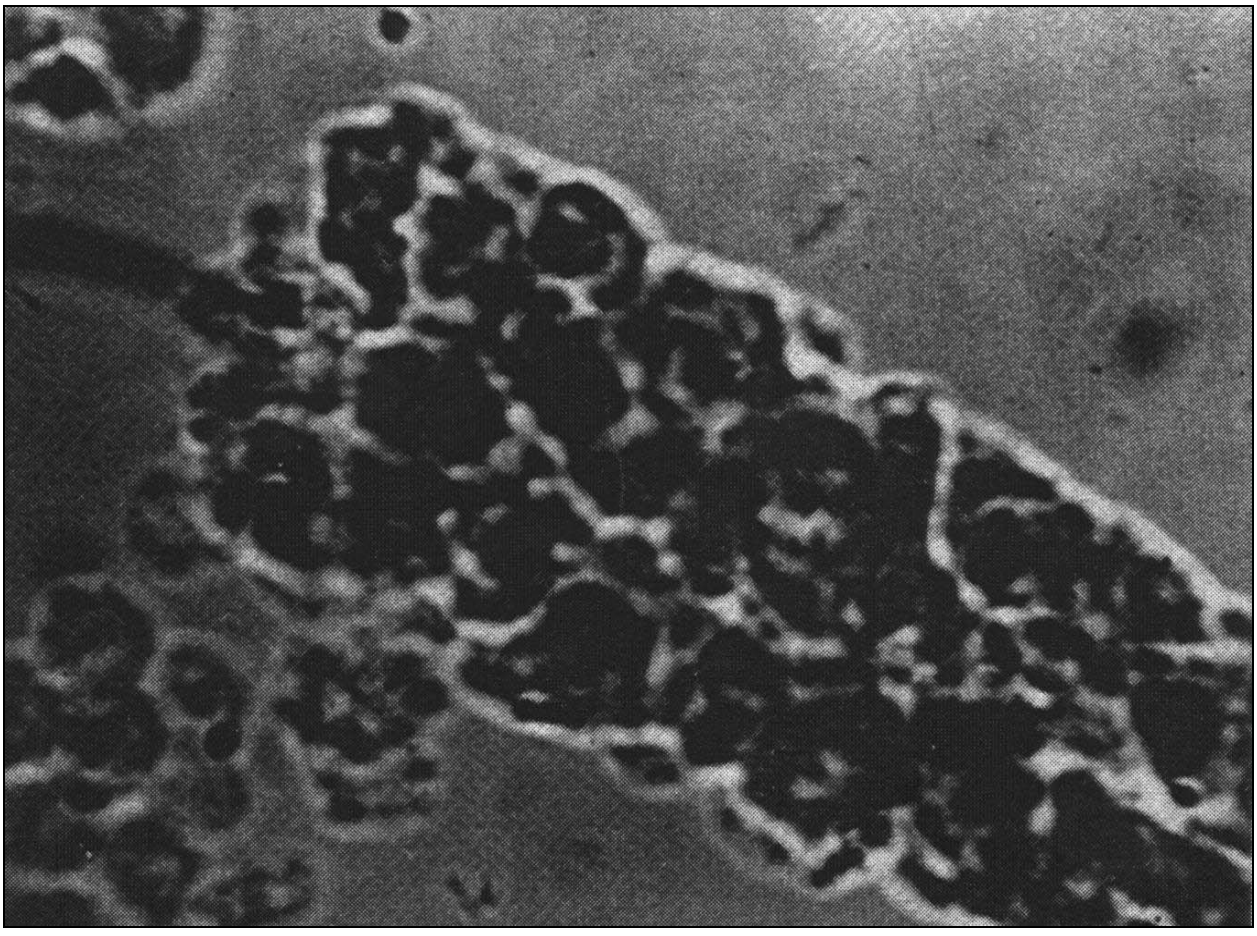


Figure 3-13. White blood cell casts.

b. **Red Blood Cell Casts** (figure 3-14). Red blood cell casts are hyaline casts containing erythrocytes and are usually orange to red in color. These casts are filled with intact erythrocytes, and one can readily distinguish the typical spherical shape of the cells as well as the distinct cell margins. Many red blood cells must be present in the matrix to call the structure a red blood cell cast. If only a few red blood cells are present, the cast is reported as hyaline with inclusions. As mentioned previously, if the erythrocytes have degenerated so that only the characteristic orange-red color of hemoglobin is present, the cast is termed a hemoglobin or true blood cast. Red blood cell casts are pathological and are usually indicative of bleeding into the tubules or of glomerular damage. Red blood cell casts are found in lupus, acute glomerulonephritis, bacterial endocarditis, and septicemias.

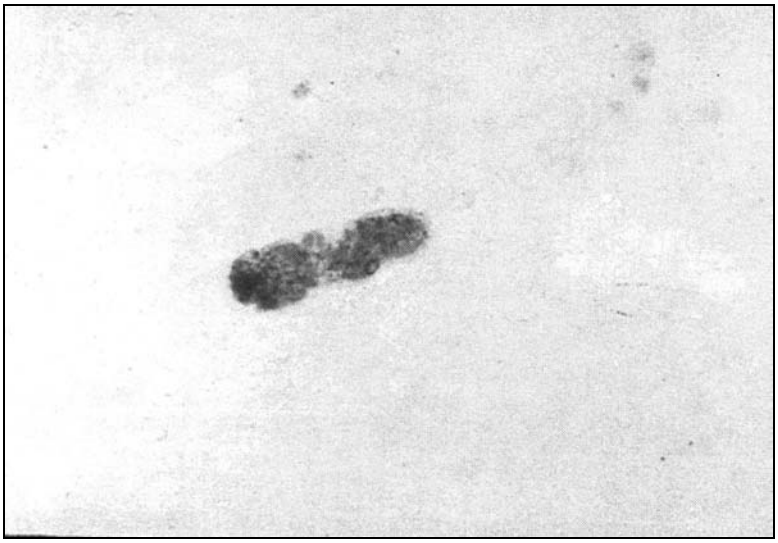


Figure 3-14. Red blood cell casts.

c. **Epithelial Cell Casts** (figure 3-15). When epithelial cells are sloughed off from the tubules, they tend to coalesce (grow together) and subsequently adhere to or become incorporated within a protein matrix. Such a structure is called an epithelial cell cast. These casts are usually swollen and tinged with a yellow or brown color. Generally, these casts are about the same size and shape as hyaline casts. They may also resemble white blood cell casts, although the epithelial cells within the cast may be larger than the leukocytes and usually show more fatty and hyaline cytoplasmic degeneration. Nevertheless, since they are frequently confused with white blood cell casts, 10 percent acetic acid is used to bring out the nuclei and aid in recognition of the cells. As explained previously, [para 3-10b(1), (2)], if the epithelial cells have deteriorated, granular casts, and ultimately, waxy casts are formed. Epithelial cell casts can signify aseptic degeneration of the renal tubules. If fat is present within the degenerating epithelial cells, the nephrotic syndrome may be indicated. The ingestion of phosphorus, carbon tetrachloride, or bichloride of mercury results in tubular necrosis that is manifested by the presence of large numbers of tubular epithelial casts containing deteriorated cells.

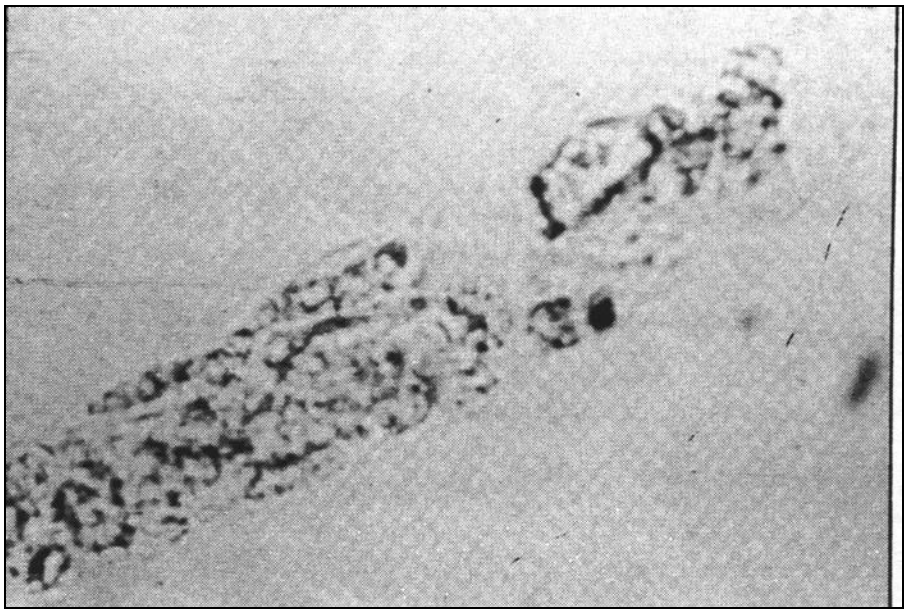


Figure 3-15. Epithelial cell casts.

d. **Mixed Cell Casts**. Mixed cell casts sometimes appear in urine. They are about the same size and shape as hyaline casts and may contain white blood cells, red blood cells, and epithelial cells, or any combination of these structures. They are classified according to the predominant element present.

3-12. PSEUDOCASTS

Occasionally, due to inexperience, someone may identify a structure as a cast only to discover upon reexamination that the object looked like a cast, but was actually something else.

a. **Cylindroids** (figure 3-16). Cylindroids are an unusual type of hyaline cast and are often called pseudocasts. They are composed of clear hyaline material and have ends which taper to slender, twisted, or curled tails. They are often irregular and striated and may contain fat globules. Cylindroids are usually found in conjunction with hyaline casts and proteinuria, although their origin and process of formation are unclear. They have generally the same diagnostic significance as hyaline casts and could possibly result from inflammation in the renal pelvis or ureter.

b. **Mucus Threads** (figure 3-17). Mucus threads are long, slender, transparent strands, which can occur normally in small numbers. Increased numbers tend to be present in various urinary tract infections or irritations. They are often twisted into various formations, and this characteristic aids in distinguishing them from casts.

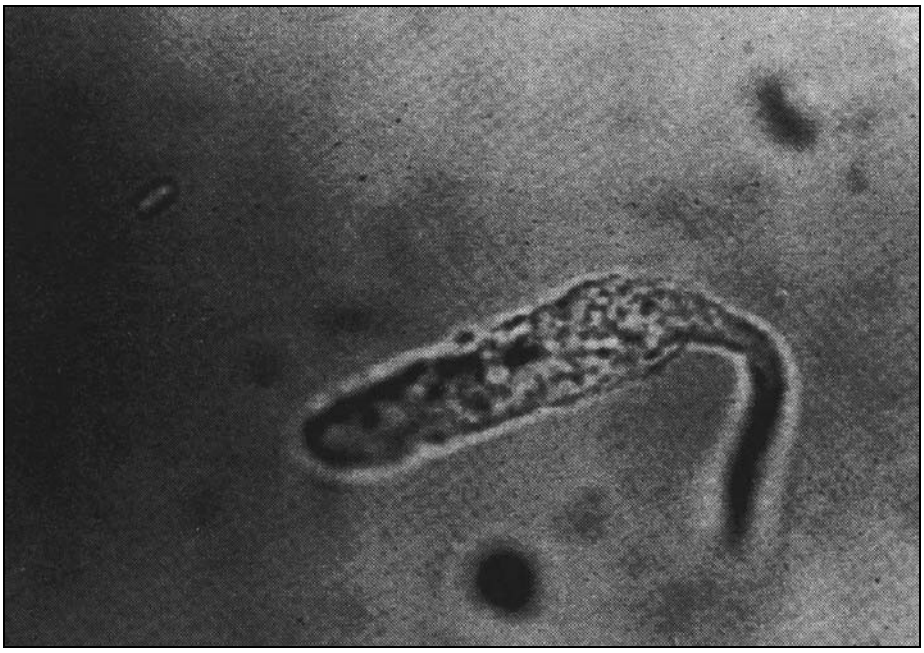


Figure 3-16. Cylindroids.

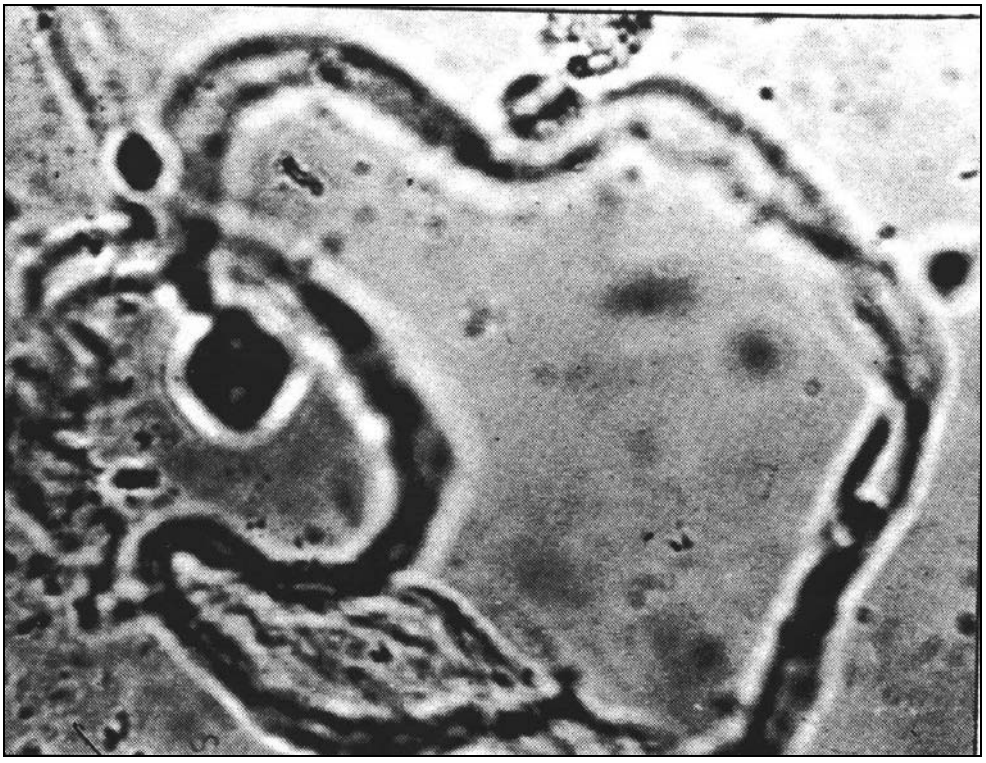


Figure 3-17. Mucus threads.

Section III. MICROSCOPIC EXAMINATION OF UNORGANIZED SEDIMENT

3-13. INTRODUCTION

a. **Significance.** Unorganized sediment includes amorphous structures such as urates and phosphates as well as crystals. Crystals are termed unorganized urinary sediment although they usually manifest distinct, specific, and characteristic forms. In general, crystals found in urine have little or no diagnostic importance. Most of them have been precipitated because they are present in excessive amounts or their solubility has changed as a result of temperature decrease. Crystal deposition is also likely if the urinary pH has altered due to changes in dietary habits. Although the majority of crystals found in fresh urine are not clinically significant, they may be important if present in large numbers; in this case, they may be associated with the formation of urinary calculi. Likewise, certain other pathologies are accompanied by the excretion of abnormal crystals (for example, cystinuria) or by elevated excretion of normal sediments (for example, gout).

b. **Classification.** Unorganized sediments are usually classified according to the pH of the urine in which they occur most frequently. This method of classification is helpful, but many exceptions can occur. The characteristic sediments of acid urine may remain after the urine has become alkaline; likewise, typically alkaline sediments may be precipitated in a urine that is still acid. In addition, as the specimen ages, the number of crystals appearing in the specimen increases. The crystals that are present in acid urine are described first, followed by an account of crystals occurring in alkaline urine.

3-14. NORMAL CRYSTALS FOUND IN ACID URINE

It is important to be able to identify normal crystals found in urine so that one can recognize the presence of abnormal crystals.

a. **Uric Acid Crystals** (figire 3-18). Uric acid crystals are often found in acid specimens, particularly after standing for extended periods of time. If uric acid crystals are found in a fresh sample, a stone may be present in the renal system. These crystals can also be found in 16 percent of patients with gout. However, their presence does not necessarily indicate a pathological condition. Uric acid and its derivatives dissolve if the specimen is warmed. Uric acid crystals are found in many different forms and are greatly divergent in size and shape. They may take the form of prisms, plates, rosettes, and sheaves. They are yellow or reddish-brown in color, and may, like urates, impart a cloudy or milky appearance to the specimen. The yellow color of this crystal is its most characteristic attribute.

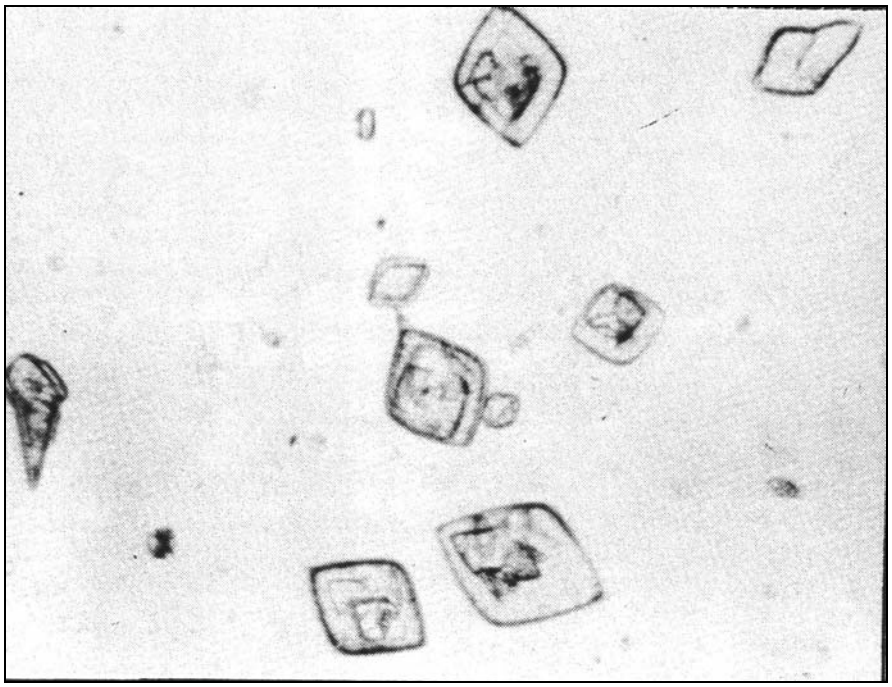


Figure 3-18. Uric acid crystals.

b. **Amorphous Urate Crystals** (figure 3-19). Amorphous urates appear as a granular precipitate having a brick-red color. Under the microscope, they can appear as fine yellowish granules, and at times they are almost colorless. They can be dissolved by treatment with alkali or by gentle heating of the urine. Amorphous urates are also dissolved by adding acetic acid or hydrochloric acid; after standing, they become colorless, rhombic uric acid crystals.

c. **Calcium Oxalate Crystals** (figure 3-20). Calcium oxalate crystals are commonly found in acid urine but may also be seen in neutral or slightly alkaline specimens. They are usually not significant, and their presence is frequently the result of a diet rich in oxalic acid (for example, tomatoes, spinach, rhubarb, and asparagus). Calcium oxalate crystals vary greatly in size and shape but are generally seen as colorless, dodecahedral (12-sided) or octahedral (8-sided) crystals. They resemble small squares crossed by two intersecting diagonal lines giving them an "envelope" appearance. They may also appear as dumbbells or spheres and may tend to form urinary calculi. They are soluble in hydrochloric acid and not in acetic acid.

d. **Sodium Urate** (figure 3-21). These crystals are usually fan-shaped and may be yellow in color.

e. **Calcium Sulfate** (figure 3-22). These crystals, which are rarely observed, are colorless and assume the form of long needles or elongated prisms.

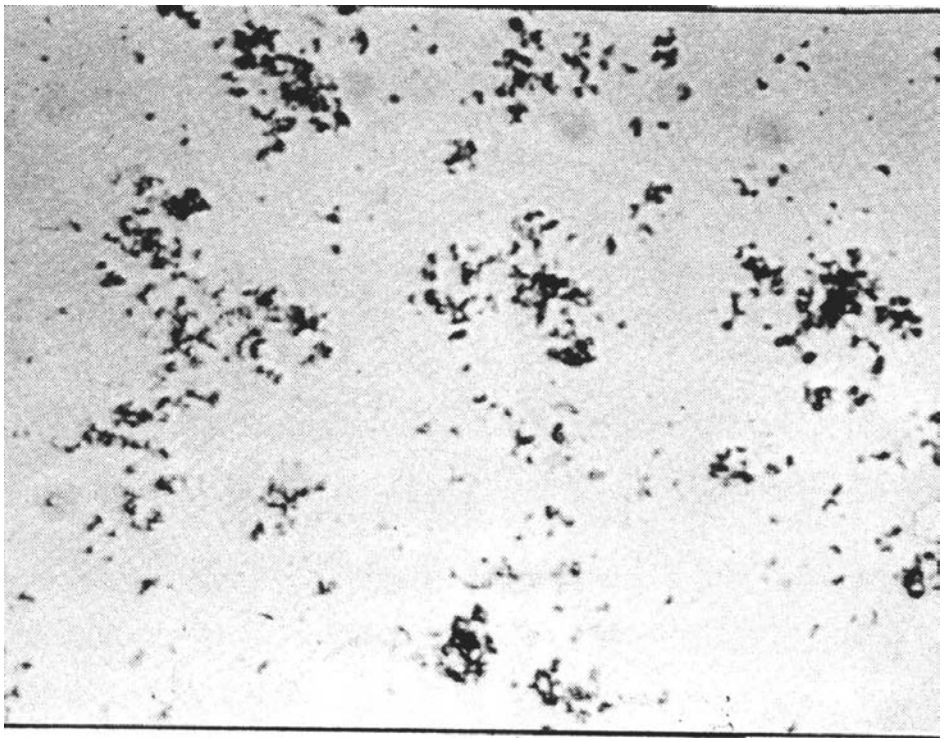


Figure 3-19. Amorphous urate crystals.

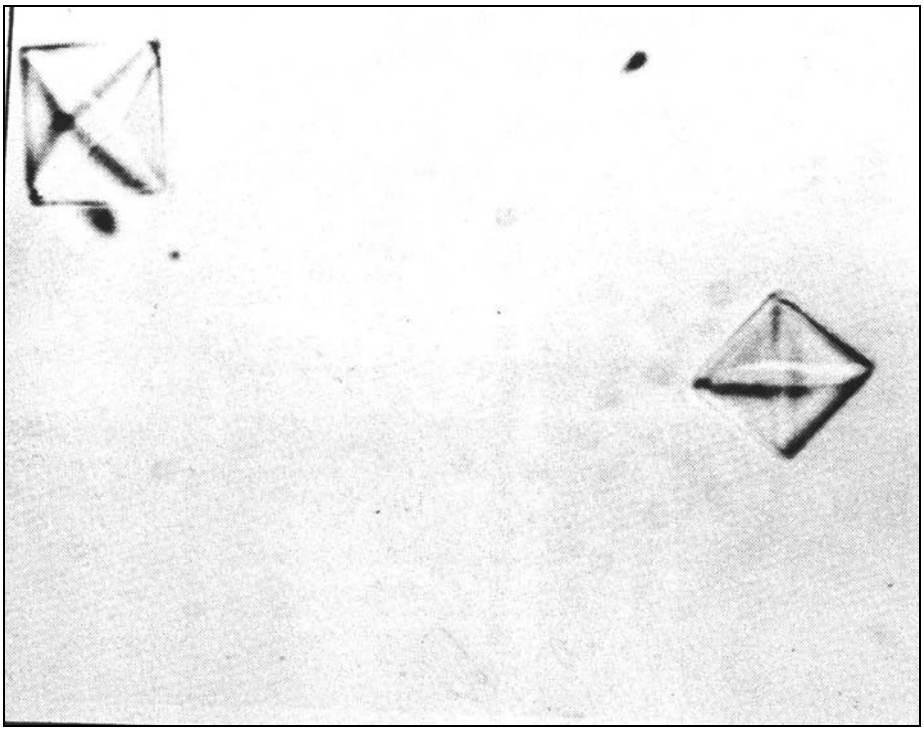


Figure 3-20. Calcium oxalate crystals.

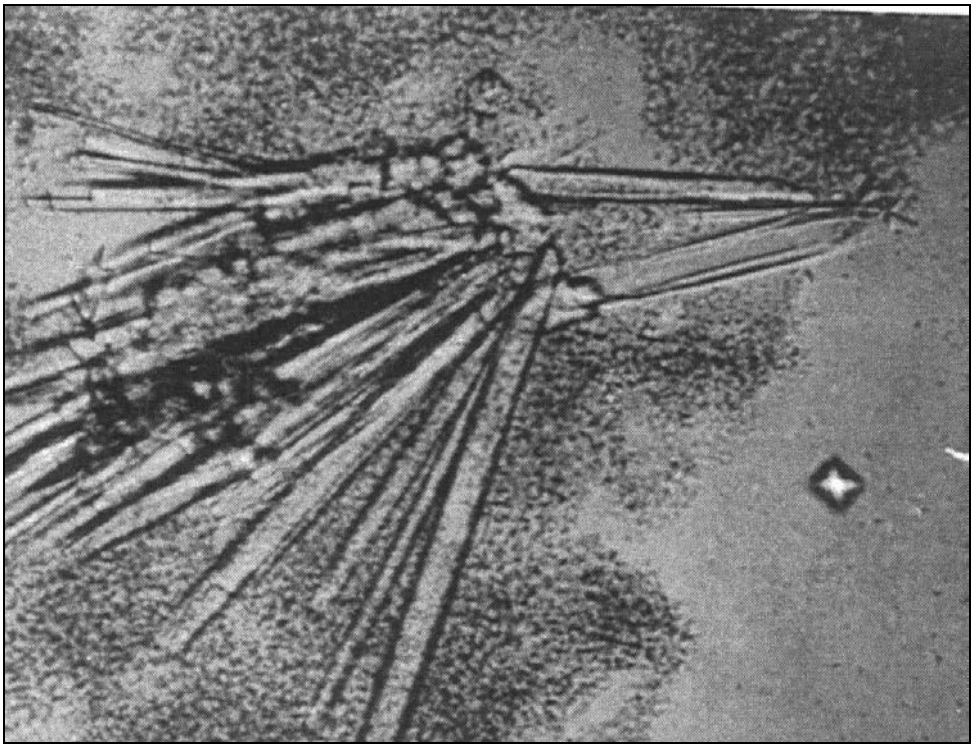


Figure 3-21. Sodium urate crystals.

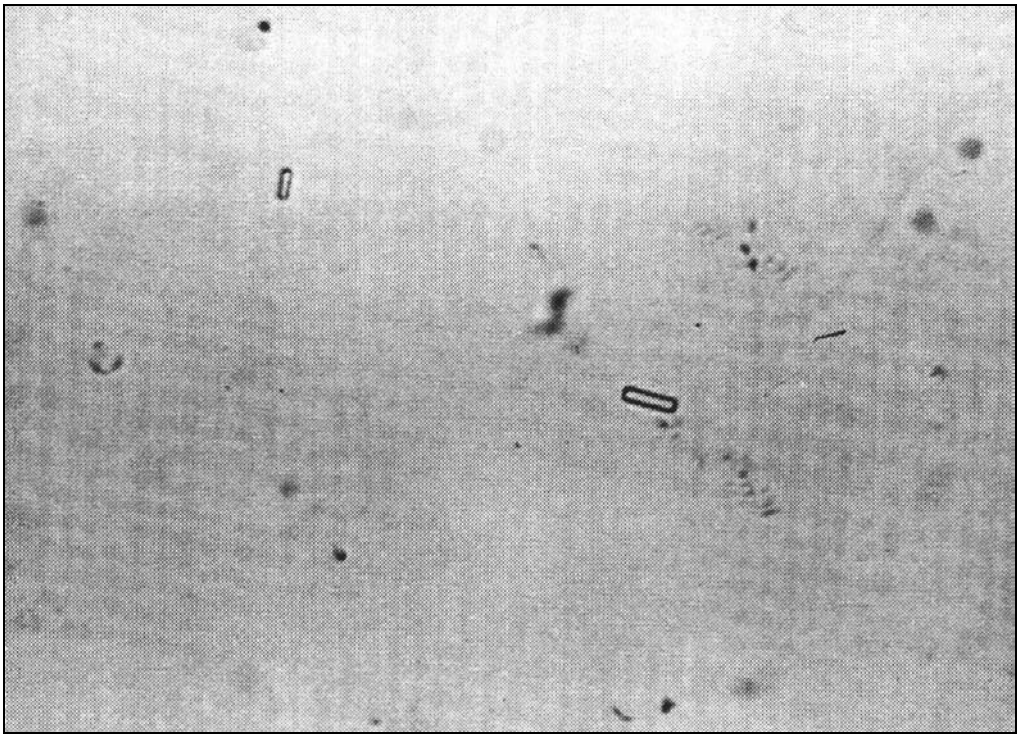


Figure 3-22. Calcium sulfate crystals.

3-15. ABNORMAL CRYSTALS FOUND IN ACID URINE

Although small amounts of the chemicals from which "abnormal" crystals are derived occur normally in urine, the appearance of the substance in crystalline form is frequently of clinical significance.

a. **Leucine/Tyrosine** (figure 3-23). Leucine and tyrosine crystals are cleaveage products of protein and usually occur simultaneously. They are not common and, if present in urine, usually indicate liver damage. Leucine crystals are yellowing, oily spheres often possessing radial and concentric striations. Tyrosine crystals appear black and resemble very fine needles arranged in sheaves with a constriction in the middle. Both leucine and tyrosine have been found following sulfonamide therapy. Leucine and tyrosine crystals may be differentiated to some degree by their different solubilities in the following substances:

	Hydrochloric acid	Dilute acetic acid	Alkali
Leucine	not soluble	not soluble	soluble
Tyrosine	soluble	not soluble	soluble

It should be noted that leucine, unlike tyrosine, is soluble in acetic acid if it is boiling. In addition, chemical tests exist to differentiate between the two crystals and confirm microscopic examination. First, albumin is removed from the specimen, which is evaporated to a small volume. One portion is fixed at pH 5.8 for leucine and another portion at pH 6.8--7.0 for tyrosine. These portions are placed in the refrigerator, and the tests are subsequently performed.

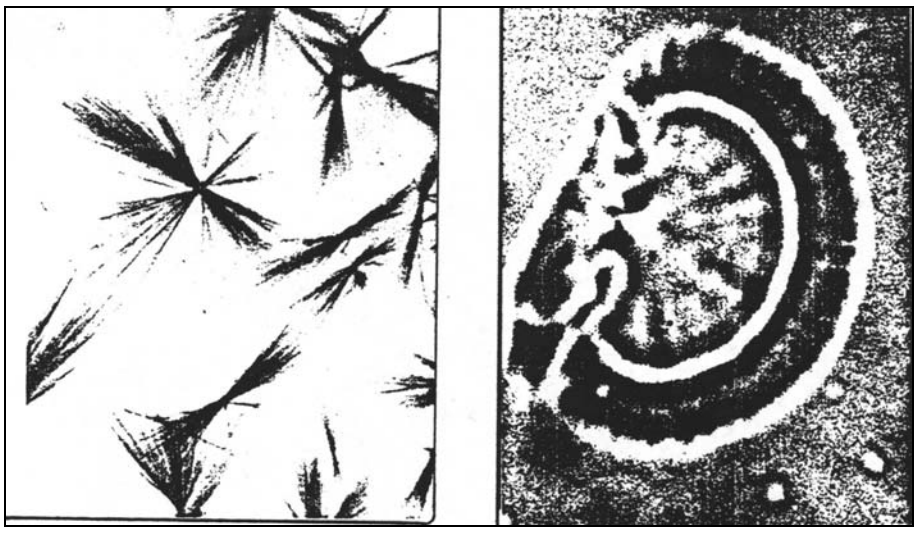


Figure 3-23. Tyrosine/leucine crystals.

(1) Test for leucine. The crystals are dissolved in a little water and a drop of 10 percent copper sulfate is added. Leucine produces a blue color that remains after heating.

(2) Test for tyrosine. The crystalline precipitate is added to a few milliliters of Morner reagent. It is then heated to boiling. If the crystals are tyrosine, they will produce a green color. Morner reagent is composed of 1 part formalin, 45 parts water and 55 parts sulfuric acid.

b. **Cystine** (fig. 3-24). Cystine is a breakdown product of protein which appears very rarely. The crystals occur in acid urine as colorless, highly refractile hexagonal plates with unequal sides. These crystals are not soluble in acetic acid, but they are soluble in hydrochloric acid or alkali. In cystinuria, an inborn metabolic error, the crystals appear very frequently. Cystine may be identified using a chemical test by the following procedure:

STEP 1: Place an Acetest Tablet in a spot plate depression.

STEP 2: Add 1 drop of 10 percent sodium cyanide in 1 mol/L sodium hydroxide to the tablet.

STEP 3: Then add one drop of urine to the tablet.

STEP 4: Observe the color of the solution around the tablet at 1 minute. A cherry-red color indicates more than 25 milligrams of cystine per 100 milliliters of sample.

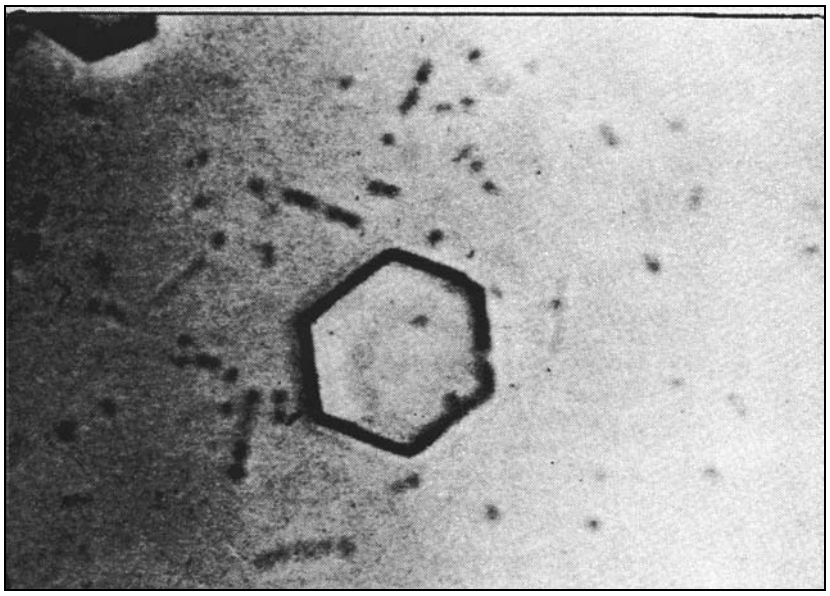


Figure 3-24. Cystine crystals.

c. **Cholesterol** (figure 3-25). Cholesterol crystals are another form rarely found in urine. They appear in acid specimens as large, flat, transparent plates with abrupt edges and characteristic missing corners. They are quite soluble in chloroform and ether but are insoluble in alcohol. Cholesterol crystals often accompany chyluria, which results from an abdominal or thoracic obstruction to proper lymph drainage. These crystals may also appear in urine as a result of severe urinary tract infections or nephritis.

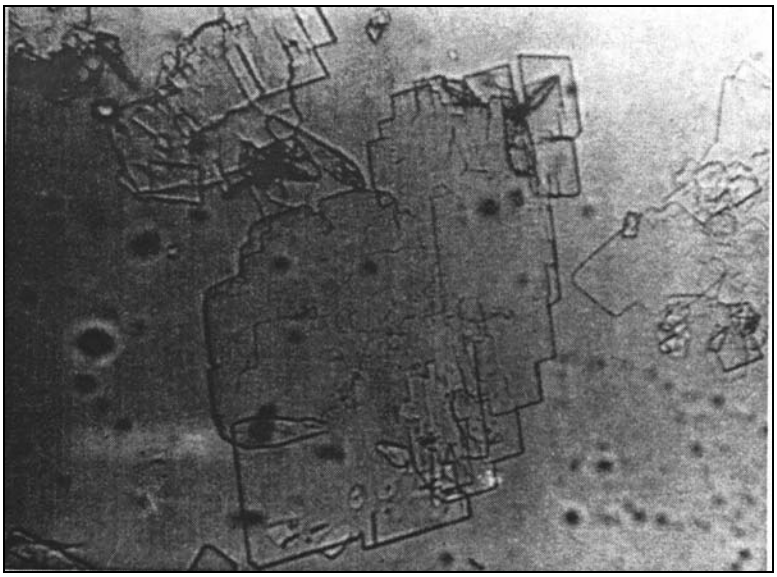


Figure 3-25. Cholesterol crystals.

d. **Sulfonamide Crystals**. Following sulfonamide therapy, crystals of the drug, or a derivative, may be found in acid specimens. The sulfa compounds are more soluble in an alkaline pH and the maintenance of alkaline urine during drug administration may be required. The purpose of this alkalinity is to prevent crystallization of sulfa compounds in the kidney tubules with resulting damage. The various sulfa drugs have different crystalline forms that are often colored. A relatively simple way of identifying sulfa crystals is to dissolve the drug being administered in an alkaline solution, evaporate the solution almost to dryness, and compare the resulting crystals with those observed in the urine. Also to be included as an identifying test for sulfa crystals is the Hallay Test. Most sulfa compounds react with crude paper in the presence of acids, to form a yellow to orange color. Place 2 drops of urine on a blank strip of newspaper or paper towel. Add 1 drop of 25 percent hydrochloric acid. The immediate appearance of a yellow to orange color is positive for a sulfa compound.

(1) Sulfanilamide (figure 3-26). These crystals are seen in the form of transparent bars or needles which may be grouped in sheaves.

(2) Sulfathiazole (figure 3-27). The form assumed by this crystal is a hexagonal plate or "shock of wheat" with central binding.

(3) Sulfadiazine (figure 3-28). These crystals are in the form of "shocks of wheat" with the binding toward one end, or they may resemble burrs.

(4) Sulfaguanidine (figure 3-29). These crystals appear as either needles or plates.

(5) Sulfapyridine (figure 3-30). Crystals of this drug resemble arrowheads or flower petals.

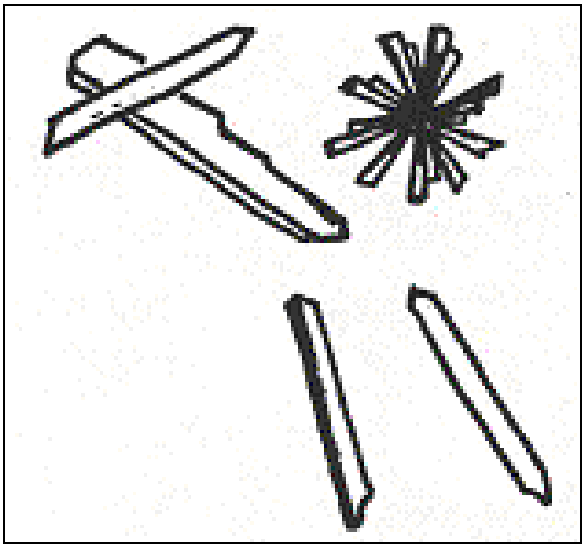


Figure 3-26. Sulfanilamide crystals.

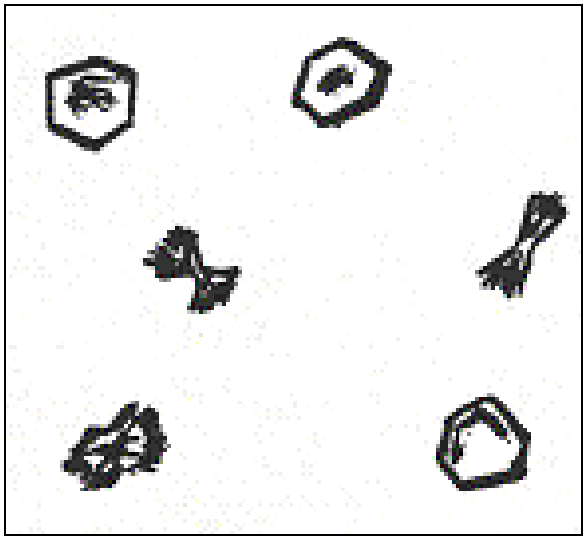


Figure 3-27. Sulfathiazole crystals.

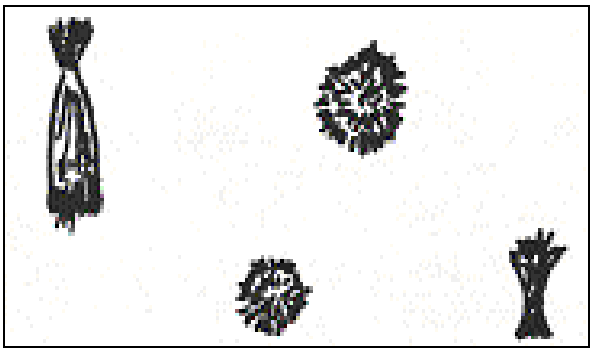


Figure 3-28. Sulfadiazine crystals.

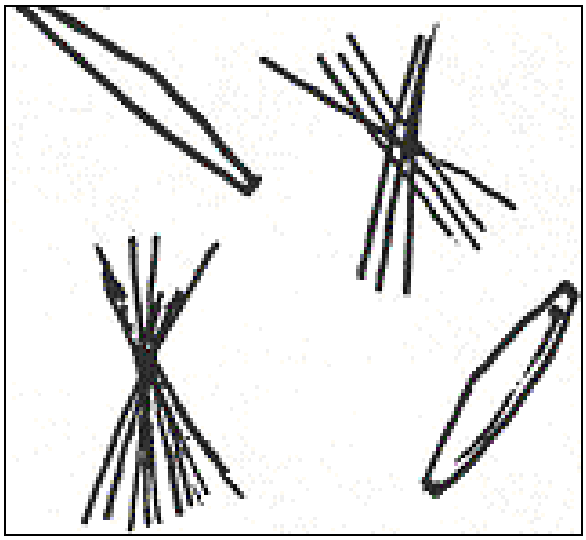


Figure 3-29. Sulfaguanidine crystals.

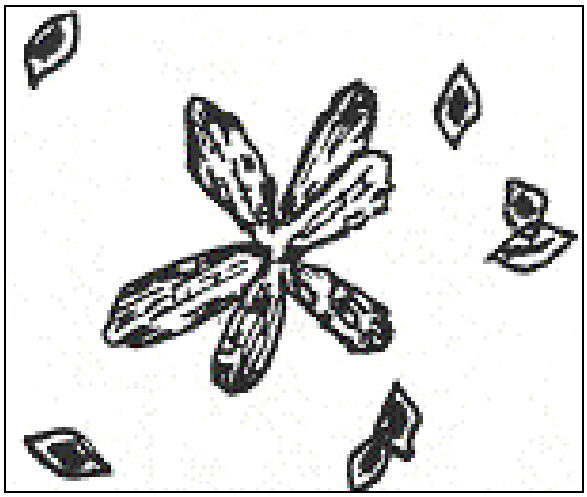


Figure 3-30. Sulfapyridine crystals.

3-16. CRYSTALS FOUND IN ALKALINE URINE

Amorphous phosphate, triple phosphate (ammonium magnesium phosphate), calcium phosphate, and ammonium urate crystals are frequently found in alkaline urine specimens. The phosphates are all soluble in acetic acid and may be differentiated from other crystals by this characteristic. They have no clinical significance unless present in large numbers and are always found in urine that has been standing for an extended period of time.

a. **Amorphous Phosphates** (figure 3-31). The amorphous phosphates are common in alkaline urine and appear as a granular white amorphous precipitate. They are soluble in acetic acid.

b. **Triple Phosphate** (figure 3-32). Triple phosphate crystals manifest a typical coffin lid shape with three, four, or six sides. The edges may frequently appear colored due to light diffraction. When they are artificially precipitated or rapidly deposited, they can assume feathery, leaf-like forms. In alkaline urine, they are occasionally seen as large, irregular, flat, granular plates that float on the surface and resemble iridescent scum. Although characteristically present in alkaline urine, triple phosphate crystals may also occur in neutral or slightly acid specimens. They dissolve in 100 percent acetic acid without effervescing. Triple phosphates may appear in the urine after the ingestion of fruits.

c. **Calcium Phosphate and Dicalcium Phosphate** (figure 3-33). These crystals are usually found in alkaline urine and are deposited in several forms. Frequently calcium phosphate forms large, thin, granular, colorless plates. Dicalcium phosphate may appear as colorless prisms arranged in star or rosette patterns. The individual prisms are usually slender with one beveled, wedge-like end.

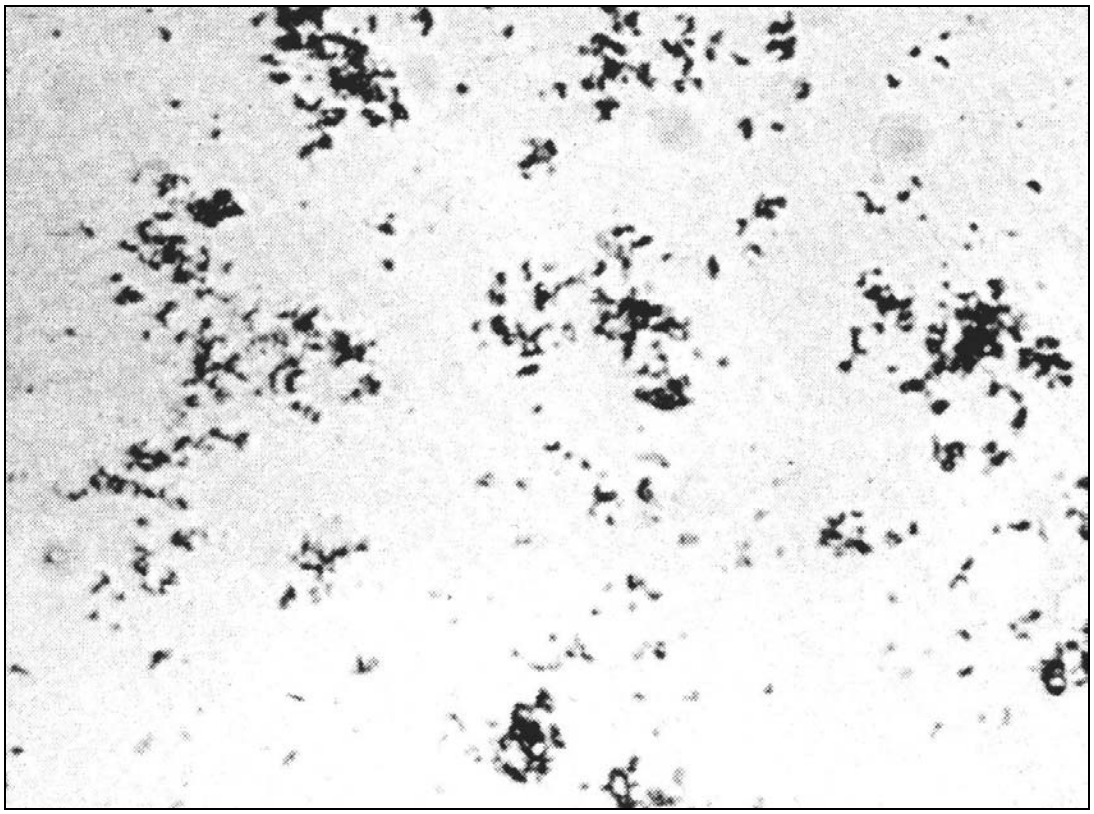


Figure 3-31. Amorphous phosphates crystals.

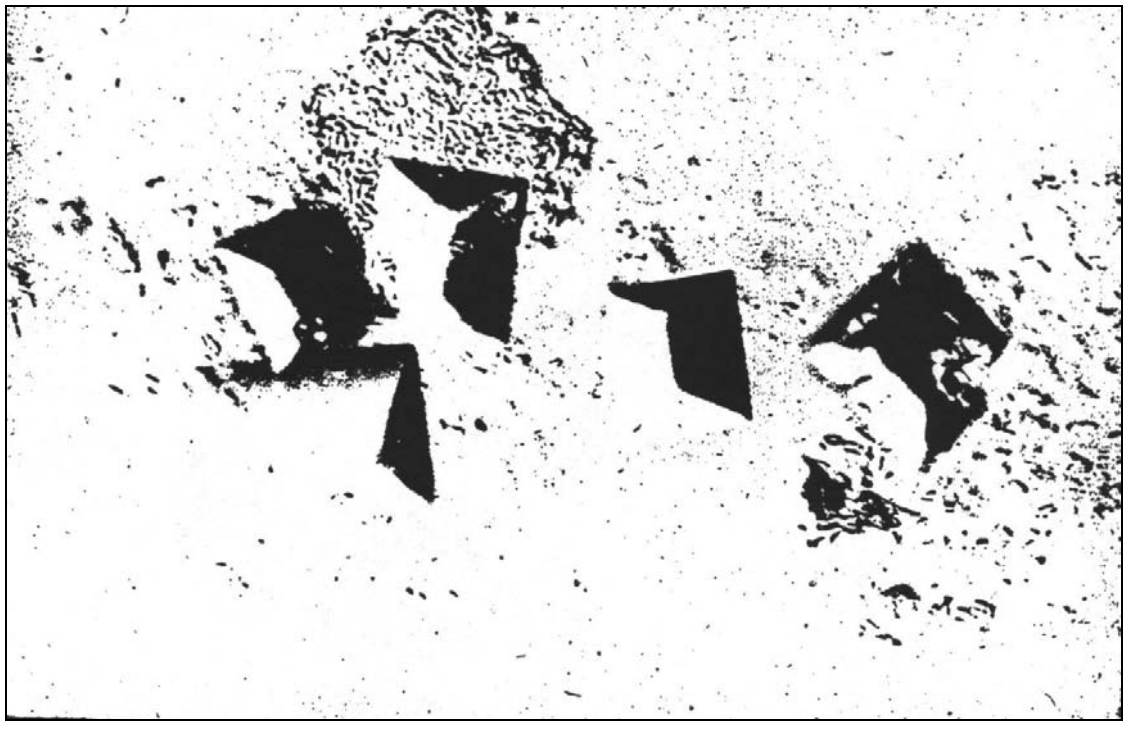


Figure 3-32. Triple phosphate crystals.

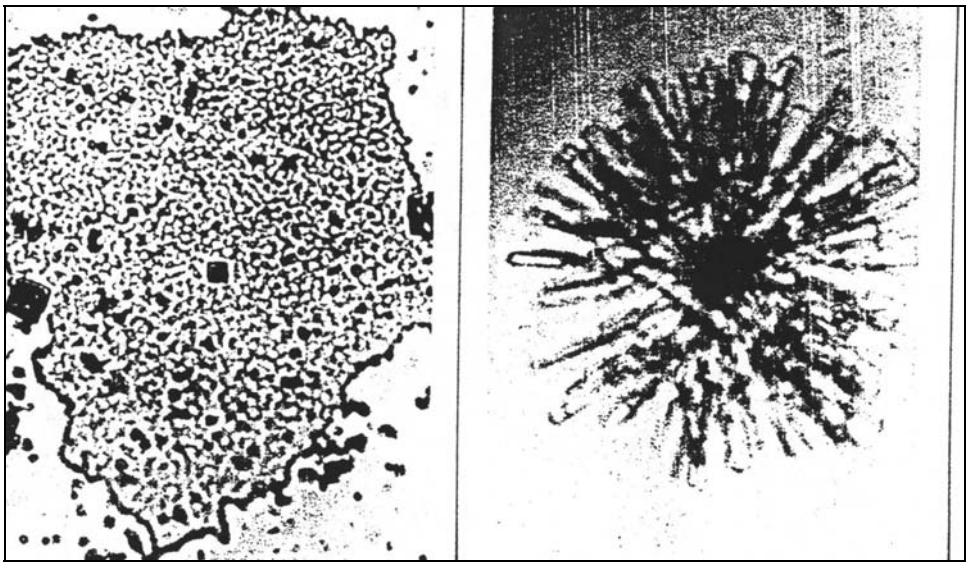


Figure 3-33. Calcium phosphate/dicalcium phosphate crystals.

d. **Ammonium Urates** (figure 3-34). Ammonium urate crystals are precipitated when free ammonia is present as a result of bacterial action on long standing specimens. They are often seen when phosphates are present in the specimen. Ammonium urate crystals can be found in several different forms; they can appear as sheaves of fine needles, as dumbbells, and as "thorn apple" crystals, which are yellow, opaque, sphere-like bodies with irregular, spine-like projections. They can be dissolved by heating and by the addition of acetic acid, which, upon standing, results in the formation of colorless uric acid crystals.

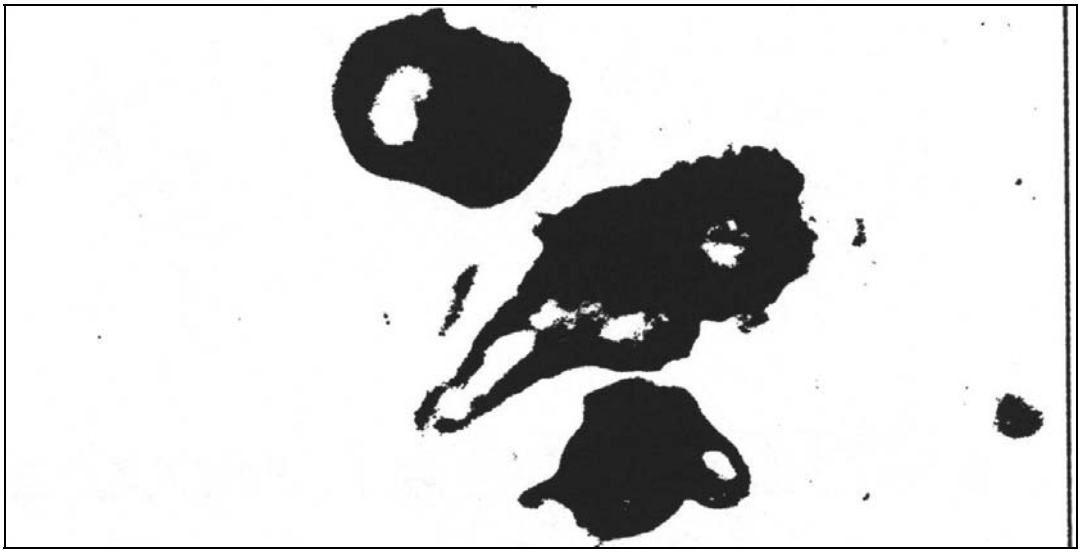


Figure 3-34. Ammonium urate crystals.

e. **Calcium Carbonate** (figure 3-35). Calcium carbonate crystals occur as amorphous granules or small, colorless spheres with a dumbbell shape. If 10 percent acetic acid is added to alkaline urine containing calcium carbonate crystals, they dissolve, and a gas is evolved as indicated by effervescence. This gas is CO_2 (carbon dioxide).

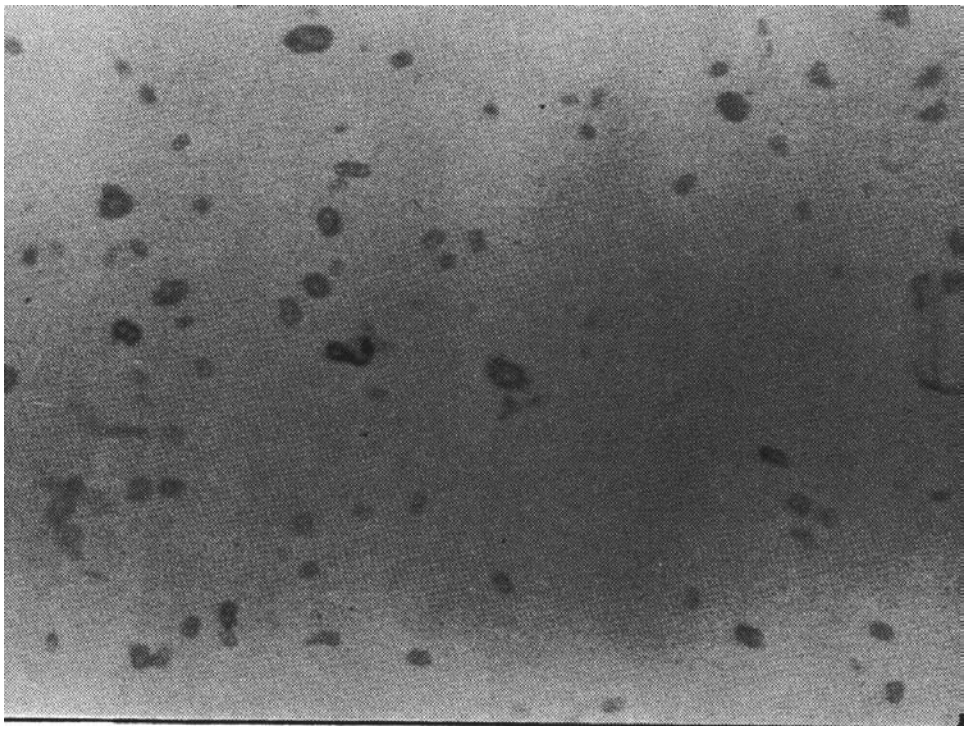


Figure 3-35. Calcium carbonate crystals.

3-17. EXTRANEOUS STRUCTURES

The presence in urine of extraneous materials, both organic and inorganic, can produce serious confusion and error in interpreting results. A number of circumstances can lead to contamination by foreign materials. Allowing urine to stand may result in such bacterial growth that the specimen becomes useless for analysis. Excessive exposure to air can cause confusing crystal formation. Unclean glassware frequently leads to contamination and subsequent misinterpretation; disposable containers should be used to avoid this problem. Contaminants may also be introduced from the lower urinary tract, from the external genitalia, and from fecal matter. Thus, great care should be taken while obtaining and preparing a specimen. A brief account is given of some of the common extraneous substances that may be present in urine.

a. **Bacteria.** Bacteria are not present in normal urine except as contaminants. Bacteria multiply rapidly and cause a uniform cloudiness throughout the sample. If they are found in a freshly voided specimen, urinary tract infection may be indicated. Large numbers of bacteria can give a positive test for protein.

b. **Parasites.** Parasites are sometimes found in urine. Animal parasites are relatively uncommon. Flagellates (such as Chilomastix mesnili and Trichomonas hominis), Schistosoma haematobium, and filaria are seen. One can also find the ova of intestinal parasites (for example, the ova of Enterobius vermicularis). Trichomonas vaginalis is by far the most common parasite present in urine.

c. **Spermatozoa** (figure 3-36). Spermatozoa are easily identified by their characteristic shape and affinity for stains, especially methylene blue or Gram stain. They have no pathological significance and are reported only if the physician or pathologist has specifically requested a sperm report.

d. **Yeast Cells** (figure 3-37). Yeast cells resemble erythrocytes and leukocytes but usually show characteristic budding. They are nonnucleated and are insoluble in acetic acid. Yeast cells may be found in the sediment of a diabetic and of females but generally appear as contaminants. Their presence should be reported with some indication of the numbers present.

e. **Foreign Elements Resembling Organized Sediments (Artifacts)**. The main sources of contamination are improperly cleaned specimen bottles and slides. A number of contaminants resemble blood cells and parasites, and may be mistaken for these structures. Scratched slides, glass chips, dirty eyepieces, and smudged objectives often cause confusion. It is wise to rotate the eyepiece periodically to be certain that extraneous structures, which may adhere to the eyepiece are not being identified as objects of significance contained in the specimen.

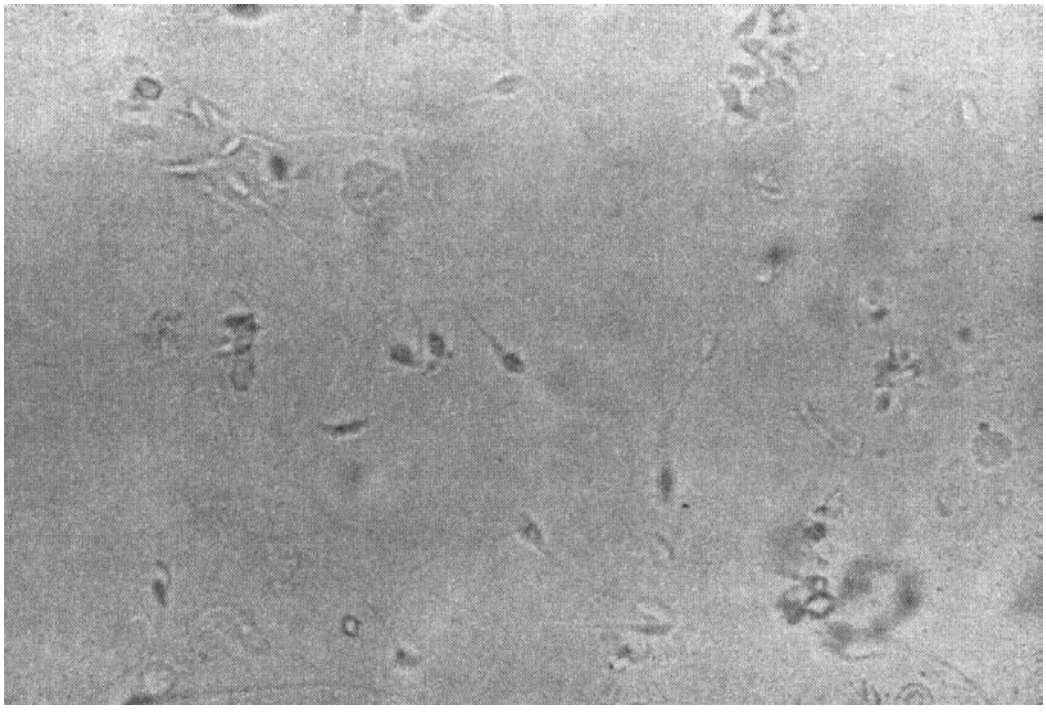


Figure 3-36. Spermatozoa.

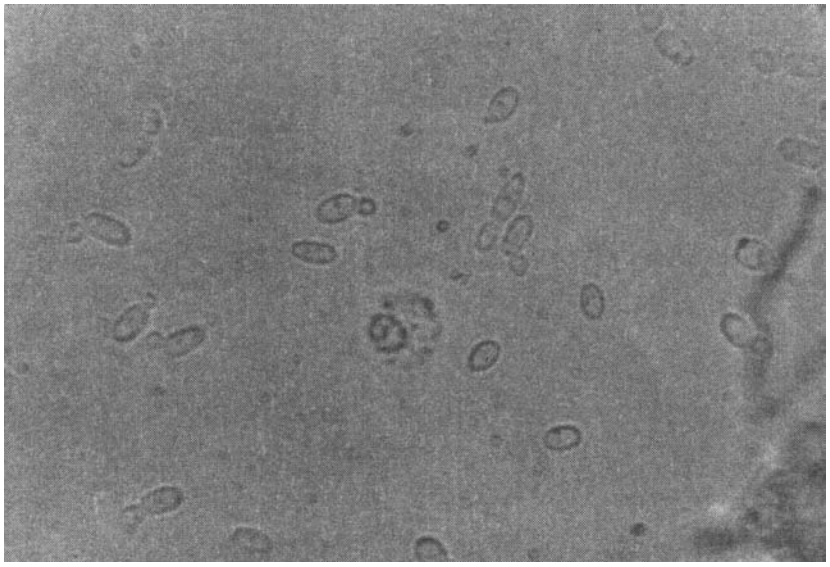


Figure 3-37. Yeast cells.

(1) Starch granules (figure 3-38). These granules vary in shape and size. They turn blue-black upon the addition of iodine.

(2) Oil droplets (figure 3-39). Oil droplets are spherical and show concentric rings of light refraction upon focusing up and down with the fine adjustment. There is a wide variation in size.

(3) Pollen granules (figure 3-40). Pollen granules may be confused with erythrocytes or parasites. They vary in size and appearance according to their source. Those illustrated represent only a few of the many different types.

(4) Diatoms (figure 3-41). Diatoms are one-celled plants which may be introduced into collecting bottles with tap water. Those illustrated here represent only a few of the many different types.

(5) Rotifers. Rotifers are unicellular animals with a pointed tail-like projection on one end. They appear in urine specimens when contaminated water is used to wash urine containers.

(6) Hyphae of molds (figure 3-42). The hyphae of molds are frequently mistaken for hyaline casts. The high degree of refraction of mold hyphae, the jointed or branching structures, and the accompanying spores should be looked for in order to identify them as mold hyphae.

(7) Cloth fibers (figure 3-43). Fibers of wool, cotton, silk, or other materials are sometimes mistaken for casts. One should become familiar with the appearance of such materials by suspending samples in water and examining them microscopically.

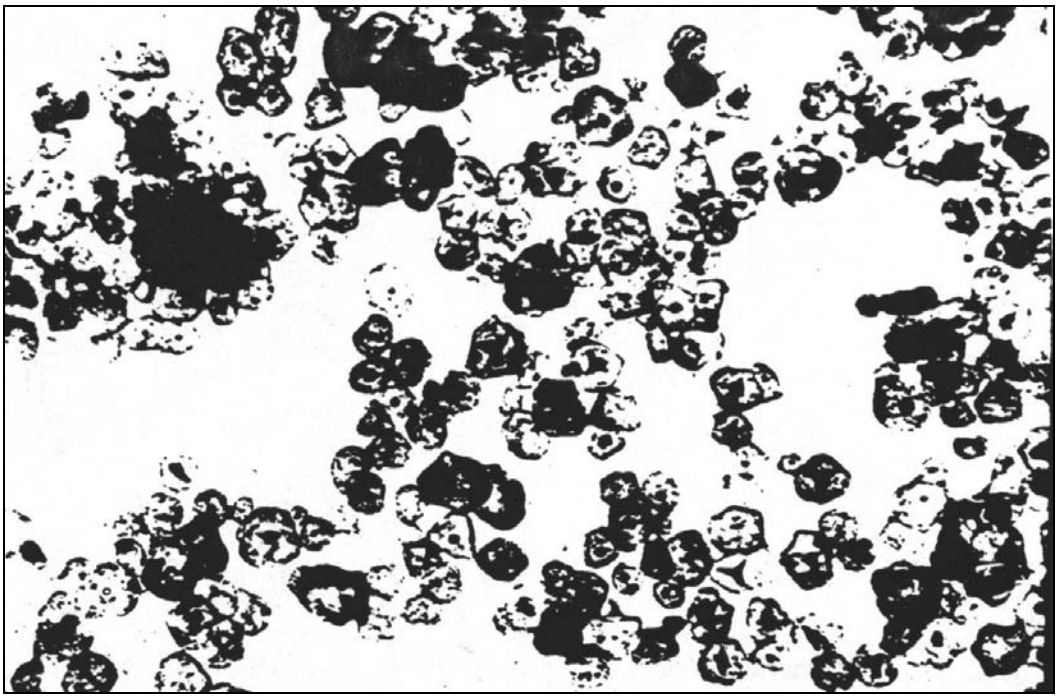


Figure 38. Starch granules.

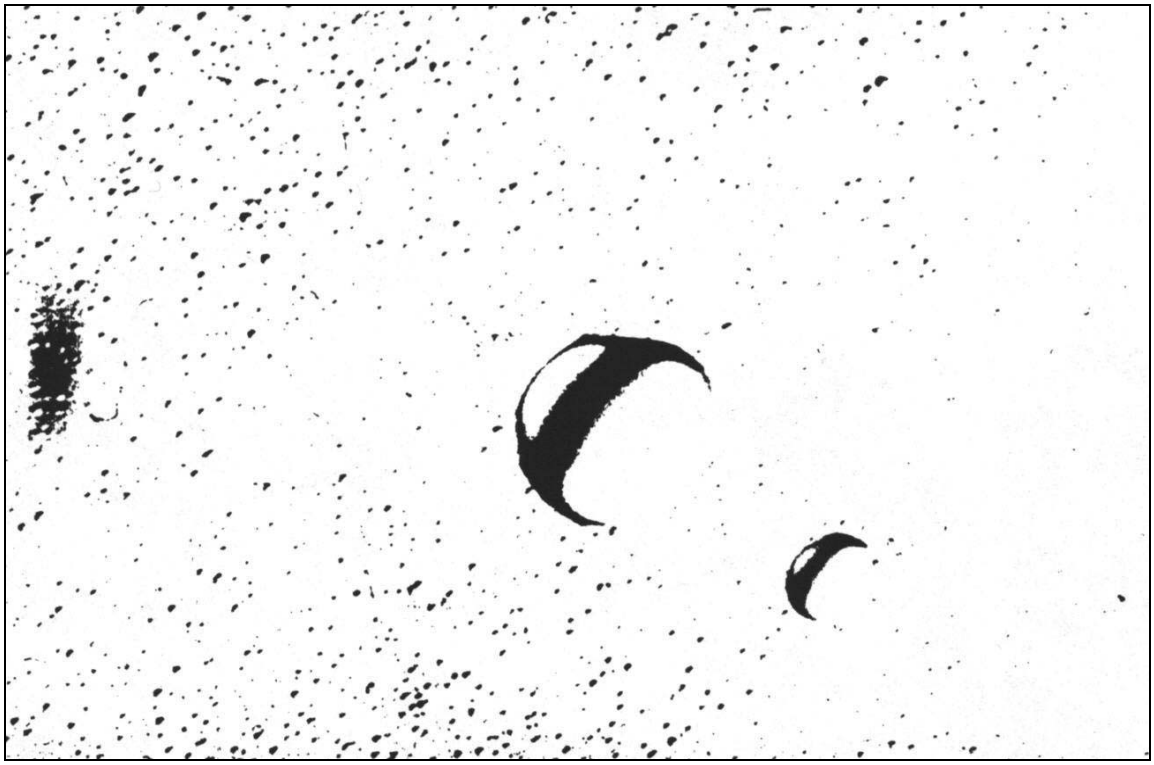


Figure 3-39. Oil droplets.

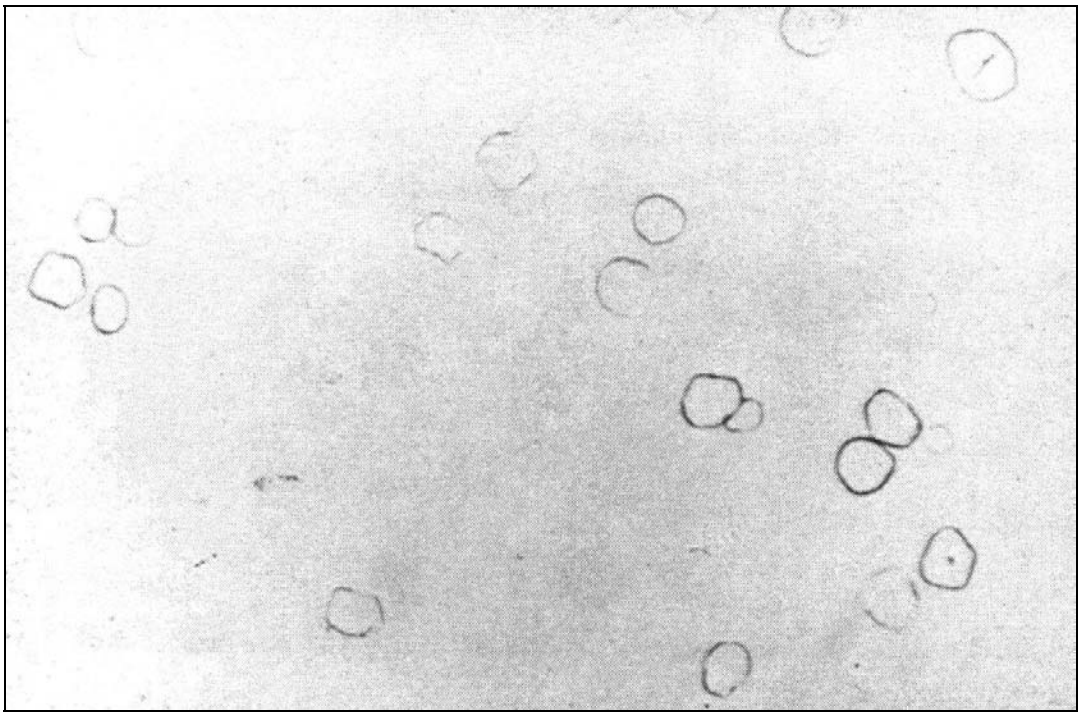


Figure 3-40. Pollen granules.

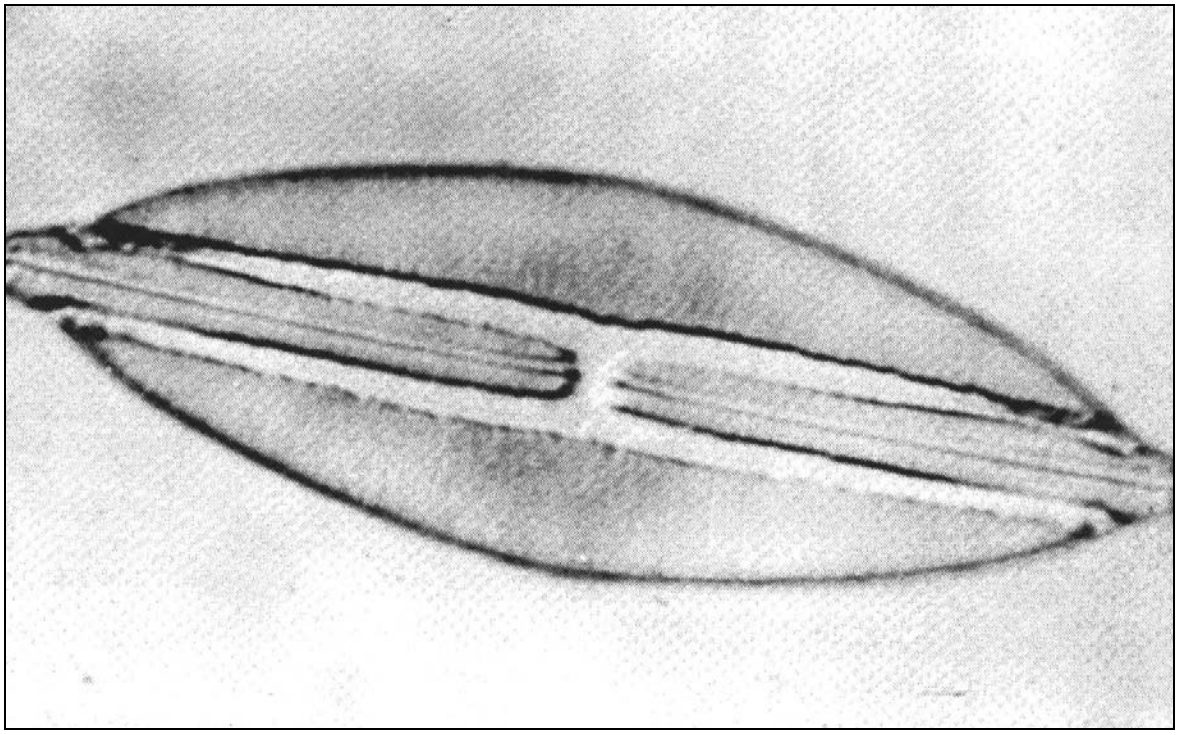


Figure 3-41. Diatoms.

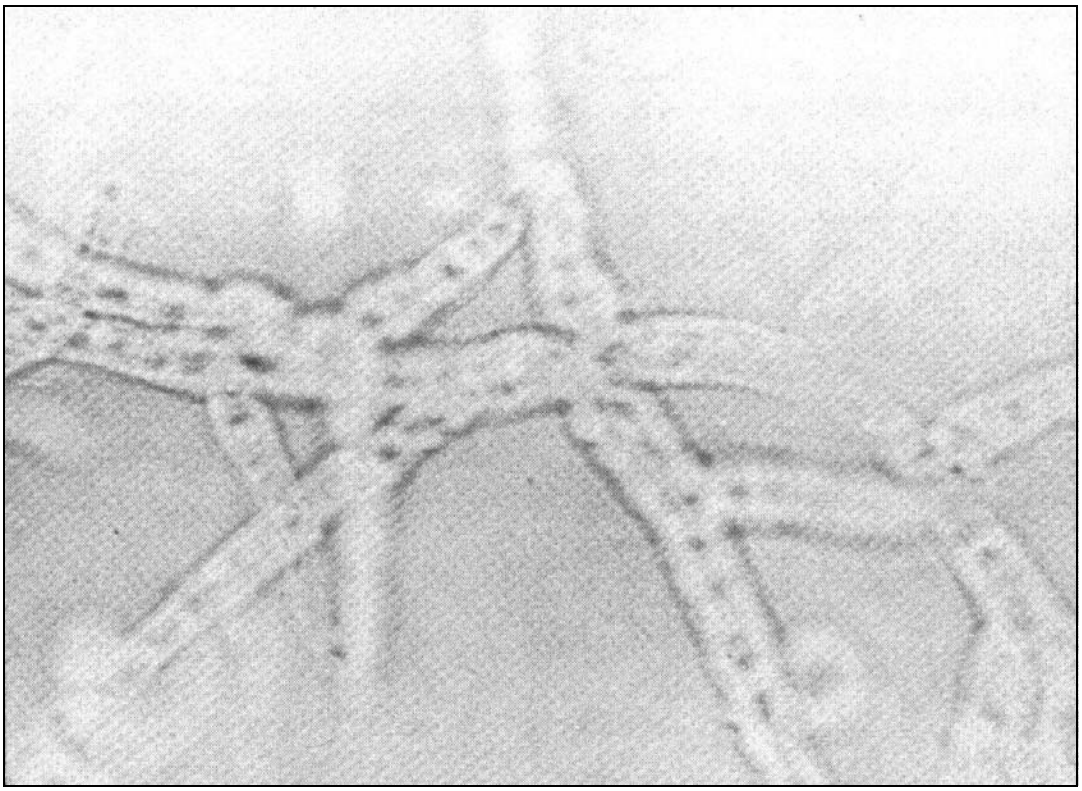


Figure 3-42. Hyphae of molds.

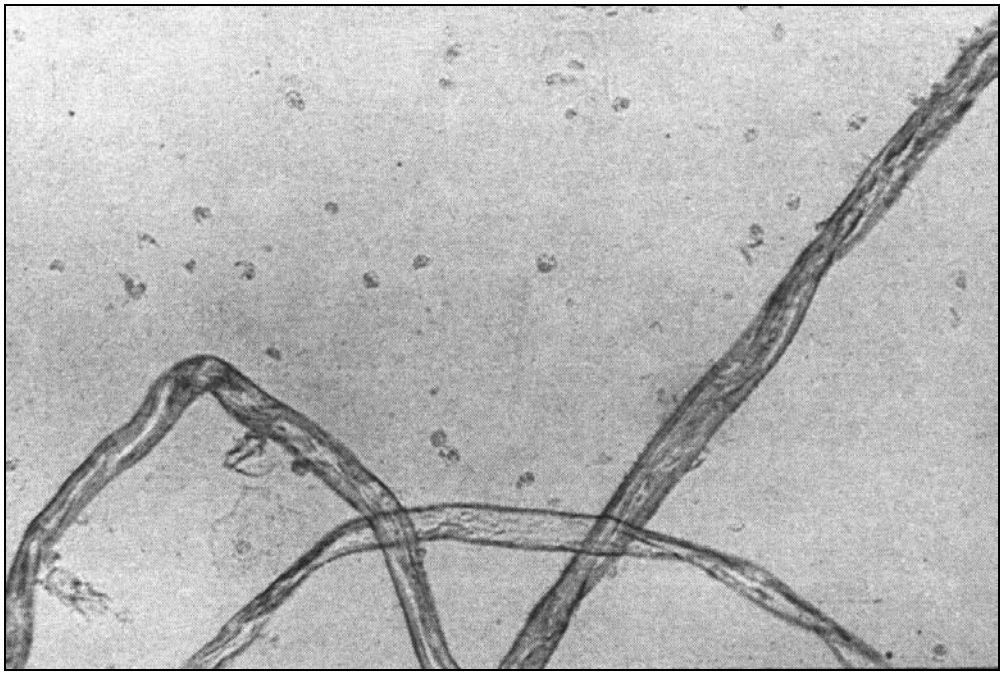


Figure 3-43. Cloth fibers (cotton fibers).

Section IV. THE MICROSCOPIC EXAMINATION OF STAINED URINARY SEDIMENT USING THE STERNHEIMER-MALBIN STAIN

3-18. INTRODUCTION

The Sternheimer-Malbin (S-M) stain is named for the two American workers who developed and pioneered its use. For convenience, it is frequently called the "S-M stain." The descriptions of the urinary structures that follow are made with reference to this stain only.

3-19. FORMULA

a. **Stock Solution A.** Stock solution A is made by dissolving 3.0 g of crystal violet (gentian violet) in 20.0 mL of 95 percent ethyl alcohol, adding 0.8 g of ammonium oxalate, and diluting to a final volume of 80.0 mL with distilled water. The reagent may be stored indefinitely.

b. **Stock Solution B.** Stock solution B is composed of 0.25 g of safranin dissolved in 10.0 mL of 95 percent ethyl alcohol and diluted to a final volume of 100.0 mL with distilled water. It also is good indefinitely.

c. **Working Solution C.** Working solution C, which must be replaced every 3 weeks, is made by mixing 3 parts of solution A and 95 parts of solution B. The solution is filtered and stored in a dropper bottle. It is important to filter solution C every 3 days during use so that particles of precipitated stain do not interfere with microscopic examination.

3-20. DISCUSSION

All basic ingredients of the S-M stain are also components of the gram stain for bacteria and can be found in any medical laboratory. It is basically a general stain for most organized structures. In addition, it is both convenient and economical since the chemicals are readily available. The preparation of the urinary sediment is the same as for a routine analysis of unstained sediment, and all the structures have the same basic recognizable features as unstained structures. The S-M staining procedure is not intended to replace any method for the identification of elements found in urinary sediment. Instead, the real value of the staining technique is its use as an aid in making a more rapid and accurate analysis of the urinary sediment.

3-21. PROCEDURE

A 10 mL to 15 mL sample of well-mixed urine is placed in a standard conical centrifuge tube. The urine is centrifuged at 1500 rpm for five minutes. The supernatant urine is discarded, and the sediment is resuspended by vigorous "finger-flicking." The

staining procedure is quite simple. A drop of stain is added for each estimated drop of sediment. The sediment and stain are mixed by "finger-flicking" and then examined under the microscope, using a cover slip.

3-22. WHITE BLOOD CELLS

White blood cells are characterized by lobulated nuclei and relatively scant cytoplasm. The nuclei of granulocytes (granular white blood cells; neutrophils, eosinophils, and basophils) stain either pale blue or dark red to purple.

a. **Pale-Staining Variety.** The pale-staining variety is often larger than the dark-staining variety. Occasionally these granulocytes may be small with a glassy appearance and with an indistinct nucleus. However, they usually appear swollen and variable in shape. The nucleus is typically multilobulated or divided into four separated nuclei; it stains a very light blue. The cytoplasm of such cells contains granules, which show brownian movement if the specific gravity of the urine is not too low. As this brownian movement causes a constant variation of reflected light, the pale-staining white blood cells are often termed "glitter cells." Previously these cells were regarded as specific for pyelonephritis. However, it has been shown that glitter cells can be seen in almost any active urinary tract infection. Apparently pale-staining white blood cells are still living and are unable to bind dye molecules.

b. **Dark-Staining Variety.** Dark-staining white blood cells represent inert forms that have undergone autolysis and thus have binding sites available to take up the dye. These cells have dense, purple nuclei. Granules in the cytoplasm are either not evident or are characterized by a purple granularity. They are generally uniform in size and occur commonly in lower urinary tract infections with renal involvement.

3-23. EPITHELIAL CELLS

a. **Renal Epithelial Cells.** Renal epithelial cells are only slightly larger than white blood cells. They have a very thin rim of cytoplasm and a round nucleus with a dark band of chromatin at the periphery. The cytoplasm stains an orange-purple color.

b. **Bladder Epithelial Cells (Caudate Cells).** Bladder epithelial cells are frequently boat-shaped (navicular cells), and some appear to have tails. The cells with tails are often called caudate cells. These cells also have a round nucleus. However, they have more cytoplasm than the renal cell, and the cytoplasm is distinctively pale blue with occasional inclusions.

c. **Squamous Epithelial Cells.** Squamous epithelial cells have small, dark purple, pyknotic (thickened, shrunken) nuclei, and extensive pale purple cytoplasm. They frequently occur in sheets. It is not possible to differentiate squamous cells by their site of origin.

3-24. CASTS

a. **Waxy Casts.** Waxy casts represent the ultimate stage in cellular degeneration. Their typical features are a homogeneous "ground glass" appearance, indentations, and angulation. The ends are sharp as if they were broken off. They stain pale pink or may not stain at all.

b. **Hyaline Casts.** Hyaline casts stain pale pink to light purple and have a homogeneous matrix. These casts are much more readily observed with the S-M stain than without any stain. However, at times these casts may not stain at all.

c. **Granular Casts.** The individual cells, which originally composed the coarsely granular cast have lost their integrity and demonstrate indistinguishable cell margins. The granules stain deep purple. The finely granular casts have fine granules, which stain a lighter purple and the hyaline matrix is light pink.

d. **Red Blood Cell Casts.** Red blood cell casts appear as hyaline casts with unstained or pale lavender red blood cells in a pale pink hyaline matrix.

3-25. MISCELLANEOUS STRUCTURES

a. **Crystals.** Crystals have the same general appearance when they are stained as when they are unstained. However, it should be noted that improper filtration can result in a precipitate of the stain which can be confused with various types of crystals. Therefore, it is crucial that the staining solution be filtered properly before using it.

b. **Spermatozoa**. Spermatozoa appear as usual except for the heads, which stain purple or blue. For this reason, they can be confused with other structures when the tail is not attached.

c. **Trichomonas.** They stain a pale blue with a purple nucleus.

d. **Bacteria.** Bacteria vary in color when stained due to their great diversity.

e. **Identification of Double Refractile Fat Bodies.** Refractile fat bodies often occur together with fatty casts. Therefore, one must be quite careful in identifying fat bodies. Staining and the use of polarized light facilitate the examination for fat bodies, particularly those containing cholesterol. Under polarized light, the double refractile bodies stand out against a dark background. They also manifest the distinctive Maltese cross pattern whereby the body appears to be divided into four quadrants. This technique also highlights hair and clothing particles and crystals; however, these structures do not exhibit the Maltese cross pattern. Likewise, neutral fat (triglyceride) does not exhibit the Maltese cross form.

Continue with Exercises

EXERCISES, LESSON 3

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise, by completing the incomplete statement, or by writing the answer in the space provided at the end of the exercise.

After you have completed all these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. Microscopic examination of urinary sediment is clinically important because

   a. Such examination can quickly identify the constituents of calculi present in the sample.

   b. It can provide valuable information that enables the physician to diagnose renal and other abnormalities.

   c. Bacteria contaminating the sample can be identified in order that proper antibiotic therapy can be instituted by the physician.

   d. Cloudy urine always reveals clinically significant elements under microscopic examination.

2. Which of the following best describes the basic technique, which should be used to prepare a urine sample for microscopic examination?

   a. The urine sample is shaken well and small volumes of it are examined using the 10X objective.

   b. The urine sample is well mixed and then centrifuged prior to its microscopic examination.

   c. The urine sample is well mixed and 15 milliliters of the sample are centrifuged. Only the bottom contents of the tube are examined microscopically.

   d. Approximately 15 milliliters of the sample are centrifuged and carefully examined under the microscope.

3. Which of the following are organized structures found in urine sediment?

    a. Red blood cells.

    b. White blood cells.

    c. Epithelial cells.

    d. All of the above.

4. Casts in the urine are clinically significant because.

    a. Their presence in the urine usually indicates some pathological change in the kidney.

    b. The casts tend to be formed when the urine is very dilute or alkaline.

    c. The presence of these casts usually indicates the patient has proteinuria.

    d. Casts are gelatinous products that can cause serious damage by occluding the kidney tubules.

5. What is the clinical significance of epithelial cell casts?

    a. These casts indicate the patient has a severe infection of the kidney.

    b. These casts are found in acute glomerulonephritis and septicemias.

    c. These casts can signify tubular degeneration.

    d. These cells usually signify the end stage of severe renal disease and approaching renal failure.

6. Which of the following is the best description of calcium oxalate crystals?

    a. Yellow crystals which are divergent in shape and size and can be found in 16 percent of patients who have gout.

    b. Granular crystals, which are brick-red and can be dissolved by gentle heating of the urine.

    c. Crystals, which are colorless and have the form of long needles or elongated prisms.

    d. Crystals commonly found in acid urine, which are usually the result of a diet rich in oxalic acid.

7. Which of the following is the best description of sulfadiazine crystals?

    a. These crystals exist in the form of transparent bars or needles.

    b. These crystals exist in the form of "shocks of wheat" with the binding toward one end.

    c. These crystals exist in the form of "shocks of wheat" with central binding.

    d. These crystals appear as needles or plates.

8. A cast is best defined as

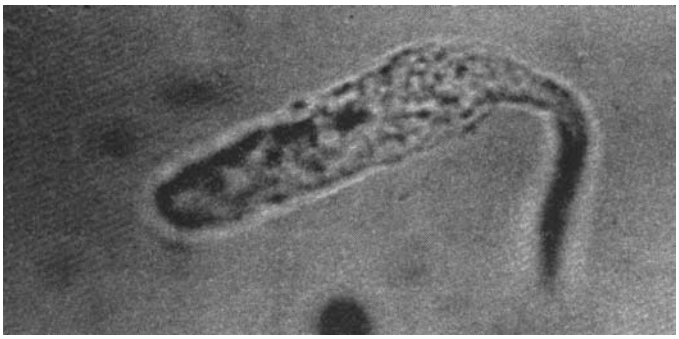
    a. A proteinaceous product of the renal tubules, which is often shaped in the form of the tubules.

    b. A gelatinous secretion produced by the renal tubules which is often found in the urine of healthy persons.

    c. A gelatinous substance, which causes a marked decrease in urine flow.

    d. A proteinaceous mold of the renal tubules which is formed when the urine is very acidic.

9. Below is a microscopic view of sediment found in a urine sample. Select the name of the sediment shown.



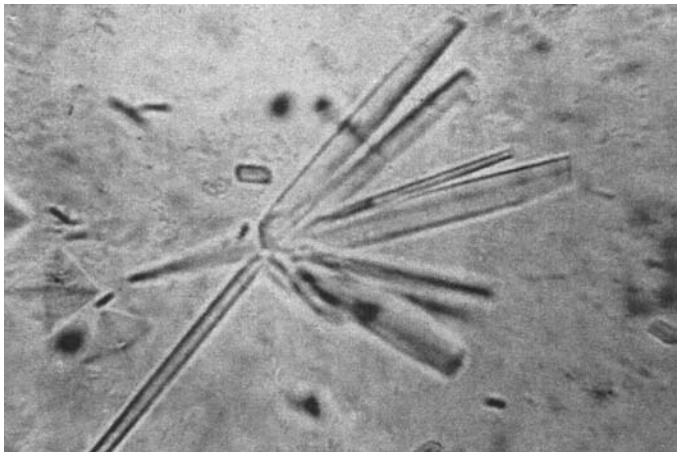
a. Simple.

b. Hyaline cast.

c. Granular casts.

d. Cylindroids.

10. Below is a microscopic view of some sediment found in a urine sample. Select the name of the sediment shown.



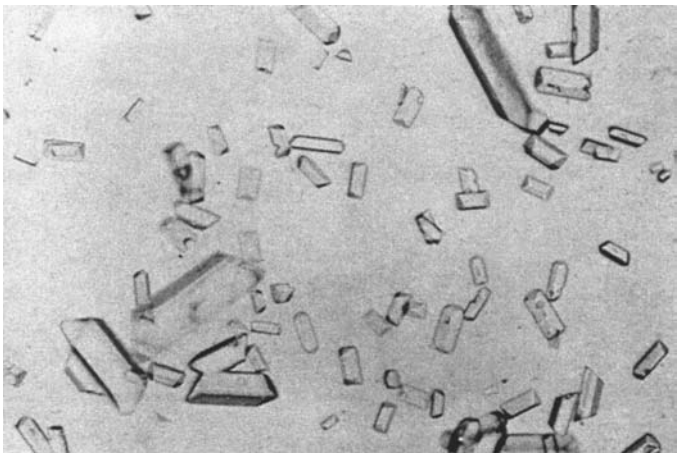
a. Sodium urate crystals.

b. Calcium sulfate crystals.

c. Amorphous urate crystals.

d. Uric acid crystals.

11. Below is a microscopic view of some sediment found in a urine sample. Select the name of the sediment shown.



a. Sulfaguanidine crystals.

b. Sulfanilamide crystals.

c. Sodium urate crystals.

d. Triple phosphate crystals

12. While performing a microscopic examination of a urine sample you observe several small, colorless spheres which have a dumbbell shape. How would you report the sediment?

a. Ammonium urate crystals.

b. Calcium carbonate crystals.

c. Triple phosphate crystals.

d. Tyrosine crystals.

13. While performing a microscopic examination of a urine sample you observe several colorless and semitransparent structures with cylindrical bodies that have parallel sides and rounded ends. How would you report these?

    a. Waxy casts.

    b. Red blood cell casts.

    c. Epithelial cell casts.

    d. Hyaline casts.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES

1. b (para 3-1)
2. c (para 3-2)
3. d (para 3-5)
4. a (para 3-9a)
5. c (para 3-11c))
6. d (para 3-14c)
7. b (para 3-15d(3))
8. a (para 3-9a)
9. d (para 3-12a, figure 3-16)
10. a (para 3-14d, figure 3-21)
11. d (para 3-16b, figure 3-32))
12. b (para 3-16e, figure 3-35)
13. d (para 3-10, figure 3-8)

End of Lesson 3