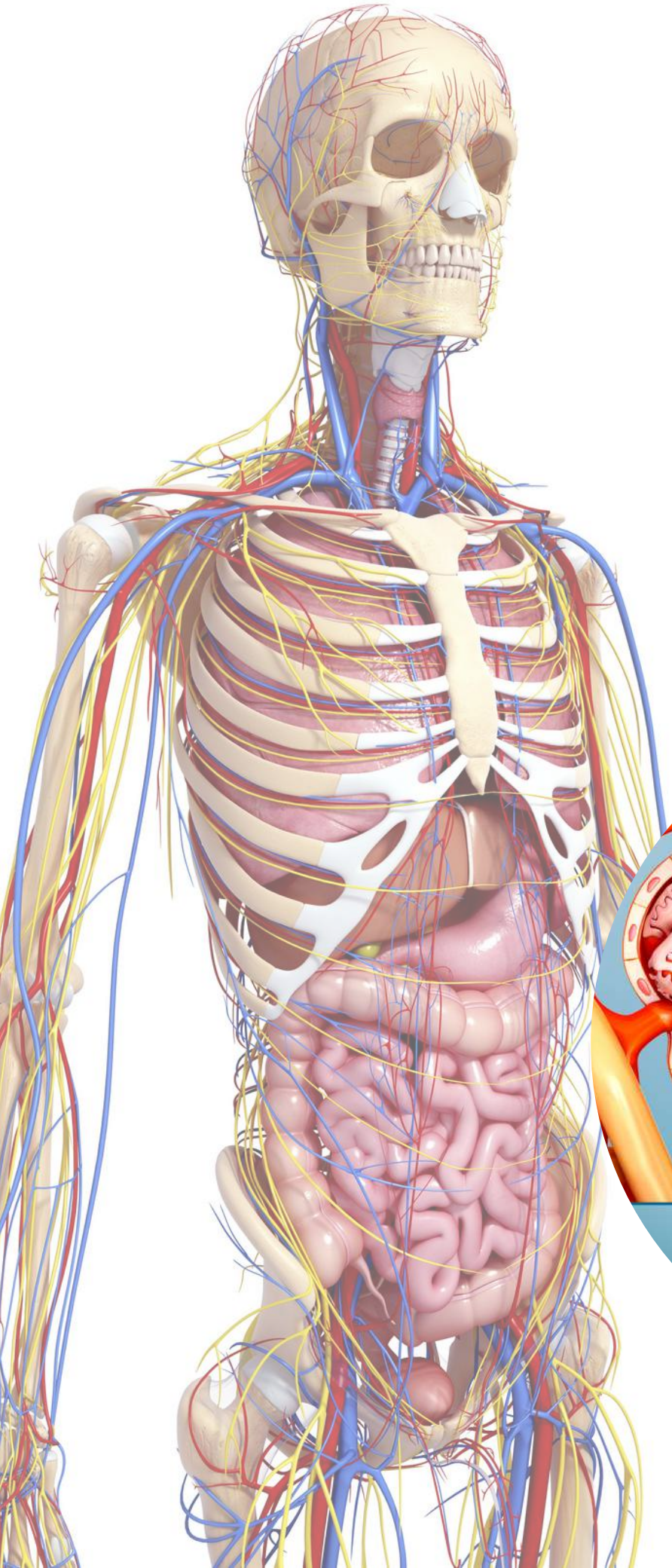
Urinary System
Lesson Plan
Grade 12



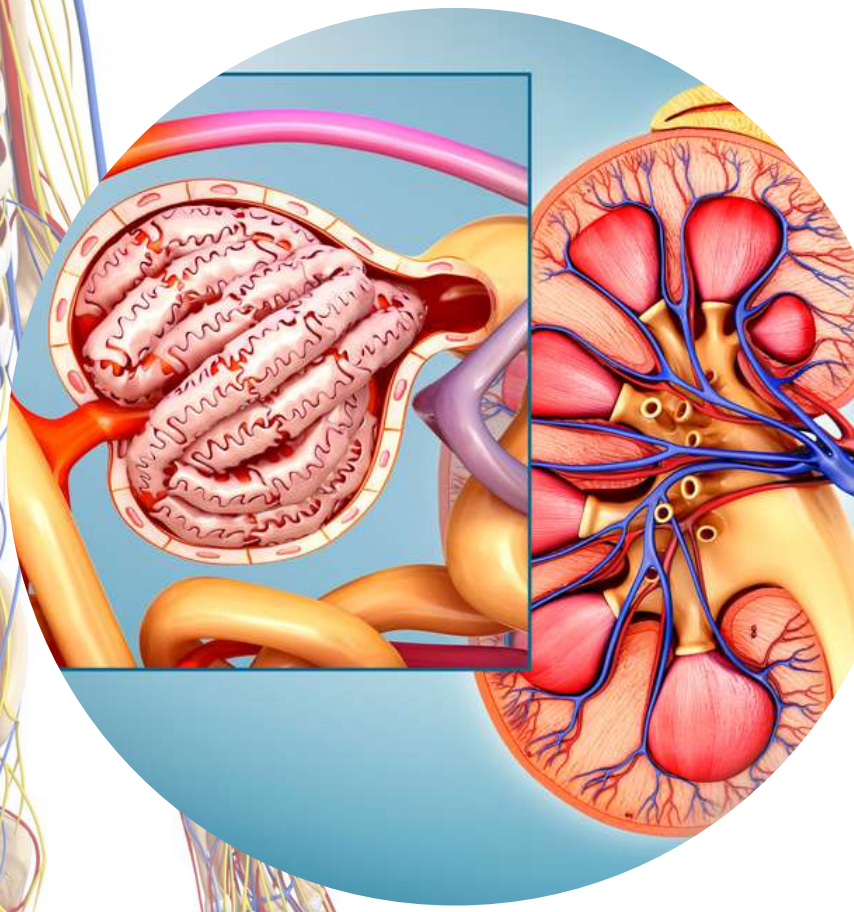


TABLE OF CONTENTS

The following unit plan was created in accordance with the Canadian Council on Animal Care's recommendations to replace any present procedures involving the use of animals in teaching, testing and research.

The Three Rs principle of Replacement states that if you can meet your scientific or educational goals without the use of animals, it is your ethical obligation to use non-animal methods. Grade 12 anatomy content is often taught using fetal pigs - here we offer an effective and humane alternative.

This is in alignment with the public's concern for animal welfare and a cultural respect for animals passed down from the Aboriginal perspectives of the First Peoples.

Elisabeth Ormandy created this unit plan and series of lesson plans for your use in teaching life science content to Grades 12 based on the BC Science Curriculum.

These Humane Science Education materials were developed to provide equivalent or greater standards in education for Canadian youth without the use of animals.

Curriculum Alignment

This lesson plan can be used to create classes for Grades 12 based on the BC Science Curriculum. Specific **Big Ideas** covered in this lesson plan include:

Grade 12 - Organ systems have complex interrelationships to maintain homeostasis.

ORGAN SYSTEMS:

- Structure and function
- Structural and functional interdependence
- Maintenance of homeostasis

We have recommended specific virtual anatomy tools to use to get the most out of the unit plan. You'll find links to those on pages 5 & 6.

Lesson Plan Overview

Subject: Science

Unit Overview: Anatomy and Physiology

Unit Duration: ~90 minutes

Grade: 12

Big Idea: Organ systems have complex interrelationships to maintain homeostasis

Curricular Competencies

- *Analyze cause-and-effect relationships*
- *Construct, analyze, and interpret graphs, models, and/or diagrams*
- *Consider the changes in knowledge over time as tools and technologies have developed*

Content

- By the end of this lesson, students are expected to demonstrate understanding of the following:
  - *Urinary system:*
    - *structure and function*
    - *structural and functional interdependence*
    - *maintenance of homeostasis*

Recommended Education Tools

Hardware & Workbooks:

This inventory is for a regular in-person class - use x1 iPad/tablet per student for responsible physical distancing. If teaching online, teachers can screen share their iPad/tablet or desktop.

- 6 (or more) iPads or other tablets
- 6 (or more) Urinary System workbooks

Recommended Software:

- 3D Anatomica: https://3danatomica.com
- 3D4Medical Complete Anatomy: https://3d4medical.com

Lesson Plan Overview

Topic: Organ systems have complex interrelationships to maintain homeostasis. Homeostasis is maintained through physiological processes.

Content: The human urinary system: organs, structure and function

Goals	Students will be able to: • Describe the function of the urinary system and its major organs. • Describe the relationships between the different components of the urinary system. • Explain how the urinary system is interdependent with the circulatory system. • Explain how the urinary system maintains homeostasis in the body.
Objectives	After this lesson students will state the structure and function of each organ/tissue in the urinary system and explain how the urinary system is functionally interdependent with other body systems.
Materials	• 3DAnatomica • 3D4Medical • Urinary System Workbook
Introduction	Using the 3DAnatomica and/or 3D4Medical app(s), the teacher will introduce the topic of urinary organ structure and function.
Development	Questions to support inquiry-based learning: • What is the advantage of having specialized tissues in the urinary system? • How does the urinary system help the body maintain internal balance during exercise? • What are the impacts of external stimulants (e.g. alcohol, caffeine) on the urinary system? • What lifestyle decisions would you make to improve your urinary system health? • How does the urinary system respond to infection by a pathogen?
Practice	Students will work independently or in pairs to navigate 3DAnatomica and/or 3D4Medical to learn about the structure and function of the urinary organs.

Lesson Plan Approach

If teaching regular in-person classes:

- Split students into **6 groups**.
- Give each group a **Urinary System workbook** to refer to, and one (or more) iPad(s) or tablet(s) with the **3D Anatomica app**, and/or **3D4Medical Complete Anatomy app** loaded and ready to use.
- Your **introduction** should include discussion of the function of the urinary system, identifying its major components, and the vocabulary you would like students to learn (~ 15 mins). **Define homeostasis**. Have the students follow along using the 3D Anatomica and/or 3D4Medical Complete Anatomy app.
- Have students **label "Major Structures"** diagram.
- **Discuss the function** each major structure in the urinary system. Have students use the 3D Anatomica and/or 3D4Medical Complete Anatomy app to fill their Urinary System workbook and/or handouts provided. This can be student or teacher led. (30 mins)
- Explore the "**Kidney and Nephron"** page content using the 3D4 Medical App and 3DAnatomica app. The students can cut away at the organs in the app to locate structures that need to be labeled. Use the **Kidney Lobe Model** located in 3D4Medical app under "Models". Discuss kidney and nephron function.
- Go through the stages of urine formation as a group, following along using the **models in the apps,** then ask students to summarize each stage.
- Ask students to brainstorm **ways the urinary system interacts with other systems,** and go over the specific examples provided on page 20.
- Discuss different ways the urinary system helps maintain homeostasis using examples provided on pages 22 and 23, then ask students to provide their own examples using what they've learned.
- **Close the class with a 20-minute recap** of what the students have learned, discuss how the parts of the urinary system work together, and check for understanding. Begin a **conversation on ethics** of animals in science using the questions provided.

If teaching a physically-distanced class:

- Use x1 iPad for each student and proceed as per the directions above.

If teaching online:

- Lead the students through the urinary system by screen sharing your own iPad/tablet or desktop with 3D Anatomica and/or 3D4Medical Complete Anatomy apps installed, filling out the tables, and labeling the models as you go
- Use Kahoot quizzes to keep the class interactive!

Detailed Lesson Plan & Teaching Notes

Introduction to the Lesson

Include a First Nations land acknowledgement and ask students to reflect on what respect for animals means to them. Provide an introduction to the apps and models that will be used in class. Provide an overview of how to access Urinary System workbooks and other handouts if teaching remotely.

What is Homeostasis? Discuss with Students

In biology, **homeostasis** refers to the body's ability to maintain a stable internal environment despite changes in external conditions.

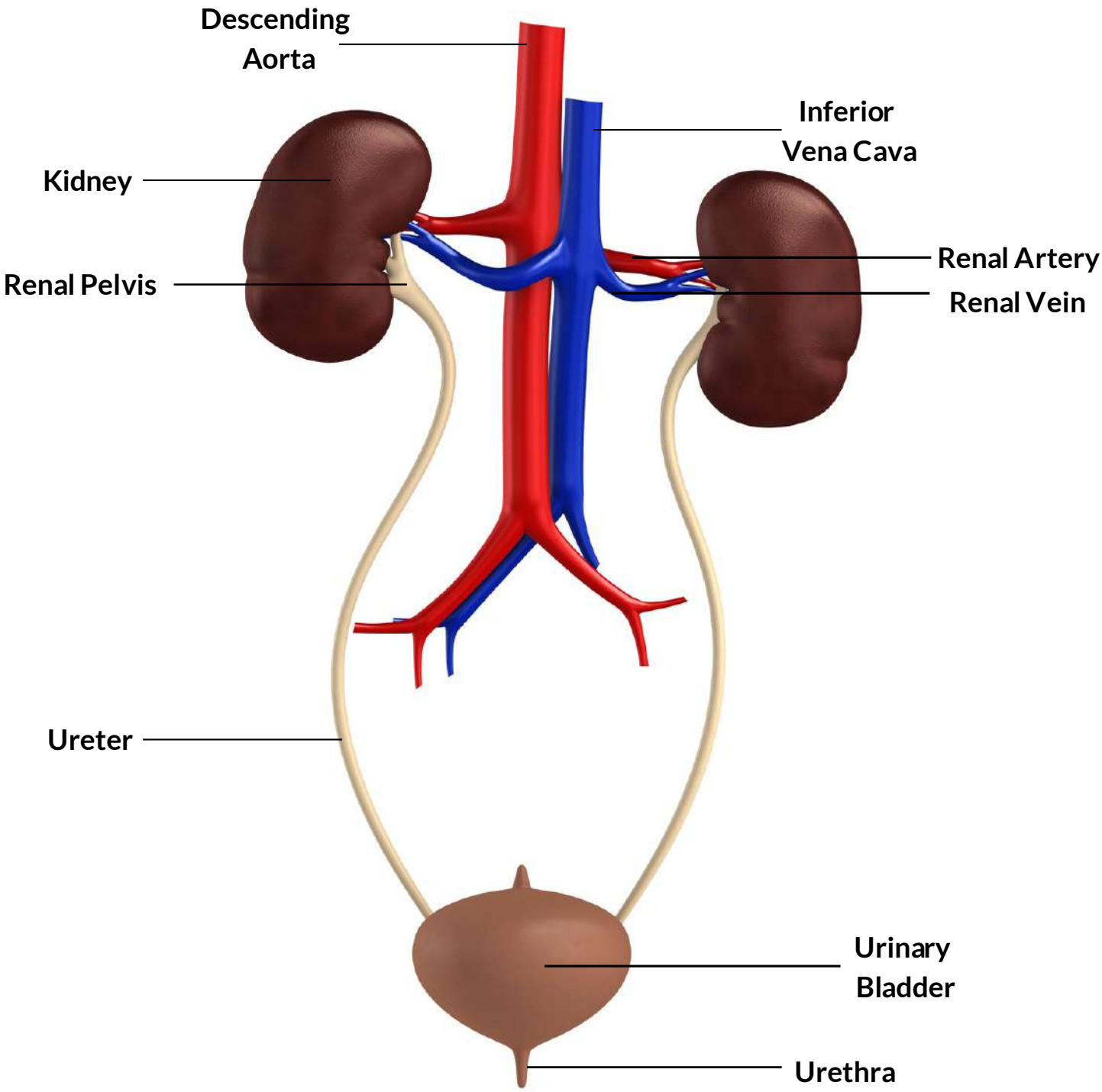
Introduction to the Topic

Students will use the **3DAnatomica and/or 3D4Medical Complete Anatomy** app to explore the urinary system at large. We recommend covering the function of the urinary system, identifying the major components of the system, and discussing the vocabulary you would like the students to learn early in the lesson.

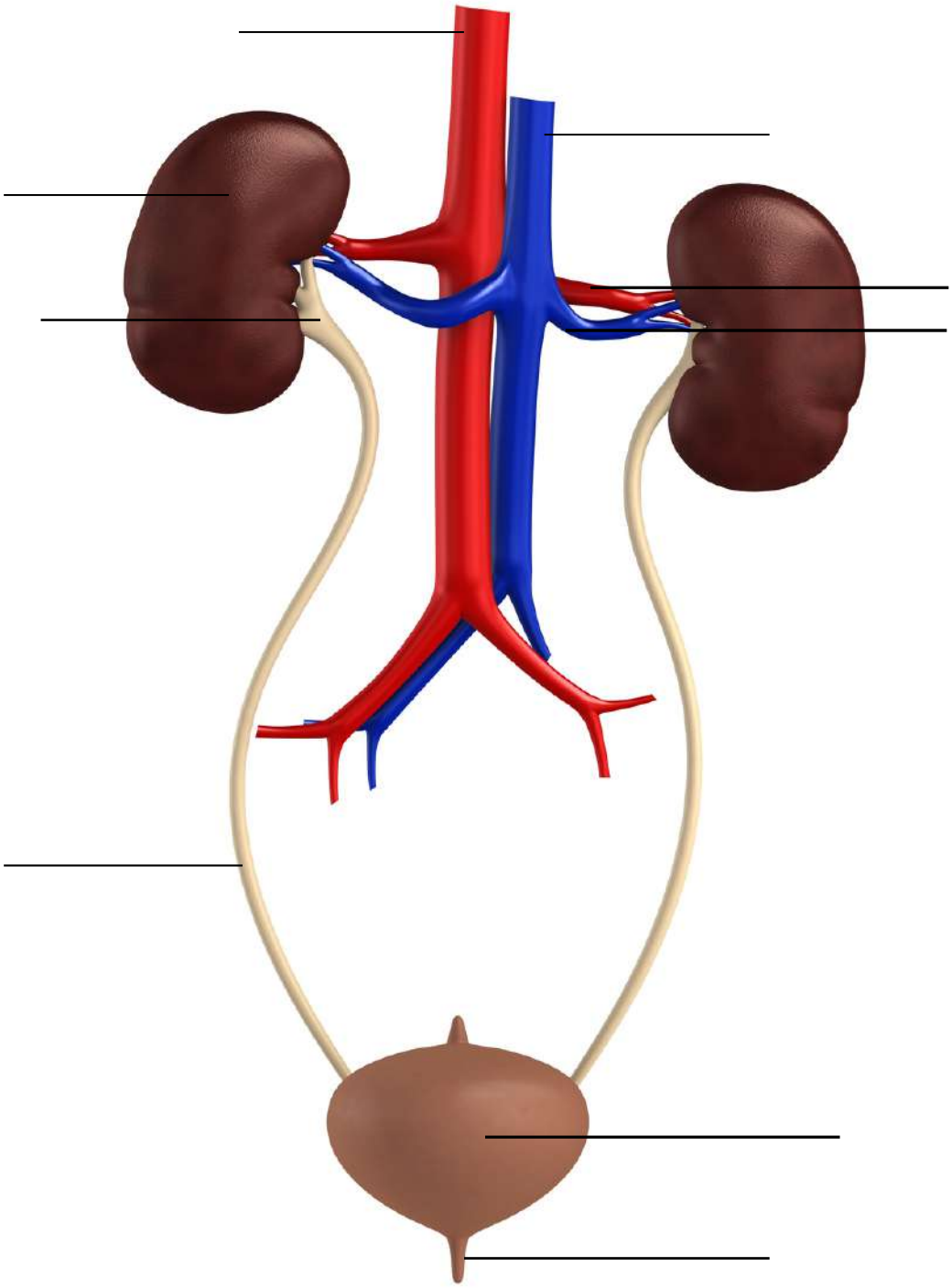
THE URINARY SYSTEM AT-A-GLANCE

Function	The urinary system is responsible for excretion. This is defined as the removal of nitrogen-containing waste products of metabolism and any excess substances due to cell metabolism.
Components	Kidney, ureter, bladder, urethra
Important Vocabulary	kidney, ureter, urethra, bladder, renal pelvis, descending aorta, inferior vena cava, renal artery, renal vein, renal cortex, renal medulla, minor calyx, major calyx, interlobar blood vessels, nephron, bowman's capsule, proximal convoluted tubule, distal convoluted tubule, collecting duct, afferent arteriole, glomerulus, efferent arteriole, peritubular capillaries, descending loop of Henle, hypotonic, hypertonic, hyperosmotic

Urinary System Major Structures (Teacher Copy)



Urinary System Major Structures (Student Copy)



Functions of major organs (Teacher Copy)

Using both **3D4Medical app**, and **3DAntatomica**, locate each structure and summarize the function.

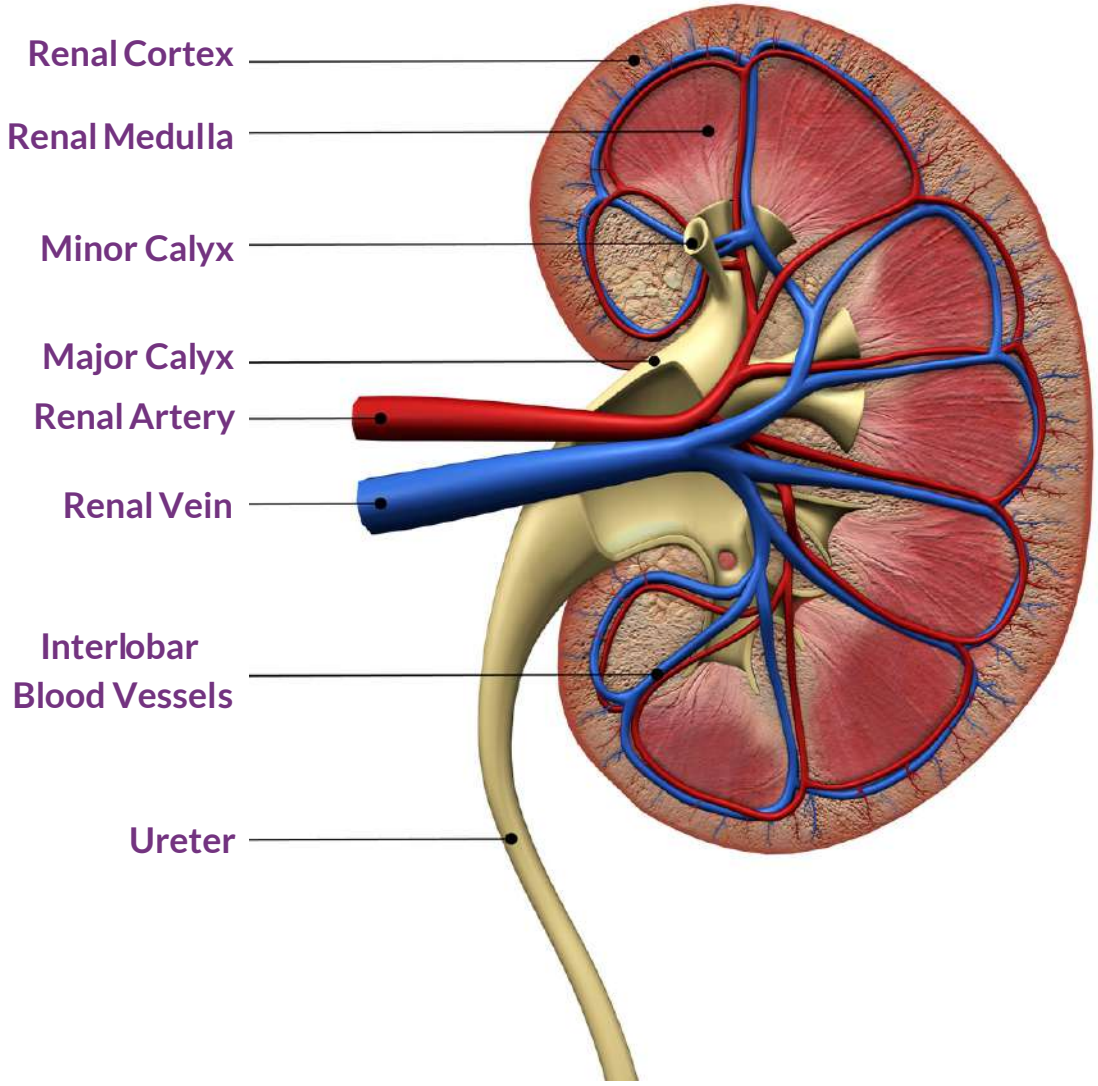
Organ	Structure, function & information
Kidney	• Aids in homeostasis maintenance by regulating water and ions • Main excretory organ • Regulation of hormone secretion, glucose production, and homeostatic • Regulation of extracellular substances • Blood is cleaned in the kidney: enters via renal artery, exits via renal vein
Ureter	• Transports urine from kidney to bladder via peristalsis • Lined with smooth muscle
Urinary bladder	• Reservoir that stores urine • Expandable • Sphincter muscles control urine release from the bladder when full • Located in pelvic cavity
Urethra	• Tube that carries urine outside the body when sphincter relaxes from the bladder, as well as semen during ejaculation in males

Main Structures of the Urinary System (Student Copy)

Explore the urinary system, noting the function and structure of each major organ, and how urine is formed. Use the apps provided to fill out your Urinary System workbook, and complete this table.

Organ	Structure, function & information

Components in Detail: 3D anatomica and 3D4 Complete Kidney (Teacher Copy)



Kidney Function

Kidneys are chief regulators of the body's internal environment, and therefore perform several **homeostatic functions:**

Regulates osmotic balance and blood volume by conserving or excreting H20 as demanded by the situation

Regulates ion concentration between the extracellular fluid (ECF) and the blood by controlling the excretion of inorganic **salts**

Regulates blood pH by excreting excess bases or acids:

- H^+ is excreted and HCO3- is reabsorbed if **blood is acidic**
- H^+ is **NOT** excreted and HCO3- is **NOT** reabsorbed if **blood is basic**

Excretes toxic metabolic by-products like **urea**, ammonia, uric acid, and creatinine

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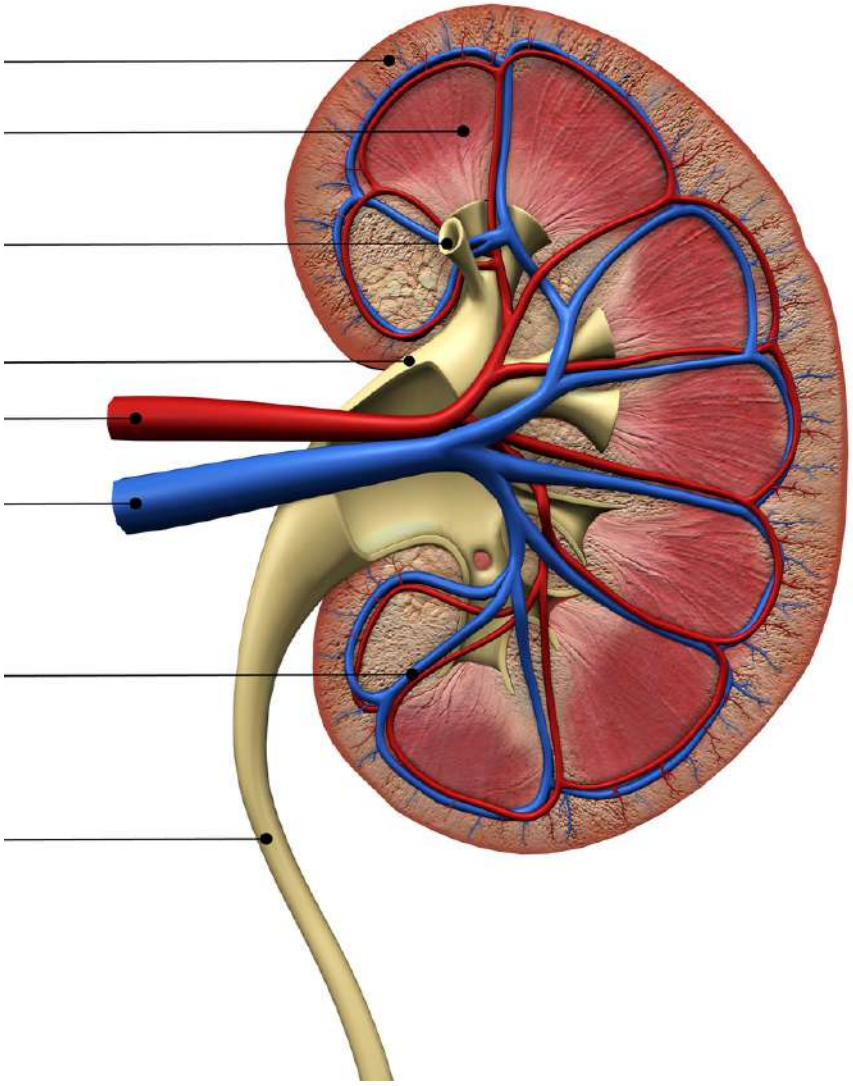

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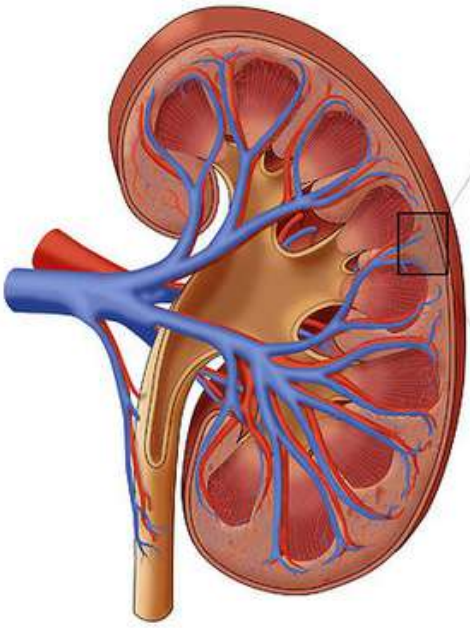
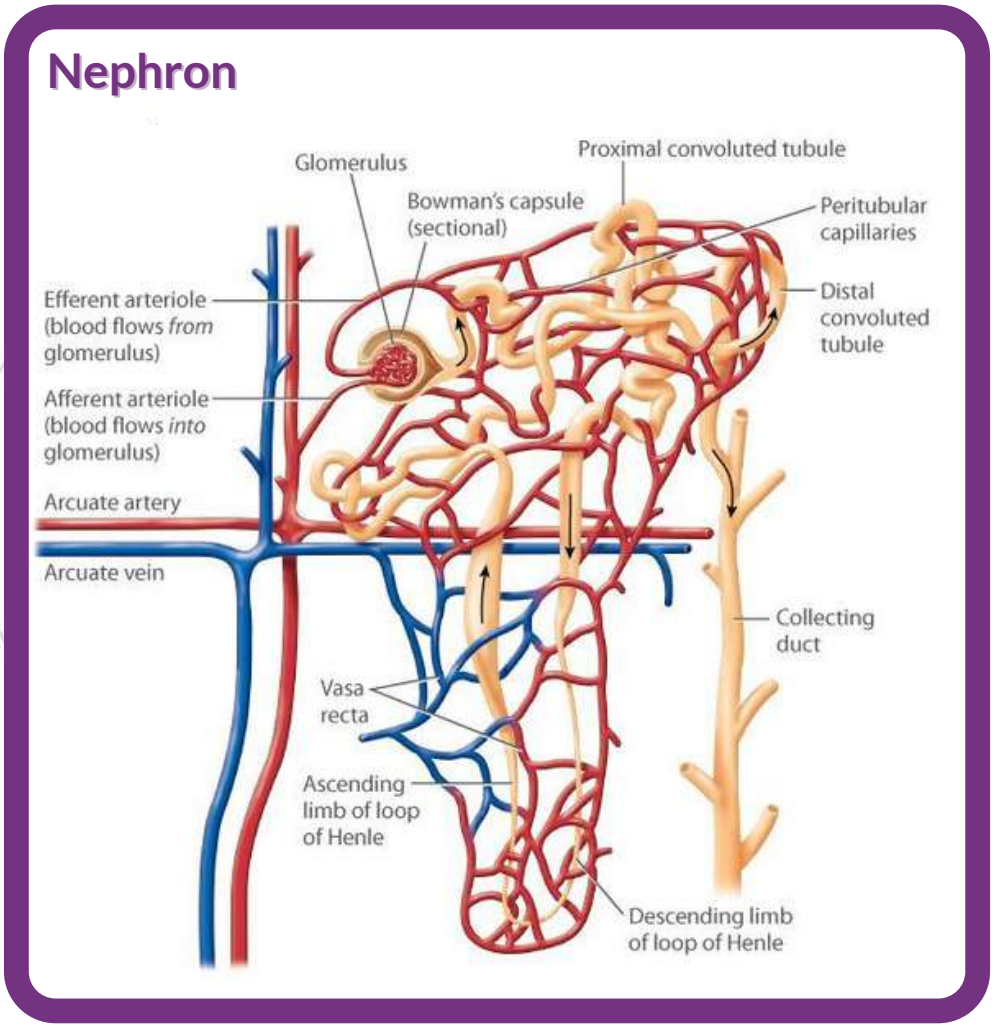
Components in Detail: Nephron (Teacher Copy)

The **nephron** is the functional unit of the kidney.
It consists of a **renal tubule** and its associated blood vessels.





Nephron Structure:

Bowmans Capsule:

- cup shaped receptacle, blind end of the renal tubule.
- **receives filtrate** from blood
- encloses ball of capillaries known as the **glomerulus**

Proximal Convoluted Tubule (PCT):

- **reabsorbs** most important fluids/nutrients (water, salt...)

Distal Convoluted Tubule (DCT):

- **blood excretes waste into DCT** to be removed in urine

Collecting Duct:

- **collects filtrate** from many tubules, and transports urine into renal pelvis.
- urea and water also reabsorbed here

Nephron Capillaries

Each nephron has its own blood supply, which comes from the renal artery

Afferent Arteriole:

- enters **bowman's capsule** from renal artery

Glomerulus

- its capillaries are very **twisted** and **porous**
- **within bowman's capsule**

Efferent Arteriole:

- **leaves bowmans capsule**
- blood very **hypertonic** since most plasma has left

Peritubular Capillaries:

- surround the **proximal and distal convoluted tubules**

Blood then travels to the renal venule -> renal vein -> vena cava

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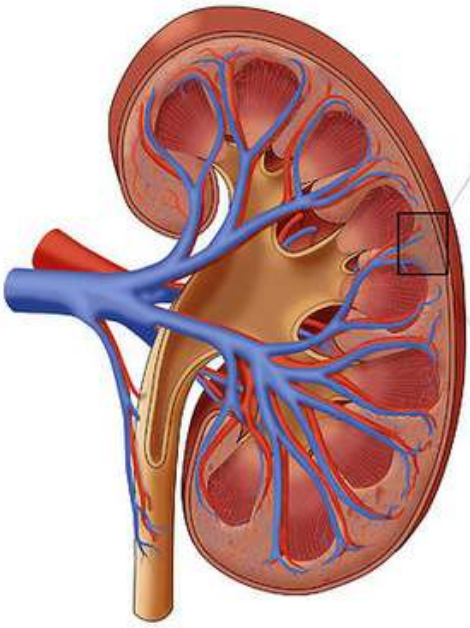

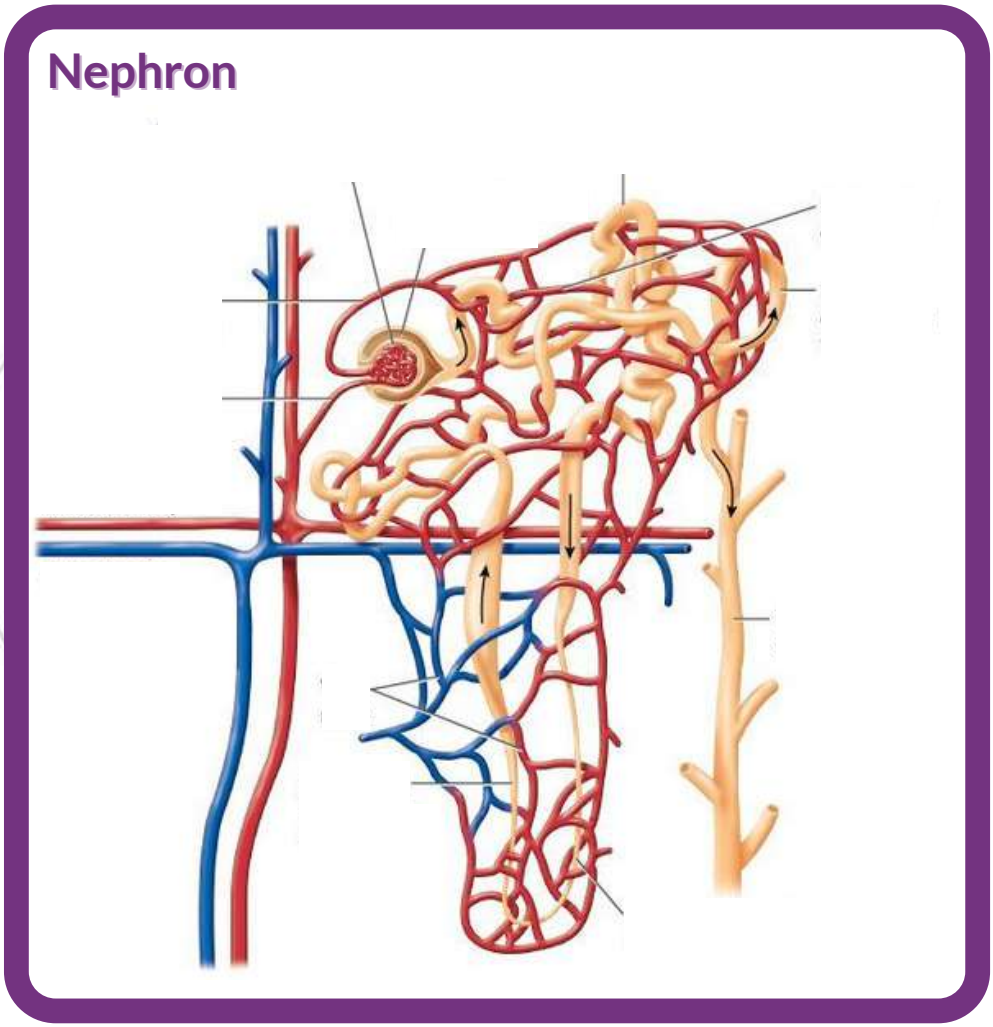

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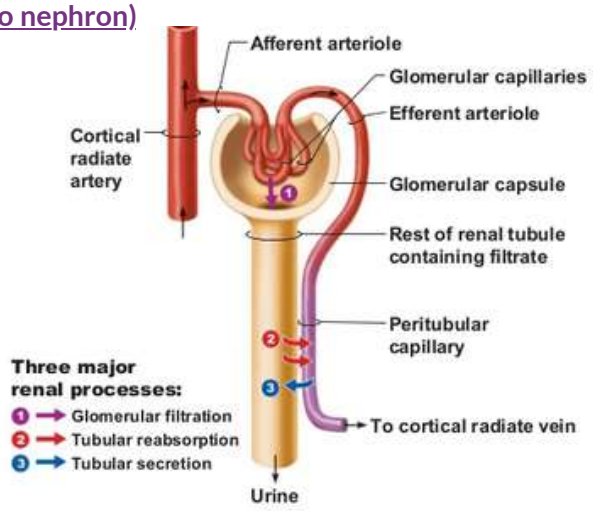
Components in Detail: Steps of Urine Formation

1 Pressure/Glomular Filtration (movement from blood to nephron)

a. **Pressure filtration:** water and solutes are forced through the **glomerulus pores** into the **Bowman's capsule** via **high blood pressure**
b. Pores in glomerulus are **small** enough to be permeable to water and small solutes, but **not large enough for blood cells or blood proteins**
c. A mixture of **nutrients, salts, water, and other small molecules** make up the **filtrate** **blood plasma** is **isotonic** (equal) to filtrate at this point



2 Selective/Tubular Reabsorption (movement from nephron to blood-peritubular capillary network)

a. **Important molecules (nutrients, sugar, salts, water) returned to blood**
   i. Sodium ions actively transported, chloride ions passively transported, and water by osmosis
   ii. Glucose, amino acids, and other nutrients are actively transported into the blood
   iii. Active transport **requires ATP**

Tubular/Water Reabsorption (mainly occurs in collecting duct and loop of Henle)

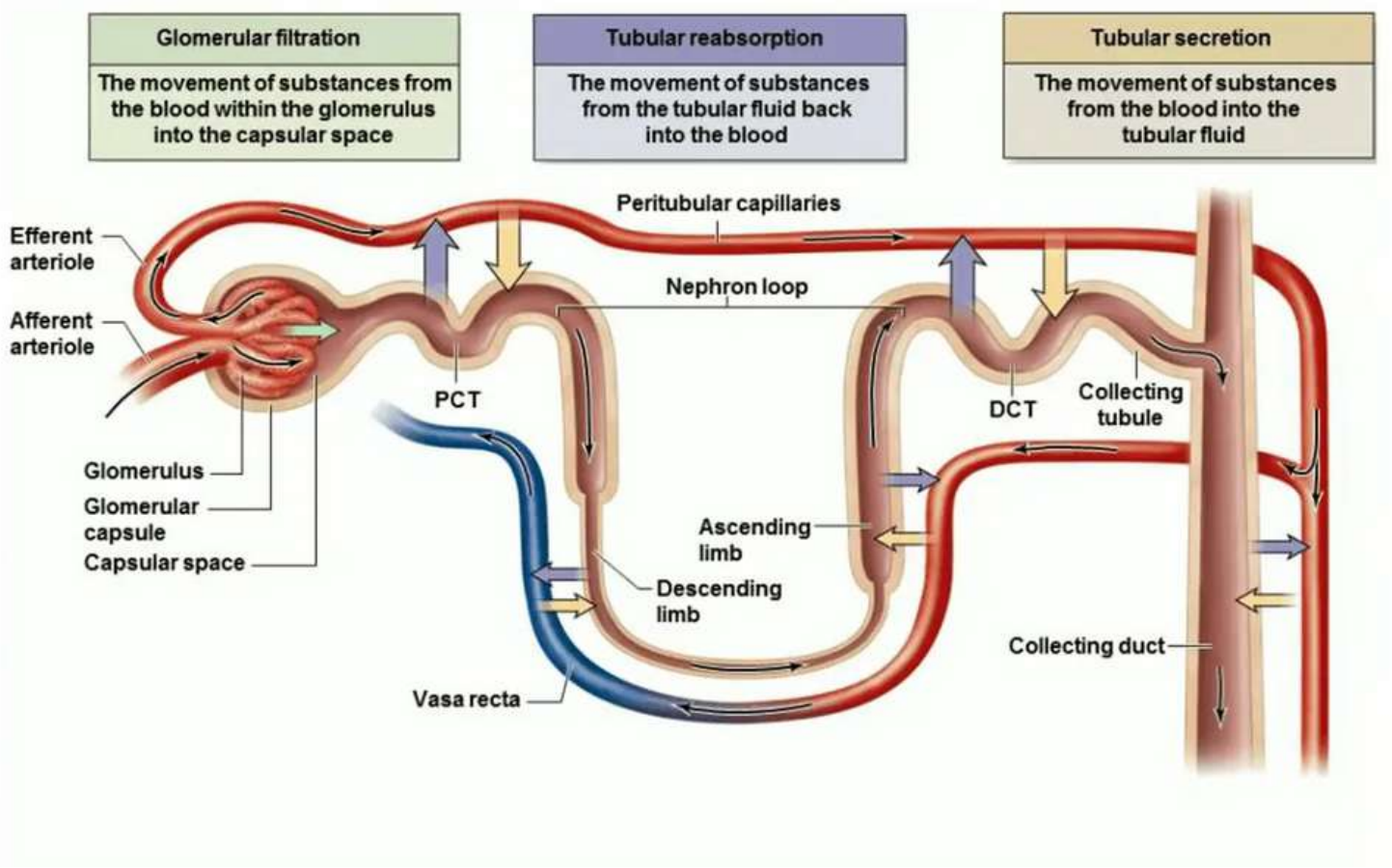
a. Nephron pumps urea and salt out, which makes medulla very **hyperosmotic**
   i. Allows water to move back into blood via osmosis
b. **Descending Loop of Henle:**
   i. As filtrate moves down to concentrated medulla from cortex, water is continued to be reabsorbed
   ii. Not very permeable to salt, but permeable to water
   iii. **Filtrate becomes concentrated** as a result from the great loss of water into the **hypertonic** blood by osmosis
c. **Ascending Loop of Henle:**
   i. **NOT WATER PERMEABLE,** but salt can pass
      1. NaCL actively and passively moves into the blood in the renal medulla, from the tubule
   ii. This leads to a **hypertonic** blood solution: filtrate moves **toward DCT** and **becomes more dilute** as most of the salt has left it.
d. **Collecting Duct**
   i. **Water** also **reabsorbed** here
   ii. **Filtrate loses more water by osmosis** as the duct moves down into the very **hypertonic** medulla
   iii. Leads to concentration of urea in filtrate, and since there is such a large amount of urea in the collecting duct, some diffuses back into the blood and medulla, down its concentration gradient

3 Tubular Secretion (movement from blood to nephron)

a. Occurs by **active transport** from blood to tubular fluid in **distal convoluted tubule (DCT)**
b. If blood still needs to get rid of more waste and ions, it will secrete them into the DCT
c. Very selective process involing passive and active transport

Components in Detail: Steps of Urine Formation (Teacher Copy)

Under each heading, summarize the movement of substances for the stage of urine formation in question.



Check Your Understanding

Make sure you can explain what the main processes are that occur during each stage of urine formation.

Components in Detail: Steps of Urine Formation (Student Copy)

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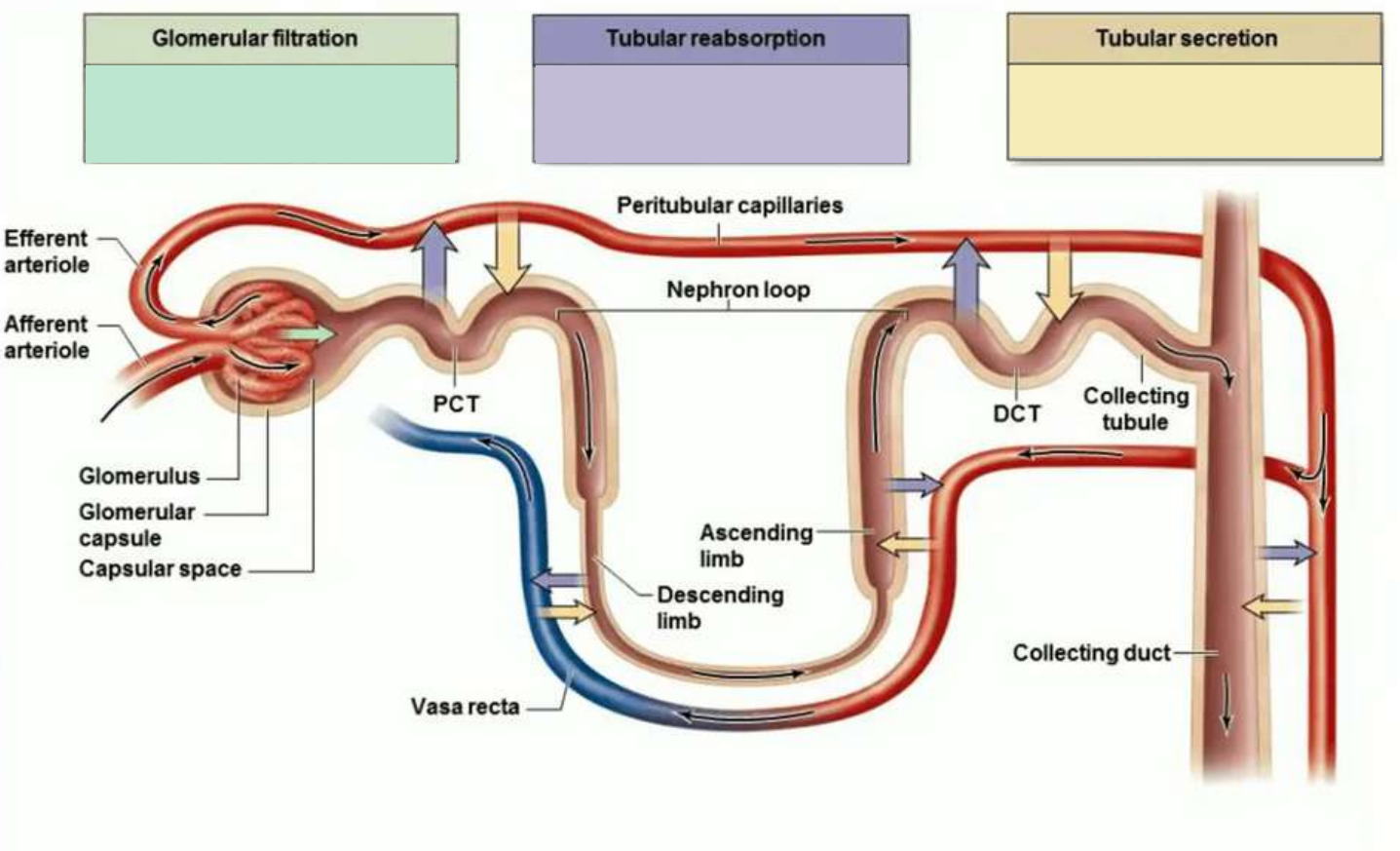


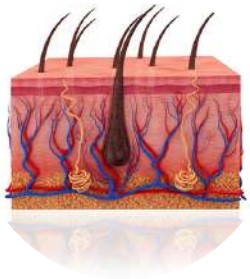
Check Your Understanding

Make sure you can explain what the main processes are that occur during each stage of urine formation.

How Does the Urinary System Work Together With Other Organ Systems? (Teacher Copy)

Ask students how they think the different organ systems work together based on what they've learned so far – specific questions can include:

1. How do the integumentary and urinary system interact?
2. Does the muscular system create any waste products?
3. How does the urinary system help with nutrient absorption in the digestive system?
4.Why is the urinary system so important to the cardiovascular system?

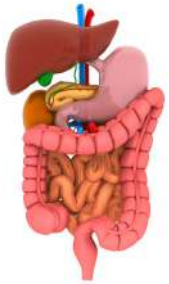


Integumentary System

When you sweat, kidneys compensate for this loss of water. Skin helps, regulate water loss, with sweat glands carrying on some excretion processes. Vitamin D is made by the skin, which is converted by kidneys to its active form for calcium absorption.

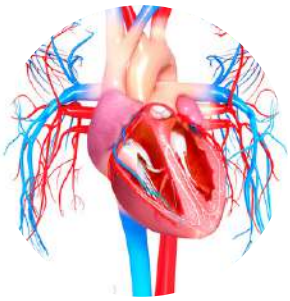
Muscular System

Kidneys help maintain the blood levels of calcium, potassium, and sodium. These are important for muscle innervation and aid in the elimination of creatinine, a muscle waste. Skeletal muscles protect and support urinary organs. Smooth muscular contractions aids in urination.



Digestive System

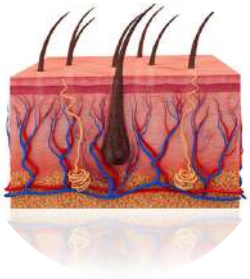
Urea is synthesized by the liver. Kidneys convert vitamin D to its active form needed for calcium absorption. The urinary system regulates water levels in the body by compensating for water loss in the digestive tract. The kidneys can conserve water if a person becomes dehydrated.



Cardiovascular System

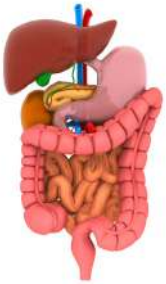
Kidneys maintain blood values within the normal limits of the body so that hormone transport in the body continues. They also filter blood and excrete wastes, maintain blood pressure, volume and pH levels. Blood vessels transport waste that needs to be excreted to the kidneys, and removes waste-free blood away.

How Does the Urinary System Work Together With Other Organ Systems? (Student Copy)

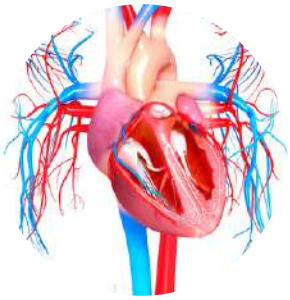


Integumentary System

Muscular System



Digestive System



Cardiovascular System

How Does the Urinary System Help Maintain Homeostasis?

To keep the internal environment in the body functioning properly, maintaining homeostasis is required. The urinary system, along with other body systems, help maintain energy homeostasis.

Blood Pressure

The kidneys play a role in regulating blood volume, and therefore blood pressure. Kidneys release renin, an enzyme that leads to the formation of powerful hormones, which eventually aid in sodium retention within the kidneys. Water follows passively as sodium is reabsorbed. This raises both blood pressure and volume. As blood pressure rises, the heart releases another hormone which has the opposite effect on the kidneys.

Control of pH

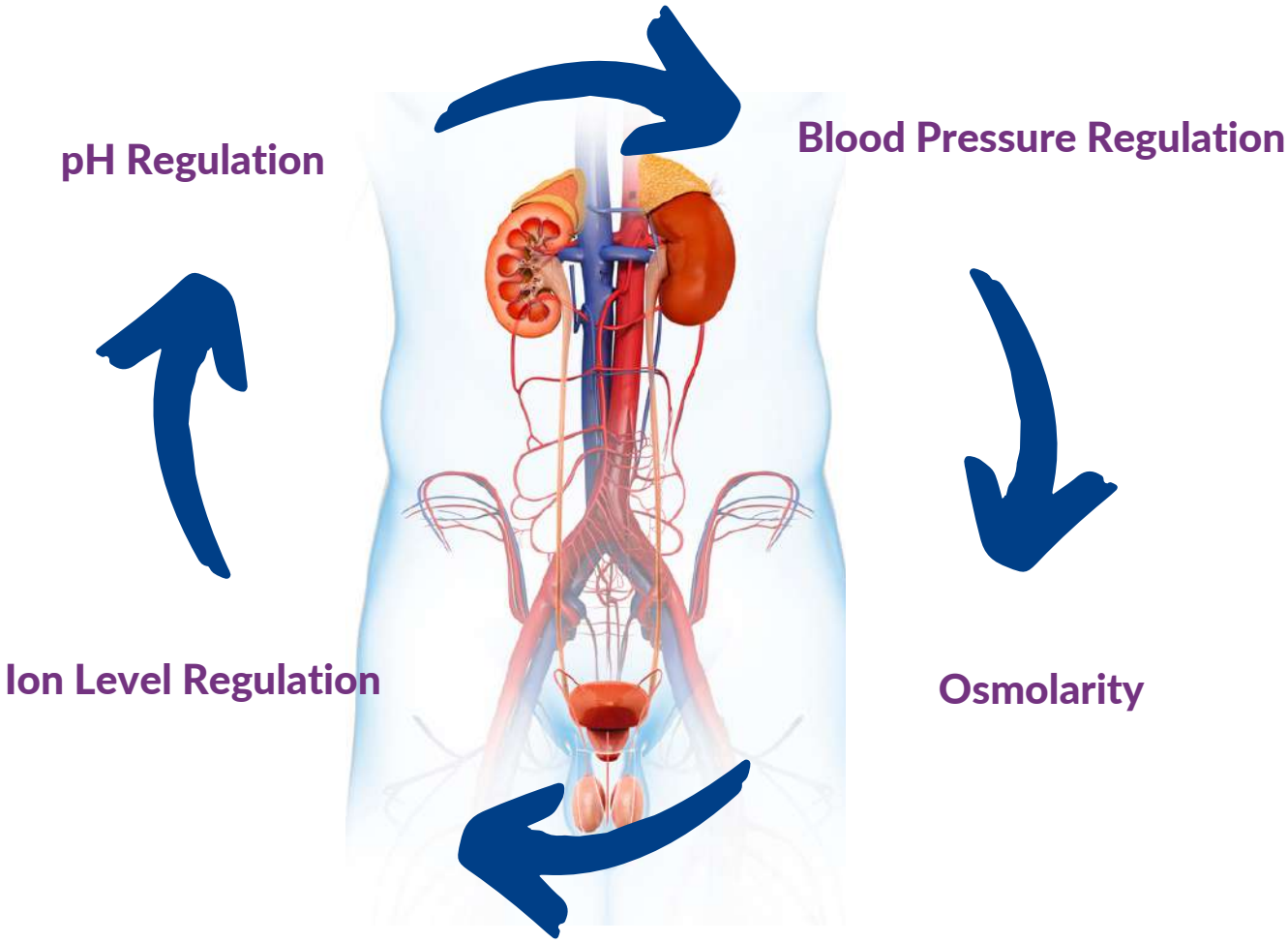
The kidneys are one of the body's most powerful tools in pH regulation. They form either alkaline or acidic urine, which reverts concentration of hydrogen ions back to normal. H+ ions are excreted by the kidneys when acidic urine is formed, and bicarbonate ions are excreted when alkaline urine is formed

Osmolarity

Cells need an isotonic environment to grow and maintain electrolyte and fluid balances. The body's osmotic balance is controlled by the kidneys - they regulate the amount of water filtered out of the blood and excreted into urine. If a large amount of water is consumed by a person, kidneys can reduce their water reabsorption. This allows excess water to be excreted and leads to diluted urine. If a person is dehydrated, kidneys will try and reabsorb the maximum amount of water possible back into the blood. Urine will then be highly concentrated with excreted ions and wastes. These changes in water excretion are controlled by the antidiuretic hormone (ADH).

What are some other examples of the urinary systems ability to maintain homeostasis within the body?

How Does the Urinary System Help Maintain Homeostasis?



In Summary:

What is the urinary system's role in homeostasis?

- Homeostasis of several important internal conditions is maintained by the kidneys by controlling excretion of substances out of the body.

Examples:

- Regulate pH levels by changing the acidity or alkalinity of urine
- Releasing hormones which increase sodium retention, and therefore change both blood pressure and volume
- With the help of ADH, maintain water levels within the body by controlling water retention and excretion within the urine.

Closing Check-In and Discussion

During the check closing in:

Recap with the students the stages of urine formation within the urinary system. Go over ways the urinary system interacts with other body systems, as well as how it helps maintain homeostasis. Ask the following questions:

- **What are main structures of the urinary system and their functions?**
- **How might virtual dissections and models compare with using real specimens?**

Closing - Discussion on Ethics

Generally, when studying human anatomy, schools often use fetal pigs for dissection due to the similarities between pig organ structures and systems, and our own. Would you feel any different about dissections if schools were to use human specimens over fetal pigs? What about other species? Why, or why not?

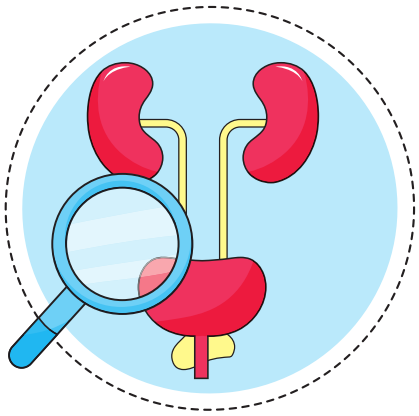
Think

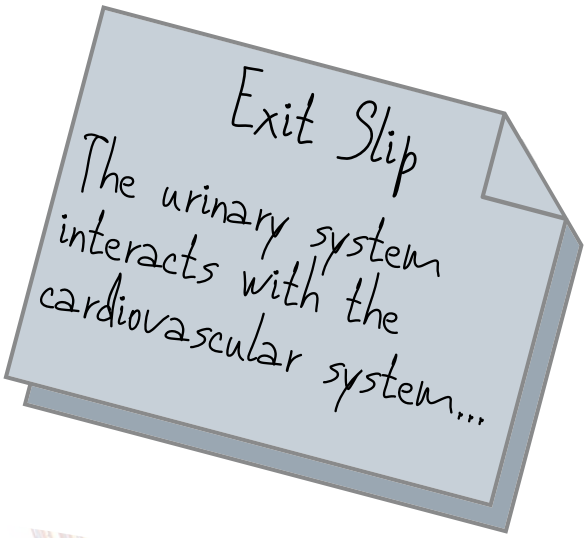
Ask the students to think about where they stand on the subject of animal dissections and the use of animals in science. They don't need to answer right away, rather, this is to get them to start forming their own ethical opinions about their own role in science education.

Formative Assessment

The formative assessment can be in the form of an exit slip. This involves asking each student at the end of the class to answer 2-3 questions on a sheet of paper and hand it in, with their names on it, to ensure understanding of the main concepts covered. Examples of questions to include:

- **What is one way the urinary system maintains homeostasis within the body?**
- **What is one way the urinary system interacts with other body systems?**
- **What are the main structures that make up the nephron?**





Thank you for choosing these materials to support your class adventures!

These Humane Science Education materials were developed by Elisabeth Ormandy for the Canadian Society for Humane Science (2015-2022) working to achieve better science without animals. By choosing these unit plans, you have joined a growing family of Humane Science Educators!

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