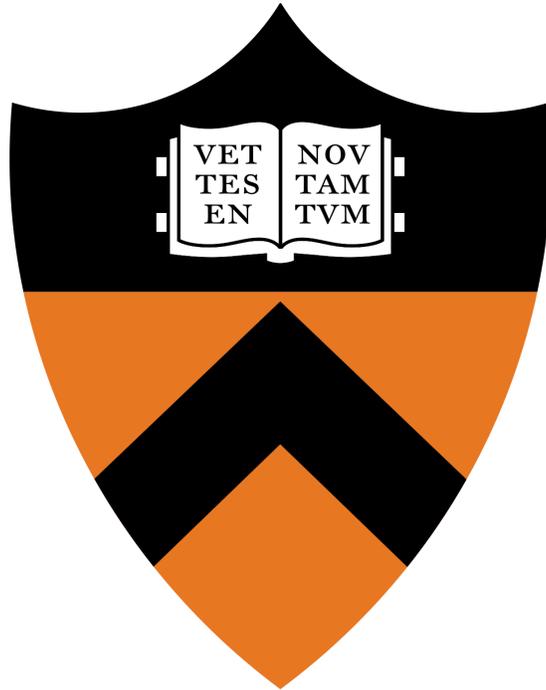


# Princeton High School



## Anatomy and Physiology Captains Tryouts 2018-2019

Score: \_\_\_\_ / 142

## Excretory System

Which of the following substances is the standard used to measure the glomerular filtration rate? (3 pts)

- A. NaCl
- B. Inulin
- C. Creatine
- D. Renin

Charlie has been more tired, hungry, and thirsty than usual. His doctor decides to test his urine for the renal clearance of glucose but forgets how to do basic math! Charlie's urine flow is 1 ml/min, the plasma concentration of glucose is 1.6 mg/ml, and the urine concentration of glucose is 240 mg/ml. Calculate the renal clearance of glucose and try to diagnose his condition. (4 pts)

$$C = UV/P$$

$$240 \text{ mg/ml} * 1 \text{ ml/min} / 1.6 \text{ mg/ml} = 150 \text{ ml/min}$$

Diabetes (diagnosed using glycosuria)

Describe the sequence of the RAS hormone cascade and the mechanisms by which it regulates blood pressure. (8 pts)

Granular cells release renin in response to lower systemic blood pressure (specifically renal bp). Renin cleaves a peptide called angiotensinogen into angiotensin I. Angiotensin I is then cleaved by ACE (angiotensin converting enzyme) into angiotensin II, the active hormone. (4 pts)

One point for each effect: (max 4)

Peripheral vasoconstriction

Directly causes renal tubules to increase  $\text{Na}^+$  reabsorption

Stimulates release of aldosterone, which increases  $\text{Na}^+$  reabsorption and  $\text{K}^+$  secretion

Promotes release of ADH which both increases water reabsorption and thirst

Causes glomerular mesangial cells to contract and reduce GFR which decreases total surface area.

Brian has a serious kidney condition: his proximal convoluted tubule has lost all function! Describe what would happen to Brian's blood pH and blood volume and why. (6 pts)

Blood pH would become more basic and less stable because of less reabsorption of  $\text{H}^+$ ,  $\text{NH}_4^+$ , and  $\text{HCO}_3^-$ . (3pts)

Blood volume would decrease dramatically because the PCT cannot perform its function of reabsorbing about 65% of the filtrate volume. (3 pts)

Match the following diseases with their symptoms: (1 pt each)

- |                            |   |
|----------------------------|---|
| Incontinence c)            | a) Sudden onset pain, severe and intermittent pain          |
| Calculus a)                | b) Swelling in limbs, decreased urine volume, drowsiness    |
| Renal Failure b)           | c) Loss of bladder control                                  |
| Urinary Tract Infection e) | d) Hematuria, foamy urine, hypertension                     |
| Glomerulonephritis d)      | e) Strong persistent urge to urinate, strong smelling urine |

Choose two diseases from above and describe how to treat each of them. (6 pts)

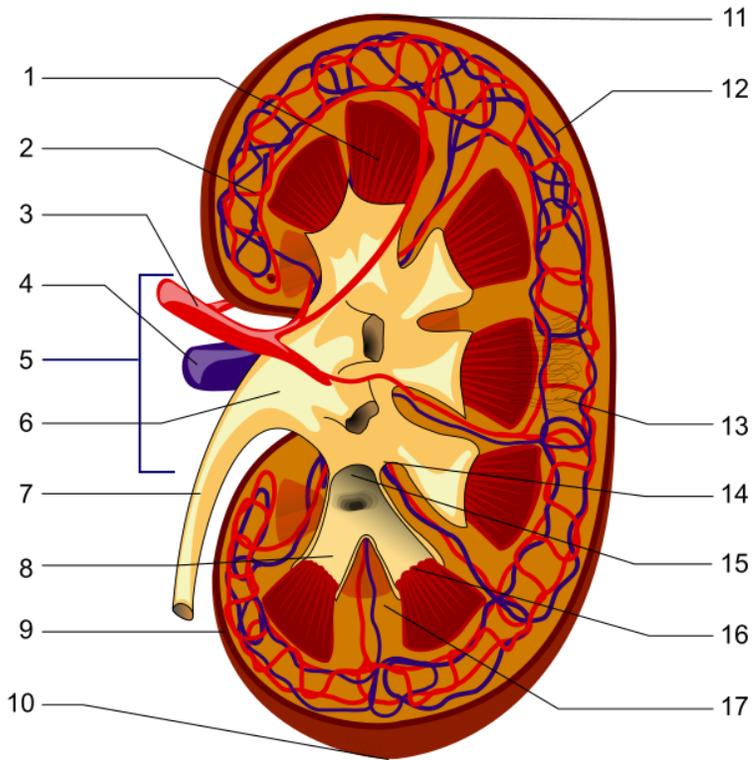
Incontinence - Anticholinergic medications or surgery

Calculus - Surgery

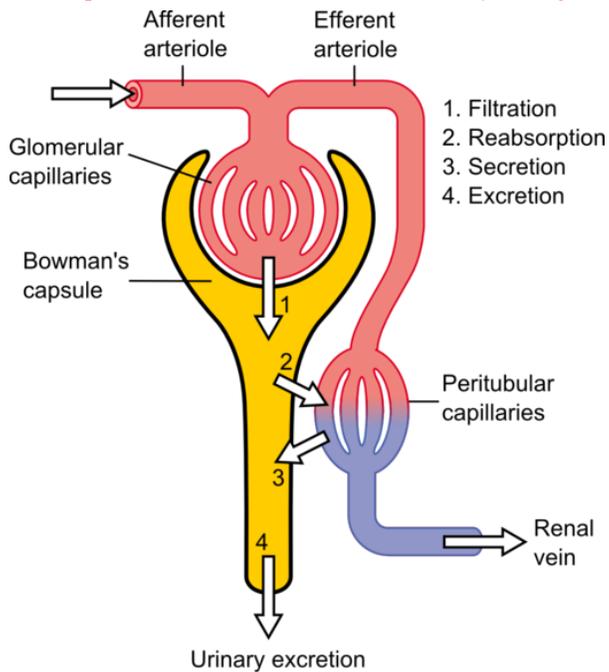
Renal failure - hemodialysis, peritoneal dialysis, kidney transplant

Urinary tract infection - antibiotics, vaginal estrogen therapy

Glomerulonephritis - sometimes will go away on its own. if caused by high blood pressure: diuretics, beta blockers, ACE inhibitors. if caused by bacterial infection: antibiotics. if results in long-term kidney failure: hemodialysis and kidney transplant



1. Renal pyramid • 2. Interlobular artery • 3. Renal artery • 4. Renal vein 5. Renal hilum • 6. Renal pelvis • 7. Ureter • 8. Minor calyx • 9. Renal capsule • 10. Inferior renal capsule • 11. Superior renal capsule • 12. Interlobular vein • 13. Nephron • 14. Renal sinus • 15. Major calyx • 16. Renal papilla • 17. Renal column (0.5 pts each)



Excretion = Filtration - Reabsorption + Secretion (0.5 pts each)

# Lymphatic System

What is the difference between primary, secondary, and tertiary lymphatic tissues? Give examples for each. (6 pts)  
(2pts each)

Primary - generate lymphocytes from immature cells e.g. thymus, bone marrow.

Secondary - provide a place for antigen presentation, mature naive lymphocytes, initiate adaptive immune response. Examples include lymph nodes, spleen, and MALT (Peyer's patches, adenoid tonsils, skin)

Tertiary - develop in response to long-term immune responses after birth such as inflammation and are organized lymphoid aggregates. No example needed.

What two structural modifications allow lymph vessels to be so permeable? (4 pts)

Endothelial cells are not tightly joined like in blood vessels and overlap instead, forming "minivalves"

Collagen filaments attach to surrounding tissue so when interstitial fluid volume increases, minivalves open instead of collapse.

Describe the role of the spleen as a lymphatic organ in immune function. (5 pts)

Provides a site for lymphocyte proliferation and immune surveillance and response. (2 pts)

Blood cleansing functions such as extracting aged and defective blood cells from blood or having macrophages remove debris and foreign matter from blood. (2 pts)

Contains huge amounts of lymphocytes in white pulp. (1 pt)

Describe the function of the thymus. (4 pts)

Organ where immature T-cells go through clonal selection to become immunocompetent.

What are the two main lymph ducts? What area does each drain? (4 pts)

Right lymphatic duct drains right upper limb and right side of head and thorax.

Thoracic duct drains rest of body.

Describe the role of the lymphatic system in fat absorption. (3 pts)

Lacteals, a type of lymphatic capillary, are found in the villi of the small intestine and directly absorb fat. This fat is then transported to the blood as a milky-white substance called chyle via other lymphatic ducts.

Which of the following lymphoid tissues are found in the walls of the intestines? (2 pts)

- A. Palatine tonsils
- B. Adenoid tonsils
- C. Peyer's patches
- D. Vermiform appendix

What term collectively describes all of those tissues above? (2 pts)

MALT (Mucosa-Associated Lymphatic Tissue)

Match the following diseases with their symptoms. (1 pt each)

Lymphedema d)

a) Painless swelling of lymph nodes in neck, armpits and groin, persistent fatigue, Reed-Steinberg cells detected in biopsy

Hodgkin's lymphoma a)

b) Enlarged spleen, swelling of lymph nodes in neck

Lymphadenopathy b)

c) Painless swelling of lymph nodes in neck, armpits and groin, persistent fatigue, no Reed-Steinberg cells detected in biopsy

non-Hodgkin lymphoma c)

d) Swelling in arms and legs, restricted range of motion, fibrosis

Choose two diseases from above and describe how to treat each of them. (6 pts)

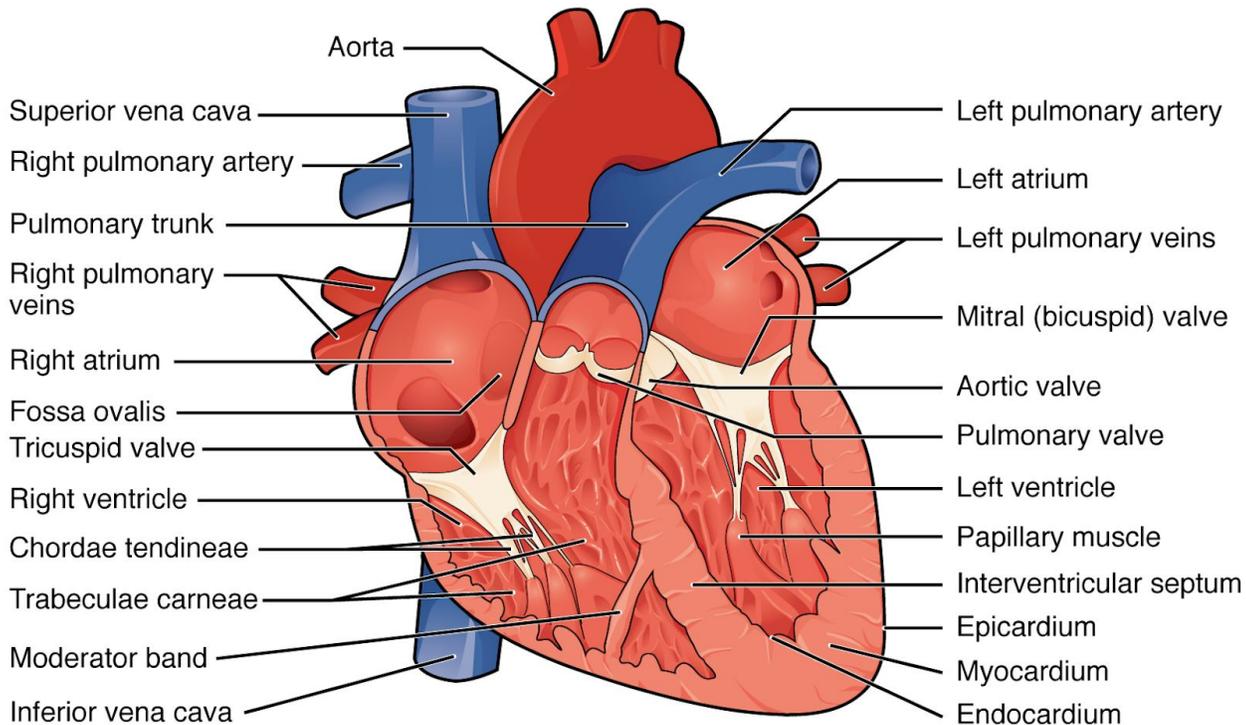
Lymphedema - lifestyle changes: exercise, compression. will naturally resolve as new lymph vessels grow into area

Hodgkin's lymphoma - chemotherapy in early stages, possibly radiotherapy in later stages

Lymphadenopathy - biopsy to identify underlying cause of inflammation then treated accordingly

non-Hodgkin lymphoma - chemotherapy, radiotherapy, immunotherapy

# Cardiovascular System



**Anterior view**

(0.5 pts each)

Daniel is a member of Princeton High School's Live Action Role Playing Club. As a putrid orc, he regularly gets into physical combat with other members. John, a blade shaman, has just stabbed Daniel in the back of his thigh. List and describe the 3 general steps that Daniel's body will take to stem the flow of blood. (7 pts)

- 1) **Vascular spasm - local arteries constrict immediately (2 pts)**
- 2) **Platelet plug formation - platelets bind to exposed collagen fibers and form a positive feedback loop by releasing chemical messengers (ADP, serotonin, thromboxane  $A_2$ ) (2 pts)**
- 3) **Coagulation - fibrin threads seal the cut. Intrinsic and extrinsic pathways both activate prothrombin which activates thrombin which then catalyzes formation of fibrin from fibrinogen. (3 pts: two for naming, one for correct description)**

Congestive Heart Failure e)	a) Blood clots, angina, can lead to stroke or heart attack
Atrial Fibrillation f)	b) Pressure or tightness in chest, pain in the jaw or back that lasts for a few minutes and goes away
Myocardial Infarction b)	c) Long QT interval, palpitations, sudden cardiac death
Atherosclerosis a)	d) Fluttering in chest, skipped beats, extra beats
Premature Ventricular Contractions d)	e) Very rapid weight gain, dyspnea, persistent cough
Torsades c)	f) Irregular and rapid heart rate, heart palpitations, weakness

Choose three diseases from above and describe how to treat each of them. (9 pts)

Congestive Heart Failure - treat hypertension (the underlying cause) using diuretics, beta blockers, ACE inhibitors, vasodilators, or cardiac inotropic drugs.

Atrial Fibrillation - cardioversion: electric cardioversion therapy, antiarrhythmic drugs

Myocardial Infarction - anti-clotting drugs: aspirin, tPA; surgical procedures such as coronary artery bypass grafting, angioplasty, or a coronary stent

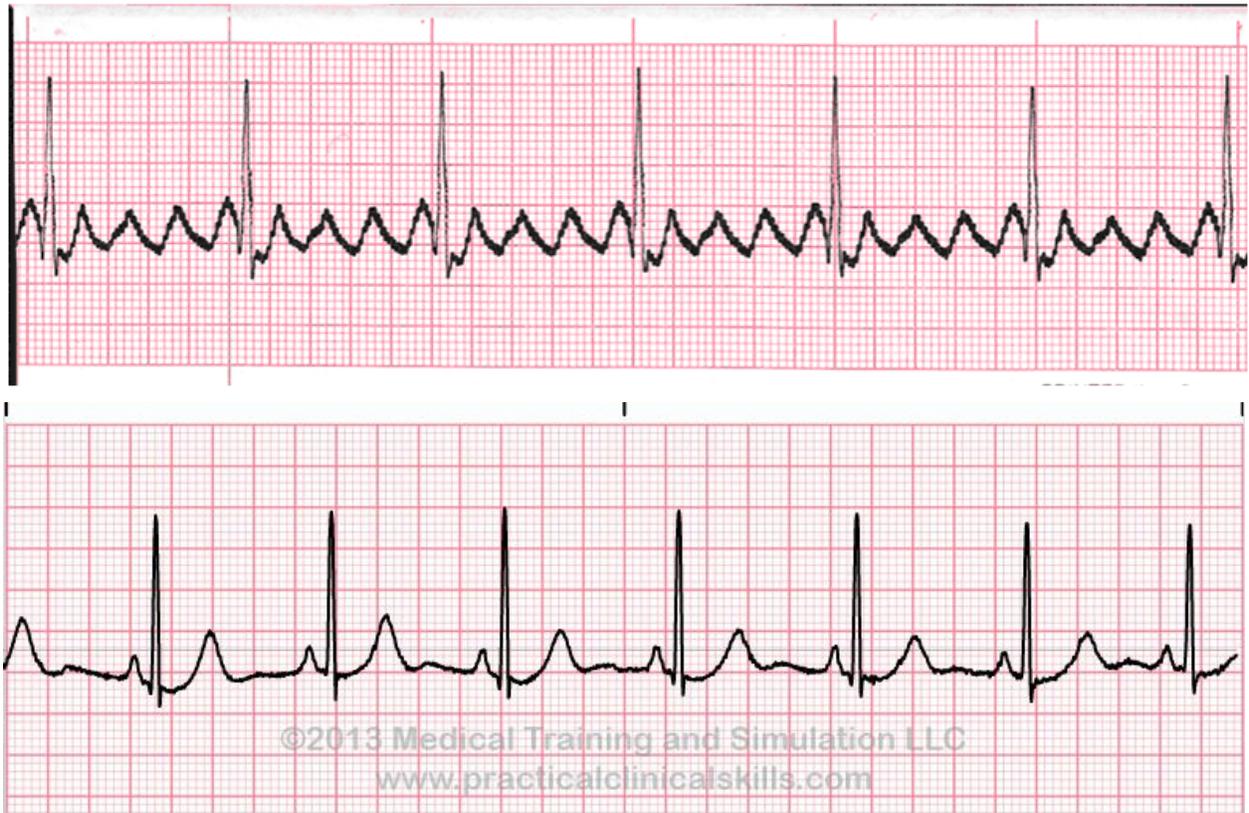
Atherosclerosis - lifestyle changes: no smoking, alcohol, eating healthier; anti-clotting drugs: aspirin, tPA; surgical procedures such as coronary artery bypass grafting, angioplasty, or a coronary stent

Premature Ventricular Contractions - hypertension drugs: beta blockers, ACE inhibitors; anti-arrhythmic drugs

Torsades - hypertension drugs: beta blockers, ACE inhibitors; anti-arrhythmic drugs; fish oil; implantable cardioverter-defibrillator to stop potentially fatal arrhythmias

Saumya is at her physical check-up. The doctor uses an instrument to calculate her blood pressure. The reading is 110/72. Answer the following questions:

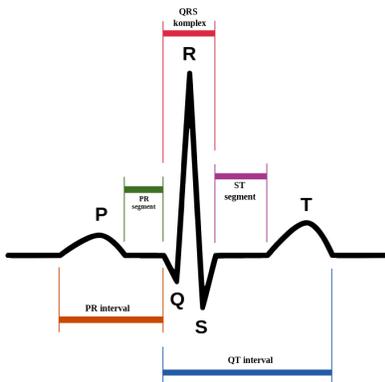
- What is the name of the method and instrument used to measure Saumya's blood pressure? (2 pts)  
auscultatory method, sphygmomanometer (2 pts)
- What is her systolic blood pressure? What is her diastolic blood pressure? (1 pt)  
110 - systolic (0.5 pts)  
70 - diastolic (0.5 pts)
- Calculate her mean arterial pressure. (2 pts)  
 $(SBP + 2DBP)/3 = 83.3$  (2 pts)



Label either EKG as normal or abnormal. What disease does the abnormal EKG suggest? Label the different waves of the normal sinus rhythm. (6 pts)

Above - atrial fibrillation

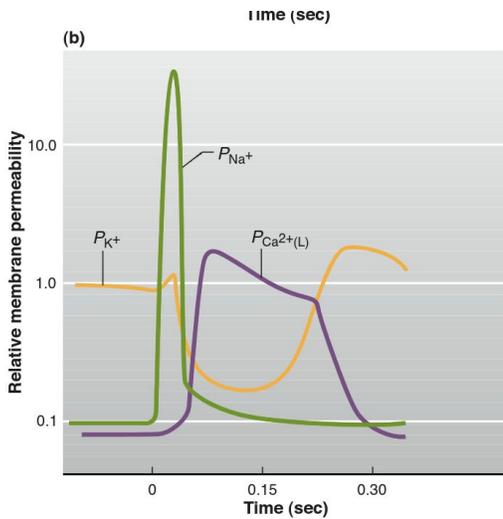
Below - normal sinus rhythm



4 pts for correct identification of EKG, 2 pts for correct labeling of PQRST.

Describe how, physiologically, pacemaker cells generate automatic action potentials. (6 pts)

- 1)  $K^+$  channels opened during repolarization close slowly.
  - 2) F-type  $Na^+$  channels open during negative membrane potentials
  - 3) T-type  $Ca^{2+}$  channels provide a small but important depolarization for the membrane to reach threshold
- (6 pts total)



Calculate the net filtration pressure given the capillary hydrostatic pressure is 20 mmHg, the capillary osmotic pressure is 1 mmHg, the interstitial hydrostatic pressure is 5 mmHg, and the interstitial osmotic pressure is 10 mmHg. (6 pts)

$$NFP = (HP_c - HP_{if}) - (OP_c - OP_{if})$$

$$NFP = (20 - 5) - (1 - 10)$$

$$NFP = 24 \text{ mmHg}$$