Manitoba

Education, Citizenship and Youth

SENIOR 3 BIOLOGY 30S
A Foundation for Implementation
Unit 4 – Excretion and Waste Management

DRAFT / Unedited Version

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Manitoba
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Unit 4: Excretion and Waste Management

General

S3B-4-01 Identify the primary metabolic wastes produced in the human body and the source of each.
Include: ammonia, urea, mineral salts, carbon dioxide, water.

S3B-4-02 Describe the roles of the major excretory structures in eliminating wastes and helping the body maintain homeostasis.
Include: kidneys, lungs, skin, intestines

S3B-4-03 Describe the important role of the liver in the process of excretion and the maintenance of homeostasis.

Suggestions for Instruction

ACTIVATE

What are Waste Products?

Ask students the following questions and record responses.

- What would happen if you never threw out your garbage or leftover food?
- Why do we sweat?
- Why do we urinate?

Have students list as many waste products of the human body as possible.

Acquire / Apply

Charting Waste

Explain to students that excretion is the removal of the wastes products of cellular metabolism from our body. Ammonia, one of the products of cellular metabolism, is very toxic. This is why it is converted to urea (which is much less toxic than ammonia) in the liver before being released into the blood stream. With the use of their text or another resource, have students create a chart that links metabolic waste product with the organ that excretes this product.
For example:

Waste Product	Origin of Waste Product	Excretory Organ
Ammonia	*Breakdown of amino acids in the liver*	*Kidneys*
Urea	*Conversion of ammonia in the liver*	*Kidneys, skin*
Carbon Dioxide	*Cellular Respiration (breakdown of glucose in cells)*	*Lungs, intestines, skin*
water	*Cellular respiration (breakdown*	*Kidneys, lungs,*

	of glucose in cells)	*intestines, skin*
Mineral salts	*Food and water*	*Kidneys, skin*

Have students answer the following question:

- Why is excrement not included in the list of metabolic wastes? (Excrement is not a product of cellular metabolism. It is a "leftover" after the body absorbs what nutrients it needs from the small intestine.)

Suggestions for Assessment: Review the chart with students to verify their comprehension and review or re-teach if necessary (formative assessment).

Have students complete a concept frame or concept overview for excretion (see SYSTH, p. 11.23-11.25).

Have students answer the following questions:

- What is the liver's role in excretion?
- Why is the liver not considered an excretory organ?

Summative Assessment: Have students create a concept map illustrating the liver's roles in various body systems (e.g. digestion, excretion).

Urinary System

S3B-4-04 Identify structures of the human urinary system from a diagram, model or specimen and describe the function of each. Include: kidneys, renal cortex, renal medulla, renal pelvis, renal arteries and veins, ureters, urinary bladder, urethra, and urinary sphincters.

Suggestions for Instruction

ACTIVATE

Kidney Size

Have students make two fists and place them on their back just above hips. Discuss the size and location of their kidneys. Students brainstorm the role of the kidney.

ACQUIRE / APPLY

Charting the Urinary System

Have students label a diagram of the urinary system while dissecting a specimen or examining models. Using information from texts or the Internet, have students place arrows on the diagram to indicate the direction of flow of fluids through the system as well as construct a chart listing the structures and their functions.

Suggestions for Assessment: The diagram and chart can be used as a formative assessment to determine the level of students' understanding of urinary system structures and their functions.

Processes

S3B-4-05 Explain the processes of filtration, re-absorption and secretion in the nephron.

Suggestions for Instruction

Activate

Have students discuss the following question:

- Where does your urine come and how is it formed?

Acquire / Apply

Direct Instruction: Filtration, Re-absorption and Secretion

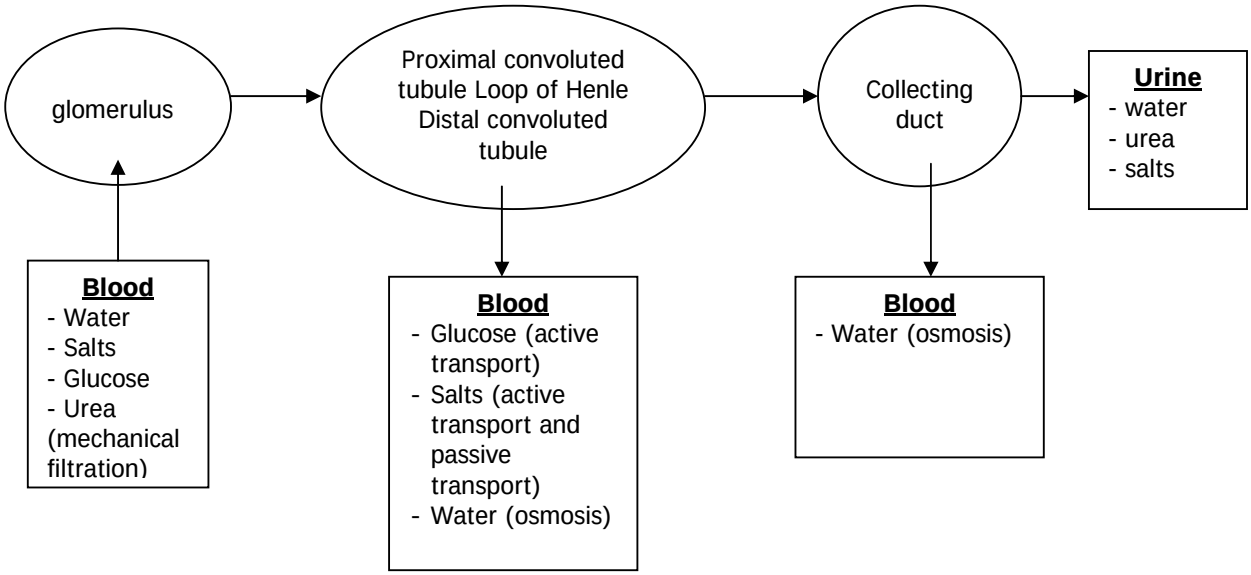
Using visuals to show the location of the nephron and provide students with a variety of views of the parts of the nephron (e.g. micrograph, slide-phase contrast). Explain the processes of filtration, reabsorption and secretion. Have students create a labelled diagram of a nephron. Have them place arrows on the diagram that indicate the direction of water and solute movement at the locations of filtration, re-absorption and secretion through the nephron to the collecting duct, as well as the mechanisms by which they are filtered and reabsorbed.

Teacher note: The kidneys filter about 125 ml of blood every minute, which adds up to about 180 litres per day. We obviously don't excrete 180 litres of urine per day so most of the water filtered out of the blood is returned to the circulatory system. The body excretes only about 2 litres of urine every day. Water isn't the only substance that is reabsorbed into the circulatory system. All of the glucose that is filtered out of the blood is reabsorbed. This important nutrient necessary for the production of ATP is actively transported back into the circulatory system so that is reaches the cells. Salt concentration in the blood also needs to remain constant. The amount of salt excreted and reabsorbed into the blood depends on how much salt we get from the foods that we eat. If we intake a lot of salt, less is reabsorbed into the blood stream, and more is excreted in the urine.

Suggestions for Assessment: Have students answer the following questions:

- Why do we need to drink regularly?
- How would organisms adapt to an environment such as a desert?

Have students use a chain concept map to illustrate the main parts of the nephron as well as the direction of water and solute movement in each part. For example:



Kidney Analogies

Have groups of students create an analogy of the kidney or one of its parts. Students must include the following in their analogy:

- ✓ Description of the structure (biological concept)
- ✓ Identification of a familiar object (analog) that shares some similar characteristics
- ✓ Identification of the shared characteristics of the structure (biological concept) and the analogy
- ✓ Indication of where the analogy breaks down

(Teaching with Analogies Model, Glynn 1989; Glynn, Duit, and Thiele 1995)

Suggestion for Assessment: Kidney analogies can be shared with the classroom and discussed in order to arrive at a consensus as to whether the analogy is helpful or not. The following criteria can help determine the effectiveness of an analogy:

- a familiar analog is selected
- similarities between the analog and the structure are clear and help understand the structure and/or function of the structure
- differences between the analog and the structure are clear

Feedback

S3B-4-06 Describe the feedback mechanisms associated with water and salt balance and their role in the maintenance of homeostasis in the human body.

Include: antidiuretic hormone (ADH) and aldosterone

Suggestions for Instruction

ACTIVATE

Control of Excretion

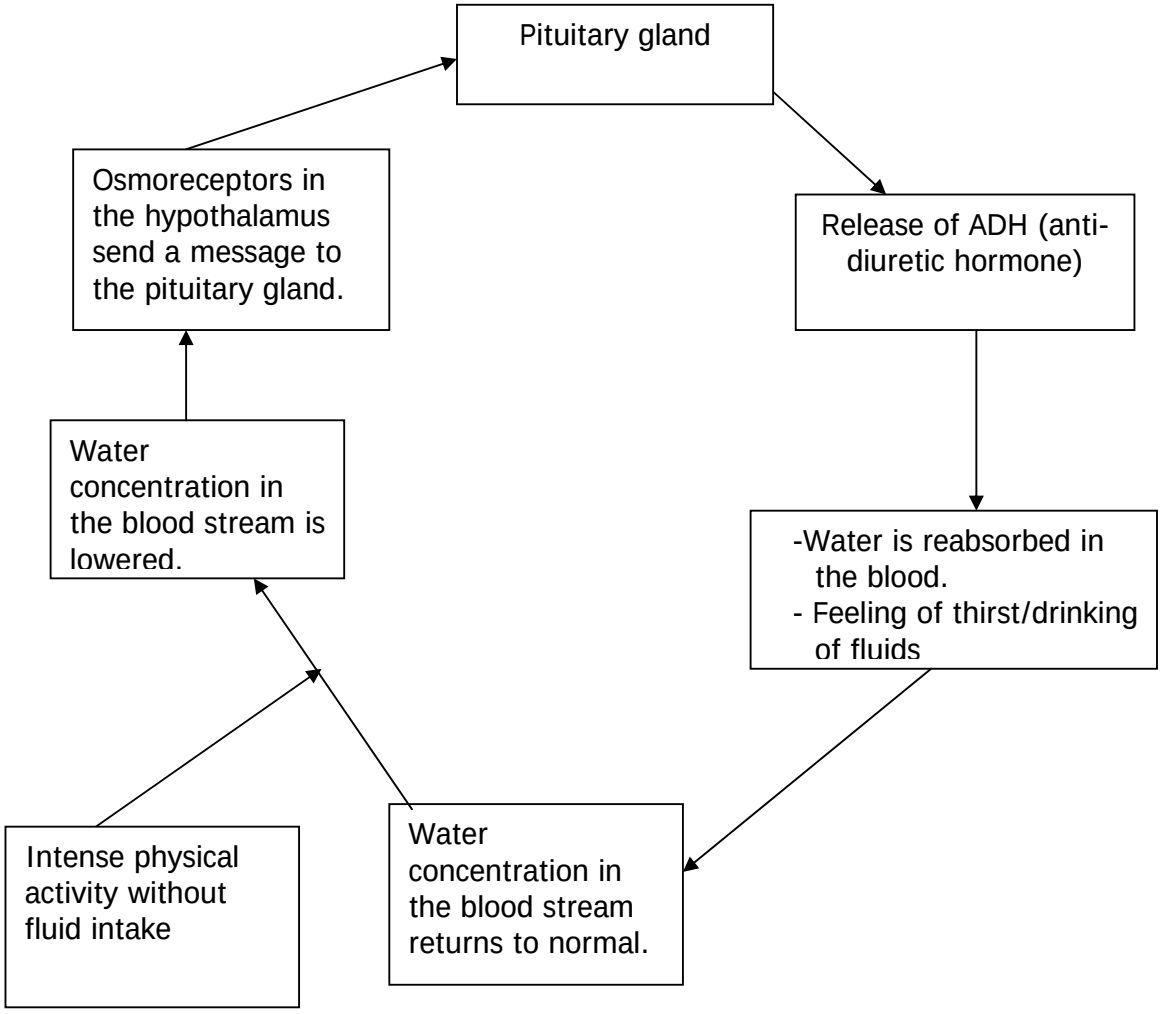
Have students discuss the following question:

- Why do we sometimes excrete a lot of urine and sometimes hardly any?
- Why do we sometimes feel so thirsty we can hardly get enough to drink, but sometimes we don't want to drink anything at all?

ACQUIRE / APPLY

Direct Instruction - Water Balance and Hormonal Control

Describe the release of ADH and the relationship to osmotic concentration in terms of a negative feedback mechanism. Have students fill out a blackline master about the negative feedback mechanism involved in osmoregulation. The concept map could look something like the following:



Suggestions for Assessment: Review answers with the class to check for understanding (formative assessment).

Have students complete a second blackline master, this time to illustrate the negative feedback mechanism involved with a high fluid intake by the body. Have students meet in small groups to compare their results. Any discrepancies should be discussed and a consensus reached.

Have students answer the following questions:

- Alcohol inhibits the secretion of ADH. What would be the effect of ingesting alcohol on the process of excretion?
- What causes a hangover?
- Caffeine increases glomerular blood pressure and decreases the reabsorption of sodium. What would be the effect of ingesting caffeine on the process of excretion?

- If you drink a large pop at the beginning of a movie, you would probably have to urinate before the end of the movie. Explain what would happen if you ate salty popcorn with your large pop?

Teacher notes: The amount of water and salt in the body needs to remain constant. Fluid excreted by the body must therefore balance out fluid taken in by the body. The kidneys, acting with hormones named ADH (antidiuretic hormone) and aldosterone, maintain the balance of blood volume and composition through negative feedback mechanisms. Receptors in the hypothalamus sense when your body's fluid intake is low, when your blood volume decreases and when the sodium concentration in your blood increases. ADH is then released from the pituitary gland and increases the permeability of the nephron to water. More water is therefore reabsorbed into the circulatory system. Aldosterone also helps to regulate water balance. This hormone is released by the adrenal cortex. Factors that cause its release are low blood volume and pressure, which put in motion a complex series of events that start with the release of a hormone called rennin in the kidney. Aldosterone causes the reabsorption of sodium into the circulatory system. Water follows the sodium and blood volume and pressure are restored.

Microtheme: Water as a Need

"Water, water, everywhere
Nor any drop to drink."
Samuel Taylor Coleridge (1798)

In modern English this phrase from the famous poem *The Rime of the Ancient Mariner* can be read as "Water, water everywhere but not a drop to drink." Samuel Coleridge tells the sad tale of survivors of shipwrecks, even though they float on a vast body of water teeming with life.

Why can't we drink seawater? What will happen to our bodies if we do? What systems in our body are most affected? What needs to be done to the seawater to make it drinkable? How can this be done? What does dehydration do to the human body?

After answering these questions, write about what you could do to conserve your body's water if you are in a survival situation where drinkable water is unavailable.

"And every tongue, through utter drought, was withered at the root; we could not speak, no more than if we had been choked with soot."

Suggestions for Assessment: Refer to **Appendix 3b and 3c** in Unit 1 for assessment tools.

Urinalysis

S3B-4-07 Describe what types of information can be gained through urinalysis.
Examples: performance enhancing drugs, diabetes, recreational drugs, pregnancy, infections, kidney failure or damage…

Suggestions for Instruction

ACTIVATE

Thinking about Urine Tests

Pose the following question to the class:

Why do we give urine samples when we get a physical at the doctor's?
What kinds of things can doctors find with a urine test?
Why do athletes get their urine tested?

Have students do a Think-Pair-Share to discuss the issue (see SYSTH, p. 3.10).

ACQUIRE / APPLY

Fake Urine - Laboratory

Have students complete a urinalysis laboratory activity (**see Appendix 1**) using synthetic urine. Have students analyze urinalysis results to determine potential disorders (i.e. clarity of urine, sample opaque may indicate yeast).
Suggestions for Assessment: Refer to **Appendix 9** in Unit 1 for Teacher Background Information on assessing and evaluating student lab skills. **Appendix 14 through 15** in Unit 1 provides assessment ideas for laboratory skills.

Researching Urine Tests

Have students research how a commercial pregnancy test kit works or conduct research about one specific type of urine test and research possible diseases or medical illnesses that can be detected with this test.
Suggestions for Assessment: Develop criteria for assessment with students. Criteria might include:

- A description of how the urine test works is included
- A description of the condition that the urine test can detect is included
- Appropriate vocabulary is used
- Few spelling or grammatical errors are evident

Mandatory Testing Debate

Have students debate whether urinalysis should be mandatory at all athletic competitions. While conducting research in preparation for the debate, have them create a Fact and Opinion Sheet (Freman, 1999). To create a Fact and Opinion Sheet, students fold a sheet of loose leaf in half and label one half "Fact" the other "Opinion". During the course of their research, students

document statements that are either Facts or Opinions. If no opinions are stated in a given article, students can add their own opinions.
Suggestions for Assessment: Collect Fact and Opinion Sheets and assess them based on accuracy of categorizing statements. Establish performance criteria with the class before a debate and use the class-based criteria to create a rubric. Use the Debate Assessment Rubric in **Appendix 2**.

Guest Speaker
Invite an athlete to speak about performance enhancing drugs. Develop some questions related to the factors that would impact excretory health.

Teacher notes: Students are not permitted to use samples of human fluid or tissue in the classroom.
The Senior 2 English Language Arts Foundation document suggests a strategy for debating called Creation Controversy (1.1.2 Consider Other's Ideas, pg. Senior 2-34). This debating strategy requires students to gather arguments so that they can switch sides in a debate, and then move to consensus.

Wellness

S3B-4-08 Investigate and describe issues related to kidney failure and treatment options available.
Examples: organ transplant, personal lifestyle, dialysis.

Suggestions for Instruction

ACTIVATE

Kidney Disease
Ask students to brainstorm what could cause kidney failure/malfunction/disease.
Ask students if they have signed a donor card and have them discuss reasons for deciding to sign or not.

ACQUIRE / APPLY

Performance task (Part 1) - You are a doctor
Give students the following scenario:
Imagine you are a new doctor who has received test results for a patient showing signs of renal failure. Your task is to prepare an explanation for the patient on what the problem is, within the context of what normal kidney function looks like, and what the treatment options are (dialysis and transplant). Your must describe the options in detail, including pros and cons. Your preparation will take the form of written notes, which will be shared with fellow doctors to confirm your information.

Suggestions for Assessment: Students must prepare a written submission which will be evaluated by the teacher as well as shared in small groups. Criteria for the written piece as well as the oral sharing should be developed and may include:

- Explanation of kidney function is clear and complete
- Appropriate terminology is used
- Diagrams are included
- Accurate explanation of the consequences or renal failure are included
- Description of treatment option is clear, concise, accurate, understandable by patient and includes pros and cons
- Share ideas with the group
- Listens when others talk

Performance Task – Part 2 (You are the patient)

Give students the following scenario:
You have just been told that you are experiencing renal failure. You must decide which treatment option to utilize.
Give different patient scenarios to different students (see **Appendix 3**). Students of the same patient profile can meet together to discuss treatment options, but the final decision is made individually then shared with a group of students who have different patient profiles. A written decision-making sheet will be submitted to the teacher along with a reflection about the decision-making process. The following questions can help guide the students:

- What is the issue?
- What are my alternatives?
- What are the risks and benefits for each alternative?
- What is my decision?
- Why have I made this decision?
- Did the people in my group all make the same decision?
- Why would people make different decisions in a similar situation?

Suggestions for Assessment: Establish a rubric for the decision-making sheet as well as the reflection. Criteria could include:

- The issue is clearly stated.
- The risks and benefits for each alternative are included.
- The decision is justified with supporting details related to the patient profile.
- The reflection shows an understanding of different factors that can affect a decision (i.e. values) and that there isn't one right answer.

Donor Programs

Acquire information on living donor transplants for kidney, skin and liver. Refer to Manitoba Transplant Program. 2002. *Organ and Tissue Donation – A Fact of Life.* Supplemental Curriculum Document, Senior 3 Biology. Winnipeg: Manitoba Transplant Program. Pg. 5,6,14,15,16,37. Why do some tissues regenerate (e.g. liver)?
Suggestions for Assessment:

Living with Kidney Disease

Invite a person undergoing dialysis and/or a person who received a kidney transplant to the classroom to talk about kidney disease and the process of dialysis. Brainstorm with students prior to the presentation questions they would like to ask the speaker. Relate the parts of a dialysis machine to that of a kidney (filtration, reabsorption, secretion) by labelling a diagram. Have them write an exit slip on whether they would consider donating their kidney and what they would anticipate experiencing once one of their kidneys was removed.

Suggestions for Assessment: Establish with students the criteria required to complete an exit slip. Use agreed-upon criteria for exit slip.

Microtheme: Renal Failure

Imagine that your father has been showing signs of renal failure. Hemodialysis or kidney transplant are the realistic treatments that he will need very soon. Research the impact of hemodialysis treatments on your family's lifestyle. How will your lives change? Examine the current state of organ donation in Canada. What are organ availabilities in Canada? What steps are taken to get access to organs and to harvest them? As a teenager, how can you make your wishes regarding transplantation known? What will influence the likelihood of your father getting a transplant?

Suggestions for Assessment: Refer to **Appendix 3b and 3c** in Unit 1 for assessment tools.

Teacher Resources

Manitoba Transplant Program. 2002. *Organ and Tissue Donation – A Fact of Life.* Supplemental Curriculum Document, Senior 3 Biology. Winnipeg: Manitoba Transplant Program. Pg. 5,6,14,15,16,37.

History of transplants began in Manitoba, Manitoba Transplant Program. Pg. 28, 30-33, 46-48.

Appendix

Appendix 1a Urinalysis – Student Handout (BLM)

Objectives

- Conduct various tests on a known urine sample to identify characteristics of urine
- Identify the characteristics of an unknown urine sample

Procedure

Design a table for your results. The table should have space to record your data and drawings for eight tests on two known samples and one unknown practice sample.

Part A: Examination of Known Samples

1. Initial Examination of Urine

1. Examine each urine sample for odour. Describe the odour you smell.
2. Comment on the colour of the sample. Use terminology such as yellow, amber, dark pale.
3. Describe the clarity of the sample. Use terminology such as clear, cloudy etc.

2. Determining Specific Gravity

1. Remove the hydrometer from its cylinder and empty the water from the cylinder into the sink. Fill the hydrometer cylinder three quarters full with the urine sample.
2. With a spinning motion, float the hydrometer in the urine. Be sure that the hydrometer stays suspended in the urine and does not adhere to the sides of the cylinder.
3. When the hydrometer has stopped spinning and is not touching the sides of the cylinder, read the specific gravity of each sample at the bottom of the meniscus formed at the hydrometer column. Record the specific gravity.
4. Pour the urine sample in the hydrometer cylinder into a test tube for Part 3 and 4 of the activity. Pour any remaining urine back into the sample container.
5. Rinse and repeat with each sample.
6. Rinse and fill the hydrometer cylinder with water and place the hydrometer in the water.

3. Testing for pH

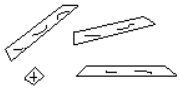
1. Use pHydrion pH test paper to test the sample.
2. Compare with the coloured pH scale provided.
3. Record the pH in the table.
4. Repeat with each sample.

4. Sediment Analysis

1. In this part of the activity you will be looking for blood cells, crystals and phosphate granules in the urine sample. The presence of blood cells in the urine may be indicative of an abnormal condition, while the crystals may indicate the presence of drugs.
2. Fill one small test tube with the urine sample.
3. Set the tube in the centrifuge opposite someone else's sample and spin for five minutes. (Please check with the teacher that your setup is correct before you turn on the centrifuge).
4. After centrifuging, pour off the liquid or supernatant and place into a clean test tube. Place the test tube to the side to be used in part 5.

What You May See in the Urine Sample

Amorphous phosphates(normal)



Oxalate crystals(normal)

Red Blood Cells (May indicate disease)

Acetylsalicylic Acid Crystals (Aspirin Present)

5. Shake the test tube to re-suspend the sediment in the small amount of urine left in the test tube. Pour this onto a slide and prepare a wet mount to observe under the microscope.
6. Describe the sediment you observe under the microscope. (Remember to include any blood cells, phosphate granules or crystals you observe.)
7. Repeat for each sample.

5. Testing for Albumin (protein)

1. Observe and record the clarity of the supernatant.
2. Separate the supernatant into two parts. Place one part to the side for use in Part 6.
3. Place the second part of the supernatant in a test tube and place in a hot water bath.
4. Compare the cloudiness of the heated supernatant with the unheated portion of the supernatant. If cloudiness increases in the heated sample, then protein is present.
5. Repeat with each sample.

6. Testing for Glucose

1. Add 10 drops of Benedict's solution to the unheated portion of the supernatant from part 5.

2. Fill a second test tube one quarter full of water and add 10 drops of Benedict's Solution (this is the control).
3. Boil both test tubes for 4-5 minutes and then allow test tubes to cool.
4. An orange precipitate will form when glucose is present.
5. Repeat with each sample.

Part B: Analysis of Unknown Urine Sample

You will be required to complete an analysis on an unknown urine sample using the procedures you have learned in Part A.

1. Obtain 50 ml of one of the unknown urine sample.
2. Perform the urine analysis procedure on your unknown sample and compare the results to the known samples.
3. Check your results with the teacher's key.

Analysis

1. Research to determine what are the normal ranges of the tests you have completed for human urine. Pick one specific test and research the possible diseases or medical illnesses that can occur if a person exceeds the normal range.

Urinalysis Lab 1b - Teacher Background

Suggestions for Instruction

The following concepts may be developed in this section:
- Kidney function and disease
- Chemical reactions

- Review/discuss kidney function and the formation of urine. Include a look at conditions and diseases that might be tested for with a urinalysis.

Urinalysis

Part A: Analysis of Known Samples

1. Initial Examination of Urine
Students make a visual examination of the odour and colour of the sample. While the urine is synthetic, it may take some time for students to "settle down" with the idea of working with urine. It is important for them to consider the samples as "real" and perform the procedures accordingly. This means, that they should keep their equipment clean and be aware of potential health concerns if they spill their samples.

2. Specific Gravity of Urine
Some time may be needed to show the class the proper use of a hydrometer and how it is used to determine specific gravity. Students should understand that having a change in the specific gravity of urine could indicate a medical problem.

3. pH of Urine
pH paper is used to determine the pH of urine.

4. Sediment Analysis
Analysis of sediment can provide clues such as an abnormal condition of blood in the urine or the presence of crystals in the urine that may indicate drug use. Students are provided with diagrams to assist in identification.

5. Presence of Albumin (protein)
Using part of the supernatant, students heat the liquid. If protein is present it will denature and make the solution cloudy.

6. Presence of Glucose

Testing for sugar may give an indication of diseases such as diabetes. Students will need to use care when working with Benedicts solution and a hot plate.

Part B: Unknown Sample Analysis (Practice)

Students are given a choice of samples to choose from and they are to determine the composition of the urine by performing the eight tests. Each sample has a different set of conditions based on how you prepare the sample. You may choose to make up your own samples or you may choose to follow sample preparation key.

Materials

- Stock and sample solutions
- Hydrometers
- pH testing paper
- Centrifuge
- Microscope (including slides and coverslips)
- Test tubes
- Beakers
- Hot plate
- Benedicts Solution

Preparation of Urine Samples

Stock Solution
To 1 L of distilled water add:
3 g NaCl
3 g Ammonium oxalate
3 g Potassium phosphate

For Parts 1 to 6 of the activity make the following solution:

To the 1 L stock solution add:

- 2 drops of 1 M HCl
- 1 aspirin tablet
- 1 g glucose
- 1 g albumin powder
- 5 g urea
- blood cells (Obtain fresh from butcher/meat department)

Sample Solutions
To a 1 L stock solution for each sample add the following:

- Sample #1
  24 ml 0.1M NH3
  1 g glucose
- Sample #3
  1 g glucose
  1 g albumin powder
  blood cells

- Sample #2
  5 g urea
  1 g albumin powder

- Sample #4
  1 aspirin
  2 drops of 3M HCl

Note:
Solutions will keep for about a week in the fridge.

- Adjust pH as required.

- Fresh blood cells should be added to appropriate samples each time the sample is used as they tend to lyse in solution.

- Blood obtained from butcher or meat department usually contains few whole blood cells. Centrifuge blood and pour off liquid. Re-suspend cells in a small portion of "urine" and add to sample.

Sample Preparation Key

Specimen #	pH	Protein	Glucose	Amorphous Phosphate	Crystals	Blood	Specific Gravity
1	8	-	+	+	Oxalate	-	Varies
2	6	+	-	+	Oxalate	-	Varies
3	6	+	+	+	Oxalate	+	Varies
4	2/3	-	+	+	Oxalate, Aspirin	-	Varies

Appendix 2: Debating Skills Rubric

Debating Rubric	Exemplary	Accomplished	Developing	Beginning
	4	3	2	1
Organization of Opening Statement	Always maintains focus on the topic	Sometimes maintains focus on the topic	Rarely maintains focus on the topic	Does not maintain focus on the topic
Use of Evidence to support claims	Always uses evidence to support claims	Sometimes uses some evidence to support claims	Rarely uses evidence to support claims	Does not use evidence to support claims
Persuasiveness	Arguments are clear and convincing	Arguments or sometimes clear and convincing	Arguments arer rarely clear and convincing	Argments are not clear and not convincing
Teamwork	Always uses team members equally effectively	Sometimes uses team members equally effectively	Rarely uses team members equally effectively	Team members are not used equally effectively
Organization of Closing Statement	Always responds with points that are specific to the topic	Usually responds with points that are specific to the topic	Rarely responds with points that are specific to the topic	Did not respond with points specific to the topic

APPENDIX 3: Patient Profiles

- 15 years old; has had kidney disease since the age of three.
- 23 years old; received a kidney transplant 5 years ago, but the kidney was rejected.
- 45 years old, recovering alcoholic; was diagnosed with kidney failure 3 years ago due to the medications he was taking.
- 61 year old woman with years of high blood pressure which probably caused her kidneys to fail.
- 26 year old male who has a rare kidney disease.
- 55 year old female, smoker, with type 2 diabetes. Does not exercise regularly.
- 65 year old male with atherosclerosis. Has a heart condition and suffered a stroke one year ago.