

Chapter 5

PHYSICAL EXAMINATION OF URINE



Color

Normal color is yellow due to urochrome

- Dark yellow
 - Concentrated urine
- Pale yellow
 - Dilute urine

Urochrome is a lipid-soluble pigment in plasma excreted in urine at a constant rate

Standard terms are used to describe urine color; refer to laboratory's policies and procedures

Substances That Change Urine Color

Blood or myoglobin

Bilirubin

Porphyrins

Melanin

Indican

Homogentisic acid

Ingested substances

- Medications
- Dyes
- Vitamins
- Pigmented foods

Foam

Not normally included on report forms

Normal urine when shaken will produce white foam that rapidly dissipates

Stable white foam indicates large amounts of albumin in urine

Yellow foam caused by increased bilirubin

Clarity

Describes cloudiness of urine caused by suspended particulate matter that scatters light

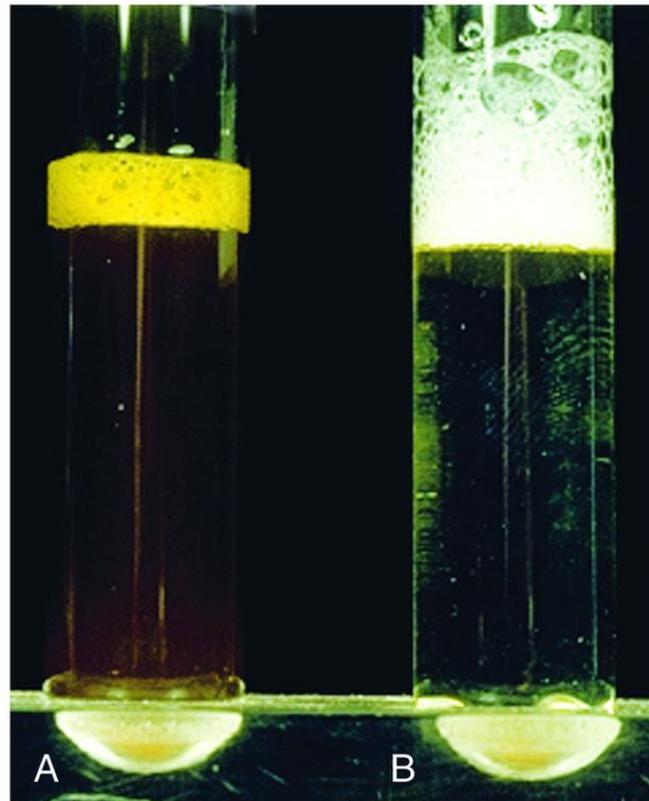
Refer to laboratory policies for a list of terms to use

Normal specimens are clear

Causes of cloudiness

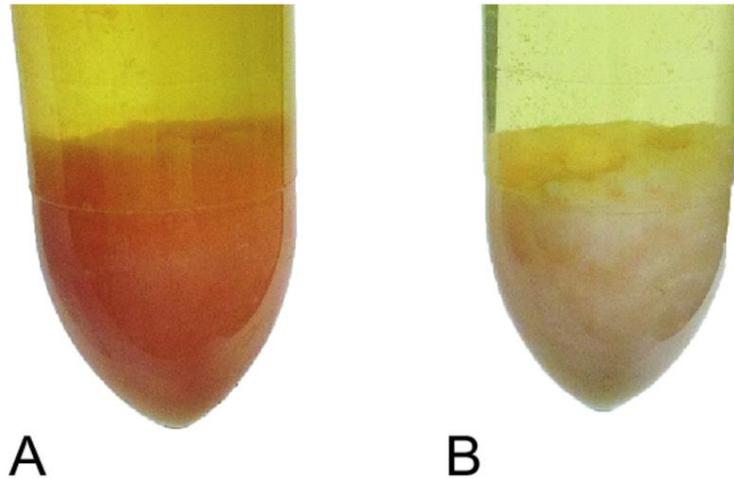
- Contamination from skin or vaginal secretions, bacterial growth, or fecal material
- Precipitation of dissolved solutes, x-ray contrast media
- Red blood cells (RBCs), white blood cells (WBCs), epithelial cells, clots, bacteria, casts

Figure 5-1. Urine Foam. **A**, Urine foam has distinct color due to the high bilirubin concentration in the urine specimen. **B**, Large amount of urine foam due to a high concentration of protein, specifically albumin, in the urine specimen.



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Figure 5-2. (A) Amorphous urates in acid urine; note the pink color similar to “brick dust.” (B) Amorphous phosphates in alkaline urine; note the whitish or beige color.



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Odor

Normal urine has an aromatic odor

Urine on standing becomes odorous due to bacterial conversion of urea to ammonia

Ingestion of certain foods or drugs change odor

Unusual odors of some metabolic disorders:

- Ketones produce sweet or fruity smell
- Amino acid disorders often produce odd odors

Concentration

Concentration refers to amount of solutes present in volume of water excreted

Urine normally consists of 94% water and 6% solutes

Solute types vary with patient's diet, physical activity, and health

Dilute urine has fewer solute particles per volume of urine

Color is a crude indicator of concentration

Specific Gravity (SG)

An expression of concentration in terms of density

- Mass of solutes present per volume of solution

Ratio of urine density to density of an equal volume of pure water under standard conditions

Both number of solute particles and molecular size affect specific gravity

$$SG = \frac{\text{Density of urine}}{\text{Density of equal volume of pure water}}$$

Specific Gravity (SG) (Cont.)

The greater the density, the greater is the SG

Lowest possible urine SG is about 1.002 and highest about 1.040

Methods of measurement direct or indirect

Molecular size of solutes does not affect indirect SG measurements as much as it does direct

Today's laboratory uses indirect methods such as refractometry and reagent strip chemical method

Refractometry

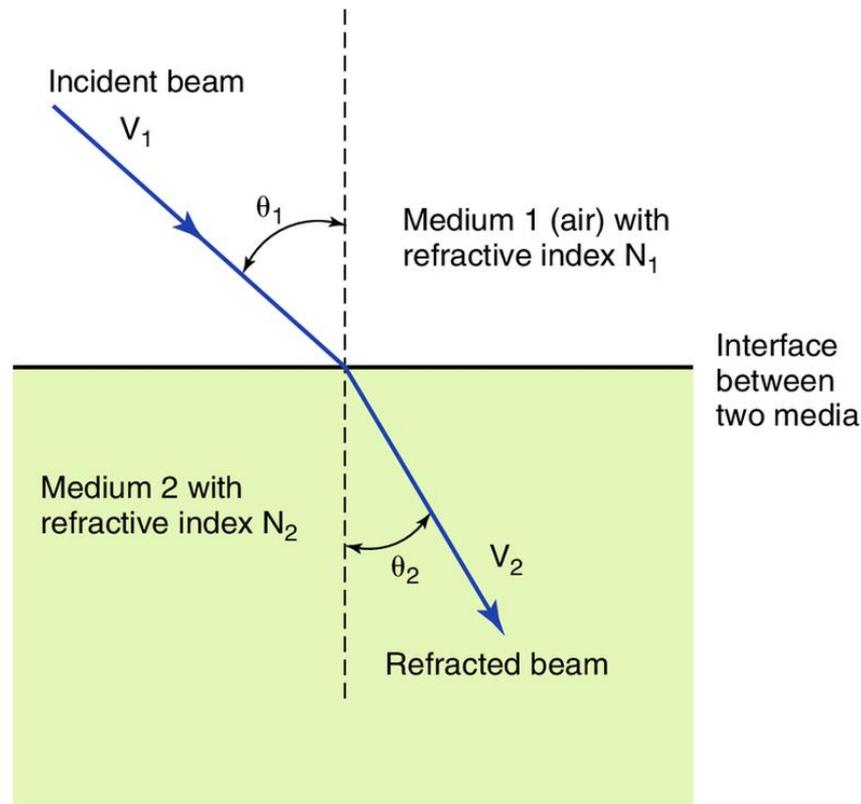
Indirect method based on refractive index of light

When light passes from air into a solution at an angle, it refracts and slows direction of beam

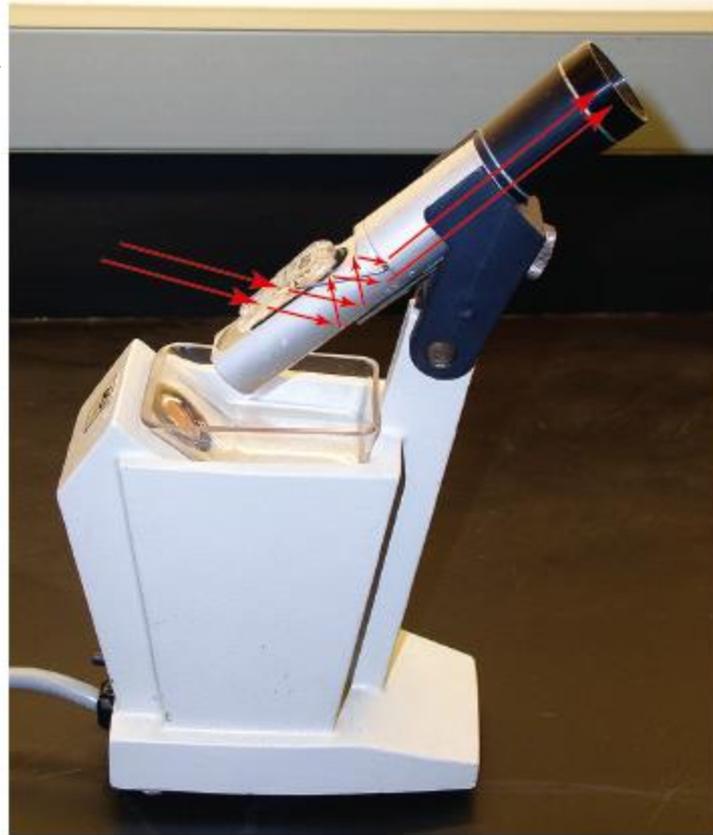
The ratio of light refraction in two differing media is called *refractive index*

As number of solutes increases, light velocity decreases, and light angle decreases

Figure 5-3. A schematic diagram illustrates the refraction (or bending) of light as it passes from one medium to another of differing density. The velocity of the light beam also changes.



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Refractometry (Cont.)

Three factors affect the refractive index of a solution:

- Wavelength of light used
- Temperature of solution
- Concentration of solution

Refractometry measures all solutes present, including protein and glucose

Most common wavelength used is 589 nanometers (nm)

Proper calibration of refractometer important

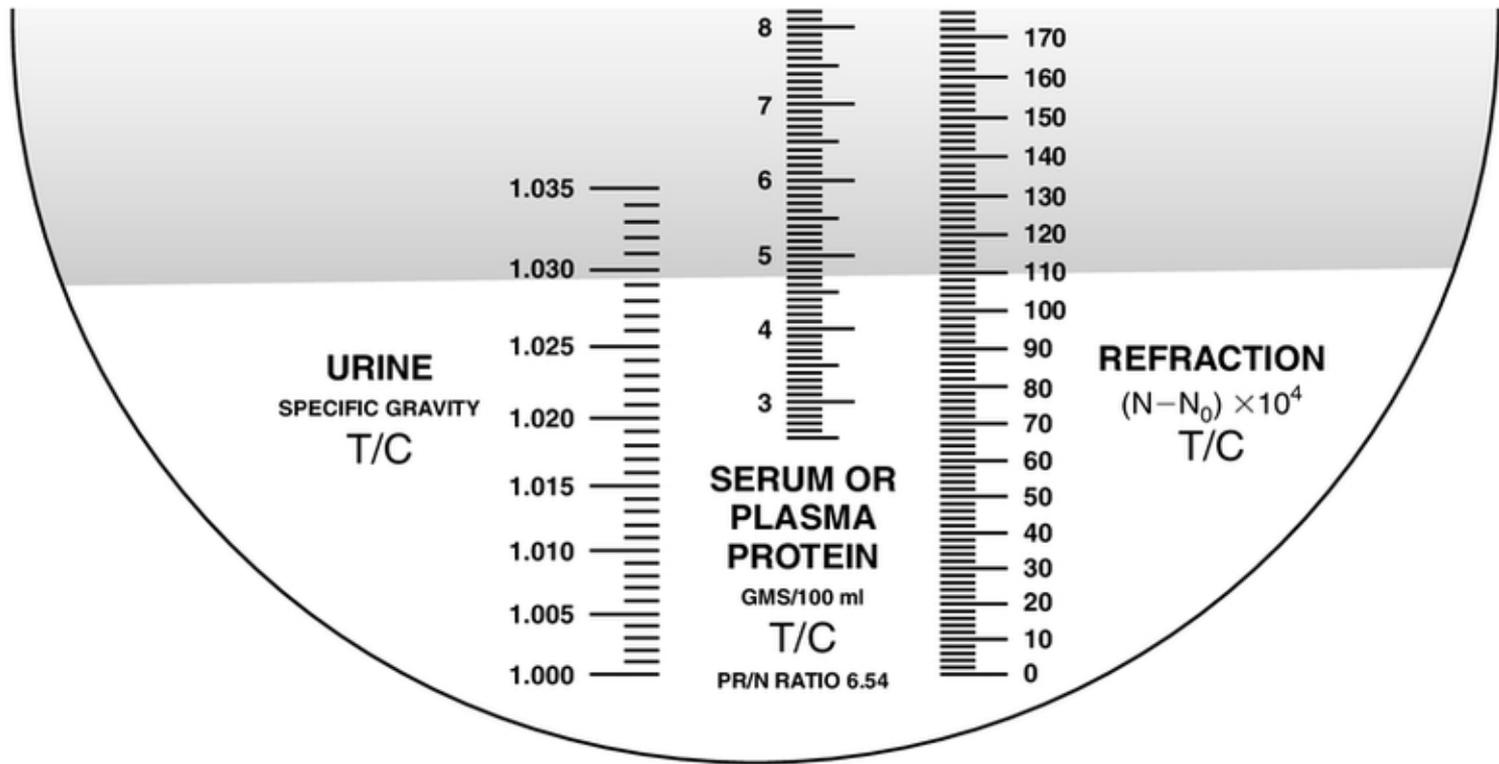
Advantages of Refractometry

Small sample size of 1 to 2 drops

Automatic temperature compensations between 15°C and 38°C

In viewing field, distinct edge between light and dark areas makes reading the specific gravity scale easy

Figure 5-5. A schematic representation of the viewing field and scale in the refractometer. (Courtesy Leica, Inc., Buffalo, NY. Reprinted with permission).



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Reagent Strip Method

Indirect colorimetric estimation of urine density based on amount of ionic or charged solutes present (sodium [Na], potassium [K], chloride [Cl], ammonium [NH₄])

Nonionic solutes such as glucose, urea, protein, or radiographic media are not measured

Only method that eliminates effect of nonionic large-molecular-weight solutes on specific gravity

- Especially useful when radiographic media present

May not represent true density of urine, but it does reflect renal concentrating ability to handle solutes and water

Reagent Strip Method (Cont.)

Reagent strip pad impregnated with polyelectrolyte and pH indicator at an alkaline pH

When strip immersed in urine, protons released from polyelectrolyte in proportion to ionic concentration

Released protons change pH of test pad, resulting in a color change of pad

Osmolality

Concentration of a solution expressed in terms of osmoles of solute particles per kilogram (kg) of water

Milliosmoles (mOsm) often used for convenience due to low osmolality of biological solutions

Normal urine values: 275 to 900 mOsm/kg

Normal serum values: 275 to 300 mOsm/kg

Serum remains relatively constant, but urine value depends on diet, fluid intake, and physical activity

Osmolality (Cont.)

Principal uses of osmolality:

- Evaluate renal concentrating ability of kidneys
- Monitor renal disease
- Monitor fluid and electrolyte balance
- Differentially diagnose cause of polyuria

Determined by measuring a colligative property of solution such as freezing point depression or vapor pressure depression

Freezing Point Osmometry

Able to detect presence of volatile solutes

Accurate results even with lipemic samples

Pure water freezes at 0°C , and adding 1 osmole of solute particles to 1 kg of pure water decreases freezing point by 1.86°C

Osmometer reads freezing point of sample and converts to a direct readout in milliosmoles

Vapor Pressure Osmometry

Not as common as freezing point osmometry

Small sample size, but inability to measure volatile solutes

- Thus limiting its clinical applicability relative to freezing point depression method

Indirectly measures decrease in vapor pressure caused by solutes in a sample by measuring decrease in dew point temperature

Volume

Normal volume 600 to 1800 mL/day

Amount of solutes excreted increases as water required to excrete them increases

Terminology:

- Isosthenuria
 - Inability of kidneys to change specific gravity of plasma ultrafiltrate (which is 1.010)
- Polyuria
 - Excretion of greater than 3 L/day
- Oliguria
 - Excretion of less than 400 mL/day
- Anuria
 - Complete lack of urine excretion