

viewed while held up to a light source. Correct calibration is vital for accuracy. Most recently, an indirect colorimetric reagent strip method for assaying SG has been added to most dipstick screens. Unlike the refractometer, dipsticks measure only ionic solutes and do not take into account glucose or protein. The normal range for urinary SG is 1.003 to 1.035 g/mL. SG can vary in pathologic states. Low SG can occur in diabetes insipidus, pyelonephritis, and glomerulonephritis, in which the renal concentrating ability has become dysfunctional. High SG can be seen in diabetes mellitus, congestive heart failure, dehydration, adrenal insufficiency, liver disease, and nephrosis. SG will increase about 0.004 units for every 1% change in glucose concentration and about 0.003 units for every 1% change in protein. Fixed SG (isosthenuria) around 1.010 is observed in severe renal damage, in which the kidney excretes urine that is iso-osmotic with the plasma. This generally occurs after an initial period of anuria because the damaged tubules are unable to concentrate or dilute the glomerular filtrate.

16 pH Determinations of urinary pH must be performed on fresh specimens because of the significant tendency of urine to alkalinize on standing. Normal urine pH falls within the range of 4.7 to 7.8. Acidity in urine (pH < 7.0) is primarily caused by phosphates, which are excreted as salts conjugated to Na⁺, K⁺, Ca²⁺, and NH₄⁺. Acidity also reflects the excretion of the nonvolatile metabolic acids pyruvate, lactate, and citrate. Owing to the Na⁺/H⁺ exchange pump mechanism of the renal tubules, pH (H⁺ concentration) increases as sodium is retained. Pathologic states, in which increased acidity is observed, include systemic acidosis, as seen in diabetes mellitus, and renal tubular acidosis (RTA). In RTA, the tubules are unable to excrete excess H⁺ even though the body is in metabolic acidosis, and urinary pH remains around 6. Alkaline urine (pH > 7.0) is observed postprandially as a normal reaction to the acidity of gastric HCl dumped into the duodenum and then into the circulation or following ingestion of alkaline food or medications. Urinary tract infections and bacterial contamination also will alkalinize pH. Medications such as potassium citrate and sodium bicarbonate will reduce urine pH. Alkaline urine is also found in Fanconi syndrome, a congenital generalized aminoaciduria resulting from defective proximal tubular function.

Chemical Analyses Routine urine chemical analysis is rapid and easily performed with commercially available reagent strips or dipsticks. These strips are plastic coated with different reagent bands directed toward different analytes. When dipped into urine, a color change signals a deviation from normality. Colors on the dipstick bands are matched against a color chart provided with the reagents. Automated and semiautomated instruments that detect to green color is a result of bile pigment oxidation. Red and brown after standing are due to porphyrins, whereas reddish-brown in fresh specimens comes from hemoglobin or red cells. Brownish-black after standing is seen in alkaptonuria (a result of excreted homogentisic acid) and in malignant melanoma (in which the precursor melanogen oxidizes in the air to melanin). Drugs and some foods, such as beets, may also alter urine color. Odor Odor ordinarily has little diagnostic significance. The characteristic pungent odor of fresh urine is due to volatile aromatic acids, in contrast to the typical ammonia odor of urine that has been allowed to stand. Urinary tract infections impart a noxious, fecal smell to urine, whereas the urine of diabetics often smells fruity as a result of ketones. Certain inborn errors of metabolism, such as maple sugar urine disease, are associated with characteristic urine odors. Turbidity The cloudiness of an urine specimen depends on pH and dissolved solids composition. Turbidity generally may be due to gross bacteriuria, whereas a smoky

appearance is seen in hematuria. Thread-like cloudiness is observed when the specimen is full of mucus. In alkaline urine, suspended precipitates of amorphous phosphates and carbonates may be responsible for turbidity, whereas in acidic urine, amorphous urates may be the cause. 16 Volume The volume of urine excreted indicates the balance between fluid ingestion and water lost from the lungs, sweat, and intestine. Most adults produce from 750 to 2,000 mL every 24 hours, averaging about 1.5 L per person. Polyuria is observed in diabetes mellitus and insipidus (in insipidus, as a result of lack of ADH), as well as in chronic renal disease, acromegaly (overproduction of the growth hormone somatostatin), and myxedema (hypothyroid edema). Anuria or oliguria (