Lab Exercise 38

The Urinary System

Objectives

- Be able to identify the structures of the urinary system and give their function
- Be able to recognize the gross anatomy of the kidney
- Identify the components of a nephron and be able to give their functions
- Know the normal components of urine and conduct a urinalysis to screen for renal diseases

Introduction

An undesired consequence of the body conducting its metabolism is the production of waste products. Perhaps the most abundant of these are nitrogenous waste products that are generated by the metabolism of nucleic acids and proteins. The majority of these nitrogenous wastes are converted into the compound urea.

To rid the body of urea before it reaches toxic levels, the urinary system filters this out of the blood and excretes it in urine. Other functions of the urinary system include the regulation of blood composition, helping to regulate blood pressure and volume, controlling the ionic balance of sodium and potassium and helping to regulate the blood’s pH.

Urine formation begins when blood is force-filtered through the tiny capillary network of the kidney known as the glomerulus. The pressure entering this capillary network is tremendous. This pressure, together with fenestrated (leaky) capillaries, allows everything small enough to squeeze through the glomerulus and enter the Bowman’s capsule, the head of a tubular structure called the nephron. As this filtrate travels through the nephron, it is modified as substances are reabsorbed by the body and secreted into the fluid. Ultimately this fluid, now urine, leaves the kidney to be expelled from the body.

To begin this exercise, in the Mammalian Systems section of the BiologyOne DVD, select The Urinary System simulation.
Activity 38.1
The Urinary System

From the introductory page of the Urinary System tutorial, click on the forward arrow in the lower right to study the organs of the urinary system. Before you leave this section, be sure you can locate and identify the following organs and structures of the urinary system.

- kidneys
- medulla
- cortex
- renal pelvis
- ureters
- bladder
- urethra

Test your ability to identify these structures by labeling the diagram in the Results Section.

Activity 38.2
The Nephron

After viewing the gross anatomy of the urinary system and kidney, examine the kidney’s microscopic structure. Click on the forward arrow in the lower right to view micrographs of the cortex and medulla of the kidney. In these micrographs, look for structures of the nephron. You should be able to find Bowman’s capsule and many tubes of the nephrons.

Label the illustration of the nephron in the Results Section.

Urinary System of a Fetal Pig
Activity 38.3
Urinalysis

The urine generated by the urinary system will normally have certain characteristics and contain certain amounts of several compounds. Deviation from those characteristics or the presence of certain components may reflect various disease states in the body.

Several bench-top laboratory tests of the urine to determine its characteristics and the presence or absence of various substances have been developed. Today, most of these tests can be accomplished using urine dipsticks that will show color changes to indicate the presence and amount of the compounds of greatest interest.

In this simulation, you will be able to conduct a urinalysis on six individuals. To begin the analysis, select one of the individuals by clicking on their urine sample.

After selecting the urine sample, on the screen you will see a container of urinalysis dipsticks. These are plastic strips with squares of paper treated to chemically react to various components in the urine. Click on the dipstick container to remove a urinalysis strip.

Drag the dipstick into the urine sample. The squares on the dipstick will react with chemicals in the urine and change color.

To interpret what these colors indicate, open the test key color chart by clicking on its tab (this can then be closed by clicking on the gray circle in the upper left of the chart). Drag the dipstick to match the color of the square to the color on the chart. The top square of the dipstick indicates glucose levels in the urine. The square second from the top indicates bilirubin levels in the urine, etc.

Record the results of the urinalysis for this patient in the Results Section.

Click on the New Sample button to select another patient. Repeat the urinalysis for all six patients, recording your results in the Results Section. Use the following information about these substances to answer the questions asked in the Results Section.
Glucose
Glucose is absent in normal urine. Glycosuria, the presence of glucose in the urine indicates abnormally high levels of glucose in the blood. Glucose may be temporarily found in the urine after an excessive carbohydrate intake that overwhelms the body’s ability to clear the glucose from the blood quickly enough. Persistent glycosuria occurs when the body is unable to absorb glucose from the blood due to inadequate insulin production by the pancreas or abnormalities in the insulin receptors of the body’s cells. This condition is diagnostic of diabetes mellitus.

Bilirubin
Bilirubin is a bile pigment produced by the breakdown of hemoglobin and released into the small intestine. The presence of bilirubin in the urine (bilirubinuria) indicates liver damage resulting from diseases such as hepatitis or cirrhosis.

Ketone Bodies
Ketone bodies composed of acetoacetic acid, beta-hydroxybutyric acid or acetone. Very small amounts of ketone bodies are found in normal urine. Excessive amounts of these (ketonuria) indicate an abnormal metabolism is occurring. Ketonuria is expected when the body is using its fat stores as during starvation. Ketonuria coupled with glycosuria is generally diagnostic for diabetes mellitus.

Specific Gravity
Specific gravity is the relative weight of a given volume of fluid to an equal volume of distilled water. The specific gravity of distilled water is 1.000. Since urine contains dissolved substances in water, it's specific gravity will be greater than 1.000. If the urine is very dilute, it’s specific gravity will be close to 1.000. This can occur if the person drinks excessive amounts of water, uses diuretics, or suffers from chronic renal failure. Concentrated urine with many solvents will have a higher specific gravity. This can result from limited fluid intake, fever, or inflammation of the kidneys. When the urine is excessively concentrated, the dissolved substances will begin to precipitate or crystallize out of solution, forming kidney stones.

Blood
Red blood cells (non-hemolized cells) are too large to normally pass through the glomerular pores so their presence in urine (hematuria) indicates a problem. Possible causes of red blood cells in the urine include damage to the urinary tract by kidney stones, infection or physical trauma.

If red blood cells in the circulatory system burst (hemolized), the released hemoglobin will appear in the kidney’s filtrate. The presence of hemoglobin (hemoglobinuria) can be caused by reactions to a transfusion, burns, hemolytic anemia and renal disease.

pH
Urine is usually slightly acidic with an average pH of 6.0, but is still considered normal from 4.5 to 8.0. The pH of the urine will be greatly affected by an individual’s diet. A diet high in protein (meat, cheese or eggs) or whole wheat products will cause the pH to be more acidic (a lower pH). A vegetarian diet will cause the urine’s pH to become more alkaline (raising the pH).

Protein
Albuminuria is the presence of the protein albumin in the urine. Albumin is used in the body to regulate the osmotic balance of the blood. Normally, the molecule is too large to pass through glomerular filtration. Temporary albuminuria may be caused by an overabundant protein intake, excessive exertion or pregnancy. Pathological conditions that can result in albumin in the urine include physical trauma to the kidney, ingestion of heavy metals, some bacterial toxins and high blood pressure.

Urobilinogen
Urobilinogen is produced by the breakdown of bilirubin by bacteria in the digestive tract. The urobilinogen is reabsorbed by the circulatory system and then excreted from the body through the urinary system. If urobilinogen in the urine is in lower than normal amounts or is absent, it may mean the person is suffering from hepatic jaundice or have an obstruction in their bile duct. Higher than normal levels of urobilinogen may indicate hemolytic jaundice.
Nitrite
Nitrites are normally absent in urine. A positive test for nitrites usually indicates an infection, usually by gram-negative bacteria, within the urinary tract.

Leucocytes
The presence of white blood cells in the urine indicates an inflammation of the urinary tract. This is called pyuria.

Screen for Urinalysis Simulation

- Urinalysis dipstick
- Container for dipsticks
- Button to select new patient
- Chart for reading dipsticks

(Urinary System) Urinalysis

Quit
Activity 38.1
The Urinary System

1. _____________________
2. _____________________
3. _____________________
4. _____________________

Activity 38.2
The Nephron

1. _____________________
2. _____________________
3. _____________________
4. _____________________
5. _____________________
Activity 38.3
Urinalysis

<table>
<thead>
<tr>
<th>Test</th>
<th>Normal</th>
<th>AD 632</th>
<th>SB 403</th>
<th>HP 229</th>
<th>HG 205</th>
<th>RW 821</th>
<th>LV 884</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>Negative</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>Bilirubin</td>
<td>Negative</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>Ketone Bodies</td>
<td>Negative</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.015 – 1.025</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>Blood</td>
<td>Negative</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>pH</td>
<td>4.5 – 8.0</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>Protein</td>
<td>Negative</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>Urobilinogen</td>
<td>0.1 – 1.0</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>Nitrite</td>
<td>Negative</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>Leucocytes</td>
<td>Negative</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>________</td>
</tr>
</tbody>
</table>

Which patient(s) appear to be suffering from diabetes mellitus? Which results made you come to this conclusion?

Which patient(s) appear to be suffering from an infection of the urinary system? Which results made you come to this conclusion?