# Anatomy & Physiology 2 Mazes

MEDscience Physiology Maze Collection is Free as is Bio101 Pak

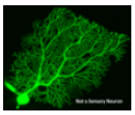
If new to physiology, FIRST try our free MEDscience Physiology Pak - for students thinking about PreMed and Health Sciences. THEN try A&P II to test your *Organ System Physiology* chops: Respiratory, Digestive System, Renal, Metabolism, Cardiovascular, Endocrine and Neural Physiology. Nice aid for tutors, MCAT prep and MOOCs!

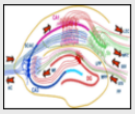
**Make sure to use the TIPS! - and if sent back to a question you probably got it right the first time: *try it again* and it may turn GREEN!**

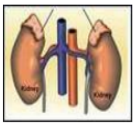
Collapse all

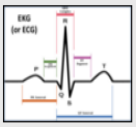
## Anatomy & Physiology 2: Organ Systems Physiology

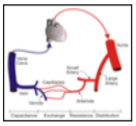
10 MAZE COLLECTION = $2.99 Purchased −

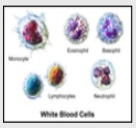
1. 
   **Anatomy & Physiology 2.1 Neurons & Sensory Systems**
   First Maze in the A&P II Semester Pak (which builds upon the free MEDscience Physiology Pak). This maze game on Systems Physiology introduces some neuronal basics and the operation of sensory systems.

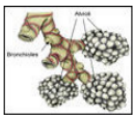
2. 
   **Anatomy & Physiology 2.2 - Systems Neuroscience**
   A&P 2.2 completes a very brief introduction to neurobiology. Type *neuro* in the Search Box, or scan the BIOLOGY TAB for more neurobiology maze games.

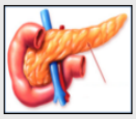
3. 
   **Anatomy & Physiology 2.3 - ANS / Endocrine System**
   This Maze spans autonomic and endocrine functions, including insulin, nerve agent, thrxine & more. Can try MEDscience Endocrine first--a bit easier.

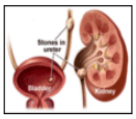
4. 
   **Anatomy & Physiology 2.4 - The Heart**
   The first of two cardiovascular mazes, this one focuses on the structure and function of the heart.

5. 
   **Anatomy & Physiology 2.5 - The Circulatory System**
   Review / Learn about types of blood cells, vessels and capillary dynamics and how they are regulated by CNS, lungs and kidneys.
   ⭐ You completed this maze on Dec 23, 2015 - 08:03 PM

6. 
   **Anatomy & Physiology 2.6 - Immunology & Lymphatics**
   Focus is on Innate & Adaptive Immunity, as well as Lymphatic Tissue. T cells and B cells and Nodes, oh my! For an easier immuno maze try: MEDscience06

7. 
   **Anatomy & Physiology 2.7 - The Respiratory System**
   This maze covers the physiology of the lungs as well as blood gasses and neural control of breathing. For Respiratory Basics try MEDscience 02 maze game.

8. 
   **Anatomy & Physiology 2.8 - The Digestive System**
   The GI system: know it from beginning to end! Includes transport, peristalsis, bile, regulation & more.

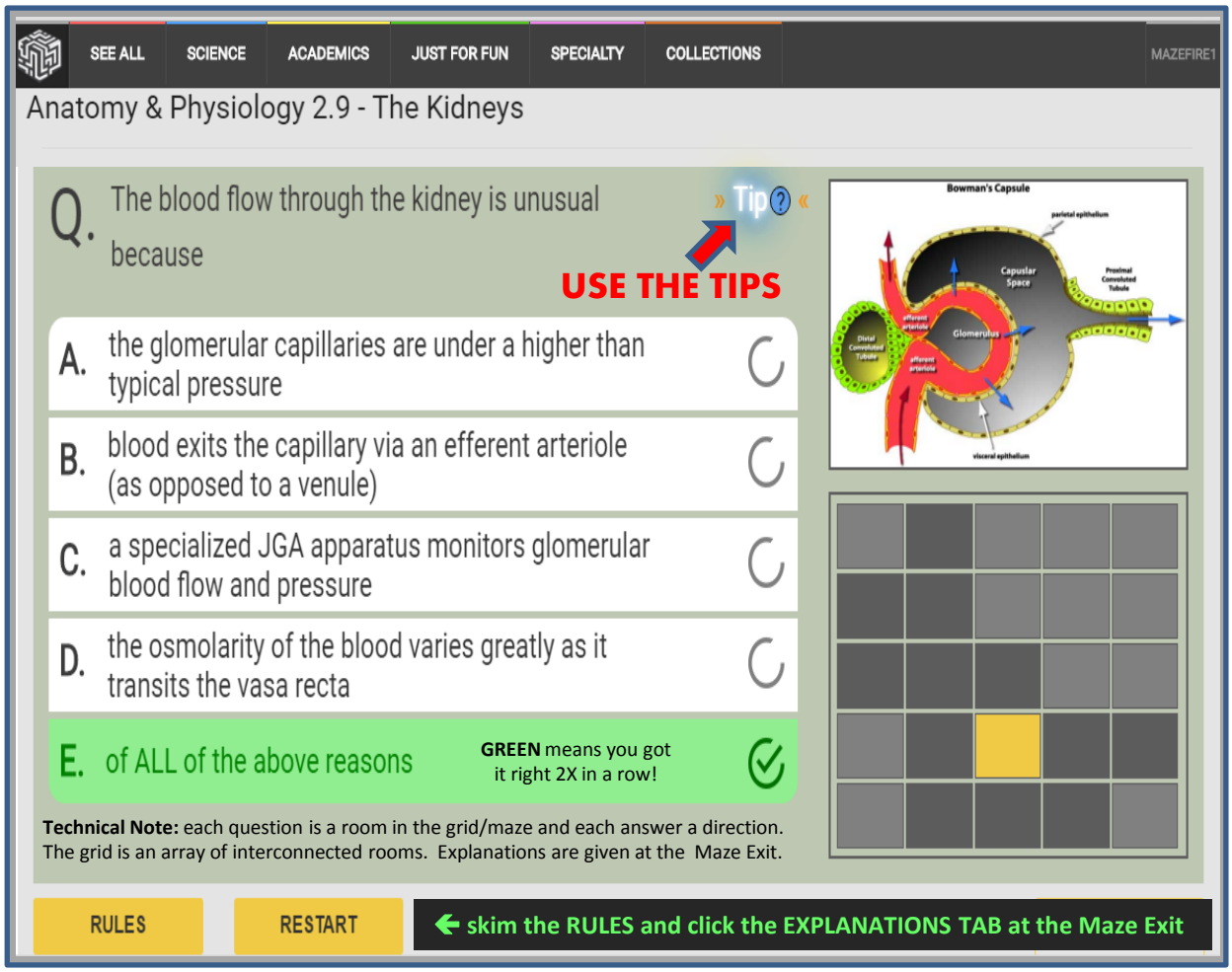
9. 
   **Anatomy & Physiology 2.9 - The Kidneys**
   This A&P II game takes you from Bowman's capsule, through the nephron and on down to the bladder and tests water and pH balance.

10. 
    **Anatomy & Physiology 2.10 - Energy & Homeostasis**
    Metabolism & Balance samples such topics as fluids, temperature, pH, homeostasis, nutrition & bioenergetics. Complementary maze games include Nutrition101 and Bio101.7-Bioenergetics.

# How to Play Digital Maze Games

1. **CORRECT** answers ALWAYS take you closer to Maze Exit
2. **WRONG** answers take you further away or boot you from maze.
3. **The Maze Exit** could be in ANY room!

**#1 TIP = when you see a question AGAIN you probably got it *correct* the first time *and* were sent back from DEEPER in the Maze:**
***try your answer again*- if it turns GREEN *you were right*!**




## How to WIN Digital Maze Games: MORE TIPS!

1. **use the TIPS!**
2. **ponder the images.**
3. **google unfamiliar terms.**
4. **play with friends.**
5. **email professor@mazefire.com for help.**

# Anatomy & Physiology 2.9 - The Kidneys

Please email contact@mazefire.com for corrections / technical issues. Use the ALL MAZES button to find other fun maze games.

Collapse all

**Q1. Which of the following is NOT a function of the kidneys?**

A. cleanse the blood of metabolic wastes
**B. cleanse the blood of bacteria and viruses**
C. regulate the pH of bodily fluids
D. regulate blood osmolarity
E. contribute to the regulation of blood pressure

**Tip at: 0 sec**
*Let's leave this to the immune system.*

**replaying maze games:** we do not have a "scramble" function, but if you want to re-test yourself do this: on most Mazes choose (A) in first room and this leads you on parallel forward path towards maze exit, with questions you may not have seen on your first playing of the maze.

*Regulating the composition of bodily fluids, as well as our overall fluid volume and osmolarity, are the immediate responsibilities of the kidneys, aka our urinary/renal system. One might think that when the kidneys filter blood this would also remove viruses and bacteria, but that does not happen because those particles are too large to pass through the glomerular filtration slits into the renal tubules. This is a good thing because if viruses passed into the renal tubules, so would all our plasma proteins, removing them from the circulation. And THAT would cause all kinds of problems. Instead, the kidneys focus more on removing smaller molecular waste products from the blood, which means that nutrients like glucose and amino acids, as well as important electrolytes, all end up in the filtrate--headed for the bladder. A PRIMARY downstream job of the kidney's nephrons is therefore to retrieve all the good stuff, including water, and void everything else.*

**Q2. Blood is filtered**

**A. by the proximal tubule**
B. by the distal tubule
**C. inside Bowman's capsule**
D. by the loop of Henle
E. by the counter-current exchanger

**Tip at: 20 sec**
*The glomerulus is a spherical structure.*

**INCORRECT** responses are shown in **RED**
**CORRECT** responses are shown in **GREEN**

*Renal filtration (aka ultrafiltration) is the process where blood is pushed through the glomerular capillary bed at relatively high pressure. This pressure not only moves fluid along the capillary, but also pushes some fluid out of the capillary, through the filtration slits, into Bowman's space, thus creating renal filtrate. The filtrate is not identical to blood plasma, because proteins are too large to pass through the slits (although peptides can pass, so some circulating hormones may be filtered out of the blood). Bowman's capsule, with the glomerulus inside, is called the Renal Corpuscle and is the beginning of a nephron. Filtrate continues to flow along the different sections of the nephron and while some materials are absorbed and others secreted, these should not be construed as filtration.*

**Q3. The final segment of the nephron is**

A. the glomerulus
B. Bowman's capsule
C. the proximal convoluted tubule
**D. the distal convoluted tubule**
E. the loop of Henle

**Tip at: 40 sec**
*O'er the hills and far away!*

*Filtrate is formed by fluid leaving the glomerular capillaries and entering Bowman's space. It then flows through the PCT, where much reabsorption of nutrients takes place. It next moves down and up the loop of Henle which invokes the countercurrent exchange mechanism that is discussed below. Finally the filtrate courses through the distal convoluted tubule (DCT) where some additional reabsorption and secretion can take place, in a regulated fashion. The DCT is nominally the end of the nephron, but filtrate (now urine) continues to flow into the collecting ducts, each of which receives fluid from multiple nephrons.*

**Q4. The blood flow through the kidney is unusual because**

**A. the glomerular capillaries are under a higher than typical pressure**
B. blood exits the capillary via an efferent arteriole (as opposed to a venule)
C. a specialized JGA apparatus monitors glomerular blood flow and pressure
D. the osmolarity of the blood varies greatly as it transits the vasa recta
**E. of ALL of the above reasons**

**Tip at: 60 sec**
*Strange and complex circulation!*

*The arcuate arteries deliver blood to the afferent arterioles which feed into the glomeruli. The efferent arteriole prevents blood from easily exiting the glomerulus. This backing up of flow (in effect) elevates glomerular pressures to where effective filtration can occur. The juxtaglomerular apparatus senses flow and if it falls substantially (which is a very BAD physiological sign) it initiates emergency steps to regulate blood pressure and volume, as discussed below. The efferent arteriole feeds into the vasa recta network in which blood flows in parallel with the loop of Henle, i.e. down deep into the renal medulla and back up to exit via the arcuate veins.*

**Q5. The counter-current multiplier refers to**

A. the exchanges of salt and water that occur in the vasa recta
B. the exchanges of salt and water that occur in the loop of Henle
C. the exchange of Na+ and K+ along the distal convoluted tubule
D. the exchange of Na+ and H+ along the distal convoluted tubule
E. the exchange of solutes between proximal and distal convoluted tubules

**Tip at: 80 sec**
*Requires that two streams flow past one another.*

*By virtue of the patterns of solute pumping and permeabilities of the descending and ascending limbs of the Loop of Henle, an osmolarity gradient is created, where the concentration of urea and other solutes in the interstitial fluid becomes increasingly concentrated the deeper you go into the renal medulla. While the PCT solution is isotonic (i.e. ~300 mOsm--same osmolarity as plasma and ISF), at the deepest parts of the medulla, the osmolarity is between 1200 and 1400 mOsm. The process of solute pumping as the descending and ascending limbs run anti-parallel to one another is called the counter-current multiplier. In contrast, the blood vessels that parallel the Loop, passively exchange solutes in a way that does not disrupt the established osmolarity gradients: this is called the counter-current exchanger. These processes are also used in Chemical Engineering!*

**Q6. Inulin is**

A. a pro-hormone version of insulin released by the JGA
B. a common misspelling of insulin
C. a substance that is neither secreted nor reabsorbed
D. an inert protein required for kidney dialysis
E. a key osmotic regulator

**Tip at: 100 sec**
*It provides a good measure of how much blood is being filtered.*

*GFR or glomerular filtration rate is the rate at which blood is filtered, i.e. the number of liters per day of fluid that is passed into Bowman's space. This can be measured with any small compound that is *inert* in the sense that it is neither secreted (i.e. an extra amount added to the filtrate) nor reabsorbed (transported from the filtrate back into the body). But common compounds in our body do not have this characteristic, since many wastes are secreted, while most nutrients are actively reabsorbed from the filtrate. Inulin, however, meets these criteria and based upon the concentration of inulin in the urine, in relation to its concentration in the blood, one can calculate GFR. Inulin is unrelated to *insulin*, and is in fact a plant carbohydrate, specifically a polymer of fructose. While inulin is sometimes used in dialysis research, it is not required for dialysis. The *key osmotic regulator* term sounds good but doesn't actually make any sense.*

**Q7. To increase the concentration of urine exiting the kidney, the hormone ADH**

A. activates aquaporins in the collecting duct
B. inhibits aquaporins in the collecting duct
C. increases the concentration of urea in the renal medulla
D. enhances the urea concentration gradient across the kidney
E. activates water pumps that pump water from filtrate into collecting duct cells

**Tip at: 120 sec**
*You need water to flow out of the dilute urine at the top of the collecting duct.*

*For brevity, we indicated that ADH *activates* aquaporin pumps, but to be more precise we should say that it initiates the insertion of vesicle-bound aquaporin proteins into the apical membrane of the collecting duct cells. It does this by binding the ADH receptor, which is a GPCR that increases cAMP, which in turn triggers the insertions. It does this when we have too little water and need to retain it. If we are over-hydrated, the aquaporins are removed and a very dilute urine is produced instead. As filtrate flows into the DCT, it is more dilute than the surrounding tissues and adding aquaporins near the end of the DCT begins the process of facilitating diffusion of water out of the filtrate. As the filtrate continues down the collecting duct, it encounters increasingly high medullary urea concentrations, and as long as aquaporins are present, water leaves the filtrate making it equal in osmolarity to the medullary urea- which is very concentrated and deep yellow in color (due to a hemoglobin breakdown product). Absent aquaporins, the recovery of water from the filtrate is greatly reduced and therefore a a very dilute, clear urine is excreted.*

**Q8. The outer portion of the kidneys, where the glomeruli are situated, is called**

A. renal cortex
B. renal medulla
C. renal pyramid
D. major calyx
E. minor calyx

**Tip at: 0 sec**
*Same term also applies to the cerebrum.*

*The kidney-bean shaped kidneys have a diffuse outer cortex that is richly supplied by blood vessels, which deliver blood to the ~1.3 million nephrons. The renal filtrate found here flows deep into the kidney, into the renal medulla, to the deepest parts of the nephrons. The nephrons are organized into large aggregates called renal pyramids. The minor calyxes collect filtrate/urine from the collecting ducts and, in turn, funnel into several major calyces, which funnel urine to the ureter which leads to the bladder. Dehydration might contribute to the formation of kidney stones-- tiny pebble-sized precipitates that can lead to an astonishing level of pain.*

**Q9. Which would NOT be found in or associated with a renal corpuscle?**

A. filtration slits
B. juxtaglomerular cells
C. podocytes
D. Bowman's space
**E. aquaporins**

**Tip at: 20 sec**
*The filtration membrane already passes water quite easily.*

*The renal corpuscle contains a glomerulus (tuft of capillaries) inside Bowman's capsule. This constitutes a sophisticated filtration apparatus beginning with the glomerular endothelial cells which have small windows called fenestrations. Fluid must then pass through a relatively porous basement membrane, which is supported on the other side by the end feet of podocyte cells. The gaps between the end feet are called filtration slits. Collectively, this device will pass molecules smaller than 30 kilodaltons, although negatively charged molecules will not pass as easily as neutral ones. This means that most molecules in the blood (glucose, amino acids, salts, etc.) will pass relatively freely though the membrane and their concentration in the filtrate will be the same as in the blood plasma--but this is only true at the START of the nephron. Aquaporins are specialized channels for water diffusion and are not present in the glomerulus. They are found past the nephron in the collecting duct and are used to regulate the degree to which urine is concentrated: yellow means less water!*

**Q10. Which of the following is NOT reabsorbed in the proximal convoluted tubule (PCT)?**

A. glucose
B. amino acids
C. sodium
**D. urea**
E. chloride

**Tip at: 40 sec**
*Why would you retrieve a waste product?*

*Because the volume of blood filtered (i.e. entering the renal filtrate) every day is VERY large relative to the amount of urine that needs to be excreted, the kidney needs to recover as much of the water and nutrients as possible. This is mostly accomplished in the proximal convoluted tubule. The NaK-ATPase (pump) provides the driving force for recovering many different solutes from the filtrate including phosphate, bicarbonate, Mg++, citrate and a variety of sugars. The sodium pump continuously pushes sodium out of PCT cells into the ISF (to the blood). This creates a large sodium gradient and now sodium in the filtrate can be used to actively transport assorted solutes into the PCT cells. This builds up the concentrations of those solutes inside the cells and now facilitated diffusion is sufficient to deliver them to the ISF/blood. Urea is not a nutrient, but is quite important to the functioning of the kidney as discussed below.*

**Q11. The macula densa cells**

A. comprise the juxtaglomerular apparatus (JGA)
**B. sense rising levels of potassium**
**C. are found in the *ascending* limb of the Loop of Henle**
D. are found in the *descending* limb of the Loop of Henle
E. release renin in response to low GFR

**Tip at: 60 sec**
*They check on the fluid entering the distal convoluted tubule.*

*Perhaps no homeostatic variable is so urgent as maintenance of blood pressure (BP), since circulatory collapse means death. While the SNS and baroreceptors can evoke immediate vasoconstriction to boost BP, over all longer time periods the kidney plays a crucial role in retaining salts and water, which are the main constituents of blood volume (no blood = no BP). The macula densa cells at the top of the ascending limb are positioned near the juxtaglomerular cells and *together* they comprise the JGA. Our current understanding is that macula densa cells sense a drop in filtrate flow and/or a decreased filtrate sodium (which go together), which leads to prostaglandin release and *afferent* arteriole vasodilation (which boosts GFR). This also causes renin release, which boosts aldosterone release and increases recovery of sodium and water in the distal tubule and collecting duct. Renin also causes *efferent* arteriole vasoconstriction, which further boosts GFR (blood backs up into the glomerulus). Locally, this preserves GFR which means the kidneys keep functioning, which is critical over longer time frames.*

**Q12. In cases of congestive heart failure, diuretics are used to**

A. increase the flow of blood to the heart
B. raise blood pressure
C. raise blood volume
**D. lower blood volume**
E. increase blood flow to the lungs

**Tip at: 80 sec**
*Alcohol is a diuretic!*

*Congestive heart failure (CHF) often results in poor ejection of blood into the systemic circulation, resulting in blood backing up into the pulmonary veins and capillaries, and edema, the leakage of fluid into the pulmonary tissues. This impairs capillary gas exchange and thus leads to shortness of breath, which can worsen when lying down (CHF patients rely on pillows and may resort to sleeping sitting up). Diuretics promote increased urination by preventing reabsorption of sodium (or bicarbonate) or by osmotic effects (e.g. mannitol). This lowers blood volume which lowers blood pressure and can alleviate the edema in pulmonary tissues, in part by increasing capillary oncotic pressure. Alcohol is a diuretic that works by inhibiting ADH secretion from the pituitary. The conjunction of dehydration and lots of alcohol is a great recipe for a wicked hangover!*

**Q13. Which ion is often exchanged with H+ in the regulation of body/ISF pH?**

**A. potassium, K+**
B. sodium, Na+
C. magnesium, Mg++
D. calcium, Ca++
E. chloride, Cl-

**Tip at: 100 sec**
*This ion also works with sodium in the propagation of action potentials.*

*Cells in the body have transporters that can exchange H+ and K+ ions. This exchange is important for maintaining extracellular, aka Interstitial Fluid (ISF) pH within a narrow range near pH 7. This might seem problematic since we also want to regulate K+ concentrations, but the pH 7 concentration of [H+] is 0.0000001 M whereas [K+] levels are in the 0.001 M range or higher, so moving K+ is often sufficient to adjust H+ levels i.e. pH. This said, if large quantities of metabolic acids are produced, K+ levels can be affected. A person with severe acidosis will secrete a large amount of H+ into the kidney tubules and this can result in hyperkalemia, aka elevated blood potassium. Na and K are also counter-regulated in the kidney, so everything is to some degree inter-connected, which makes this seem complicated to us. Fortunately, evolution is very smart in its inimitable, dumb blind-watchmaker style.*

**Q14. Urea**

A. is an important nutrient for the kidney
**B. plays a major role in the renal osmotic gradient and formation of a concentrated urine**
C. increases the glomerular filtration rate via efferent arteriole vasodilation
D. regulates acid-base balance via bicarbonate-chloride exchange
E. does ALL of the above

**Tip at: 100 sec**
*Not a nutrient, not a regulator.*

*Urea is a byproduct of amino acid metabolism. Ammonia, a nitrogenous and toxic waste product, is converted to urea which is non-toxic and is excreted in urine. Evolution somehow figured out that instead of excreting all our urea, we could use it to create a concentration gradient and use that gradient to regulate urine volume and concentration. Urea is a major component of the renal concentration gradient, in which osmolarity increase from an isotonic ~300 mOSm in the cortex to 1200 mOsm or more in the deep medulla (desert animals have even larger gradients). When water is to be conserved, the urine flowing past the 1200 mOsm medulla passively looses water (via aquaporins) to the high-urea interstitial fluid, and so we can excrete very concentrated (1200 mOsm) urine, i.e. we can secrete wastes that must be removed with a minimum loss of water. Urea is not a nutrient and does not regulate GFR or acid-base balance.*

**Q15. The appearance of glucose in the urine in diabetes mellitus is a result of**

**A. reverse transport of glucose in the proximal convoluted tubule**
B. glucose secretion in the distal convoluted tubule in an attempt to lower blood glucose
C. an increased GFR
**D. saturation of Na-glucose transporters**
E. ALL of the above

**Tip at: 80 sec**
*Our kidney tubules, like us, can only take so much.*

*Most glucose is reabsorbed in the proximal convoluted tubule via sodium-glucose co-transport into kidney epithelial cells (followed by facilitated diffusion into the ISF). In diabetes mellitus, the excessive levels of blood glucose overwhelm (i.e. exceed saturation of) the Na-glucose co-transporters, making for sweet (mellitus) urine (or so I am told). While GFR is not substantially altered in diabetes mellitus, the excessive glucose in the filtrate produces an increased osmotic pressure, drawing fluid into the filtrate, thus increasing urine volume, leading to thirst and frequent urination. It's nature's way of telling you something's wrong.*

**Q16. Micturition**

**A. is a purely reflexive behavior**
B. is a purely volitional behavior
C. does NOT involve sacral segments of the spinal cord
**D. *does* involve neocortical networks**
E. is done only at appropriate times

**Tip at: 60 sec**
*You'll also need these to Google *micturition*.*

*Micturition (or urination, as us commoners would say) is a complex behavior that involves reflexive and volitional or conscious controls. The urge to void arises due to stretch receptors in the bladder, whose size can range from 600 to 2500 ml! A modest volume e.g. 300 ml will evoke the need to void and trigger a spinal reflex relaxing the internal urethral sphincter. The external sphincter is under volitional control, which requires the development of inhibitory, cortical mechanisms (and additional spinal mechanisms). As far as answer (E) goes, Justin Bieber has ruled that out! It is also true that most children at age 2 lack volitional control and void reflexively. As to which instance is inappropriate, we leave that to you!*

**Q17. Dialysis is**

A. a technique used in biochemistry research
B. a chemical technique that can be used in industrial water treatments
C. a treatment for acute renal injury
D. a treatment for chronic renal failure
E. ALL of the above

**Tip at: 40 sec**
*In all cases, it depends upon diffusion.*

*In biochemical settings, dialysis can separate molecules using a semi-permeable membrane. For example, if a dialysis tube with protein and unwanted small molecules is placed in a large volume of buffer, the small molecules will be removed by diffusion. Our kidneys also use a semipermeable membrane, i.e. the basement membrane and filtration slits in the glomerulus, but that process is more one of filtration, where a large volume of fluid is filtered. But in medical kidney dialysis, the blood is run though dialysis tubing so that small wastes can be removed by diffusion. Dialysis machines do not have the elegance of our kidneys (lacks selective secretion and reabsorption mechanisms) and they also do not replace kidney endocrine functions. Dialysis is often sufficient for acute renal injury when the kidneys can recover, but in end-stage renal failure, the need for a kidney transplant becomes acute.*

**Q18. Which is NOT a contributing factor to the large volume of filtrate produced in renal glomeruli?**

A. large surface area created by the large numbers of nephrons
B. unusually high afferent arteriolar pressure
C. unusually low efferent arteriolar pressure
D. large number of capillary fenestrations
E. ALL of the above ARE significant factors in producing a large volume of filtrate

**Tip at: 20 sec**
*One of these would collapse the glomerular blood pressure which would be bad, real bad.*

*The kidneys filter about 180 liters of blood per day, i.e. a large multiple of our total blood volume. This is necessary because of the constant generation of metabolic wastes that must be removed from the circulation. The kidney has a rich and unusual blood supply where the body's high pressure arterial system feeds rather directly into the afferent arterioles supplying the glomeruli. Especially unusual is a high-resistance efferent arteriole on the outflow side of the glomerular capillary beds. This results in high pressure that backs up into the glomerulus, creating a high hydrostatic pressure that is essential for the creation of a large volume of renal filtrate. To our knowledge this is the ONLY organ in the body with an afferent and efferent arteriole. This is distinct from low pressure portal circulations where veins connect one capillary bed to a downstream capillary bed (in the GI and hypothalamic-pituitary systems).*

**Q19. The portion of the urinary system that delivers urine from the renal pelvis to the bladder is called:**

A. the major calyx
B. the ureter
C. the urethra
D. the franklin
E. NONE of the above

**Tip at: 0 sec**
*Like getting a good education, you gotta pick the right *U*.*

*The calyces collect urine from collecting ducts and funnel it through the renal pelvis into the ureter, which is a narrow muscular tube leading to the bladder. At this point, the hydrostatic pressure is near zero and fluid flow occurs via peristalsis. This is where kidney stones can lodge with excruciating consequences. Folk lore suggests that drinking cranberry juice can help prevent these, but remaining well hydrated is no doubt more important. The urethra is the tube leading from the bladder to the outside world via the urethral orifice. The franklin is a $100 bill.*